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**Prof. Dr. Osman Nuri UÇAN**
Baş Editör

## From Editor

The scope of the Aurum Engineering Systems and Architecture (A-JESA) covers the novel scientific papers about Electronics, Image Processing, Information Theory, Electrical Systems, Power Electronics, Control Theory, Embedded Systems, Robotics, Motion Control, Stochastic Modeling, System Design, Multidisciplinary Engineering, Computer Engineering, Optical Engineering, Design Optimization, Material Science, Metamaterials, Heat and Mass Transfer, Kinematics, Dynamics, Thermo-Dynamics, Energy and Applications, Renewable Energy, Environmental Impacts, Structural Analysis, Fluid Dynamics, Theoretical and applied Mathematics, Physics and Chemistry, Architectural Researches and other topics such as Urban Design, Interior Architecture and Cinematic Architecture.

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It is our great pleasure to publish Volume 3, Number 1 of international journal, "Aurum Engineering Systems and Architecture" (A-JESA) after serious review process.

I sincerely wish to thank members of the editorial board, reviewers and authors of this issue who have generously contributed their time and knowledge to the work and the mission of the journal.



**Prof. Dr. Osman N. UÇAN**
Editor in Chief

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**AURUM MÜHENDİSLİK SİSTEMLERİ VE MİMARLIK DERGİSİ**
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**DERLEME/REVIEW**

# ÇUBUK AĞI AHŞAP KUBBELER

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## Öz

Geniş açıklıklı yapı ihtiyacına yönelik tasarım anlayışının, 20. yy'ın başlarından itibaren kendini gösterdiği söylenebilir. Bu anlayışta, malzeme, biçim ve taşıyıcı sistem bir bütün halinde değerlendirilir ve tasarıma katılır. 20.yy'ın ikinci yarısından itibaren gelişen lamine ahşap kompozit eleman (glulam) üretim teknolojileri, geniş açıklıklı ahşap yapı tasarımını mümkün kılmıştır. Bu çalışmada çubuk ağı kabuk sistemler genelinde; önemli bir uygulama alanı bulan tek tabakalı ahşap kubbeler incelenmektedir. Malzeme, form ve taşıyıcı sistemin verimliliği, bilinen en geniş açıklıklı ahşap kubbe örnekleri üzerinden karşılaştırmalı olarak irdelenmektedir. Kubbe maliyetine etki eden parametrelerden biri taşıyıcı sistemin tipi ve basıklığıdır, jeodezik sistem ekonomikliği ile tercih edilmektedir. Birleşimlerin teşkil biçimi ve yükleri taşıma kapasitesinin yanısıra; kubbe yüklerinin zemine aktarılma biçimi de önemlidir. İncelenen örneklerden, yüklerin payandadan çekme çemberine aktarım biçiminin en uygun çözüm olduğu görülmektedir.

**Anahtar Kelimeler:** Lamine ahşap kiriş, Geniş açıklık, Çubuk ağı kubbe, Ahşap, Düğüm noktası.

## RETICULATED TIMBER DOMES

## Abstract

It can be said that the concept of design for the needs of the wide span structure has emerged from the beginning of the 20th century. In this approach, the material, form and structural system are evaluated as a whole and are included in the design. Since the second half of the 20th century, the production of glue laminated members (glulam) has made possible to design wide span wooden structures. In this study, single-layer reticulated wooden domes which have an important position in application area are adressed. The efficiency of the material, form and structural system is investigated on the well known largest-span timber domes. One of the parameters affecting the cost of the dome is the type and aspect ratio of the structural system, geodesic system is economically preferred. In addition to the load carrying capacity of nodes and connections, transferring of the loads on domes to the ground is also important. The load transfer from buttresses to the tension ring seems the most appropriate solution.

**Keywords:** Glulam, Large-span, Reticulated dome, Wood, Node.

## 1. GİRİŞ

Çubuk ağı kabuk sistemler (ızgara kabuk sistemler), çubuk elemanların ağsı bir düzen oluşturduğu, yüzeye etkiyen yüklerin ağsı düzeni oluşturan çubuk elemanlar tarafından taşınarak temele aktarıldığı yapılardır. Bu tür yapıların üretiminde kullanılan malzemeler çelik, ahşap veya alüminyum olabilmektedir. Çubuk ağı kabuk sistemlerin başlıca üç tip oluşturma tekniği mevcuttur.

I) Düğüm noktalarında birbirinin içinden geçen ve tüm yapı boyunca uzanan sürekli elemanlara sahip ızgara sistemler (amorf ahşap ızgara kabuk sistemler, Şekil 1)

**Şekil 1.** Amorf formlar (Weald and Downland Museum ve Savill Garden, İngiltere) (Chilton ve Tang, 2017) [1,2]

II) Düğüm noktalarında metal birleşim elemanlarına birleşen kısa çubuklar ile teşkil edilen sistemler

- Tek tabakalı sistemler (Şekil 2): Dış yükler genellikle tali elemanlar ile söz konusu çubuk elemanlara aktarılır, taşıyıcı sistemde M,N,T kesit tesirleri oluşur.
- İki tabakalı sistemler (Şekil 3): Dış yükler doğrudan düğüm noktalarına aktarılır, bu durumda genellikle tipik bir kafes sistemde olduğu gibi sadece N sözkonusudur.



Bu çalışmada tek tabakalı ahşap çubuk ağı kabuk sistemlerin kubbe tipi incelenecektir. Söz konusu sistemlerde tipik birleşim modellenmesi ve maliyet karşılaştırması yapılacaktır.

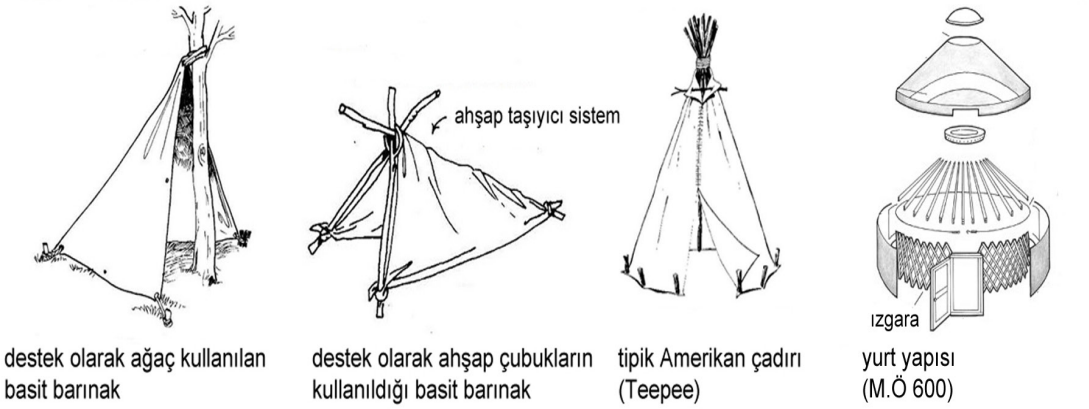

**Şekil 2.** Ashiro Gymnasium Dome, Ashiro, Japonya, 1986 [3] (Misztal B. 2017)


**Şekil 3.** Oguni Dome, Japonya, 1988 [4, 5] (Nordström ve Orstadius, 2014)

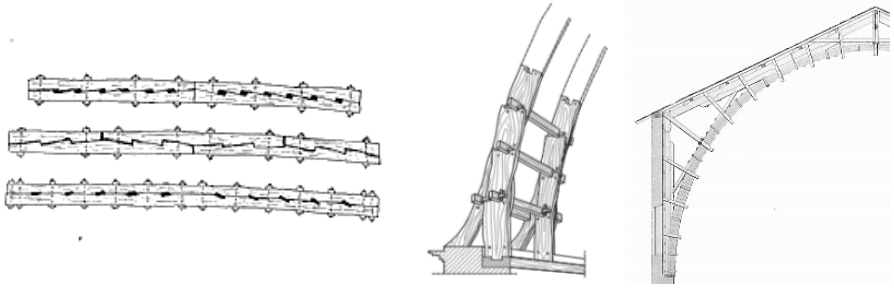
## 2. ÇUBUK AĞI KABUK SİSTEMLER

### 2.1 Tarihçe

Çubuk ağı sistemlerin ortaya çıkışı, ahşaptan ilk basit barınakların yapımı ile başlamış, kısa düz çubuklar birbiri ile kesiştirilerek yaşanabilir hacimler elde edilmiştir (Şekil 4). Lamine kompozit ahşap elemanların ise 16.yy dan başlayarak üretildiği görülmektedir. Da Vinci, dişlendirilmiş ahşap elemanların kamalı birleşimlerini üretmiştir. Philibert de L'Orme'nin doğrudan lamine elemanlar ile kamalı birleşimli kemer tasarımı, 19. yy'da Emy'nin lamine elemanlar ile bulonlu yine kemer formlu tasarımı, geniş açıklıklı yapılarda lamine kompozit ahşabın ilk yapısal örnekleri olmuştur (Şekil 5).




**Şekil 4.** Basit barınak örnekleri

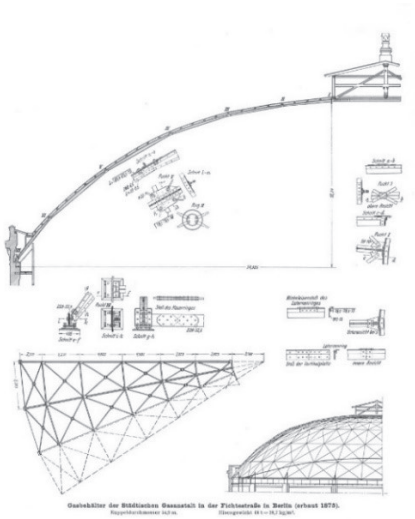


(a) (b) (c)

**Şekil 5.** 16-19.yy döneminde ahşap elemanların gelişimi; (a) Da Vinci sistemi (Jasieńko ve diğerleri, 2011); (b) De l´Orme sistemi (Misztal, 2017); (c) Emy sistemi (Mongelli, 2006)

Sistemin bugünkü modern yapım sistemine dönüşmesinde, lamine ahşap ve çelik üretim teknolojilerinin paralel gelişimi ve yaygınlaşması en önemli etkenlerdir. 19. yy'ın ikinci yarısında çelik, ekonomik ve seri şekilde üretilmeye başlanmıştır. Bu durum, malzemenin çubuk ağı kabuklarda uygulanmasına zemin hazırlamıştır. 1874'de J.W.Schwedler, paraleller ve meridyenler doğrultusundaki çelik çubuklar ve stabiliteyi arttırmak için diyagonal yönde çok ince kesitli elemanlar ile hafif ve şeffaf kubbe tasarımı (*Schwedler kubbesi)* gerçekleştirmiştir (Şekil 6).

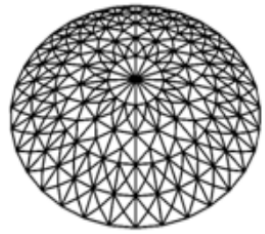
Tutkal kullanılan ahşap kompozitlerin ilk örnekleri Old Rusholme Chapel (Manchester, 1927) ve King Edward College (Southampton, 1860)'dir (Slavid, 2005). 1901'de Almanya'da Otto Hetzer'in kazein tutkalı ile patentini aldığı lamine ahşap kiriş (*glulam*) ise, bu alanda gerçek bir gelişme olmuştur. İki veya daha fazla sayıda ahşap katmanı, kazein bazlı yapıştırıcılar ile birleştirilerek geniş açıklıklı kemerler tasarlanmış, 40 m'ye kadar ahşap kompozit elemanlar üretilmiştir.



(a)

(b)

(c)



(d)

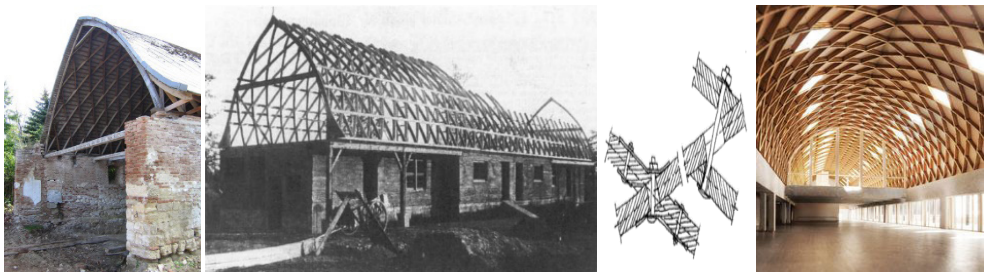


**Şekil 6.** (a) 12 m yüksekliğinde ve 54 m çapında Fichte-Bunker, Berlin, 1874 (Kurrer, 2018)
(b) Kubbe basınç çemberi [6]
(c) Günümüzdeki görünümü [7]
(d) Schwedler kubbe (Kurrer, 2018)

Ahşap çubuk ağı sistemlerin ilk uygulaması; mevcut yapılara önemli yük getirmeden yaşam alanlarını genişletmek amacına yönelik olarak, F. Zollinger'in geliştirdiği ve patentini aldığı (1910) hafif, ön üretimli *Lamella sistem*'de hayat bulmuştur (Şekil 7a). Lamella sistem günümüzde de yaygın şekilde uygulanmaktadır (Şekil 1,7b).

Neme dayanıklı, nitelikli sentetik tutkallar ile üretilen ahşap çubuk ağı kabuklar için, 1931'de Kaurit'in sentetik reçine esaslı (üre- ve fenol- formaldehit)[1] tutkalı ticari kullanıma sunması öncü bir gelişme olmuştur, ekonomik ama neme dayanıksız kazein tutkalların yerini almıştır. 2.Dünya Savaşı sırasında phenol-resorsinol-formaldehit (PRF) tutkalların kullanıma sunulması ile günümüzün glulam elemanlarının üretimi başlamıştır.

**1** Sözkonusu sentetik reçineler üzerine araştırmalar; Almanya'da A.V Baeyer (1872)'in fenol-formaldehit üzerine, Goldschmidt (1896)'in üre-fomaldehit üzerine çalışmaları ile başlamıştır (Kollmann ve diğerleri,1975).

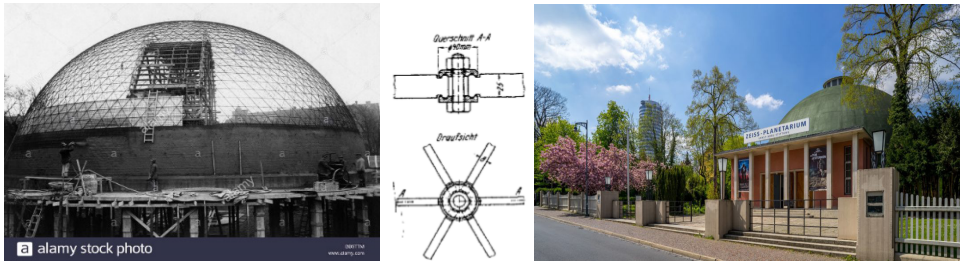


(a) (b)

**Şekil 7.** (a) Zollinger'in lamella sistem uygulaması, Merseburg, 1922 ve düğüm noktası [8], (b) Günümüzden bir lamella silindirik kabuk uygulaması [5]

1922'de, ilk defa Alman mühendis W. Bauersfeld tarafından tasarlanan *Jeodezik kubbe* sistemi (Şekil 8), 1954 yılında B. Fuller tarafından yeniden, ancak iki tabakalı kafes sistem olarak tasarlanmıştır (Şekil 9). Daha sonraki dönemde geliştirilerek tek tabakalı jeodezik kubbe günümüz formunu almıştır.






(a) (b) (c)

**Şekil 8**. (a) Tek tabakalı çubuk ağı kubbe örneği; 82 m çapında Zeiss Planetarium yapısı, Jena, Almanya, 1922 [9] ; (b) düğüm noktası (Aondio,2014); (c) günümüzden görünüm [10]

(a) (b)

**Şekil 9.** (a) Biosphère, American Pavilion Expo 67, Kanada, 1967 [11]; (b) İki tabakalı çubuk ağı (uzay kafes) kubbe ve düğüm noktası [12]

### 2.2 Modern Tek Tabakalı Çubuk Ağı Sistemler ve Ahşap Kubbelerin Gelişimi

1950'lerde Dr.Kiewitt, Zollinger'in lamella sisteminden esinlenerek, kendi ismi ile anılan Kiewitt kubbesini (Diamatic kubbe) tasarlamıştır. Houston Astrodome (1965) bu tasarımın sonucudur, 217 m açıklığı ile dünyanın en büyük çelik kubbelerinden biridir. Günümüzün modern düğüm noktalarının henüz geliştirilmemiş olması ve geçilen açıklığın çok büyük olması gibi nedenler ile kirişler, 150 cm'lik düzlem kafes kiriş (Bass, 1965) formunda tasarlanmıştır (Şekil 10), yapının modern tek tabakalı uygulamalara öncü olduğu söylenebilir.


(a) (b) (c)

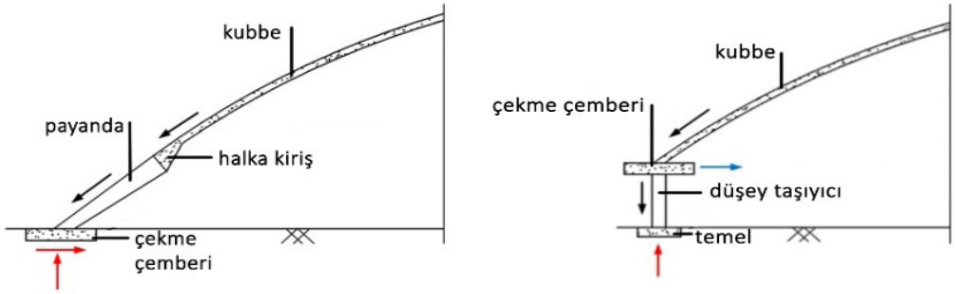
**Şekil 10.** (a) 217 m açıklıklı Kiewitt kubbe Astrodome, Houston, A.B.D, 1965 [13]; (b) kafesler ve mesnet birleşimleri [14]; (c) Kiewitt kubbe görünümü (Yan ve diğerleri, 2016)

2.Dünya Savaşı sonrası, tutkal ve lamine kompozit ahşap eleman üretim teknolojilerindeki gelişmelerin sonucunda; tek tabakalı ahşap kubbelerin uygulaması ilk olarak 1950'li yıllarda A.B.D'de ortaya çıkmıştır (Brick Breeden Fieldhouse, 1957). Ancak en ekonomik sonuç veren kubbe tipi olan jeodezik kubbe (*Varax kubbe* ismi ile), kesit tesirleri için yeterli rijitliği sağlayan metalik düğüm noktası tasarımının geliştirilmesi ile 1970'lerden itibaren uygulama alanına girmiştir. Jeodezik kubbenin rijitliği; Kiewitt kubbe ile aynı olup, Schwedler kubbenin 20 katıdır (Jorissen, 1989), ortaya çıkan iç kuvvetler de jeodezik kubbe durumunda diğerlerine kıyasla en düşük olmaktadır.



Çubuk ağı kubbelerde genel olarak; yükseklik/açıklık oranı (*h/D*) azaldıkça, yapının yanal yöndeki itkisi dolayısıyla yanal doğrultuda mesnetlenme ihtiyacı ve artan iç kuvvetler ile birlikte burkulma eğilimi artar, böylece yapının rijitliğini sağlamak için taşıyıcı sistem maliyeti artar. Burkulma eğilimindeki artış, *h/D*'nin artışı durumunda da sözkonusu olur. Literatürde $h/d = 0.23\text{-}0.38$ aralığının kullanılabilir ve 0.29'un ideal olduğu (Pan ve Girhammar, 2002), 0.16'nın ise kabul edilebilir sınır durum olduğu belirtilmektedir (Fredriksson ve Herrström 2017). Lamella ve diamatic kubbe karşılaştırıldığında *h/D* optimum oranının, lamella kubbe için 0.25, diamatic kubbe için 0.30 olduğu görülmektedir (Nahar ve Aleyas, 2017).

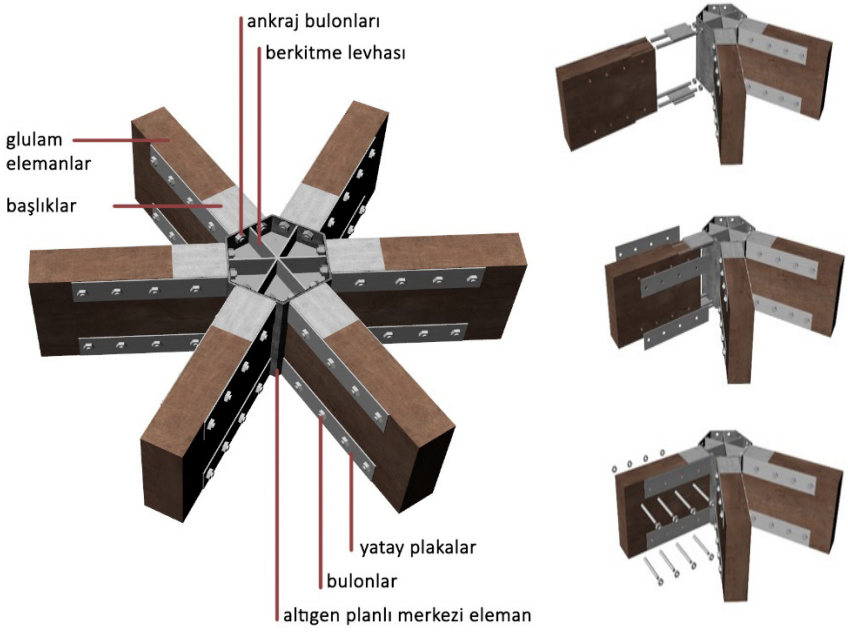
Çubuk ağı kubbe sistemlerin uygulamalarında, kubbeden zemine aktarılacak çekme kuvveti, çekme çemberi tarafından alınır. Kubbelerde karşılaşılan iki tip mesnetlenme durumu Şekil 11'de verilmiştir. Payandaya mesnetleme durumunun, hem ekonomik tasarım hem de artan kullanılabilir alan nedeniyle daha çok tercih edildiği görülmektedir. Payandalar; betonarme ve sıklıkla ardgermeli betondan yapılan çekme çemberine birleşir, Walkup Skydome (1977) ve Round Valley Ensphere (1991) bu tip uygulamaya örnek verilebilir. Kolonlara birleşme durumunda ise çekme çemberi, kubbenin kolonlara birleştiği yerde düzenlenir, Tacoma Dome (1983) bu tipte düzenlenmiştir. Kubbe basıklığı arttıkça, payanda uygulaması daha ekonomik sonuç verir.




**Şekil 11.** Kubbenin tipik mesnetlenme biçimleri (Segal ve Adriaenssens, 2013)

Tek tabakalı ahşap çubuk ağı kubbeler; metalik olarak altıgen/silindirik formlu düğüm noktalarına karşılıklı altı farklı yerden 60° lik açı ile birleşen kısa ahşap çubuk elemanlar ile teşkil edilir. Sözkonusu elemanlar; sıklıkla Douglas köknarı, ladin, Güney Sarıçamı gibi ibreli (iğne yapraklı) yumuşak ağaçlardan üretilmiş glulam tarzı tutkallı lamine kompozit elemanlardır, tabaka kalınlıkları genellikle 3.8 cm (1-1/2 in) alınmaktadır. Düğüm noktaları, tek tabakalı çubuk ağı sistemlerden beklendiği üzere, tüm kesit tesirlerini taşıyacak ve aktaracak özellikte tasarlanır. Birleşimin bulonlu olması uygulama kolaylığı sağlar. A.B.D'de 1970' lerden itibaren kullanılmış olan altıgen düğüm noktası tipi bu çalışmada modellenerek Şekil 12'de verilmiştir.






**Şekil 12.** Tek tabakalı ahşap çubuk ağı sistemde (a) düğüm noktası şematik gösterimi (b) Kurulum safhaları

Tek tabakalı kubbe sistemlerin montajı iki şekilde gerçekleştirilebilir:

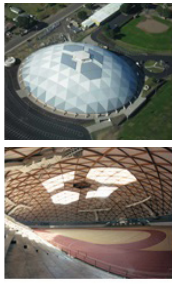
- Zemin seviyesinde oluşturulan üçgen birimlerin sistem üzerindeki koordinatlarına uygun olarak vinç ile oturtulması,
- Zemin seviyesinde üçgenlerden oluşturulan blokların hidrolik krikolar yardımıyla kaldırılarak kubbe üzerine yerleştirilmesi.

Tek tabakalı kubbelerde ilk yöntem çok kullanılmıştır.

## 3. TEK TABAKALI AHŞAP KUBBELER VE SAYISAL KARŞILAŞTIRMALAR

Bu çalışmada, tek tabakalı ahşap kubbe sistemlerin geniş açıklıklı beş uygulama örneği (Misztal, 2017; Verbout, 1991; Marshall, 1977) ve [15-21] kaynaklarından yararlanılarak, karakteristik özellikleri ile Tablo 1'de incelenmiştir. Yapıların yapıldıkları yıldaki maliyetleri, homojen bir karşılaştırma için, 2018 yılı US$ kuruna güncellenerek [22] verilmiştir. Takiben, bu yapılar ile ilgili sayısal karşılaştırmalar yapılmaktadır.

**Tablo 1**. Tipik tek tabakalı ahşap kubbe sistemler ve teknik özellikleri

| Yapı | Walkup Skydome (1977)<br>Flagstaff, Arizona, ABD | Tacoma Dome (1983)<br>Seattle , ABD | Superior Dome (1991)<br>Michigan, ABD | Round Valley Ensphere (1991)<br>Arizona, ABD | Enel Dome (2015)<br>Brindisi, Italya |
|---|---|---|---|---|---|
| Yapının içten ve dıştan görünüm |  |  |  |  |  |
| Yapı boyutları: | D: 153 m , H:28 m<br>h: 26.6 m , h/D: 0.17<br>A: 18400 $m^2$ | D: 161.5 m , H: 48 m<br>h: 29 m , h/D: 0.18<br>A: 20500 $m^2$ | D: 163 m , H: 49 m<br>h: 39 m , h/D: 0.24<br>A: 20900 $m^2$ | D: 134 m , H:31.6 m<br>h: 30 m , h/D: 0.22<br>A: 17500 $m^2$ | D: 143 m , H: 50 m h: 39.8 m , h/D: 0.28<br>A: 16300 $m^2$ |
| Taşıyıcı sistem ve boyutlar: | Kirişler: Glulam, Güney çamı, 222-311$^{mm}$ x 686$^{mm}$, 36 betonarme payanda, 13 m aralık ile 10 MPa ard-germe basıncı uygulanan beton çekme çemberine 1200$^{mm}$ x 900$^{mm}$) birleşir. Yıllık ortalama 2.4 m kar yükü de dikkate alınmıştır. | Kirişler: Glulam, Douglas Köknarı, 170-220$^{mm}$ x 760$^{mm}$ 36 dairesel kolon (660$^{mm}$) üst seviyesinden ard-germeli beton çekme çemberine birleşir. | Kirişler: Glulam, Douglas Köknarı (220$^{mm}$ x 950$^{mm}$) 40 payanda,3 tendon ile 16 MPa ard germeli çekme çemberi (1500$^{mm}$x 750$^{mm}$). Kubbe tasarımında 129kmh rüzgar hızı da dikkate alınmıştır. | Kirişler: Glulam (680$^{mm}$), Güney çamı, 2.4 m boy 36 betonarme payanda 3.5m betonarme istinad duvarı üst kısmında (zemin seviyesi) 700$^{mm}$ yüksekliğinde çekme çemberi. 56 kablo ile 48 MPa ard germe uygulanmıştır . | Kirişler: Glulam, ladin 180$^{mm}$x1130$^{mm}$ (GL 28c), 220$^{mm}$x1130$^{mm}$ (GL 32h), Tali kirişler:100$^{mm}$x240$^{mm}$ -100$^{mm}$x650$^{mm}$ (GL 28c) Çekme çemberi: HEB 550 (S355) , 6.2 m lik 40 betonarme payandaya birleşmektedir. |
| İnşaat süresi ve maliyet*: | 24 ay, kubbe:6 ay,<br>33.1 million $ | 21 ay, kubbe: 5 ay<br>111 million $ | 9 ay , 44 milyon $ | 19 ay, kubbe: 9 ay<br>20.2 milyon $ | 24 ay, 76.5 milyon $ |

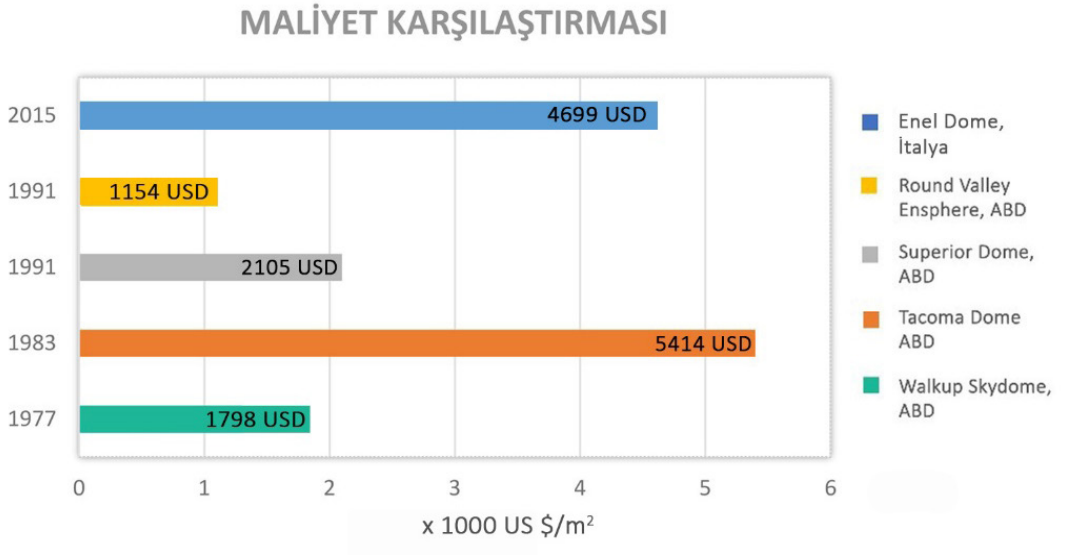
D: Yapı açıklığı H: Tüm yapı yüksekliği h: Kubbe yüksekliği A: Taban alanı *2018 Tüketici Fiyat Endeksi verilerine göre [22] güncellenerek

**Süre:**

Tablo 1'deki ahşap kubbelerde, yerde hazırlanan üçgen birimlerin vinç ile kurulması yöntemi izlenmiştir. Ancak örneğin, dünyanın en geniş açıklıklı çelik kubbelerinden biri olan Nagoya Dome (D:187 m, 1997)'da hidrolik kriko ile blok blok kaldırma yolu izlenmiştir, bu yöntemin inşaat süresini altı ay kısalttığı belirtilmektedir (Miyazaki ve diğerleri, 1996). Böylece, bir ayda ahşap kubbelerde ~3000 $m^2$ alan kapatılırken, sözkonusu çelik kubbede de benzer rakamın yakalandığı görülmektedir.

**Maliyet:**

Ahşap kubbelerin kolonlara mesnetlenme biçimleri maliyeti etkileyen önemli bir unsurdur. Tablo 1'deki yapıların karşılaştırmasında, çekme çemberinin kolon üstünde tasarlandığı kubbelerde (Tacoma Dome, 1983; Enel Dome, 2015), 2018'e güncellenmiş maliyet 4700-5400 $/$m^2$'yi bulurken, kubbenin ~1.5 m lik payandadan doğrudan çekme çemberine birleşmesi durumunda (Walkup Skydome, 1977; Round Valley Ensphere, 1991; Superior Dome, 1991) maliyet 1100-2100 $/$m^2$ seviyesinde kalmaktadır (Şekil 13), en ekonomik sistemdir.




Şekil 13 Tablo 1'deki tek tabakalı ahşap kubbelerin $m^2$ maliyet karşılaştırması

**Diğer:**

Ahşap yapılarda, %12 düzeyine kadar kurutulmuş lamine elemanların kullanılması, ahşabın dayanıklılığı açısıdan önemli bir faktördür. Ahşap yapının yangın dayanımı açısından, hiç bir boyutu 8 cm'in altında olmamak koşulu ile, projede istenen yangın dayanımı süresince düşük kömürleşme kalınlığının, tasarım aşamasında taşıyıcı sistem için gerekli kesit boyutlarına ilave edilmesi yeterli olmaktadır. Diğer taraftan çelik yapılar için, hem yangın hem de korozyon dayanımı açısından dikkatle ön işlemler gereklidir.

Ahşap kubbelerin iç kaplamaları da ahşap olmakta, ayrıca doğal aydınlatma açısından şeffaf uygulama da yapılabilmektedir (Tablo1, Round Valley Ensphere, 1991). Isı yalıtımı özelliği nedeni ile ahşap, özelllikle soğuk iklimde ve/veya buz sporları merkezlerinde çok kullanılan bir taşıyıcı sistem malzemesi haline gelmiştir.

## 3. SONUÇLAR VE ÖNERİLER

Bu çalışmada incelenen konulardan aşağıdaki sonuçlara ulaşılmıştır.

- İncelenen örnekler bazında tek tabakalı ahşap kubbelerde yükseklik/açıklık oranının 0.17-0.28 aralığında olduğu görülmektedir, kubbelerde en ekonomik tasarımı sağlayan jeodezik form uygulanmaktadır.
- Kubbeden payandaya oradan da zeminde çekme çemberine yapılan birleşimler, yapının en ekonomik şekilde çözümlenmesine imkan sağlamaktadır. Çekme çemberinde genellikle ard germe uygulaması mevcuttur.
- Dünyanın halen en geniş açıklıklı ahşap kubbesi Superior Dome (163 m)'dur. Ahşap, geniş açıklıkta çeliğe alternatif bir malzemedir. Ayrıca ahşap, özellikle soğuk iklim koşullarında ve/veya buz sporları sözkonusu olduğunda, yapının hizmet ömrü boyunca ısıtma giderleri açısından oldukça ekonomik olmaktadır.
- Tek tabakalı sistemlerin blok blok kriko ile montajı, üçgen birim halinde yerinde montaja göre çok daha ekonomik sonuç vermektedir.
- Genişliği 20 cm, istenen mekanik karakteristikleri sağlayacak şekilde ~4 cm lik tabakalardan yüksekliği genellikle 60-120 cm aralığındaki glulam elemanlardan oluşan ahşap kubbelerin yangın dayanımı korunmasız çeliğe kıyasla çok yüksektir. Dünyada ahşap geniş açıklıklı yapıların sigorta giderlerinin çelik olanlara kıyasla ekonomik olması da geniş açıklıkta ahşabın tercih edilmesinin diğer bir nedenidir.
- Türkiye'de ahşabın; yangın dayanımı, hafiflik, ısı yalıtımı avantajları ve nefes alabilirlik açısından daha yaygın kullanımı bir gerekliliktir. Endüstriyel ormancılığın geliştirilerek; yerel ve sertifikalı çam grubu ağaçların ekonomik biçimde yapı üretimine kazandırılması gereklidir.



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**RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ**

# A TIGHT BINDING MODEL FOR QUANTUM SPIN HALL EFFECT ON TRIANGULAR OPTICAL LATTICE

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## Abstract

We propose a tight binding model for the quantum spin Hall system on triangular optical lattice and we determined the edge state spectrum which contains gap traversing states as the hallmark of $Z_2$ topological insulator. The advantage of this system is the possibility of implementing it in the fermionic ultracold atomic system whose nearly free electron limit is proposed by B. Beri and N. R. Cooper, Phys. Rev. Lett. 107, 145301 (2011).

**Keywords:** Ultra cold atom, Topological insulator, Tight binding model, Quantum mechanics, Optical lattice.

## ÜÇGEN OPTİK ÖRGÜDE KUANTUM SPİN HALL ETKİSİ İÇİN SIKI-BAĞ MODELİ

## Öz

Bu makelede, üçgen örgü üzerinde kuantum spin Hall sistemi için bir sıkı-bağ modeli önermekte ve Z2 topolojik yalıtkanının ayırt edici özelliği olan boşluk geçiş durumlarını da içeren kenar durum spektrumunu incelemekteyiz. Bu sistemin avantajı, serbest elektron sınırı B. Beri ve N. R. Cooper tarafından verilen (Phys. Rev. Lett. 107, 145301, 2011) fermiyonik aşırı soğuk atomik sistemlerde de incelenme imkanının olmasıdır.

**Anahtar Kelimeler:** Aşırı soğuk atomik sistemler, Topolojik yalıtkan, Bir sıkı-bağ modeli, Kuantum mekaniği, Optik örgü.

## 1. INTRODUCTION

Topological insulators (TIs) are insulating in the bulk but have metallic states on their boundaries [Hasan and Kane (2010), Zhang (2011)]. Robustness of these states against disorder and perturbations makes them promising for applications such as spintronics [ Moore J. E. (2010)] and topological quantum computation [Nayak *et al.* (2008)]. Topological invariants of the bulk material are essential for the robust boundary modes. This urged consideration of topological insulators on different lattice geometries [ Hu, Kargarian, and Fiete (2011), Weeks and Franz (2010), Guo and Franz (2009a), Guo and Franz (2009b), Kane, Fu and Mele (2007)].

It is widely acknowledged that the cold atomic systems are ideal systems to simulate solid-state phenomena in a controlled way. The two and three dimensional topological insulators with band gaps in the order of the recoil energy have recently been proposed in ultracold fermionic atomic gases [Beri and Cooper (2011)]. The proposal utilizes interactions which preserves time reversal symmetry (TRS), analogous to synthesized spin-orbit coupling [Lin, Jimenez-Garcia and Spielman (2011)], so that the insulators are classified by the so-called Z2 topological invariant [Fu and Kane (2006)].

Even if the band gap in tight binding models are not as large as in nearly free electron limit, TIs in ultra-cold atomic systems have been studied vastly in tight binding regime [Juzelians, Ruseckas and Dalibard (2010), Goldman *et al.* (2010)]. The optical lattices are described by continuous potentials formed by the combinations of standing waves. It is convenient to treat them as deep potentials. Our aim in this article is to propose a tight binding model for the quantum spin Hall effect which can be realized in the ultracold atomic systems. The corresponding model in the nearly free electron limit is proposed by Beri and Cooper [Beri and Cooper (2011)] with this advantage that the band gap is large. We also determine the band structure of the edge state which exhibits the hallmark of TIs due to its robustness against all perturbations that preserve the TRS. In the Sec. II of this paper we propose the tight binding model for quantum spin Hall (QSH) system in the triangular optical lattice. In Sec. III we briefly review the proposal of Z2 topological insulator in ultracold atomic gases [Beri and Cooper (2011)]. We conclude in Sec. IV.



## 2. TIGHT BINDING MODEL

### 2.1 Bulk band structure

The charge quantum Hall effect depends on the breaking of time-reversal symmetry and it has been shown that even in the absence of average non-zero external magnetic field the quantum Hall effect can be created [Haldane (1988)]. However, in the QSH effect one needs to preserve the time reversal invariance. Among the first models proposed for dissipationless QSH effect are the works by Bernevig and Zhang (2006) and by Kane and Mele (2005), where the authors used the spin-orbit coupling such that the two-different spin direction experiences the same magnetic field strength but with opposite sign. In other words, their system were two copies of a quantum Hall system for each spin where the total first Chern number adds up to zero and the system is time reversal invariant.

Physically our model corresponds to the same scenario. We propose a Hamiltonian for a fermion on triangular lattice Fig. 1 with a mirror symmetric spin orbit coupling as:

$$H = t\sum_{m,n} C^{\dagger}_{m+1,n}C_{m,n} + C^{\dagger}_{m,n+1}e^{i4\pi m\phi}\sigma_z C_{m,n} + C^{\dagger}_{m+1,n-1}e^{i2(m+1)\pi\phi}\sigma_z C_{m,n}, \quad (1)$$

where $\varphi = p/q$ is flux per plaquette and we take $p = 1$ and $q = 4$ in this paper. $C_{m,n} = (c_{m,n\uparrow}, c_{m,n\downarrow})^T$ and $C_{m,n}{}^{\dagger}$ are annihilation and creation operators on site (m, n) respectively. We take the hopping parameter $t = 1$ throughout this paper. The first term is nearest neighbor hopping term on the triangular lattice with $\boldsymbol{a}1 = (3/4, 1/4)a$ and $\boldsymbol{a}2 = (0, 1/2)a$, where a is the lattice constant (see Fig. 1). The second and third terms are mirror symmetric spin-orbit interaction. σz is the Pauli matrix. In the absence of spin this Hamiltonian implies that electron acquires φ = 1/4 of flux quantum enclosing the elementary plaquette of the triangular lattice.

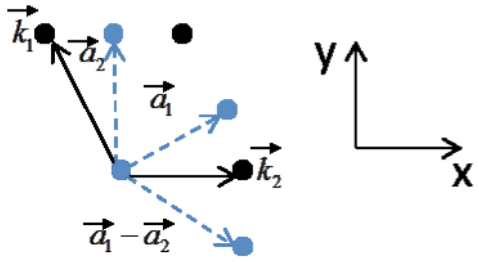



**Figure 1**. The light points and dashed lines show the lattice sites of the atoms and the hopping directions in the triangular lattice respectively, and the dark points and lines are the corresponding Brillouin zone sites and vectors respectively.



To calculate the band structure, we take the Fourier transform of the Hamiltonian Eq. (1). We use the momentum representation of fermionic operator

$$C_{\mathbf{k}} = \sum_{m,n} e^{i\mathbf{k}\cdot\mathbf{R}_{m,n}} C_{m,n}, \quad (2)$$

where $\boldsymbol{R}_{m,n} = m\boldsymbol{a}1 + n\boldsymbol{a}2$. We obtain the energy dispersion in triangular lattice by solving the determinant for the eigenvalues ε,

$$\mathrm{Det}\begin{bmatrix} -A-\epsilon & B+iC & 0 & 0 \\ B-iC & A-\epsilon & 0 & 0 \\ 0 & 0 & A-\epsilon & B-iC \\ 0 & 0 & B+iC & -A-\epsilon \end{bmatrix} = 0, \quad (3)$$

where A, B and C are defined to be:

$$A = \cos(k_y a/2),$$
$$B = \cos\tfrac{a}{4}(\sqrt{3}k_x + k_y), \quad (4)$$
$$C = \cos\tfrac{a}{4}(\sqrt{3}k_x - k_y).$$

To solve Eq. (3), we used a 2D grid for the k-space. Fig. 2a shows the band structure of the Eq. (3) for a cell with specific **k** points as its corners taken to be $(k_1 + k_2)/2, k_1/2, 0, k_2/2$, as shown in the inset. These points are the TRS invariant points in the Brillouin zone Since each of the two blocks of the Eq. (3) corresponds to two-fold spin degenerate bands, each band of the Fig. 2a is four-fold degenerate.

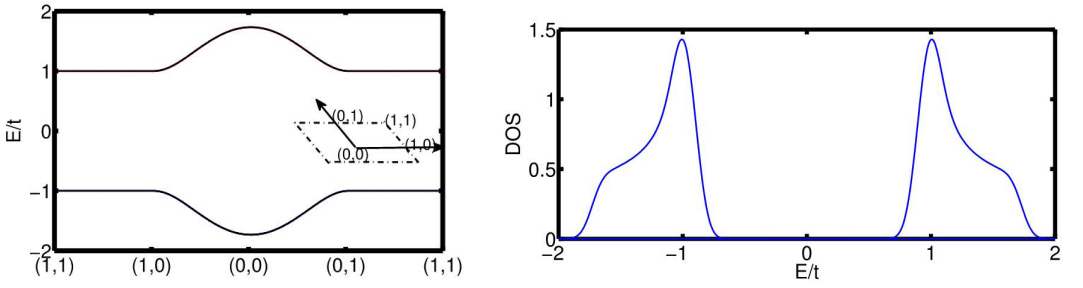



**Figure 2**. Left (a): The band structure of the Hamiltonian Eq. (1) along the path (1,1), (1,0), (0,0), (0,1) where 1 and 0 are referrıng to the inset (m,n) in $\boldsymbol{\Gamma}_{m,n} = (mk_1 + nk_2)$, which are the TRS invariant points in Brillouin zone. Right (b): The DOS for all the energy bands is shown where the horizontal axis is the energy.

We also calculated the density of states (DOS) for the Hamiltonian in Eq. (3). This quantity is defined by the expression:



$$\rho(E) = \frac{1}{A}\sum_{\boldsymbol{k}} \delta(E - E_n), \tag{5}$$

where A is the area of the system in reciprocal space and En is the energy of the bands. In Fig. 2b the DOS is depicted for all the energy bands.

### 2.2 Edge-state band structure

The characteristic of the Z2 topological insulator is the gapless edge states. They describe two spin currents at the edge, propagating in opposite direction. This property is because of the time-reversal symmetry and it prevents the gap opening due to any TR invariant perturbation as the result of the Kramer's theorem [Kane and Mele (2005)].

We follow the method in Ref. [Hatsugai (1993)] to find the energy dispersion of the edge states. The Hamiltonian Eq. (1), must be reduced to a one-dimensional problem. We take the y direction as the periodic part and we use the momentum representation as:

$$C_{m,n} = \frac{1}{\sqrt{L_y}} \sum_{k_y} e^{ik_y n} C_m(k_y), \tag{6}$$

where $\frac{k_y a}{2} = \frac{2\pi n_y}{L_y}, n_y = 1, \ldots,$ is the system size along y direction. By inserting the single particle state

$$|\Psi(k_y)\rangle = \Sigma_m \, |\Psi(k_y)_m\rangle C_m^{\dagger}(k_y)|0\rangle \tag{7}$$

into the Schrödinger equation $H|\Psi\rangle = E|\Psi\rangle$, the spin up part of the problem is reduced to the one-dimensional problem with parameter ky as:

$$G^*\Psi_{m+1} - G\Psi_{m-1} - 2\cos\left(\frac{k_y a}{2} - 4\pi\phi m\right)\Psi_m = E\psi_m. \tag{8}$$

where $G = 1 + e^{-i(-k_y a/2 + \pi\phi(2m+1))}$. Including the spin down as well, this equation can be written as a generalized Harper equation [Harper (1955)] in transfer matrix form:

$$\begin{pmatrix} \Psi_{m+1\uparrow}(k_y) \\ \Psi_{m\uparrow}(k_y) \\ \Psi_{m+1\downarrow}(k_y) \\ \Psi_{m\downarrow}(k_y) \end{pmatrix} = M \begin{pmatrix} \psi_{m\uparrow}(k_y) \\ \psi_{m-1\uparrow}(k_y) \\ \psi_{m\downarrow}(k_y) \\ \psi_{m-1\downarrow}(k_y) \end{pmatrix}, \tag{9}$$

where M is the transfer matrix, which is given by:

$$M = \begin{pmatrix} \frac{F}{G} & \frac{G^*}{G} & 0 & \\ 1 & 0 & & \\ & & \frac{F'}{G'} & \frac{G'^*}{G'} \\ 0 & & 1 & 0 \end{pmatrix} \tag{10}$$

with

$G' = 1 - e^{-i\left(-\frac{k_y a}{2} + \pi\phi(2m+1)\right)}$, $F = -\epsilon - 2\cos\left(\frac{k_y a}{2} - 4\pi\phi m\right)$ and $F' = -\epsilon + 2\cos(k_y a/2 - 4\pi\phi m)$.

Under the boundary condition that the wavefunction goes to zero at the boundaries of lattice we can solve this equation. The band structure along the path $k_y a = 0 - 2\pi$ is shown in the Fig. 3. We used 100 k-points along ky direction. The shaded area is the bulk band and the gap traversing edge states as the signature of Z2 topological insulator are plotted as the solid line. Since the TRS is preserved no TR symmetric perturbation can open the gap at $k_y a = \pi$.

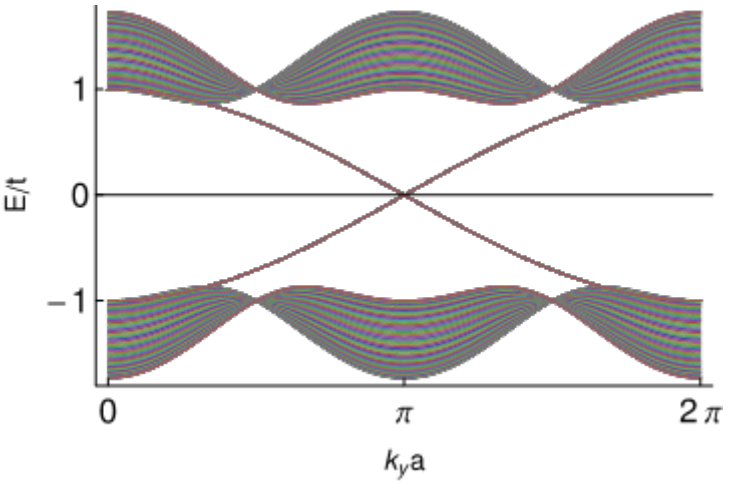



**Figure 3.** The spectrum of the edges of triangular lattice. The shaded area is lowest energy bands for the triangular lattice (for uniform spacing of -4 $\pi/\sqrt{3} < k_x a < 4\pi/\sqrt{3}$). The solid lines show the spin polarized edge sate band, traversing the gap. The edge states cross at

## 3. COLD ATOMIC SYSTEM



In this section, we review briefly the Z2 topological insulator model proposed by Beri and Cooper (2011). This model is studied in nearly free electron limit which has the advantage of large band gap.

The Hamiltonian which describes an atom with position r and momentum p and with N internal states is given by

$$H = \frac{\vec{p}^2}{2m} 1_4 + \hat{VM}(\vec{r}) \tag{11}$$

where $\widehat{VM}(\boldsymbol{r})$ is a position dependent potential. To have a system with low spontaneous emission one can use ytterbium (Yb) which has long-lived excited state. The two internal states, ground state (1S0 = g) and long-lived excited state (3p0 = e) of Yb have spin degree of freedom which leads to four states. Another interesting aspect of Yb is the existence of a state dependent scalar potential for λmagic with opposite sign $\pm V_{am}(r)$. Therefore, we can write the potential part of Hamiltonian when we have external electric field as $E = \varepsilon e^{-i\omega t} + \varepsilon^* e^{-i\omega t}$ with complex amplitude ε and frequency ω. All four e-g transitions have the same frequency $\omega 0 = (E_e - E_g)/\hbar$. Using rotating wave approximation [Cohen-Tannoudji, Dupont-Roc, and Grynberg (1992)] we have the optical potential as following:

$$\hat{VM}(\vec{r}) = \begin{pmatrix} (\frac{\hbar}{2}\Delta + V_{\text{am}})1 & -i\vec{\sigma}.\vec{\epsilon}\, d_r \\ i\vec{\sigma}.\vec{\epsilon}\, d_r & -(\frac{\hbar}{2}\Delta + V_{\text{am}}) \end{pmatrix} \tag{12}$$

where $\Delta = \omega - \omega_0$ is the atom-field detuning and dr is the dipole moment. One can write the Hamiltonian in terms of Dirac matrices [Murakami, Nagaosa, and Zhang (2003)]:

$$\Gamma^{1,2,3} = -i\sigma^y \otimes \sigma^i, \Gamma^4 = \sigma^x \otimes I \text{ and } \Gamma^5 = \sigma^z \otimes I, \tag{13}$$

which gives:

$$H = \frac{\hat{\boldsymbol{P}}^2}{2m}\mathbf{1} + \Gamma^i d_r \epsilon_i + \Gamma^5\left(\frac{\hbar}{2}\Delta + V_{am}\right), \tag{14}$$

For the two-dimensional system one can make following choice for the potential matrix Eq. (12):

$$\begin{aligned} d_r\epsilon &= [V\delta, V\cos(\vec{r}.\vec{k}_1), V\cos(\vec{r}.\vec{k}_2)], \\ \tfrac{\hbar}{2}\Delta + V_{am}(\vec{r}) &= V\cos(\vec{r}.(\vec{k}_1 + \vec{k}_2)) \end{aligned} \tag{15}$$

with $\boldsymbol{k}_1 = k\,(1,0,0)$ and $\boldsymbol{k}_2 = k(cos(\theta), sin(\theta), 0)$ . The optical potential in Eq. (17) is formed from three standing waves which are linear polarized light at the coupling frequency ω. Two of these waves have equal amplitude in the 2D plane ($\boldsymbol{k}_1$ for y polarization and $\boldsymbol{k}_2$ for z polarization) the x-polarized wave vector is normal to the 2D plane with an amplitude smaller by a factor of δ. Since the $\cong \omega_0$ , we have $k \cong 2\pi/\lambda_0$ with $\lambda_0 = 578\,nm$ the wavelength of the e-g transition. The spatial dependence of Vam is set by a standing wave at the antimagic wavelength $\lambda_{am}$ [Gerbier and Dalibard (2010)], which creates a state-dependent potential with $|\boldsymbol{k}_1 + \boldsymbol{k}_2| = 4\pi/\lambda_{am}$ that leads $\theta = 2\,arccos(\pm\lambda_0/\lambda_{am})$. For simplicity, in all following discussions one can fix $\theta = 2\pi/3$ and define $a \equiv 4\pi/(\sqrt{3}k)$ Therefore the optical coupling M^ has the symmetry of a triangular lattice. In Fig. 4a we show the few lowest energy bands for δ = 0. The bands were calculated by numerical diagonalization in the plane wave basis (49 plane waves are used). All bands are fourfold degenerate like tight binding regime. The relation of this system to the tight binding model given in previous section becomes clearer as one applies the unitary transformation $\hat{U} = (1 - i\hat{\Sigma}_3\hat{\sigma}_2)/\sqrt{2}$ to the coupling $\hat{M}$ in Eq. (12):

$$\hat{M}' = \hat{U}^\dagger \hat{M} \hat{U} = c_1\hat{\Sigma}_1 + c_2\hat{\Sigma}_2\sigma_3 + c_{12}\hat{\Sigma}_3 \tag{16}$$

here $\Sigma_i = \sigma_i \otimes 1_{2\times 2}$ , $c_i \equiv \cos(\boldsymbol{r}\cdot\boldsymbol{k}_i)$ and $c_{12} = \cos(\mathbf{r}\cdot(\mathbf{k}_1 + \mathbf{k}_2))$ . This matrix is 2×2 block diagonal matrix for each eigenvalue of σ3 ( since the kinetic part is diagonal this is the case for the Hamiltonian as well) thus the four-level system decouples into two two level system each of which experiences an effective magnetic field due to the optical dressed state of the $c_1\hat{\Sigma}_1 \pm c_2\hat{\Sigma}_2 + c_{12}\hat{\Sigma}_3$ [Cooper (2011)]. This means that opposite spin direction undergoes an effective magnetic field of the

same strength but with opposite signs. Beside the lowest band energy of these systems have ±1 Chern number which they cancel out each other because of the time-reversal symmetry. These are the required criteria for the quantum spin Hall effect.

To make the connection to the previous section we consider the adiabatic limit $V \gg \hbar k^2/2M$ [Jaksch and P. Zoller (2005)] when the potential part of the Hamiltonian Eq. (11) plays the dominant role. To find the minima of the adiabatic energy which gives the lattice sites in tight binding regime [Jaksch *et al.* (1998)] we diagonalized the potential in Eq. (16) analytically and obtained:

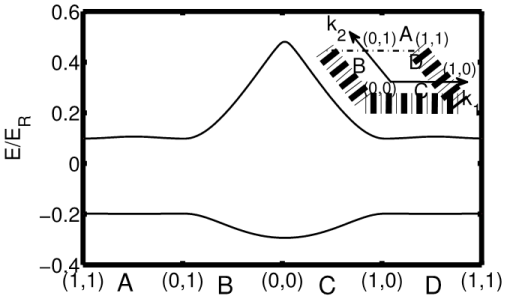
$$V_{ad} = \pm\sqrt{c_1^2 + c_2^2 + c_{12}^2}, \tag{17}$$

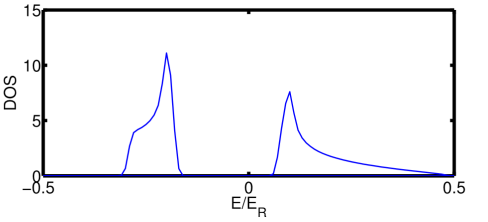
as plotted in Fig. 5.

Now if we ignore the spin here, the effective magnetic field strength experienced by the neutral atom following the adiabatic path is equivalent to the 1/4 of a flux quantum that a charged particle acquires enclosing the elementary plaquette of the triangular lattice in tight binding limit [Ashcroft and Mermin (1976)]. This is equivalent to the Hamiltonian Eq. (1) proposed in this paper without spin. Therefore, tight binding limit of the ultra-cold atomic system of Ref. [Beri and Cooper (2011)] is given in Eq. (1) and the hopping parameter t is related to the potential scale of optical coupling V based on the formalism in [Jaksch, et al. (1998)]. The difference is in the (0, 0) point in k-space where the upper band of cold atom limit has a sharper peak Fig. 4a than the tight binding upper band Fig. 2a. This can be understood as the characteristic behavior of the energy levels of free electron which are just a parabola in k (momentum), by getting distorted due to a periodic potential [Ashcroft and Mermin (1976)].



As the potential becomes stronger the energy dispersion resembles the tight binding regime Fig. 4b. The DOS for the nearly free electron limit is also depicted in Fig. 4c which shows that states are distributed around the two energy bands across the gap asymmetrically due to the asymmetrically located van Hove singularities of the upper and lower bands in contrast to that of tight binding case in Fig. 2b. Finally, we note that realization of QSH models in Eq. (1) and Eq. (11) does not require any spin flipping interactions and thus does not need any additional cooling mechanism [Kennedy *et al.* (2013)].



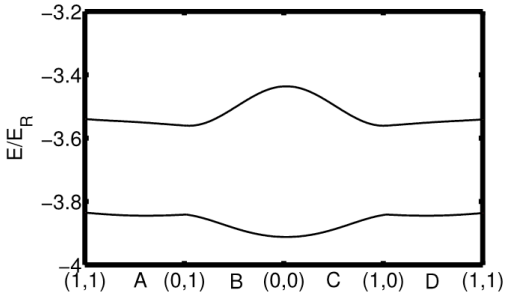



**Figure 4.** Top Left(a): Lowest energy bands of the cold atom system in nearly free electron limit as the result of the solution (a). Lowest energy bands of the cold atom system in nearly free electron limit as the result of the solution of Eq. (14). The energy is plotted relative to recoil energy $E_R$. Here $V = 0.5E_R$ and $\delta = 0$ are shown here. The k-points are labeled as $\Gamma_{mn} = (m\boldsymbol{k}1 + n\boldsymbol{k}2)/2$ and each band is four-fold degenerate.

Bottom left (b): Energy bands for the potential $V = 3.5E_R$ which resembles the band structure of tight binding regime Fig. 2a.

Right (c): DOS of the energy bands in Fig. 2a which are depicted in the band structure is shown. Energy is expressed in the unit of $E_R$.

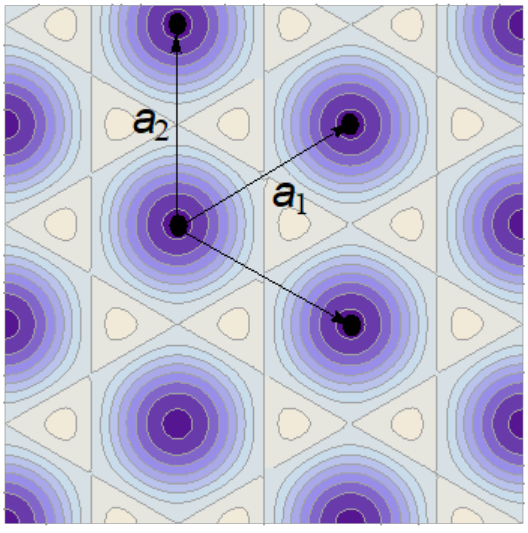



**Figure 5.** The dark circles show the local minima of the adiabatic energy which forms a triangular lattice in the tight binding limit.



## 4. CONCLUSION

Summarizing, we considered the quantum spin Hall effect on the triangular lattice in the tight binding limit and we proposed that this can be realized in the ultra-cold atomic system. We studied the edge state band structure which reveals the Z2. The nearly free electron limit of the system we proposed here is introduced as Z2 topological insulator in Ref. [Beri and Cooper (2011)].

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**Conflict of Interests/Çıkar Çatışması**

Authors declare no conflict of interests/Yazarlar çıkar çatışması olmadığını belirtmişlerdir.

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**RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ**

# STATIC STRENGTH AND HARMONIC VIBRATION ANALYSIS OF THE SPIDER CRANE BY COMPUTATIONAL MECHANICS SOFTWARE

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## Abstract

In this study, it is aimed to investigate and perform the static structural and natural frequency analysis of the mini spider crane which is designed to lift 0-500 kg load and 0-3 meters extend range, by using computational mechanics software. The crane works and driven by hydraulic system and in order to get the more realistic result, hydraulic cylinders modeled as springs instead of stiff rigid bodies in the analysis. This simulation approach provides a different method than the conventional method. Detailed analysis show that the spider crane statically can lift 1200 kg before the plastic region, so its safety factor is 2.4 when it is lifting 500 kg and its natural frequencies are 16.2 Hz and 50 Hz.

**Keywords:** Spider Crane, Static Analysis, Hydraulics, Finite Elements, Computational Mechanics, Design.



# HESAPLAMALI MEKANİK YAZILIMIYLA ÖRÜMCEK VİNCİN STATİK MUKAVEMET VE HARMONİK TİTREŞİM ANALİZLERİNİN YAPILMASI

## Öz

Bu çalışmada, 0-3 metreden 0-500 kg yük kaldırmak üzere tasarlanmış bir mini örümcek vincin statik yapısal ve doğal frekans analizlerinin araştırılması ve hesaplamalı mekanik yazılımı kullanılarak uygulanması hedeflenmiştir. Hidrolik sistemle çalışan ve tahrik edilen vincin hidrolik silindirleri daha gerçekçi bir sonuç almak için katı bir cisim yerine yay olarak modellenmiştir. Bu simülasyon yaklaşımı geleneksel metoda göre farklı bir metot sağlamaktadır. Detaylı analizler sonucunda, örümcek vincin plastik bölgeye geçmeden en fazla 1200 kg yük kaldırabileceği yani 500 kg yükte iken güvenlik katsayısının 2.4 olduğu, doğal frekansının ise 16.2 Hz ve 50Hz olduğu saptanmıştır.

**Anahtar Kelimeler**: Örümcek Vinç, Statik Analiz, Hidrolik, Sonlu Elemanlar, Hesaplamalı Mekanik, Tasarım.

## 1. INTRODUCTION

Engineering software programs are developing every day and they provide to design, analysis and manufacture complex machines and structures. Also, thanks to Finite Element Methods, complex mathematical problems can be solved in a short time by the computers and it provides us to model, simulate and analyze the mechanical system on the computer by using minimum material and sources.

In this study, a mini spider crane was modeled and analyzed under the different loading conditions and maximum load capacity has been obtained with a realistic approach by using ANSYS software. Furthermore, natural frequency of the crane was obtained to avoid resonance failures by using modal and harmonic response analysis. In order to get the realistic results, hydraulic cylinders modeled as springs because as Drexler indicates that hydraulic oil is compressing under the high pressure and acting like a spring instead of transmitting the force directly like a rigid body and also damping the vibration (Drexler et al., 1988; Sochacki and Bold, 2016; Bold et al., 2018).

Computational engineering software programs also provide us to realize the weak and strong parts of the design before the manufacturing phase so that we can re-design and make the necessary changes to obtain an optimum model as made in this study as well.

Another advantage of the software is that it allows us to change the input variables like loading forces and it calculates the outputs such as total stress and deformation values parametrically, so solution envelope of the model could be obtained easily.



## 2. RESEARCH OBJECT AND MATERIAL

The Spider Crane which used for analysis was designed for "Design and Manufacture of Mini Spider Crane" project by using Autodesk Fusion 360 CAD program. The Crane is designed to carry 500 kg load when the maximum extend is 3 meters and It has 3 booms which one of them is knuckle and another one is telescopic. The booms are made up of Domex700, high strength low alloy steel, with 700 MPa yield strength and 210 GPa Young's modulus (Ahmad, 2011).

The main parts of the spider crane can be seen in Figure 1 as booms, chassis, slewing drive, outriggers, solid tires and hydraulic cylinders. Also, the booms and the cylinders can be seen with their numbers in Figure 2 and general dimensions of the spider crane can be found in Figure 3.

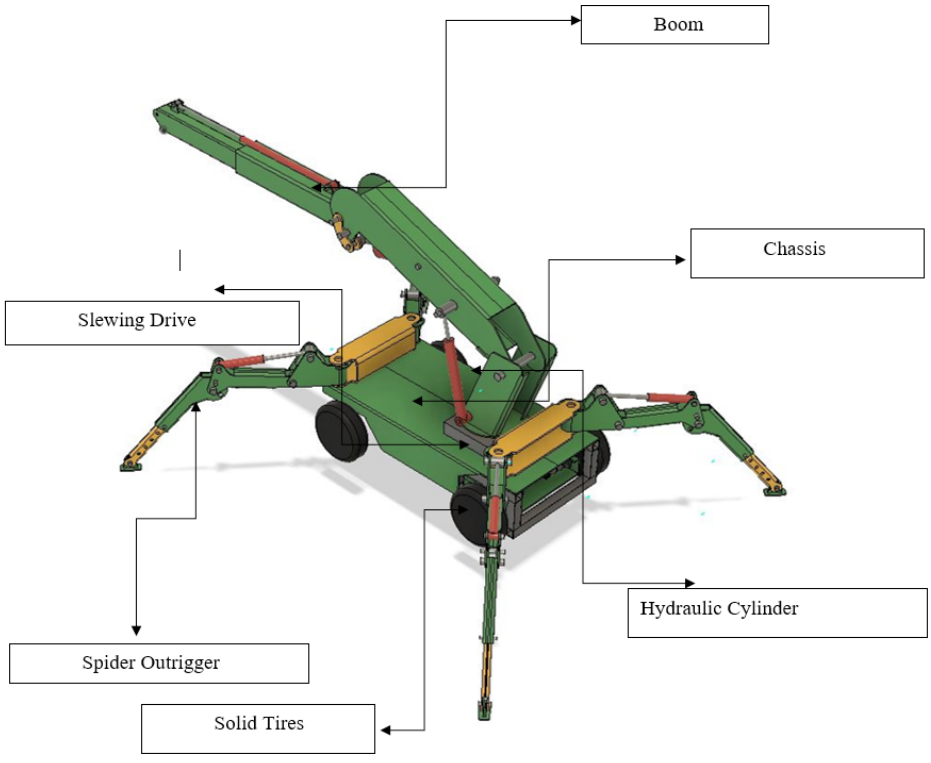


**Figure 1**. Isometric view of the spider crane.

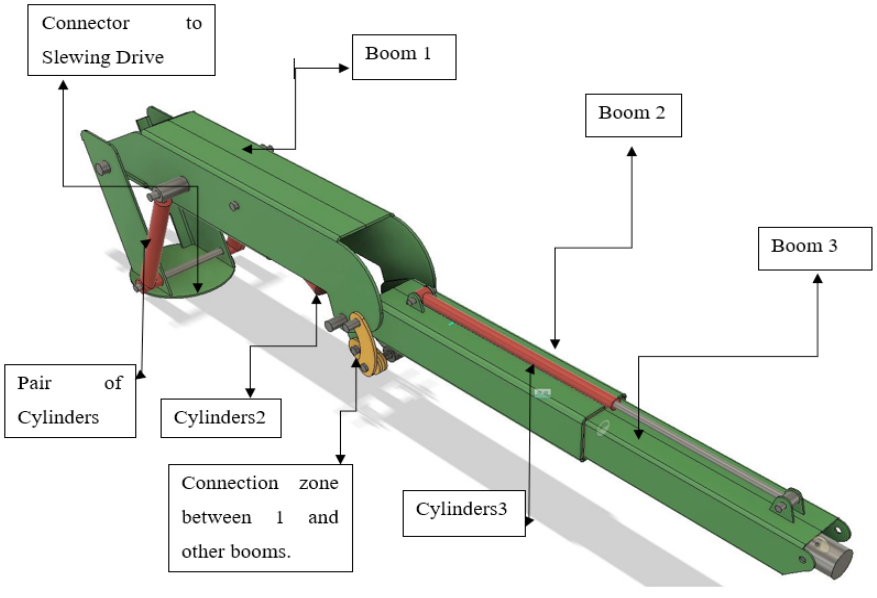


**Figure 2.** Booms of the Spider Crane.

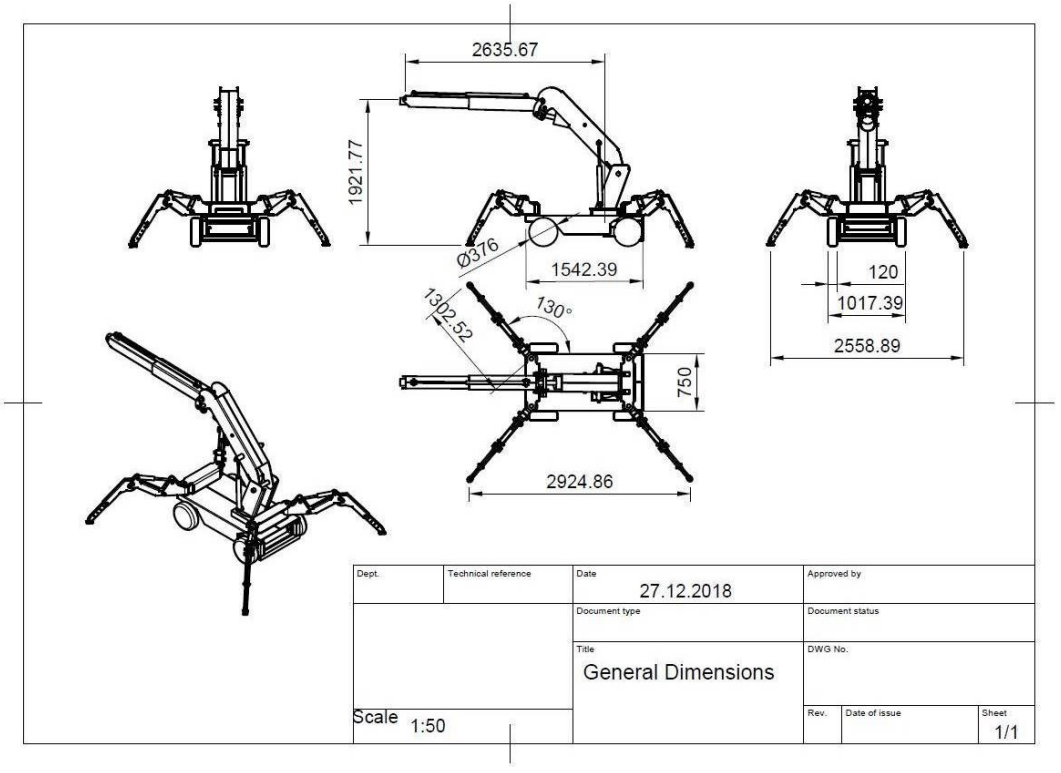




**Figure 3.** General dimensions of the spider crane.

## 3. STATIC STRUCTURAL ANALYSIS

The steps of the static structural analysis can be divided into these parts such as selecting the material, choosing the connection and/or joint types, if more than one body exist in the analysis, meshing the bodies and finally setting the conditions of the analysis which is obtaining that from where the structure will be fixed and from where the force is applied.

### 3.1 Static Analysis For Booms:

#### 3.1.1 Choosing the Joint and Connection Types Between the Bodies of the Model

Choosing accurate joint/connection type is very crucial step for the static structural analysis. For example, when the connection type between the booms are "bonded" (acts like a rigid body) instead of the "revolute" joint, very high stress results occurred around the joint elements (ANSYS Inc., 2013). In order to obtain the more realistic results, joints and connections were chosen as seen in Figures 4-7. Figure 4 shows the frictionless connection between the first boom and body and revolute joint between the first boom and the shaft because the first boom is turning around the shaft. Figure 5 and 6 show the revolute joints around the shafts as well. Figure 7 shows the telescopic connection as translational joint between the second and third booms.

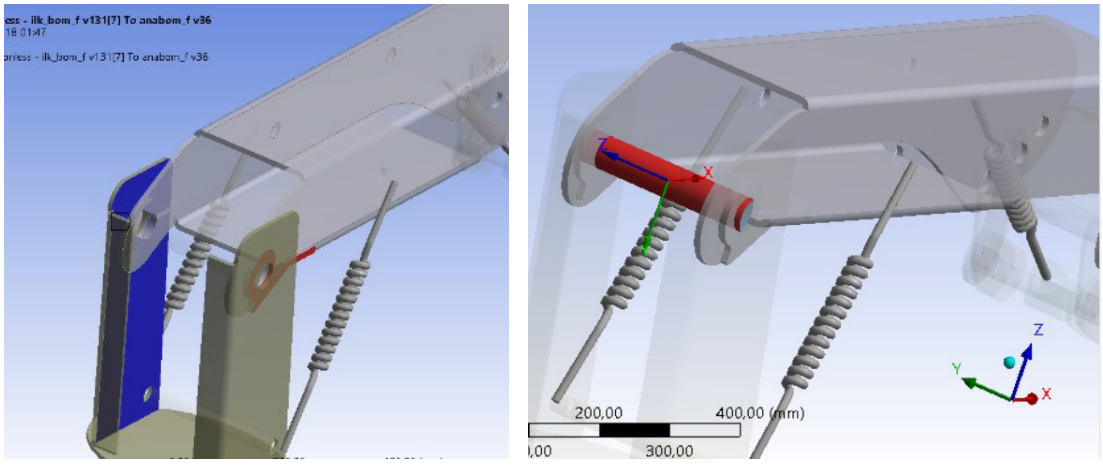


**Figure 4.** Frictionless connection between walls of the first boom and body (Left), Revolute joint between the first boom and shaft at the body (right).



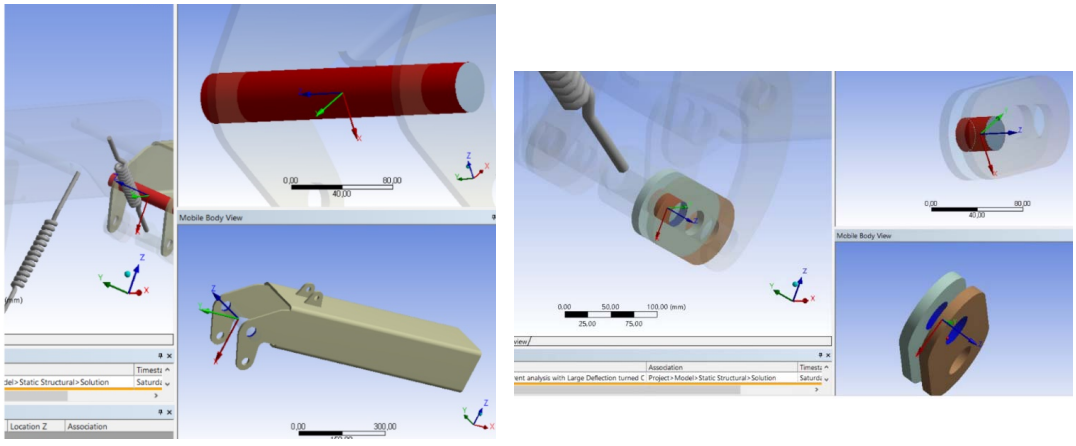


**Figure 5.** Revolute joint between the second boom and shaft at the first boom (left), Revolute joint between the support parts which connects the first and the second booms and the connection shaft between them (right).

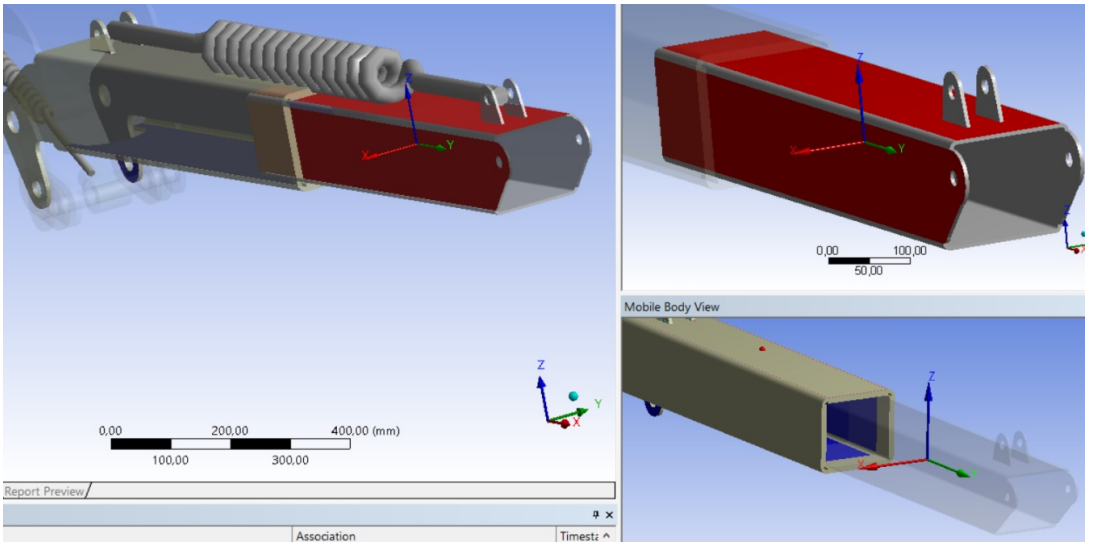


**Figure 6.** Translational joint between the second and third booms.



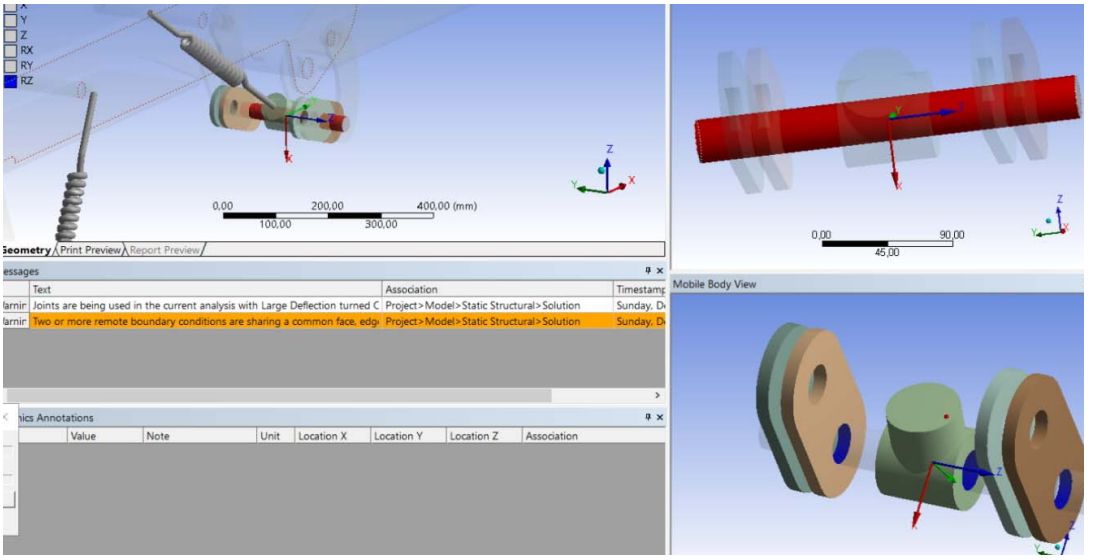


**Figure 7.** Revolute joint between the support parts, second cylinder connection part and shaft between second and third booms.

### 3.1.2 Setting the Conditions of the Static Structural Analysis

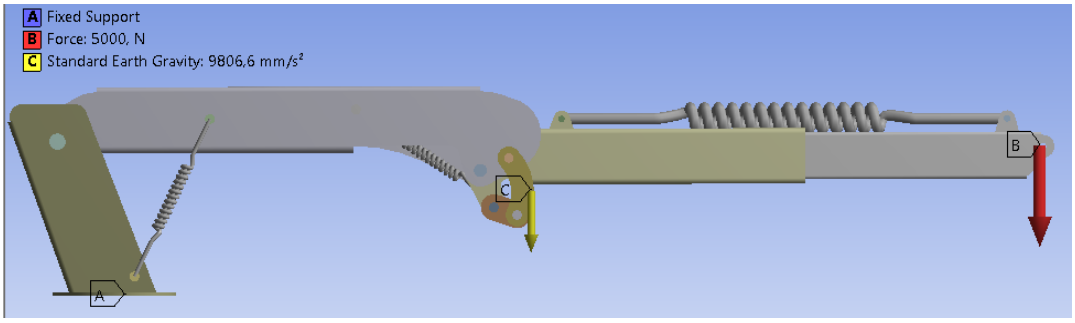


**Figure 8.** Static structural of the model.

First of all, the model has to be fixed in the space that is why booms are fix supported at point A which is a connection surface between the body and the chassis as seen in Figure 8. Secondly, downward load applied from the holes at the end of the third boom which can be seen in Figure 8 at point B as 5000 N load. Also, Standard Earth Gravity accounted into the analysis to calculate booms' own weight as well.

### 3.1.3 Von Misses Stress Distribution Results

The Maximum Stress will be occurred when the crane is working at zero degree, where it is the farthest point and therefore, the moment will be the maximum. Results of the analysis seen in Figure 9 show that while 5000 N load applied at the end of the third boom, the maximum stress occurred around the shaft between the first boom and the body as 328 MPa, which means approximately half of the 700 MPa Yield strength and the factor of safety is equal to 2.1. Also note that, the crane is tested with 500 kg load but for continuous work it will be better to use with 250-300 kg load so, safety factor will be 3-3.5 for continuous working conditions.

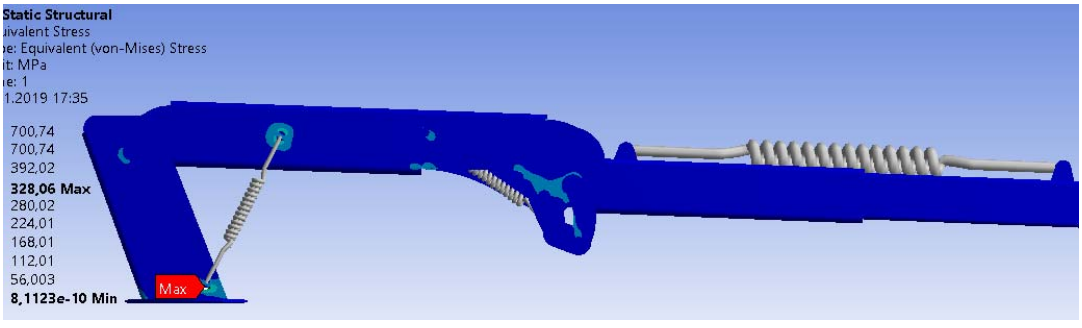


**Figure 9.** Von misses stress distribution because of 500kg load.

### 3.1.4 Total Deformation Results

We could obtain the amount of the elongation from the deformation results. Three important point can be drawn from Figure 10, first cylinder is compressed almost as calculated as in the "modelling a hydraulic cylinder as a spring". There is around 60 mm difference between the connections of the third cylinder. It shows relatively high deformation on the third cylinder, in order to avoid from bending situation, some hydraulic oil can be kept in front of the piston.

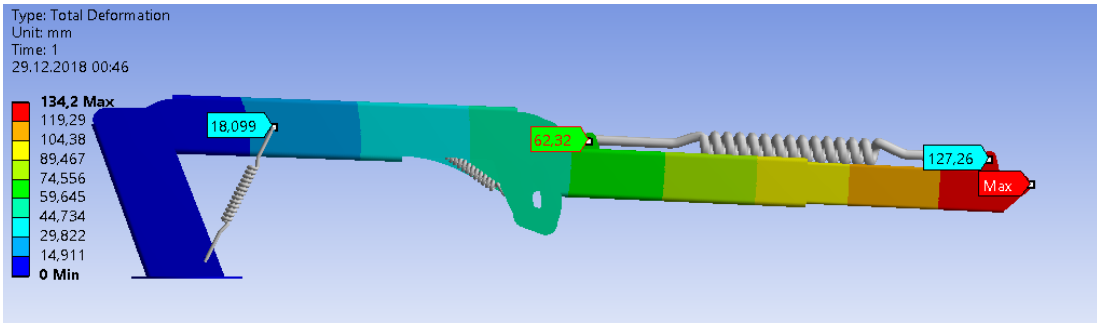


**Figure 10.** Total deformation because of 500 kg load.



| P1 - Load | P2 - Equivalent Stress Maximum | P3 - Total Deformation Maximum |
|---|---|---|
| N | MPa | mm |
| -5000 | 328,06 | 124,67 |
| -3000 | 218,96 | 80,399 |
| -2500 | 191,76 | 69,33 |
| -8000 | 489,21 | 191,04 |
| -12000 | 699,43 | 279,5 |

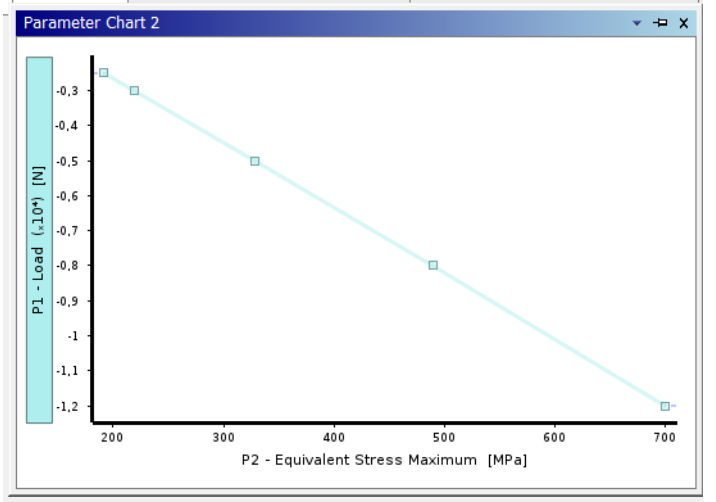


**Table 1.** shows the values and graph of Load versus- Stress/Deformation chart for different loading conditions.

Parametric analysis allows us to see the difference between Stress/Deformation results under the different loading conditions. This parametric result shows that in the worst situation for load of booms' position (minimum angle and furthest elongation working), Crane can carry max 1200 kg statically while factor of safety is equal to 1 and just before the passing through the plastic region.

### 3.2 Static Analysis For Outriggers:

The maximum load on the foots will be occurred in the position as seen in Figure 11. From moment calculation below, max load for one foot for 500 kg was found as 11 kN.

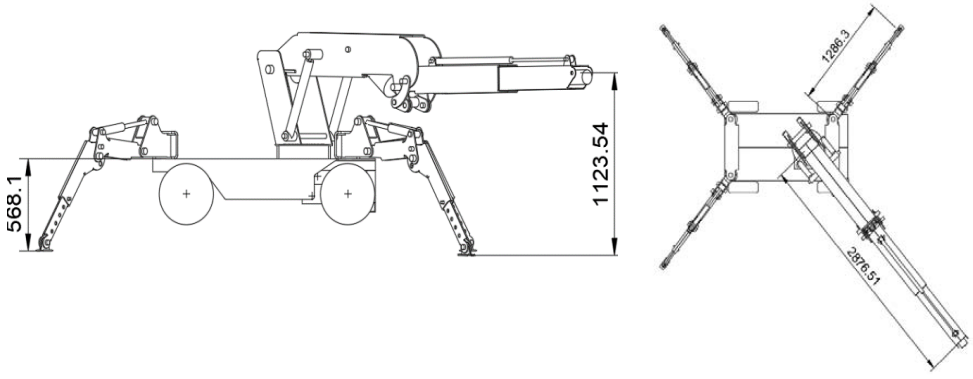


**Figure 11.** The maximum load on the foots.



### 3.2.1 Setting the Static Structural of the Outrigger Model

Foot is fix supported at point B which has the connection surface to the chassis and 11 kN force is applied at point A as seen in Figure 12.

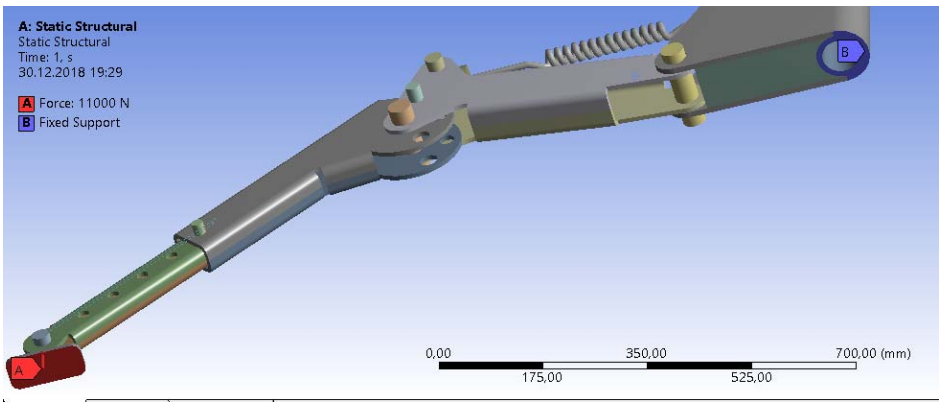


**Figure 12.** Static structural of the model.

### 3.2.2 Von Misses Stress Distribution Results

Figure 13 and 14 show that the maximum stress occurred only around the one point which is located next to the fix supported area as shown as point B in Figure 14.

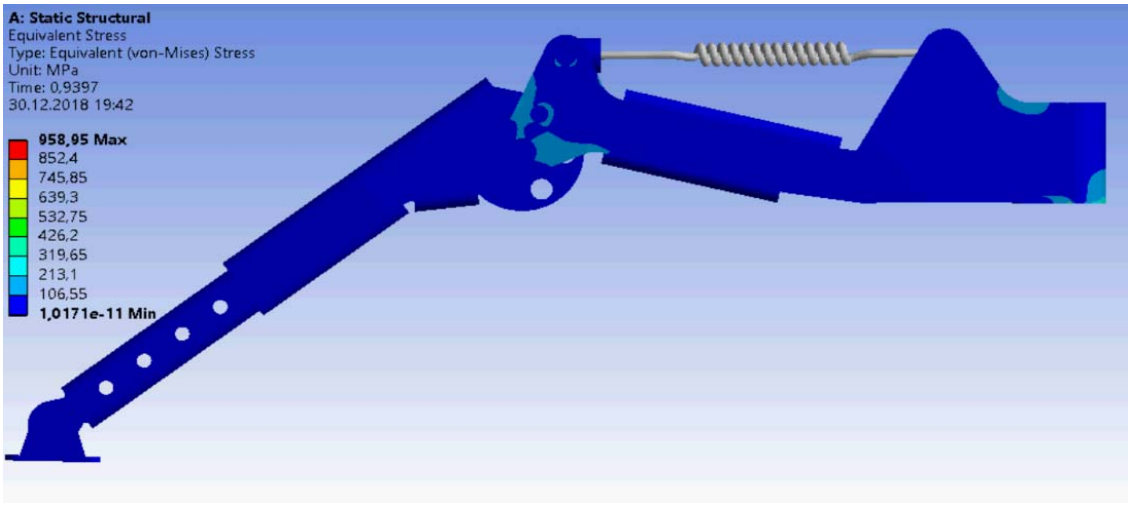


**Figure 13.** Von misses stress distribution because of 500 kg load, 11 kN.



When it is zoomed to the vertex which maximum stress occurred and checked the stress distribution next to this point shows us that the actual stress is relatively high because of supporting method. That is why we can ignore this point and assume that we are in safe region but in the limits.

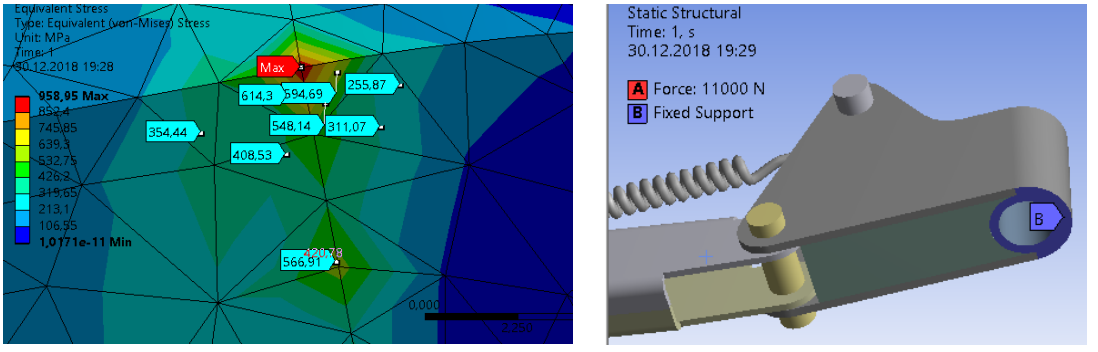


**Figure 14.** Maximum stress area (Left), Maximum stress occurred because of fix supported face (right).

### 3.3 Modelling a Hydraulic Cylinder as a Spring

Hydraulic cylinders are acting like more a spring than a rigid body under the high pressure (especially 150 Bar and above). Drexler et al., 1988 says that "in the case of a fluid containing no air bubbles the volume

reduces by 0.7% when the pressure is increased by 100 bar.". According to this ratio, volume will reduce by 0.14% with 200 Bars.

**Calculating Spring Coefficients:**

Area of the piston is defined as $A = \frac{\pi * d^2}{4}$ (1)

Volume of the cylinder= Area x Stroke = $V = A * S$ (2)

Compressed volume under 200 Bar is $Vc = V * 0.0014$ (3)

Compressed Stroke is Compressed Volume / Area = $Sc = \frac{Vc}{A}$ (4)

Stiffness coefficient of the spring is $k = \frac{F}{x} = \frac{F}{Sc}$ (5)

When the first cylinder is completely open, volume of the first cylinder is 0.46 L, stroke is 370 mm and Diameter is 40 mm, so the stiffness coefficient of the spring is calculated as k=1290 N/mm.

Ansys used for testing the stiffness coefficient (k) of the spring which is obtained from the above mentioned calculation. First cylinder's piston diameter and stroke length modeled with the spring and the same pressure applied to the first piston (200 Bar = 20 MPa). Also, gravitational acceleration was applied.



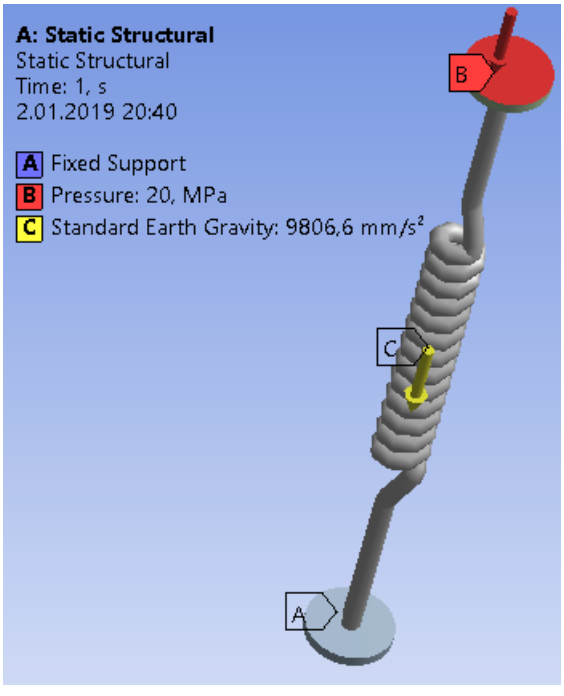


**Figure 15.** Static structural set.

| | |
|---|---|
| Material | None |
| Type | Longitudinal |
| Spring Behavior | Both |
| Longitudinal Stiffness | 1290, N/mm |
| Longitudinal Damping | 0, N·s/mm |
| Preload | None |
| Suppressed | No |
| Spring Length | 370, mm |

**Table 2**. Properties of the spring.

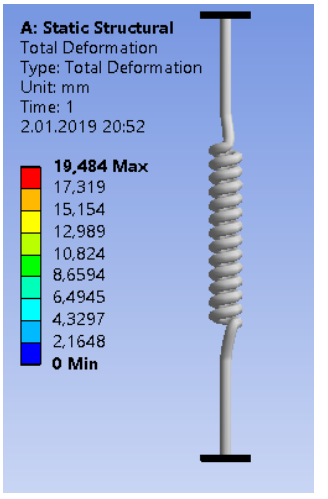


**Figure 16.** Directional deformation of the spring.

This test shows us that springs can be used as hydraulic cylinders. Instead of having more realistic result another advantage of using springs that we do not have to mesh bodies of the cylinders, so solving time and the number of elements are reduced (Rodriguez et al., 2017). On the other hand, when we do not use the cylinders as a body, their weights are not accounted in the analysis. Note that when the first cylinder is closed (0 degree and maximum elongation horizontally) stroke is 4.7 cm. Spring coefficient of cylinders are calculated by using the values shown in Table 3.

| Cylinder | Piston Area ($cm^2$) | Stroke (cm) | Volume ($cm^3$) | Compressed Volume ($cm^3$) | Compressed Stroke(cm) | Force (N) | Spring Coefficient (N/mm) |
|---|---|---|---|---|---|---|---|
| 1. | 12,56 | 4,7 | 59 | 0,0826 | 0,06583 | 21040 | 319594 |
| 2. | 78,54 | 30 | 2356,19 | 3,29 | 0,42 | 144050 | 342976 |
| 3. | 39,4 | 57 | 2245 | 3 | 0,79 | 7350 | 9303 |

**Table 3.** Values which are used to calculate the spring coefficients for each cylinder.

## 4.HARMONIC RESPONSE ANALYSIS

Harmonic Response Analysis shows us that how and in which directions the structure is responding when the natural frequency values are applied to the overall assembly. It is known that vibration plays a crucial role for fatigue and crack failures. In order to get Harmonic Response results firstly natural frequency intervals were found from Modal Analysis and then by using these interval, natural frequency can be found from the harmonic response analysis. Sochacki and Bold explain that the hydraulic cylinders are damping the vibration by an important amount (Jiang et al., 2016; Feng et al., 2017). That is why, using the springs for simulate the hydraulic cylinders provided a more realistic result for harmonic response analysis as well.

| | Mode | Frequency [Hz] |
|---|---|---|
| 1 | 1, | 8,7561 |
| 2 | 2, | 16,415 |
| 3 | 3, | 35,069 |
| 4 | 4, | 39,084 |
| 5 | 5, | 50,925 |
| 6 | 6, | 92,46 |
| 7 | 7, | 100,1 |
| 8 | 8, | 108,73 |
| 9 | 9, | 125,83 |

**Table 4.** Natural frequency interval found from Modal Analysis.



As seen from Table 2, we are interested in first 5 modes which generally electrical motors work 0-3000 rpm equals to 0-50 Hz. That is why in harmonic response analysis 0-60 Hz interval accounted.

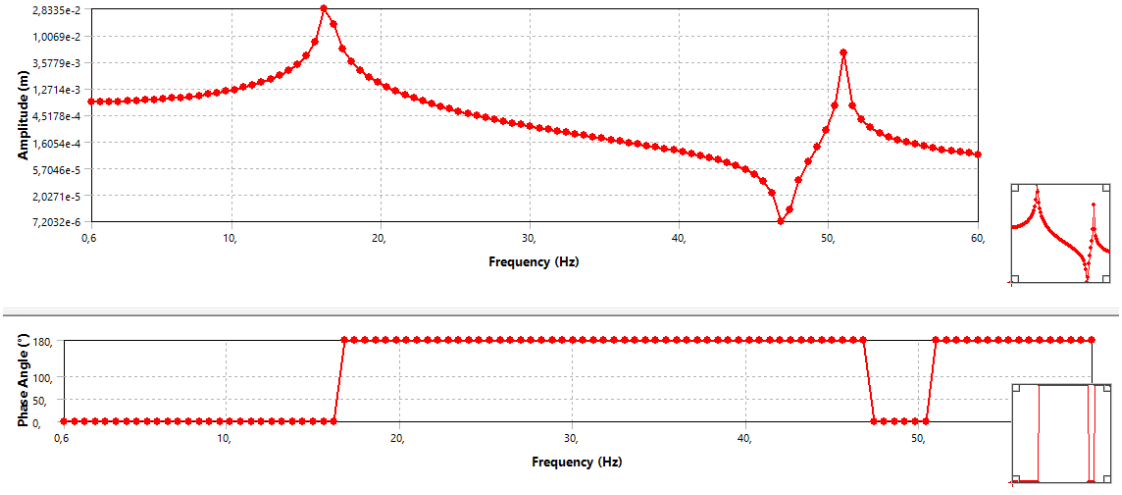


**Figure 17.** Natural frequency interval founded from harmonic response analysis.

| | Frequency [Hz] | Amplitude [Pa] | Phase Angle [°] |
|---|---|---|---|
| 1 | 0,6 | 49337 | 180, |
| 2 | 1,2 | 49520 | 180, |
| 3 | 1,8 | 49829 | 180, |
| 4 | 2,4 | 50269 | 180, |
| 5 | 3, | 50846 | 180, |
| 6 | 3,6 | 51572 | 180, |
| 7 | 4,2 | 52459 | 180, |
| 8 | 4,8 | 53524 | 180, |
| 9 | 5,4 | 54788 | 180, |
| 10 | 6, | 56278 | 180, |
| 11 | 6,6 | 58029 | 180, |
| 12 | 7,2 | 60084 | 180, |
| 13 | 7,8 | 62497 | 180, |
| 14 | 8,4 | 65319 | 180, |
| 15 | 9, | 68871 | 180, |
| 16 | 9,6 | 72882 | 180, |
| 17 | 10,2 | 77810 | 180, |
| 18 | 10,8 | 83881 | 180, |
| 19 | 11,4 | 91490 | 180, |
| 20 | 12, | 1,0126e+005 | 180, |
| 21 | 12,6 | 1,1419e+005 | 180, |
| 22 | 13,2 | 1,3205e+005 | 180, |
| 23 | 13,8 | 1,5823e+005 | 180, |
| 24 | 14,4 | 2,0015e+005 | 180, |
| 25 | 15, | 2,7779e+005 | 180, |
| 26 | 15,6 | 4,7003e+005 | 180, |
| 27 | 16,2 | 1,7356e+006 | 180, |
| 28 | 16,8 | 9,4549e+005 | 0, |
| 29 | 17,4 | 3,5999e+005 | 0, |
| 30 | 18, | 2,1792e+005 | 0, |
| 31 | 18,6 | 1,5395e+005 | 0, |
| 32 | 19,2 | 1,176e+005 | 0, |
| 33 | 19,8 | 94178 | 0, |
| 34 | 20,4 | 77836 | 0, |
| 35 | 21, | 65794 | 0, |
| 36 | 21,6 | 56555 | 0, |
| 37 | 22,2 | 49246 | 0, |
| 38 | 22,8 | 43320 | 0, |
| 39 | 23,4 | 38418 | 0, |
| 40 | 24, | 34296 | 0, |
| 41 | 24,6 | 30781 | 0, |
| 42 | 25,2 | 27746 | 0, |
| 43 | 25,8 | 25098 | 0, |
| 44 | 26,4 | 22765 | 0, |
| 45 | 27, | 20693 | 0, |
| 46 | 27,6 | 18837 | 0, |
| 47 | 28,2 | 17164 | 0, |
| 48 | 28,8 | 15644 | 0, |
| 49 | 29,4 | 14256 | 0, |
| 50 | 30, | 12979 | 0, |

| | Frequency [Hz] | Amplitude [Pa] | Phase Angle [°] |
|---|---|---|---|
| 50 | 30, | 12979 | 0, |
| 51 | 30,6 | 11799 | 0, |
| 52 | 31,2 | 10702 | 0, |
| 53 | 31,8 | 9675, | 0, |
| 54 | 32,4 | 8709,6 | 0, |
| 55 | 33, | 7797,1 | 0, |
| 56 | 33,6 | 6930,5 | 0, |
| 57 | 34,2 | 6106,4 | 0, |
| 58 | 34,8 | 5354,1 | 0, |
| 59 | 35,4 | 4446,2 | 0, |
| 60 | 36, | 3726,9 | 0, |
| 61 | 36,6 | 2994, | 0, |
| 62 | 37,2 | 2270,4 | 0, |
| 63 | 37,8 | 1563,6 | 0, |
| 64 | 38,4 | 916,51 | 0, |
| 65 | 39, | 1740,6 | 0, |
| 66 | 39,6 | 1153,7 | 180, |
| 67 | 40,2 | 1809,7 | 180, |
| 68 | 40,8 | 2617, | 180, |
| 69 | 41,4 | 3501,2 | 180, |
| 70 | 42, | 4462,2 | 180, |
| 71 | 42,6 | 5514,1 | 180, |
| 72 | 43,2 | 6679,3 | 180, |
| 73 | 43,8 | 7989,2 | 180, |
| 74 | 44,4 | 9486,8 | 180, |
| 75 | 45, | 11233 | 180, |
| 76 | 45,6 | 13316 | 180, |
| 77 | 46,2 | 15867 | 180, |
| 78 | 46,8 | 19097 | 180, |
| 79 | 47,4 | 23355 | 180, |
| 80 | 48, | 29281 | 180, |
| 81 | 48,6 | 38172 | 180, |
| 82 | 49,2 | 53131 | 180, |
| 83 | 49,8 | 83880 | 180, |
| 84 | 50,4 | 1,8461e+005 | 180, |
| 85 | 51, | 1,3172e+006 | 0, |
| 86 | 51,6 | 1,5017e+005 | 0, |
| 87 | 52,2 | 81121 | 0, |
| 88 | 52,8 | 56181 | 0, |
| 89 | 53,4 | 43278 | 0, |
| 90 | 54, | 35369 | 0, |
| 91 | 54,6 | 30010 | 0, |
| 92 | 55,2 | 26128 | 0, |
| 93 | 55,8 | 23180 | 0, |
| 94 | 56,4 | 20860 | 0, |
| 95 | 57, | 18982 | 0, |
| 96 | 57,6 | 17428 | 0, |
| 97 | 58,2 | 16119 | 0, |
| 98 | 58,8 | 14998 | 0, |
| 99 | 59,4 | 14027 | 0, |

**Table 5.** Natural frequency interval found from harmonic response analysis

Table 5 and Figure 17 show that 16.2 Hz (around 1000 rpm) and 50 Hz (3000 rpm) are natural frequencies for this structure. That is why, electrical motor should not work continuously exactly in these rpms. 1500 rpm (25 Hz) can be chosen as a safety area.

## 5.CONCLUSION

In this study, loading capacity and natural frequencies of the spider crane are obtained and results of the analysis enabled us to claim where the maximum stress occurred and in which frequencies the structure have the natural frequencies. Selecting the appropriate connection/joint types between the bodies and modelling the hydraulic cylinders as the springs are crucial steps for this kind of analysis which has many connections and joint parts. According to the static structural analysis results, strokes of the cylinders are optimized in the design process to avoid bending failures, because of high deformation values especially on the third boom. Furthermore, harmonic response analysis' results enabled us to determine the working rpm of the electrical motor in order to avoid from fatigue or crack failures based on the resonance problems. The natural frequency of the model can be changed by adding some supports or changing the material/thickness in the design if it is necessary.

This study can be a reference for the future studies such as reducing the vibration at the end of the booms' of the cranes or optimizing the model of the booms and the cranes.



### Conflict of Interests/Çıkar Çatışması

Authors declare no conflict of interests/Yazarlar çıkar çatışması olmadığını belirtmişlerdir.

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**AURUM MÜHENDİSLİK SİSTEMLERİ VE MİMARLIK DERGİSİ**
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**ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE**

# VERİ MADENCİLİĞİ YÖNTEMLERİ İLE ÜLKELERİ GELİŞMİŞLİK ÖLÇÜTLERİNE GÖRE KÜMELEME ÜZERİNE BİR UYGULAMA

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## Öz

Bir amaç doğrultusunda elde edilen verilerden anlamlı sonuçlar çıkarılması işlemine veri madenciliği denir. Kümeleme analizi de veri madenciliği alanında sıklıkla kullanılmaktadır. Bu makalede öncelikle kümeleme analizi kavramları açıklanmıştır. Çalışmada kullanılacak algoritmalar tanıtıldıktan sonra Dünya Bankası 'nın web sitesinden elde edilen verilere bu algoritmalar uygulanmıştır. Bu çalışmada amaç, önceden belirlenmiş parametreler göz önüne alınarak ülkelerin gelişmişlik ölçütlerine göre kümelenmesidir. Çalışma kapsamında 214 ülkeye ait 2015 verileri ele alınmıştır. Bu verilere Self Organizing Map ve K-Means kümeleme algoritmaları uygulanmış, sonrasında da elde edilen kümeler değerlendirilmiştir. Ayrıca ülkemizin bu kümelerdeki konumu da incelenmiştir.

**Anahtar Kelimeler:** Kümeleme analizi, K – Means algoritması, Self Organizing Map algoritması, İstatistik, Gelişmişlik.



# AN APPLICATION ON CLUSTERING COUNTRIES WITH DATA MINING METHODS BASED ON DEVELOPMENT CRITERIA

## Abstract

The process of extracting meaningful results from data obtained in the direction of a goal is called data mining. Clustering analysis is also frequently used in the field of data mining. In this article, firstly clustering analysis concepts are explained. These algorithms have been applied to the data obtained from the World Bank website after the algorithms to be used in the study have been introduced. The purpose of this study is to cluster countries according to their development criteria, taking into account pre-determined parameters. The study covered data from 214 countries. Self Organizing Map and K-Means clustering algorithms were applied to these data, and then the obtained clusters were evaluated. In addition, the position of our country in these clusters has been examined.

**Keywords:** Clustering Analysis, K- Means Algorithm, Self Organizing Map, Statistics, Development.

## 1. GİRİŞ

Sınıflar veya objelerin konsept olarak anlamlı grupları, benzer karakteristik özellikler taşırlar. Bu da insanların dünyayı analiz etmesi ve anlamlandırmasında büyük rol oynar. Aslında insanoğlu objeleri gruplama ve bu gruplara obje atama yeteneğine doğuştan sahiptir. Küçük çocuklar bile bir fotoğraf albümündeki objeleri insan, hayvan, bitki ve cansız varlıklar olarak sınıflandırabilir.

Kümeleme analizi, bir veri setini benzer özellikler taşıyan objeler aynı grupta yer alacak şekilde gruplamayı amaçlayan çok değişkenli bir metottur. Bu sayede veriler anlamlı ve kullanışlı kümelere bölünür. Bazı durumlarda ise veri özetleme gibi bir amaç için kullanışlı bir başlangıçtır.

Verilerin anlaşılması bağlamında, kümeler potansiyel sınıflardır ve kümeleme analizi de bu sınıfları otomatik olarak bulmayı sağlayan teknikler çalışmasıdır.

Kümeleme analizinin öneminin kavranabilmesi için kullanım alanlarını incelenmesi yeterlidir. Psikoloji ve diğer sosyal bilimler, biyoloji, istatistik, örüntü tanıma, makine öğrenmesi ve veri madenciliği kümeleme analizinin kullanım alanlarından sadece birkaçıdır.

Selim Çam 2014 yılında hazırladığı yüksek lisans çalışmasında, Sivas Cumhuriyet Üniversitesi Hastanesi'ne 2006-2011 yılında kayıt olmuş 18-65 yaş aralığındaki hastalara ait verileri kullanmıştır. Çalışma kapsamında K-Ortalamalar ve Yoğunluk Tabanlı Kümeleme Algoritması yöntemlerini kullanmış, demografik verilere ise Ki-Kare, Kruskal-Wallis H ve Mann-Whitney testlerini uygulamıştır. Sonuç olarak hastaları yaş, yaşadıkları yer, başvurdukları hastalık çeşitleri gibi sınıflara ayırmıştır. Çalışmanın uygulama alanı ise kayıt olan bir hasta için uygun ilaç ve personel tedariğinin doğru tespit edilebilmesidir (Çam, 2014).



Nesrin Alptekin ve Gözde Yeşilaydın'ın 2015 yılında sağlık alanında yaptığı bir çalışmada, veri kümesi olarak OECD' ye üye 34 ülkenin sağlıkla ilişkili 10 değişkeni ele alınmıştır. Çalışma kapsamında bulanık c-ortalamalar algoritması ve NCSS 10 paket programı kullanılmıştır.Farklı sayıda kümeler oluşturulmuş ve 5 küme sayısının en anlamlı olduğu tespit edilmiştir. Sonuç kümesinde Türkiye'nin Estonya, Meksika, Macaristan, Şili ve Polonya ile aynı kümede yer aldığı görülmüştür (Alptekin, Yeşilaydın, 2015).

Osman Kaya 2008 yılında hazırladığı yüksek lisans çalışmasında, özel bir kurumda çalışan 1100 personele ait 2 yıllık performans ölçütleri, bu ölçütlerin ağırlıkları,tanımı ve departman bilgisini veri kümesi olarak ele almıştır. Çalışma kapsamında bu veri kümesine c-mean ve x-mean kümeleme algoritmalarını uygulamış, 4 küme elde etmiş ve küme doğruluğunun test edilmesi için ROC eğrisinden faydalanmıştır. Çalışma sonucunda personellerin başarı ölçümünün en doğru şekilde yapılabilmesi, personelin zam ve terfi kararların adaletli olması ve kurumun başarısının değerlendirilmesini amaçlamıştır (Kaya, 2008)

Halil Darakçı 2011 yılında hazırladığı yüksek lisans çalışmasında, veri kümesi olarak özel bir akarkayıt firmasına ait 2008 ve 2009 yıllarındaki ürün ve müşteri verilerini kullanmıştır. Veri kümesi yaklaşık 48 milyon veri içerdiğinden günlük bilgiyi içerecek şekilde indirgeme yapmıştır. Uzaklık ölçümünde öklit metriği, kümeleme kısmında k-ortalamalar algoritması ve KNIME programını kullanmıştır. Sonuç olarak elde edilen kümelerdeki en verimsiz istasyonları tespit ederek kurumiçi performans değerlendirmesi yapmıştır (Darakçı, 2011).

Onur Değerli 2012 yılında hazırladığı yüksek lisans çalışmasında, veri kümesi olarak blog içeriklerini kullanmıştır. Bloglara ait içerikleri web-crawler teknolojisi ile veritabanına kaydetmiş, kelime kökünün tespit edilmesi için doğal dil işleme metotlarından faydalanmıştır. Bu içeriği Naive Bayes algoritması ile sınıflandırmış, kategorisi belli olmayan örneklerin hangi kategoriye ait olduğunu belirlemiştir. Kümeleme analizi algoritmalarının semantik web ve metin madenciliği alanında kullanılmasına dair bir çalışma yapmıştır (Değerli, 2012).

Gaffari Çelik 2013 yılında hazırladığı yüksek lisans çalışmasında veri kümesi olarak Ağrı İbrahim Çeçen Üniversitesi Meslek Yüksekokulu öğrencilerinin 2011-2012 yılına bilgilerini ele almıştır. Çalışma kapsamında K-Means, DBSCAN, OPTICS algoritmaları ve WEKA programını kullanmıştır. Çalışma sonucunda öğrenci başarısını etkileyen faktörleri tespit etmiştir. Bunlardan bazıları; öğrencinin sağlık sorununun olmaması, kardeş sayısının az olması, öğrencinin yurtta kalması ve annesi çalışmayan öğrencinin daha başarılı olması gibi çarpıcı sonuçlardır (Çelik, 2013).

Mahmut Karakaya 2012 yılında hazırladığı yüksek lisans çalışmasında, veri kümesi olarak Movielens, Jester ve Bookcrossing den aldığı verileri kullanmıştır. Çalışma kapsamında k-means ve yoğunluk tabanlı kümleme algoritmalarından faydalanmıştır. Bu çalışmada kullanıcılara müzik, film, kitap gibi öğeler önerilirken çeşitliliğin arttırılması hedeflenmiştir. Sonuç olarak, öneri sistemleri için kullanılan veri kümesine ait ortalama ve standart sapmayı değerlendiren bir çeşitlilik ölçümü geliştirmiştir (Karakaya, 2012).

Yasemin Akın 2008 yılında hazırladığı bir doktora çalışmasında, veri kümesi olarak 2004 yılında TÜİK tarafından yapılan "Hanehalkı Bütçe Anketi" verilerini kullanmıştır. Verilerin uygun olup olmadığını Ki-Kare Bağımsızlık Testi ile ölçmüştür. Çalışma kapsamında CLARA algoritması ve yoğunluk tabanlı kümeleme algoritmaları, S-Plus 2000 ve WEKA programlarını kullanmıştır. Farklı küme sayılarına ait verileri karşılaştırılarak en anlamlısının 5'li küme olduğunu tespit etmiştir. Sonuç olarak katılımcıların yaşadığı yerleşim yeri, sahip olduğu çocuk sayısı, eğitim düzeyi gibi özelliklere göre tüketicilerin harcama davranışları incelemiştir (Akın , 2008).



Tuna Vardar 2010 yılında hazırladığı yüksek lisans çalışmasında, özel bir bankadan alınan verileri ve bu verilere uygun finansal tablolardan belirlenen 13 adet değişkeni veri kaynağı olarak kullanmıştır. Çalışma kapsamında uzaklık ölçüsü olarak Öklid Metriği, küme sayısının belirlenmesinde BIC ve AIC kriterleri, kümelerin anlamlılığını ölçmek için Ki-Kare Bağımsızlık testi ve analizler için SPSS 15.0 programından faydalanmıştır. Çalışma sonucunda bankaların müşteri segmentasyonlarının bilimsel analizlerle elde edilen segmentasyonla uyuşmadığını ortaya çıkarmıştır (Vardar, 2010).

Ünzile Yılmaz 2011 yılında hazırladığı yüksek lisans çalışmasında veri kaynağı olarak Türkiye'deki 81 ilin 2008 yılına ilişkin DİE bültenlerini kullanmıştır. Çalışmada faktör analizi, kümeleme analizi yaklaşımları ve SPSS 12 programından faydalanmıştır. Çalışmanın amacı Türkiye' deki illerin gelişmişlik düzeylerine göre kümelenmesidir. Sonuç olarak 3 küme belirlemiş, İstanbul en gelişmiş iller kümesinde tek başına yer almıştır. İkinci kümede ise Bursa, İzmir, Ankara, Kocaeli yer almaktadır. Geri kalanlar ise üçüncü yani gelişmemiş iller kümesinde yer almıştır (Yılmaz, 2011).

### 1.1 Hiyerarşik Kümeleme Analizi

Hiyerarşik kümeleme analizinde toplamsal(agglomerative) ve parçalayıcı(disimisive) olmak üzere iki yöntem vardır.

Toplamsal yöntemde başlangıçta her nesne bir kümedir. Her adımda en yakın kümeler birleşir ve küme sayısı bir eksilir. Birleşen kümeler daha sonraki adımlarda kesinlikle ayrılmaz. Adımlar tamamlandığında, tüm nesneleri içeren tek bir küme elde edilir.

Parçalayıcı yöntemde başlangıçta tek bir küme vardır. Her adımda küme bir alt kümeye ayrılır ve küme sayısı bir artar. Ayrılan kümeler daha sonraki adımlarda kesinlikle birleşmez. Adımlar tamamlandığında her nesne bağımsız bir küme meydana getirir. Toplamsal yönteme göre daha az kullanılır.

### 1.2 Uzaklık Ölçümleri

Xi ve Xj gözlem vektörleri olsun, d (xi, xj) fonksiyonunun uzaklık fonksiyonu olabilmesi için aşağıdaki şartları sağlaması gerekir (Duran, Odell, 1974):

- $E_p$ 'deki (p boyutlu öklit uzayındaki) tüm $x_i$ ve $x_j$ ler için d $(x_i, x_j) \geq 0$ 'dır.
- Ancak ve ancak $x_i = x_j$ ise d $(x_i, x_j) = 0$ dır.
- D $(x_i, x_j)$ = d $(x_j, x_i)$ dir.
- D $(x_i, x_j) \leq$ d $(x_i, x_k)$ + d $(x_k, x_j)$ dır. Burada $x_i$, $x_j$ ve $x_k$ vektörleri de $E_p$ vektörlerdir.



En sık kullanılan uzaklık fonksiyonları aşağıdaki Tablo 1'deki gibidir (Duran, Odell, 1974):

| Fonksiyon | Matematiksel Gösterim |
|---|---|
| Öklit | $d_2(x_i, x_j) = (\sum_{k=1}^{p}(x_{ki} - x_{kj})^2)^{1/2}$ |
| $B_1$ norm | $d_1(x_i,x_j) = (\sum_{k=1}^{p}\lceil x_{ki} - x_{kj} \rceil)$ |
| Sup-norm | $d_\infty(x_i,x_j) = sup_{k=1,2,\ldots,p}\{\lvert x_{ki} - x_{kj} \rvert\}$ |
| $B_p$ norm | $d_p(x_i,x_j) = \sum_{k=1}^{p} \lvert x_{ki} - x_{kj} \rvert^{p} ]^{1/p}$ |
| Mahalanobis | $D^2 = (\overline{x_A} - \overline{x_B})' W^{-1} (\overline{x_A} - \overline{x_B})$ |

**Tablo 1.** Uzaklık Fonksiyonları ve Matematiksel Gösterimleri

Benzerlik matrisi, gözlemlerin birbirine olan uzaklıklarından oluşan simetrik kare matristir. Nesnelerin birbirine olan uzaklığının 0 olduğu aşikardır. Nesneler $x_i$ ve $x_k$ ile ifade edilsin. (i ve k N kümesinin elemanlarıdır.) Uzaklık fonksiyonu d ($x_i$, $x_k$) ile ifade edilir. $x_i$ ve $x_k$ nın birbirine uzaklığı, $x_k$ ve $x_i$ nin birbirine uzaklığına eşittir. Bu nedenle benzerlik matrisi simetriktir. Bu bilgilere göre oluşturulan benzerlik matrisi Şekil 1'deki gibidir:

$$\begin{bmatrix} d_{11} & \cdots & \\ \vdots & \ddots & \vdots \\ d_{n1} & \cdots & d_{nn} \end{bmatrix}$$

**Şekil 1.** Benzerlik Matrisi Gösterimi

Nesnelerin birbirine olan uzaklığı ne kadar az ise aynı kümede olma ihtimalleri de o ölçüde fazladır.

### 1.3 Hiyerarşik Kümeleme Analizi Algoritmaları

#### 1.3.1 Tek bağlantı tekniği

En yakın komşuluk tekniği olarak da bilinir. Bu teknikte, iki küme arasında birbirine en yakın elemanların uzaklığı, kümeler arasındaki mesafe olarak kabul edilir. Birbirine en yakın iki gözlem bulunur ve bu şekilde ilerlenerek kümeler oluşturulur. Algoritmanın zaman karmaşıklığı $O(n^2)$'dir (Manning ve ark., 2008)

#### 1.3.2 Tam bağlantı tekniği

En uzak komşuluk tekniği olarak da bilinir. Bu teknikte, iki küme arasında en uzak elemanların uzaklığı, kümeler arasındaki mesafe olarak kabul edilir. Birbirine en uzak iki gözlem bulunur ve bu şekilde ilerlenerek kümeler oluşturulur.

#### 1.3.3 Ortalama grup bağlantı tekniği

Bu teknikte, iki kümedeki elemanların uzaklıklarının ortalaması, kümeler arasındaki mesafe olarak kabul edilir. Bu yöntem, biyoloji alanında türlerin ortak kökenleri araştırmalarında kullanılmaktadır.

### 1.4 K-Ortalama Yöntemi

K-Means kümeleme metodu olarak bilinir. K- Means algoritması uygulama kolaylığından dolayı, en çok kullanılan algoritmalardan biridir. Büyük ölçekli veriler için kullanışlıdır. Buradaki k küme sayısıdır. Küme içi benzerliğin yüksek fakat kümeler arası benzerliğin düşük olması amaçlanır. (Yıldız, Çamurcu, Doğan, 2010)

K-Means algoritmasının adımları aşağıdaki gibidir:

1. K küme sayısı başlangıçta belirlenir.
2. K adet başlangıç noktası rastgele seçilir.
3. Küme merkezleri belirlenir. Burada uzaklık öklid uzaklığı kullanılarak ölçülür.
4. Her nesne en yakın olduğu kümeye atanır.
5. Küme merkezi yeniden ölçülür ve yeniden atama yapılır.
6. Nesnelerin yerleri artık değişmeyene kadar önceki adımlar tekrarlanır.

K-Means kümeleme analizi Karesel Hata Kriteri yardımıyla ölçülür. Başarı kriteri, karesel hatayı en küçük yapacak k adet kümenin elde edilmesidir.

K-Means algoritmasının dezavantajı, başlangıçta K sayısının belirlenme zorunluluğudur. K sayısının belirlenmesi kolay değildir. Algoritma farklı K değerleri için uygulanır ve sonuçlar doğruluk analizleri ile sınanır. Algoritma farklı K değerleri için çalıştırıldığında çok farklı sonuçlar üretebildiği için kararlı değildir.

### 1.5 Self Organizing Map (SOM) Yöntemi

SOM, bir gözetimsiz öğrenme algoritmasıdır. Yüksek boyutlu verilerin bir, iki veya üç boyutlu görselleştirilmesinde kullanılan bir yöntemdir. Öğrenme ve tahmin safhalarından oluşur. Öğrenme safhasında, harita oluşturulur ve eğitim verileri rekabetçi bir süreçten geçirilerek ağ oluşturulur. Tahmin safhasında, yakınsama haritasında yeni vektörlere bir lokasyon verilir ve yeni veriler hızlıca kategorilere ayrılır.



Öğrenme sürecinin adımları aşağıdaki gibidir:

1. Her düğüm için ağırlıklar belirlenir.
2. SOM'u temsil etmesi için eğitim verisinden rastgele bir vektör seçilir.
3. Girdi vektörü ile her vektörün ağırlığı arasındaki uzaklık hesaplanarak en iyi eşleşen birim (BMU-Best Matching Unit) bulunur.
4. BMU çevresindeki komşuluk yarıçapı hesaplanır. Komşuluk ölçüsü her tekrarlamada azaltılır.
5. BMU'nun komşuluğundaki her düğümün ağırlıkları, BMU'ya daha çok benzemek için ayarlanmıştır. BMU'ya en yakın düğümler komşulukta en uzaktaki düğümlerden daha fazla değiştirilir.
6. İkinci adımdaki işlemler yakınsama gerçekleşene kadar tekrar edilir.

## 2. VERİ MADENCİLİĞİ YÖNTEMLERİ İLE ÜLKELERİ GELİŞMİŞLİK ÖLÇÜTLERİNE GÖRE KÜMELEME

Dünya Bankası'nın internet sitesinden alınan veriler üzerinde, kümeleme algoritmalarından K-Means ve SOM uygulanarak ülkeler değerlendirilmiştir. Tezin amacı kümeleme algoritmaları kullanılarak önceden belirlenmiş parametrelere göre ülkelerin aldığı değerlerin karşılaştırılması ve anlamlı kümeler oluşturulmasıdır. Dünya Bankası verilerinin bulunduğu internet sitesinden 2015 yılına ait veriler incelenebilmesi için excel formatında indirilmiştir. Aşağıdaki Tablo 2'de, çalışmada kullanılan değişkenler ve kısaltmaları yer almaktadır.

| Değişen Kısaltması | Değişken Adı |
|---|---|
| Tarım_GDP | Agriculture, value added (% of GDP) [NV.AGR.TOTL.ZS] |
| Ölüm_Oranı | Mortality rate, under-5 (per 1,000 live births) [SH.DYN.MORT] |
| GDP_endeksi | GDP per capita (current US$) [NY.GDP.PCAP.CD] |
| DısBorc_GNI | External debt stocks (% of GNI) [DT.DOD.DECT.GN.ZS] |
| Banka_Sube_Say | Commercial bank branches (per 100,000 adults) [FB.CBK.BRCH.P5] |
| Internet_Kullanıcı_Say | Internet users (per 100 people) [IT.NET.USER.P2] |
| IsYapılabilirlik | Ease of doing business index (1=most business-friendly regulations) [IC.BUS.EASE.XQ] |
| İnsan_Hakları_Endeksi | Strength of legal rights index (0=weak to 12=strong) [IC.LGL.CRED.XQ] |
| Teknoloji_İhracatı | High-technology exports (% of manufactured exports) [TX.VAL.TECH.MF.ZS] |
| Kadın_Milletvekili | Proportion of seats held by women in national parliaments (%) [SG.GEN.PARL.ZS] |
| Ihracat_GDP | Exports of goods and services (% of GDP) [NE.EXP.GNFS.ZS] |
| Temiz_Su | Improved water source, urban (% of urban population with access) [SH.H2O.SAFE.UR.ZS] |

**Tablo 2.** Değişkenler ve kısaltmaları

### 2.1 K-Means Algoritması Kullanılarak Yapılan Kümeleme

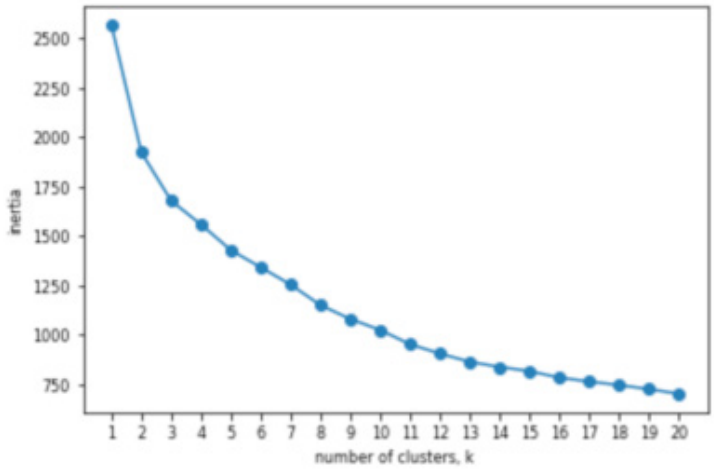
#### 2.1.1 Küme sayısının belirlenmesi

K-Means algoritmasında uygun küme sayısının belirlenmesi için inertia(atalet) kriterinden faydalanılmıştır. İnertia'nın diğer bir ismi ise küme içi kareler ölçütü toplamıdır. Kümeleme algoritması sonucunda oluşan kümelerin tutarlılık ölçüsü olarak algılanabilir.



İnertia algoritması veriye uygulandıktan sonra oluşan noktalar incelenir. İki nokta arasındaki uzaklıkların hangi noktadan itibaren fazla değişmediği belirlenir.

Aşağıdaki Şekil 14'de, İnertia kriterinin Dünya Bankası'nın web sitesinden alınan verilere uygulanarak elde edilmiştir. Grafikte görüldüğü üzere uygun küme sayısı 16 olarak belirlenmiştir.




**Şekil 2.** İnertia Kriterinin Verideki Sonuç Grafiği

Dünya Bankasının web sitesinden alınan verilere K-Means algoritması uygulanarak elde edilen onaltı küme aşağıdaki gibidir.

### 2.1.2 K-Means Algoritması Sonucu Oluşan Kümeler

Dünya Bankasının web sitesinden alınan verilere K-Means algoritması uygulanarak elde edilen onaltı küme aşağıdaki gibidir.

**Sıfırıncı küme**: Iran, Islamic Rep., Venezuela, RB, Morocco, Egypt, Arab Rep., Sri Lanka, Paraguay, Jordan, Azerbaijan, Dominican Republic, Arab World, Lebanon, Maldives, Brazil, Turkey, Suriname, Chile, Argentina, Antigua and Barbuda, Oman, Saudi Arabia, Bahrain, Bahamas, The, Kuwait, Qatar

**Birinci küme**: Burundi, Malawi, Madagascar, Guinea, Mozambique, Ethiopia, Rwanda, Nepal, Uganda, Tanzania, Tajikistan, Senegal, Zimbabwe, Timor-Leste, Bangladesh, Cameroon, Kenya, Pakistan, South Asia, Sub-Saharan Africa, Lao PDR, Sudan, Algeria, Guyana,Turkmenistan

**İkinci küme**: Cambodia, Ghana, India, Solomon Islands, Uzbekistan, Honduras, Vanuatu, Micronesia, Fed. Sts., Tuvalu, Indonesia, Marshall Islands, Guatemala, Samoa, Tonga, Fiji, Botswana, Nauru

**Üçüncü küme**: Korea, Rep., Israel, France, New Zealand, Germany, Finland, Canada, Austria, United Kingdom, Iceland, Sweden, Denmark, North America, United States, Australia, Norway, Macao SAR, China, Switzerland



**Dördüncü küme**: Cuba, Andorra, Nicaragua, Bolivia, Tunisia, Namibia, Macedonia, FYR, Serbia, South Africa, Belarus, Ecuador, Grenada, Seychelles, Portugal, Spain, Italy

**Beşinci küme**: San Marino, Colombia

**Altıncı küme**: Eritrea, Mauritania, South Sudan, Haiti, West Bank and Gaza, Angola, Equatorial Guinea

**Yedinci küme**: Malta, Hong Kong SAR, China, Singapore, Ireland, Luxembourg

**Sekizinci küme**: Kyrgyz Republic, Moldova, Ukraine, Bhutan, Cabo Verde, Armenia, Georgia, Albania, Bosnia and Herzegovina, Belize, Jamaica, Mauritius, Panama

**Dokuzuncu küme**: Vietnam, Hungary, Central Europe and the Baltics, Poland, Latvia, Lithuania, Slovak Republic, Estonia, Czech Republic, Slovenia, Cyprus, Belgium, United Arab Emirates, Netherlands

**Onuncu küme**: Central African Republic, Niger, Congo, Dem. Rep., Togo, Afghanistan, Burkina Faso, Comoros, Sierra Leone, Mali, Benin, Chad, Cote d'Ivoire, Nigeria

**Onbirinci küme**: Liechtenstein, Bermuda, Korea, Dem. People's Rep., Virgin Islands (U.S.), Guam, Cayman Islands, French Polynesia, New Caledonia, Greenland, Aruba, Monaco, Thailand, St. Vincent and the Grenadines, Dominica, St. Lucia, China, Latin America & Caribbean, Russian Federation, East Asia & Pacific, Caribbean small states, Croatia, Barbados, Uruguay, St. Kitts and Nevis, Trinidad and Tobago, Greece, Brunei Darussalam, Japan

**Onikinci küme**: Sao Tome and Principe, Philippines, Malaysia, Kazakhstan, Palau

**Onüçüncü küme**: Mongolia

Ondördüncü küme: Libya, Papua New Guinea, Syrian Arab Republic, Gambia, The, Liberia, Somalia, Guinea-Bissau, Lesotho, Myanmar, Yemen, Rep., Zambia, Kiribati, Djibouti, Congo, Rep., Swaziland, Iraq, Gabon

**Onbeşinci küme**: Puerto Rico, Kosovo, El Salvador, Peru, Montenegro, Bulgaria, Romania, Mexico, Costa Rica

### 2.2 Self Organizing Map (SOM) Algoritması ile Kümeleme

Dünya Bankasının web sitesinden alınan verilere SOM algoritması uygulanarak elde edilen onaltı küme aşağıdaki gibidir.

**Küme (1, 2)**: Liechtenstein, Virgin Islands (U.S.), Guam, Cayman Islands, French Polynesia, Greenland, Vietnam, South Africa, Thailand, Latin America & Caribbean, Argentina, Barbados, Seychelles, Uruguay

**Küme (0, 2)**: Bermuda, Cuba, Philippines, China, Mexico, East Asia & Pacific, Costa Rica, Palau, Trinidad and Tobago

**Küme (3, 1)**: Korea, Dem. People's Rep., Sri Lanka, Samoa, El Salvador, Peru, Nauru

**Küme (2, 3)**: Puerto Rico, Monaco, Russian Federation, Croatia, St. Kitts and Nevis, Greece, Portugal, Bahrain, Cyprus



**Küme (2, 2)**: New Caledonia, Aruba, Tunisia, Jordan, Azerbaijan, Belarus, Dominica, St. Lucia, Lebanon, Maldives, Turkey, Caribbean small states, Chile, Antigua and Barbuda, Oman, Saudi Arabia, Bahamas, The, Kuwait

**Küme (1, 1)**: Libya, Syrian Arab Republic, Venezuela, RB, Nicaragua, Egypt, Arab Rep., Guyana, Ecuador, Dominican Republic, Arab World, Suriname

**Küme (1, 3)**: Andorra, Hungary, Central Europe and the Baltics, Poland, Latvia, Lithuania, Slovak Republic, Slovenia, Spain, Italy, Brunei Darussalam, Japan

**Küme (2, 0)**: Papua New Guinea, Yemen, Rep., Zambia, Ghana, India, Congo, Rep., Swaziland, Indonesia, Gabon

**Küme (2, 1)**: Iran, Islamic Rep., Morocco, Paraguay, Fiji, St. Vincent and the Grenadines, Brazil

**Küme (0, 0)**: Eritrea, Mauritania, Burundi, Madagascar, Central African Republic, Niger, Congo, Dem. Rep., Somalia, Guinea, Mozambique, Togo, Afghanistan, Burkina Faso, Ethiopia, Nepal, Uganda, South Sudan, Sierra Leone, Haiti, Mali, Benin, Tanzania, Chad, Cameroon, Kenya, Pakistan, Sub-Saharan Africa, Lao PDR, Sudan, Nigeria, West Bank and Gaza, Angola, Equatorial Guinea

**Küme (3, 3)**: San Marino, Kyrgyz Republic, Moldova, Ukraine, Georgia, Mongolia, Bosnia and Herzegovina, Macedonia, FYR, Jamaica, Serbia, Colombia, Montenegro, Bulgaria, Romania, Mauritius, Panama

**Küme (1, 0)**: Malawi, Gambia, The, Liberia, Guinea-Bissau, Comoros, Tajikistan, Zimbabwe, Myanmar, Bangladesh, Kiribati, Cote d'Ivoire, South Asia, Djibouti

**Küme (0, 1)**: Rwanda, Senegal, Lesotho, Timor-Leste, Sao Tome and Principe, Bolivia, Algeria, Namibia, Iraq, Turkmenistan

**Küme (3, 0)**: Cambodia, Solomon Islands, Uzbekistan, Honduras, Vanuatu, Micronesia, Fed. Sts., Tuvalu, Kosovo, Marshall Islands, Guatemala, Tonga, Botswana

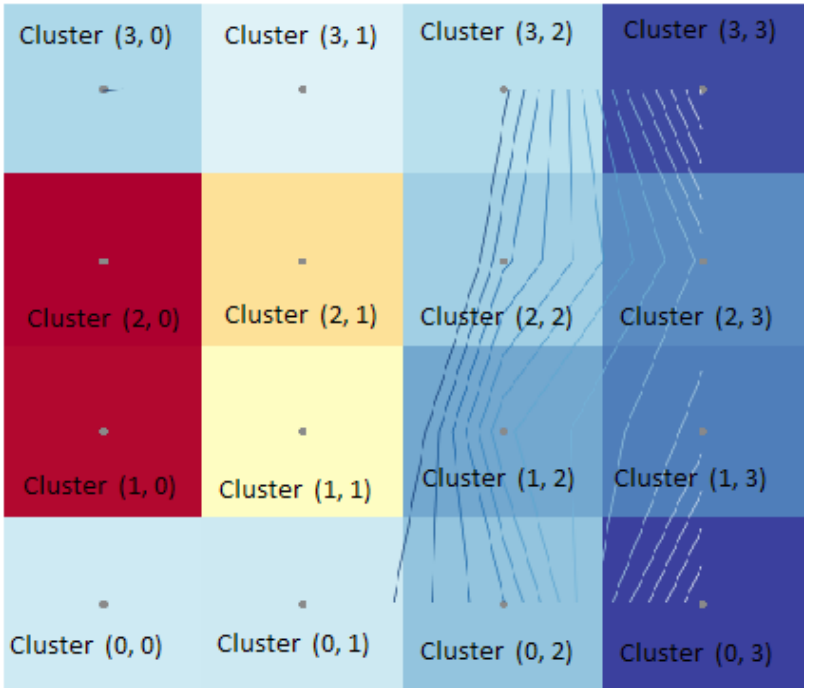
**Küme (3, 2)**: Bhutan, Cabo Verde, Armenia, Albania, Belize, Grenada

**Küme (0, 3)**: Malaysia, Kazakhstan, Estonia, Czech Republic, Malta, Korea, Rep., Israel, France, New Zealand, Belgium, United Arab Emirates, Germany, Finland, Hong Kong SAR, China, Canada, Austria, United Kingdom, Netherlands, Iceland, Sweden, Denmark, Singapore, North America, United States, Australia, Ireland, Qatar, Norway, Macao SAR, China, Switzerland, Luxembourg

### 2.2.1 SOM Algoritması Sonuçlarının Görselleştirimesi

SOM algoritması görselleştirilirken en çok kullanılan yöntemlerden biri bileşen düzlemleri yöntemidir. Bu görselleştirme şeklinde haritanın rengi, hedefin ortalamasına göre göreli değerini belirtir. Parlak kırmızı yüksek bir değeri, mavi ise düşük bir seviyeyi belirtir. Bazı renkler bazılarından daha parlaktır: dinamik aralık, simüle edilmiş boş hipotez ile belirlenir (Anonim 2013).






**Şekil 3.** Bileşen düzlemleri grafiğinin isimlendirilmiş hali

### 2.2.2 SOM Sonuçlarının Kalitesinin Ölçülmesi

Giriş verileri için her zaman en uygun harita mevcut olsa da, başlangıçtan itibaren doğru parametreleri seçmek zordur. Farklı parametreler ve başlatmalar farklı haritalara neden olduğundan, haritanın eğitim verilerine düzgün şekilde adapte olup olmadığını bilmek önemlidir. Haritanın kalitesini belirlemek, uygun öğrenme parametrelerini ve harita boyutlarını seçmek için yaygın olarak kullanılan iki kalite önlemi, ortalama nicemleme hatası(Average quantization error) ve topografik hata(Topographic error) dır (MOVSOM Research Lab).

Nicemleme Hatası, geleneksel olarak tüm vektör kuantizasyon ve kümeleme algoritmaları ile ilgilidir. Dolayısıyla, bu ölçüm tamamen harita topolojisini ve hizalamayı gözardı eder. Nicemleme hatası, örnek vektörlerin temsil edildiği küme merkezlerine ortalama mesafesini belirleyerek hesaplanır. SOM durumunda, küme merkezleri prototip vektörlerdir (Polzlbauer, 2004).

Verilen herhangi bir veri kümesi için, harita düğümlerinin sayısını arttırmakla nicemleme Hatası azaltılabilir, çünkü veri örnekleri daha seyrek olarak harita üzerinde dağıtılır.

Topografik Hata, topoloji koruma önlemlerinin en basitidir. Bu hesaplama şu şekilde yapılır: Tüm veri örnekleri için en ilgili ve en iyi eşleşen birimler belirlenir. Harita kafesinde bunlar bitişik değilse, bu bir hata olarak kabul edilir. Toplam hata daha sonra 0 ile 1 arasında bir aralıkta normalize edilir. Burada 0, mükemmel bir topoloji koruması anlamına gelir.

Elde edilen kümeler için topographic değer 0.056074766355140186 olarak bulunmuştur. Bulunan değer 0 ile 1 aralığında olduğundan topolojinin korunduğu sonucuna varılır.



## 3. SONUÇ VE ÖNERİLER

Bu çalışmada Dünya Bankası'nın web sitesinden alınan verilere kümeleme analizi yöntemlerinden olan K-Means ve Self Organizing Map algoritmaları uygulanmıştır. Bu algoritmalar sonucunda oluşan kümeler ve Türkiye' nin bu kümelerdeki yeri incelenmiştir.

K-Means algoritması sonucunda ülkemiz İran, Venezuela, Mısır, Sri Lanka, Paraguay, Ürdün, Azerbaycan, Dominik Cumhuriyeti, Arap Devletleri, Lübnan, Maldivler, Brezilya, Surinam, Şili, Arjantin, Antigua ve Barbuda, Umman, Suudi Arabistan, Bahreyn, Bahama Adaları, Kuveyt ve Katar ile aynı kümede yer almaktadır. Bu küme ağırlıkla Orta Doğu ülkelerinden oluşmaktadır.

K-Means algoritması sonucunda, her bir parametre için küme merkezleri incelenmiştir. Bu değerlere genel olarak bakıldığında ülkemizin genel olarak iyi bir noktada olduğu söylenebilir. Türkiye'nin daha iyi bir noktaya gelebilmesi için T.C. Kalkınma Bakanlığı tarafından kalkınma planları düzenlenmektedir. Güncel kalkınma planı 2014-2018 yıllarını kapsayan Onuncu Kalkınma Planı'dır (Kalkınma Bakanlığı, 2014).

SOM algoritması sonucunda ülkemiz Yeni Kaledonya, Aruba, Tunus, Ürdün, Azerbaycan, Belarus, Dominika, Saint Lucia, Lübnan, Maldivler, Karayipler, Şili, Antigua ve Barbuda, Umman, Suudi Arabistan, Bahama

Adaları ve Kuveyt ile aynı kümede yer almaktadır. Bu küme ağırlıkla Amerika kıtasındaki gelişmekte olan ülkelerden oluşmaktadır.

Değişkenlere ilk bakıldığında tarım parametresi ön plana çıkar. Sahip olduğumuz coğrafi konum ve iklim göz önüne alındığında, tarım alanı bu parametreler arasından en hızlı sonuç alınabilecek parametredir. Onuncu Kalkınma Planı'nda bu sektörün yıllık ortalama büyüme hızının yüzde 3,1 olması, toplam istihdam içerisindeki payının yüzde 21,9'a gerilemesi ve GSYH içerisindeki payının ise yüzde 6,8 olması beklenmektedir.

Bebek ölüm oranı parametresinde, ülkemiz diğer ülkelerin ortalamasına bakıldığında iyi bir noktadadır. Bu değerin daha da düşürülmesi için ana çocuk sağlığı ve aile planlama merkezleri sayısı arttırılmalıdır.

Kişi başına düşen milli gelir miktarına bakıldığında ülkemiz ortalamaya yakın bir değere sahiptir. Bu değer vatandaşların bireysel mutluluğuna etki eden en önemli parametrelerden biridir. Onuncu Kalkınma Planı'nda 2023 yılı hedefi olarak kişi başına düşen milli gelirin 16 bin dolara ulaşması beklenmektedir.

Dış Borç parametresi, Türkiye'nin bu parametreler içinde en çok geliştirmesi gereken alandır. Onuncu Kalkınma Planı'nda cari açığın kademeli olarak 5,2 seviyesine gerilemesi hedeflenmiştir.

Her yüz bin kişiye düşen banka şube sayısı parametresine bakıldığında, ülkemizin ortalamanın üzerinde bir değere sahip olduğu görülür. Türkiye' nin bankacılık sektöründe uluslararası standartlara sahip olması için Basel II standartları 2012 yılından itibaren uygulanmaktadır. Ayrıca Onuncu Kalkınma Planı dönemi sonunda İstanbul'un Küresel Finans Merkezleri Endeksinde ilk 25 içinde yer alması hedeflenmektedir.



İnternet kullanıcı sayısı parametresinde ülkemiz ortalamanın üzerinde bir değere sahiptir. 2009 yılından bu yana 3G hizmeti verilmeye başlanmış ve abone sayısı 12 milyonu aşmıştır.

İş yapılabilirlik parametresine bakıldığında ülkemizin bu alanda gelişmesi gerektiği görülür. Bu hedef için Onuncu Kalkınma Planı'nda İş ve Yatırım Ortamının Geliştirilmesi Programı oluşturulmuştur.

İnsan hakları parametresinde Türkiye 12 üzerinden 3 almıştır. Gelişmişlik düzeyi incelemesinde sosyal anlamda en önemli parametrelerden biri insan haklarıdır. 2013 yılında dördüncü yargı reformu paketi kabul edilmiştir. Bu pakette AİHM'in "yeniden yargılama" kararlarının tümü uygulanabilir olmuştur.

Teknoji ihracatı alanında Türkiye son yıllarda gelişme göstermektedir. Her geçen yıl yüksek teknolojiye yatırım yapan firma sayısı artmaktadır. Bu firmalardan Vestel, Venüs marka yerli cep telefonu ile kayda değer bir başarı elde etmiştir. Airties, yerel ağ ve internet üzerinden telefon ürünleri ile teknoloji ihracatında önemli bir paya sahiptir. Telekom sektöründe ise Netaş'ın ürettiği çözümler beş kıtada kabul görmektedir (Anonim, 2015).

Kadın milletvekili sayısı ülkemizde gelişmesi gereken alanlardan biridir. TÜİK'in 2014 yılında seçilmiş ülkeler için kadın milletvekili sayısını listelemiştir. Türkiye bu listede 45 ülke arasından %14.4 oranı ile 39. sıradadır. Listenin ilk üç sırasında ise İsveç, Finlandiye ve İzlanda bulunmaktadır.

Mal ve hizmetlerin ihracatı, dünyanın geri kalanına sağlanan malların ve diğer piyasa hizmetlerinin değerini temsil eder. Mal, nakliye, sigorta, nakliye, seyahat, gayrimaddi hak bedelleri, lisans ücretleri ve

iletişim, inşaat, finans, bilgi, iş, kişisel ve devlet hizmetleri gibi diğer hizmetlerin değerini içerirler. Türkiye ihracat alanında gelişme göstermektedir. TİM 'in 2015 yılı için hazırladığı sektör bazlı raporda, kimyevi maddeler ve mamulleri, otomotiv endüstrisi,hazırgiyim ve konfeksiyon ilk üç sırada yer almaktadır (Türkiye İhracatçılar Meclisi, 2016).

Geliştirilmiş bir su kaynağına erişim, gelişmiş bir içme suyu kaynağını kullanan nüfus yüzdesini ifade eder. İyileştirilmiş içme suyu kaynağında banyolarda su boruları ve diğer geliştirilmiş içme suyu kaynakları bulunmaktadır. Türkiye bu alanda gelişmiş ülkeler seviyesinde yer almaktadır.

**Conflict of Interests/Çıkar Çatışması**

Authors declare no conflict of interests/Yazarlar çıkar çatışması olmadığını belirtmişlerdir.

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**ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE**

# DAĞITIK SİSTEMLERDE BİRLİKTELİK KURALLARI İLE SEPET ANALİZİ*

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## Öz

Büyük miktardaki veri yığınları içerisinden anlamlı ve kullanılabilir olan bilgileri ortaya çıkarabilmek için veri madenciliği teknikleri ve algoritmaları kullanılmaktadır. Birliktelik kuralları veri tabanı sistemlerinde önceden bilinmeyen, kullanışlı örüntülere ulaşabilmek için kullanılan tekniklerden biridir. Birliktelik kurallarının yaygın olarak kullanıldığı bir alan olan sepet analizi müşterilerin satın aldıkları ürünler arasındaki ilişkileri analiz etmektedir.

Bir iş yükünü parçalara bölerek eş zamanlı olarak gerçekleştiren bilgisayar ağları dağıtık hesaplama sistemleri olarak adlandırılmaktadır. Bu çalışmada birliktelik kurallarını dağıtık sistemlere taşıyarak daha kısa süreli sonuçlar elde etmek amaçlanmıştır. FP- Growth algoritması kullanılarak kurallar oluşturulmuş, dağıtık sistem mimarisinde büyük boyutlu veriler işlenerek üzerinde anlık sepet analizi yapılmış ve daha hızlı sonuçlara ulaşılmıştır.

**Anahtar Kelimeler:** Dağıtık Sistemler, Sepet Analizi, FP-Growth Algoritması, Birliktelik Kuralı, Veri.



## BASKET ANALYSIS WITH ASSOCIATION RULES IN DISTRIBUTED SYSTEMS

## Abstract

Data mining techniques and algorithms are used to reveal information that is meaningful and usable in large amounts of data. Association rules are one of the techniques used to access previously unknown, useful patterns in database systems. Basket analysis, a field where association rules are widely used, analyzes the relationships between the products purchased by customers.

Computer networks that perform a workload simultaneously by dividing them into parts are called distributed computing systems. In this study, it is aimed to obtain the shorter results by moving the association rules to distributed systems. Rules were created by using FP- Growth algorithm, large-scale data were processed in distributed system architecture and instant basket analysis was performed and faster results were obtained.

**Keywords:** Distributed Systems, Basket Analysis, FP-Growth Algorithm, Association Rule, Data.

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## 1. GİRİŞ

İçinde bulunduğumuz Bilgi ve Teknoloji çağında verilerin hızlı bir şekilde işlenerek, gelişmiş veri analizinin yapılabilmesi, verilerin önemini her geçen gün daha da artırmaktadır. Veri analizi ile daha anlamlı sonuçlar elde edilerek, veriler daha etkili bir şekilde kullanılmaktadır (Sönmez, Zontul ve Kaynar, 2018). Büyük miktardaki verilerin içinden geleceğe dair tahmin yapılabilmesini sağlayan ilişkiler veri madenciliği ile analiz edilmektedir (Savaş, Topaloğlu ve Yılmaz, 2012). Veri madenciliği teknikleri ve algoritmaları ile kullanışlı bilgiler ortaya çıkarılmaktadır (Gemici, 2012).

Birliktelik kuralları büyük miktardaki veri yığınları arasından daha önceden bilinmeyen örüntüleri bulmak için kullanılan tekniklerden biridir (Erdoğan, Gülcan ve Karamaşa, 2015). Birliktelik kurallarının kullanıldığı en belirgin örnek olarak sepet analizi verilebilir. Sepet analizi ile müşterilerin alışverişlerde satın aldıkları ürünler arasındaki ilişkiler analiz edilerek, satın alma alışkanlıkları belirlenmektedir (Takçı ve Hayta, 2014).

Büyük boyutlu hesaplama problemlerinin parçalara ayrılarak, birbirlerine bir bilgisayar ağı ile bağlı olan makinelerde her bir parçanın çözülmesine dağıtık hesaplama adı verilir (Kuzu, 2014). Bu çalışmada diğer çalışmalardan farklı olarak büyük veriyi işleyebilmek ve anlık sepet analizi yapabilmek için dağıtık sistemler kullanılmıştır. Veriler birden fazla işlemci üzerinde dağıtılmış ve FP-Growth algoritması kullanılarak birliktelik kuralları daha hızlı bir şekilde oluşturulmuştur.



Literatürde birliktelik kuralları ve sepet analizi üzerine çeşitli çalışmalar yapılmıştır. Ayhan Döşlü tarafından 2008 yılında yazılan yüksek lisans tezinde, veri madenciliğinde yer alan temel kavramlar, yöntem ve teknikler incelenerek, birliktelik kuralları ve bu kuralların oluşturulması için kullanılan algoritmalar araştırılmıştır. Uygulama sonucunda, FP-Growth algoritmasının Apriori algoritmasına göre daha iyi performans gösterdiği tespit edilmiştir (Döşlü, 2008).

Ufuk Ekim tarafından 2011 yılında yapılan çalışmada, öğrenci başarısına etki eden faktörlerin birlikte bulunması amacıyla Selçuk Üniversitesi otomasyonundaki anket verilerine, Karar Ağacı ve Apriori algoritmaları uygulanarak sonuçlar karşılaştırılmıştır (Ekim, 2011).

Mine Durdu 2012 yılındaki yüksek lisans tezinde, müşteri verileri ve satış bilgilerini anlamlı verilere dönüştürerek, market sepet analizi uygulamıştır. Apriori algoritmasını kullanarak market veri seti üzerinden birliktelik kurallarını oluşturan bir uygulama tasarlamıştır (Durdu, 2012).

Elif Şafak Sivri 2015 yılında hazırladığı yüksek lisans tezinde, bir e-ticaret sitesine ait giyim verilerini kullanarak birliktelik analizi yapmıştır. Müşterilerin birlikte satın aldığı ürünler FP- Growth ve Apriori algoritmaları ile tespit edilmiştir (Sivri, 2015).

Gamze Yılmaz Erduran tarafından 2017 yılında hazırlanan doktora tezinde, Türkiye'de faaliyet gösteren bankalara ait online müşteri şikayetleri üzerinde veri madenciliği uygulanmış, FP- Growth algoritması kullanılarak birliktelik kuralı oluşturulmuştur (Erduran, 2017).

Çalışmanın ikinci bölümünde veri madenciliği hakkında bilgi verilmiş, üçüncü bölümde ise birliktelik kuralı ve sepet analizi açıklanarak, birliktelik kuralı çıkarma algoritmalarından FP- Growth algoritması

incelenmiştir. Dördüncü bölümünde dağıtık sistemler hakkında bilgi verilen çalışmanın beşinci bölümünde, işlemcilerde dağıtık mimari kullanılarak FP-Growth algoritması ile birliktelik kuralı analizi yapan bir uygulama geliştirilmiştir. Çalışma, sonuçların aktarıldığı altıncı bölüm ile sona ermektedir.

## 2. VERİ MADENCİLİĞİ

Veri madenciliği geçerli tahminler yapmak için çeşitli analiz aracı kullanılarak veri içerisindeki örüntü ve ilişkileri keşfetmeye yarayan bir süreçtir (Koyuncugil ve Özgülbaş, 2009). 1990'lı yıllardan itibaren kullanılan veri madenciliği, Gregory Piatetsky-Shapiro ve William Frawley tarafından "verideki gizli, önceden bilinmeyen ve potansiyel olarak faydalı enformasyonun önemsiz olmayanlarının açığa çıkarılması" şeklinde tanımlanır (Koyuncugil, 2006).

Şekil 1'de ilgi alanları verilen veri madenciliği istatistik, veri görselleştirme, makine öğrenimi, yapay zekâ ve örüntü tanımlama gibi çeşitli alanlarda kullanılmaktadır (Hand, 1998). Çeşitli amaçlarla pek çok alanda kullanılan veri madenciliğinde veri tanımlama, sınıflandırma, kümeleme, ilişkilendirme, tahmin etme gibi uygulama türleri kullanımı yaygındır (Larose, 2005).


**Şekil 1.** Veri madenciliği ilgi alanları (Baykasoğlu, 2005)

Veri madenciliği veri, bilimsel hesaplamalar, donanım, bilgisayar ağları ve ticari eğilimler olmak üzere beş ana faktörden etkilenmektedir. Veri ortamlarında bulunan veri miktarı arttıkça sorunlar da artabileceğinden boş veri, belirsizlik, eksik veri, veri tabanı boyutu, artık veri, sınırlı bilgi veri madenciliğinde ortaya çıkabilecek problemlerden bazılarıdır (Savaş, Topaloğlu ve Yılmaz, 2002).

Veri madenciliği algoritmalarından verimli sonuçlar alınabilmesi için, veri madenciliği sürecine başlamadan önce, üzerinde çalışılacak verinin özellikleri detaylı analiz edilmelidir. Genel olarak veri madenciliği sürecinde uygulanan adımlar; problemin tanımlanması, verilerin hazırlanması, modelin kurulması ve değerlendirilmesi, modelin kullanılması, modelin izlenmesi şeklindedir (Savaş, Topaloğlu ve Yılmaz, 2002).

Veri madenciliğinde tahmin edici ve tanımlayıcı modeller kullanılmaktadır (Özekes, 2003). Tahmin edici modelde, sonucu belli olan veriler üzerinden bir model oluşturularak sonuçları belli olmayan veri kümeleri için tahminler yapılır. Tanımlayıcı modellerde ise mevcut verilerde bulunan ve karar vermeye yardımcı olabilecek örüntüler tanımlanır (Şimşek, 2006). Veri madenciliğinde kullanılan modeller; Sınıflama - Regresyon, Kümeleme ve Birliktelik Kuralları olarak ayrılır. Sınıflama ve regresyon tahmin edici, kümeleme ve birliktelik kuralları tanımlayıcı modellerdir (Savaş, Topaloğlu ve Yılmaz, 2002).

Veri madenciliğinde bilgilerin verimli kullanılabilmesini sağlayan tekniklerden biri birliktelik kuralıdır (Ateş ve Karabatak, 2017). Birliktelik kuralı; veri tabanında bulunan nesneler arasındaki ilişkileri analiz ederek, eş zamanlı olarak gerçekleşebilecek olayları belirlemektedir (Miholca, Czibula ve Crivei, 2018).

## 3. BİRLİKTELİK KURALI VE SEPET ANALİZİ

İlk defa 1993 yılında market sepet verisi üzerinde uygulanan birliktelik kuralı, veri yığınları içerisinden önceden keşfedilmemiş örüntüleri bulmak için kullanılmaktadır (Ateş ve Karabatak, 2017). Açık ve anlaşılır sonuçlar elde edilen, büyük miktardaki veriler üzerinde çalışılabilen birliktelik kurallarında, yeni bilgi analizinin zaman alıcı olması, doğru özellik sayısı bulunurken zorluk yaşanması, seyrek görülen özelliklerin göz ardı edilmesi gibi sorunlar yaşanabilmektedir (Koyuncugil, 2006).



Literatürde pazar sepet analizi olarak da adlandırılan birliktelik kuralı, müşterilerin çapraz satın alma davranışları ve birlikte satın alınma eğilimi olan ürünler hakkında bilgi vermektir (Erdoğan, Gülcan ve Karamaşa, 2015). "Eğer A ürününü alıyorlarsa % x ihtimalle B ürününü de almaya da yatkındırlar." biçiminde elde edilen bir sonuç, A ürününü satan bir market için fayda sağlayabilmektedir (Ateş ve Karabatak, 2017)

| İşlem / Hareket | Elemanlar |
|---|---|
| *t*1 | Ekmek, Jöle, Yerfıstığı yağı |
| *t*2 | Ekmek, Yerfıstığı yağı |
| *t*3 | Ekmek, Süt, Yerfıstığı yağı |
| *t*4 | Bira, Ekmek |
| *t*5 | Bira, Süt |

**Tablo 1.** Birliktelik kurallarını göstermek için örnek veri seti

Yukarıdaki tabloda birliktelik kuralları açısından süpermarket nakit kayıt işlemlerine yönelik veriler gösterilmiştir (Ateş ve Karabatak, 2017). Özel kural formunda olan bu kurallar sol ve sağ olarak birbiriyle bağlantılı iki bölümden oluşmaktadır. Bu iki bölümde nesneler ya da yapılan iş yer alır ve eğer-sonra ifadeleri aracılığıyla veriler arasındaki ilişkiler gösterilir (Tüzüntürk, 2010).

Sepet analizinde destek ve güven değerleri kullanılarak ürünler arasındaki bağıntı hesaplanmaktadır. Kuralın gücünü ölçmek için güvenilirlik, veri tabanında kuralın ne kadar sıklıkla görüldüğünü belirlemek için ise destek ölçütü kullanılır (Erdoğan, Gülcan ve Karamaşa, 2015). Aşağıda *A* Þ *B* kuralı için destek ve güvenilirlik değerlerine ait formüller yer almaktadır:

$$\text{Destek değeri : } P(A \rightarrow B) = \frac{\text{A ve B mallarını satın alan müşteri sayısı}}{\text{Toplam müşteri sayısı}} \quad (1) \tag{1}$$

$$\text{Güven: } P(A/B) = \frac{P(A \wedge B)\ \{\text{A ve B mallarını satın alan müşterisayısı}\}}{P(A)\ \{\text{A malını satın alan müşteri sayısı}\}} \quad (2) \tag{2}$$

Her iki değerin de yüksek olması sürekli ilginç ve önemi yüksek kuralların elde edileceği anlamına gelmediğinden, bir kuralın ne derece ilginç olduğu lift değeri kullanılarak tespit edilmektedir (Ateş ve Karabatak, 2017).. Lift ölçütünün 1'den küçük ya da büyük değerler alması ilginçliğin arttığını, "1" değerini alması ise ilginçliğin olmadığını belirtmektedir (Jabbour, Mazouri ve Sais, 2018). Lift değeri denklemi aşağıda gösterildiği gibi hesaplanmaktadır.

$$\text{Lift } (A \rightarrow B) = \frac{\text{destek } (A \wedge B)}{\text{destek(A).destek(B)}} = \frac{P(B/A)}{P(B)} \tag{3}$$



Birliktelik kuralı oluşturmak için Conviction (Kanaat) ve Leverage (Kaldıraç) ölçütleri de kullanılmaktadır. Conviction değeri hesaplanırken, A elemanlarının, B elemanı olmaksızın görülme olasılıkları hesaplanır. Eğer conviction değeri 1 ise A ve B birbirinden bağımsızdır. Conviction değeri 1'den uzak ise ilişkili kural oluşturulabilir (Şeker, 2011) .

$$\text{Conviction } (A \rightarrow B) = \frac{1\text{- destek(B)}}{1\text{- güven(A,B)}} \quad (4) \tag{4}$$

Leverage değeri ise bir satış verisi üzerinde A ve B ürünlerinin birlikte satılmasının A ve B'nin ayrı ayrı satılmasından ne kadar fazla olduğunu bulmaktadır (Şeker, 2011).

$$\text{Leverage } (A \rightarrow B) = P(\text{ A ve B}) - (P(A)P(B)) \quad (5) \tag{5}$$

Tablo 1'deki veri setinden oluşturulan bazı birliktelik kuralları için bulunan destek ve güvenilirlik değerleri Tablo 2'de yer almaktadır.

| *A* Þ *B* | **Destek değeri (s)** | **Güvenilirlik değeri** (*a* ) |
|---|---|---|
| Ekmek Þ Yerfıstığı yağı | %60 | %75 |
| Yerfıstığı yağı Þ Ekmek | %60 | %100 |
| Bira Þ Ekmek | %20 | %50 |
| Yerfıstığı yağı Þ Jöle | %20 | %33,3 |
| Jöle Þ Yerfıstığı yağı | %20 | %100 |
| Jöle Þ Süt | %0 | %0 |

**Tablo 2.** Birliktelik kuralları için destek ve güvenilirlik değerleri

FP-Growth (Frequent Pattern Growth) Algoritması birliktelik kuralı ortaya çıkarmak için tasarlanmış yöntemlerden biridir. Sık örüntüleri bulmak için kullanılan FP-Growth algoritması, tüm veri tabanını sadece iki kez tarayarak maliyeti azaltmaktadır (Erdoğan, 2010).

FP-Growth Algoritması sistem kaynaklarını verimli bir şekilde kullanabilme, yaygın nesne kümelerini aday kümeleri üretmeye gerek olmadan test edebilme ve büyük veri kümelerinde hızlı çalışabilme gibi özelliklere sahip olmasıyla diğer algoritmalardan ayrılır. Böl ve yönet yaklaşımını kullanarak, bir arada sık bulunan nesneler kümesini ortaya çıkartan FP-Growth algoritmasının sözde kodu Şekil 2'de verilmiştir (Erpolat, 2012).



```
Girdi: FPTree
Çıktı: Tüm sık ögekümeleri
Metod: FP-Growth(Fp-tree,null)
FP-Growth(Tree, α)
{
    if Tree tek bir yol P içeriyorsa then
        for each β (P yolu içerisindeki düğümlerin
          kombinasyonu) do
            sup ← min{b.support | b in β}
            Sık ögekümesi αU{b.item | b in β } yı
             sup destek değeri ile üret
    else
        for each item α ( α in Tree.header)
            sup ← a.support
            αUα için sık ögekümelerini sup destek değeri
             ile üret
            β = αUα için şartlı örüntü temellerini ve sonra
            β için şartlı örüntü ağacını Treeβ oluştur
            If Treeβ ≠ Ø then
                FP-Growth(Treeβ, β)
}
```

**Şekil 2.** FP-Growth Algoritması sözde kodu (Han, Pei ve Yin, 2000)

## 4. DAĞITIK SİSTEMLER

Bir problemin küçük iş parçacıklarına ayrılarak eş zamanlı koordine edilmesi paralel hesaplama olarak adlandırılır. Seri hesaplamada problem her bir zaman aralığında bir komut olmak üzere CPU (Merkezi İşlem Birimi)'ne gönderilirken, paralel hesaplamada öncelikle problem belirli sayıda parçalara ayrılarak her bir problem parçası bir zaman aralığında bir komut olarak CPU'ya gönderilir (Kuzu, 2014).

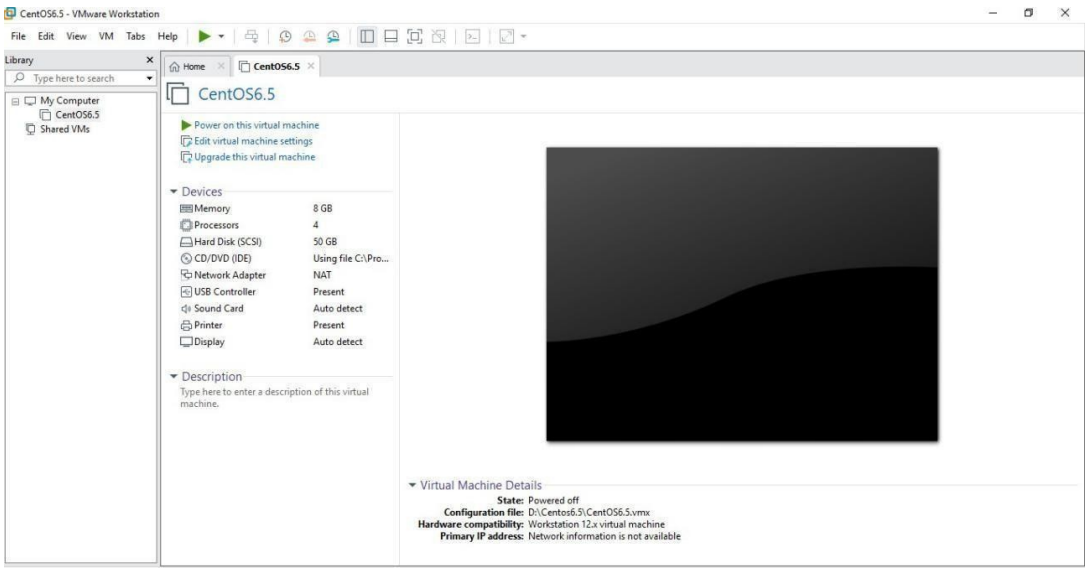
Dağıtık hesaplama sistemleri büyük bir probleme uygun görev dağılımı ve bağlantı ile ortak çözüm getiren veya bir işi parçalara bölerek eşzamanlı gerçekleştiren bilgisayar ağlarıdır. (Türkoğlu ve Arslan, 2002). Paralel ve dağıtık hesaplama teknolojileri, bilgisayar bilimlerinin üzerinde çalıştığı, ticari ve ekonomik anlamda pek çok araştırmaların yapıldığı etkinliğini sürdüren alanlardan biridir. Bu alanda Hadoop ve MapReduce teknolojileri son yıllarda ön plana çıkmaktadır (Yıldırım, Aydın, Alli ve Tatar, 2014).

## 5. UYGULAMA

Bu çalışmada bir giyim firmasına ait veriler üzerinde FP-Growth algoritması kullanılarak birliktelik kuralı analizi yapılmıştır. İlk olarak Python Flask ile tek işlemci üzerinde çalışan bir uygulama oluşturulmuş, daha sonra veriler birden fazla işlemciye dağıtılarak birliktelik kuralı analizi yapılmıştır. Orientdb ile veri tabanı oluşturulmuş ve veri tabanı örnek sunucuda veriler saklanmıştır (http://localhost:2480). VMware programı ile bilgisayarda sanal bir makine oluşturularak mevcut Windows makine üzerinde Linux işletim sistemi kurulmuştur.



Şekil 3'te başlangıç ekranı verilen sanal makine 8 GB hafıza, 50 GB sabit disk, 4 işlemciye sahiptir.




**Şekil 3.** VMware Centos6.5 başlangıç ekranı

FP-Growth algoritması kullanılarak birliktelik kuralı oluşturmak için geliştirilen uygulama ilk çalıştırıldığında http://localhost:5000 veri tabanı sunucusuna bağlantı yapılmasını istemektedir. Sunucuya bağlanıldığında veriler okunmaya başlayacaktır.

```
client = pyorient.OrientDB("localhost", 2424)
client.set_session_token(True)
client.db_open("pcrmdatabase", "root", "123456")
sessionToken = client.get_session_token()

del client

client = pyorient.OrientDB("localhost", 2424)
client.set_session_token(sessionToken)
client.set_session_token(True)  # set true
client.db_open("pcrmdatabase", "root", "123456")
new_sessionToken = client.get_session_token()

assert sessionToken != new_sessionToken
## product get category for analysis
class getproductcategory(Resource):
    def get(self):
        myarraylist = []
        print(time.strftime("%H:%M:%S"),'Data Okunuyor')
        records = client.query("Select list(distinct(product_name)) f
        print(time.strftime("%H:%M:%S"),'Data basariyla okundu')
        for x in range(0, len(records)):
```



**Şekil 4.** Tek işlemcili uygulamanın kod yapısı

```
        for x in range(0, len(records)):
            try:
                myarraylist.append(records[x].oRecordData)

            except:
                print(sys.exc_info()[0])
        print(time.strftime("%H:%M:%S"),'Fp Growth baslatiliyor')
        trans = read_from_json_basket(myarraylist)

        rules = find_association_rules(trans, 0.5, 0.7)
        a = json.dumps(rules)
        print(time.strftime("%H:%M:%S"), 'Fp Growth basariyla bitirildi.')
        time.sleep(1)
        print(rules)
        return rules

api.add_resource(getproductcategory, '/', methods =['GET'])

if __name__ == '__main__':
    app.run(debug=True, host='localhost', port=5000)
```

**Şekil 5.** Tek işlemcili uygulamanın kod yapısı (devam)

Şekil 4 ve Şekil 5'te kodları verilen tek işlemcili uygulama 100 adet veri üzerinde çalıştırıldığında analiz 54 saniye sürmüş ve sonucunda çok sayıda kural üretilmiştir.

```
{
    "consequents": "BL2539 CONSPIRACY RAZOR OUTDRY",
    "confidence": 1.0,
    "lift": 34.5,
    "antecedent": "SL7904 Bugaboo Interchange Jacket",
    "sup_count_AC": 1,
    "sup_count_A": 1,
    "conviction": 0.0,
    "sup_count_C": 2,
    "leverage": 0.014072673808023524
},
```


**Şekil 6.** Kural 1

Şekil 6'da elde edilen kurala göre ayakkabı alınırken %100 olasılıkla (confidence:1.0) ceket de alınmıştır. İki ürün faturada toplam (sup_count_C) 2 kez birlikte alınmıştır. Elde edilen kuralın lift değeri 34.5 olarak tespit edilmiştir. İki ürünün birlikte satılmasının ayrı ayrı satılmasından ne kadar farklı olduğunu belirlemek için leverage ölçütü kullanılmıştır. Conviction değeri 1'den uzak olduğu için ilişkili bir kural oluşturulabilmiştir. Şekil 7'de uygulamaya ait tüm analiz sonuçları verilmiştir.


```
/home/user/Desktop/Pycharm/tugceproje/virtualenv/bin/python
 /home/user/Desktop/Pycharm/tugceproje/webservice/ram_ile_web_uygulamasi.py
 * Running on http://localhost:5000/ (Press CTRL+C to quit)
 * Restarting with stat
 * Debugger is active!
 * Debugger PIN: 143-045-047
09:44:56 Data Okunuyor
09:45:50 Data basariyla okundu
09:45:50 Fp Growth baslatiliyor
09:45:50 Fp Growth basariyla bitirildi.
[{'consequents': 'CL9040 W THERMARATOR GLOVE, SM9481 M Wind Bloc Glove', 'confidence':
1.0, 'lift': 69.0, 'antecedent': 'WL5378 VARALUCK III MID JACKET', 'sup_count_AC': 1,
'sup_count_A': 1, 'conviction': 0.0, 'sup_count_C': 1, 'leverage': 0
.014282713715605966}, {'consequents': 'CL9040 W THERMARATOR GLOVE, WL5378 VARALUCK III
MID JACKET', 'confidence': 1.0, 'lift': 69.0, 'antecedent': 'SM9481 M Wind Bloc
Glove', 'sup_count_AC': 1, 'sup_count_A': 1, 'conviction': 0.0, 'sup_count_C': 1,
'leverage': 0.014282713715605966}, {'consequents': 'SM9481 M Wind Bloc Glove',
'confidence': 1.0, 'lift': 69.0, 'antecedent': 'CL9040 W THERMARATOR GLOVE, WL5378
VARALUCK III MID JACKET', 'sup_count_AC': 1, 'sup_count_A': 1, 'conviction': 0.0,
'sup_count_C': 1, 'leverage': 0.014282713715605966}, {'consequents': 'WL5378 VARALUCK
III MID JACKET', 'confidence': 1.0, 'lift': 69.0, 'antecedent': 'CL9040 W THERMARATOR
GLOVE, SM9481 M Wind Bloc Glove', 'sup_count_AC': 1, 'sup_count_A': 1, 'conviction':
0.0, 'sup_count_C': 1, 'leverage': 0.014282713715605966}, {'consequents': 'CL9040 W
THERMARATOR GLOVE', 'confidence': 1.0, 'lift': 13.799999999999999, 'antecedent':
'WL5378 VARALUCK III MID JACKET, SM9481 M Wind Bloc Glove', 'sup_count_AC': 1,
```


**Şekil 7.** 100 adet veri ile tek işlemci üzerinde uygulama sonucu

Şekil 8'de tek işlemci üzerinde çalışan uygulamanın dört işlemci üzerinde dağıtılarak çalıştırılmasını sağlayan kodlar verilmiştir.

```
sys.getdefaultencoding().encode('utf-8')
client = pyorient.OrientDB("localhost", 2424)
client.set_session_token(True)
client.db_open("pcrmdatabase", "root", "123456")
sessionToken = client.get_session_token()
del client
client = pyorient.OrientDB("localhost", 2424)
client.set_session_token(sessionToken)
client.set_session_token(True)  # set true
client.db_open("pcrmdatabase", "root", "123456")
new_sessionToken = client.get_session_token()
assert sessionToken != new_sessionToken
myarraylist = []
print(time.strftime("%H:%M:%S"), 'Data Listesi Olusturma baslatildi.')
records = client.query("Select list(distinct(product_name)) from "
                       "tbl_product_transaction_line where transaction_group_code in "
                       "(Select transaction_group_code as siparis from "
                       "tbl_product_transaction_line limit 100) group by "
                       "transaction_group_code")

print(time.strftime("%H:%M:%S"), 'Data Liste olusturuldu.')
for x in range(0, len(records)):
    try:
        myarraylist.append(records[x].oRecordData)
    except:
        print(sys.exc_info()[0])
print(time.strftime("%H:%M:%S"), 'Process Start')
def a():
    trans = read_from_json_basket(myarraylist)
    rules = find_association_rules(trans, 0.5, 0.7)
    a = json.dumps(rules)
    time.sleep(1)
    print(rules)
    return rules
results = [a() for i in range(4)]
print(time.strftime("%H:%M:%S"),'Process Finished')
```



**Şekil 8.** İşlemcilerde dağıtık mimari oluşturma kodu

Kodları dört işlemci üzerinde 100 adet veriyi dağıtarak çalıştırdığımızda oluşan sonuç Şekil 9 ve Şekil 10'da verilmiştir. Dört işlemci üzerinde 48 saniye sürede bir adet aynı kural üretilmiştir. Dört işlemci de aynı anda çalıştırılmış ve tek işlemci üzerinde çalıştırılan uygulama ile elde dilen kuralın aynısı dört işlemci tarafından daha kısa sürede üretilmiştir.

```
/home/user/Desktop/Pycharm/tugceproje/virtualenv/bin/python
 /home/user/Desktop/Pycharm/tugceproje/webservice/islemci_ile_konsol_uygulamasi.py
10:16:39 Data Listesi Olusturma baslatildi.
10:17:23 Data Liste olusturuldu.
10:17:23 Process Start
[{'sup_count_A': 1, 'sup_count_AC': 1, 'lift': 69.0, 'consequents': 'WL5378 VARALUCK
 III MID JACKET', 'conviction': 0.0, 'sup_count_C': 1, 'leverage': 0.014282713715605966,
  'confidence': 1.0, 'antecedent': 'SM9481 M Wind Bloc Glove'}, {'sup_count_A': 1,
 'sup_count_AC': 1, 'lift': 69.0, 'consequents': 'SM9481 M Wind Bloc Glove',
 'conviction': 0.0, 'sup_count_C': 1, 'leverage': 0.014282713715605966, 'confidence':
 1.0, 'antecedent': 'WL5378 VARALUCK III MID JACKET'}, {'sup_count_A': 1,
 'sup_count_AC': 1, 'lift': 69.0, 'consequents': 'CU8204 Columbia Bugascarf',
 'conviction': 0.0, 'sup_count_C': 1, 'leverage': 0.014282713715605966, 'confidence':
 1.0, 'antecedent': 'CL9724 W Thermarator Glove'}, {'sup_count_A': 1, 'sup_count_AC':
 1, 'lift': 69.0, 'consequents': 'CL9724 W Thermarator Glove', 'conviction': 0.0,
 'sup_count_C': 1, 'leverage': 0.014282713715605966, 'confidence': 1.0, 'antecedent':
 'CU8204 Columbia Bugascarf'}, {'sup_count_A': 1, 'sup_count_AC': 1, 'lift': 34.5,
 'consequents': 'AL8996 SATURDAY TRAIL II STRETCH LINED PANT', 'conviction': 0.0,
 'sup_count_C': 2, 'leverage': 0.014072673808023524, 'confidence': 1.0, 'antecedent':
 'AL6500 Dotswarm II Fleece Full Zip'}, {'sup_count_A': 1, 'sup_count_AC': 1, 'lift':
 23.0, 'consequents': 'SM8360 BUGABOO II PANT', 'conviction': 0.0, 'sup_count_C': 3,
 'leverage': 0.013862633900441084, 'confidence': 1.0, 'antecedent': 'AM6197 KLAMATH
 RANGE FULL ZIP'}, {'sup_count_A': 1, 'sup_count_AC': 1, 'lift': 69.0, 'consequents':
 'WM7118 RARE EARTH PARKA', 'conviction': 0.0, 'sup_count_C': 1, 'leverage': 0
```

**Şekil 9.** 100 adet verinin işlemcilere dağıtılarak uygulamanın çalıştırılması (devam)

'sup_count_AC': 1, 'lift': 34.5, 'consequents': 'WM1053 BUGABOO INTERCHANGE JACKET',
'conviction': 0.0, 'sup_count_C': 2, 'leverage': 0.014072673808023524, 'confidence':
1.0, 'antecedent': 'EL4735 Mia Monte II Jacket'}, {'sup_count_A': 1, 'sup_count_AC':
1, 'lift': 69.0, 'consequents': 'CU9857 Thermarator Hat', 'conviction': 0.0,
'sup_count_C': 1, 'leverage': 0.014282713715605966, 'confidence': 1.0, 'antecedent':
'AM6889 Mens Heavyweight Long Sleeve Top'}, {'sup_count_A': 1, 'sup_count_AC': 1,
'lift': 69.0, 'consequents': 'AM6889 Mens Heavyweight Long Sleeve Top', 'conviction':
0.0, 'sup_count_C': 1, 'leverage': 0.014282713715605966, 'confidence': 1.0,
'antecedent': 'CU9857 Thermarator Hat'}, {'sup_count_A': 1, 'sup_count_AC': 1, 'lift':
34.5, 'consequents': 'BL2539 CONSPIRACY RAZOR OUTDRY', 'conviction': 0.0,
'sup_count_C': 2, 'leverage': 0.014072673808023524, 'confidence': 1.0, 'antecedent':
'WM7118 RARE EARTH PARKA'}, {'sup_count_A': 1, 'sup_count_AC': 1, 'lift': 23.0,
'consequents': 'BCK04 CONVERSE BAGCIK 140 CM DESENLI PAKET', 'conviction': 0.0,
'sup_count_C': 3, 'leverage': 0.013862633900441084, 'confidence': 1.0, 'antecedent':
'3J235C CT KIDS CHUCK TAYLOR ALL STAR CORE/BLACK'}, {'sup_count_A': 1, 'sup_count_AC':
1, 'lift': 69.0, 'consequents': 'CU8204 Columbia Bugascarf', 'conviction': 0.0,
'sup_count_C': 1, 'leverage': 0.014282713715605966, 'confidence': 1.0, 'antecedent':
'CU9857 Thermarator Hat'}, {'sup_count_A': 1, 'sup_count_AC': 1, 'lift': 69.0,
'consequents': 'CU9857 Thermarator Hat', 'conviction': 0.0, 'sup_count_C': 1,
'leverage': 0.014282713715605966, 'confidence': 1.0, 'antecedent': 'CU8204 Columbia
Bugascarf'}]
10:17:27 Process Finished

Process finished with exit code 0

**Şekil 10.** 100 adet verinin işlemcilere dağıtılarak uygulamanın çalıştırılması (devam)

Farklı boyutlardaki veriler üzerinde uygulama çalıştırılarak deneyler yapılmış ve elde edilen sonuçlar Tablo 3'te gösterilmiştir. Web uygulaması ile işlemcilere dağıtılarak çalışt ırılan uygulama arasındaki kural üretme süresinin veri miktarı arttıkça arttığı görülmüştür.



| Veri (Satır) | Süre (Tek işlemci ile) | Süre (4 işlemci ile) | Fark |
|---|---|---|---|
| 100 | 54 saniye | 48 saniye | 6 saniye |
| 500 | 4 dakika 3 saniye | 3 dakika 15 saniye | 48 saniye |
| 1000 | 7 dakika 23 saniye | 6 dakika | 1 dakika 23 saniye |
| 2000 | 14 dakika 31 saniye | 12 dakika 7 saniye | 2 dakika 24 saniye |
| 3000 | 20 dakika 21 saniye | 17 dakika 7 saniye | 3 dakika 14 saniye |
| 4000 | 33 dakika 9 saniye | 27 dakika 21 saniye | 5 dakika 48 saniye |
| 5000 | 44 dakika 7 saniye | 31 dakika 29 saniye | 12 akika 38 saniye |

**Tablo 3.** Oluşan fark tablosu

## 6. SONUÇ

Veri madenciliği kullanılarak işletmelerin daha etkili kararlar alınmasını sağlayan eğilimler ve davranış kalıpları ortaya çıkarılmaktadır. Birliktelik kuralı veri madenciliğinde yararlı ve kullanışlı bilgi elde etmek için kullanılan tekniklerden birisidir. Çalışma kapsamında Python programlama dili kullanılarak FP-Growth algoritması ile veri eklendikçe yeni kurallar üreten bir uygulama geliştirilmiştir. Birliktelik kuralı analizi için,

veriler işlemcilere dağıtılarak uygulama çalıştırılmış ve daha kısa sürede kurallar oluşturulmuştur. Farklı veri boyutları üzerinde deneyler yapıldığında, veri miktarı arttıkça tek işlemcili uygulama ile dört işlemci üzerinde dağıtık olarak çalışan uygulama arasındaki süre farkının da arttığı görülmüştür.

**Conflict of Interests/Çıkar Çatışması**

Authors declare no conflict of interests/Yazarlar çıkar çatışması olmadığını belirtmişlerdir.

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**RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ**

# CLOUD AUTHENTICATION BASED FACE RECOGNITION TECHNIQUE

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## Abstract

The recognition process for a single face can be completed in relatively less time. However, large scale implementation that involves recognition of several faces would make the procedure a lengthy one. Cloud computing service has been employed in this paper to provide a solution for scalability, where cloud computing increases the essential resources when larger data is to be processed. The programming and training of the developed system has been done in order to detect and recognize faces through cloud computing. Viola and Jones algorithm is employed for detecting faces that used integral image, cascaded classifiers, five sorts of Haar-like features, and Adaboost learning method. Face recognition has been done using Linear Discriminant Analysis (LDA), as it is more efficient compared to Principal Component Analysis (PCA) algorithm. Several MUCT database images have been used for assessing the performance of system.

**Keywords**: Histogram equalization, Cloud computing, Face detection, Viola and Jones algorithm, Linear Discriminant Analysis.

## BULUT DOĞRULAMA TEMELLİ YÜZ TANIMA TEKNİĞİ

**Öz**

Tek bir yüz için tanıma süreci nispeten daha kısa sürede tamamlanabilir. Bununla birlikte, birkaç yüzün tanınmasını içeren büyük ölçekli uygulama, prosedürü uzun bir hale getirecektir. Bulut bilişim hizmeti, daha fazla veri işleneceği zaman bulut bilişimin temel kaynakları artırdığı bir ölçeklenebilirlik çözümü sağlaması için bu araştırmada kullanılmıştır. Geliştirilen sistemin programlanması ve eğitimi, bulut bilişim yoluyla yüzleri tespit etmek ve tanımak için yapılmıştır. İntegral görüntü, basamaklı sınıflandırıcılar, beş çeşit Haar benzeri özellikler ve Adaboost öğrenme yöntemi kullanılan yüzleri tespit etmek için Viola ve Jones algoritması kullanılır. Yüz tanıma, Temel Bileşen Analizi (PCA) algoritmasına göre daha verimli olduğu için Doğrusal Diskriminant Analizi (LDA) kullanılarak yapılmıştır. Sistemin performansını değerlendirmek için çeşitli MUCT veritabanı görüntüleri kullanılmıştır.

**Anahtar Kelimeler:** Histogram eşitleme, Bulut bilgi işlem, Yüz algılama, Viola ve Jones algoritması, Doğrusal Diskriminant Analizi

### 1. INTRODUCTION



Computers have become a much significant element of life in current times. They have found applications in almost all areas of life may it be work, fun, research or other similar domains. This constantly increasing computer usage in daily life has resulted in an escalated need of resources relevant to computing (Karthik, 2010). The highly established organizations like Microsoft, Google or similar can easily make use of these resources according to their needs at any point of time (Jagadish, 2014). But, cost is certainly a considerable factor for smaller organizations. A solution has been provided by cloud computing to huge infrastructures for problems such as software viruses, crashing of hard drive, machine or equipment failure etc., so that such issues can be nullified (Younis, 2013). Furthermore, the different shapes and positions as per the circumstances have made the detection of humans within images quite complicated and tricky. Besides this, a lot of resources are needed during the recognition and detection of faces, especially in case of very big databases (Cheng, 2015). There is an increased requirement of computing capabilities because of the usual challenges faced in allocation of resources, which are substantial for bigger corporations. Considering the launch of cloud computing, it has become quite feasible to merge cloud computing with the requirements of resources for facial recognition and detection.

#### 1.1 Face Detection

Face detection has become an interesting topic of research at present. The image processing market is giving considerable attention to face detection (Ogbu , 2013). Face detection has offered an efficient coding scheme in the domain of video calls and teleconferencing. It is basically referred to the procedure of human face identification in images and videos (Kalyani, 2013). It is fundamentally a unique function of image segmentation. The portioning of a digital image or video frame has been done through image segmentation method into different segments i.e. set of pixels. Things are essentially made simple by means of image segmentation, which expresses major elements of digital images, thus leading to easier

detection of face. During face detection, a preprocessing step is required by all the face analyzers as well as face recognition systems (Ian, 2008). The main motive behind image segmentation is to process the image and split it into a number of parts (Puja, 2012). At this stage, the main focus is to split images into elements being connected strongly within objects. A major role is played by segmentation in image analysis applications (Rajesh, 2012). The detection of exact position of human face within provided image is pretty complex (Senthil, 2012). The following sections have covered a comprehensive discussion on face detection process, its importance and encountered challenges.

### 1.1.1 Applications of Face Detection

Face detection and analysis in machine vision are required by numerous applications of real world. Some of these applications are as follows (Ganesh, 2013):

- Person identification at time of login
- Interaction between human and computer, such as mouth and eyes tracking etc.
- Video calls while doing video conferences

### 1.1.2 Challenges in Face Detection

Face detection has become a challenging process due to the following factors (Peter, 2011):

- Scale
- Direction or posture
- Expressions of face
- Resultant brightness owing to variations in illumination
- Video frames or resolution of images
- Facial cover due to beard or glasses etc.
- Variations in background like complicated/basic and still/dynamic.



### 1.2 Face Recognition

The capability of human beings to interact with objects or with each other is fairly reliant upon their recognizing capabilities (Nilesh, 2016). The identification and recognition of objects becomes easy because of this capability. The development of an automatic system for face detection by using machines would be easier, once a substantial understanding and knowledge has been attained regarding the cognitive aspect of human brain mechanism (Sung, 2010). Presently, the face recognition method has gained noteworthy attention and found various applications in law enforcement as well as commercial areas. For example, the videos captured by security cameras can be reviewed in case of robbery in banks and valuable items shops etc., which can help in the detection of culprits' faces by comparing them with the criminal records maintained by police.

Besides this, active research has been going on in this domain due to the unavailability of an ideal model or approach till date, which can perform the facial recognitions in a perfect manner (Hiroyuki, 2007).

### 1.3 Cloud Computing

What is exactly meant by the term 'cloud computing'? It is basically a computerized model in which information (data) and functions are established in massive data centers within cloud, which is accessible to every device connected to the network (Alireza, 2013). A demonstration of directly related expressions is required by cloud computing, just like other definitions relevant to this subject. Although there is not any particular definition for this, however, it is possible to define it generally.

Cloud computing is the first thing one can think of while considering the things required by us most of the time. Thus, it has become essential to raise the capability of computing methodology or append extra abilities that are able to perform within advanced infrastructure, allow latest software and offer newest techniques of staff learning. Both paid as well as subscription-based facilities are provided by cloud computing that are helpful in extending the present capacities of real time communications and information technology.

The recent time is considered as a quite essential phase of cloud computing having a broad and extensive range of providers. Small, medium and large groups have offered numerous cloud-based services, including spam filtering, storage facilities, full blown applications and lot more (Zahid, 2012).

The word "cloud" is the origin of term "cloud computing" that refers to the internet-based development, whereas "computing" means the use of computer technology (Alireza, 2013). This computing method can be scaled and involves virtualized resources that effectively offer functions based upon internet. This is not necessary for user to possess complete knowledge or expertise in the cloud technology infrastructure (Ming, 2010).



Cloud computing has lately turned out be one of the most boosted advancements of information technology (Jie, 2015). The cloud computing approach is the latest standard that has opened doors for massive opportunities in several fields. It is in fact a combination of devices and servers that are publically accessible via internet (Blanz; Vetter, 2003). The users are allowed to use uninstalled applications by means of cloud computing, moreover, cloud computing also facilitates users in accessing data from any gadget having access to internet. Several important functions that need internet connection are offered by cloud computing such as infrastructure, programs, hardware and storage of data etc. (Rupali, 2017).

#### 1.3.1 Benefits of Cloud Computing

1. Enhanced capacity: Cloud computing requires less time and smaller workforce for completing huge tasks
2. Lower cost: No expensive devices are required since typical customer's programs, data and computers are employed in cloud computing
3. Ease of access: Cloud computing facilitates users in accessing their data at any corner of the world with any gadget having internet access
4. Less training expenses: Since smaller number of personnel is needed for completion of tasks in cloud computing, therefore, users are only required to have basic knowledge about the issues related to software and hardware.

### 1.3.2 Characteristics

1. Self Service available on demand: The customers are provided with all the requisite computing facilities by cloud
2. Wide Network Access: The customers can easily access the cloud applications by means of laptops, personal computers, smart phones etc. via internet
3. Extensive Resources: The cloud designed funds are provided to customers as per their requirements
4. Quick Turnaround: Requirements are swiftly identified through cloud computing, and identified functions are returned in accordance with requirements
5. Check and Balance on Services – The resources consumption is controlled by the cloud provider (Deniz; et la., 2003).

### 1.3.3 Offered Services

Data centers: Hardware resources for raw calculations, data storage and networking are offered by data centers, within cloud computing technology infrastructure. In general, the set up of data centers are laid in areas having less population, lower energy charges and minimum possibility of natural calamities. A lot of servers, connected with each other, are included in the data center setup (Deniz; et la., 2003).

1. SAAS Model: Through this model, software applications such as Microsoft office, Turbo C, and so on are offered as a utility by the providers to cloud clients. The software is then finally made available for users in the form of an on-demand facility through application layer, typically in browser. Nearly all organizations involved in e-commerce have embraced this service. This facility is a substitute of applications that run locally and that too with some important additional benefits. The clients are mostly not required to do installation and frequent updating of applications, which are being run on their personal systems through cloud. This service facilitates users by saving their disk space plus time, as a result enhancing ease of access and usage (Deniz; et la., 2003).



2. PAAS Model: A platform for computations is given by cloud providers to the cloud customers under this model, which includes operating systems, database, web servers etc. Platform layer, the second layer, adds on an extra abstraction level to the facilities provided by Infrastructure Layer. This leads to an effective combination that provides a whole platform for application designing, control, implementation, analysis and further improvements. In particular, programming models and APIs for cloud functions are offered by this layer, such as, Map Reduction

3. IAAS Model: Each company has a major objective of reducing charges and timing of operations. These most important goals can be achieved through the implementation of IAAS model. This layer manages the fundamental data center resources and offers them to clients as services in the form of storage space, computational power, virtualized communications, and other essential computing basics that are needed to run software. The companies offering such services are typically called Infrastructure Providers (Deniz; et la., 2003).

### 1.3.4 Cloud Deployment Models

The classification of cloud infrastructure can be done on the basis of its deployment model. Presently, three main deployment models have been acknowledged by the IT community including public, hybrid and private clouds. However, some other models like community clouds and virtual private clouds are also under consideration.

**Public Clouds:** Those companies that sell cloud services own the cloud infrastructure in this deployment model. The resources are offered by these companies to large groups of industries including Amazon, Microsoft, and Google, as well as to general public. These types of clouds offer several benefits to the users, as the set up has been done without any substantial investment and the pertinent natural threats have been conveyed to the infrastructure providers. On the other hand, there are certain constraints as well, for instance, lack of fine-grained data control, network settings and security, which hampers the activities within a few business environments (Deniz; et la., 2003).

**Private Clouds**: Though the development of a cloud network has been done around widespread clouds, but more interest has been shown by corporations in such tools of cloud computing that are open-source, which makes easy for them to create private clouds by using own or rented infrastructures. For that reason, the major motive behind the deployment of private clouds is to provide company clients a flexible, unique and smart infrastructure rather than providing internet based services, and to drive service workloads inside the managerial spheres. The maximum level of control is provided by this model over the performance, precision and privacy of resources (Deniz; et la., 2003).



**Hybrid Clouds:** A company develops a private cloud over its own infrastructure that retains the advantage of managing aspects related to performance and security, as well as provides the opportunity of using supplementary resources from public cloud according to the needs; such as in case of high demands upon the infrastructure of an online dealer, particular during vacations season. Keeping this in view, a vigilant decision is needed by hybrid cloud for categorization of specific and general parts of cloud, and the charges of implementing interoperability between these two deployment models (Deniz; et la., 2003).

**Community Clouds:** These clouds occupy a spot somewhere in between the public clouds and private ones. Community clouds are neither entirely accessible for common people like commercial services nor under the control of single company as in the private clouds. This cloud infrastructure is offered to a particularly classified group of companies that have similar concerns and interests.

**Virtual Private Clouds:** These clouds are one more strategy for dealing with the typical and particular weaknesses of could. A platform has been established under this model over the infrastructure of public cloud, with the purpose of replicating a private cloud that manages the technology of Virtual Private Network (VPN) (Deniz; et la., 2003).

### 1.4 Authentication Types

Password authentication is considered to be the most common method of authentication. This form of authentications requires the users to create a specific key (password) that is known only to them. However, there are numerous limitations of password based authentication, like weak password strength. Moreover,

not just the handling of passwords is tough but it is also a quite insecure approach as they can be guessed or cracked effortlessly by professional hackers. The hacking tools have also developed with the constant growth of technology, thus making it simpler to crack credentials of individuals. Along with the hit and trial method, an established technique named brute-force attack is also typically used by the hackers. The hackers use a software program under this technique, which runs through all possible password passwords cannot be remembered easily thus this authentication approach is generally regarded as weak and less user-friendly (Killoran, 2018).

Smart card based authentication is another important authentication type, where a pin code is used that is printed at the back side of card. But this can become quite critical if the card is lost somewhere as it will become vulnerable to attack.

The third form of authentication is known as biometric authentication, in which image verification is done through fingerprint scan that is matched with the information stored in database. Biometric authentication is recently replacing the password based authentication system. This technique is preferable since it is quite fast and easier for users as they are not required to create and remember complex and lengthy passwords. Furthermore, this authentication type offers more security with respect to password authentication, as the unique genetic features cannot be cracked or duplicated quite easily (J. L, 2018).

Another major type of authentication involves face recognition approach, where the expected ID is basically the output of face recognition process. This ID has to be matched with the stored details of authorized individual in the records. This type of authentication is considered to be a promising approach for providing improved security. The face recognition software takes help of aliveness detection and facial data points for authenticating the users in a precise manner (Onespan, 2018).



## 2. METHODOLOGY

Human beings recognize numerous faces effortlessly on daily basis. The ease of access, embedded systems and inexpensive desktops have led to increased interest in involving digital image processing in a lot of functions and applications, such as management of multimedia, interactions between human and computers, and biometric authentications. This has resulted in the analysis and enhancement of approaches based on dynamic face recognition. A number of benefits have been noticed in the face recognition approach as compared to other modalities of biometric like fingerprint or iris scan. Furthermore, face recognition is more normal and non-invasive. The major plus is that it is possible to capture and detect face at any point or under vague situations. Amongst the biometric characteristics described by Hietmeyer (Stan, 2011), the most amount of conformity has been witnessed by face features within Machine Readable Travel Documents system (Scott, 2000).

The elementary dynamic system for recognizing faces has been developed by Takeo Kanade during PhD research, back in the year 1973 (Dufaux, 2006). No substantial developments have been witnessed by the automated face recognition field until Kirby and Sirovich carried out research on a miniature portrayal of facial dimensions, by using Principal Component Analysis (PCA) or Karhunen– Loeve convert. The research interest in this domain is aggravated by the Pentland and Turk work related to Eigen faces (Phillips,2010).

Other major advancements in the area of faces recognition take in Fisher face method (Avidan, 2006); (Paula, 2009) involving Linear Discriminant Analysis (LDA).

### 2.1 Proposed Methodology

The method of face recognition is generally started by taking a video or picture as an input. The target is to detect or recognize some object existing inside the input. Figure1 has shown the major steps that form the proposed face recognition system.

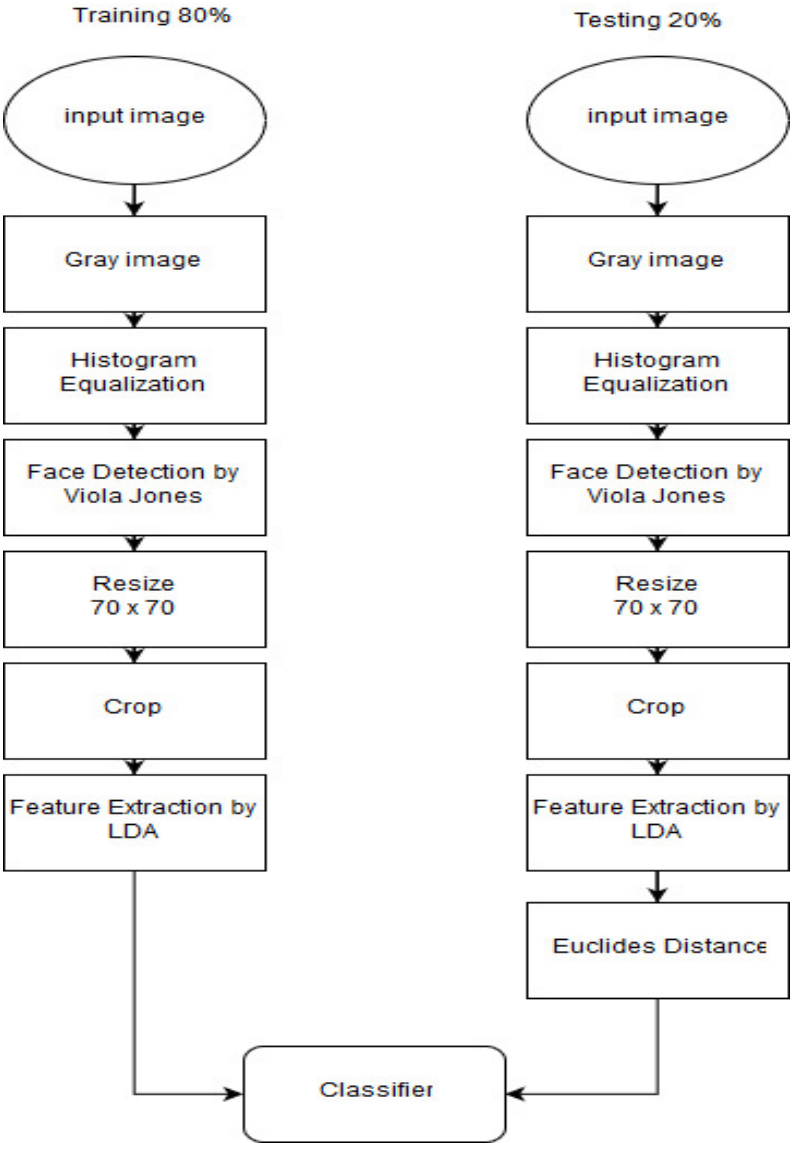


**Figure 1.** The Proposed System

### 2.2 Image Preprocessing

A number of researchers have been showing keen interest in the domain of image processing and numerous applications have involved the image analysis process. The scientists have been successful in accomplishing new objectives in this area such as segmentation of images, restoration and compression etc.; so that the existing procedures of image processing are improved and new techniques are discovered to solve the limitations of this field. Image processing has most recently found applications in different areas like processing of satellite, molecular and clinical images by using different image processing techniques (Stan, 2011).

### 2.3 Gray image

In various domains, it has been considered a useful application of image processing to translate a colorful image into a grayscale one. Three main colors including Red, Blue and Green form a pixel in case of a colored image. All these three colors are applied along the three dimensions i.e. XYZ axis concisely by considering the attributes of brightness, hue and purring. Under the brightness factor, the image color quality is provided by the number of bits based upon color indication (Stan, 2011). 8 bits and 16 bits are used for representing basic and high-quality colored images respectively. Moreover, an actual colored image is indicated by 24 bits but it takes 32 bits to denote a dusky one.

Bit number represents the maximum value of various color numbers that are given by the digital appliance. For instance, if every color in RGB (Red, Green and Blue) takes 8 bits then the integration of these colors will be shown by 24 bits, offering a broad range of around 16,777,216 colors. Within the colored picture, the pixel color is basically denoted by this 24-bit representation. In case of a grayscale image, the intensity of light is symbolized by an 8 bit value. The pixel amplitude intensity of grayscale images is within 0 to 255. The translation of a colored image to that of grayscale version is actually to transform RGB (24 bit) into grayscale (8 bit) (Stan, 2011). This similar process, involving 3 stages, is employed by every grayscale method, i.e.



1. To acquire values of RGB pixel
2. To perform mathematical calculations for translating these obtained values to one gray value
3. To use following equation to substitute RGB values with the gray ones

   Gray = 0.2989 (Red) + 0.1140 (Blue) + 0.5870 (Green)

### 2.4 Equalization of Histogram

It is a general technique adopted for enhancing a poor quality image. Histogram equalization is somewhat same as histogram stretching, but usually more visually satisfying outcomes are offered by it with an extended range of images (Roger, 2010). The outcome of histogram with a mount that has been closely assembled, in order to unfold or smooth histogram, creates a profound interpretation of dark pixels while a trivial display of lighter ones. Appearance is a major concern, as it is not possible for dark pixels within images to go extra dark, however, they will be shown as darker one because of those pixels that are comparatively lighter to them.

The process of histogram equalization can be divided into 4 major steps for digital images (Roger, 2010):

1. To identify the values of histogram
2. To normalize the values attained at the first step
3. To multiply the normalized values with the gray level value and round off.
4. To use 1-1 correspondence for mapping the 3rd step outcome to gray level

The cumulative distribution function (CDF) is given by the equation below:

$$C.D.F.\ (y) = \sum_{j=1}^{y} H(j)$$

**2.5 Face Detection**

The latest face verification applications are in need of efficient face detection procedure. The image of a face is seldom normalized prior to storing it in the database. The face detection system is aimed to determine if any face is present in an image, and if yes, then to validate and locate that. It has been observed through numerous analyses that the major challenges in detecting faces are due to posture, expressions, color of skin and ethnicity. In addition to this, a number of other external causes that may affect the detection system include quality of image, complex background and inaptness with lighting conditions (Brown et al. 2000). The important approaches that can be adopted for performing face detection include appearance based approach, template matching approach, feature invariant approach and knowledge-based approach.



**2.5.1 Viola Jones**

The first method that allowed the quick detection of objects was put forward by Paul Viola and Michael Jones, back in the year 2001 (Neeti, 2014). This method used Adaboost machine learning for facilitating the quick and precise object detection. It has been considered as a most important mechanism for object detection, where sufficient detection rate has been offered in real time. Viola Jones method is capable of learning various object classes through Haar-like feature, in order to identify a range of objects. This method is mostly recommended to solve the problems in face detection process (Neeti, 2014).

Following are the main aspects of Viola and Jones algorithm:

**1.** The integration of images was first and foremost done by Papageorgioun (Paul, 2001), which helped in indicating Haar-like features during fast rectangular calculations of face detection tool. At the place *u, w,* the fundamental image has involved the pixel addition in the left and on top of *u, w* (Stan, 2011):

$$\mathbf{jj}(\mathbf{u},\mathbf{w}) = \sum_{\acute{u}\leq \mathbf{u},\acute{w}\leq \mathbf{w}} \mathbf{j}(\acute{u},\acute{w}),$$

**2.** The process of filtering Haar-like features depends on how the images are classified by the Viola and Jones' process, where the pixels are not put in use directly. However, a whole selection process is carried out for implementing characteristics, which facilitates in the adaptation of ad-hoc field and code knowledge of functional properties. Besides this, it is also possible to rapidly increment the system using pixels. Moreover, a broad significant impact of Haar-like features has been observed in face detection. Once the primary image is identified, this will be followed by immediate detection of each Haar-like property at all places or scales. Figure 2 has displayed the types of Haar-like features.

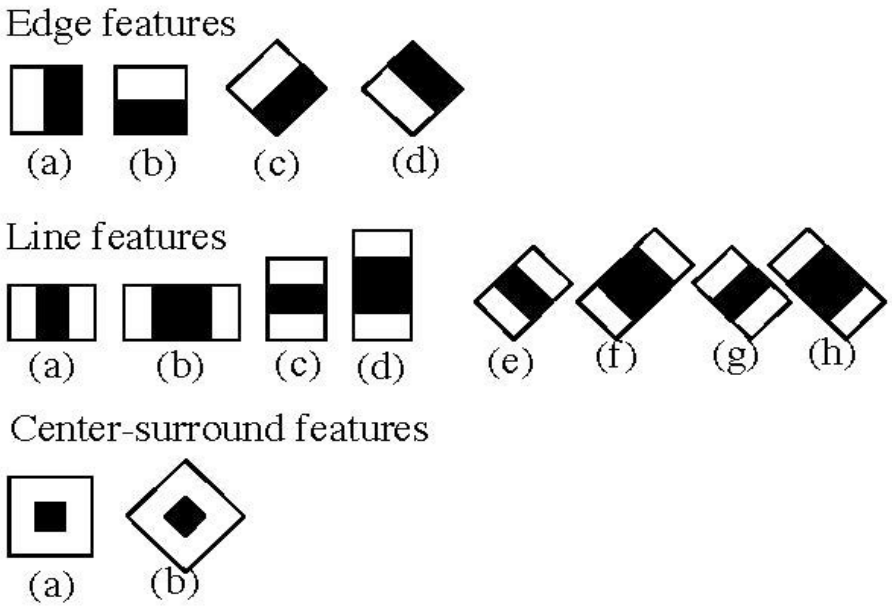


**Figure 2.** Examples of Haar-like features

**3.** AdaBoost training is basically a machine learning technique. In this process, some weak classifiers are selected that are then perfectly specified by one Haar- like feature, which are eventually combined to develop a strong classifier (Jensen, 2008).

A weak classifier $[M_i(u)]$ that is $N_i(u)$ multipart is shown as:

$$M(u) = \begin{cases} 1 \; if \; P_i N_i(u) < P_i \varphi_i \\ 0 \qquad otherwise \end{cases}$$

Here $\varphi_i$ symbolizes ideal threshold and $p_i$ refers to equality. The unequal sign is due to this reason which minimizes the unclassified number of cases. The parameter u indicates a subnet window of image pixel (24 x 24)

At every turn, the algorithm collects just one weak classifier that can do effective categorization of negative and positive case examples within the learning set. A bigger value weight is provided in the following rounds through the negative address cases, while the right ones will offer a smaller value weight (Paul, 2001).

The following resultant strong classifier $M(u)$ is the output of linear integration of weak ones:

$$M(u) = \begin{cases} 1 & if \sum_{t=1}^{T} \alpha_t h_t(x) \geq \gamma \sum_{t=1}^{T} \alpha_t \\ 0 & otherwise \end{cases}$$

**4.** Cascaded Classifiers

A cascaded classifiers configuration has been created by Viola and Jones, where a chain of strong classifiers are involved, in order to swiftly discard the poor areas of an image. These strong classifiers are put within cascaded form in an increasing order with respect to complexity. This helps in disposing of several areas that are rare for compound faces in an effortless manner, as lengthy calculations are to be done subsequently on the contender's regions (advanced classifiers). This approach helps in incrementing the detection performance and reduces the calculation time as well. Viola detector based AdaBoost learning is both fast and precise; moreover, its application is easy and yields high efficiency. Along with these advantages, the main drawbacks are more amount of time needed for training and the deep search done by it all through the feature space (Jensen, 2008).



### 2.6 Crop

Face cropping is considered to be an important step to achieve an effective rate of recognition. In this section, a smart graphic tool is employed for removing the unwanted portions of an image. Extraction of an area of interest is done by cropping the actual picture ) (Dharavath et, al., 2014).

### 2.7 Resize

Resizing is another important pre-requisite step of image processing for an efficient face recognition system. The images being detected through various face detection procedures are resized using interpolation method, in order to give particular sized output images (Dharavath et, al., 2014). In the process of image interpolation, the image is resized and shifted from one pixel grid to another. The resizing of images is important for decreasing or increasing the number of pixels. The effect of different scaled image resizing has been noticed during the recognition process. As images of different size carry different information, therefore, the in-depth analysis of optimal image size is critical. Image resizing has been done to produce lower data size that in turn accelerates the processing time. Images are generally resized at a scale ranging from 0.1 to 0.9 (Barnouti, 2016). In this work, this step is carried out

to normalize the dimensions of image at 70 x 70, after face detection through Viola Jones algorithm for carrying out linear discriminant analysis.

### 2.8 Linear Discriminant Analysis (LDA)

This analysis has been done in statistics, pattern recognitions and machine learning, in order to compute integration of linear features, which divides or point sup two or more classes of object or events. The resultant may function as a linear classifier, or to minimize the dimensions prior to LDA correspondence with the principal component analysis (PCA), since both of them rely upon multiplication of matrix and linear conversions (Jindong, 2016). For PCA, this conversion is dependent on reducing mean square error within initial data vectors and its assessment with respect to the reduced dimensions of data vector. In addition to this, principal component analysis does not consider any class variation. But in LDA, the conversion depends on enhancing the rate of "within class variance" relative to the rate of "between class variance". It is focused on reducing changes in data within same class and increasing the division amongst classes (Li, Cheng, and Bingyu Wang, 2014). The linear discriminant analysis is initiated by calculating total mean ($\boldsymbol{\mu}$) using following equation, where class mean ($\boldsymbol{\mu i}$) is calculated as follows:

$$\mu = \frac{1}{N}\sum_{l=1}^{N} x_i$$

$$\boldsymbol{\mu_i = \frac{1}{x_i}\sum_{x_j \epsilon x_1} x_j}$$



The following equations are used to identify scatter matrixes, which are denoted by $S_b$ and $S_w$.

$$\boldsymbol{S_{b=}\sum_{i=1}^{c} N_{i(}\mu_i - \mu)(\mu_i - \mu)^T}$$

$$\boldsymbol{S_{w=}\sum_{i=1}^{c}\sum_{xj\,\epsilon xi}(x_j - \mu_i)(x_j - \mu_i)^T}$$

Finally, the maximization of class separation criterion is achieved using the LDA algorithm through the following equation:

$$\boldsymbol{W_{opt} = arg\,max_W \frac{|W^T S_B W|}{|W^T S_W W|}}$$

### 2.9 Classifier

After doing feature extraction using LDA algorithm, the system stores them as a file, termed as classifier. The Euclidean distance is then found by comparing it with that of test image. The Euclidean distance is defined as the standardized direct line distance that has been calculated between the two points in

Euclidean space. The space is represented in Euclidean plane by the following equation, provided that p1 = ($P_{x1}$, $P_{y1}$), p2 = ($Px_2$, $P_{y2}$):

$$d(p1,p2) = \sqrt{(P_{x2} - P_{x1})^2 + (P_{y2} - P_{y1})^2}$$

## 3. RESULTS AND DISCUSSION

This research work is aimed at developing a cloud computing based system for face recognition, in order to validate users. The faces have been detected using Viola and Jones algorithm that employed Adaboost learning method, cascaded classifiers, Haar like features (5 types) and integral image. The faces have been recognized with the help of Linear discriminate analysis (LDA). The LDA algorithm was preferred over PCA since it yields better performance. Furthermore, this approach offered improved results because of its lower lightning sensitivity, quick processing and less features. It has been found that conversion of images to grayscale is essential prior to the face detection step as it increases the speed and subsequently moves across the histogram equalization step. Histogram equalization in image processing is a procedure where contrast has been adjusted with the help of image histogram. The contrast of various images is raised on the whole by this approach, especially when close contrast values are used for the characterization of integral image data. This adjustment helps in having an improved intensities distribution on histogram. The low contrast areas are also allowed to have improved contrast through this adjustment. The edges of images are identified through cropping and eventually resizing is carried out to unify the size of used image. A database cloud is established to validate the faces inside image.



### 3.1 Proposed method

The elementary layout of the proposed face recognition system has been shown in the figure 3 . Two interfaces are involved in this system:

i. cloud interface

ii. client interface

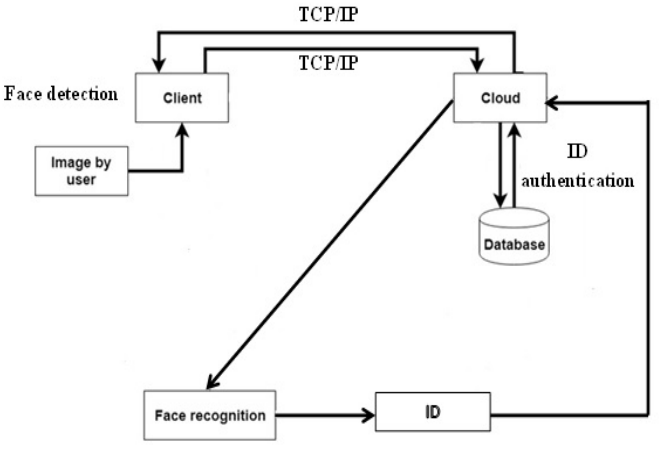


**Figure 3.** General Model of the System

### 3.2 Discussion

In order to develop an efficient system that is capable of detecting effortlessly and accurately under various situations, a dataset comprised of twenty individuals is taken. All these individuals have different complexions (black or white), different face features and belonged to varied origins. The following table shows the results attained by this system.

| Total trains | Total tests | Total hit | Total miss | Precision |
|---|---|---|---|---|
| 160 | 80 | 79 | 1 | 98.75% |

**Table 1.** System Results

## 4. CONCLUSION

The dataset employed for this research work is able to produce a very authentic and precise system. The security will improve as only client will be having information regarding the port. The accuracy will be high since complete server training has been done using images that are verified previously; thus the original image cannot be replaced by any unknown one. The TCP/IP protocol integrated system will facilitate in getting acknowledgments upon sending. The potential of this face detection system has been incremented by using Viola & Jones algorithm. The results achieved by this system have an accuracy of about 98%.



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**RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ**

# ADAPTIVE VIDEO TRANSMISSION OVER COMMUNICATION NETWORKS

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## Abstract

This paper is to minimize video bitrate and keeping the high resolution video file manageable. This process is achieved by using new generation of Advanced Video Coders (AVC). Such process can be done at one level encoder or multi levels of encoders by means of transcoding, where reformatting the content to be streamed on channel is called transcoding. The goal is concerned of encoder processes that can be used to achieve transcoding. The codec used for compression of video is H.264, a standard for providing high definition video at substantially low complicity and lower bit rates. The x264 Library is used for encoding H.264 AVC, undergirds some of the most profiles for broadcasting and streaming operations over wired and wireless channels, including different applications. When a technique of bit-rate control is incorporated with the encoder, more reliable and qualified system for low bitrate video streaming over constant bit rate communication channel is achieved, where output rate of the video encoder is controlled by feedback based on the buffer level. Where the most effective parameters such as skip frame, QP, cycle length (Gop), etc. are configured and it used as a rate control tools to test the streaming coded bit rate and the decoded video quality. Testing scenarios use many different videos with QCIF, CIF, and HD formats encoded under main profile. JM19 reference software is used for implementing and testing the standards.

**Keywords:** Codec, Transcoder, AVC, HEVC, H.264.

## İLETİŞİM AĞLARI ÜZERİNDEN UYARLANABİLİR VİDEO İLETİMİ

**Öz**

Bu makalenin amacı video bithızını düşürme ve yüksek çözünürlüklü video dosyasının boyutunu uygun halde tutabilmektir. Bu işlem yeni nesil bir İleri Video Kodlayıcı ile yapılır. Bu tür bir işlem, tek düzeyli ya da çok düzeyli kodlayıcılarla yapılabilir. Amaç, kod çevrimine ulaşılabilecek bir sürecin yürütülmesidir. Video sıkıştırması için kullanılan kod çözücü H.264'tür. H.264 AVC'nin kodlanması için x264 kütüphanesi kullanılmıştır. Bithızı kontrolü kodlayıcının içine yerleştirildiğinde, daha güvenilir ve iyileştirilmiş bir sisteme ulaşılır ve video kodlayıcının çıkış oranı geçici bellekten sağlanan geri besleme ile sağlanır. QP, döngü uzunluğu gibi etkin parametreler, video kodlama sürecinde kullanılabilir. Deneme senaryolarında QCIF, CIF, HD gibi farklı biçimlerde videolar kullanılmıştır. Standartların uygulanması ve denenmesinde ise JM19 referans yazılımı kullanılmıştır.

**Anahtar Kelimeler:** Kod çözücü, Kodlayıcı, AVC, HEVC, H.264.

### 1. INTRODUCTION

The data networks that include of information technologies, such as computer, telephone, television allow interactive multimedia (Conklin, 2001). The heterogeneity of network client devices and the mobility of clients are the two problems of multimedia delivery (Cisco, 2019). The above two problems make it dificult for a multimedia server to provide a streaming appropriate service for every client (Karmakar and Dooley, 2008). Because the video is the main traffic of the communication networks, 86% of the traffic (Khalil and Weipl, 2011), a solution to the problems above, which is presented in this article, is by encoding/converting video streams to the appropriate format. The converting process is also known as transcoding, which means converting the video from one format to another. The main purpose of the project is to develop a system infrastructure for encoding video stream and transmit them via a suitable network to the device of end-user.



The main issue with the transmission of video over communication channel is the Internet due to the congestion control of the shared resources, resulting in variations in bandwidth availability. In order to tackle these problems a video encoder of rate-adaptation (rate-control) techniques have been proposed.

The "International Standards Organization/International Electrotechnical Commission" (ISO/IEC) and the "International Telecommunication Union" (ITU) had developed many compression standards like MPEG-1, MPEG-2, MPEG-4, H.263, H.264 and H265 (Meraj and Kumar, 2015). Each coding standards had designed to reach a target point to represent the efficient way that can solve video transmission problem. H.264/MPEG-4 part10, Advanced Video Coding standard (AVC), is the efficient video coding standard developed by the ITU-T (VCEG) and the ISO/IEC (MPEG) (Yun and Sun, 2000). H.264/AVC has achieved a network-friendly representation of the conversational and non-conversational applications [7,8] which can be applied for different applications including the HD. H265 is more efficient with more complicity that mainly applied for UHD video. The UHD video is out of the article scope, so mainly the job is concerned with H264 with the features configuration and the video rate adaptation.

H264 standard provides better peak signal to noise ratio and visual quality since this standard provides new compression tools to increase quality and decrease bit rate (Meraj and Kumar, 2015)(Yun and Sun, 2000). Such tools will be used through system testing.

The rest of this paper is organized as follows. The proposed system idea is explained in section 2. The adopted compression standard configuration is illustrated in section 3. The buffer optimization and rate control is explained in section 4. Section 5 gives the experimental results while section 6 concludes the paper.

## 2. PROPOSED SOLUTION OF VIDEO STREAMING SYSTEM

For wide range of applications, it needs to have an idea about channel. Where the delay, packet losses, as well as, how to avoid overloading of network, how to share the resources and how to arrange efficient and scalable simultaneously transmission are the main parameters to be considered. To know the suggested standard as a solution for video streaming over channel, the wireless network like Wimax is suggested to be simulated through buffering activities as well as over wired ADSL network to measure and evaluate the main matrices of the video signal like delay, jitter and through bit. After we compress video sequence according to selected profile, the transmitted proposed model consists of encoder and controller. A proposed rate control technique by transcoding video sequence to transmission over Channel will be modeled to demonstrate a full encoder-channel-decoder layout operation through a mechanism at making the bitrate of video to be compatible with the available channel bitrate. By estimating the channel bandwidth capacity, we can determine the channel bit streaming. Such control is using the effective parameters tools like quantization, skip frames, Group of picture (GOP) and so on, to reduce the output rate video to meet the requirement. The encoder send a request of bitrate change through a received feedback encoder buffer signal, then the compressed bits will encapsulated with the side information and pre-coding information in packet as syntax to be transmitted through the channel. Figure (3.1) shows the system block diagram while Figure (1) explains the sequential process of the proposed model.



## 3. H.264 ENCODER

At this section the controller is incorporated to be used with H264 encoder stander at specific configurations that represent the contribution of this article, see Fig.2.

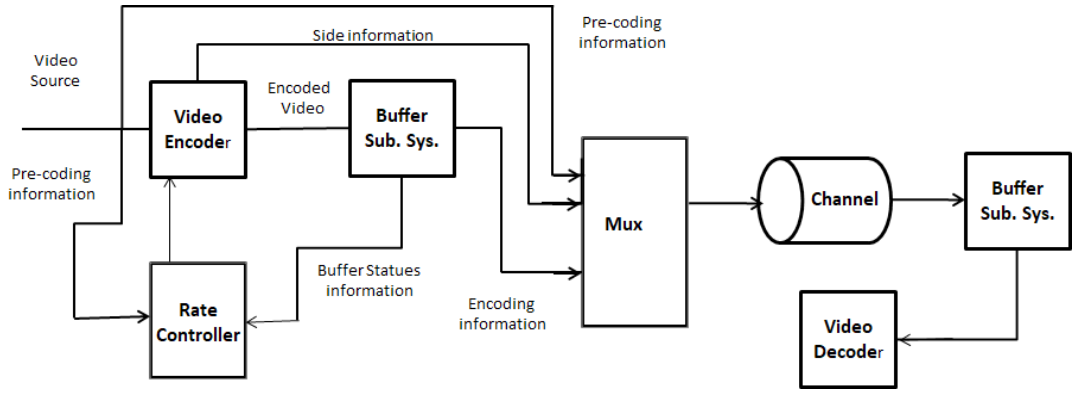



**Figure1.** Proposed system block diagram

A video sequence of QCIF, CIF or HD formats is used as input to the system. The input video sequence will be divided into cycles, where the cycle start with Intra (I) frame and followed by a number of predicted (P) and bi-predicted (B) frames. Each frame is divided into slices of many macroblocks. The encoder forms the prediction of the current block either from the current frame using intra prediction to remove spatial redundancy as in Fig.3, or from other frames that have already been coded and transmitted using inter prediction to remove temporal redundancy as in Fig.4. A residual error then produced by subtracting the prediction from the current block. This residual block is then transformed, quantized and finally encoded to be streamed over the channel, as shown in Fig.2. These steps will be described through the system operation and explination in the next subsections.

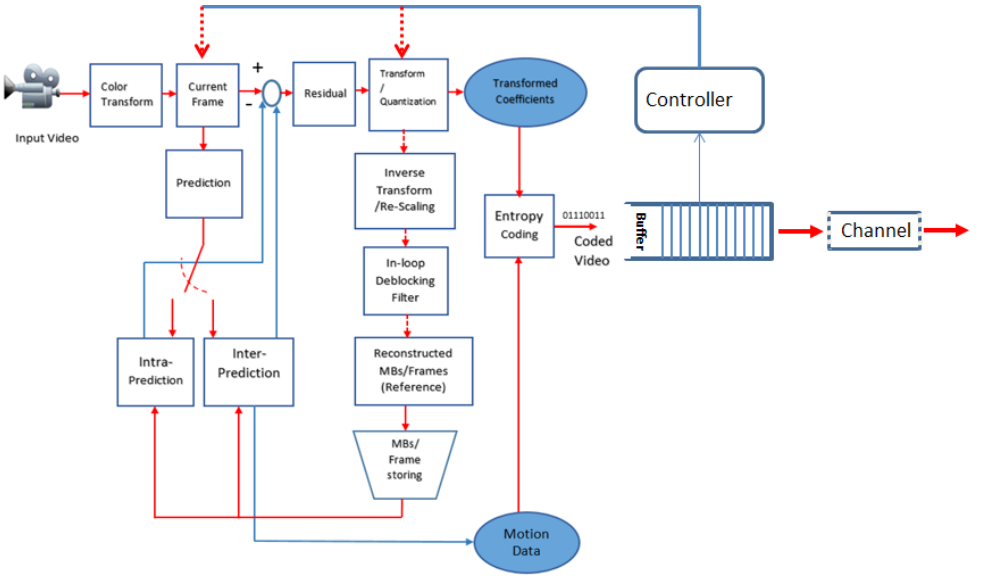



**Figure 2**. Proposed system encoder

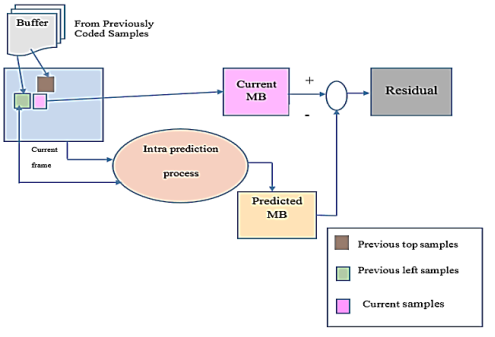



**Figure 3.** Intra frame prediction

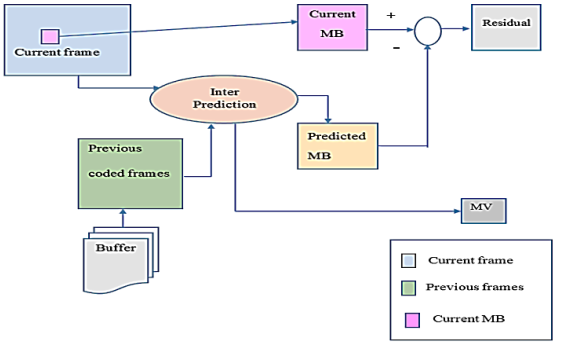



**Figure 4.** Inter frame prediction

### 3.1 Prediction Mode

In this subsection the mechanism applying prediction as intra or inter one will be defined. **Intra prediction** is carried out by using the different modes (0-9), applying the best matched one applied in the same frame as spatial prediction, see Figure.3.Tree block size 16×16 to 4×4 are used for luma components, and one of 8×8 block size is used for each chroma components, all types are considered in this work. As mentioned previously, for each block size, different prediction modes are used, the 16×16 block size has 4-modes, while the 4×4 has 9-modes and 8×8 chroma block has 4- modes. The Sum of Absolute Errors (SAE), as defined in Eq.1, is calculated to indicate the error magnitude that is used in finding best matching. The best mode that will be selected is the mode that has minimum SAE.

$$SAE = \sum_{i,j} |C(i,j) - P(i,j)| \quad (1)$$

Where; C (i, j) is the current sample and P (i, j) is the predicted samples.

The decision to choose the best block size form 16×16 or 4×4 luma block size is based on rate-distortion cost calculation, defined previously, as steps of implementation in this work is described in Fig.3, the best block size is of minimum RDO.

$$RDO = Distortion + \lambda\ MODE * Rate \quad (2)$$

$$Distortion = \sum_{i=1}^{m} \sum_{=1}^{n} (\mathrm{po}\ (i,j) - \mathrm{pt}\ (i,j))^{2} \quad (3)$$

$$\lambda = 0.852 \times 2^{(QP-12)/3} \quad (4)$$

**Inter prediction** is used to exploit the temporal redundancy between successive frames. It uses backward prediction type for P-frame prediction and backward and forward prediction types for B-frame prediction process. Each partition of inter macroblock is predicted from an area of the same size in a reference picture, by finding the prediction region. Residual is determined by the subtraction of prediction block and the original one. Motion vector (MV) represents the offset displacement between the two origins of the two blocks. H.264 inter prediction achieves considerably higher coding efficiency since it provides mechanizes of; tree structured partitioning, multiple reference frame for prediction, - in Loop de-blocking filter, and quarter pixel accurate motion vectors. Consider a previously reference coded frames, as a source for prediction. Search area of 16×16 is opened on the choice reference frames for block matching, for the best block matching, a process is known as motion estimation. It is the lowest energy in the sum of residual. To generate the best MV of ¼ resolutions, an interpolation of the reference picture(s) need to be achieved. MV represents the relative position for the matching interpolated area in the reference frame.

### 3.2 H.264 Transform

After prediction process, the residual block samples, luminance and chrominance, are transformed using a 4 × 4 integer Discrete Cosine Transform (DCT). Three transforms are used; integer DCT-based transform of 4 × 4 blocks, in additional to two Hadamard transform of 4×4, and of 2 × 2. These transforms templates are used as shown in Fig.5.

Where the **X** 4×4 blocks residual coefficients are transformed using the following equation results of transformed **Y**, where $a=\frac{1}{2}$, $b=\sqrt{\frac{1}{2}}$, $d=\frac{1}{2}$ and E is scalling matric.

$$\mathbf{Y}=H_1\times\mathbf{X}\times H_1\otimes E=\begin{bmatrix}1&1&1&1\\2&1&-1&-2\\1&-1&-1&1\\1&-2&2&-1\end{bmatrix}\times\mathbf{X}\times\begin{bmatrix}1&2&1&1\\1&1&-1&-2\\1&-1&-1&2\\1&-2&1&-1\end{bmatrix}\cdot\begin{bmatrix}a^2&\frac{ab}{2}&a^2&\frac{ab}{2}\\\frac{ab}{2}&\frac{b^2}{4}&\frac{ab}{2}&\frac{b^2}{4}\\a^2&\frac{ab}{2}&a^2&\frac{ab}{2}\\\frac{ab}{2}&\frac{b^2}{4}&\frac{ab}{2}&\frac{b^2}{4}\end{bmatrix} \quad (5)$$

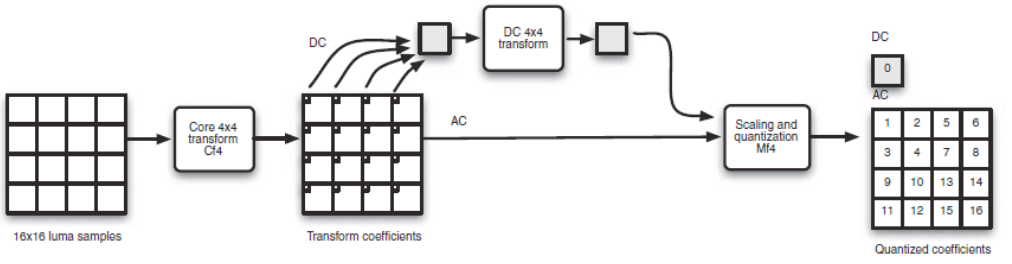



**Figure 5**. 4×4 block transformation

A 4×4 Hadmard transform will be applied for the residual block 16×16 intra prediction mode, in addition to the integer transform (H1), for all the 16 DC coefficients, where these DC, $\mathbf{Y}_{dc}$, values tend to be highly correlated, as given in Eq.6.

$$\mathbf{Y}_{dc}=\left(\begin{bmatrix}1&1&1&1\\1&1&-1&-1\\1&-1&-1&1\\1&-1&1&-1\end{bmatrix}\times[dc]\times\begin{bmatrix}1&1&1&1\\1&1&-1&-1\\1&-1&-1&1\\1&-1&1&-1\end{bmatrix}\right)/2 \quad (6)$$

While the Chroma 8×8 blocks components are transformed in four 4×4 using H1, integer DCT transform, results in a 2 ×2 block (dc), that are transformed using Hadmard transform of size 2 ×2 prior to quantization process as in Eq.7.

$$Ydc=\left(\begin{bmatrix}1&1\\1&-1\end{bmatrix}[dc]\begin{bmatrix}1&1\\1&-1\end{bmatrix}\right)/2 \quad (7)$$

### 3.3 Quantization

The resultant of transformed coefficients, $Y_{i,j}$, of the assigned block are quantized, $Q_{i,j}$, using Eq.8. In this work a set of 52 values are used as allowed within H.264 stander.

$$Q_{(i,j)} = \text{round}\left(\frac{Y(i,j)}{Qstep}\right) \quad (8)$$

After quantization process each 4×4 block of quantized coefficients is converted to 1-D 16 array using zig-zag scanning order.

### 3.4 3.5.8 Entropy Coding

For main profile, the residual blocks, prediction modes, motion vector data are encoded by using Context Adaptive Binary Arithmetic Coding (CABAC), as shown in Fig.6. Figure (7) shows the decoder block diagram, which are the reverse operations of the encoder.

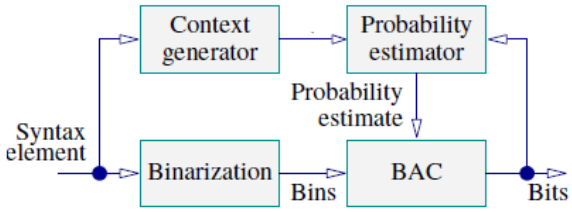



**Figure 6**. 4×4 **CABAC** block coding



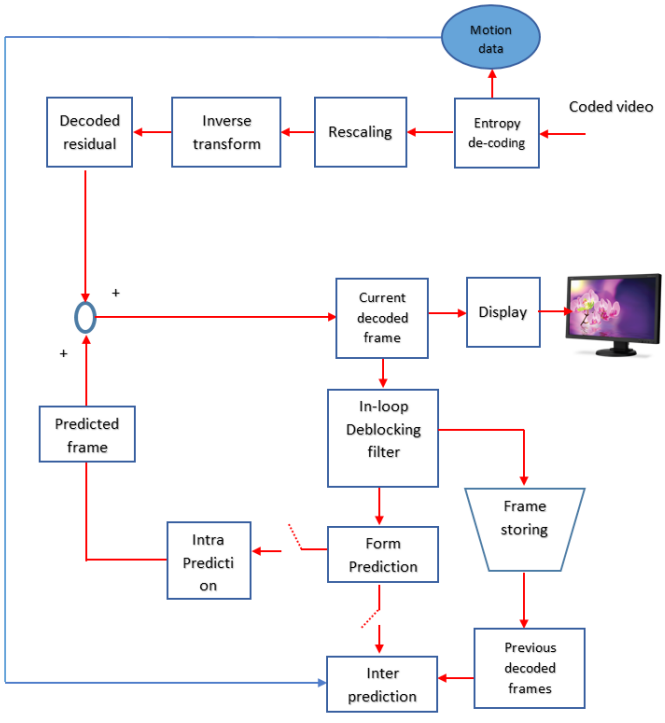



**Figure 7.** H.264 decoder processing

## 4. BUFFER OPTIMIZATION AND RATE CONTROL

This work manipulates video encoding for applications such as conferencing and video broadcasting that are adopted over the wireless channel, 3G or 4G mobile channel and WiMAX, or over wired channel like ADSL as proposed early. As known the high quality video encoder output is VBR while the communication system channel is a "Constant Bit Rate" (CBR), to map this varying data rate into a CBR channel, the buffer sub system is used, as shown in Fig.8. The coded video data (VBR) is the buffer input while its output is the transmission channel rate. At the other side, at receiver, is the decoder buffer, where its input rate is the channel rate while its output is the derived reconstructed frames. Video quality and output rate of the video encoder is controlled by the rate controller subsystem by feedback signal based on the buffer level statues. The system as designed reduces end to end delay, by encoder compression mechanism, and keeps of data flow by control buffer from over flow and under flow with the help of rate controller.

Buffering system is designed at size depending of the initial delay time at the decoder, a delay that allowed for video signal decoding corresponding to time transmitting. In this work such delay is in term of not more than 1mSec, which is mostly within the allowable time delay. The buffering subsystem sends control signal to the controller rate subsystem when the accumulated data at encoder buffer reaches maximum allowable accumulated data. The allowable encoder accumulated data is calculated as in Eq.9.

$$\textbf{Maximum accumulated data} = \textit{initial delay time} \times \textit{channel data rate} \tag{9}$$



When the accumulated data at buffer reaches the maximum accumulated data, alarm signal is sent to the controller to take an action of bit rate reduction, like increasing quantization step value, increasing GOP length, introduce interpolation mechanism, introducing partitioning, or others as mentioned early. This action avoids over flow. In the same time there is a minimum buffer level not allowed to reach lower of it to avoid under flow, where another alarm signal is sent used by the controller to take an action of increasing the bitrate using opposite action of that used for increasing the bitrate. Each of the tools of controlling the bitrate is arranged in lookup tables, a table for each tool. For example of what are used in this work, the 52 quantization step values are arranged in ascending order, where increasing order takes action of reducing bitrate while decreasing the order decreasing the bitrate. The priorities of using the tools are arranger as follows; QP, GOP, and skip frames are used adaptively as controller parameters, while partitioning, number of references and interpolation are used in full ranges as possible depending of system hardware size. More calculations will be considered in results chapter where scenarios of using video format and required application channel are considered.

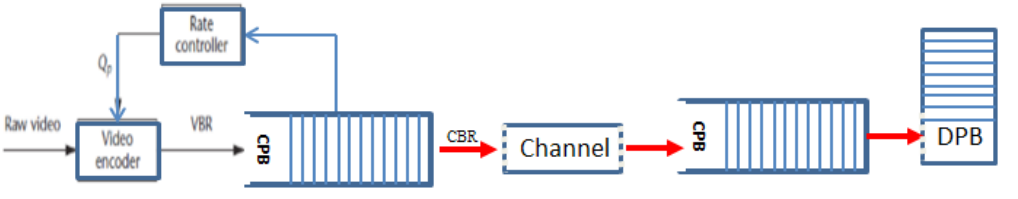



**Figure 8.** Rate control and buffering mechanism

## 5. TESTING RESULTS

Many configuration scenarios were used for testing H.264 video compression standard based on main profile that is adopted in this work to be used for video broadcasting over 3G and 4G mobile networks. Two video formats were considered CIF (288×352) and QCIF (144×176). After compressing the video sequence; a stream of bits are generated CABAC for main profile. The tested scenarios are reflected to the proposed rate control scheme of encoded bit streams and output quality. The H264 features values of these experiments are fixed of quantization (I QP=25, P QP=25 and B QP=28), GoP of (10),reference frame of (2), frame skipping of (2) and frame rate of 30fps, while the feature under test will be changed to check its effect.

Two simulated experiments are carried out for two video clips at different **GoP** lengths (5, 10, 15 and 20). Fig.9 shows the results of QCIF and CIF formats under the main profile, where the impact of GoP length on the PSNR (a) and encoded bitrate (b) for high motion details video. The results show that increasing the cycle length leads to decreasing in the quality of the decoded video and decreasing the bitrate. This outcome helps us to measure the allowable ranges of used GOP that are incorporated in the controller subsystem. CIF and QCIF result of different resolutions; lead us to introduce transcoding.

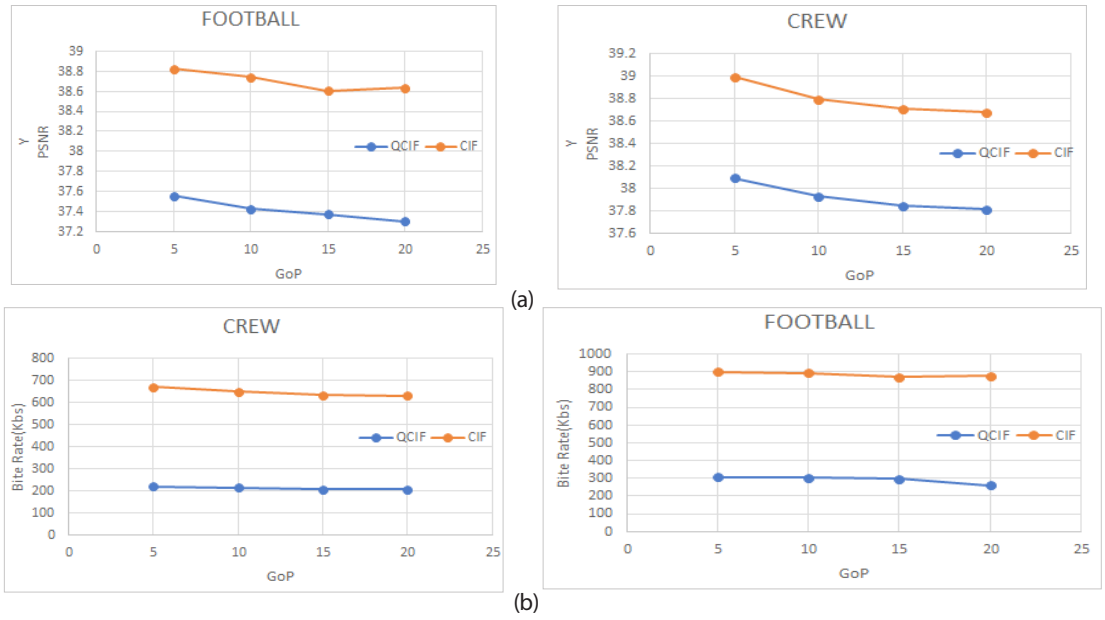
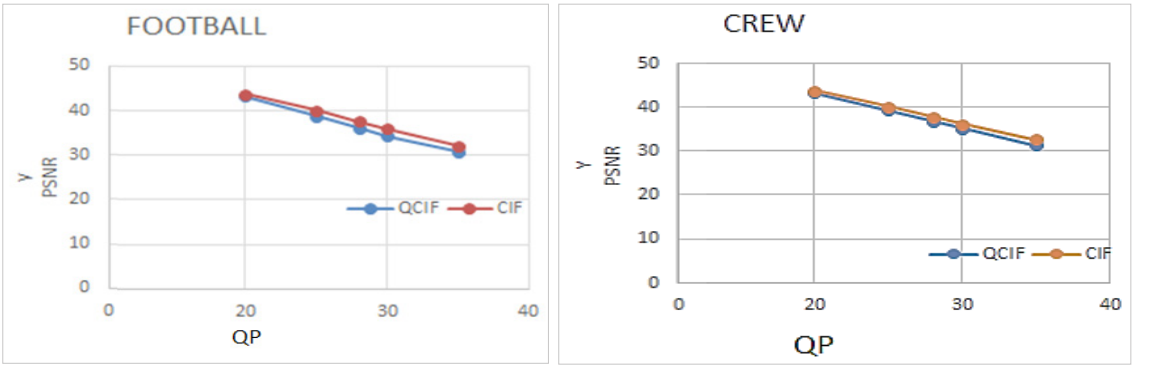


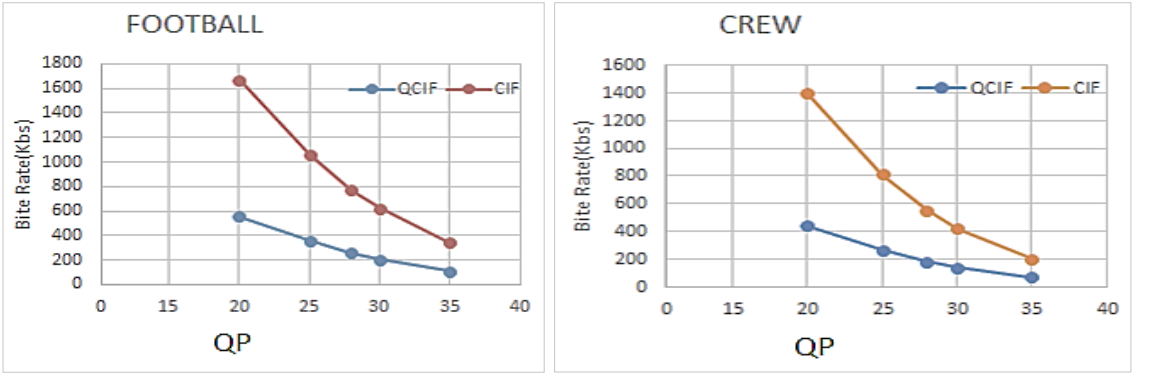

**Figure 9.** Impact of changing GoP on H.264 main profile (a) PSNR (b) bitrate

**Quantization parameter** (QP) is the most important effective parameter of rate control mechanism. A rang of quantization parameters (20, 25, 28, 30, 35) while keeping others are applied. For this work, quantization parameter specifically takes high priority due to its effects in the implementation of the controller for its direct effects and simplicity in implementation. Scenario is designed to test the quantization parameter effects under main profile. Fig.10 illustrates the effect of quantization parameter on the peak signal to noise ratio and encoded bit rate for Football and Crew clips. This figure, presents a road map for available mobile service based on 3G, which show to get 2Mbs for indoor applications the two formats

with the suggested range of quantization values result of minimum PSNR more than 30db, which can be applied to get proper video quality. When we are applying for outdoor of 384Kbs the CIF can be applied at quantization value more than 30 less than 35. While when we are applying for high speed vehicles at 144Kbps only QCIF with QP not less than 35 must be used. It is clear from these experiments how QP can be used for channel streaming adaptation.




(a)




(b)

**Figure 10.** Quantization parameter effect on H.264 main profile performance (a) PSNR (b) Bitrate

Fig.10 clearly shows that increasing the quantization parameter has direct and quick effect of decreasing PSNR and bit rate, for this reason it is used as the solution for the emergency cases of buffer overflow and underflow. Such analysis is the guide of designing the controller where quantization parameters are mainly used to reduce bitrate while the other tools are used in smoothing the effects of quantization parameters to keep of reasonable PSNR.

To study the effect of **frame dropping** on the bitrate and decoded video quality an experiment is carried out for video sequence of 15 frames with different frame dropping values (0, 2, 4, and 6) with CIF and QCIF while others are fixed. Fig.11 shows the impact of frame dropping on the PSNR (a) and encoded bitrate (b) under main profile. The figure shows that increasing of frame dropping leads to slightly decreasing of quality of the decoded video with clearly decreases of bitrate at increasing the number of frame dropping. Dropping of 6 frames from total sequence of 15 still gives acceptable PSNR, which shows the effect of such technique of bitrate controlling.

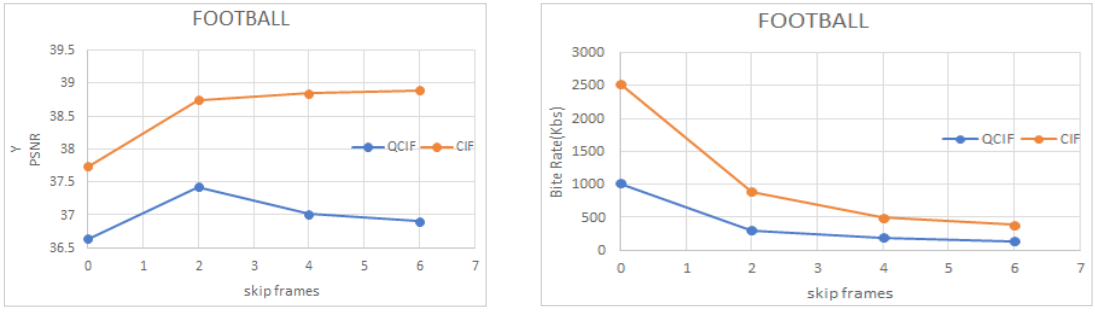
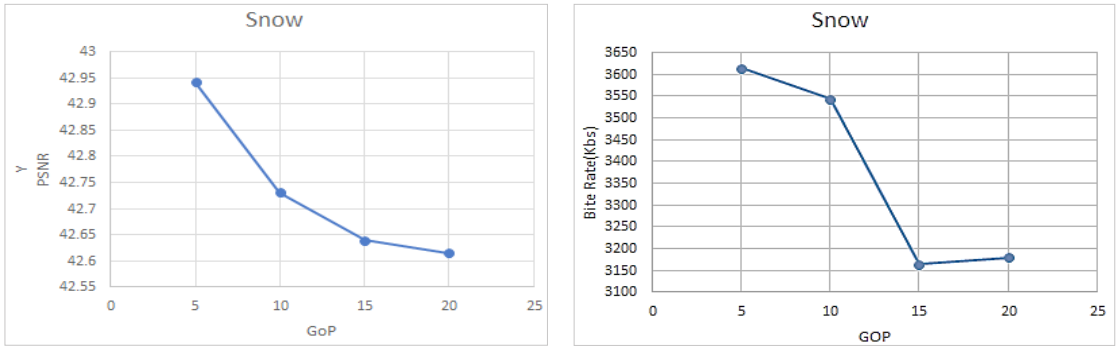


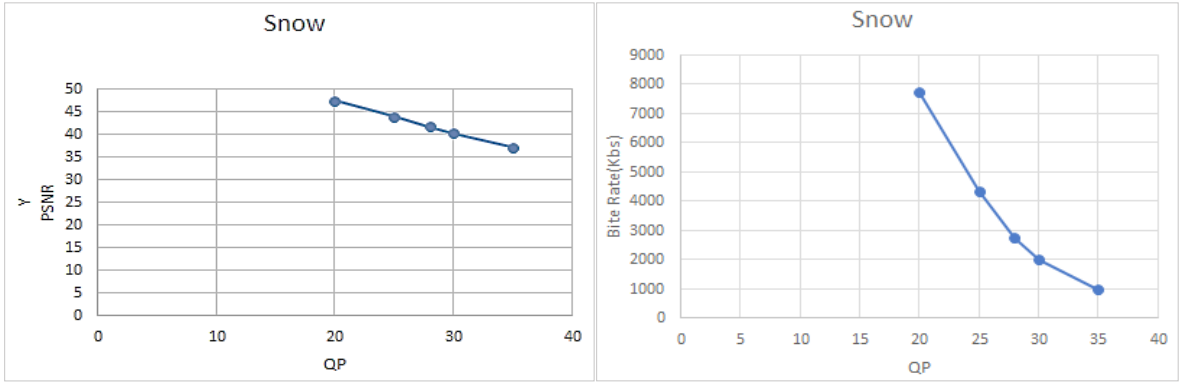

**Figure 11. H264** main profile frame dropping performance test (a) PSNR and (b) bitrate

Figures 12, 13, and 14 are the tests of GOP, QP, and skip frames parameters effect measurements of PSNR and bitrate of the main profile HD format snow videos with the same features as above.



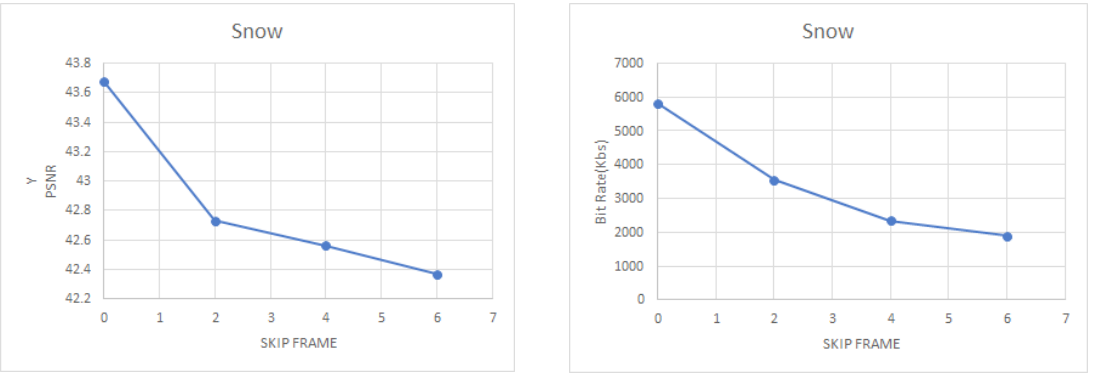

(a) (b)

**Figure 12.** H.264 HD main profile format GOP range (a) PSNR (b) bitrate




(a) (b)

**Figure 13.** H.264 HD main profile format quantization range (a) PSNR (b) bitrate

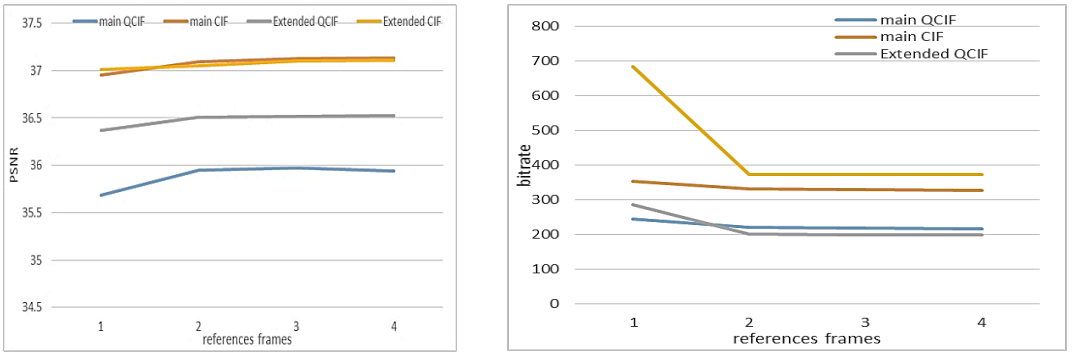



(a) (b)

**Figure 14.** H.264 HD main profile format quantization range (a) PSNR (b) bitrate

**P-Reference frames number** is one of the tools parameters that have an effect of the PSNR and bitrate. This parameter has its smooth effect that it is used in this work with allowable range of H264, where the limitations are the available hardware. Generally scenario test studies the impact of the number of the P reference frames on PSNR, bitrate. For main profile CIF and QCIF video format, a sequence of 30 frame video is encoded based on a different number of reference frames (1, 2, 3, and 4). The quantization parameter is set to 28 at GOP of (10). Fig.15 displays the performance for the tested scenario of H.264 main profile, in comparison with extended profile.





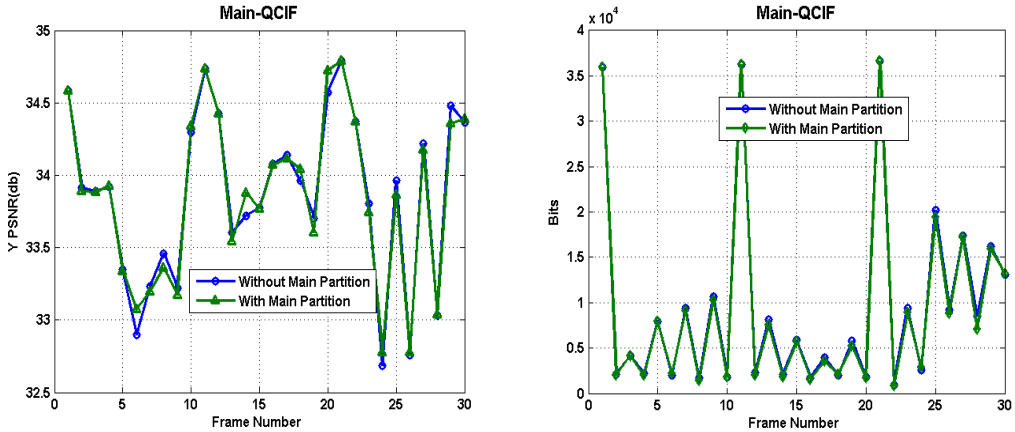

(a) (b)

**Figure 15. H264** main profile number of references performance test (a) PSNR and (b) bitrate

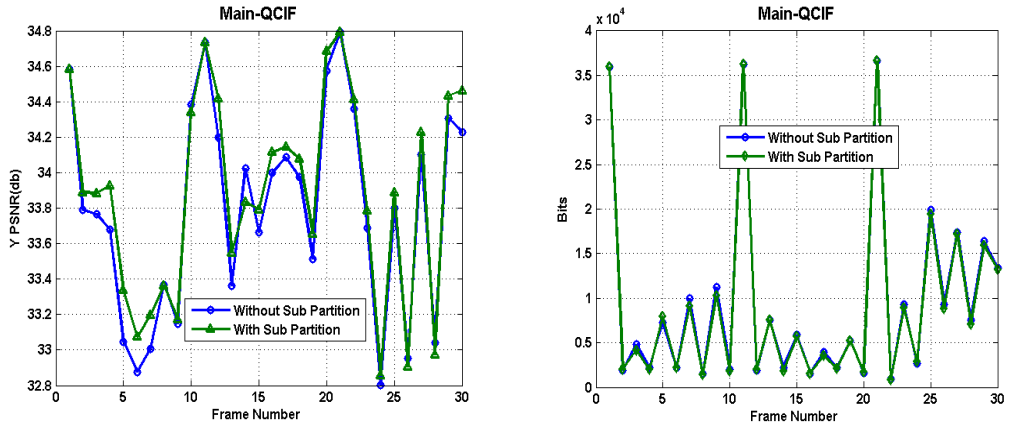
For QCIF, this figure shows that increasing the number of reference frames reduces bitrate about 12% while slightly reducing PSNR. We need to pay for additional processing and intermediate area memory saving.

H264 inter frames, P and B frames, use **partitioning and skip modes** to achieve reduction in bitrate and improving of quality. For partitioning of prediction modes of main partitions (16×16, 16×8, 8×16) and sub-partition modes are tested for foreman video clips of 30 CIF and QCIF formats with number of reference frame 2, frame rate=30fps, fixed QP =28, Gop = 15 and skip frame =0. Fig.16 shows the

results for the main profile H.264 encoder. The results show that PSNR and bitrate are enhanced when partitioning technique is used.



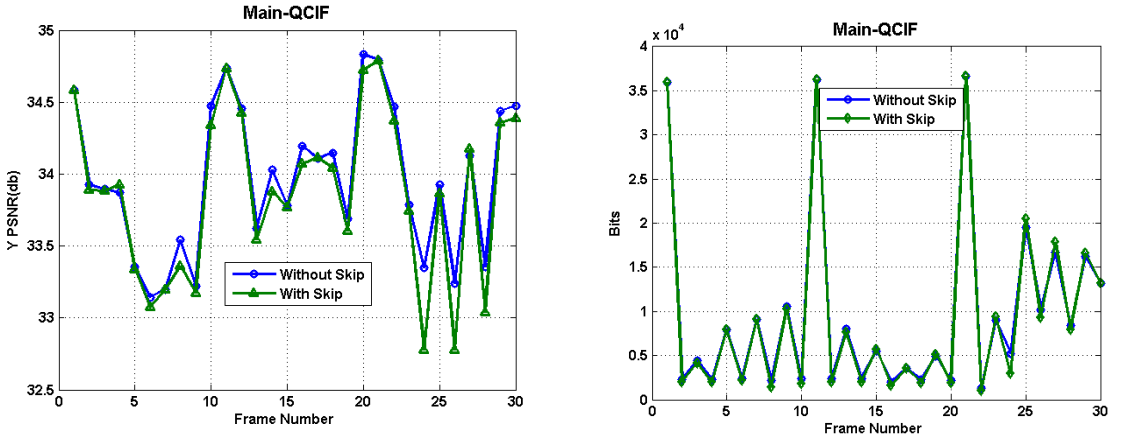

(a)




(b)

**Figure 16.** H.264 main profile Prediction Modes in (a) Main Partitioning): (b) sub-partitioning

The **skip mode** is applied for macroblock skipping. Skip means drop (16×16) macroblock that has very similarity with previous ones to reduce computational complexity as well as the encoded bits. Fig.17 shows applying skip mode on the decoded frame quality and bitrate of main profile. The figure shows that degradation in the PSNR when using the skip mode with reduction of inter frames bitrate.

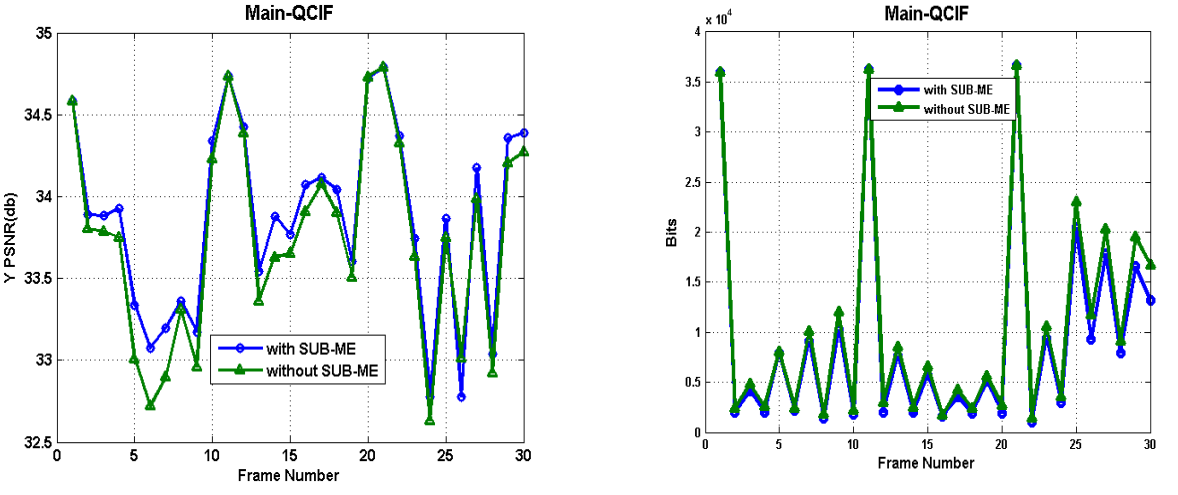



(a) (b)

**Figure 17.** H.264 main profile skip Modes (a) PSNR (b) Encoded bits per frame

The **sub-pixel** motion estimation feature over 30 frames QP=28 and GoP=10 is applied, Fig.18 shows the results effects of PSNR and bitrate of main profile. Sub-pixel motion estimation gives best quality with reduced bitrate of 9% for QCIF and 17% for CIF.



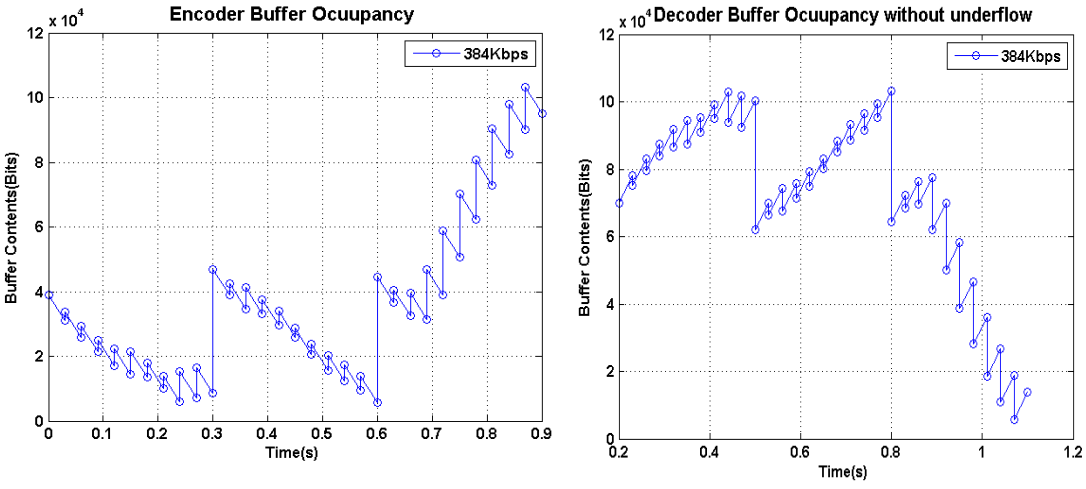



(a) (b)

**Figure 18.** H.264 main profile Sub-Pixel Motion Estimation in: (a) PSNR (b) bitrate

## 6. BUFFERING OPTIMIZATION

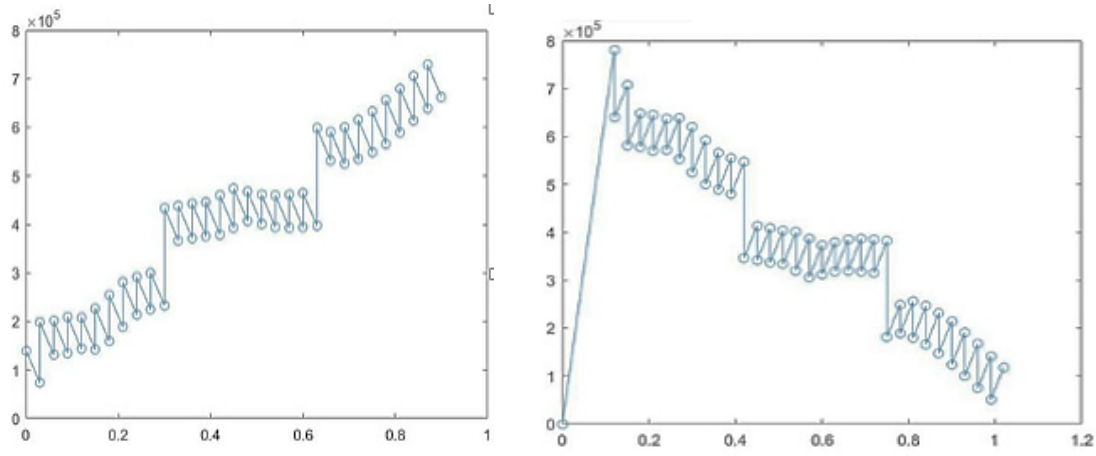
In this subsection the buffering system is analysed due to buffer status over the time operation. For a buffer of size 500Kbit, two observations are recorded one for QCIF and HD formats. A 30 frames at QP=28 QCIF format under 384 Kbps channel buffer status is shown in Fig. 19 with initial removal delay of 0.2msec.




(a) (b)

**Figure 19.** Buffer Occupancy (a) Encoder (b) Decoder

The second observation is done for HD format for 30 frames per second at buffer size of 8Mbits over a channel of 2Mbps (3G indoor application), see Fig.20.




(a) (b)

**Figure 20.** HD format (a) encoder (b) decoder



## 7. CONCLUSION

The main topic of this study is how to use the different tests for the purpose of bitrate control to achieve an assigned goal of PSNR. The H264 CODEC features; QP, GOP, skip frames, Skip MB, Sub pixel ME and Number of reference frames are used and tested with main profile of CABAC coding technique for broadcasting application. The using of reference number, Sub pixel ME and size of macroblock partitioning are depending of available hardware, where increasing of them need more hardware spaces and speed,

while frame dropping, GoP and QP play an effective roles in the rate and PSNR video quality, since encoded bits and PSNR are decreased with increasing them, so they are used as an adaptive features dynamically changed corresponding to the channel state. The encoder buffer is used to sense the channel, where the threshold, under threshold and over threshold buffer levels are the mechanism of channel sensing. The controller sub-system is applied as the adaptive mechanism of video streaming over the channel. A more than 50% bitrate saving is achieved, compared with previous stander, with keeping of video quality within required ranges that guaranty accepted PSNR.

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**RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ**

# A MODERNIZATION UTOPIA: GALATA AND PERA DURING THE LATE OTTOMAN ERA

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## Abstract

Following the Ottoman conquest in 1453, *Intra Muros* Stamboul was adorned with edifices reflecting Ottoman monumental and vernacular architecture. With all the Muslim influence dominating the Historic Peninsula, a different story was taking place just across the Golden Horn. The autonomous Genoese city, Galata, and its extension Pera continued housing Levantine, European, and non-Muslim populations. By the 19th century, due to its cosmopolitan population, architectural fabric, and urban layout, this area has developed into a "typical" European city and accepted as the "modern" face of the Ottoman capital. This paper develops an understanding of the "modernization utopia" of the Ottomans and focuses on the urban implications of this utopia in Galata and Pera. This paper offers a critical, yet, theoretical framework for reading architectural and urban transformations that took place in Beyoğlu, beginning with the declaration of Tanzimat until the Young Turk revolution. The article also discusses the first municipal body that was established at Galata and Pera and presents some of the projects conducted by the Sixth District in urban scale as modernization interventions.

**Keywords:** Galata, Pera, Modernization Utopia, Sixth District, Urban Transformation.



## BİR MODERNLEŞME ÜTOPYASI: GEÇ OSMANLI DÖNEMİNDE GALATA VE PERA

## Öz

Osmanlı fethinden sonra Suriçi İstanbul hızla dönüşmüş ve klasik Osmanlı mimari eserleriyle donatılmış olsa da, Haliç'in karşı yakasında yer alan Galata ve uzantısı olan Pera'da farklı bir hikaye süregelmiştir. Ceneviz döneminden itibaren otonom bir statüye sahip olan bu bölge, gayri-Müslim yoğunluklu bir nüfus barındırmaya devam etmiş, özellikler yabancı elçiliklerin kurulması ile Avrupalı ve Levanten nüfus için bir çekim alanı haline gelmiştir. 19. yüzyıla gelindiğinde ise bölge, kozmopolit yapısı, mimari dokusu ve kentsel yerleşimi ile "tipik" bir Avrupa kenti görünümüne bürünmüş, Osmanlı başkentinin "modern" yüzünü temsil etmeye başlamıştır. Bu makale 19. yüzyılda Osmanlı "modernleşme ütopyası"nın kentsel alandaki etkilerini incelemektedir. Dolayısıyla Tanzimat'ın ilanından Jön Türk devrimine kadar olan süreçte, Galata ve Pera'nın kentsel ve mimari dönüşümü modernleşme penceresinden değerlendirilmektedir. Bu bağlamda, Altıncı Daire'nin kurulması, ilk belediyecilik hizmetleri ve tarihi Galata surlarının yıkılması gibi örnekler, kentsel modernleşme bağlamında incelenmektedir.

**Anahtar Kelimeler:** Galata, Pera, Modernleşme Ütopyası, Altıncı Daire, Kentsel Dönüşüm

## 1. INTRODUCTION

> The urban fabric can be described by using the ecosystem, a coherent unity constituted around one or several cities, old and recent. Such a description may lose what is essential. Indeed the significance of urban fabric is not limited to its morphology. It is the support of a more or less degraded, 'way of life': *urban society*. On the economic base of the urban fabric appear phenomena of another order, that of social and 'cultural' life (Lefebvre, 2000, 72).

A city is composed of a complex stratum and integrated web of practices. The spatial character of a place, informs us about its history, culture, and nature while deciphering the economical, political and social characteristics of its inhabitants. Obviously, the opposite is also valid: a place gains character with all the culture that was produced, that is being produced, and that will be produced by the urban society. However, culture is not something solid to be seen, or static to be read, or something frozen to be defined. It is a dynamic and always changing and interconnecting web of structures, traditions, beliefs, and relations that surrounds the individual, influencing the perceptions, actions and reactions of the society. Culture can be defined as a dynamic human production of difference and variety; and it is the non-reducible multiplicity of this production (Tanju, 2007). Cities, then, can be defined as the cross-sections of intersecting cultures. The city, by its nature, becomes the meeting point and stratification of different cultures, traditions, customs, and societies. When an urban entity is considered, instead of focusing on an isolated layer, the ever changing/evolving character of the city needs to be considered. All cultural practices are either closely or loosely connected and related with one and other in a given time and/or space, forming a complex network of socio-cultural relations and interactions.



Istanbul, as the capital of the Ottoman Empire since the 15th century, reflects the centralized power and political authority of the Ottoman court. However, due to its multi-cultural, multi-lingual, and heterogeneous social structure, complex historical strata, and its diverse population, the definition and conceptualization of the imperial capital is away from its rather homogeneous counterparts. This study focuses on a specific part of Istanbul at a specific time period to explore the unavoidable tension between the past and the present, tradition and modernization, continuity and change. Being one of the major capitals of the Orthodox Christian world for many centuries, Constantinople has finally transformed into the very center of the Muslim world with the Ottoman conquest in 1453. Starting with Mehmed II, Ottoman emperors have (re)constructed the city to reflect their imperial powers and to reclaim the city as an Islamic capital. With all the Ottoman monumental and vernacular architecture dominating the *Intra Muros* city of Stanboul, a different story was taking place just across the Golden Horn. Galata and its extension Pera -meaning 'the other side' in Greek- continued housing a dense non-Muslim population.

Located in between the Northern shore of the Golden Horn and the Bosporus, Galata had a different architectural, social, economical, and physical character than the Historic Peninsula. Galata has always had a special and autonomous status, since the Genoese settlement in the 10th century (Eyice, 2006). The Genoese colony -dominating and controlling the overseas trade- settled down just across from Constantinople, on the district that was called the 'Pera', meaning the other side in Greek (Eyice, 2006).

Through the end of the Middle Ages, Galata ports were among the most important centers of Eastern Mediterranean trade (Akın, 1998).

At the beginning of the 15th century, Italians were well aware of the inevitable expansion of the Turks. The Ottoman dream for invading Istanbul was about to realize and the Genoese were furtively supporting the Turks against Byzantines (Akın, 1998). Finally, in 1453 Mehmed II the Conqueror captured Constantinople. It was not just a city that the sultan invaded, but the very center of Orthodox Christianity, an empire that was the successor of ancient Rome, the Eastern frontier of Western civilization, and a vital hub for Mediterranean commerce. The deep impacts of this incident on the Ottoman, Turkish and World history have been studied in detail, however this article focuses on the course of developments within Galata and Pera after this great shift of power. Under Ottoman control, Galata continued keeping its autonomous character with a governor referred to as *Voyvoda* and several Greek, Jewish, and Turkish neighborhoods were created around the area to balance the Italian dominancy in the area (Çelik, 1993).

Between the 15th and 18th centuries, Galata remained as an important trade center and an international harbor of Ottoman the capital. For several centuries, Ottoman vernacular architecture dominated the urban landscape of the area, creating a somewhat homogeneous residential fabric (Tanyeli). The face of Galata and Pera has started changing with the establishment of the first foreign embassy in 1535 by France, probably due to the increased trade between France and Ottomans following the capitulations granted.[1] During the 16th and 17th centuries, English, Venetian, Dutch, Polish, and Danish embassies were also established in the area. In fact, foreign embassies, were refrained from *Intra Muros* city of Stamboul (Çelik, 1993). Hence, a considerable number of Europeans, Levantines[2], and non-Muslim Ottomans started residing in Pera, accumulated around their embassies (İnalcık, 1993-94). Thus, the face of Galata and Pera started changing by the 18th century; and during the course of the 19th century, the district faced a rapid urban transformation (Figure 1). Actually by the end of the19th century, this area has developed into a 'typical' European city with its dominant Levantine, European, and non-Muslim population and Western social, cultural, urban, and architectural fabric.



## 2. TWO SHORES OF THE GOLDEN HORN

> Wooden houses with large spread-out roofs warm their purple colors amidst fresh greenery and within enclosures whose mystery delights me; although they group themselves quite harmoniously around all these summits formed by really enormous mosques, a poisoned atmosphere hangs over Pera, under an unrelenting light (Le Corbusier, 1911, 92).

Le Corbusier, during his *Journey to the East* in 1911, visited Constantinople and admired the harmonious and mysterious urban fabric of the Historic Peninsula. However, his depiction of Pera as "poisonous" reflected the Orientalist anticipations of this renowned architect and his disdain for the mimicry of European architecture and city form (Figure 2). In fact, after the second quarter of the 19th century, there appeared a profound gap between the two shores of the Golden Horn. The "oriental and traditional" Stamboul, with

**1** Capitulation: Special economic rights and tax benefits for foreign traders.
**2** Levantine: Otoman citizens of European origin.

its impressive monuments and modest residential fabric lay against the "Europeanized" Galata and Pera with its masonry apartments, narrow streets and dense layout (Girardelli, 2007). Against all the physical, social, economic, and urban distinction between Galata and Stamboul, neither in Stamboul nor in Galata there was an obvious architectural distinction among Turkish, Jewish, Christian, or Muslim houses (Barata, 1840; Cerasi, 1998). The main distinction in the Ottoman capital emerged between the local residents of the city and its newcomers, especially from Europe.

19th century was defined as a period of decline for the Ottoman Empire, which was then called the "sick man of Europe" (İnalcık & Quataert, 2004). Starting with the 19th century, Empire's ruling elite reluctantly accepted the superiority of European powers and desperately tried to close the military, technological, and intellectual gap between them. Along with consecutive reforms, many European architects, scholars, military commanders, and technicians were invited to "modernize" Ottoman military practices and educational, cultural, and architectural institutions. Nevertheless, modernization of institutions or practices was not sufficient, as the distinction between the East and the West was deeper than Ottoman elites presumed it was. Despite the Ottoman elite's attempts for a rather 'immanent modernity' at the beginning of the 18th century during the Tulip Age, those efforts for modernity came to an end in 1730 with the Patrona Halil uprising, which clearly proves the severe public resistance against 'change' (Salzmann, 2000). The resistance against change rooted in the diverse epistemological understandings of the Eastern and Western contexts. According to the cultural theory of modernity, "progress" occurs in "traditional" societies through modernization as a culture-neutral process (Taylor, 2001). In this case, all cultural and historic contexts are believed to unfold and institutions, practices and the society would transform into a single layered, homogeneous state of modernity.



The Anglo-Turkish Convention of 1838 was a manifestation of economic and political superiority of European powers over the Ottoman Empire. According to this treaty, the Ottoman Empire will allow British merchants and their collaborators to have full access to all Ottoman markets, abolishing all monopolies and will provide tax exemptions. It was also an attempt of Ottomans for becoming a part of the European league and foreign capital flow officially commenced in the empire, which declare economical and political dominance of European powers over the "sick man of Europe" (Çelik, 1993). The declaration of *Tanzimat* reforms in 1839 provided great rights and benefits especially for Europeans and also for non-Muslim minorities. With this treaty, European model was appropriated and applied to all institutions from military to education, from bureaucracy to judiciary. In 1855, the Ottoman Empire was provided foreign loans for the first time in its history to finance the Crimean war (Çulcu, 2006). This was apparently an economic intervention and within a short time period, a significant number of European merchants, traders and bankers settled down in Istanbul, around Pera close to their embassies. Between 1840 and 1900, approximately 100,000 non-Muslim newcomers settled down in Galata and Pera (Shaw & Shaw, 2002).

During the 19th century, Galata and Stamboul regions had considerably diverse social, physical, and cultural structure and strata. While *Intra Muros* city of Stamboul maintained a more traditional structure, in terms of buildings and social institutions; Galata and Pera faced a significant transformation and according growth. As shown in the 1840 S.D.U.K. Map of Constantinople (Figure 3), Stamboul did not grow much beyond the traditional Byzantine city-walls. However, Galata faced an incredible population increase and

the city extended beyond the city-walls in three different directions, from Taksim to Şişli, from Tophane to Dolmabahçe, and from Beşiktaş to Teşvikiye and Nişantaşı (Çelik, 1993). The traditional population rate of 60% Muslim and 40% non-Muslim in Istanbul has changed during the 19th century and reached a reverse rate of 40% Muslim and 60% non-Muslim by the end of the century (Girardelli, 2007). The reason for this demographic shift, despite the heavy Muslim migration from the Balkans to Istanbul, was the settlement of Europeans to the area due to the legal rights and economic benefits ensured with the capitulations and *Tanzimat* reforms (Çelik, 1993).

The urban fabric of Galata and Pera was away from harmony and unity by the beginning of the 19th century. The crowded, dirty and narrow streets were packed with a mix of masonry apartments, single-family residences, timber houses, shops and ateliers inside the city-walls (Akın, 1998). The uncanny places located around the ports of Galata housed bars, taverns, brothels, pawnbrokers. The disorganized pattern of the streets and dense building pattern -interrupted sometimes with an embassy complex, a medium sized church, an Armenian school, a Jewish Synagogue or a large scale commercial building- formed a complex web of urban functions. The diverse crowd accumulated towards the Galata Bridge, which dominated the trade axis between the two shores of Golden Horn. Famous Italian writer Edmondo De Amicis described the cosmopolitan multiplicity of the Galata Bridge by these words: "Standing there, you can see all Constantinople pass by in the course of an hour.… Try to imagine the most extravagant contrasts of costume, every variety of type and social class, and your wildest dreams will fall short of the reality; in the course of ten minutes, and in the space of a few feet, you will have seen a mixture of race and dress you never conceived before." (Amicis, 1896, 45-46). In fact, it was the modernization ideal of Ottoman elites to establish "order" within the city and to develop the area with modern infrastructure, transportation, and municipal services.



## 3. THE MODERNIZATION UTOPIA

> Utopias are emplacements having no real place. They are emplacements that maintain a general relation of direct or inverse analogy with the real space of society. They are society perfected or the reverse of society, but in any case these utopias are spaces that are fundamentally and essentially unreal (Foucault, 2000).

According to Foucault (2000) utopia is closely related with the society that it belongs, referencing to what it lacks. The desire for a perfected society is basically the reverse of that particular society, a society that hopes to be something else, something idealized, and of course something un-real and non-existing. A utopia cannot be understood as a willingness of a particular society to become another actual society. On the contrary, a utopia should have its roots deep inside the society itself, trying to transform a society into what it lacks. 'Modernization utopia' in the Ottoman case, shall not be interpreted as an Ottoman aspiration for becoming inherently European, but rather, a reluctant desire for change.

There are many underlying reasons for the 'modernization utopia' of the Ottoman emulating the West. One of the main factors is the problematic understanding and definition of modernity. The utopia dreams of absorbing everything positive about the Western society and excluding all the defects of its inner dynamics.

According to Charles Taylor, there are two main theories of modernity, *cultural* theory of modernity and *acultural* theory of modernity (Taylor, 2001). *Cultural* theory describes modernity as a transformation that took place in a specific culture, namely in Western culture. According to this theory, modernization is related with social context and culture. According to the *acultural* theory, modernity is taken as a set of rules and transformations, which are applicable to any culture. The general understanding of modernity falls under the second theory. Not surprisingly, Ottomans Westernization and modernization utopia was not an exception, as their understanding of modernization counterpart with Taylor's description of *acultural* theory: "The belief that modernity comes from a single, universally applicable operation imposes a falsely uniform pattern on the multiple encounters of non-Western cultures with the exigencies of science, technology, and industrialization. As long as we are bemused by the "enlightenment package, we will believe that all cultures have to undergo a range of cultural changes. (…) As they lose their traditional illusions, they will come together on the "rationally grounded" outlook, which has resisted the challenge. The march of modernity will end up making all cultures look the same. This means of course, that we expect they will end up looking Western." (Taylor, 2001).

**4. REORDER & CORRECTION (TANZIMAT & ISLAHAT)**

> With reference to the other points, as they must be regulated the concurrence of enlightened opinions, our Council of Justice (augmented by as many new members as may deemed necessary), to whom will be adjoined, on certain days which we shall appoint our Ministers and the Notables of the Empire, will meet for the purpose of establishing the fundamental laws on those points relating to the security of life and property, and the imposition of the taxes. Every one in these assemblies will state his ideas freely, and give his advice freely (Gülhane Hatt-ı Hümayunu, 1839).



*Tanzimat-ı Hayriye* or "Auspicious Reorderings", a set of administrative reforms declared in 1839, were acclaimed by the majority of the Ottomans with the desire for "order" and "correction" (Shaw & Shaw, 2002). The charter, giving equal rights to all Muslim and non-Muslim citizens and secure their basic rights, was accepted as a major step towards the modernization utopia (İnalcık & Quaraert, 2004). With the support of Western nations, the Ottoman government aimed at reforming state institutions, replacing the traditional ones with modern institutions imported from the West (Shaw & Shaw, 2002). The results of this regularization were much different from its initial goal. The charter created a motive for modernization and initiated a set of social and institutional changes imported from Europe (Özer, 2005). Creating a robust central authority, setting a modern and continuous army, protecting the rights of individuals, providing freedom and equality to all citizens, and adapting the European life-style to the Ottoman society were the objectives of the reforms. Hence, Western art, architecture, fashion, clothing, entertainment became popular among the Ottoman elite.

Even though, Tanzimat Reforms and the following Islahat Charter -declared in 1856- had serious political, economical, and social impacts, these reforms were away from entirely transforming the traditional structure of the Ottoman society. There existed resistance towards change, especially within the traditional neighborhoods of Istanbul. Not only among the Muslim but also Christian and Jewish communities living at the Historic Peninsula resisted this enforced change (Eren, 2001). However, it could be stated

that European, non-Muslim, Levantine populations of Galata and Pera affirmed, endorsed, and benefited from these reforms.

Galata and Pera inhabited the most cosmopolitan, mobile, and liberal population of the capital. As an essential port of Mediterranean trade and due to its historically autonomous status, the social, political and economic institutions were woven with much looser set of rules. This flexibility and openness for change made the district a point of attraction for a small number of liberal Turks as well. Especially, the new generation of Ottoman elite, admiring Europe and Western way of living, started moving to or at least regularly visiting the area. Along with resistance there was also curiosity and interest for the new, different, and uncanny prospects of modern life-style.

Pera underwent a frenzied urban development after the second half of the 19th century. New building types were introduces responding to the new modern lifestyle. A hybrid architectural style combining Western and Eastern elements has developed (Özlü Kayaalp & Eyüce, 2007). With the increasing number of Europeans residing in the district, European workforce and craftsmanship became available for the construction of masonry buildings with neo-classical façades, bay windows and angle braces. Apart from the residential fabric many schools, hospitals, restaurants, hotels, theaters, shops, and apartments were built in European fashion, especially on *Grand Rue de Pera*, an important axis connecting Taksim to Galata (Shaw & Shaw, 2002).

In 1854, as a part of the modernization efforts, a municipal organization for the city was established for the first time. The city was divided into 14 regions while Beyoglu district was chosen as the pilot area and named as the Sixth District (Akın, 1998). This municipal body bore a wide range of responsibilities and powers, from construction and maintenance of buildings, streets, transportation, and infrastructure to tax collection (Shaw & Shaw, 2002). As a result, the inhabitants of Galata and Pera benefited from a series of services and projects provided by the Sixth District, as the area attained a more "European" and "modern" look.



## 5. THE SIXTH DISTRICT

> There are fifty-four cities in the island, all large and well built, the manners, customs, and laws of which are the same, and they are all contrived as near in the same manner as the ground on which they stand will allow. The nearest lie at least twenty-four miles' distance from one another, and the most remote are not so far distant but that a man can go on foot in one day from it to that which lies next it. (…) Every city is divided into four equal parts, and in the middle of each there is a market-place (Thomas More, 1895, 55, 74).

The physical and urban transformations taking place in Galata and Pera were directly related with the economic and political developments of the era. As Zeynep Çelik (1993) points out, following the Tanzimat reforms there was a conscious effort for the regularization of the urban fabric by introducing modern administrative units. One of the first attempts to modernize the urban administration was the establishment of prefecture (*şehremaneti*) and foundation of the Commission for the Order of the City (*İntizam-ı Şehir Komisyonu*) in 1855. However, these bodies proved to be insufficient and a new set of regulations were

issued, and the city of Istanbul was divided into fourteen municipal districts in 1857. According to this legislation, the "Sixth District" (*Altıncı Daire*) was founded as a pilot municipal body, responsible from Galata, Beyoğlu, and Tophane regions of Istanbul (Tümerkan, 1946).

The central government initiated the municipal organization starting from Galata, due to the increasing demand and willingness of the "Westernized" inhabitants of the region for municipal services. Such a local authority was believed to create a sense of Ottoman citizenship and secular identity in the heterogeneous demographic structure of the area (Rosenthal, 1980). It is believed that the municipal organization adopted the French model and took the *Sixieme Arrondissement* of Paris as a name for itself. This semi-autonomous body would be directed by a municipal council that was composed of Turkish, non-Muslim, and European members, which represented the cosmopolitan population of the area. A Muslim director has to be appointed to the council by the central government, who was responsible for directly reporting to the Sublime Porte.

Against all the public enthusiasm and governmental support, the Sixth District council was not able to achieve its ambitious goals, failed to collect the anticipated taxes and finally bankrupted in 1862. According to Rosenthal (1980), foreign embassies and European power holders played a major role in the failure of the council, due to their conflicting interests with the municipal body. Still, the Sixth District managed to evoke public awareness, provided basic municipal services, and initiated urban transformation of the area, starting from the prosperous commercial zones of the district. Some of the services included the cadastral survey of the area; leveling, paving, lighting, and widening of major streets; opening up new transportation axes between Galata and Şişli; planning of the port area; the construction of Karaköy Han; and the fight against prostitution (Toprak, 1993-95).



In 1863, central government took a more active role in the administration of the region and implemented a broader social service policy. During the directorship of Server Paşa the District managed to gain financial stability. A public hospital was founded to serve the poor inhabitants of the area; a public park, named *Taksim Bahçesi*, was inaugurated at the *Grands Champs des Morts*; and municipal services were distributed more egalitarian within the district. According to Rosenthal (1980), against the common prejudice, Ottoman officials proved to be more effective than their Levantine and Christian counterparts in directing the local authority and offering municipal services.

One of the most ambitious operations of the Sixth District, which severely transformed the urban layout of the district, was the demolition of the historic Genoese walls surrounding Galata in 1863. The historic walls and towers, accept for the Galata Tower were demolished, remaining moats were filled up and the cut-stones were auctioned for ongoing construction work (Figure 4). Following the European examples, new streets were formed, and modern settlements were established within the evacuated lots and filled-up lands (Figure 5). It could be stated that the demolition of the historic walls and construction of modern row houses in the area could be defined as the first "modern urban transformation" project realized in Istanbul during the Tanzimat era. The great fire of Pera in 1870, also severely transformed the urban character of the district. Apparently, the fire had a catastrophic impact on the area damaging approximately 3,500 houses and 163 neighborhoods. Following the catastrophic fire, the municipal works were suspended for some time and the district was almost entirely rebuilt with the international aid (Keyvaoğlu, 2017).

Following the fire, several large-scale masonry buildings were erected especially on and around *Cadde-i Kebir - Grand Rue de Pera*, which will change and define the architectural character of the axis.

With the declaration of Istanbul Municipal Act (*Dersaadet İdare-i Belediye Nizamnamesi)* in October 5th, 1877, the earlier regulations of 1857 and 1858, ensuring the autonomous and distinctive character of the Sixth District, came to an end. The Sixth District became one of the regular regions of the 20 districts of Istanbul (Toprak, 1993-95), later the number of the districts was decreased to ten. The sources and funds were directed towards the areas around the imperial palaces at Beşiktaş, Yıldız, and Ortaköy (Çelik, 1993). Still, the Sixth District kept its name and significance. During this period, one of the prominent figures of Istanbul, Edouard Blacque (Blak Bey) became the director of the Sixth District from 1879 to 1883 (Toprak, 1993-95) and again in 1893 (Akın, 2002). According to local sources, the period of Blacque was believed to be the most successful era in public works (Ortaylı, 1985). The opening of the Tepebaşı public garden and the construction of the *Sixth District Palace* by Barborini at Şişhane Circle during this period were significant urban projects changing the architectural and social fabric of the area (Akın, 2002).

However, in January 3rd, 1913 the Union and Progress government, having nationalist and centralist tendencies, discarded all municipal councils and united all districts under one municipal body. After loosing its privileged status in 1877, the Sixth District has finally lost its characteristic name as well in 1913 (Toprak, 1993-95). During the Young Turk era, the municipal body continued providing public services all round Istanbul. Reorganization of the Gülhane gardens in the Historic Peninsula and opening of main urban arteries during the directorship of Istanbul mayor Dr. Cemil Topuzlu could be considered as some of the memorable works conducted within this period. Bernard Lewis summarized this era of municipal organization as: "The Young Turks may have failed to give Turkey constitutional government. They did however, give Istanbul drains." (Lewis, 2002, 228).



Osman Nuri Ergin's magnum opus *Mecelle-i Umur-i Belediye* (1995), provides a detailed and meticulous survey of the history, institutional organization and legislative body of Istanbul municipalities from 1855 to 1928. Ergin also provides detailed accounts on the mayors of Istanbul during the same era, in his renowned work *İstanbul Şehreminleri* (1996). Starting with the Tanzimat reforms until the collapse of the empire, ordering and planning the urban landscape, municipal activities and interventions to the city were given utmost priority, as urban planning and municipal works were accepted as an ultimate indication of civilization and modernization. During this period, urban squares were planned, several public parks were opened, new arteries were established, major streets were paved, city walls were demolished, roads were widened, new settlements were organized, transportation was improved, and large scale impressive buildings were built (Çelik, 1993). Hence, modernization utopia of Ottoman elites -partially and inadequately- came to realization through the urban interventions facilitated by the local municipality during the late Ottoman era. The act of regulating and planning the urban fabric as a showcase of modernity continued after the foundation of the Turkish Republic as well.



**Figure 1.** Traditional Ottoman vernacular architecture vs. the new apartments of Pera.

**Figure 2.** Apartments of Pera from the perspective of young Edouard Jeanneret, Le Corbusier, 1911


**Figure 3.** 1840 S.D.U.K. Map of Constantinople

**Figure 4.** The walls of Galata before the demolition.



**Figure 5.** New row of apartments built after the demolition of Galata walls.

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