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Hikâyeler İçin Artırılmış Gerçeklik Yaklaşımı

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ÖZ

Artırılmış gerçeklik çevremizde algıladığımız fiziksel unsurların üzerinde bilgisayar kaynaklı grafik, video ve ses gibi verilerin gerçek zamanlı olarak görüntüleyen gerçek dünya ile sanal dünyanın iç içe girdiği bir teknolojidir. Askeri, sanayi, tıbbi, ticari, reklam ve eğlence alanlarında sıklıkla kullanılan artırılmış gerçeklik eğitim alanında da kullanılmaya başlanmıştır. Eğitim alanında kullanılmasındaki amaç çocukların merak duygusunu geliştirmek, derslerde kullanılan materyaller ile katılıma teşvik ederek öğrenme sürecini kolaylaştırmak, sınıf ortamında yapılması mümkün olmayan konuların hazırlanmasına olanak sağlamasıdır. Bu projede hikâye kitaplarındaki olay akışını çocuklara hissettirmek, dikkatlerini çekmek ve okuma isteklerini artırmak için bu teknolojiden yararlanılmaktadır. Yapılacak uygulamada artırılmış gerçeklik geliştirme ortamlarından Unity3D ve Vuforia SDK (yazılım geliştirme kiti) yazılımları kullanılmıştır.3 boyutlu görsellerin birleştirilerek olayın akışına göre hareket eden karakterler ve olayın sesli bir şekilde de duyulabileceği bu sayede çocukların dinleyerek ve gözlemleyerek hem görsel hem de işitsel duyularının gelişeceği düşünülmektedir. Öğrenciler üzerinde gerçekleştirilen testlerde başarılı dönüşler elde edilmiştir.

Augmented Reality Approach for Stories

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ABSTRACT

Along with the developing technology in recent years, our lifestyle and habits have also changed. Many new applications are emerging every day. One of these applications is the augmented reality application. Augmented reality is designed to improve people's perception of reality. Augmented reality is a technology in which the real world and the virtual world are intertwined, displaying data such as computer-generated graphics, video and audio in real time on the physical elements we perceive in our environment. Augmented reality, which is frequently used in military, industrial, medical, commercial, advertising and entertainment fields, has also started to be used in the field of education. The purpose of its use in the field of education is to develop children's sense of curiosity, to facilitate the learning process by encouraging participation with the materials used in the lessons, and to enable the preparation of subjects that cannot be done in the classroom environment. In this project, this technology is used to make children feel the flow of events in storybooks, to attract their attention and to increase their desire to read. In the application to be made, Unity3D and Vuforia SDK (software development kit) software, which are augmented reality development environments, were used. It is thought that by combining 3D visuals, the characters moving according to the flow of the event and the event can be heard audibly, so that children's both visual and auditory senses will develop by listening and observing. Successful returns were obtained in the tests performed on the students.

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GİRİŞ (INTRODUCTION)

Son yıllarda gelişen teknoloji ile birlikte yaşam biçimimiz ve alışkanlıklarımız da değişmektedir. Her geçen gün birçok yeni uygulama ortaya çıkmaktadır. Bu uygulamalardan biri de artırılmış gerçeklik uygulamasıdır. Artırılmış gerçeklik insanların gerçeklik algısını geliştirmek için tasarlanmıştır. Artırılmış Gerçeklik (AG) teknolojileri geliştikçe kullanım alanları da her geçen gün artmaktadır. Bu değişim ve gelişim bireylerin gündelik yaşamlarını olumlu yönde etkilemektedir. Özellikle eğitim süreci ve ortamlarında bu teknolojinin kullanımı yaygınlaşmıştır [1]. Eğitim alanında yapılan çalışmalarla birlikte çocuklara yeni bir bakış açısı kazandırma, teknolojiden en verimli şekilde yararlanma ve çocukların dikkatini çekecek uygulamalar yapılmıştır. Geometrik şekillerin üç boyutlu hale getirilmesi, kimyada elementlerin, moleküllerin gösterilmesi coğrafya dersinde güneş sisteminin anlatımının gerçeğe yakın oranda benzetimiyle anlaşılır hale getirilmesi örnek olarak verilebilir. Bu sayede çocuklar derslerde sadece dinleyici olarak kalmayıp AG teknolojileriyle donatılan modellemeler ve dijital simülasyonlarla aktif olarak çalışarak etkinliklere katılımları sayesinde daha sosyal bir birey olma yolunda ilk adımlarını atmış olacaklardır.

Günümüz bilişim çağında teknolojik aletlere ulaşım kolaylaşmıştır. Buda toplumu dijitalleşmeye doğru sürüklemiştir [2]. Dijital çağın getirdiği birtakım yeniliklerle alışkanlıklarımız ve öğrenme biçimimiz de değişmiştir. Birçok alana AG teknolojisinin girmesiyle yeni bir dönem başlamıştır. Bu yeni dönemde eski ürünlerin yerini yeni ve daha gelişmiş dijital ürünler almıştır [3]. AG teknolojisinin gün geçtikçe geliştiği ve telefonlarda da kullanılmaya başlanmasıyla hayatımızın her alanına girmiştir. Bu çalışma alanlarından biri de eğitim alanıdır [4].

AG uygulamaları ile çocuklara sunulan kolaylıklar sayesinde çocukların dersi anlama ve derse katılımlarında olumlu değişimler gözlemlenmiştir [5]. Bir dinozorun eğlenceli hikâyesinin anlatıldığı Rocks In My Socks isimli etkinlik kitabı artırılmış gerçekliğin kullanıldığı çocuk kitaplarından biridir. Dinazor karakterlerini eşleştirme oyunu, müzik yapma ve dinozorları dans ettirme gibi etkileşimli aktiviteler bulunmaktadır. AG ile gerçekleştirilen bir başka hikâye kitabı ise Küçük Prenstir. Bu uygulamayı indirerek oyun, müzik ve üç boyutlu evrene yolculuk yapılabilmektedir. AG teknolojisinin kullanıldığı bir diğer hikâye kitabı ise Animal Kingdom'dur. Bu kitapta AG ile hayvanların vahşi yaşam özellikleri etkileşimli öğelerle sunulmuştur. Kitapta hayvanların vahşi yaşamı animasyonlarla desteklenerek hayvanları hareket ettirme, çalan müziği açıp katabilme ve farklı coğrafyadaki hayvanları tanıma imkânı sağlanmıştır [6]. Sinema, turizm, alışveriş, sağlık, müzeler, oyunlar vb. pek çok alanda karşımıza çıkan artırılmış gerçeklik teknolojisi, gerçek dünyamızın telefon, tablet, bilgisayar gibi teknolojik aletler yardımıyla sanal dünyayla zenginleştirerek insanların dokunma, hissetme gibi yaşattığı duygularla farklı bir bakış açısı kazanmasını sağlamaktadır [7].

Bu çalışmada, Nasrettin hocanın komik, eğlenceli ve düşündürücü fıkraları ile tavşan ile kaplumbağa kullanılmıştır. Çalışmanın ana temasında çocukları AG teknolojisi yardımıyla hem güldürüp hem de onların hikâyenin konusu üzerinde düşünmeleri amaçlanmıştır. Kitabın içinde geliştirilen olay örgüleriyle Nasrettin Hocaya sorulan sorularla ve hocanın sorulara verdiği cevaplarla çocuklara soru sorma becerilerini kazandırma, hikâyeyi diri tutma ve çocukların olaylara bakış açısını geliştirme konusunda önemli kazanımlar elde edilmiştir. Tavşan ile kaplumbağa hikâyesinde ise pozitif düşünülerek ve inanılarak her şeyin başarıla bileneceği ana konusunu çocuklara aktarmak ve bunu 3 boyutlu görsellerle zenginleştirerek olayları anlaşılır hale getirmek hedeflenmiştir .Bu projede sanal butonlar kullanılarak karakterlerin 3 boyutlu görsellerini hem büyütüp hem de küçültme butonları ile daha yakından görme fırsatı, durdurma, oynatma ve tekrar başlatma butonları ile olayları kontrol etme ve son olarak bölümler arasında geçişlerle uygulamanın hem kolay kullanılabilmesi hem de her yaş grubundaki çocuklara hitap etmesiyle ön plana çıkmaktadır.

MATERYAL VE METOT (MATERIALS AND METHODS)

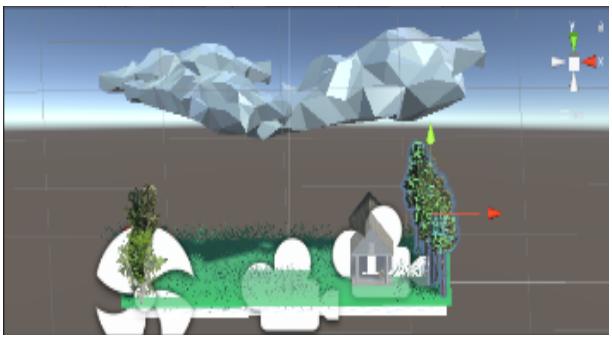
Bu uygulamada herhangi bir plana bağlı kalmadan ürün ortaya çıkana kadar kodlama yapılacağı için

kodla düzelt modeli kullanılmıştır. Küçük projeler için uygun olması, modelin herkes tarafından kullanılıyor olabilmesi, herhangi bir planlamaya ihtiyaç duymaması, analiz yapma vs. kısımlarla çok fazla ilgilenilmeden ana problem üzerine odaklanılarak sonuca gitmenin hedeflenilmesi modelin avantajlarından bazılardır [8]. Takım çalışması için uygun olmaması ve ne zaman biteceğinin belli olmaması dezavantajlarındandır.

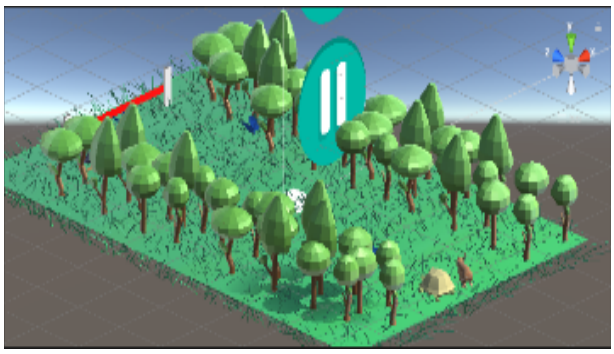
Bu çalışmanın geliştirilmesinde görüntü ve işaretçi tabanlı artırılmış gerçeklik sistemleri kullanılmıştır. Gerçek görüntü üzerine eş zamanlı olarak 3 boyutlu görsellerin, sanal verilerin eklenmesi esasına dayanır. Kullanıma göre işaretli ve işaretsiz tabanlı olarak ikiye ayrılır [9]. İşaretli tabanlı sistemde gösterilmesini istediğimiz nesnenin veya görselin sisteme daha önceden tanıtılması veya yüklenmesi gerekmektedir. Bu sistemin avantajları arasında fazladan donanıma ihtiyacının olmaması (gps, sensörler), yazılım desteğinin birden fazla oluşu ve kullanım alanının genişliği örnek olarak verilebilir [10]. Dezavantajı ise hedeflenen görselin veya nesnenin kameranın görüş alanında olması mesafe ile gelen görseli okuma sorunu uygulamanın çalışmasını etkileyen faktörlerdir [11].

Geliştirme ortamı için Unity 3D programı kullanılmıştır. Unity 3D programı ücretsiz olması, herhangi bir platforma (Mac, Android, PC vb.) dönüştürülebilmesi ve animasyonlar yapılabilmesinden dolayı tercih edilmiştir. AG uygulamasında işaret tabanlı yöntem kullanılmıştır. İşaret tabanlı AG platformu için ücretsiz Vuforia yazılım geliştirme kiti kullanılmıştır. Vuforia yazılım geliştirme kiti Android, iOS, Lumin ve UWP cihazları için AG uygulaması geliştirmeyi desteklemektedir. Unity 3D ile uyumlu ve hızlı şekilde çalışmasından dolayı tercih edilmiştir.

Çalışmada Nasrettin Hoca ve Tavşan-Kaplumbağa isimlerinde iki tane hikâye kullanıldı. Nasrettin Hoca hikâyesinin Unity 3D uygulamasında gerçekleştirilen AG çalışmasına ait bir kesit Şekil 1'de, Tavşan-Kaplumbağa hikâyesinin Unity 3D uygulamasında gerçekleştirilen AG çalışmasına ait bir kesit ise Şekil 2'de gösterilmiştir.

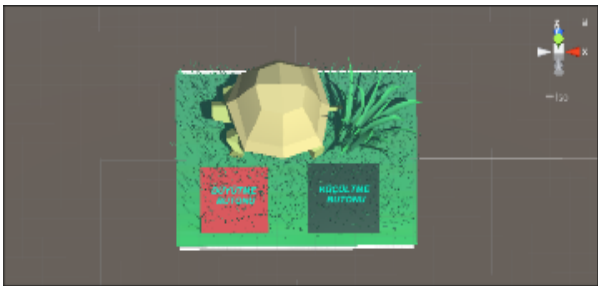


Şekil 1. *Nasrettin Hoca hikâyesi AG çalışması*

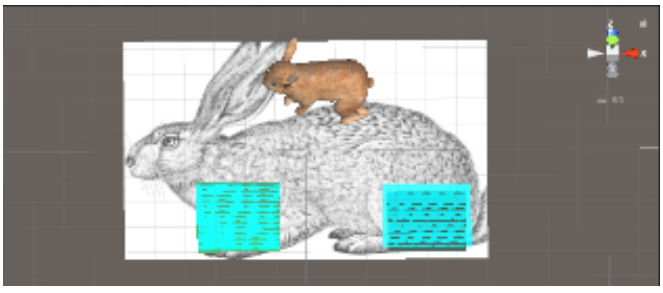


Şekil 2. *Tavşan kaplumbağa hikâyesi AG çalışması*

Tavşan-Kaplumbağa hikâyesinde kullanılan 3D kaplumbağa ve tavşan nesnelerinin büyütülmesi ve küçültülmesi için kullanılan menü tasarımları Şekil 3 ve Şekil 4'te gösterilmiştir.



Şekil 3. *Kaplumbağa sanal buton (büyütme küçültme)*



Şekil 4. *Tavşan sanal buton (döndürme)*

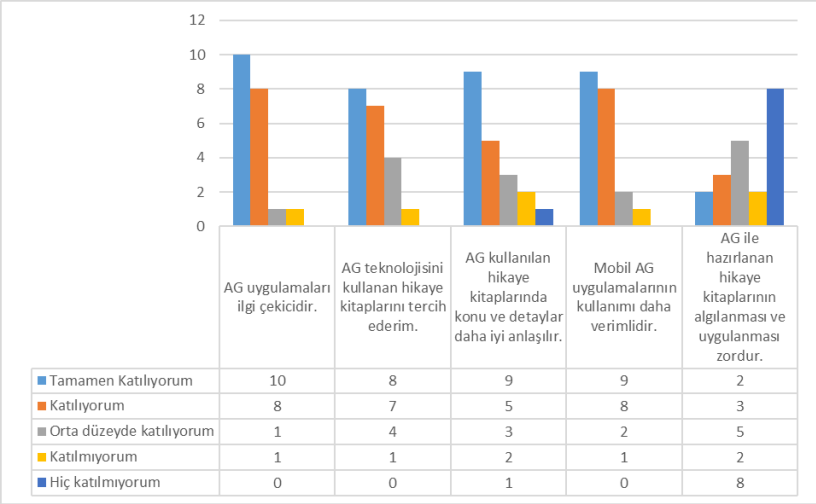
ARAŞTIRMA SONUÇLARI VE TARTIŞMA (RESULTS AND DISCUSSION)

Deneysel çalışmaya katılan 20 öğrenciye mobil AG uygulamasının kullanılabilirliğini ölçmek ve

değerlendirmek için 20 sorudan oluşan bir anket uygulanmıştır. Anketin cevap bölümünde 5'li Likert ölçeği (1=tamamen katılmıyorum ila 5= tamamen katılıyorum) kullanılmıştır.

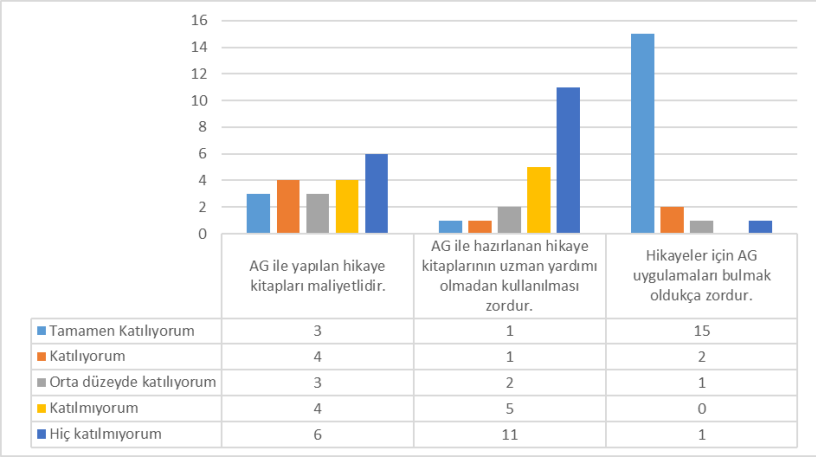
Şekil 5'te AG'nin önemi ve algısı ile ilgili ankete verilen yanıtların istatistiksel ve grafiksel sonuçları gösterilmiştir. Sorulara görüş bildirmeyen öğrenciler istatistiksel verilerin değerlendirilmesinde dikkate alınmamıştır. Deneysel çalışmaya katılan öğrencilerin %95'inin AG uygulamalarına ilgi gösterdiği görülmüştür. Öğrencilerin %95'inin AG teknolojisini kullanan hikâye kitaplarını tercih ettikleri anlaşılmıştır. Öğrencilerin %85'inin AG kullanılan hikâye kitaplarında konu ve detayların daha iyi anlaşıldığı belirtilmiştir. Katılımcıların %95'i mobil AG uygulamalarının kullanımını daha verimli bulmuştur. Deneye katılanların %75'i AG ile hazırlanan hikâye kitaplarının algılanması ve uygulanmasını zor görmemiştir.

Şekil 6'da AG maliyeti ve zorluğu ile ilgili ankete verilen yanıtların istatistiksel ve grafiksel sonuçları gösterilmiştir. Deneysel çalışmaya katılan öğrencilerin %50'sinin AG ile yapılan materyallerinin maliyetli olmadığı kanaatinde oldukları görülmüştür. Öğrencilerin %90'ının AG ile hazırlanan hikâye kitaplarının uzman yardımına ihtiyaç duymadan öğrenilmesinin zor olduğu görüşünde olduğu tespit edilmiştir. Katılımcıların %90'ı hikâyeler için AG uygulamalarını bulmanın oldukça zor olduğu kanaatinde olduklarını belirtmişlerdir.



	AG uygulamaları ilgi çekicidir.	AG teknolojisini kullanan hikaye kitaplarını tercih ederim.	AG kullanılan hikaye kitaplarında konu ve detaylar daha iyi anlaşılır.	Mobil AG uygulamalarının kullanımı daha verimlidir.	AG ile hazırlanan hikaye kitaplarının algılanması ve uygulanması zordur.
Tamamen Katılıyorum	10	8	9	9	2
Katılıyorum	8	7	5	8	3
Orta düzeyde katılıyorum	1	4	3	2	5
Katılmıyorum	1	1	2	1	2
Hiç katılmıyorum	0	0	1	0	8

Şekil 5. *AG'nin önemi ve öğrenilmesi.*

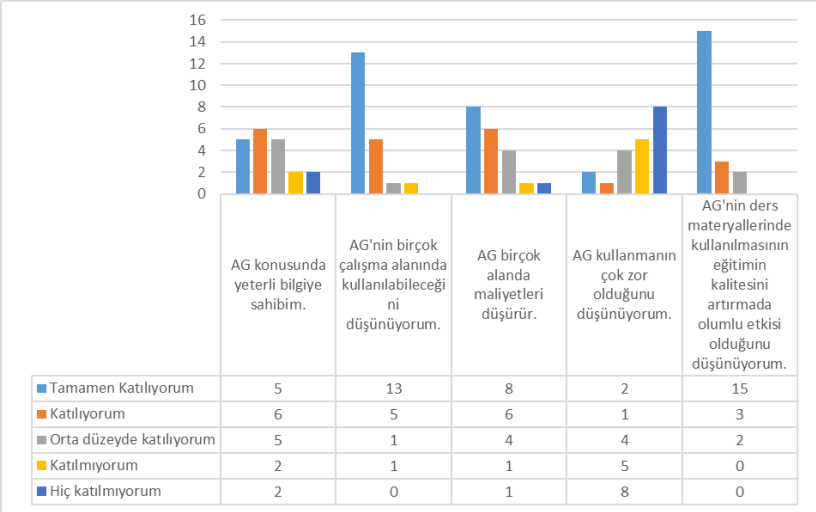


	AG ile yapılan hikaye kitapları maliyetlidir.	AG ile hazırlanan hikaye kitaplarının uzman yardımı olmadan kullanılması zordur.	Hikayeler için AG uygulamaları bulmak oldukça zordur.
Tamamen Katılıyorum	3	1	15
Katılıyorum	4	1	2
Orta düzeyde katılıyorum	3	2	1
Katılmıyorum	4	5	0
Hiç katılmıyorum	6	11	1

Şekil 6. *AG'nin maliyeti ve zorluğu.*

Şekil 7'de AG yönteminin önemi ve kullanımı ile ilgili sorulara verilen cevapların istatistiksel değerleri ve grafikleri gösterilmiştir. Deneysel çalışmaya katılan öğrencilerin %80'inin AG yöntemi hakkında yeterli

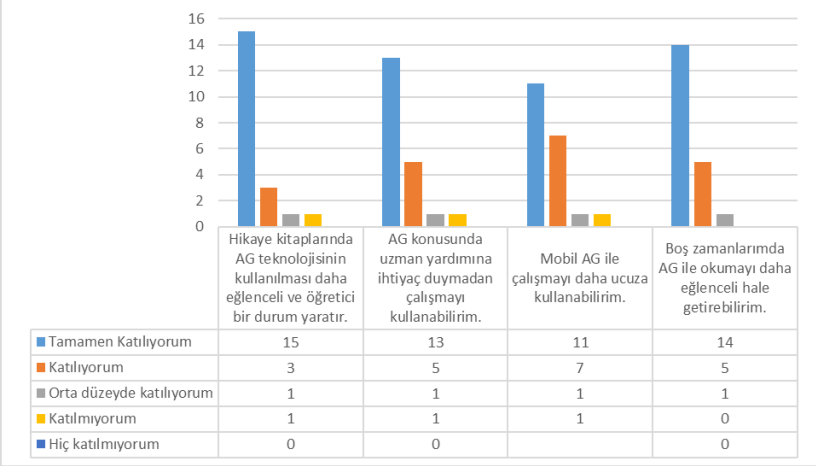
bilgiye sahip olduğu belirlenmiştir. Deneysel çalışmaya katılan öğrencilerin %95'inin AG'nin birçok çalışma alanında kullanılabileceğini düşünmüştür. Deneysel çalışmaya katılan öğrencilerin %90'ının AG yönteminin birçok alanda maliyetleri düşürdüğünü belirtmişlerdir. Deneysel çalışmaya katılan öğrencilerin %85'inin AG kullanımının zor olmadığı fikrine sahip olduğu belirlenmiştir. Deneysel çalışmaya katılan öğrencilerin tamamının ders materyallerinde AG yöntemi kullanılarak eğitim kalitesinin önemli ölçüde arttığını düşündükleri görülmüştür.



	AG konusunda yeterli bilgiye sahibim.	AG'nin birçok çalışma alanında kullanılabileceğini düşünüyorum.	AG birçok alanda maliyetleri düşürür.	AG kullanmanın çok zor olduğunu düşünüyorum.	AG'nin ders materyallerinde kullanılmasının eğitimin kalitesini artırmada olumlu etkisi olduğunu düşünüyorum.
Tamamen Katılıyorum	5	13	8	2	15
Katılıyorum	6	5	6	1	3
Orta düzeyde katılıyorum	5	1	4	4	2
Katılmıyorum	2	1	1	5	0
Hiç katılmıyorum	2	0	1	8	0

Şekil 7. *AG yönteminin kullanımı ve önemi.*

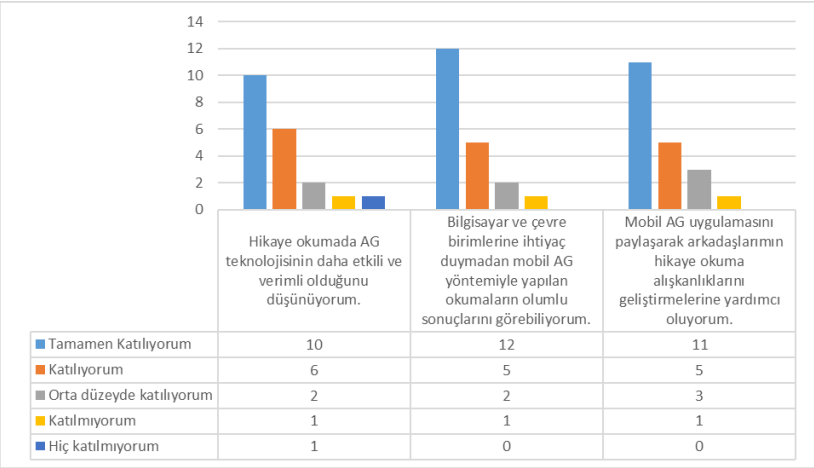
Şekil 8'de AG uygulamasının hikâye alanına katkısı ile ilgili sorulara verilen cevapların istatistiksel değerleri ve grafikleri gösterilmiştir. Deneysel çalışmaya katılan öğrencilerin %95'inin hikâye uygulamalarında AG teknolojisini kullanarak daha eğlenceli ve öğretici bir ortam olduğunu düşündükleri görülmüştür. Deneysel çalışmaya katılan öğrencilerin %95'inin AG konusunda uzman yardımına ihtiyaç duymadan çalışmayı kullanabilecekleri görülmüştür. Öğrencilerin %95'i hikâye kitaplarını mobil AG ile daha ucuza kullanabileceklerini belirtmiştir. Deneysel çalışmaya katılan öğrencilerin tamamı boş zamanlarında AG ile okuma yapmayı daha eğlenceli hale getirebileceklerini söylemiştir.



	Hikaye kitaplarında AG teknolojisinin kullanılması daha eğlenceli ve öğretici bir durum yaratır.	AG konusunda uzman yardımına ihtiyaç duymadan çalışmayı kullanabilirim.	Mobil AG ile çalışmayı daha ucuza kullanabilirim.	Boş zamanlarımda AG ile okumayı daha eğlenceli hale getirebilirim.
Tamamen Katılıyorum	15	13	11	14
Katılıyorum	3	5	7	5
Orta düzeyde katılıyorum	1	1	1	1
Katılmıyorum	1	1	1	0
Hiç katılmıyorum	0	0		0

Şekil 8. *AG uygulamasının eğitime katkısı.*

Şekil 9'da mobil AG uygulamasının hikâye alanına katkısı ile ilgili sorulara verilen cevapların istatistiksel değerleri ve grafikleri gösterilmiştir. Deneysel çalışmaya katılan öğrencilerin %90'ının hikâye okumada AG teknolojisinin daha etkili ve verimli olduğunu düşündükleri belirlenmiştir. Öğrencilerin %95'inin bilgisayar ve çevre birimlerine ihtiyaç duymadan mobil AG yöntemiyle yapılan okumaların olumlu sonuçlarını görebildiği görülmüştür. Katılımcıların %95'i mobil AG uygulamasını paylaşarak arkadaşlarının hikâye okuma alışkanlıklarını geliştirmelerine yardımcı olduklarını belirtmiştir.



Şekil 9. *Mobil AG uygulamasının eğitici katkısı.*

Hikâye alanında yapılmış bu çalışmanın kullanımına yönelik çocuklardan gelen dönütler incelendiğinde çocukların uygulamanın menülerini kolay kullanabilmesi ve işaretleyicileri uygulamaya rahat bir şekilde adapte ettirebilmeleri uygulamanın kullanılabilirliğini artırmıştır. Ayrıca işaretleyicilerin hareket halinde de uygulama tarafında algılanması, hikâye üzerinde nesnelerin gösterimi ve kodların çözümlenmesinin doğru olarak çalıştığı gözlemlenmiştir. Bu çalışma farklı teknolojik cihazlarla da kullanabilmesi için kullanımının daha kolay ve erişimin daha hızlı olması sağlanmıştır.

Mobil cihazlar için geliştirilen bu AG uygulamasında tasarlanan menü yardımı ile 3D nesneleri ve detaylı bilgiler hikâye kitapları üzerinde gösterilmiştir. Ayrıca uygulamada 3D nesnesinin 360 derece döndürülmesi, büyültme ve küçültme işlemleri de yapılmıştır.

Geliştirilen uygulama kullanılırken çocukların hikâyeye olan ilgilerinin ve konsantrasyonlarının önemli oranda arttığı gözlemlenmiştir.

SONUÇ (CONCLUSION)

Artırılmış gerçekliğin eğitim alanında kullanılması öğrenme biçimini de değiştirmiştir. Bu süreçte çocuklara eğitimin tam verilebilmesi için öğreten kişilerinde bu süreçte dikkat etmesi gereken birtakım unsurlar bulunmaktadır. Öğreticilerin de AG teknolojileri hakkında bilgi sahibi olması gerekmektedir. Yapılan uygulamaların çocuklar üzerinde bıraktığı olumlu veya olumsuz gelişmeler dikkate alınmalıdır. Elde edilen bu veriler ilerleyen zamanlarda yapılacak uygulamalar için önemli bir kaynak olacaktır. Hikâye kitapları alanında yapılan çalışmalarda bu elde edilen veriler ihtiyaçların giderilmesi için önemli gelişmeler sağlayacaktır. Çocukların yaratıcılığını artırmaya, konsantrasyonlarını güçlendirmeye ve konular üzerinde düşündürmeye yönelten bu hikâye kitaplarında AG teknolojisi kullanılarak okumaya yeni bir boyut kazandırmıştır.

Teknolojinin sunduğu imkânlarla donatılan ses, animasyon ve görüntü teknikleri ile desteklenen bu hikâye kitabında geleneksel yaklaşım ile teknoloji bir araya getirilmiştir. AG teknolojisinin hikâye kitabını destekleyen zengin içeriği ile çocuklara unutulmaz bir deneyim yaşatılmıştır. Bu sayede çocuklar için kitapların aslında eğlenceli olduğu, okuma sevgilerinin ve okuma alışkanlıklarının kazanılacağı düşünülmüştür.

AG teknolojisini eğitimde kullanırken dikkatli olmak gerekiyor. Teknolojinin getirdiği yenilik ve kolaylıkların çocukları tembel ve bağımlı hale getirmeden düşünmeye ve problemleri çözmeye yönelik adımlar atılmalıdır. Bunun için öncelikle öğreten kişilerin AG konusunda bilinçlendirilmesi ve gerekli donanıma sahip olması gerekmektedir. Öğrenme çağındaki çocukları teknolojiye bağımlı hale getirmeden teknolojiyi en verimli şekilde kullanmalarını sağlamak gerekir. AG uygulamalarının çocuklar üzerinde olumlu sonuçlar doğurduğu bilinmektedir.

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3D Beden Ölçülerinin 2D Görüntülerden Elde Edilmesi için Net Silüetler

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ÖZ

3D beden ölçülerinin 2D görüntülerden elde etmek için net silüetler gerekmektedir. Yazarların 3D beden ölçülerini elde etmek için 2D görüntülerden piksel koordinatları ile yeni bir yöntem geliştirdikleri devam eden araştırmalarında el ile ve beden tarayıcıları ile yaygın olan beden ölçüsü almak için bedene ihtiyaç duyulmayacağı için ve giysilerin e-alışverişler ile artması ile ortaya çıkan bedene oturmama probleminin çözülmesi amaçlandığı için, ilk adım, önden ve yandan çekilmiş fotoğraflardan net beden silüetlerinin elde edilmesidir. Bu makalenin amacı, net beden silüetlerinin elde edilmesi için, yeni geliştirilen ve ImPrNGF-1.0 ve ImPrNGF-2.0 adları verilen görüntü işleme programları ve yine yeni geliştirilen ve Python programlama dilindeki PyNGF-1 adı verilen programın geliştirilmesinde yapılan araştırmaların sunulmasıdır. Geliştirilen bu üç yeni programlarda izlenen işlem basamakları, önden ve yandan görüntülerde renkli görüntüyü gri tona dönüştürerek bir beden silüeti elde etmek, eşik değerleri ve ikili dönüşüm, farklı eşik değeri algoritmalarının uygulanması ile karşılaşılan problemlerin tanımlanması, Paint 3D programı ile arka planın kaldırması (arka planın temizlenmesi) (gürültünün azaltılması), kenar algılama algoritmasını çalıştırılması (Sobel filtresi) ve elde edilen görüntünün negatifinin alınmasıdır. Böylece net beden silüetlerinin elde edilmesi başarılmıştır ve 3D beden ölçülerinin 2D görüntülerden elde edilmesi amacı için kullanılması mümkün olmaktadır.

Sharp Silhouettes for Obtaining 3D Body Measurements from 2D Images

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ABSTRACT

Sharp silhouettes are needed for obtaining 3D body measurements from 2D images. Since the main goal in the authors' continuing research where a new method with pixel coordinates is developed to obtain 3D body measurements from 2D images, eliminating the need for human body common in manually and body scanning techniques, and solving the unfit problem aroused with increasing e-shopping of garments, the first step is to receive sharp body silhouettes derived from photographs taken from the front and side. The objective of current manuscript is to present the research done to obtain sharp body silhouettes by, first, developing new image processing programs named ImPrNGF-1.0 and ImPrNGF-2.0, then developing another new program in Python programming language named PyNGF-1. The procedures followed in these new developed three programs are obtaining the body silhouettes from the front and side images by converting color image to grayscale, thresholding and binary transformation, indicating the problems encountered by applying different threshold value algorithms, background (noise) removal with Paint 3D program (background cleaning), running edge detection algorithm (Sobel filter), and attaining the negative image which is finally the sharp silhouette achieved for obtaining 3D body measurements from 2D images.

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INTRODUCTION

Internet is widespread all over the world and is used intensely leading to e-shopping being preferred more and more every day via online stores. Considering Türkiye, the rate of internet usage is increasing significantly in due time, being 45.0% of the households in 2011 and up to 92.0% in 2021. On the other hand, the rate of internet usage among individuals aged 16-74 was 42.9% in 2011 and increased to 82.6% in 2021 (Figure 1). The proportion of same individuals who purchased goods or services over the internet was 8.4% in 2011 and it increased significantly to 44.3% in 2021 (Figure 2). Among people using internet for shopping, 70.7% of individuals purchased apparel, shoes and accessories in the first three months of 2021. Internet shopping is expected to increase further in the coming years [1].

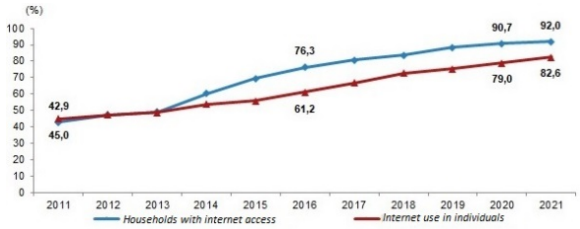


Figure 1. *Internet use in households and individuals with internet access between 2011-2021 [1]*

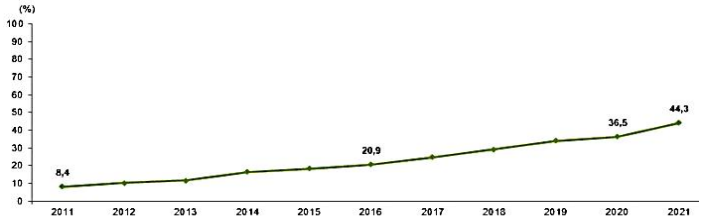


Figure 2. *Individuals aged 16-74 who purchased goods or services over internet 2011-2021 [1]*

There are many problems consumers face while e-shopping garments such as there are different measurements of the same size, lack of large size products, faulty products in fabric or sewing, short arm lengths for tall people or vice versa, unsuitable colors for the chosen ones, and the most important of all is that the clothes bought do not fit the person's own body, the unfit problem. It is aimed in our research to solve the unfit problem by obtaining 3D body measurements from 2D body measurements where the body measurements of the consumer will be determined by using the two-dimensional front and side images of the consumer, and it will be ensured that the clothes they buy will fit their body perfectly, besides, the need for the body to take body measurements will be eliminated. While working, the need to obtain sharp silhouettes from 2D images aroused. In this manuscript the intensive research of the reference studies conducted to obtain sharp body silhouettes is presented.

Body measurements are one of the most important data in apparel making. When done in tailor sense, the tailor takes body measurements from our body by hand and the product fits us when sewn. The case leading to the unfit problem is the improvement of ready-wear industry because when production is done massively it is unknown to whom the product will be sold, so body measurements needed to be generalized. Expressions like S, M, L or 36, 38, 40, etc. are developed and these didn't fit everyone's body, arousing the unfit problem. In the traditional way of obtaining body measurements manually, the human body and a non-stretchable tape measure are used. In Figure 3, some examples of the definitions of body measurements and the way they are taken are given [2, 3], they are standardized by ISO-8559. With the rapid improvement of technology, body scanning technologies are developed to obtain body measurements quickly, easily and more precisely, also aiming to get over the unfit problem but as mentioned above the generalized sizes are still limiting them. Some examples of body scanning systems are TC^2 3D Body Scanner, Cyberware, Polyworks, Anthroscan, Vitus, etc. (Figure 4). These systems take cross-sectional images from different areas by scanning the body from top to bottom, allowing examining the body in terms of cross-sectional shape, slice area and volume [4]. 3D body scanning systems offer solutions to problems especially in the apparel industry. With the improvement of 3D body scanner technologies, time saving and flexibility in the processes of clothing production such as resequencing and sizing of the garment have been achieved. Another benefit can be named as to be able to dress clothes on 3D models and show virtually how the clothes look on the model

[5]. Besides, a calibrated Kinect sensor was also used to obtain widths at different positions like shoulder width, bust width, arm open width, total height and hand up height. These measurements were obtained with accuracies of 98.46% to 99.6%, when compared with the results of sensor and the actual body measurements. It was suggested that this kind of a depth image sensor can be used as an alternative way to measure body measurements [6]. Additionally, virtual fitness tests were performed for online shopping after body measurements were taken with a 3D body scanner [7]. These body scanners still need the human body to obtain the body measurements, whereas in our research, the need for the human body will be eliminated because the front and side images will be used and the unfit problem will be solved.

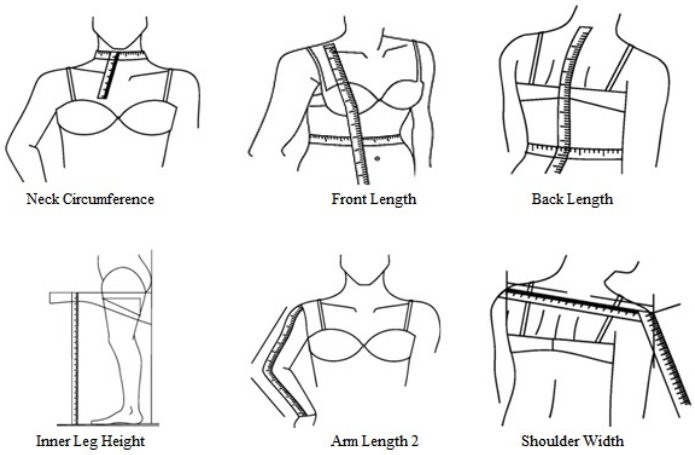


Figure 3. *Method of taking body measurements by hand [2, 3]*

(a) *(b)* *(c)*

Figure 4. *Examples of body scanning systems a) TC² 3D Body Scanner b) Cyberware c) Vitus [4]*

In literature, there are studies on investigating the suitability of standard body sizes, where standard size trousers provide a good fit especially in small size groups, while problems with large sizes, hence tailor-made production for people with large bodies and non-standard body shapes [8]; establishing a neck circumference size estimation model (Figure 5), top view of the created neck circumference measurements (Figure 6) [9]; acquiring the chest circumference by comparing the measurements obtained from the 2D images and the elliptical measurements obtained from the virtual mannequin [10]; examining the simulation systems in garment design and body sizing, and explaining that they can be used for cross-sectional areas of body measurements with B-spline curve approaches, and developing software to extract body measurements from a 3D body scanner (Figure 7-9) [11,12].

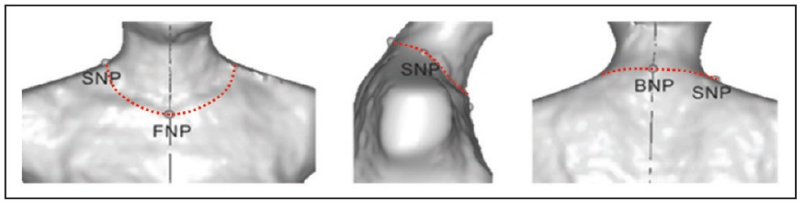


Figure 5. *Establishing a neck circumference size estimation model [9]*

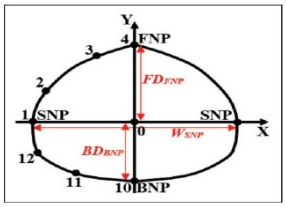


Figure 6. *Top view of the created neck measurement [9]*

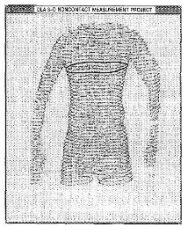


Figure 7. *Cross-sectional areas of body measurements [11]*

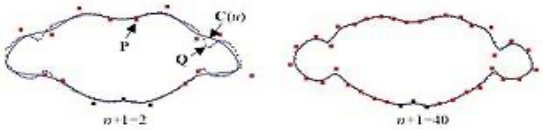


Figure 8. *B-Spline curve approaches [11]*

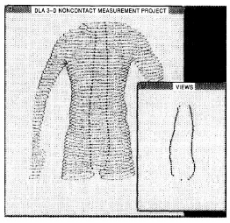


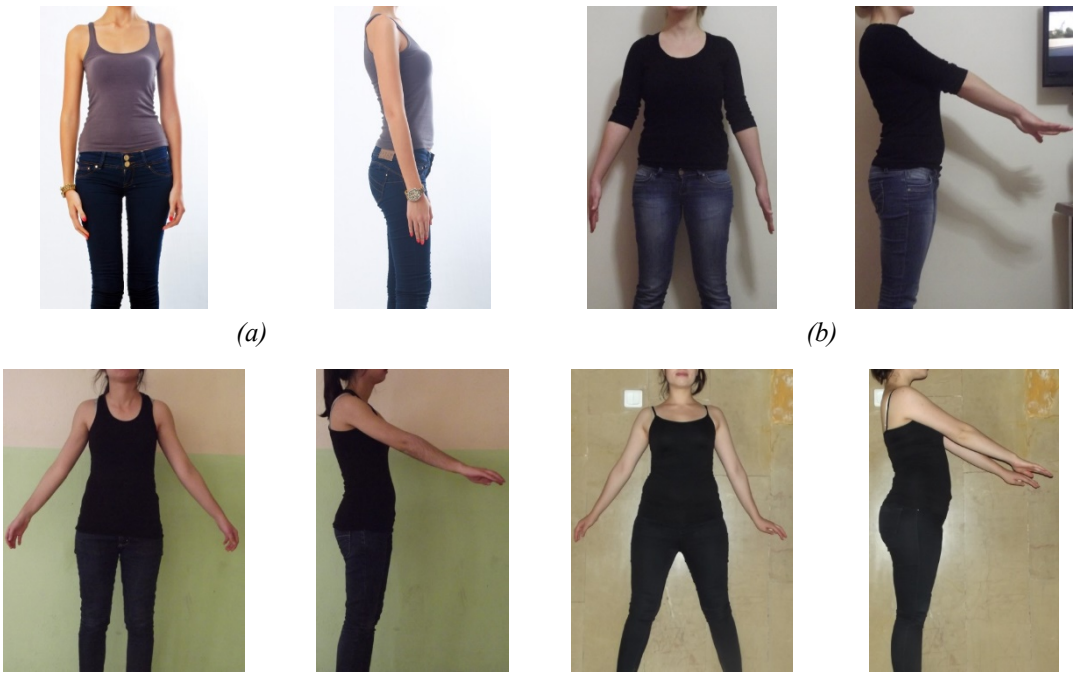
Figure 9. *Developing software to extract body measurements [12]*

Another important literature on this subject is initiating a study to obtain 3D body measurements from 2D images to eliminate the need for body when taking body measurements by hand or body scanners and to seek a solution to the problem of not fitting of the garment to the body. The photographs of 500 female participants aged 18-25, all volunteers, weights 43-85 kg, wearing tight clothes, from 3 m distance, from front and side rotated 90^0, from neck and to knees, arms and legs slightly open, using a camera that focuses on the waist and parallel to the ground, the camera being digital Canon EOS 7D and Fujifilm FinePix S2980 brand were taken. Some examples of the photographs for Person-13, Person-137, and Person-433 are given in Figure 10. Different body measurements up to 20 were manually measured according to ISO-8559 standard using a non-stretchable tape measure, and the age, height and weight of the same person were recorded. In the mentioned research, the descriptive statistics of the obtained data were calculated, and the relationships between height and weight were examined with regression analyses [2, 13].

In this research, to reach the goal of obtaining 3D body measurements from 2D images, first a sharp silhouette of the front and side images is searched and presented here.

MATERIALS AND METHODS

Sharp silhouettes for obtaining 3D body measurements from 2D front and side images is presented in this manuscript. Sharp silhouettes are the initial step of the present research to obtain 3D body measurements from 2D front and side images, incidentally the attributing studies are exhibited here. The material used in this research is mainly the front and side photographs of females [2, 13]. They are necessarily benefited to acquire sharp silhouettes for obtaining 3D body measurements from 2D images. Some other examples of the photographs from the front and side for Person-10, Person-9, and Person-14 are given in Figure 11 [2, 13].



(a) *(b)* *(c)* *(d)*

Figure 10. *Examples of photographs from front and side, a) Person-1, b) Person-13, c) Person-137, and d) Person- 433 [2,13].*

(a) *(b)* *(c)*

Figure 11. *Examples of photographs from front and side, a) Person-10, b) Person-9, and c) Person-14 [2,13].*

In this research, in order to acquire sharp silhouettes for obtaining 3D body measurements from 2D front and side images, new image processing programs are developed. Two of them are the programs in Microsoft Visual Studio in C# programming language Windows Form Application and Visual Studio Code compiler in image processing which are named as ImPrNGF-1.0 and ImPrNGF-2.0, besides the OpenCV (Open Source Computer Vision) library is also taken advantage of. The third one is in Python programming language, which is named as PyNGF-1. The procedures followed in these new developed programs are obtaining the body silhouettes from the front and side images by converting color image to grayscale, then thresholding and binary transformation, indicating the problems encountered and how they are solved, later background (noise) removal with Paint 3D (background cleaning), running the edge detection algorithm (Sobel Filter), and finally attaining the negative image, they will be explained in detail in the next section. At the end, sharp silhouettes are successfully obtained for the purpose of obtaining 3D body measurements from 2D images.

RESULTS AND DISCUSSION

In this research, studies are conducted to acquire sharp silhouettes for obtaining 3D body measurements from 2D front and side images. Below are explained the intensive work carried out, the results, and discussion to reach this goal.

Obtaining Body Silhouettes with the New Developed Program ImPrNGF-1.0

The front and side images to obtain body silhouettes are colored as seen in Figure 10 and 11. It is first needed to transform the color images into grayscale images. Grayscaling needs further work to get only the outlines with thresholding and binary transformation to obtain body silhouettes. The structural design to convert the color images to grayscale and thresholding and binary transformation are explained in the following sections below:

Converting Color Image to Grayscale

In general, each pixel in a color image consists of three color components, which are red, green, and blue (RGB), and each component in a pixel is given a value between 0 and 255. If the RGB is (0, 0, 0) respectively, then the color is black, similarly, white when they are (255, 255, 255). The gray color has equal RGB values, where light gray is defined by (230,230,230), and dark gray (100,100,100), furthermore, a dark pink color is reached with (200, 20, 80). In Figure 12, examples of RGB values for dark pink and dark gray colors are given [14].

(a) *(b)*

Figure 12. *Examples of RGB values, a) Dark pink (200, 20, 80); b) Dark gray (100, 100, 100) [14]*

When a color pixel is converted to grayscale, the arithmetic average of the RGB values is taken and the resultant value is assigned to all three RGB components [15]. The dark pink color in Figure 12a possesses RGB values (200, 20, 80), their average is given in Equation 1, which is 100, and this value is issued to each RGB component, outcoming as (100, 100, 100), indicating the final grayscale of the dark pink color pixel in Figure 12b.

$$\text{Gray Value} = (R+G+B) / 3 \quad (1)$$

Gray Value= (200+20+80)/3=100 for each RGB

When the image is taken as a whole, the average of RGB in every pixel is calculated one by one and replaced within the same pixel, at the end the whole image turns into different shades of gray. In this research, the new developed program ImPrNGF-1.0 is compiled and executed successfully on Microsoft Visual Studio. The algorithm structure C# programming language is used in this program to convert the color image to grayscale and it is as given below:

```
1 private Bitmap griYap(Bitmap bmp)
2 {
3  for (int i = 0; i < bmp.Height - 1; i++)
4  {
5    for (int j = 0; j < bmp.Width - 1; j++)
6    {
7      int gray = (bmp.GetPixel(j, i).R + bmp.GetPixel(j, i).G + bmp.GetPixel(j, i).B) / 3;
8      Color grayscale = Color.FromArgb(gray, gray, gray);
9      bmp.SetPixel(j, i, grayscale);
10    }
11  return bmp;
12 }
```

In this algorithm, for-loops are used and in this case two for-loops are used to reach all of the pixels in the images. The pixels are recognized by the (i, j) components, vertical and horizontal, respectively. Sequentially one pixel is taken with “GetPixel” function, it is transferred to the predefined variable "int gray", the “Color.FromArgb” function takes the average of RGB values of that special pixel, “SetPixel” function replaces the RGB color components of that pixel with the average color value calculated. When (i++, j++) reaches the end, the image in different shades of gray is obtained. An example of gray scale conversion for Person-1 is given in Figure 13.

(a) *(b)* *(c)* *(d)*

Figure 13. *Converting the color image of Person-1 to grayscale, a) Color image front, b) Grayscale image front, c) Color image side, d) Grayscale image side*

Thresholding and Binary Transformation

In the thresholding and binary transformation process, the average color value of each pixel in the grayscale picture is compared with a certain threshold value chosen according to a certain goal, which is such as applying a kind of filter. When a threshold value 240 is chosen; if one special pixel of a grayscale image contains an average color value 220 , then the value of 220 is compared with the threshold value 240 and since it is below the threshold value the program replaces it with 0, so, that pixel is turned into black; in the same way, if another pixel of a grayscale image contains and average color value of 250 , then the value of 250 is compared with the threshold value 240 and since it is above the threshold value the program replaces it with 255, so, that pixel is turned into white (Equation 2). Correspondingly when the same thresholding is applied to all of the pixels in a grayscale image then the image is transformed into a binary system of black and white [15]. In this research the semi-body silhouettes are obtained by thresholding and binary transformations after the color images are converted to grayscale.

$$f(x,y) = \begin{cases} 0, if\ g(x,y) < T = 240 \\ 255, \quad g(x,y) \geq 240 \end{cases} \quad (2)$$

Problems Encountered

In working with different front and side images of females to obtain the body silhouettes via the new developed program ImPrNGF-1.0, some problems are encountered. It is thought that these problems would not lead to sharp silhouettes, so the images are worked on neatly and precisely to overcome these problems. A list of the problems encountered is given below:

- The background of the image is dark, besides the person is wearing dark cloths, there is no contrast between them, so unable to reach a silhouette (The same is true with light colored background and light-colored clothes)
- Presence of some objects disrupting the silhouette line such as a hairpin, hat, ring, watch, bracelet, even a curl of hair itself
- Standing position of the person such as one shoulder up or down, or arms not open enough, or arm covering chest on the side image
- Clothes of the person such as the being loose clothing makes it difficult to get the body silhouette, the pointed end of the short sleeves, traces of garment collar, folds of the clothing, etc.
- The thickness of the silhouette line
- The underarm is not aligned on the horizontal axis in the side image but has an inclined posture
- Noise in the silhouette image
- Shadows reflecting on the background but detected as a part of the body

The main screen of the new developed program ImPrNGF-1.0 is shown in Figure 14 and examples of the problems encountered by applying ImPrNGF-1.0 to Person-9 (Figure 15) and Person-10 (Figure 16) are given. First the color images are converted to grayscale and then are studied at the 180 threshold to obtain the silhouettes. The silhouettes are successfully obtained but there are problems encountered as mentioned above. For example, in Figure 15, the shadow of the right leg and the shadow of the left arm fall on the door, unfortunately silhouettes for these shadows are also obtained. Similarly, in Figure 15, the traces of the collar create a silhouette, which is not needed in the present research and considered as noise. Another example in Figure 16, there are problems with the folding of the T-shirt at the waist both in the front and a side image, the standing position of the lady is inclined, and the edge of the short sleeve T-shirt of right arm. Both have a curl of hair seen in the side image (Figure 15) and front image (Figure 16) disrupting the silhouette. Excessive amount of noise in the form of black dots appeared around the neck of the body silhouette obtained, which disrupt the silhouette and lead to redundant pixels as seen in Figures 15 and 16.

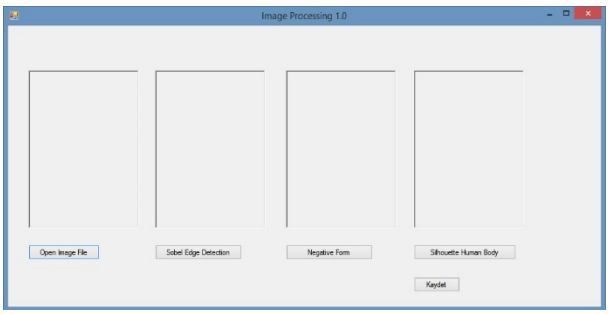


Figure 14. *Main screen of the new developed program ImPrNGF-1.0*

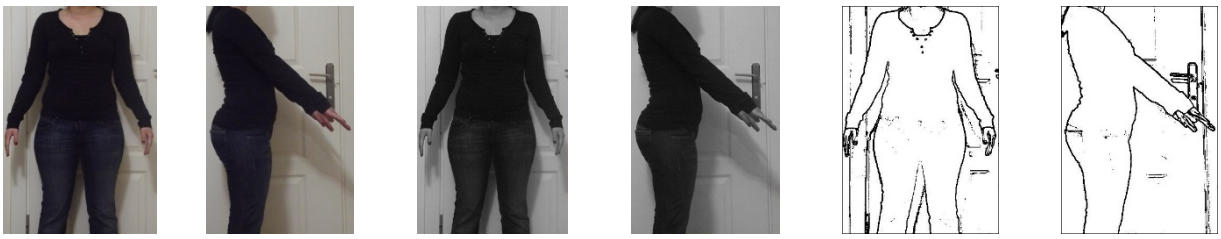


Figure 15. *Original color images of Person-9 front and side; grayscale images, and silhouettes obtained with ImPrNGF-1.0 at threshold 180*

Figure 16. *Original color images of Person-10 front and side; grayscale images, and silhouettes obtained with ImPrNGF-1.0 at threshold 180*

First of all, the problems encountered needs to be solved. To clarify the problems mentioned above, various studies have been conducted, each having different approaches and different points of views. In these studies, (1) thresholding and binary transformation studies with the new developed program ImPrNGF-1.0, (2) thresholding and binary transformation studies with the new developed program PyNGF-1, (3) background (noise) removal studies with Paint 3D Program are carefully applied with changing parameters to obtain a sharp body silhouette. A schematic workflow of the studies to clarify the problems to obtain a sharp body silhouette done is given in Figure 17.

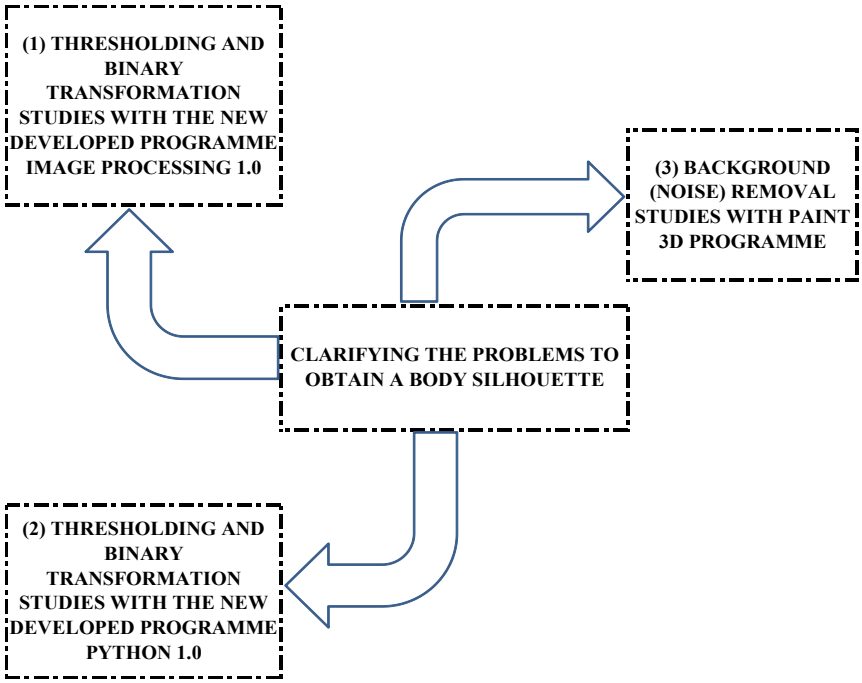


Figure 17. *Schematic workflow of studies to clarify the problems to obtain a sharp body silhouette*

Thresholding and Binary Transformation Studies with the New Developed ImPrNGF-1.0

The thresholding and binary transformations are applied to Person-9 in the new developed program ImPrNGF-1.0. The threshold values 100 , 140 , 200 , 220 , and 240 are applied as seen in Figures 18 – 22, respectively, and the body silhouettes are extracted. The outcome of each threshold value is examined in-depth and is observed that at the threshold values 100 and 140 there are some skipping points of the body silhouette especially at the right leg as seen in Figures 18 and 19, respectively; on the other hand at the threshold values 200 , 220 , and 240 the noise of the silhouettes obtained are increasing as the threshold values increase, so they become darker and darker, and the problem of the shadow of the legs falling on the door also noted as a silhouette are seen in Figures 20 – 22, respectively. No sharp body silhouettes are obtained with the new developed program ImPrNGF-1.0 demonstrated according to the criteria of this research. This situation exhibited excessive amount of noise in the form of black dots evident around the neck of the body silhouette obtained, which disrupt the silhouette and lead to redundant pixels as seen in Figures 18-22, needed denoising.

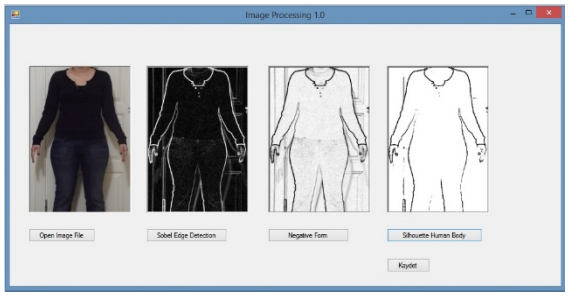


Figure 18. *Silhouette extraction with ImPrNGF-1.0 for Person-9 at threshold value 100*

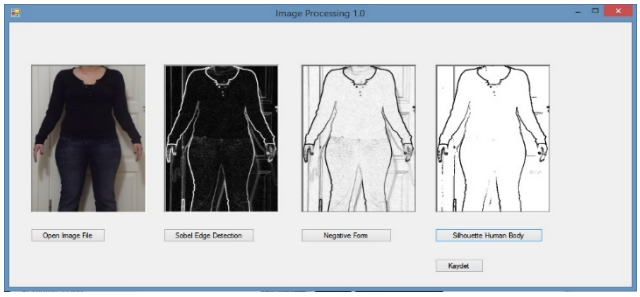


Figure 19. *Silhouette extraction with ImPrNGF-1.0 for Person-9 at threshold value 140*

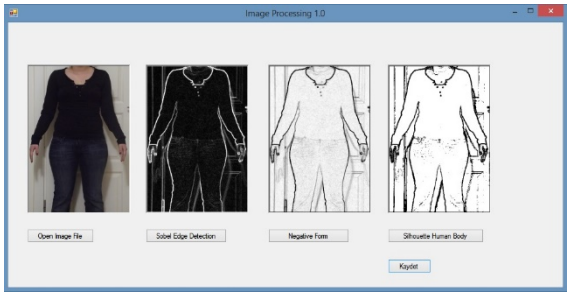


Figure 20. *Silhouette extraction with ImPrNGF-1.0 for Person-9 at threshold value 200*

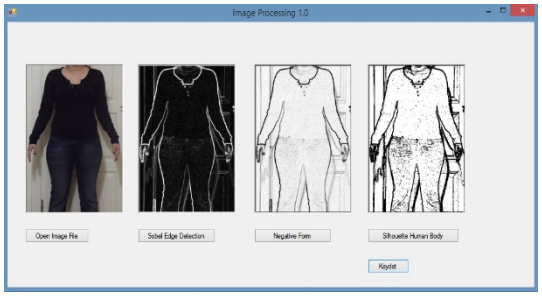


Figure 21. *Silhouette extraction with ImPrNGF-1.0 for Person-9 at threshold value 220*

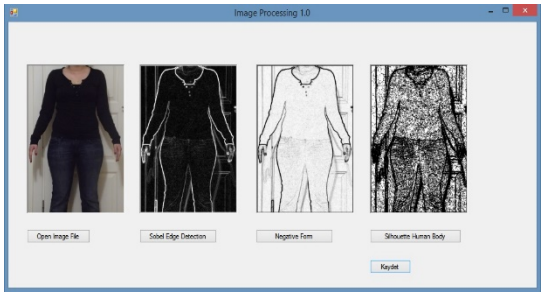


Figure 22. *Silhouette extraction with ImPrNGF-1.0 for Person-9 at threshold value 240*

Thresholding and Binary Transformation Studies with the New Developed Program PyNGF-1

The objective of applying different thresholding and binary transformations and attaining their negatives is to obtain sharp body silhouettes. To achieve this target, another program is developed in the Python programming language in Visual Studio Code compiler and is named PyNGF-1. The main screen of the new developed program PyNGF-1 is seen in Figure 23 for Person-1. The different threshold values 200, 220, 230,

240 and 250 are applied with this new program as seen in Figure 24 a-e. The outcome of each threshold value is examined in-depth and is noted that at the threshold value 200, white spots occurred around the neck which disrupt the silhouette and lead to redundant pixels; at the threshold values 220 and 230 , black and heavy black shadows appeared at the lower right corners, respectively; at the threshold value 240 , these shadows appeared on both sides of the image, even more intensely; at the threshold value 250 , the black color dominated the whole image and no clear silhouettes are obtained. Nevertheless, the research is continued and to reach the goal of obtaining clear silhouettes, the negatives of each image is attained at different threshold values with the new developed program PyNGF-1. In Figure 25, the attained negatives of the threshold values 200, 220, 230, 240 and 250 are seen. The outcome of negative of each threshold value is examined in-depth and is observed that at each of the threshold value there are some skipping points in the silhouette, noise occurred, the silhouette starts to disappear at the left leg at the threshold value 240, and almost totally disappearing in 250, revealing to no apparent silhouettes.

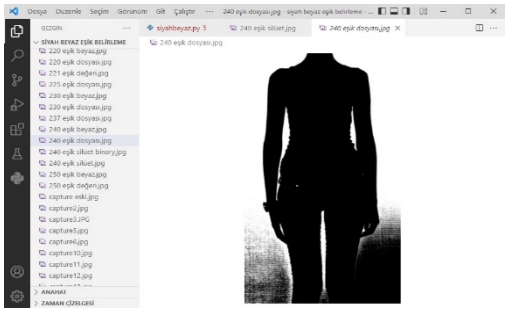
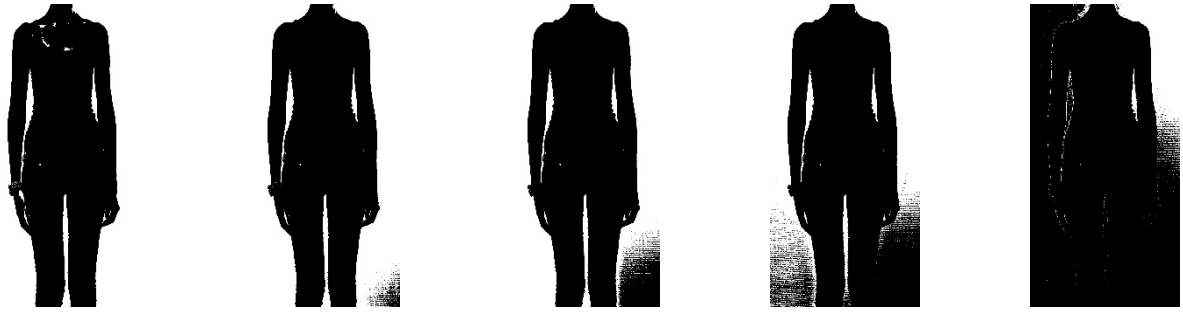
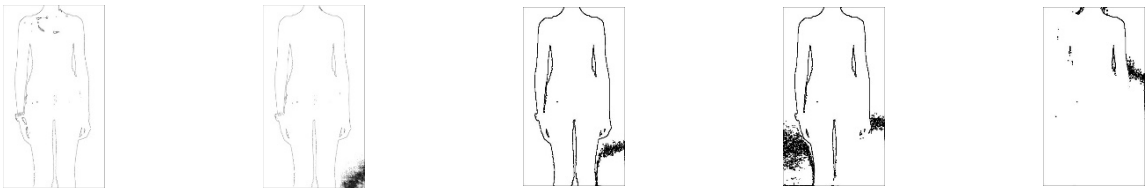


Figure 23. *Main screen of the new developed program PyNGF-1 for Person-1*



(a) *(b)* *(c)* *(d)* *(e)*

Figure 24. *Different threshold values with PyNGF-1 for Person-1, a) 200, b) 220, c) 230, d) 240, e) 250*



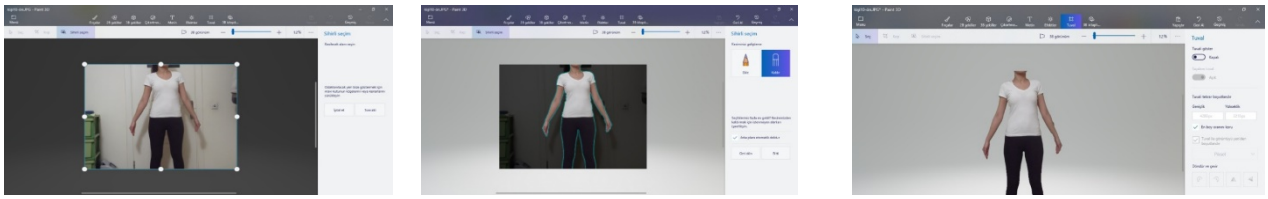
(a) *(b)* *(c)* *(d)* *(e)*

Figure 25. *Negatives of different threshold values with PyNGF-1 for Person-1, a) 200, b) 220, c) 230, d) 240, e) 250*

Background (noise) Removal Studies with Paint 3D Program (Background Cleaning)

The edge detection performed with the new developed program ImPrNGF-1.0 could not eliminate the problems to obtain a sharp body silhouette. To express more clearly, the background is included in the thresholding and binary transformations, in silhouette formation, and in attaining the negative. In this case, to achieve the goal of obtaining of a sharp body silhouette, the Paint 3D program is used to remove the background of the color image. The steps of background removal process in Paint 3D are; the color image is

loaded first (Figure 26a) then with the magic selection button the object to be focused on is selected, Person-10 in this case, the magic selection selects this object and determines its outlines (Figure 26b), at this point minor changes can be done slightly to arrange some edge regions of the object with the "Add/Remove" button, and then it removes the background of the color image and a clear object is left. In Figure 26c, the selected object which is saved as a new image file is seen where the background is removed.



(a) *(b)* *(c)*

Figure 26. *Working with Paint 3D Program, a) Color image loaded, b) Magic selection of the object, c) Selected object and removed background*

Obtaining Body Silhouettes with the New Developed Program ImPrNGF-2.0

After the background is removed, the new image file is processed with another new developed program ImPrNGF-2.0 based on Microsoft Visual Studio in C# programming language. The main screen of this other new developed program ImPrNGF-2.0 is seen in Figure 27.

Thresholding and Binary Transformation Studies with the New Developed ImPrNGF-2.0

Person-10 is processed with ImPrNGF-2.0, the different threshold values 200 and 240 are applied as seen in Figures 28-31. The outcome of each threshold value is examined in-depth and is noted that at the threshold value 200, much noise in the form of black dots appeared around the neck of the body silhouette obtained which disrupt the silhouette and lead to redundant pixels as seen in Figure 28 and 29, Person-10 front and side, respectively. At the threshold value 240, a sharp silhouette is satisfactorily extracted, the resultant silhouette reveals essentially no redundant pixels, as seen in Figures 30 and 31, Person-10 front and side, respectively, which provides the silhouette to be used in the following sections of the present research. From the aspect of effectiveness, obtaining sharp silhouettes is achieved.

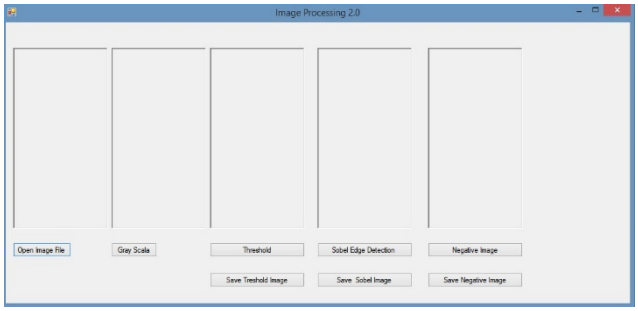


Figure 27. *Main screen of another new developed program ImPrNGF-2.0*

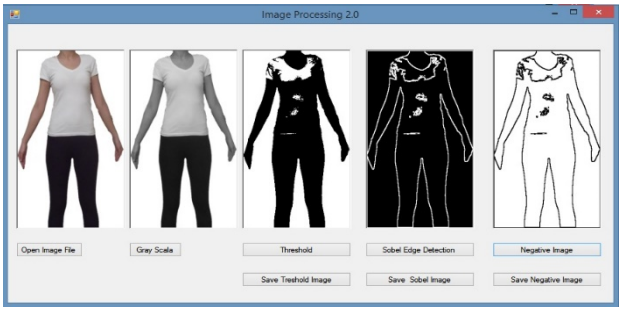


Figure 28. *Silhouette extraction with ImPrNGF-2.0 for Person-10 front at threshold value 200*

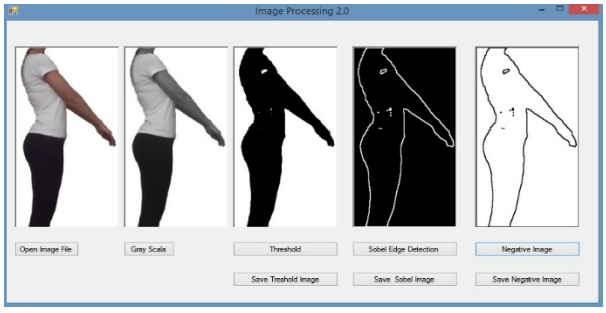


Figure 29. *Silhouette extraction with ImPrNGF-2.0 for Person-10 side at threshold value 200*

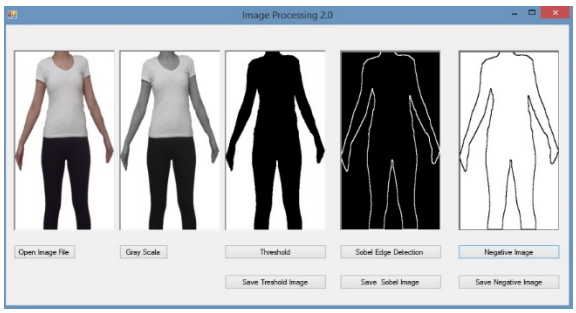


Figure 30. *Silhouette extraction with ImPrNGF-2.0 for Person-10 front at threshold value 240*

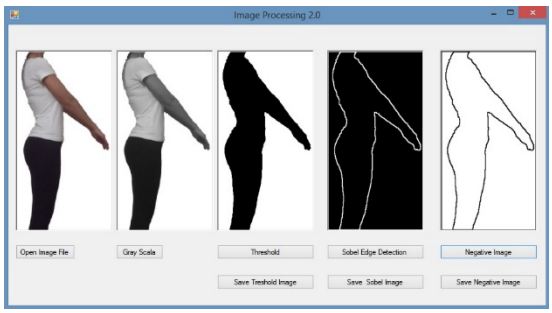


Figure 31. *Silhouette extraction with ImPrNGF-2.0 for Person-10 side at threshold value 240*

Edge Detection Algorithm (Sobel Filter) with the New Developed Program

While extracting the silhouette of the body, it is as well important to detect the edges of it also. In this new developed program ImPrNGF-2.0 it is taken the advantage of Sobel filter which detects the areas of high color variations in a grayscale. Besides detecting, this filter can efficiently dissociate the color differences and highlights them as edges. Sobel filter does these processes with masks and in the present research two different masks are used for edge detection, one for the vertical axis and one for the horizontal axis. An example of Sobel masks is given as in Figure 32 [16].

-1	0	1
-2	0	2
-1	0	1

G_x Mask

-1	-2	-1
0	0	0
1	2	1

G_y Mask

Figure 32. *Example of Sobel masks, a) Vertical axis edge detection mask, b) Horizontal axis edge detection mask [16]*

An application of Sobel masks is given in Figure 33 where A is an example of an original image, Gx and Gy masks are the matrices of the vertical and horizontal axes, respectively, Gx and Gy values are the multiplication of Gx and A, and of Gy and A. To determine the edge regions, the Gx and Gy masks are applied starting from the second row and second column of the original image as shown in Equations 3 and 4 where the Gx and Gy values are calculated. For the calculation of Gx value, the matrix of the original image A and the matrix of Gx mask are multiplied, the result is Gx=400. Similarly, for the calculation of Gy value, the matrix of the original image A and the matrix of Gy mask are multiplied, the result is Gy=0 . The mathematical model of their squares for the Sobel filter masking G value is given in Equation 5 and is the square root of the sum of the Gx and Gy values where the result is G = 400.

A: Example of an original image
G_x mask: Matrix of the vertical axis
G_x value: Multiplication of G_x and A
G_y mask: Matrix of the horizontal axis
G_y value: Multiplication of G_y and A

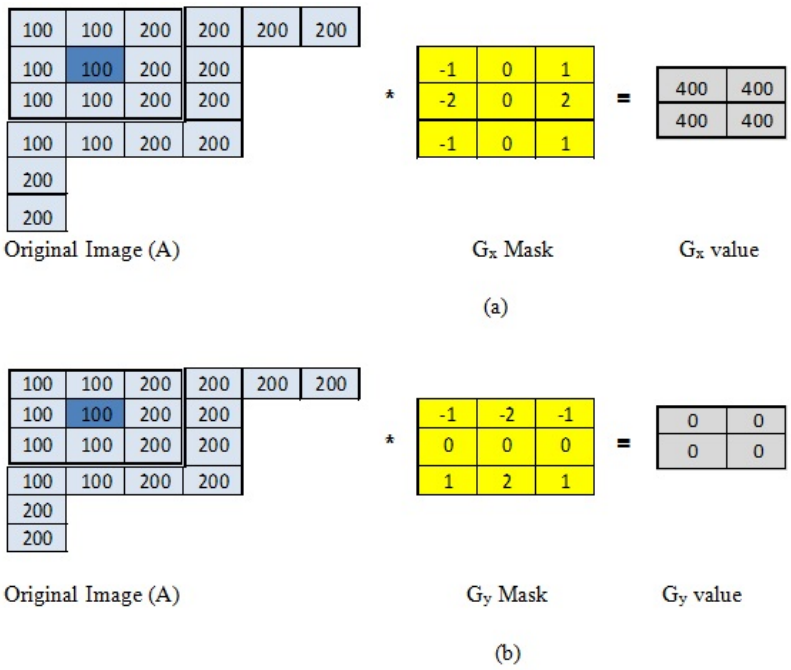


Figure 33. *Sobel Filter, a) Vertical mask, b) Horizontal mask*

$$A=\begin{bmatrix}100 & 100 & 200\\ 100 & 100 & 200\\ 100 & 100 & 200\end{bmatrix}\quad Gx=\begin{bmatrix}-1 & 0 & 1\\ -2 & 0 & 2\\ -1 & 0 & 1\end{bmatrix}*A\quad Gy=\begin{bmatrix}-1 & -2 & -1\\ 0 & 0 & 0\\ 1 & 2 & 1\end{bmatrix}*A \tag{3}$$

$$Gx(2,2)=\begin{bmatrix}100 & 100 & 200\\ 100 & 100 & 200\\ 100 & 100 & 200\end{bmatrix}*\begin{bmatrix}-1 & 0 & 1\\ -2 & 0 & 2\\ -1 & 0 & 1\end{bmatrix}$$

$$Gx\ (2,2)=[100*(-1)+(100*0)+(200*1)+100*(-2)+(100*0)+(200*2)+(100*(-1)+(100*0)+(200*1)]=-400+800=400$$

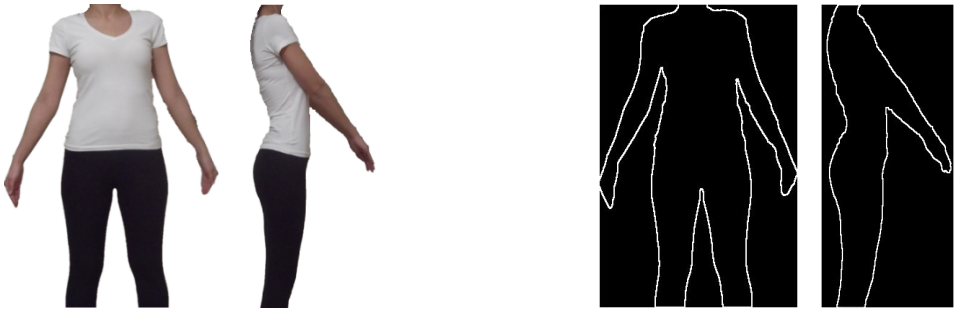
$$Gy(2,2)=\begin{bmatrix}100 & 100 & 200\\ 100 & 100 & 200\\ 100 & 100 & 200\end{bmatrix}*\begin{bmatrix}-1 & -2 & -1\\ 0 & 0 & 0\\ 1 & 2 & 1\end{bmatrix} \tag{4}$$

$$G^2=Gx^2+Gy^2$$

$$G^2=400^2+0^2$$

$$G^2=400^2\ and\ G=400 \tag{5}$$

This procedure of Sobel filter masking is for only one pixel, so the same have to be done for all the pixels in the image. At the end, an image is obtained showing the edges of the original image. In the present research Sobel filter is applied to the image of Person-10 obtained with the new developed ImPrNGF-2.0. Since the determined threshold value is 240, Sobel filter compares the calculated G value for each pixel with this threshold value, and if it is higher than 240 that pixel is assigned as white, and if it is lower than 240 that pixel is assigned as black. The background removed image and the resulting silhouette image provided after Sobel filter is given in Figure 34.

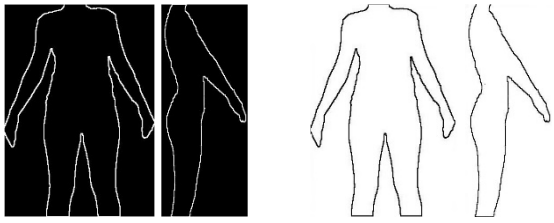


(a) (b)

Figure 34. *Person-10, a) Background removed image, b) Silhouette obtained after Sobel filter*

Attaining the Negative Image with the New Developed Program ImPrNGF-2.0

When Sobel filter process is completed, an image in black and a white silhouette line is derived from the color image. A need arouses to change the colors to just the opposite where the black areas will be white and the white silhouette line black. Since it is explained in Section 3.1.4 that black is symbolized with the number 0 and white the number 255 in the RGB color components, to attain the negative of the image simply each pixel color value must be subtracted from the number 255 in a for-loop. The remaining pixel color value gives the negative pixel color value accordingly [15]. In the current research, the silhouette is obtained by taking the negatives of the front and side image after Sobel filters process. Figure 35 shows Sobel filter process and after the negative image attained for Person-10.



(a) (b)

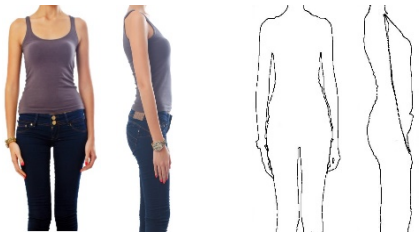
Figure 35. *Person-10, a) Sobel filter process, removed image, b) Negative image attained*

(a) (b)

Figure 36. *Person-10, a) Background b) silhouette image*

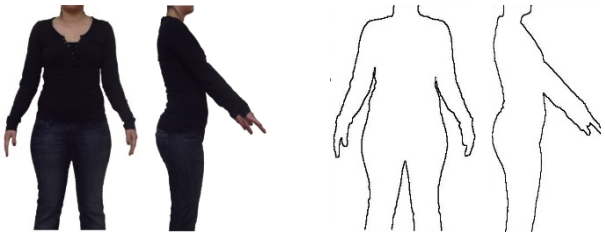
For Person-10, the background removed image for the front and side to directly their silhouettes as the negative images attained are performed as seen in Figure 36.

The same reasonable operations are applied to Person-1, Person-9 and Person-14, and their background removed images for the front and side directly to their silhouettes as the negative images attained are provided in Figures 37-39, respectively.



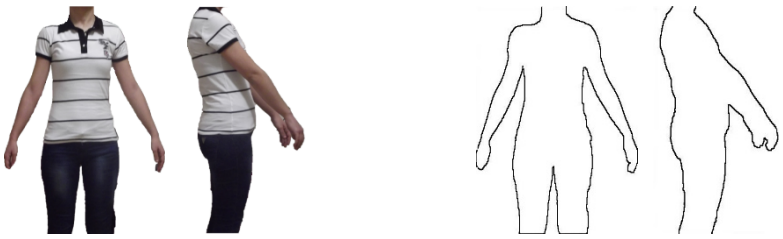
(a) (b)

Figure 37. *Person-1, a) Background removed image, b) Silhouette image*



(a) (b)

Figure 38. *Person-9, a) Background removed image, b) Silhouette image*



(a) (b)

Figure 39. *Person-14, a) Background removed image, b) Silhouette image*

The workflow chart of procedures followed in this research is briefly summarized in Figure 40.

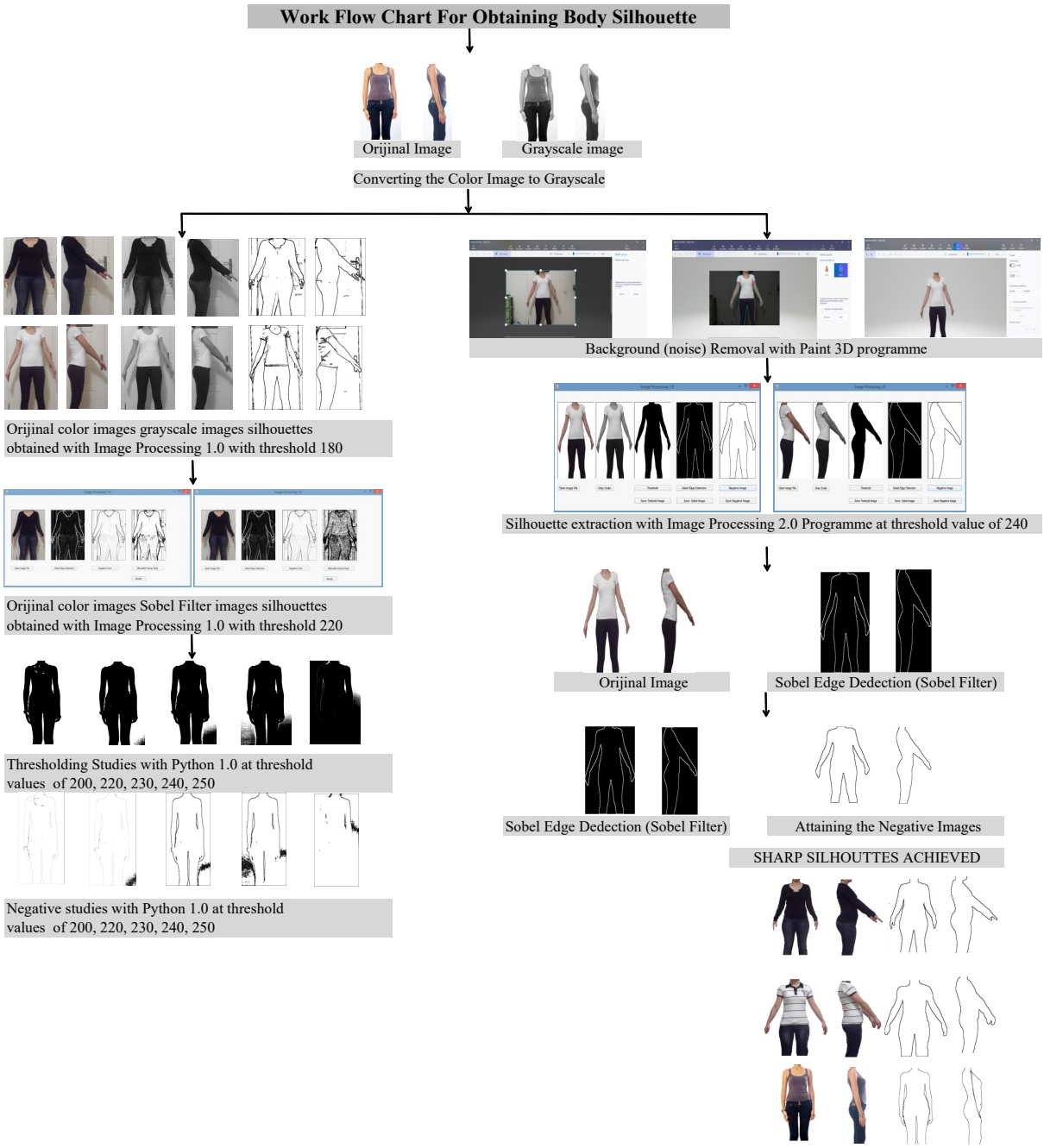


Figure 40. *Workflow chart of procedures followed in this research*

CONCLUSION

Body measurements are one of the most important data in apparel making. When done in tailor sense, tailor takes body measurements from our body by hand and the end-product fits us. With the improvement of ready-wear industry, it is unknown to whom the product will be sold, so body measurements are generalized. Size expressions like S, M, L or 36, 38, 40, etc. are developed and apparel mass produced but then the unfit problem to one's body aroused. Body scanning technologies are developed to get over the unfit problem. Besides, e-shopping of garments is increasing rapidly and the biggest problem encountered in these cases is the purchased product is not suitable for the person's body, again the unfit problem. Body scanning technologies and manually taken body measurements all need the human body to take body measurements. In order to eliminate the need for the human body and to solve the unfit problem, it is thought to obtain 3D body measurements from 2D images and in the current paper it is presented how sharp silhouettes are obtained for this purpose. The 2D images are one photograph taken from the front and one from the side rotated 90^0, female participants between ages 18-25, all volunteers, between weights 43-85 kg, wearing tight clothes, from 3 m distance, from neck and to the knees, arms and legs slightly open, using a camera that focuses on the waist and parallel to the ground [2, 13].

In this research, photographs from the front and side are used to quickly and accurately acquire sharp silhouettes for obtaining 3D body measurements from 2D images. First the color images are converted to grayscale and thresholding and binary transformation is applied with the new developed program in image processing program named ImPrNGF-1.0. But problems are encountered at this step such as no contrast with the background and the color of cloth worn, some objects disrupting the silhouette line, standing position of the person, clothes of the person, thickness of the silhouette line, side image arm position, noise in the silhouette image, and shadows reflecting on the background but detected as a part of the body. To clarify these problems, image processing studies with the new developed program in Python programming language named PyNGF-1 is conducted besides thresholding and binary transformation studies with the new developed ImPrNGF-1.0 but was not satisfactory for the current research. Then, background (noise) removal with Paint 3D (background cleaning) program is used which is helpful to get good looking front and side images. Another programd is developed ImPrNGF-2.0 and is successful. With this program it is concluded that the threshold value 240 is appropriate. After applying edge detection algorithm (Sobel filter) and attaining the negative image with the new developed ImPrNGF-2.0, perfect sharp silhouettes are achieved, revealing essentially no redundant pixels, for obtaining 3D body measurements from 2D images. A workflow chart is also presented to summarize the procedures followed in this research and the same are applied to other photographs taken.

The prescribed research is of remarkable significance to assist future work to obtain 3D body measurements from 2D front and side images. By this means, the need for human body when taking body measurements by hand and body scanners will be eliminated, made-to-fit apparel like tailor sense will be realized, the unfit problem in mass production and e-shopping will be solved and e-shopping will be much easier and extensive, and will promote less costs at today's level of competition.

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Kadastro 2034'e Doğru Kuzey Makedonya Kadastrosu

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Kuzey Makedonya.

ÖZ

Bu çalışmanın temel amacı, Kuzey Makedonya Cumhuriyeti'nin mevcut kadastrosunun ve kadastro sisteminin tanımlanması ve bu tanım aracılığıyla, bu çalışmadaki temel kaygı, Kadastro 2034 çerçevesinde Kuzey Makedonya kadastrosunun sunulmasıdır. Kadastro 2034 kavramına giden yol, çerçeve çalışmaları, görev ve sorumlulukları ile birlikte Kadastro 2014 kavramı tarafından yönlendirilmekte ve formüle edilmektedir ve bu nedenle bunun bir incelemesi de yapılmıştır. Bir vaka çalışması olarak, Kuzey Makedonya'nın Pollog bölgesine kadar uzanan Tetovo şehrinin ilçesinin bir parçası olan Shemshovo'nun kadastro belediyesi seçilmiştir. Kuzey Makedonya'nın mevcut kadastrosunun günümüzde karşı karşıya olduğu zorlukların, sorunların ve engellerin belirlenmesi ve açıklığa kavuşturulması, Kuzey Makedonya kadastrosunun Kadastro 2034 çerçevesinde olması için yapılması gerekenlerin ve takip etmesi gereken kilit noktaların neler olduğu konusunda sonuçlara ulaşma yolumuzu kolaylaştırmaktadır. Bu aynı zamanda mevcut kadastronun geleceğin kadastrosuna giden yolunu da basitleştirir. Bu da bizi bu çalışmanın formülasyonunu bir bütün olarak çizmeye ve özetlemeye ve ardından aynı konu ve aynı kavramla ilgili gelecekte yapılacak diğer çalışma ve araştırmalara önerilerde bulunmaya yöneltmiştir.

North Macedonian Cadastre Towards Cadastre 2034

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ABSTRACT

The main aim of this study is the definition of the actual cadastre and cadastral system of the Republic of North Macedonia, and through this definition, the main concern in this study is the presentation of the North Macedonian cadastre in the framework of the Cadastre 2034. The path towards the Cadastre 2034 concept is directed and formulated by the Cadastre 2014 concept, along with its framework tasks and responsibilities, and due to this, a review of this has also been carried out. As a case study, it was chosen to be the cadastral municipality of Shemshovo, which is part of the district of the city of Tetovo, extending to the region of Pollog, North Macedonia. The identification and clarification of the challenges, problems and obstacles that the current cadastre of North Macedonia face in our time, simplifies our way towards obtaining the results of what needs to be done and what are the key points that the North Macedonian cadastre must follow in order to be within the framework of the Cadastre 2034. This also simplifies the path of the actual cadastre towards the cadastre of the future. This lead us to draw and summarize the formulation of this study as a whole, and following later, to give recommendations for other studies and researches that will take place in the future, related to the same topic and the same concept.

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INTRODUCTION

The creation and development of robust cadastral systems, as well as their maintenance, affect the development and progress of society. It also affects the development of individual professionals and professions in different fields. Simultaneously, it plays a decisive and very important role in the progress and maintenance of the development of economic, social, political, cultural, civic and national processes. Undoubtedly, because of technical development, technological development and digitization, many changes are observed in different sectors and fields. The same developments are inevitable in the cadastral sector and cadastral works. These results and leads in the tendency to reform, develop and improve cadastral systems and cadastre in general and in particular. The result of this is the creation of new automated and digital infrastructures that seem to be much more vital. The same developments are foreseen and planned by analyzing the general demands and needs. Subsequently, this enables the creation of a strategy, which provides facilities for access, information retrieval, use, and other diverse requests. Created strategies, depending on the purpose, can be short-term strategies and long-term strategies. The same helps the realization of stated goals and enables predictions, forecasts, and preliminary plans to reach the desired objectives, goals, and targets.

Cadastre 2014 incorporates data, information and recommendations on the long-term status of the future of the cadastral system frameworks within the globe, present reform projects, trends and patterns related to the cadastre, and what ought to be done to create this part more viable and more effective [1]. The cadastral frameworks of the future may only support to the extension of the field of ownership by being a framework or a system that ensures or assurance this ownership [2]. The focus of Cadastre 2034 is shaping the future cadastre or the vision of the future, by continuing and proceeding with the enhancement suit and method as advanced in Cadastre 2014, and as an outcome of these demands, six standards, principles, or six fundamental pillars for Cadastre 2034 have been decided and situated [3,4]. The main aim of Cadastre 2034 is to shape the cadastre of the future by continuing the reform process as developed in Cadastre 2014 [5], and Statements of Cadastre 2014, announced by FIG [6]. Focus is given to their applicability in current contexts [3]. To remain relevant cadastral science must continue to look to the future: potential challenges and opportunities need identification, analysis and response [3]. In arranging the Cadastre 2034 guidelines, each standard, principle, or pillar is determined or decided to be the outcome of the internal and external environment analysis. Such, it is vital to show lawfully substantial, quick, precise, and definitive cadastral data information, which enacts a key part in the assembly of financial, property, tax assessment, spatial arranging, and land–land arrangement in the utterance of social needs and requests [7]. Cadastres must continue to change to meet the challenges of poverty, environmental protection, good governance and economic stability [3]. Subsequently, harmonized cadastral data information from diverse sources ought to be shared among numerous users, clients, and applications [7].

This study is organized into six sections. Within these sections, the Introduction part is prepared to be presented as a first section; enabling a general background and the main objective of this study or this paper. The purpose or the main objective of this study is to provide a general framework regarding the cadastre, and its development in the Republic of North Macedonia, its reflection in modern future times, especially within the vision of the Cadastre 2034, as well as the goals and objectives of the Cadastre 2034, following the strategies and recommendations of the same, to be part of the positive developments in the future, perhaps necessarily inevitable. The study aims to identify, present and make a general introduction of the predictions of Cadastre 2034, in cadastral works, in general and in particular, and the development of cadastre as a sector, thus is offered as a novelty or an innovation, not only in our country, but also at the same time for other developed and developing countries. The remaining part is organized as follows; after the introduction part, we develop the Problem Context, which contains part of the Cadastre 2014, Cadastre 2034 and North Macedonian Cadastre. Following is the Setting the scene section, where we are going to represent motivation and basic principles, scope and goals, strategies and problems, materials and methods, research questions and research design. The case study is the fourth section. In this part is presented the case of the study, namely

the Pollog region, the cadastral municipality of Shemshovo, city of Tetovo, and attached is displayed the investigation and occasion scrutiny. This study region was chosen because in this region or territory there are measurements carried out since the first geodetic and engineering measurements which date back to the very early days in the Republic of North Macedonia. These measurements are very important and represent high quality at the same time. Forecasting the future – 2034, is the fifth section. What should be emphasized in this part, is a general presentation about cadastral challenges, problems and obstacles in North Macedonia. Making a concept about the road of the cadastre of North Macedonia towards the cadastre 2034, leads and prepares us of what we must do and what must be done to be within the framework and on the road of the Cadastre 2034 concept. Yet, as the six section or as a final part of this work at the same time is the conclusion section, where we are going to summarise our work and conclude it. Also, it is worth noting that within this section, we also are going to make some recommendations and suggestions for future studies and future works.

PROBLEM CONTEXT

Cadastre 2014

The viewpoint provided by Cadastre 2014 is still relevant for a contemporary and actual modern cadastre. However, in addition to this perspective, it is also important to take into account the social and technological trends that will impact land management over the next 20 years [8]. Within the framework of Cadastre 2014, it is intended to ensure the legal security of all land rights, restrictions and responsibilities as well as their legal recognition [9,10]. The ideas of combining cadastral maps and records, aside from these objectives, cadastral modeling, cadastral modeling using information technology, empowering the participation of open and private division within the cadastral considers and conducting the cadastral applications as cost-recovery were decided within the Cadastre 2014 and after these principles and standards were distributed in 1998, they were interpreted in numerous different languages and they were utilizing as models for nations [1,8,10-12]. Undoubtedly, as in all other countries, also in the Republic of North Macedonia, the Cadastre 2014 has had a very important and almost irreplaceable impact. Cadastre 2014, or more precisely its principles, also known as the Statements (Statement 1, which quotes: “Cadastre 2014 will show the complete legal situation of land, including public rights and restrictions!”; Statement 2, which quotes: “The seperation between ‘maps’ and ‘registers’ will be abolished!”; Statement 3, which quotes: “The Cadastral mapping will be dead! Long live modelling!”; Statement 4, which quotes: “’Paper and pencil – cadastre’ will have gone!”; Statement 5, which quotes: “Cadastre 2014 will be highly privatized! Public and private sector are working closely together!”; and Statement 6, which quotes: “Cadastre 2014 will be cost recovering!”) of the Cadastre 2014, have been a guide for the development of a cadastral system like the cadastral system of North Macedonia and the cadastre itself [13]. It is clear that in the Republic of North Macedonia, the Cadastre 2014 vision process has not been completed and has not been fully implemented. There is still work to be done and realized, but nevertheless, it can be concluded without a doubt that a great and important work has been done so far. The performance of the Republic of North Macedonia, in the framework of the Cadastre 2014, can be concluded to be relatively high and on the right track.

Cadastre 2034

Indeed, according to Steudler, in numerous cases, such as the issues in measure accuracy, the land object or the data layers are managed and dealt within the field of Cadastre 2014, the request of land and land usage utilization is expanded, in confront of a few worldwide issues, such as the population increase, climate changes, food and nutrition and the notions or ideas emphasized with Cadastre 2014 are required to be respected more comprehensively form and way with "Cadastre 2034". According to the national strategy of cadastral reforms and innovations of Australia, and based to the concept and vision of Cadastre 2034, the cadastre of the future predicts that the actual cadastral system we recognize nowadays will not accomplish

community prospects in the forthcoming; we can yet see a gap rising among what we have in actuality and what will be needed and wanted in the future. Within the framework of Cadastre 2034 and its vision for the future, apart from the aim of providing all the basic conditions and services as in the current cadastre, it is also claimed and assumed to guide the policies, patterns and norms of the future [3,8,14-17].

Pillars of Cadastre 2034

Based on the framework of the Cadastre 2034, we can clearly state that within this framework or this vision of the cadastre of the future, six fundamental pillars, or six main points are based on the concept and vision of the Cadastre 2034 itself, and they are as follows:

1. **Survey-accuracy based cadastre –** This predicts and presupposes that the boundaries of the land will be measured and determined with very high accuracy and precision. Also, attached, it is understood that the real boundaries will be in full compliance with the cadastral plans and their content. The reduction of errors is claimed to be in the maximum form (Figure 1).

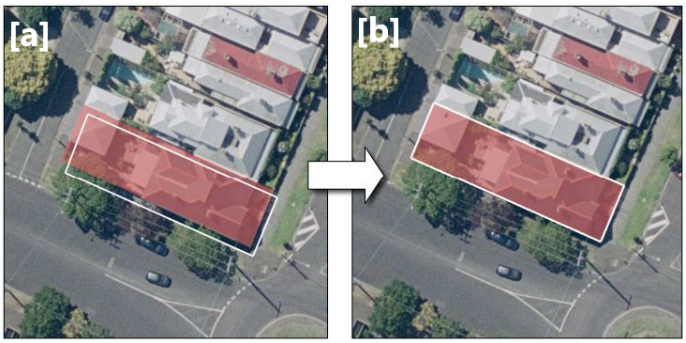

Figure 1. *Cadastres will be survey accurate: virtual representations must match reality* [3]; (a) actual cadastre, (b) cadastre of the future or Cadastre 2034.

2. **Object-oriented based cadastre –** This envisages, presupposes, and implies the redefinition and reformulation of all legal rights, restrictions, and responsibilities (RRR) over land use. Object-Based Cadastre will permit people to readily and confidently identify the location and extent of all RRRs associated to land and real property. Land parcels are properly determined in the essential cadastre, but with the new vision will be required new ways of modelling and presentation of the information. Parcels will continue to be a significant people-land organization instrument; however, many new interests display vastly further spatial footprints [3] (Figure 2).

Figure 2. *Not all property interests fit comfortably in the parcel framework: object-oriented design is required* [3]; (a) actual cadastre, (b) cadastre of the future or Cadastre 2034.

3. **3D and 4D (+Time) based cadastre –** The inclusion of height in the cadastral frames will be indisputable and an essential part of the cadastral vision. In this form, new dimensions will be opened in relation to modeling, visualization, management, integration and analysis on the property. The novelty is assumed to be the time dimension, i.e. 4D or otherwise 3D + Time. Thanks to these advances, it is claimed to minimize and dramatically reduce almost all administrative misunderstandings regarding property interests [3] (Figure 3).

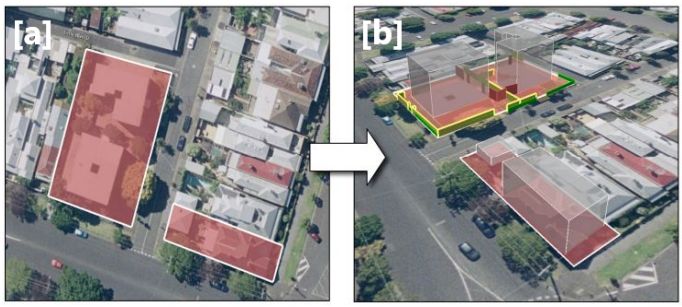

Figure 3. *2D approaches do not enable the complete legal situation on land to be easily understood: 3D and 4D cadastres will mitigate administrative friction and improve decision-making* [3]; *(a) actual cadastre, (b) cadastre of the future or Cadastre 2034.*

4. **Real-Time based cadastre –** The cadastres of the future will be up-to-date and will have full access in real time, which will enable access to information and retrieval of the desired information without any delay. In current cadastres, such processes and procedures are long and time-consuming. In future cadastres, the same processes and procedures will be able to be updated in real time, from the field. Shortly, robust checking processes and such developments will strongly enable the straightforwardness of the cadastre [3].

5. **Regional/Global based cadastre –** The cadastres of the future will have the opportunity, capacity and development to connect and interact in the sense of the regional cadastre and the global cadastre. Such an interaction between the regional cadastre and the global cadastre will enable the global management system on them, in terms of the land market and environmental management, where environmental issues and inconvenience are often spread over multiple jurisdictions [3,18] (Figure 4).

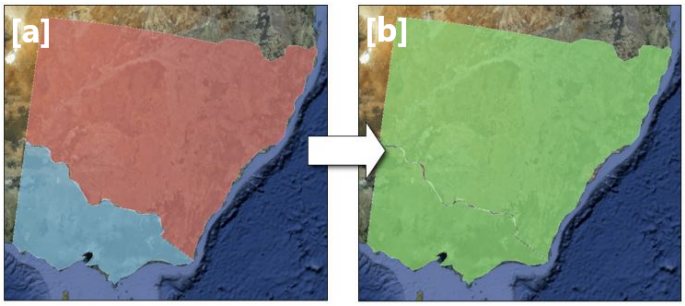

Figure 4. *Cadastral systems will become interoperable allowing management of economic and environmental concerns at regional and international level* [3]; *(a) actual cadastre, (b) cadastre of the future or Cadastre 2034.*

6. Natural or Organic based Cadastre – The cadastres of the future will be integrated in that form to enable better modeling of the natural-organic living environment. Moreover, legal controls protecting flora and fauna or the land interests of indigenous communities (such as those found in developing countries) are often vague and require new tools for representation and management [19] (Figure 5).

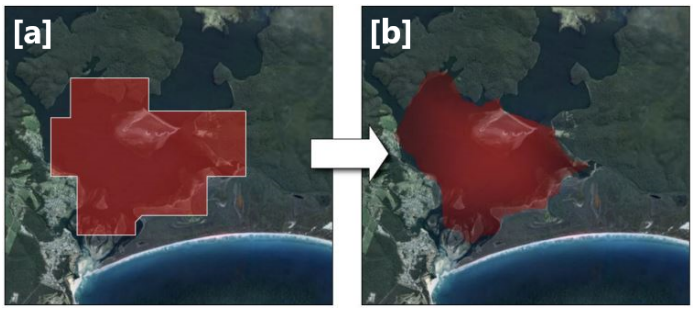

Figure 5. *Future cadastres will better model the organic natural environment [3]; (a) actual cadastre, (b) cadastre of the future or Cadastre 2034.*

Enduring Principles of Cadastre 2034

According to the national strategy of cadastral reforms and innovations of Australia, and based on the concept and vision of the cadastre of the future, there are fundamental principles that must be incorporated into future innovations to ensure that cadastral systems remain secure, accessible, transparent and efficient over time. These enduring principles will continue to be an integral part of the design of environments in which cadastral systems are managed. The enduring principles are:

- Certainty in the spatial extent of ownership.
- Uniquely defined land (and/or property) that is common to all registers – ownership, valuation, land use.
- Integrity and security of the parcel boundary system.
- A strong relationship between regulators and the industry.
- Appropriate regulatory standards.

Purpose of Cadastre 2034

According to the national strategy of cadastral reforms and innovations of Australia, and based to the concept and vision of the cadastre of the future, the purpose or the main objective of Cadastre 2034 is to provide a clear vision for what the community might anticipate and what the government must provide in the future. In order to provide a coordinated and uniform approach to preparing future policies, laws, standards, models, and research, Cadastre 2034 is meant to direct the growth of jurisdictional systems. Cadastre 2034 addresses these shifts and the difficulties they entail. It persits the trek and road to connect cadastral data and inquiry with wider social and legal interests on land and builds on the accomplishments of Cadastre 2014, which heralded the establishment of digital cadastres [10, 20].

Objectives of Cadastre 2034

According to the national strategy of cadastral reforms and innovations of Australia, and based to the concept and vision of the cadastre of the future, Cadastre 2034 takes into account user scenarios that will result in shifting requirements in the future and identifies areas where actual and present inquiry falls short of consumer anticipations today.The goal is to document the trends and present an idea of what our cadastral system will be needed for in the future by the community. The objectives of Cadastre 2034 are to:

- Constitute and determine an ordinary and normal vision for all jurisdictions, industries, and academia.
- Lay aside enduring principles to maintain the vital ingredients of the cadastral system over time.
- Extend and put the goals necessary to catch a consistent and coordinated treatment to the conversion or reduction of the cadastral infrastructure over the next 20 years.

- Identify the necessary essential outcomes that will guide the governance, policy development, standards, research programs and the design of future systems.
- Suggest operations and innovations that will direct the accomplishment of the vision.

Vision of Cadastre 2034

According to the national strategy of cadastral reforms and innovations of Australia, and based to the concept and vision of the cadastre of the future, Cadaste 2034 vision is: A cadastral system that ensures individuals quickly and safely determine the place, position, and scope of all rights, restrictions, and responsibilities associated with real property and land.The cadastral arrangement representing things to come is imagined as similar to an exceptionally powerful piece of the upcoming choice of emotionally supportive networks;directing the management, development, and investment of real estate and land.

Mission of Cadastre 2034

According to the national strategy of cadastral reforms and innovations of Australia, and based to the concept and vision of the cadastre of the future, Cadastre 2034 mission is: To encourage and encourage innovation, as well as ensure the management, coordination, and standards required to create a unified cadastral system that can be used to find long-term answers to meet new opportunities and requirements. One aspect of the journey is planning for the future. Taking ownership of the plan and leading outright all aspects, from strategic actions to clever innovations, to create a cadastral system that we can keep and proceed to be proud of in the future is the most important aspect. The defiance will be to lead the convergence of user expectations for integrated social, economic, and land-related systems, as well as increase opportunities, and the disruption caused by one technology's phasing out and the beginning of another.

Goals of Cadastre 2034

According to the national strategy of cadastral reforms and innovations of Australia, and based to the concept and vision of the cadastre of the future, the hankering targets presume how the future cadastral system will be designed, organized, accessed, operated, and make used; doing so in a way that takes into account not only how it affects the environment right now but also how we create, use, and preserve cadastral information resources for the future. Cadastre 2034 has five goals. They aim is to reach and overtake a cadastral system that:

- is essential and primary to land and property ownership, and to be guided in a sustainable manner
- is truly approachable and available, easily visualized, and perusal understood and exhausted
- is completely merged and joined with broader legal and social interests in land
- ensures a digital submission and reflection of the real world that is survey accurate, 3- dimensional and dynamic, and
- is a federated cadastral system based on ordinary and normal standards (Figure 6).

North Macedonian Cadastre

Establishing the Cadastre is extremely important, same as developed countries as well as developing ones [22]. It presents perhaps a vital, crucial and irreplaceable need for which a genuine work strategy must be created, in planning, and creating the same.

Legal aspect

According to Agency for Real Estate Cadastre (AREC), as in other countries, as well as in the Republic of North Macedonia, there are numerous laws, legal regulations, acts, orders, directives and resembling other

legal circulars which have helped and played a decisive role in the creation of the cadastre and its formulation as a sector. The first geodetic works in the Republic of North Macedonia began in 1928 [23]; with the first law formulated at that time, by the government, namely the land cadastre law - 1928. The same period, namely the years 1928-1945, is known as the period where the initial cadastral survey was also carried out [23]. Following the first law, as a result, we have several laws created and formulated by the governments of the time, amendments to the laws that were made in certain periods, and that for the sole purpose of regulating the powers of this institution and completing them. The Geodetic Authority of the People's Republic of Macedonia, as named at that time, was established on 14 July 1947 [24]. In the ambition to formulate the legal aspect in a more complete and perfect form, 8 principles have also been created, on which the cadastral system of the Republic of North Macedonia is based. The same principles are laid out in the law on the real estate cadastre.

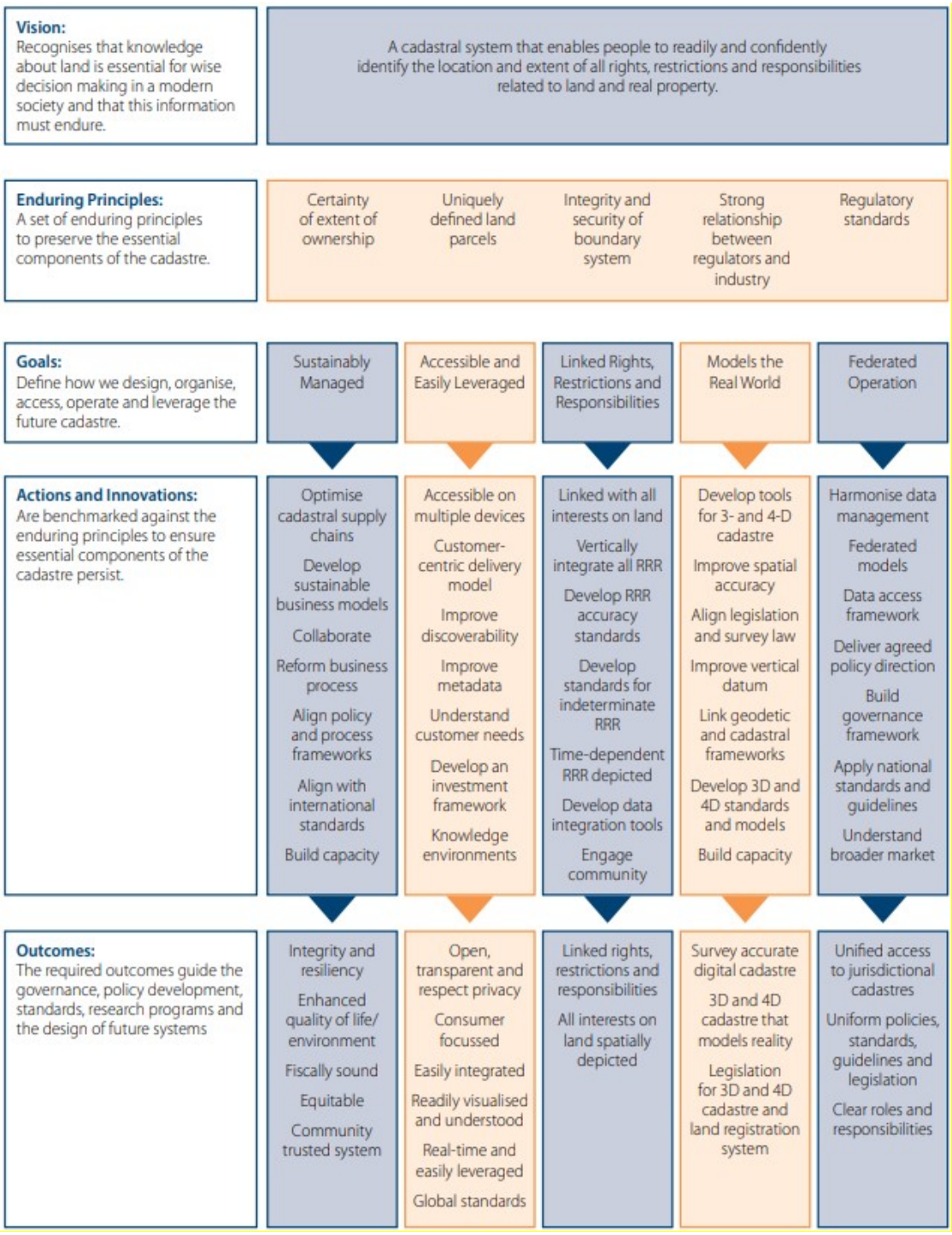

Figure 6. *Framework of Cadastre 2034* [21].

Institutional aspect

According to AREC, Agency carries out all the cadastral works in the Republic of North Macedonia. This institution dates back to 1947 and its structure was determined in 1986 by the Law on Survey, Cadastre and Real Estate Rights Registration. AREC has a modern and strong organizational structure and execution. It is managed by a Steering Board, comprised of five members. The director is the leader appointed to lead the AREC, and he has his deputy (Figure 7).

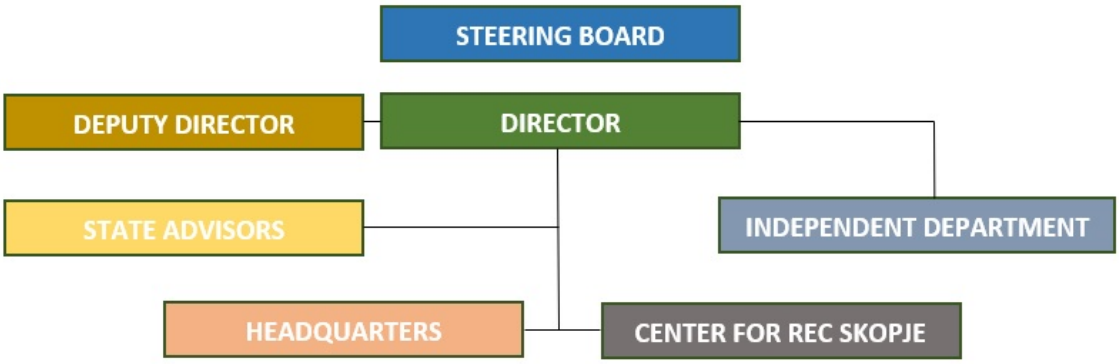

Figure 7. *The organizational structure of AREC* (according to AREC).

Technical aspect

From a time perspective and in the historical aspect, it can be said that since the first works or the first geodetic measurements carried out in the period 1928-1945, in the Republic of North Macedonia, until the present day, many works have been carried out, and many projects have been realized, which have helped the completion and formulation of the technical process of the cadastre in our country. However, we cannot conclude that all works, projects and plans anticipated in advance have been carried out in general and without omission. Some of them have not been fully realized and have not been completed based on the frameworks foreseen. Some of these continue to be in the process of development and work; however, it can undoubtedly be said that a very important basic and fundamental work has been done. Of course, both in the near future and in the distant future, many further works and developments are planned, which will help even more in the development and expansion of the same sector.

SETTING THE SCENE

Motivation

Based on preliminary research and analysis, based on observations, lack and demand, together we conclude that a study and a work of this type, is necessary and adequate for the Republic of North Macedonia as a state, more specifically for the Cadastre of the Republic of North Macedonia as a sector in particular. To be in the context of our work and for the same work to be more concise and complete, we have based it on some basic principles as well:

- *Striving for efficiency*
- *Prioritizing effectivity*
- *Encouraging Compatibility*
- *Emphasizing Satisfaction*

Scope

The basic purpose of this study is:

"*The presentation of the Republic of North Macedonia, namely the Cadastre of the Republic of North Macedonia, in the vision, path and within the framework of the cadastre 2034".*

To achieve and fulfill the goal, our study and our work is based on three goals, namely:

- **Goal 1:** *To identify, analyze, define and classify the concept of Cadastre 2034.*
- **Goal 2:** *To identify, analyze, define and classify the main challenges, problems, and obstacles that*

occur on the path of North Macedonia toward Cadastre 2034

- **Goal 3:** *To identify, analyze, define and classify the impact of Cadastre 2034 over the North Macedonian Cadastre to be in line with the cadastre of the future.*

Strategy

The creation of the work strategy is the seed of work and the final fruit. We have drawn up and designed a work strategy about what will be done, how are we going to do it, and what will be achieved as a result by doing it. To reach the objectives of the research, following work strategies, we need to address and access the following problems:

- *Recognition, the description, summary and statement of study context*
- *Elaboration of the Cadastre 2014 and North Macedonian Cadastre*
- *The presentation of the Cadastre 2034 and the path of the North Macedonian cadastre towards it*
- *Identification of Challenges, Problems and Obstacles on the way to Cadastre 2034.*

MATERIALS AND METHODS

Material – It is important to note that for this study or for this work there are original and official data, were provided by relevant institutions, such as AREC and its regional units.

Methods – As research methods that will be used to achieve the goal of the research we have listed the following:

- *Literature review,*
- *The collection of data; data analysis and data processing, and*
- *Creating a vision and idea for the cadastre of the future, with emphasis on the study over the Republic of North Macedonia*

Research questions

We have listed the study questions that will help us reach our goals and requests in the best way possible:

- *What are the current challenges, problems and obstacles of the cadastre of North Macedonia in the present time?*
- *What is the road through which North Macedonia and its cadastre should go to be on the right track of the cadastre of the future*
- *What are the requirements and what must be done to be part of the Cadastre 2034 and to create and formulate the cadastre of the future?*

Research design

Attached will be presented the design of our study, namely the research and work we have done in this article. We have prepared and presented the same in the visual form of the figure format (Figure 8).

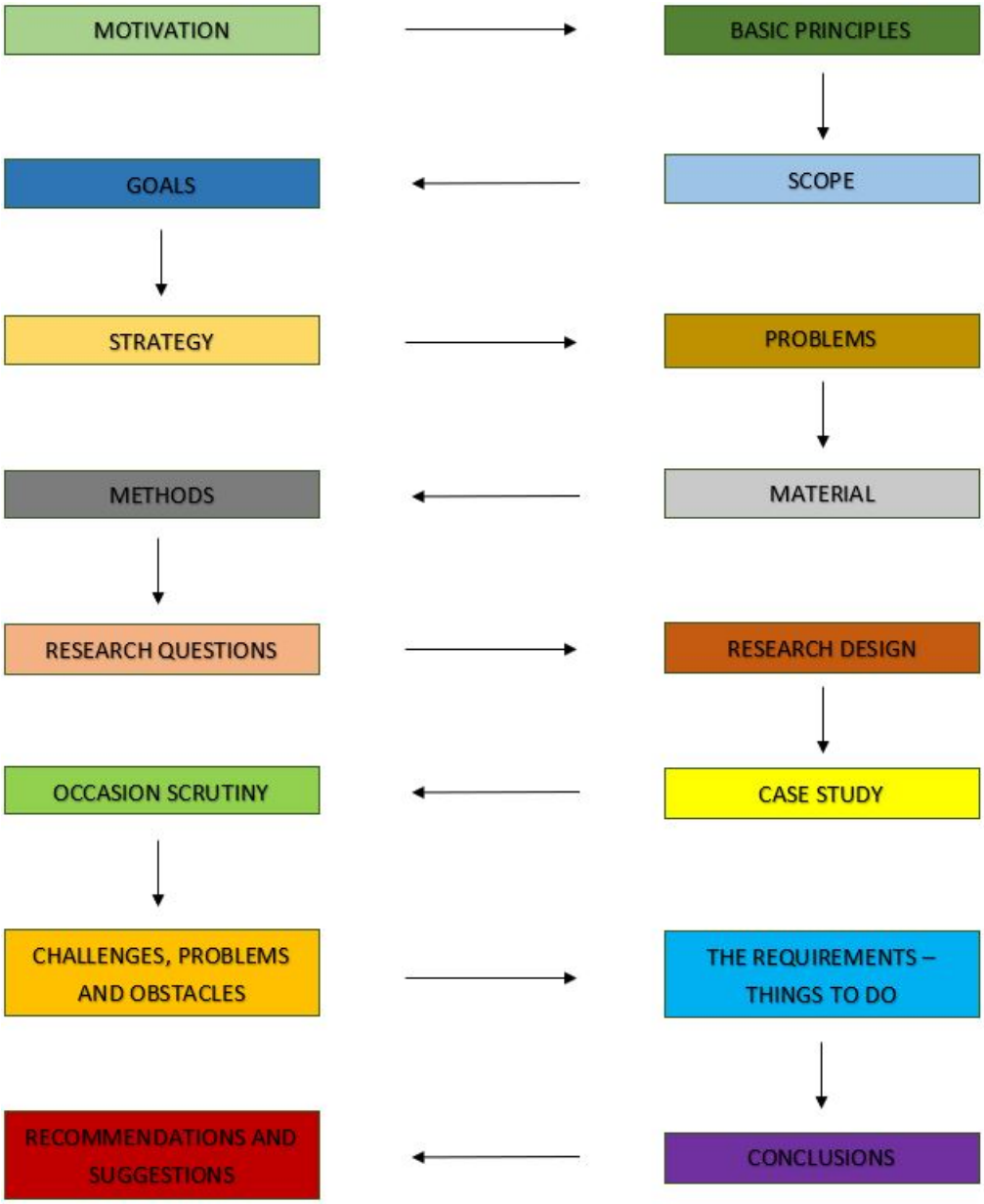

Figure 8. *Research design.*

CASE STUDY

Our study takes place in the cadastral municipality of Shemshovo, which is a settlement in the north-western part of the country, more precisely in the city of Tetovo, the region of Pollog, in the Republic of North Macedonia. The Republic of North Macedonia lies on the Balkan peninsula, the continent of Europe (Figure 9).

Figure 9. *Study Area: Pollog region – Shemshovo, Tetovo, North Macedonia [25] (internet source: VectorSctock)*

Investigation and Occasion Scrutiny

The data of the raster cadastral plan and the vector cadastral plan, for the cadastral municipality of Shemshovo, which will be presented below, were provided by the local office of the AREC, located in the city of Tetovo (Figure 10-11).

In the process of harmonization and digitization of land data, vectorized boundaries were taken as important and basic. This process was based on vectorized plans. This approach contributed to the mismatch between the boundaries on the cadastral plan and the real boundaries on the ground. This is a result of the fact that the limits are set and regulated respecting and based on tachometric measurements.

The procedure for dividing real estate, i.e., land (parcel), changes/modifies and adjusts its boundaries, creating new cadastral parcels, with a new unique number, as well as modifying the administrative data for the newly created parcels.

It is important to emphasize the fact that until now all borders in the region of Pollog have been established and regulated by the original data, namely tachometric measurements. But what is worrying and the question that follows is how the division will continue to be done in the future; taking into account the vectorized limits or the original ones, i.e. from tachometric measurements.

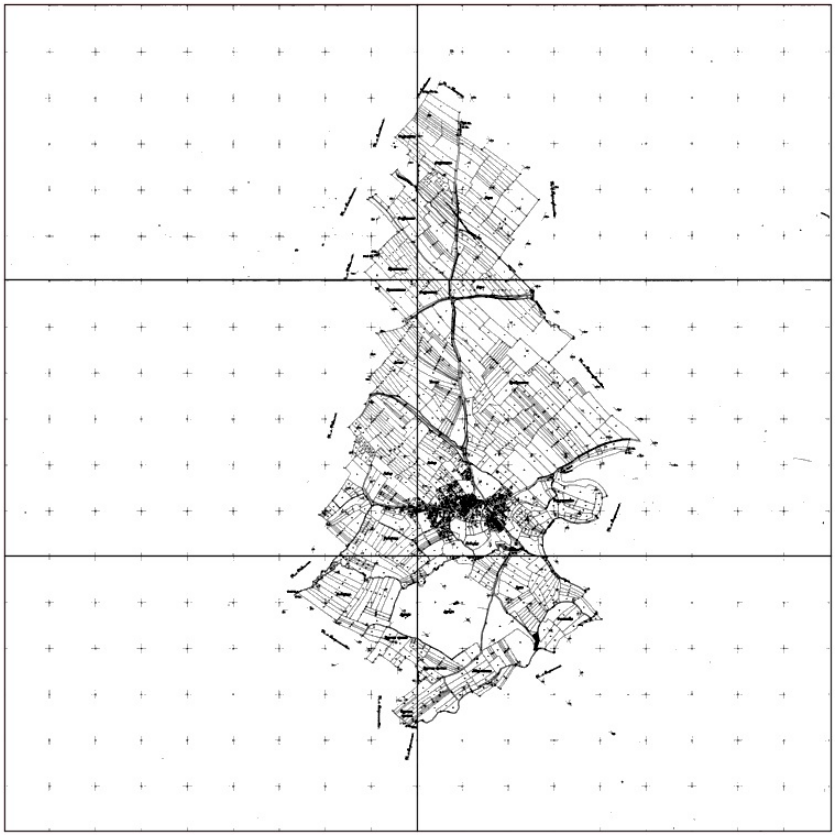

Figure 10. *Cadastral plan, raster – Pollog region, Shemshovo, Tetovo (original and official data source; powered and facilitated by the local office of AREC).*

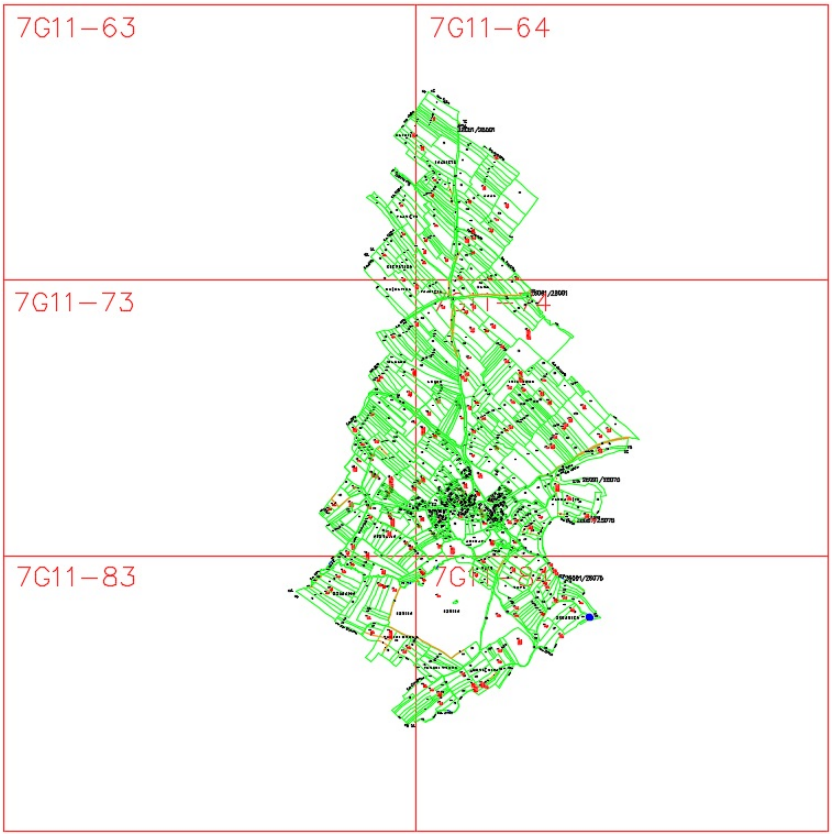

Figure 11. *Cadastral plan, vector – Pollog region, Shemshovo, Tetovo (original and official data source; powered and facilitated by the local office of AREC).*

FORECASTING THE FUTURE

Challenges, problems, and obstacles of North Macedonian Cadastre

As in any other country, also in North Macedonia, there are problems of different types, natures and characteristics. Problems of different types and natures can also be encountered within the cadastre of our country.

We have listed and classified the general problems experienced and identified in the Cadastre of North Macedonia as follows:

- The process of digitalization of cadastral plans. There are marked differences between the original data from the tachometry and the official data of the digitized plans for the boundaries of parcels. In this case, the official data of the digital plans do not appear or even cannot be seen as reliable for limits in relation to the data from tachometric measurements. These differences presented at the borders can raise and in general practice shows that they initiate new conflicts between the parties. Namely, such conflicts can be of the type between parties, between parties with private geodetic offices, and between private geodetic offices and the AREC.
- The Republic of North Macedonia has enabled its citizens several times to register buildings through the legalization process, regulated by law. However, the constructions in the form without permission continue almost as normal, and the state's control over it seems to be dysfunctional. This leads us to the fact that some buildings are not registered in cadastral maps.
- Attention to ground control points is almost zero, despite the fact they present an asset for the cadastre of North Macedonia. Ground control points such as triangulation points, or polygons which are the basis of their cadastral work have not been preserved and most of them have disappeared. The same tradition continues to be repeated even further. Care for them seems to be almost zero.
- The state does not have mechanisms to control the sale and purchase of the real estate. Manipulations with prices and values of real estate are large, and this problem occurs throughout the territory of the state. In this case, the real estate sale prices presented by the citizens do not really reflect real values. This action is recorded as loss and damage for the state because the tax value of the same property does not represent a real value either.
- There are cases when there is a lack of coordination between the real owner of the property, namely the registered owner of the property in the cadastre and the real owner of the property on the ground. This represents uncertainty and instability in general. Such cases are generally encountered in unwritten and uncontracted agreements between owners for the change of properties. As a result of such actions, later the same is faced with the problems of RRR on the same properties.
- Influenced by external factors and conditions, such as economic, political, and other crises (for example, the pandemic crisis or the impact of the war in Ukraine), directly affects the change in market conditions. In these cases, citizens or users show a decrease in interest and this leads to a decrease in requests from the same.
- The lack of creating an efficient and effective standard to regulate the systemization of employees and employment as a process within the AREC institution. This leads to unfavorable results for the institution as a whole and shows in any way, a lack of seriousness in relation to the competencies, responsibilities, and duties of an institution. Such a standard would enable the connection and advancement of new professionals, namely new staff within the institution, thus advancing the professionalism and seriousness of the institution as an organizational whole.

- A serious problem for the AREC institution is the lack of favorable working conditions and facilities. The lack of necessary and appropriate spaces probably makes normal, efficient, and productive work impossible. This problem is mostly encountered in regional units, in different cities within the territory of the North Macedonian state.

The road of North Macedonian Cadastre towards Cadastre 2034

The path of the North Macedonian cadastre towards the future cadastre, specifically the Cadastre 2034, can be described more easily, based on the so-called basic pillars of the Cadastre 2034. We have chosen to present the same summary and presentation in the form of an introductory and descriptive table, which will be presented below (Table 1).

Table 1. *A Summary, Assessment and a General Presentation of the Cadastre of North Macedonia in the Shadow of the Cadastre 2034.*

PILLARS OF CADASTRE 2034	DESCRIPTION
Survey-accuracy based cadastre	**In the present time** – Accuracy used until now, in the current cadastre of our time, can be said and found to have been at a high level, specifically high accuracy ensured in centimetre accuracy. **In the future** – The accuracy that is claimed to be used in the future, that is, in the cadastre of the future, is expected to be of very high accuracy, specifically below the centimetre accuracy.
Object-oriented based cadastre	**In the present time** – The current cadastre can be summarized as a parcel-based cadastre, and the registration of all rights, restrictions and responsibilities (RRR) are based on the ideas and principles of this type. **In the future** – The cadastre of the future is claimed to be a cadastre based on objects and therefore the registration of all rights, restrictions and responsibilities (RRR) will be based on the basis and principles of this type, so that all the needs for this can be met and fulfilled the viewpoint.
3D and 4D (+Time) based cadastre	**In the present time** – In our time, in the current cadastre, the visual presentation is almost always done in 2D format. It can be concluded that the 3D format has been overlooked almost completely. **In the future** – In the future, thus in the cadastre of the future, in addition to the height dimension, i.e. the 3D format, it is also intended to use the time dimension, i.e. the 4D format.
Real Time based cadastre	**In the present time** – In the current cadastre, after measurements or field work are done, they must be processed and updated. This action costs time and allows errors and omissions of various forms to be carried or repeated. **In the future** – The cadastre of the future claims that the data from field measurements will be updated, processed and enabled in real time. So at the same time, it is supposed to have immediate access to the cadastral data.
Regional and Global based cadastre	**In the present time** – Current traditional cadastres are generally regional cadastres. They do not have global access and are not integrated into international networks. **In the future** – The cadastre of the future claims that, in addition to the regional cadastre, it will also enable the creation of the global cadastre. This implies the integration of current traditional cadastres and cadastral systems in a network international and global level.
Natural or Organic based cadastre	**In the present time** – In the framework of the current cadastre, there was no such concept. In this aspect, there has not been a paraphrase of this type. However, with the global changes in the environment, such a thing is foreseen for the cadastre of the future. **In the future** – In the framework of the cadastre of the future, this type of cadastre gives direction and direction for a new field and a new concept. The same, it is claimed to serve and contribute specifically for flora, fauna and marine environments, namely for the modelling of flora, fauna and marine environments.

What should be done to be within the framework of Cadastre 2034

In order to be able to articulate and paraphrase the idea that the cadastre of North Macedonia is on the way to the cadastre of the future, in the shadow and under the framework of the 2034 cadastre, we have summarized some important points, concrete steps and important decisions that North Macedonia, that is, its cadastre should be taken in this direction. We have listed the same as below:

- There are marked differences between the original data from tachometric measurements and the official data for parcel boundaries. The official data from the vectorization process does not appear or even can be seen as reliable for final boundaries, as they do not correspond to real boundaries in the field. Finding a common path helps in the reflection and trust that citizens create on the cadastre and its seriousness in general
- Special care must be taken with the construction of facilities without permission and facilities that are not registered in the real estate cadastre. The same unlicensed and unregistered constructions directly affect the development, the process and the road to the cadastre of the future.
- Despite the fact that the measurement and determination of the boundaries of cadastral parcels are carried out with high accuracy, the same measurements are possible and offered and provided for users and citizens only in 2 dimensional (2D) format. Something like this prevents development and the road to the cadastre of the future. From the same measurements provided by the field, visualization in 3D format should be enabled and offered. In addition to the 3-dimensional (3D) format, the concept of Cadastre 2034 requires the development of the 4-dimensional (4D) format, namely the time parameter. In this direction, a lot of work must be done and a lot of commitment is needed to fulfill such a criterion.
- At the moment when the divisions, adjustments and changes of cadastral parcels are made, the same divisions, adjustments or changes must be uploaded and updated as quickly as possible, so that users and citizens have clearer and more regular access to updated information, changes and adjustments.

CONCLUSIONS

In advance, it is worth noting that there are not many studies regarding the cadastre of the future, specifically for Cadastre 2034. The most detailed and detailed studies of this type can be counted those of countries like Australia and New Zealand. Based on this context, we have tried to paraphrase a concept for the Republic of North Macedonia.

The idea of this paper and the purpose of this study is to present the Macedonian cadastre in the shadow of the cadastre of the future, namely the Cadastre 2034. Consequently, in order to enhance in the field of cadastre, its current and basic structure is analyzed, to choose the ideal course of action for what we should do for the future. Therefore, this study presents and explains a general framework of the current situation of the North Macedonian Cadastre, achievements and tasks are done, challenges, problems, and obstacles with which faces and confronts. Attached, we predicted, evaluated, and created a vision for the cadastre of North Macedonia under the spectrum of the cadastre of the future and the framework of the Cadastre 2034.

Overall, the AREC, has so far carried out and developed works and projects of high importance, which has helped the development of the North Macedonian cadastre as a whole. It can be freely paraphrased that the North Macedonian cadastre has been within the framework of the 2014 cadastre and has been developed in its direction, following its main principles and vision. Amazing work has been done in that direction, but not all responsibilities are finally completed. In order to complete and finish the entire project, there is still work to be done in this direction.

The works that must be started and in a form or in another must be done, in the direction of the cadastre

of the future, also represent a special and great importance in the development of the cadastre of North Macedonia. These are jobs that involve great duties, obligations and responsibilities, in the framework of the cadastre development process towards the cadastre of the future and in terms of strategical and technological planning and design.

It should not be overlooked and should not be forgotten that the development of cadastre and cadastral systems also depends on external factors and indicators and different fields, which directly affect their development process. In this context, the development of cadastre and cadastral systems must be evaluated and formulated in coordination with economic, political, social and other developments. For this, processes such as globalization, urbanization, climate change, other environmental and technological developments along with information systems should also be in focus. Finally, as a result, we can freely and without doubt conclude that North Macedonia is on the right path of development and progress towards the future.

Recommendations and Suggestions for future studies and future work

Based on our study and our aforementioned work, we are able to draw conclusions and create a concept and forecast for the cadastre of the Republic of North Macedonia under the shadow and vision of the cadastre of the future. Undoubtedly, this work will neither be the first nor the last of its kind. We hope that through this work we motivate and inspire others who want to work and do research and studies of this nature. In future studies, the data and information that are presented in our work can be taken as a basis for work and used for new and broader studies and perspectives, to create new innovative models in modern times. The point that we want to emphasize in this final part and what we want to give in the form of recommendation and suggestion is that:

- Based on our work and study in the future studies of the same type can be done, but in a context, location and point of view new.
- Reclassifying, re-evaluating and re-extending the view or model we have addressed in our research.
- Creating a concrete work or study, similar in terms of content and form, with a similar or different location, depends on the choices of the researchers, by using the well-known method of Strength, Weakness, Opportunities, Threats (SWOT) analysis.

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