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INVESTIGATION OF FLOW DISTRIBUTION AROUND A SUBMARINE

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ABSTRACT

In this paper the flow field around a submarine has been investigated. Pressure distribution and its impact on submarine hull form have been studied. The accurate and efficient prediction of hydrodynamic pressure and forces on a submarine has been achieved by investigating the flow related to the interaction of the vertical flow shed from the sail and the cross-flow boundary layer of the hull. Therefore this study aims to simulate the flow field of a submarine by using finite volume method. Finite Volume Stress Analysis Method and k-ω turbulence model have been used to simulate turbulent flow past the submarine hull surface. A submarine hull with overall length of 80 meters and diameter of 10 meters was chosen. It has aft body length 11m and sail length 7m. The speed range of the submarine is 0 to 30 knots with 5 knots increments. Calculated pressure coefficients along the submarine hull are discussed to show the effect of the sail lateral position and the stern appendages. It is also discussed a Reynolds Averaged Navier-Stokes (RANS) code application in the design of an "Advanced Sail" for a submarine.

Keywords: Flow distribituon, submarine, pressure distribution, RANS.

ÖZ

Bu makalede, bir denizaltının gövdesi üzerine etkiyen akışkan basıncı ve kuvvetlerinin daha iyi anlaşılması için denizaltının etrafındaki akış dağılımı detaylı bir şekilde incelenmiştir. Denizaltıya etkiyen hidrodinamik basınç ve kuvvetlerin doğru ve etkili bir şekilde tahmin edilebilmesi için denizaltının yelkeni üzerindeki düşey akış ve teknenin sınır tabakasındaki enine akışının etkileşimi ile ilgili olan akış incelenmiştir. Bu çalışmada Sonlu Hacim Yöntemi (FVM) ve Hesaplamalı Akışkanlar Dinamiği (CFD) kullanılarak denizaltı etrafındaki akış alanı simüle edilmiştir. Sonlu Hacim Stres Analiz Yöntemi ve k-ω türbülans modeli kullanılarak denizaltının gövdesinin yüzeyini takip eden türbülanslı akışın simülasyonu yapılmıştır. Boyu 80 m, eni 10 m, kıç kuyruk uzunluğu 11 m, yelken uzunluğu 7 m olan bir denizaltı modeli seçilmiş ve RhinoCeros^{TM} programı kullanılarak çizimi yapılmıştır. Denizaltının hızı 0'dan başlayarak 30 knota kadar 5 knot arttırılmak suretiyle hesaplamalar yapılmıştır. Günümüzdeki güçlü bilgisayarların getirdiği kolaylıklardan dolayı akışkan probleminin tam olarak Navier-Stokes denklemiyle sayısal hassas çözümü geniş bir yelpaze alanı içerisinde yapılabilmektedir. Denizaltı gövdesi boyunca hesaplanan basınç katsayıları yelken ve kıç takıntılarının etkisini göstermek için ele alınmıştır. Ayrıca, bir denizaltı için "Gelişmiş Yelken" tasarımında RANS (Reynolds Averaged Navier-Stokes) kodunun uygulaması ele alınmış ve irdelenmiştir.

Introduction

A submarine is a vessel capable of independent operation underwater. It is used as a surface naval weapons platform or as a tool of exploration and recreation. Their stealth plays an important role in a modern naval force. Therefore submarine is a warship with a streamlined hull design to operate completely submerged in the sea for long periods, equiped with a periscope and typically armed with torpedoes or missiles. Most large submarines have a cylindrical body with hemispherical (and/or conical) ends and a vertical structure, usually located amidships having navigation and other equipment devices as well as periscopes. Sometimes known as the conning tower. This vertical structure is called "sail" in U.S. Navy, "fin" in European Navies.

The propeller of submarine, vertical and horizontal control panels are located at stern. As the thrust is generated, water pushes over the planes, creating an upward or downward force that helps the sub gradually surface or dive. The fins can be tilted to change the angle of attack at which it climbs or dives.

The starting point of all scifientic studies is a literature survey to understand the status quo of the investigated topic. It is important to understand the reasons for the shape of submarines at different stages of their development and why changes were made. To neglect full scientific studies would be a serious mistake in the design of any future replacement submarine.

In submarine hydrodynamics, turbulence and vortex dynamics play an important role. The classic picture of turbulence starts from a sequence of bifurcations in a “smooth” flow, each of which introduces flow structures of smaller and smaller scales. Designers had begun to change nose and tail cone shape to improve the performance of submarine at operational speeds. Other major sources of resistance may be improved. The establishment of the detail performance of a submarine can be started by using computational fluid dynamics to obtain pressure distribution and to calculate the drag characteristics which will serve as the comparative foundation for any new design. All features affecting the shape of submarine are discussed including the boundary layer, laminar flow, transition, turbulence and separation and how the flow should be as quiet and smooth as possible. At the beginning the pressure distribution around submarine body without sail, and appendages were investigated. The next step was; the sail, tailplanes and foreplanes were added to obtain pressure distribution around the submarine and to observe how effects and changes in flow distributions. Design looks like a jigsaw puzzle where altering one piece requires alterations in all surrounding features to make a workable complete design. It is clear that scientific studies has to be a starting point for any future submarine design. A review of relevant literature has been completed which covered priorities in design and showed how enhancement of one feature interacts with other features and may even result in an overall loss of performance despite the perceived advantage of the enhanced feature. Hydrodynamic aspects were then discussed starting with the shape and reasons what should be the beam-to-depth ratio (B/D) to give minimum resistance as possible.

As it is well known, flow around submarines is exceedingly complicated, even at simple flow conditions, and the need to reduce submarine signatures from flow-induced noise put high demands on the computational model. Most of the boundary layer on a submarine is predominantly turbulent because of the high Reynolds (Re) number, which typically is encountered in ship hydrodynamics. At the bow, the flow is usually laminar, but rapidly undergoes transitions into a fully turbulent boundary layer, which often makes it reasonable to assume a fully turbulent boundary layer along the entire hull. The boundary layer is further affected by pressure gradients (mainly around the bow and the stern) and the hull curvature, potentially causing a vortex separation usually resulting in distortion of the propeller inflow.

Prediction of Submarine Resistance

Whenever a body is placed in a flow, the body is subject to a force from the surrounding fluid. In general, the force acting on a body is resolved into a component D in the flow direction U and the component L in a direction normal to U. The component D is called drag and L is called lift. The most important difference between the resistance of a surface ship (or submarine on the water surface) is that for a deeply submerged submarine will not have wave resistance. Therefore the submerged submarine resistance will sum up total skin friction and total submerged pressure. Skin friction drag acts tangentially at the surface and is proportional to the wetted surface.
The total pressure has form resistance or form drag and induced resistance or induced drag. The form drag is the viscous pressure resistance due to the shape of the submarine. The induced drag is the resistance caused by lift. This could be on appendages that are generating lift due to misalignment with the flow, or to the hull, that may be generating lift due to symmetry.
The resistance of a submarine can be determined either by model testing, or by Computational Fluid Dynamics (CFD). In this paper, CFD techniques have been used to estimate the resistance of the deeply submerged submarine. As the resistance of a deeply submerged submarine is dominated by the frictional component, there are a number of difficulties with this, in particular the choice of empirically based turbulence model. However, in principle it is possible to use CFD to obtain results at full scale Reynolds

numbers, something which is not possible using model experiments [1]. There is one of the current complications with CFD is that there is no standard method for predicting submarine resistance. This is largely because both computing power, and CFD techniques, are developing rapidly. Thus, great care needs to be taken when investigating the effect of the change in resistance due to a change in hull shape.

Numerical Model

The use of computational tools to evaluate submarine flows have been tremendously increased over the last decade since the capacity and speed of computers were raised. Thus the applications of Computational Fluid Dynamics (CFD) to the naval industry was guiding the design of submarine. In view of these developments, CFD can offer a cost-effective solution to many problems in underwater vehicle hull forms. However, effective utilization of CFD for naval hydrodynamics depends on proper selection of turbulence model, grid generation and boundary resolution. The most common turbulence modeling approach of today is RANS, which is based on Reynolds Averaged Navier-Stokes equations and is often adopted in traditional Computational Fluid Dynamics (CFD). The first fully appended submarine RANS calculation was done by Gorski et al [3] for the submarine configuration, which was extensively measured to provide a data-base to test CFD methods. The dependent variables are divided into a mean part and a fluctuating component representing deviations from this mean. The advantage of RANS is however that the approach is fast, and it is available in most CFD codes. In particular, with the advent of parallel computational capabilities, viscous RANS simulations have seen a larger role in predicting these flow fields.

In this study, Reynolds Averaged Navier Stokes (RANS) equations and continuity equation for mean velocity of the unsteady, incompressible fluid have been used as governing equations in order to determine the mean cartesian flow field, U_i, and the mean pressure (P) of the water around the hull. The well known SST (Shear Stress Transport) k-ω model have been considered to simulate the turbulance flows.

$$\frac{\partial U_i}{\partial x_i} 0 \qquad (1)$$

$$\rho \frac{\partial U_i}{\partial t} + \rho \frac{U_i U_j}{\partial x_j} = -\frac{\partial P}{\partial x_i} + \frac{\partial}{\partial x_j}\left\{\mu\left(\frac{\partial U_i}{\partial x_j} + \frac{\partial U_j}{\partial x_i}\right)\right\} - \rho \frac{\overline{\partial u_i' u_j'}}{\partial x_j} + f_i \qquad (2)$$

where f_i represents external forces. The influence on turbulence on the mean flow is given in equation represents external forces. The influence on turbulence on the mean flow is given in equation (2) by the Reynolds stress tensor $\overline{\rho\left(u_i' u_j'\right)}$. There are many turbulence models to provide solutions to the Reynolds stresses.

The k - ω model is well-suited for prediction in the vicinity of the wall, while the k - ε model is for the remaining area near the boundary region. The k- SST-model is using blending functions to be able to use the k-ω model near the wall and the k-ε in the free stream and to get a smooth transition between them. Therefore it is a hybrid between the k- ε and the k-ω model. The SST k - ω model is known to be fairly effective for better prediction of adverse pressure gradient and flow separation. This model has been designed to promote turbulence in the congestion zone of fluid flow.

The SST k-ω turbulence model is a two-equation eddy-viscosity model developed by Menter [4] to effectively blend the robust and accurate formulation of the k-ω model in the near-wall region with the free-stream independence of the k-ε model in the far field. To achieve this, the k- ε model is converted into a k-ω formulation. Transport equations for the SST k-ω model are given by:

$$\partial/\partial t\,(\rho k) + \partial/(\partial x_i)\,(\rho k u_i) = \partial/(\partial x_j)\,((\Gamma_k\ \partial k/(\partial x_j)) + G_k - Y_k + S_k$$

$$\partial/\partial t\,(\rho\omega) + \partial/(\partial x_i)\,(\rho\omega u_i) = \partial/(\partial x_j)\,((\Gamma_k\ \partial\omega/(\partial x_j)) + G_\omega - Y_\omega + D_\omega + S_\omega \qquad (3)$$

In these equations, $\tilde{G}_k$ represents the generation of turbulence kinetic energy due to mean velocity gradients, G_ω represents the generation of ω ,

Γ_k *and* Γ_ω represent the effective diffusivity of k and ω, respectively, Y_k and Y_ω represent the dissipation of k and ω due to turbulence, D_ω represents the cross-diffusion term, S_k and S_ω are user-defined source terms.

The Model of Submarine Hull

A standard submarine hull model was used as a prototype for computations. The bow of our submarine model has been chosen as ellipsoidal and the stern has been chosen paraboloidal in shape with a portion of parallel mid-body. Since CFD method was used for the computations, This method is a very grid dependent technique. Therefore CFD method needs to be meshed in proper ways to get reliable and converged results. The largest errors occur where the largest gradients are. For this reason, the resolution should be increased in such regions. Only a restricted amount of cells can be used due to restrictions in computational power. Therefore it is beneficial to have a denser grid where e.g. the curvature of the surface is high and having larger cells closer to the middle of the surface. The discretization of the geometric domain of the submarine has been divided into 950.000 hexahedral meshes and every simulation has been iterated three hundured times. Since the CFD calculations on the computer takes a lot of time and needs more memory. It is 1/50 scale model rather than the actual size of the submarine has been used for the computations. The hull model has an overall length L of 1.6 m and maximum diameter D of 0.20 m. The sail is located in front of the hull with a length of 0.24 m..

The profile of the submarine model hull is shown in Figure 1. Also shown is the profile of nose cone, tail cone and sail shape.

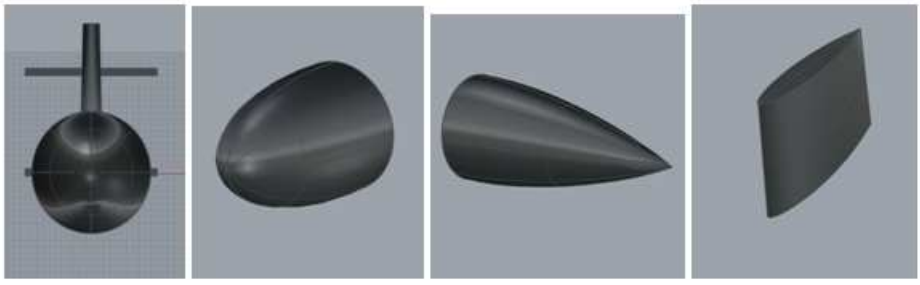


Figure 1. CAD Model of the Submarine Hull

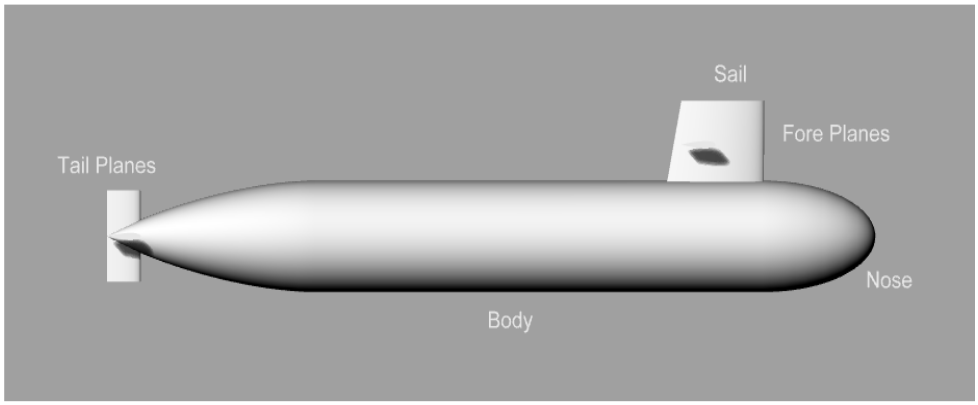
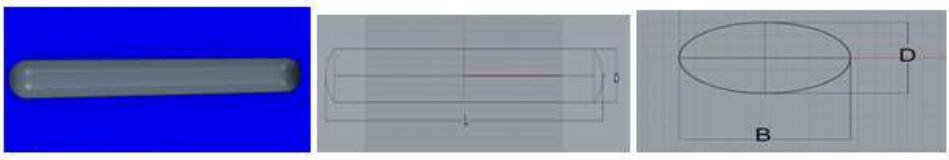


Figure 2. Submarine Control Surfaces

Numerical Computations

The numerical calculations were attempted by the following certain steps. The first step was the bare submarine body which was taken as a cylinderical shape for the flow calculations to observe how to change flow distribution according to different B/D ratios. It was analysed according to 1, 2, 4 and 8 ratio values. The subsequent steps, the numerical computations for hull with sail, with hull-sail and aft planes, and finally having all necessary control surfaces components of submarine form have been carried out seperately. All numerical computations were performed, in the following figures, on the actual size of bare submarine body. For each case, the results are shown in Figures 3 to 7 respectively.



Mesh configutaion L/D B/D

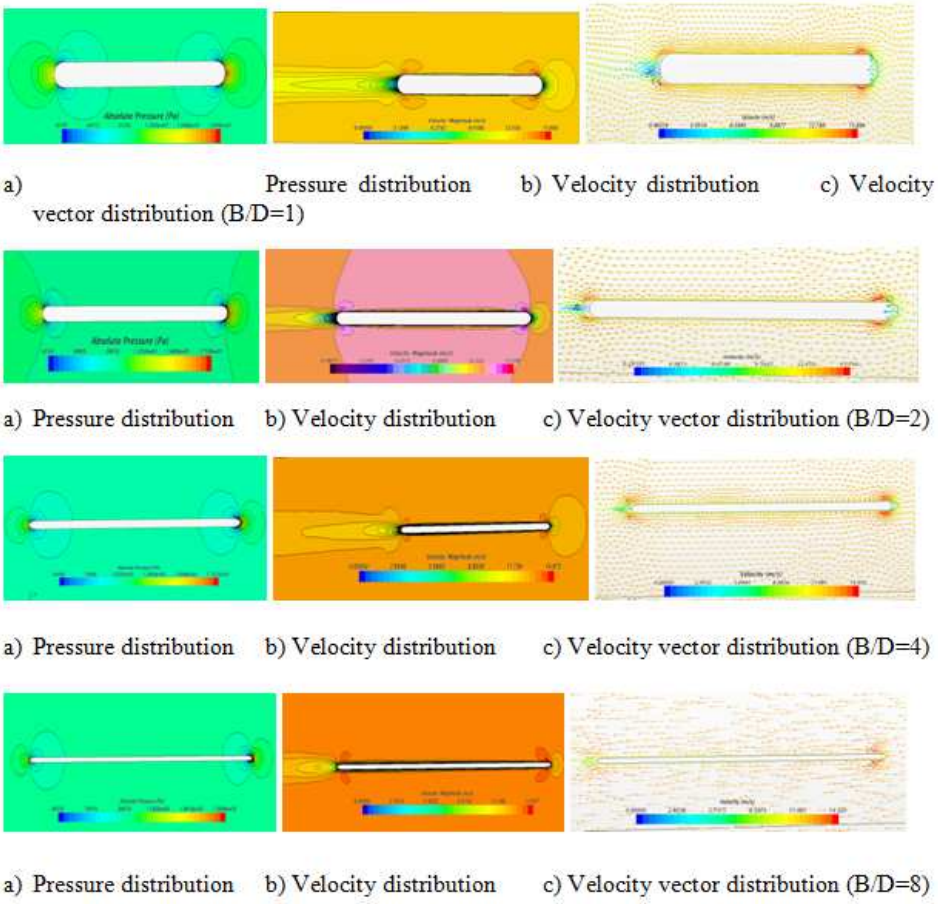


Figure 3. The pressure, velocity and velocity vector distributions around a cylindericsl submarine body (without sail, tails and other appendages) for different B/D ratios.

In these figures, it can be seen that how the absolute pressure and velocity distribution change around the submarine when the submarine body is assumed to be fixed and flow is coming from front of it. The computed values of absolute pressures and drag forces (resistance) for different B/D ratios of bare submarine body is given in table 1. The values given in this table are calculated at 25 knots of submarine speed.

Table 1. The absolute pressures and forces (resistances) values for different B/D ratios of bare submarine body

B/D	$V_{min}(m/s)$	$V_{max}(m/s)$	$P_{min}(Pa)$	$P_{max}(mPa)$	*Drag force (N)*	*Percent of Changing in force*
1	0	15.698	39795	1838	235.39	-
2	0	15.358	43192	1752	168.59	%29
4	0	14.673	54406	1747	129.43	%24
8	0	13.957	59520	1589	126.38	%3

The values given in table 1 states that, consequently increasing B/D ratio of the bare submarine body will lead to reduced the drag force (resistance). This shows that the resistance depends on the pressure distribution around the body eventhough the minimum pressure values are increasing and the maximum pressure values are decreasing acording to B/D ratios geting higher.

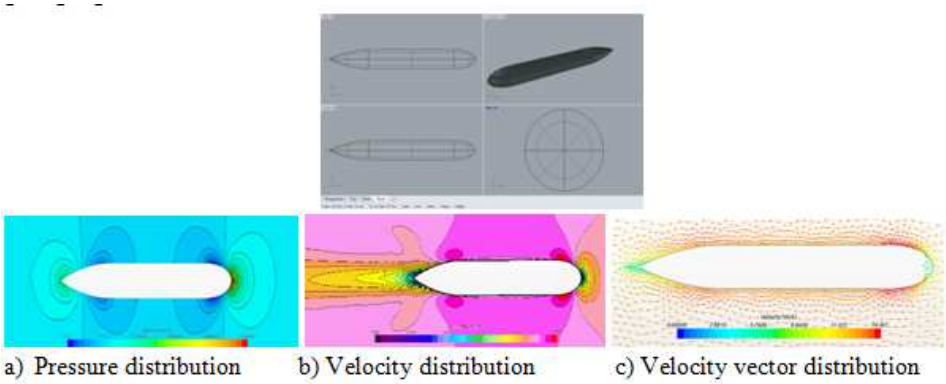


Figure 4. The pressure, velocity and velocity vector distributions around the bare submarine body (without sail, tails and other appendages).

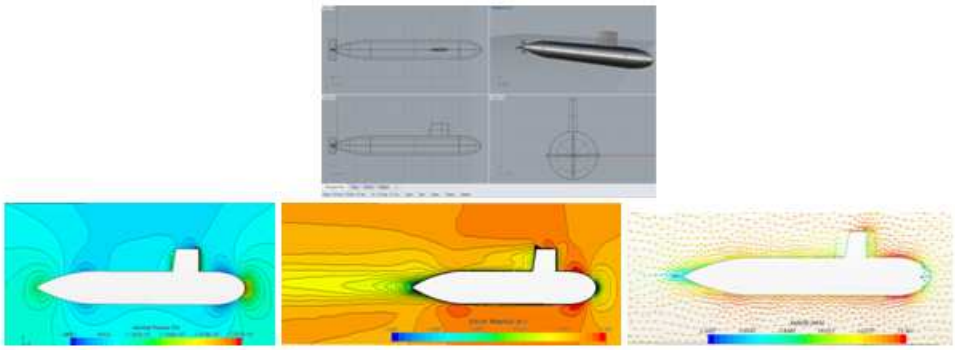


Figure 5. The pressure, velocity and velocity vector distributions around the submarine body with sail.

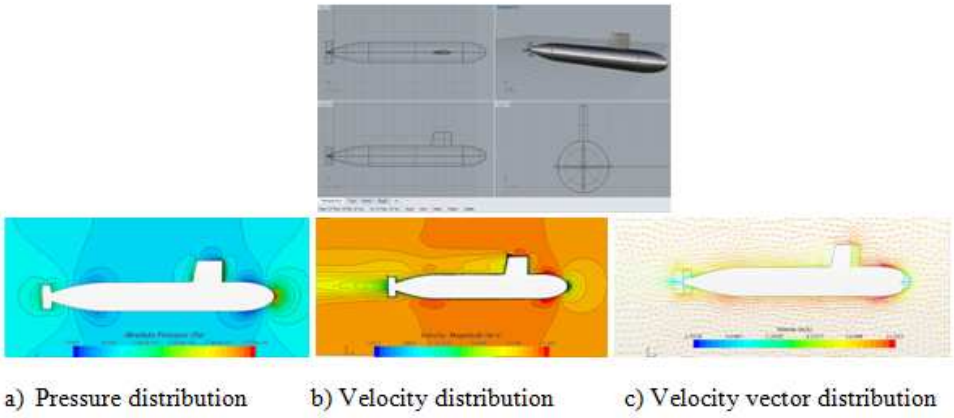


Figure 6. The pressure, velocity and velocity vector distributions around the submarine body with sail and tails (aft planes).

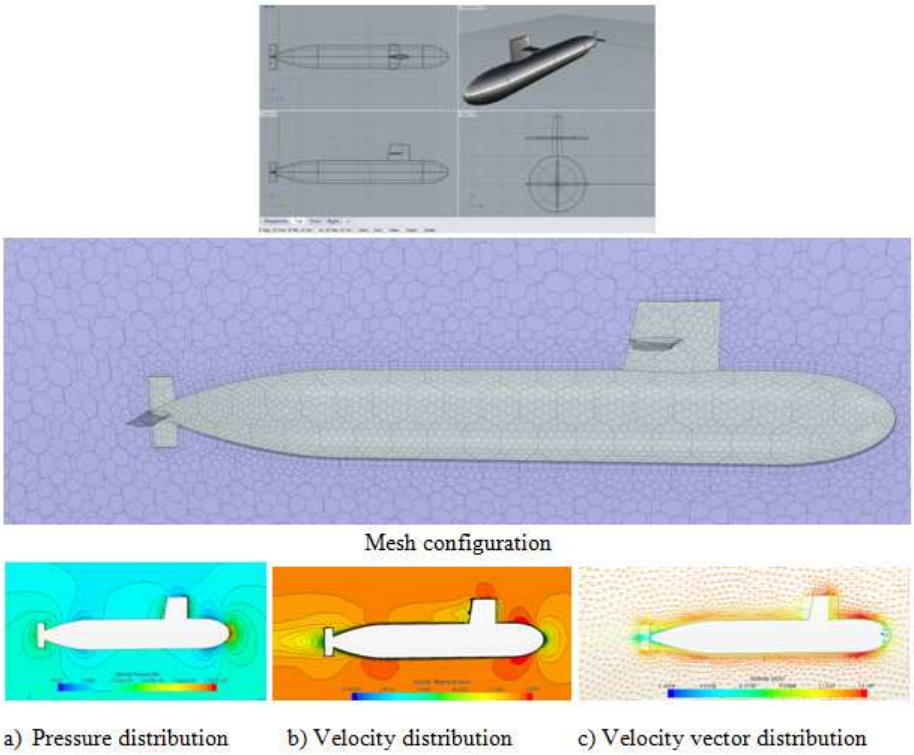


Figure 7. The pressure, velocity and velocity vector distributions around the submarine body with sail and tails (Hull+Sail+Sail Planes+Aft Planes).

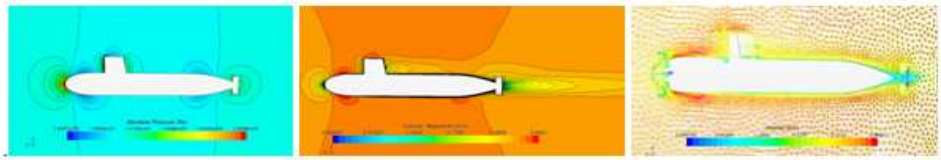
Table-2 A comparison of all results according to submarine's components

	$V_{min}(m/s)$	$V_{max}(m/s)$	$P_{min}(Pa)$	$P_{max}(mPa)$	*Force(N)*	*Percentage difference in force*
Hull	1.8506	14.386	77120	179.08	126.64	-
Hull+Sail	1.9269	14.434	68863	176.76	152.5	%20
Hull+Sail+Aft Planes	1.2536	14.409	74505	179.36	179.9	%17
Full	1.4668	14.187	70443	177.64	204.72	%14

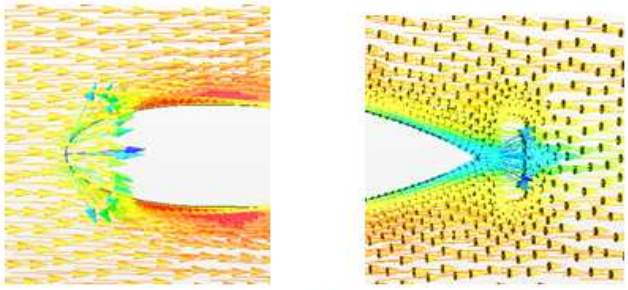
As can be seen from Table 2 that the resistance increases because the sail area creates additional surface to create more resistance. On the other hand, the pressure values do not change dramatically as it was obtained without

having sail. The full body of the submarine gives less pressure value than bare hull and Hull + Sail + Aft Planes form.

Flow Distribution Around Submarine According to Its Speed Variation
The absolute pressure and velocity distributions around the model submarine have been computed for the different submarine velocities from 0 to 2.18 m/s with increments of 0.364 m/s (corresponds to 5 knots of submarine speed). The results for each case are shown in figures 8 to 12.

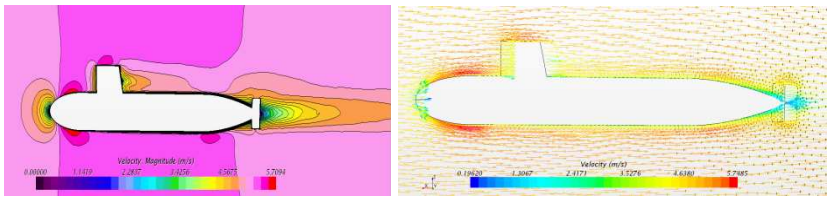


a) Pressure distribution b) Velocity distribution c) Velocity vector distribution

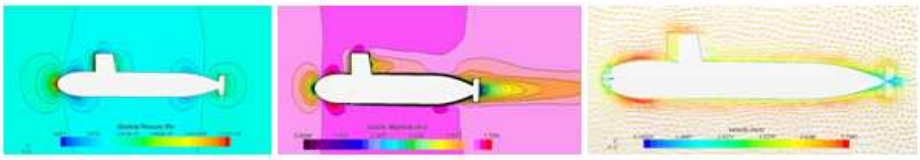


d) Fore and Aft view of the Vectorel Velocity

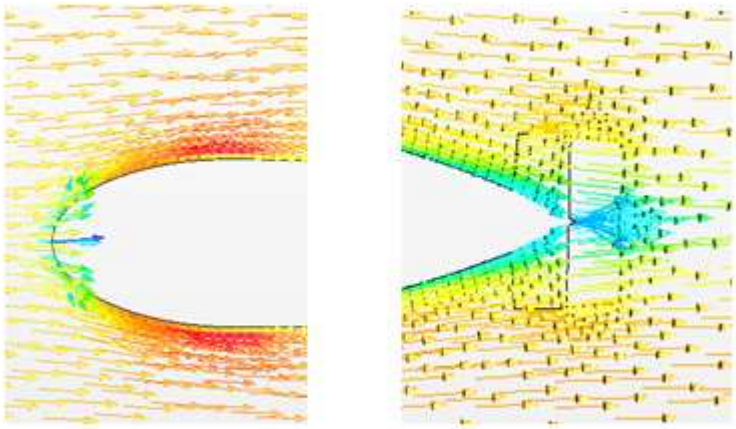
Figure 8. The pressure, velocity and velocity vector distributions around the submarine model at 0.364 m/s speed.



a) Pressure distribution b) Velocity distribution c) Velocity vector distribution



a) Pressure distribution b) Velocity distribution c) Velocity vector distribution



d) Fore and Aft view of the Vectorel Velocity

Figure 9. The pressure, velocity and velocity vector distributions around the submarine model at 0.728 m/s speed.

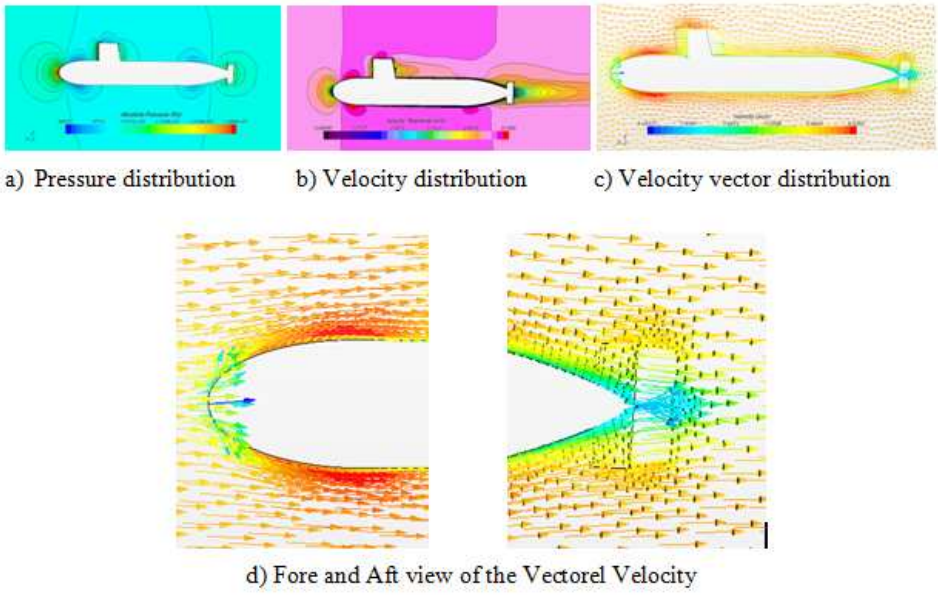


Figure 10. The pressure, velocity and velocity vector distributions around the submarine model at 1.0912 m/s speed.

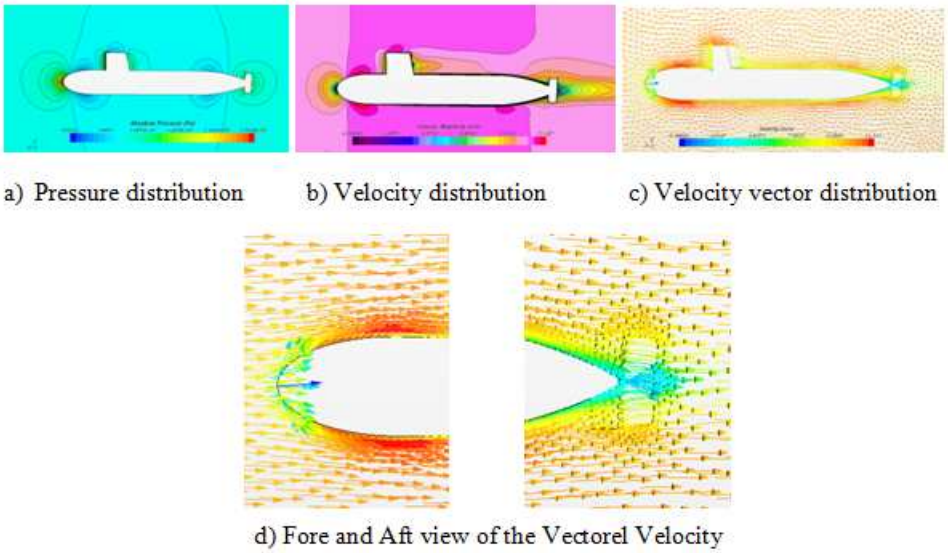


Figure 11. The pressure, velocity and velocity vector distributions around the submarine model at 1.455 m/s speed.

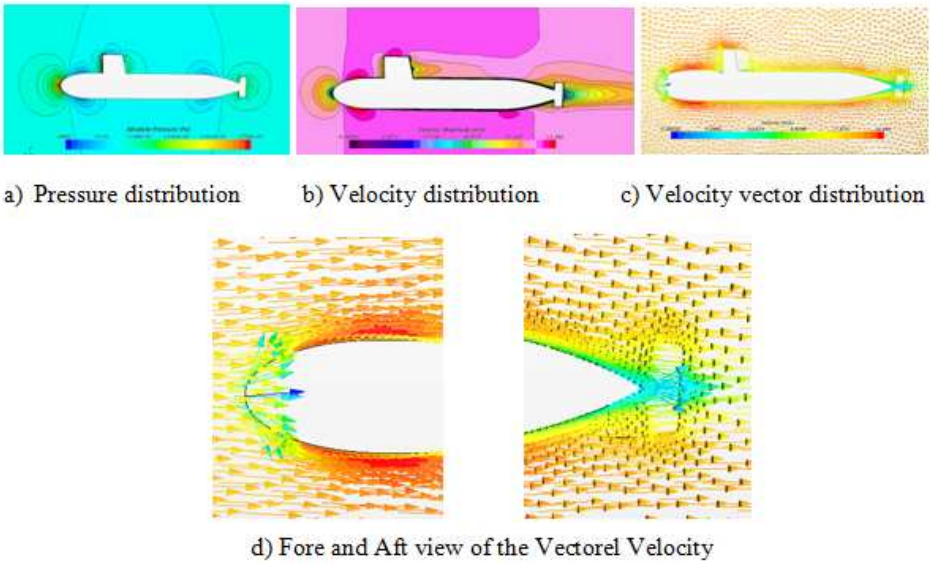


Figure 12. The pressure, velocity and velocity vector distributions around the submarine model at 1.818 m/s speed.

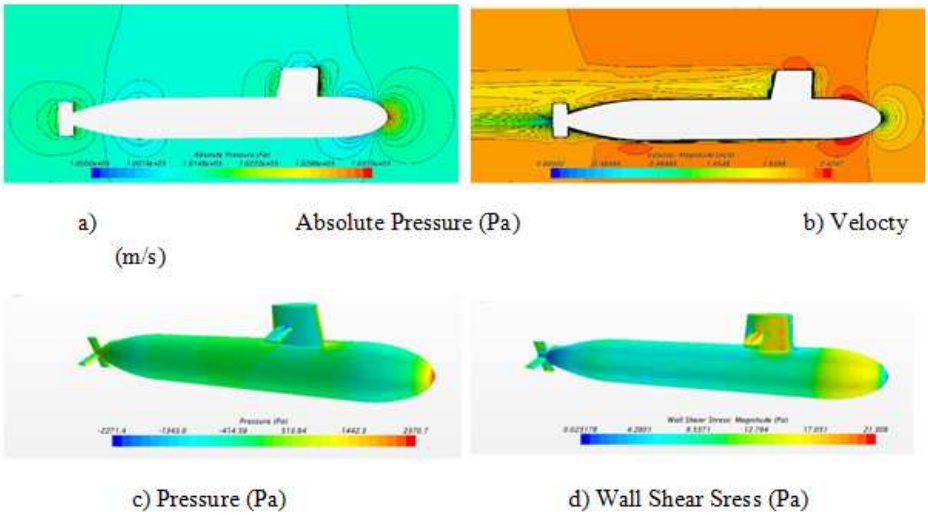


Figure 13. The pressure, velocity and velocity vector distributions and Wall Shear Stress around the submarine model at 2.1824 m/s speed.

The computed values of drag and lift forces (resistance) for different speed of submarine model is given in table 3.

Speed (m/s)*	*Drag Force (N)*	*Lift Force (N)*	*Absolute Pressure Pa (min)*	*Absolute Pressure Pa (max)*	*V m/s (max)*	*Pressure (Pa) (min)*	*Pressure (Pa) (max)*	*Thrust (N)*
0,7274	0,9934	7,528	1,0118e+05	1,0159e+05	0,80699	-248,97	263,67	0,4070
1,0912	2,1005	16,9896	1,0100e+05	1,0192e+05	1,2117	-564,10	593,15	0,8994
1,4549	3,5955	30,2581	1,0074e+05	1,0238e+05	1,6161	-1006,5	1054,2	1,5826
1,8186	5,4765	47,3348	1,0041e+05	1,0297e+05	2,0207	-1575,8	1647,0	2,4572
2,1824	7,7347	68,2035	1,0000e+05	1,0370e+05	2,4247	-2271,4	2370,7	3,5217

Table 3. The absolute pressures and drag and lift forces (resistances) values for different speed of model submarine.

* The speed values are given in the table for the model submarine. They correspond to 5 to 30 knots of actual submarine speeds with 5 knots increments.

The values of maximum pressure, drag force and lift force acting on the submarine model are given interms of Reynolds number in Figure 14-16, respectively.

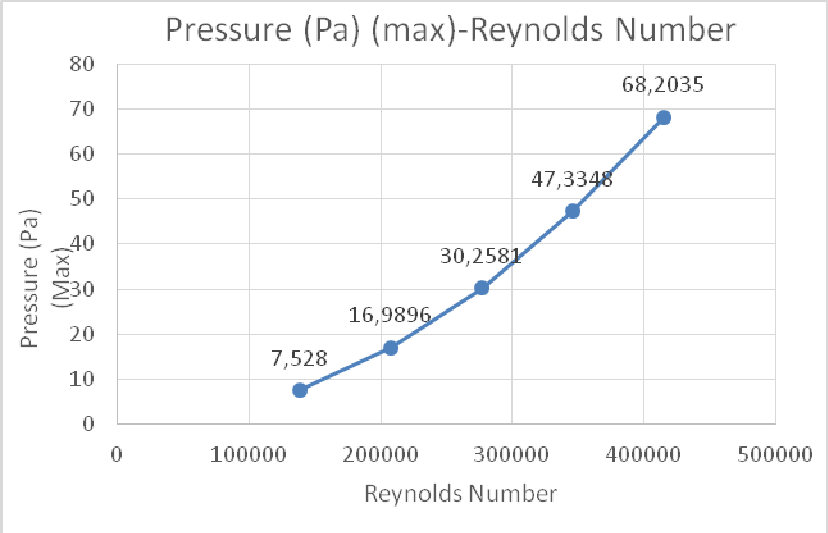


Figure 14. Reynolds Number vs Pressure (Max) (Pa)

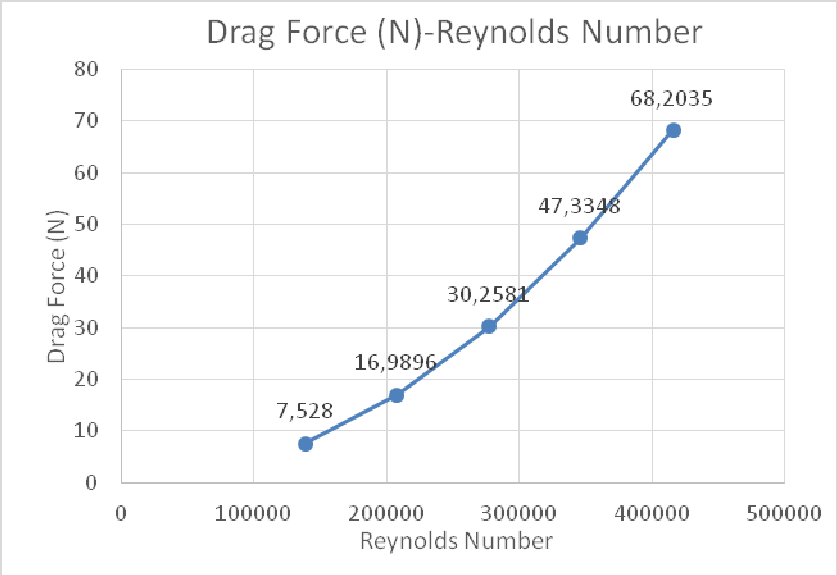


Figure 15. Reynolds Number vs Drag Force (N)

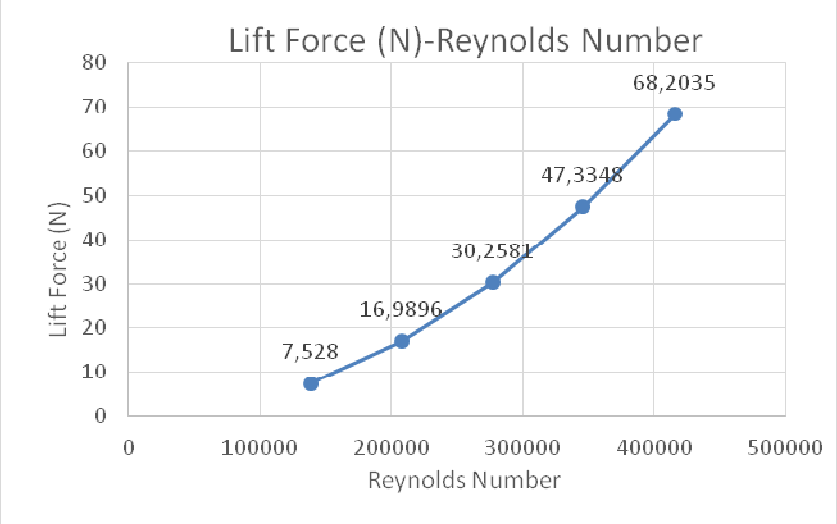


Figure 16. Reynolds Number vs Lift Force (N)

Investigation of the Sail Position According to Flow Distribution

This study was subsequently expanded to investigate the effect of sail position on design of submarine hydrodynamic. It is well known that the

details of the position and shape of the submarine sail will depend on the number of masts, type of power source, type of periscope as well as effects on steering and dynamic stability. Indeed it provides a bridge platform for conning the submarine on the surface and a supporting structure for about number of masts. It may also support the forward control fins. In the past, the location of the sail has been dictated by through-hull penetration masts like periscopes which could only be located in certain positions. This should not apply in the future because of improved designs of such systems to provide non hull penetrating masts. Choosing the correct position and height is important. If too tall it affects the centre of mass and may cause a greater snap roll [8]. Any non penetrating mast needs to be properly supported Arentzen and Mandel [6] report that the drag of these large appendages may be between 15-30 % of the bare hull drag.

In this study, six sail positions were examined, the first position has been taken from the nose point by L/(6.9) m for determination of the flow and absulate pressure distributions around it (see table 4). Then the sail position has been changed to backward by taking equal increment from its position at each step for the computation of the flow and absulate pressures distributions. On the other hand, the computations were carried out for three different sail cross sections such as NACA0012, NACA0018 and NACA0024. The velocity and absolute pressure distribution values obtained from CFD computations depending on changing the position of the submarine sailing are shown in figure 19 and 20, respectively where the sailing cross section has been taken as NACA0018. Before it can be considered the design of the submarine sail, it is important to review the basic phyics of the flow around foil sections. For example it is assumed that the foil has constant section, and is long enough; in this case, the flow around all sections of the sail foil is the same, and this is describe as 2D flow. Studying 2D flow can give many insights about the effect of the section shape on the performance.

Table 4. Sail locations

Position	Sail location distance from fore point to the back of submarine model	The distance between successive positions
Position 1	232,2 mm	113,5 mm
Position 2	345,7 mm	113,5 mm
Position 3	459,3 mm	113,5 mm
Position 4	572,8 mm	113,5 mm
Position 5	686,4 mm	113,5 mm
Position 6	800 mm	113,5 mm

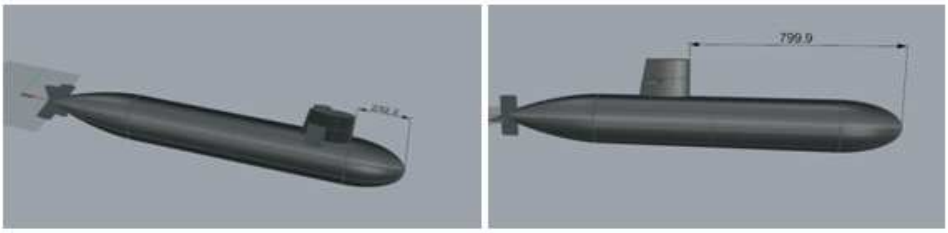


Figure 17. The first and last sail positions distance from the front of the submarine

Table 4. NACA Profiles to be used in model sail

	Thickness	Airfoil Lenght	Thickness / Airfoil Lenght
NACA0012	8,4 mm	70,0 mm	0,12
NACA0018	12,6 mm	70,0 mm	0,18
NACA0024	16,8 mm	70,0 mm	0,24

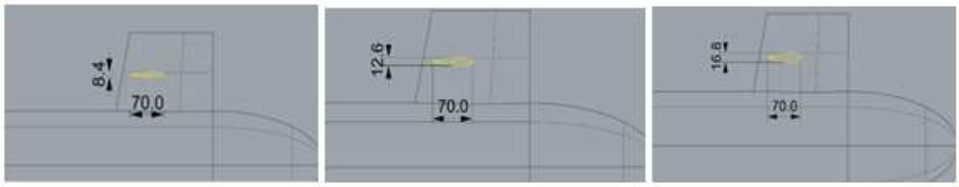


Figure 18. Sail dimension for three NACA Profiles

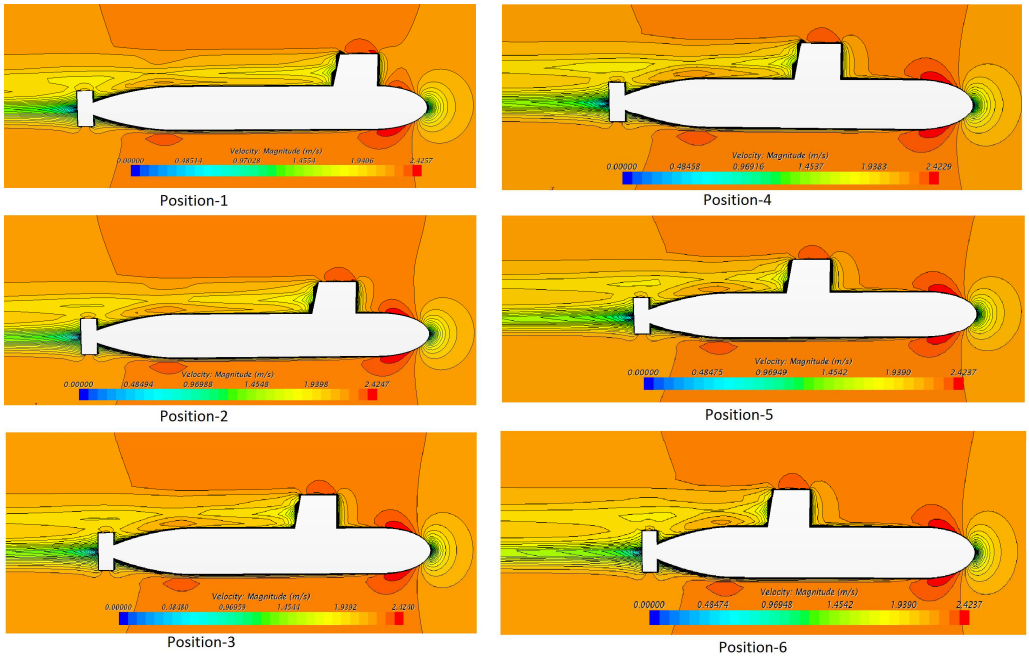


Figure 19. Velocity distribution with respect to the sail positions.

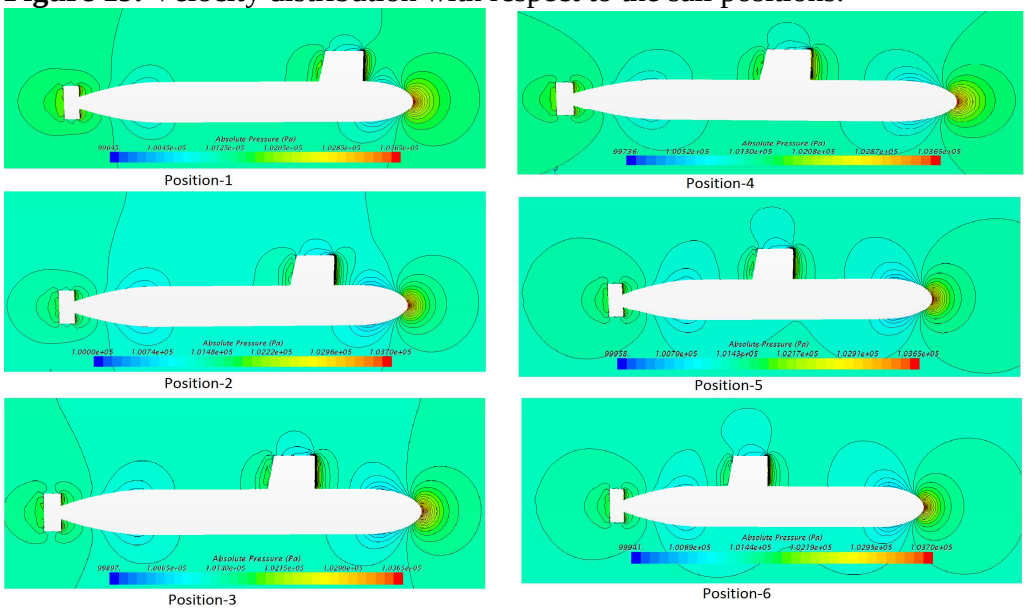


Figure 20. Absolute pressure distribution with respect to changing of sail position

From the position of the sail of the submarine with the flow lines were calculated by taking the values of absolute pressure in certain places.

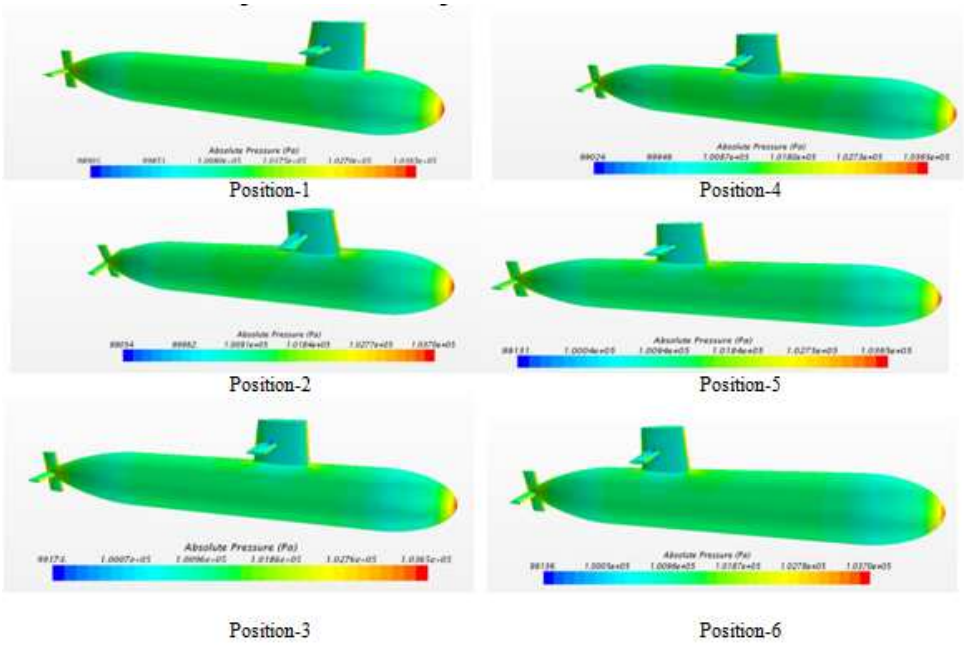


Figure 21. Absulate pressure distribution around the submarine in 3-D for different position of the sail having NACA0018 cross section

Conclusion and Recommendations

The increasing capacity and speed of computers raised the use of computational fluid dynamics (CFD) to the maritime industry. In the last decades, many developments have been observed in different areas of incompressible flow modeling including grid generation techniques, solution algorithms and turbulence modeling, and computer hardware

capabilities. One important conclusion is that CFD gives the quite accurate predictions, but requires many CPU-times. It can offer a cost-effective solution to many problems in underwater vehicle hull forms. However, effective utilization of CFD for naval hydrodynamics depends on proper selection of turbulence model, grid generation and boundary resolution. The most common turbulence modeling approach of today is RANS (with the SST k-ω turbulence model), which is based on a statistical treatment of the fluctuations about an average flow; it is expected that RANS will be the preferred, and fully sufficient, engineering tool for most design aspects. The advantage of RANS is however that the approach is fast (since only the mean flow is sought), and it is available in most CFD codes. This method can accurately predict the velocity field and absolute pressure distribution around a submarine and its resistance components. It also gives the possibility to visualize problem areas, such as separation zones. All CFD calculations were performed at model-scale Reynolds numbers of ~10^7. The study easily can be extended to full-scale Reynolds numbers.
The ratio of beam to diameter (same as length to diameter) bears a strong effect on the total resistance. The more wetted surface the greater the skin friction. This can be seen from the computational results of the submarine model used in this study (see table 1), the resistance of the bare submarine body decreases with increasing B/D (and L/D) ratio. This states that bare submarine's body resistace depens on the pressure distribution around the body eventhough the minumum pressure is increasing and the maximum pressure is decreasing. Therefore if the displaced volume of the submarine is contained in a long thin shape, then the skin friction is greater than for a shorter, beamier shape of the same volume which has less wetted surface. It is proposed that a new shape be considered of beamer shape or shorter length and greater diameter which will reduce the total drag force closer to the ideal.

In case of full submarine body including the sail and appendages, when the speed increases the resistance of the submarine increases as expected but the minimum pressure falling and maximum pressure increases opposite to the bare body case. This states that sail and appendages play an important role in submarine design. Besides, the mesh blocks in the vicinity of the sail

affected by geometry and mesh topology changes. The mesh away from the sail remained unchanged, leading to more consistent CFD results.

Apart from the hull shape, important items like the sail and control surfaces need to be optimised for position, size and shape to maximise operational effectiveness and minimise resistance. The details of the position and shape of the sail will depend on the number of items beeing built inside of sail. These details should be considered after the testing of the model of the bare hull. As a tentative first move the sail is drawn moved forward by approximately L/7 m from the front of the submarine in order to maintain the lateral stability and counter-balance the loss in lateral area aft. Indeed, the sail position, shape and size might be well provided according to the required volume for advanced future payloads. The sail of the submarine can now be discussed as it plays a major role in producing drag and hence its design is critical. Research has proven that a sail may contribute up to 30% of total submarine resistance.

As is known, it is one of the major problems in submarine noises. Flow noise is primarily caused by turbulence, and the general shape of the hull is less of a cause of turbulence than poor detailing. Many class of submarines have had the "old style" sail for many years, with only comparatively minor attempts at streamlining. Their sails have sharp corners to produce noise. It would be obvious that the "rounded" "streamlined" sail would produce less noise. Flow separation is the big cause of unavoidable turbulence, and unfortunately there isn't much you can do about that beyond a certain point. One question will rise in our mind from a hydrodynamic point of view, which is better? The hull shape leads to flow noise which is caused by flow disturbance thus the hull shape effects the submarine speed.

To validate the CFD code on similar sail shapes and positions calculations will be compared with experimentally obtained data at the same from in a wind tunnel or in a water channel. This data comparison includes flow visualization, axial velocity and surface pressures. The agreement will demonstrate that RANS codes can be used to provide the significant hydrodynamics associated with these sail shapes and positions. To improve the design several modifications can be done on sail position are evaluated

using the RANS code. Based on the predicted secondary flow downstream of the sail as well as the drag a new design is chosen, without having to build and test the inferior shapes, reducing time and cost for the program.

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TOWARDS SMART CLASSROOMS: EMERGING EDUCATIONAL TECHNOLOGIES

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ABSTRACT

Recent advances in computer technologies result in the development of E-Learning and Learning Management Systems. They provide mechanisms to organize course contents and training systems including interactions of trainers and trainees. Moreover, virtual reality systems emerge in the training and education systems to increase the trainee participation at the process and visualize the training subject. Increasing data transfer rates of the computer networks also made distant learning activities possible. Moreover, the economical solutions with the cloud computing technologies for the abovementioned systems come up. All these improvements lead the technology towards smart classrooms. It seems to alter the educational habits towards the flipped and the blended learning. In this study, general information about emerging educational technologies is given and a short evaluation with suggestions is presented.

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ÖZ

AKILLI SINIFLARA DOĞRU: YÜKSELEN EĞİTİM TEKNOLOJİLERİ

Bilgisayar teknolojilerindeki gelişmeler E-öğrenme ve Öğrenme Yönetim Sistemlerinin geliştirilmesine olanak sağlar. Eğitmen ve öğrenci etkileşimini de kapsayacak şekilde eğitim içeriklerinin ve sistemlerinin düzenlenmesi için gerekli altyapı, geliştirilen bu sistemler ile oluşturulur. Bunun da ötesinde sanal gerçeklik sistemlerinin eğitim ortamlarında yer almaya başlaması ile öğrencinin derse katılımı arttırılır ve eğitim konuları görsel olarak sunulabilir. Bilgisayar ağlarındaki artan veri aktarım hızları uzaktan eğitim faaliyetlerini mümkün hale getirir. Bulut bilişim teknolojileri ile de yukarıda bahsedilen eğitim faaliyetleri için hesaplı çözümler ortaya çıkar. Bütün bu gelişmeler teknolojiyi akıllı sınıflara doğru götürür. Bu da eğitim alışkanlıklarımızda ters-yüz edilmiş eğitim ve harmanlanmış eğitime doğru bir değişikliğe neden olur. Bu çalışmada, yeni ortaya çıkan eğitim teknolojileri hakkında genel bir bilgilendirme yapılmakta ve öneriler içeren kısa bir değerlendirme sunulmaktadır.

Anahtar Kelimeler: Öğrenme yönetim sistemleri, sanal gerçeklik, uzaktan eğitim, bulut bilişim, akıllı sınıflar, ters-yüz edilmiş eğitim, evde ders okulda ödev modeli, harmanlanmış eğitim.

Keywords: Learning management systems, virtual reality, distant learning, cloud computing, smart classrooms, flipped learning, blended learning.

1. INTRODUCTION

Recent advances in computer and networking technologies are changing current education and training philosophy, methods, and practices. Increasing computing speeds and advanced computer graphics technologies enabled virtual environments. Increasing internet speeds and storage areas together with the recent advances in cloud computing technologies, made the information available to everybody, from everywhere, at all times. As a resulting effect of the abovementioned technological advances, traditional training and education methodologies in which the trainer explains the subject in the classroom and the trainees make the exercises about the subject at home, start to leverage towards contemporary approaches like the trainees study the subject at home and the trainer make the exercises in the classroom with the trainees involvement. This new phenomenon at the training and education is called the "flipped learning" in which the in-class activities and the at home activities flip. With these advances, trainees start to get more involved and participate more actively at the training process. Thus, the quality of the learning process increases.

Learning Management Systems (LMS) and virtual environments constitute the main components of the contemporary education and training system. Advances at the internet technologies and the use of LMS systems together make the distant learning activities possible. Also, system setup and maintenance costs of the LMS and distant learning systems can be lowered with the use of cloud computing systems. All these technologies leverage the training environment towards smart classrooms. Also, training habits change to more interactive and practice oriented learning. One example is the flipped learning in which trainees have chance to do more practice on the training subject together with the trainer. Learning with the practice makes the training more permanent and useful for the trainees.

The rest of the study is organized as follows: In Section 2, emerging educational technologies, approaches, and tools including LMSs, the use of the virtual reality systems at the training environments, distant learning

technologies, cloud computing technologies and their usage for the LMSs, smart classrooms, flipped and blended learning are explained. Evaluation, conclusion and suggestions are presented in Section 3.

2. EMERGING EDUCATIONAL TECHNOLOGIES, APPROACHES, AND TOOLS

Improvements in educational technologies are enabling ubiquitous learning while increasing quality of education. These improvements cause an evolution from traditional classes to smart classes and traditional education to smart education. Technologies, approaches, and tools that provide this evolution can be list as LMS, smart classrooms, cloud computing, simulation technology, virtual reality/environments, augmented reality, e-books, mobile devices, interactive collaboration tools, gesture-based computing, distant learning, flipped learning, blended learning, game-based learning etc.[1] [2]. In this study, some of the most used ones from these technologies, approaches, and tools are covered.

Learning Management Systems

The life-cycle of the e-learning process is defined to have the following four phases; Learning design, learning production, learning deployment and learning assessment [3]. At the design phase, the targets and the requirements are specified. At the production phase, content is produced, assembled and packaged for distribution. At the deployment phase the trainees are collaborated. At the assessment phase, the learners and the process are evaluated. LMSs today are designed to support all these phases of the e-learning process.

An LMS can be defined as a software application to create, manage, and deliver online or offline electronic courses or training programs. It can support both on-campus and online education and training programs. There are commercial and open-source LMSs. Even social networking sites such as Facebook may be used as an LMS [4]. Some well-known commercial LMS software are Blackboard, Oracle ILearning, Edmodo, Successfactors,

Skillsoft, Schoology. Some of the popular open-source LMSs are Moodle, Sakai, Atutor, Eliademy, FormaLMS, Dokeos, ILIAS, Opigno, OLAT. LMSs available today are designed to have web based interface for the spread use of trainees and the trainers [5].

LMSs store and organize the educational material in a convenient and efficient manner. They provide means for the information sharing between the trainees and the trainer. Besides that, they also provide a platform for several educational activities like academic discussion, forums, online exams, grading, homework and exercise submission, attendance monitoring. Managing all the above mentioned educational activities centrally using an LMS improves the training quality [6]. In example, for the laboratory sessions of a course, the trainer doesn't need to evaluate all the trainees' activities during the limited laboratory hours. Instead the trainer can focus on the trainees' activities and the trainees can submit their resulting work using the LMS at the end of the laboratory session. And the evaluation of the work can be done by the trainer after the laboratory session.

LMSs are sometimes confused with Course Management Systems (CMS). There is a main difference between these two types of systems. While CMSs mainly feature the creation of course and training content, LMSs focus on the management of training and education programs. However, there are LMSs that include course management system functionality as well.

LMSs are not only used by schools or universities but also by many corporations and companies. LMSs are becoming an important part of enterprise management systems. There are many features provided with these systems. However, a basic LMS should be able to [7];

- centralize and automate administration,
- use self-service and self-guided services,
- assemble and deliver learning content rapidly,
- consolidate training initiatives on a scalable web-based platform,
- support portability and standards,

- personalize content and enable knowledge reuse.

According to a 2009 survey, the most valuable features of an LMS are [7];

- Reporting (52.8%),
- Compliance tracking (46.5%),
- Assessment and testing (42.5%),
- Learner-centered (39.4%),
- Content management (29.9%),
- Course Catalogue (28.3%),
- Authoring (19.7%),
- Manager approval (19.7%),
- Certification (18.9%),
- Standards (18.1%),
- Analytics (17.3%),
- Collaboration tool integration (15%),
- Security (14.2%),
- ERP/CRM integration (8.7%).

Furthermore, especially for corporate use, LMS should be able to integrate with the enterprise management system or other enterprise systems such as human resource management systems.

2.2.Virtual Environments

Virtual environments make use of the recent computer technologies to visualize the training subject. With these visualizations, the training gets more permanent for the trainee [8]. Virtual environments not only visualize the trained subject but also provide means for the trainees' active participation. With the use of virtual reality, the educational costs decrease. In example, pilot training can be done with a simulator instead of flying a real plane. The cost of using simulator is much more less than the cost of flying a real plane. In addition to that trainee can fly with a simulator as long as he/she wants and whenever he/she wants. Maintenance training can also be done much more easily with the use of virtual environments in

which the artificial training scenarios can be set up. The trainer's task is to decide whether to use the virtual reality in the training or not. A model to decide the use of virtual reality in a training course is explained in detail in [9]. In addition, to be given online is an important feature and advantage of virtual training courses [10].

2.3. Distant Learning

Recent advances in internet technologies, and increasing data transfer speeds made the distant learning possible. Asynchronous distant learning activities, in which the trainees and the trainer don't need to synchronize tightly, make the trainee download the training material and study the well prepared offline learning material like e-books, interactive e-books, and other training documents. Synchronous distant learning activities make the trainees and the trainer to meet actively in virtual classroom environment. Synchronous distant learning needs time synchronization between the trainees and the trainer in order for them to meet online at the same time. Synchronous distant learning activities provide independence of the locality of the training. In other words trainees and the trainer don't need to gather at the same physical location for the training. However, they can meet online inside a virtual classroom [11] and discuss on the training subject as if they meet in a real physical classroom. Trainers can choose from a variety of synchronous technologies including the slide presentation, audio and video conferencing, application sharing, and shared whiteboard [12]. Asynchronous distant learning activities provide independence of both locality and timing of the training. Trainees can learn every time, everywhere, whenever they want and when they are ready. However, asynchronous distant learning lacks the active real time interaction among the trainees and the trainer. The missing interaction can be enhanced with the synchronous components [13]. Recording the synchronous training session between the trainer and the trainees and making these recordings, together with the other training material, available to the trainees asynchronously with the use of an LMS commonly applied trend at the distant learning activities. Hence, the asynchronous and the synchronous solutions are combined in distant learning [14] [15] [16]. E-learning

collaborative circles in which people learn in groups while producing an outcome like an e-book, report etc. is proposed as a distant learning methodology in [17].

2.4. Cloud Computing

Recent advances at the internet technologies, increasing data transfer speeds result with the emergence of the new paradigm called cloud computing. Powerful computer centers serve their services, like LMS service, to a wide range of customers. This effort reduces the repeated effort at different sites [18]. In example, for the calculus class, each trainer does not need to prepare his own training material. Prepared high quality training material can be served centrally and can be used by all the trainers all over the world. Moreover, LMS can be operated centrally by the professionals and several different subscriber companies, schools, and the training centers can use these LMS services from the cloud [19]. Since LMSs/distant learning systems usually require many hardware and software resources, system setup and maintenance costs of the LMSs/distant learning systems can be lowered with the use of cloud computing systems. A metric system has been developed in [20] for measuring the system implementation process and the long-term usage efficiency of cloud computing based LMS solutions.

2.5. Smart Classrooms

Emerging LMSs, use of virtual reality in classrooms and use of internet technologies make the smart classrooms possible [21]. In a smart classroom, a smart board connected to a computer is employed instead of a dummy white board or blackboard. The smart board makes reuse of the training material possible. Also, eases to going back and forth on the material is possible. Integrating the computer of the smart board with an LMS and connecting to the internet make the distant learning activities with the smart classrooms possible. In other words, the high-quality training materials can be used repeatedly by both the trainer who prepared them and the other trainers, who need them, all over the world. A trainer from very distant

place can connect to the classroom and carry on the training interactively with the trainees [22]. The training session can be saved to the computer and the session can be made available with the use of an LMS. The trainees that missed the session and that participated to the session however did not understand some parts of the session, can later watch the session to catch up. On the other hand virtual reality systems are used in the smart classrooms as well. These systems help visualize the training subject for easy understanding. For example, for the biology class, 3D visualization of the human body makes the training much more efficient.

2.6. Flipped and Blended Learning

Availability of LMSs and the use of internet technologies caused a shift at the training habits. At the traditional training methodologies, the trainer talks about the subject at the classroom and the trainees perform exercises at home. Emerging Flipped Learning approach reverses this habit. Trainees study the subject at home and the exercises performed at the classroom together with the trainer [23] [24] [25]. While getting the classroom environment more trainee-centered [26] [27] [28], flipped learning requires training material to be available for self-studying of the trainer before the class. Training videos, recorded class sessions, offline training materials, e-books, interactive e-books, virtual reality tools are the materials that can be used for this purpose.

On the other hand, while flipped learning has a clear-cut of what to do in the classroom and what to do at home, blended learning, in contrast, blends at home and in class activities of the trainee. In other words, it blends the face-to-face activities with the distributed online activities [29]. In this respect, flipped learning can be thought as a subset of the blended learning.

3. CONCLUSION

In this study, the impact of the recent progress at the computer and the networking technologies on the training and education systems is examined.

The trend shift, in the training and education systems, towards flipped and blended learning caused by these progresses is also presented.

LMSs, virtual reality systems, distant learning technologies, cloud computing technologies, smart classes, flipped learning and blended learning, with the other emerging technologies, approaches and tools, cause significant change in the traditional education. This change makes the education more trainee-centric and ubiquitous as well.

It seems that the smart classrooms which contain aforementioned technologies will become widespread and can make the training and education process independent from the time and the location.

It is a fact that the use of these abovementioned technologies, approaches and tools in the educational process, will significant contribute to the quality of education.

It is evaluated that some new studies related to the contribution of the emerging educational technologies to the education processes are needed and these studies will provide acceleration in the usage of emerging technologies in the field of education.

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Bilgisayar Mühendisliği/Computer Engineering

SMART HOME SYSTEM HARDWARE and SOFTWARE DESIGN

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Abstract

The smart home system has been developed since 1980s. Its first application was built in 1984, in Turkey. In these first steps, the focused group was only people without disabilities. Initially, manufacturers tried to create all-in-one systems, yet the final products were all gadget-like and minimalistic. (Energy control units, security systems, light controllers, etc.) Smart homes have various application areas. Controlling central air conditioning in modern high-rise buildings, malls with parameters such as temperature and humidity is an example of real-time programming of these devices. The main idea here is to control the capacity of air conditioning equipment in order to save energy, thus saving money. The goal of our article is to make life easier with the help of computer science. With our knowhow and extra research of available information, by using the software portions and the hardware components, we aim to create a sensor-based smart home system. Basically, the system is getting the data from the sensors placed in different locations in home and transfer it to terminal via Wi-Fi. In the flowchart, the most crucial part is to connect the hardware problem-free. Next thing is to upload the code for these modules to an EEPROM computer to establish connection between devices and to display the information in the terminal screen. The designed system looks like an autonomous computer which can control the air conditioning with the help of various sensors with precision.

AKILLI EV SİSTEMİ DONANIM ve YAZILIM TASARIMI

ÖZ

Akıllı ev sistemi 1980'lerden beri geliştirilmeye devam edilmektedir. Türkiye'de ilk uygulama ise 1984 yılında yapılmıştır. İlk uygulamalarda, sıradan her hangi bir fiziksel engeli

olmayan insanların ev konforu düşünülmüştü. Üreticiler, bir sistemin bütününü entegre etmeyi amaçlamamışlardı. Ancak bireysel olarak kontrol edilebilecek birçok ürün çeşidi ortaya çıktı. (Enerji kontrol ünitesi, güvenlik sistemi, ışık kontrolcüleri… gibi). Literatürde bahsedildiğine göre çok farklı uygulama alanları, tipleri ve kapsamları mevcuttur. Yüksek katlı modern binalarda veya büyük alışveriş merkezlerinde, merkezi havalandırma sistemlerinin sıcaklık ve nem gibi parametre kontrolleri ile ilgili cihazların çalışma zamanlarının programlanması bu örneklerden biridir. Genel kurulum amacı binalarda kullanılan ısıtma soğutma ekipmanlarının kapasite kontrollerini yaparak enerji tasarrufu elde etmektir. Bu makaledeki amaç, insan hayatını kolaylaştırmaktır. Bilgisayar biliminin bununla ilgili kısımlarını kullanmak amaç edinilmiştir. Bu çalışamda, yazılım ve donanım unsurları kullanılıp insan hayatına katkıda bulunacak biçimde sensör temelli basit bir akıllı ev sistemi kurulacaktır. Sistem temelde ev içine farklı ortamlarda konumlandırılan alt bilgisayarlara bağlı ısı, nem ve çeşitli hayati öneme sahip gaz sensörlerinden bilgiler alıp kablosuz bağlantı yardımıyla ana bilgisayara bilgiler gönderip anlık olarak ana bilgisayara bağlı ekran vasıtasıyla bilgiler buradan görüntülenecektir. İş akışında en büyük başlangıç donanım kısmını sorunsuz bağlantılarla bir araya getirebilmektir. Ardından yapılması gereken asıl işlem ise bu modüllere uygun kodları EEPROM'lu min bilgisayarlara yükleyip cihazlar arasında iletişimi sağlayabilmek ve bilgileri doğru bir biçimde anlık olarak ekranda okunur bir biçimde görüntülemektir. Tasarlanan sistem, ilgili sensörler araclığıyla akıllı ev sistemi olarak çalışan otomatik bir bilgisayara benzemektedir.

Keywords: *Smart Home System, Hardware and Software Design, Arduino*

Anahtar Kelimeler: *Akıllı Ev Sistemi, Donanım ve Yazılım Tasarımı, Arduino*

1. INTRODUCTION

Technologic developments goes very fast and one of its application area is smart home. In this article, we develop this system both hardware and software structure. In 2005, scientists designed Arduino microcontroller. There are lots of projects implemented via this controller and this is very popular in electronical and computer science. Using this component decreases costs and increases designing of smart home. We contribute in this implementation area. Our system is secured closed loop home system which save energy and other

things. Designed system controls heat, gas, humidity, lighting and security [1-7]. It makes life easy and comfortable. Smart home also can be controlled with mobile phones and softwares. It can used with personal computer. Figure 1 shows the general structure and functions of smart home.

Figure 1. Application areas of smart home system

Arduino Mega 2560 R3 model is the central control unit of the system. Each electrical sockets can be connected with the system. For example, kettle, iron and other machines can be added easily to the system. In this case, switch on/switch off part must be added on to socket. All the sytem can be defined as automation system.

Arduino is open source microcontroller and its circuit schema is also open for every one. It is quite easy to make an electronical and software applications with it. PIC C is a programming language in order to use it. Necessary components are one type of Arduino (uno, mini, mega, leonardo) controller, USB cable, IDE program and computer.

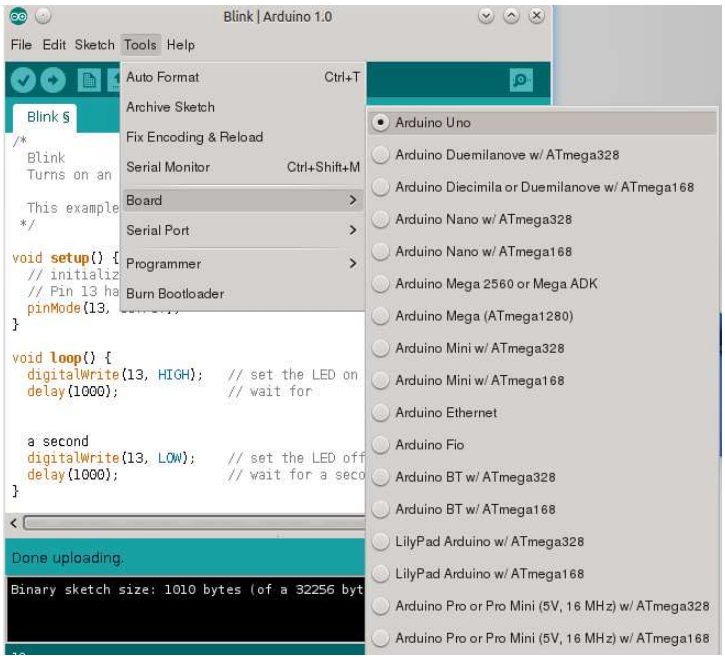

Figure 2. Arduino Model Choice Screen

We firstly choose Arduino port from menu in order to connect it with computer. After that the system has been developed.

2. HARDWARE / SOFTWARE COMPONENTS and THEIR IMPLEMENTATIONS

In this chapter we describe the hardware and software components of smart home system and their implementations. These components are Arduino Nano, Aluminium heatsink, small 5V air conditioned fan, Arduino Mega 2560 R3, 2x16 LCD keypad shield, 2.4 GHz wireless module, IR remote controller, thermal paste, DHT-11 heat and humidity sensor, MQ-2 / MQ-4 / MQ-7 gas

sensors, cables, prototype paltform (802 pointed breadboard) and other equipments. Arduino nano has ARM architecture 15 MHz clock cycled microcontroller. It has compatible with Bluetooth, wi-fi, GSM and USB.

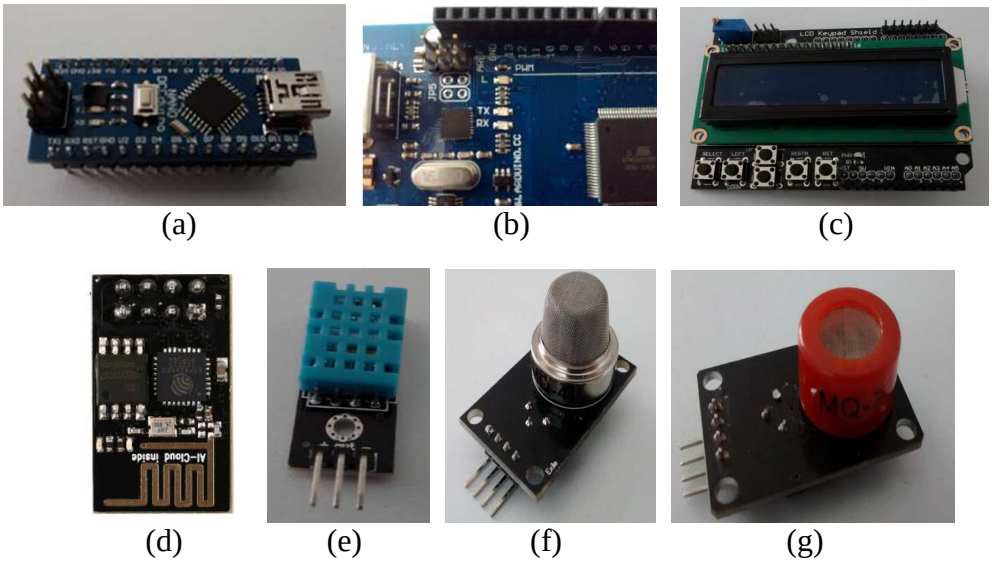

Figure 3. (a) Arduino nano (b) Arduino mega 2560 R3
(c) 2x16 LCD keypad shield (d) 2.4 GHz wireless module
(e) Heat and humidity sensor (f) MQ-4 gas sensor (g) MQ-7 gas sensor

Arduino mega 2560 R3 is our main computer which conduct the system and it has 16 MHz processor. There is USB point, 9V input on it, three LEDs and on/reset modules. 2x16 LCD keypad shield has buttons with matrix screen. Each row has 5x8 pixels. ASCII characters can be shownd and used on this screen part. 2.4 GHz wireless module works with 3.3 V. They have also antenna version. For home system development we have MQ-4 and MQ-7 gas

sensors. They detect CNG/LPG gas and carbonmonoxyde gas, respectively. These components can be seen from Figure 3. After opening the Arduino IDE, the libraries and definitions has been stored in to system. After adding libraries we defined the variables. These can be seen from Figure 4.

```
#include <LiquidCrystal.h> //lcd ekran kütüphanesini dahil ediyoruz
#include <dht11.h> // dht11 kütüphanesini ekliyoruz.
#define DHT11PIN 52 // DHT11PIN olarak Dijital 52'yi belirliyoruz.
dht11 DHT;              //Sıcaklık sensör tanımlama
LiquidCrystal lcd(8, 9, 4, 5, 6, 7);
```

```
void setup() {
  lcd.begin(16, 2); //lcd ekran başlangıcı
  lcd.createChar(0, newChar); //bar karakterini oluşturma
  pinMode(trig, OUTPUT);   //mesafe ölçmek için çıkış yapan ses dalga pini
  pinMode(echo, INPUT);    //mesafe ölçer için giriş yapan ses dalga pini
  pinMode(backlight,OUTPUT);//arka plan ışığının çıkış birimi olduğunu gösteriyoruz
  digitalWrite(backlight,HIGH);//arka plan ışığını başlangıçta aktif  ediyoruz
  menuAcilis();  //açılış menüsünü çağırıyoruz
  clearPrintTitle();     //üst satırı belirliyoruz
  }
```

Figure 4. Libraries, definitions and setup function

We define main menu with keypad. The screen is 16x2 matrix and x variable has been used for this. After that up, down, right and left keys defined for the system. Menu content also can be seen from user to control the smart home. We code the system and start the dynamical test phase.

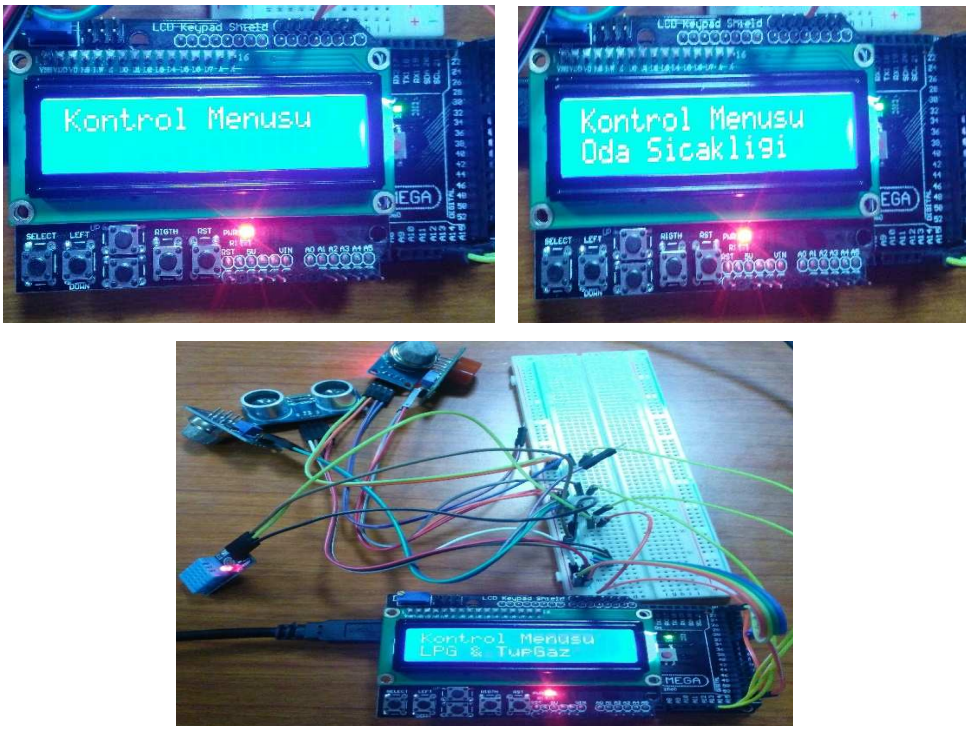

Figure 5. Smart home system

Smart home system illustrated in Figure 5. All hardware parts and software developments, coding phase has been completed in order to use it. We complete the design of the system with many parts.

5. CONCLUSION

Arduino microcontroller is one of the most popular card in a few years in order to design several electronic, robotic and software based system. It is easy to use, practical and compatible with many different hardwares. Lots of

applications developed by the scientists and they make life easier. Arduino developed in several years and there are several types of them available for the experiments. Entegrated systems also can be constructed with it. Connection can be made not only with cable but also wireless. Because of its many advantages we use it to design smart home system. These systems make life more comfortable, easier and economic. Because, controlling part of the home save energy. Especially, security, electrical machines, gas controlling, heat, humidity, lightining and automatic climate system main acquisitions from the systems. Mobile phones also can be used to control the smart home system.

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Temel Bilimler / Basic Sciences

CREATING SMART EDUCATIONAL CONTENTS FOR SCIENCE AND ENGINEERING LECTURES IN HIGHER EDUCATION INSTITUTIONS, AND SOLUTION PROPOSALS

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Abstract

The use of intelligent technologies in education increases every day. There are a lot of new technologies implemented lately. Intelligent White Boards (IWBs) are the most popular devices among them and preferred to use in education nowadays. But the use of these technologies requires compatible and supportable smart educational contents (SECs). It does not seem possible at this stage to find such SECs ready to use for university lectures. Undoubtedly one of the reason behind this issue is that contents of some lectures or their syllabuses show huge differences between universities, even from lecturer to lecturer. In addition, some of the universities could open some courses only for their specific needs. In this paper, our aim is to figure out the necessary characteristics of SECs and the lecturers who need SECs in their lessons, should take care of while preparing their own SECs.

Yüksek Öğretim Kurumlarındaki Bilim ve Mühendislik Dersleri İçin Akıllı Eğitim İçeriklerinin Oluşturulması ve Çözüm Önerileri

ÖZ

Akıllı teknolojilerin eğitim alanında kullanımı her geçen gün artmaktadır. Son zamanlarda birçok yeni teknolojinin geliştirildiği görülmektedir. Akıllı tahtalar bunlar arasında en popüler olanı olup günümüzde eğitim alanında kullanımı tercih edilmektedir. Ancak bu teknolojilerin kullanımı, bu teknolojilerle uyumlu ve desteklenebilir akıllı eğitim içeriklerini (AEİ) gerektirir. Şu aşamada üniversitelerde okutulan derslerin birçoğu için bu tür AEİ'lerinin hazır olarak temini mümkün gözükmemektedir. Bunun bir nedeni bazı derslerin içeriklerinin ya da ders müfredatlarının üniversiteler arasında köklü farklılıklar içermesi, hatta dersi veren öğretim üyeleri arasında bile uygulamada karşılaşılan farklılıkların olmasıdır. Bunun yanı sıra bazı üniversitelerin kendilerine özgü gereklilikleri karşılayacak dersler açabilmeleridir. Bu makalede bizim amacımız bahse konu AEİ'lerinin gerekli karakteristik özelliklerinin neler olması gerektiğinin ortaya konulması ve bu tür AEİ'lere ihtiyaç duyan öğretim üyelerinin kendilerine ait AEİ hazırlarken nelere dikkat etmesi gerektiğini ortaya koymaktır.

***Keywords**: Interactive White Boards, Smart Educational Contents, intelligent lectures, technological teaching tools.*

***Anahtar Kelimeler:** Akıllı tahtalar, Akıllı Eğitim İçerikleri, akıllı içerikler, teknolojik öğretme araçları.*

1. Introduction

Smart technologies find a broad usage area in our daily life and its usage is increasing every day. One of the most important inventions in this area is touchable screens. There are a number of application area for touchable screens such as smart phones, tablets and etc. Instruments supported with touchable devices give more flexibility to users to interact with their available software. These kinds of instruments are more valuable for teaching purposes, because teaching requires students' interaction during the lessons. The technological improvements accelerate one after another however their usage at specific areas need much more time than expected to become widespread. Changes in educational system should be distributed in a time period to make it work perfectly and to avoid its side effects. Otherwise, their results and contribution to education system would be more dramatic and worse than its expected benefit. In the literature there are a lot of study about the use of IWBs and their results. As summarized in the following.

Campbell et.al. stressed that while IWBs provide a means of introducing new learning opportunities, the technology must be supported from a pedagogical perspective in [1]. The effective use of IWBs must go beyond the manipulation of colorful, dynamic images to involve students acting in ways that might not readily have seen elsewhere [2]. Turel recommends researchers both to design interactive training packages for teachers and to find out the effectiveness regarding learning and interaction for students in [3].The written responses of the teachers were analyzed using descriptive analysis in [4]. According to the results teachers think that smart board increases the motivation, helps students to focus the course better, makes students attend the courses actively and also provides more enjoyable courses. There are a lot of works done in Turkey to make IWB technology to be widely used. The studies carried on the attitudes of teacher and student show that, without giving the required in-service training to teachers, there is no use to set up this kind of technology to the classrooms. Because the studies show that their use is not adequate and relevant without teachers training [5].

These literature shows that there are still problems about the aim of how to use new technologies in educational area. When a quick literature search is

done, it can be concluded that smart technologies applications are widely seen in kindergarten, primary school and high school educations. Because syllabuses are similar between these educational levels and there are lots of these kind of schools among the country. This situation take attention of business organizations and make them to invest on the smart educational tools in these schools in general. In addition, national educational system forces these schools around similar contents which helps the business organizations to apply smart technologies easily on these schools. In this aspect, even the private educational institutions have been producing their own smart contents according to their own needs and perspective. Lately these private schools started to create their educational tools such as video recorded lectures for distance learning, interactive teaching programs, educational platforms such as school specific lecture and question databases etc. But the government schools mostly supply their interactive educational software from business organizations.

The situation for universities are different. They have to find their own solutions by themselves. There are not so many alternatives to provide universities with solutions that make presentations ready for lecturers in Turkey. In this paper, the lack of such special purpose materials in universities are focused and suggestions for lecturers are figured out. Firstly the historical evolution of the intelligent devices used in education is presented. Secondly the characteristic requirements for intelligent educational contents in universities are analyzed. Thirdly the drawbacks and precautions for the usage of the intelligent systems are addressed. At the end, an example presentation and its results are shared.

2. Historical Evolution of Classroom Technology

Tremendous innovations are brought into life in classroom technology at the end of 17^{th} century. Some of the important historical improvements for the classroom technology are presented in Figure 1.

1870 Magic Lantern 	**1925 Film Projector** 	**1950 Headphones** 	**1958 Educational Television** 	**1972 Scantron** 	**2005 iClicker** 
1890 School Slate 	**1925 Radio** 	**1950 Slide Ruler** 	**1959 Photocopier** 	**1980-Plato Computer** 	**2006 XO Laptop** 
1890 Chalkboard 	**1930 Overhead Projector** 	**1951 Videotapes** 	**1960 Liquid Paper** 	**1985 CD-ROM Drive** 	**2010 Apple iPad** 
1900-Pencil 	**1940 Ballpoint Pen**	**1957- Reading Accelerator** 	**1965 Filmstrip Viewer** 	**1985 Graphing Calculator** 	**2013 Virtual Reality** 
1905 Stereoscope 	**1940 Mimeograph** 	**1957- Skinner Machine** 	**1970-The Hand-Held Calculator** 	**1999 Interactive Whiteboard** 	

Figure 1: The Evolution of Classroom Technology [9]

Invention of the first computer started a new era in all areas of life. It can be seen that after 1980, computers are started to use in the classrooms and computer based educational technologies are continuously developing. In Table 1, average starting ages to use computers, internet and mobile phone by age groups are presented based on the data of year 2013 [6].

Table 1: Use of Information and Communication Technology by Children Aged 6-15, [6]

Average Starting Ages to Use Computers, Internet and Mobile Phone by Age Groups, 2013

	Avarage Starting Age	**Age group 6-10**	**Age group 11-15**
Computer	**8**	6	10
Internet	**9**	6	10
Mobile phone	**10**	7	11

This information gives us the clues of why computer technology is being frequently used inside the classrooms. According to another statistics presented in Table 2, the ratio of the children who have their own private computer is 19.6% for 6-10 age group and this ratio increased to 29.4% for age 11-15 in Turkey [7].

Table 2: Proportion of children who have their private devices by age group [8]

	%	**%**	**%**
	Total	**Age group 6-10**	**Age group 11-15**
Computer (Desktop, Laptop, Tablet, etc.)	**24,4**	19,6	29,4
Mobile phone (including smart phone)	**13,1**	2,5	24
Game console	**2,9**	2,6	3,2
None of the above	**68,3**	78,5	58

Note: Respondents are allowed to choose more than one option. Therefore, the total is not equal to 100.

This statistics shows that student's interaction with smart technologies based on their early ages. If 29.4% of the students at age 11-15 have their own private computers, this shows that most of them can access and use computers at these ages even they don't have their own. According to another statistic given in [8], computer usage by higher education students (for last 3 months) in 2015 is 91.7%. These data shows that, computer and smart technologies are often used at higher education ages among the students. So the smart technologies should take a big role in higher education as it deserves. Opinions of the students should be investigated about the smart technologies. Are these smart technologies used properly while teaching in the classrooms and satisfies students needs? The answers are expected to provide lots of results about how the smart technologies are used in education. In this paper, our aim is to make clear how to use smart technologies while preparing lectures and to make benefit from their advantages. Interactive boards offer five different abilities, given in Table 3, to its users which are also very important properties for education. The properties of educational technologies can be listed as in the following areas; visual, sound, motion, interaction and touch. These properties are the reasons behind why Interactive White Boards (IWBs) are become so popular.

Table 3: Educational Technologies and their properties [10]

Device	Visual	Sound	Motion	Interaction	Touch
Real goods and models	*				
Written materials	*				*
Visuals (photo, picture, drawing, graphs, etc.)	*				
Show boards (chalk, bulletin, multi purpose)	*				
Overhead projector	*				
Slide and film tapes	*	*			
Sound tools (cassette, CD)	*	*			
Video and film	*	*	*		
Television	*	*	*		
Computer Software	*	*	*	*	
Multimedia	*	*	*	*	
Intelligent Board	*	*	*	*	*

3. Higher Education Needs For Interactive Education

Higher educational institutions are distinguished from primary and high schools from the perspective of the aim of the education. Universities are free to apply their own programs and they create their own teaching syllabus according to their aims. Meanwhile, course credits shows differences between universities. Bologna process is established to bring out these differences. It is managed along 50 countries around the world. The overarching aim of the Bologna Process is to create a European Higher Education Area (EHEA) based on international cooperation and academic exchange that is attractive to European students and staff as well as to students and staff from other parts of the world. This process is brought to clear the complexity to understand what other universities provide to their students around the Europe. With this complex structure of the higher educational institutions, it is difficult to find standardized smart educational tools ready to use with IWBs. Recently, business organizations provided some solutions to supply educational contents for universities. However, these are not sufficient and adequate to be used directly by lecturers. As a result lecturers in higher education still prefer to use classical teaching tools such as pens over boards in most of the essential universities.

In fact the use of smart educational technologies present lots of benefits to Science and Engineering Departments in universities. These departments mostly use high technology for research purposes. "While giving undergraduate education, how can lecturers benefit from those IWBs?" Before giving some clues about it, some of the benefits, contributions and problems to be encountered and proposals about using IWBs in higher education is presented below.

Benefits of IWBs:

- Decreasing lecture time by;
    - Recording lectures,
    - Chance to reach previous lectures to review,

  - Capability to print out the contents of the boards to give students,
- Unlimited work area and storage capability,
- Working with Learning Management Systems.

These benefits are valuable to students if it is used properly. Next, the question is "What are the contributions of IWBs to learning-teaching atmosphere?"

Contributions of IWBs:

- Positive contribution to motivation,
- Potential to support teaching and learning,
- Increasing students' participation,
- Capability to use multipurpose systems,
- Make lessons more interesting,
- Positive contribution to interaction,
- Allows usage and modification of readymade learning materials,
- Capability to store, print out and reuse lectures, using LMS systems.

In addition, some problems may be encountered during the usage of such intelligent educational tools. Possible problems that may occur are presented below:

- Technical issues while using IWBs,
- Problems in learning-teaching and motivation,
- Lack of adequate and suitable materials for using with IWBs,

- Physical problems about classroom environments, (such as lights, position of IWBs, visual clarity)
- Initial excitement to use IWBs may be lost after a while,
- Technical support requirements for teachers,
- Teachers' needs for in service training during education period.

Before using the IWBs actively in educational system, some of the precautions should be taken. These necessary precautions and proposals for using IWBs are presented below:

Proposals for using IWBs efficiently:

- Teachers and students should be trained to use IWBs,
- Proper materials should be prepared for teaching,
- Hardware and software problems should be solved quickly,
- Both hardware and software should be renewed periodically,
- There should be a user manual for efficient use of IWBs, and should be updated continuously,
- Physical properties of the classrooms should be considered,
- Technical personnel should be ready to help teachers when necessary.

The addressed subjects above are the benefits of the IWBs in education. In the next section, the requirements arose in classical education and solution proposals are investigated.

4. Requirements in Classical Lectures in Science and Engineering Classrooms

The question are “What are the difficulties while presenting science and engineering lectures?” and “How can the instructors teach and make clear some of the techniques and subjects in science and engineering students’ mind?”. These questions come from the difficulty to express some of the science and engineering subjects, which becomes cumbersome to express in classical black boards. In addition, required visuality to present some of the subjects on black board is not so easy for most of the lecturers. In this paper an example form the math lecture is given. Definition of the theory of integral in calculus is selected as an example topic. Instructor have to define partial sums and display how Riemann Sums are converging to a limit which is addressed as integral in this topic. Computing the area under a complex curve or computing the volume of a complex body can be selected as other examples which can be better presented using smart technologies. These examples can be extended to graphic drawing, 3-D coordinate systems, surface integrals, etc. "What are the significant reasons to use IWBs in science and engineering lectures?". These reasons can be listed as follows:

- Complex graphical presentations necessary to describe the subjects,
- Difficulties encountered to draw 3-D graphics and making changes to describe subjects on black boards,
- Requirements to use animations to describe difficult physical subjects which could not be understood by imagination,
- Difficulties to repeat similar problems with different scenarios,
- Needs for presenting tables during the lectures,
- Sound and motion requirements and user interaction within the presentation,

- Describing scientific problems by using moving sketches and graphs during lectures,
- Students' unwillingness to take notes while trying to understand the lectures,
- Spending time while describing and writing by lecturers and students.

This list can be extended, but at first glance, these are commonly encountered requirements.

Another requirement in classical teaching system is perfectly described with the following words written by a famous poet. *"It is the disease of not listening, the malady of not marking, that I am troubled withal."* says William Shakespeare in his history play IV. Henry. These words still preserves their value. There are two big benefits of taking notes during lectures;

- First of all, it provides active participation to the education. In this way, it is easy to keep awake, concentrate on the subject learned,
- Secondly, marking and editing notes later prevent disremembering.

Other benefits of taking note are,

- Makes students active along the lectures,
- Ensures that the learned things become permanent by repeating,
- Enables economy from time and energy,
- Reduces anxiety before exams,
- Allows easy preparation of reports and assignments,
- Develop the ability to evaluate and criticize.

What should be considered while preparing such an IWB material to make audiences to take their own notes?

- Note-taking habits should be considered,
- Prepared lecture contents should avoid giving everything ready at first sight. Lecturer should add his own statements to the subject interactively during the lecture to make students active,
- Courses should be prepared to give feeling that, it is given in a normal black board and interaction during show should be added to the screen by writing and lecturer should give time to students to take their own-notes wherever necessary,
- Lecturers should use blackboards simultaneously while using IWBs and should allow students to write their own notes during example solutions,
- Smart boards should not take the place of teachers,
- Smart boards should not be used just to transfer copy of book papers to the screen. This may be harmful to the learning process.

If lecturers misuse IWBs in their lessons, students may fail to listen after a while as illustrated in Figure 2.

Figure 2: Students are passive and not following the lecture.

Considering the subjects presented above, lecturers can prepare their own teaching materials using smart technologies better than the classical manner. In this way, students can be active during the lectures and learn the subjects with better understanding. By using IWBs' benefits such as touch screen, lecturers can add their marking simultaneously on the board while explaining the importance of the subject. During the lecture, adding useful graphics and animations may attract students attention and also save the time to describe a lot of subjects whenever necessary. List of tables can be presented easily and time consuming writing issues can be prevented. It is clear that, the lecturer can save a lot of time during presentation of their lectures, but it depends on how the subject is prepared before. It is the key issue. If the lecturer does not spend enough time to prepare the sketch of the lecture for IWBs, it may be just a simple projection of lots of uninteresting knowledge for the students. So, the lecturer should think that, "What should be presented?" and "How they should be positioned?" in each screen. In this way, lecturer can leave enough space for editing purposes to use during the presentation of the lecture on IWBs. Therefore, lecturer should study and plan each screen of the lecture step by step. After that, lecturer should consider preparing the Interactive Content for White Boards (ICWBs). In preparation step, lecturer should consider that they are going to present this material in the class and fill the necessary empty spaces of the screen with their explanations to keep students active during the lecture.

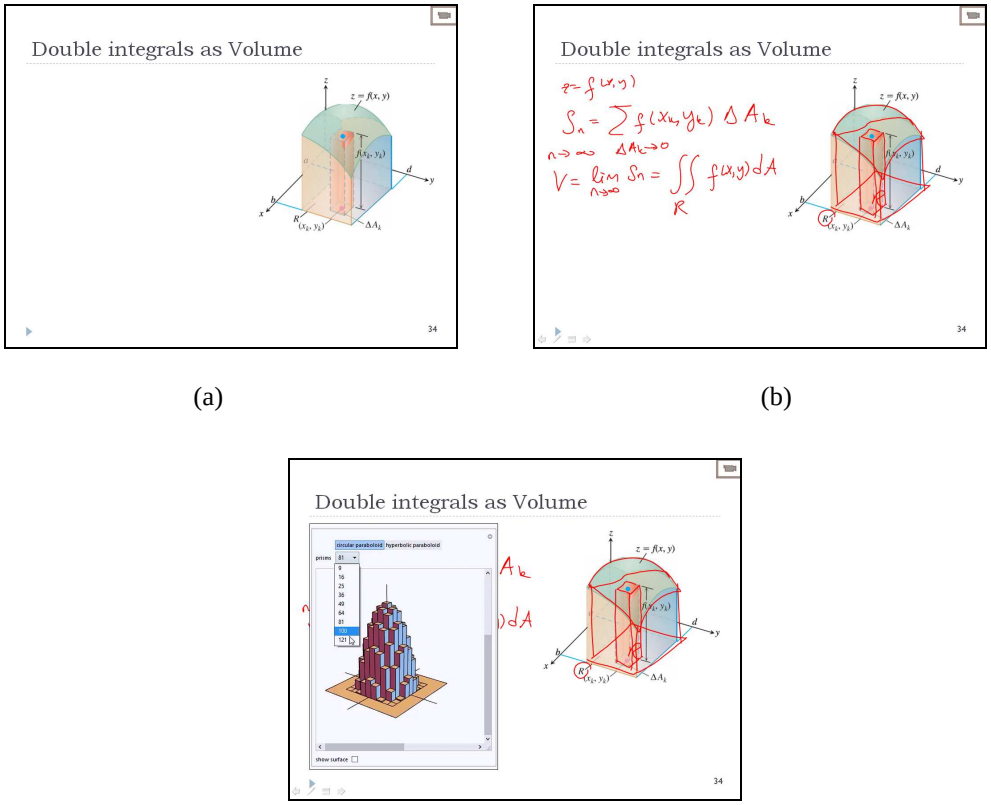
Some of the parts of an example lecture are prepared for illustrative purposes here considering the above topics using IWBs. The title of the lecture is “double integrals as volume” from the calculus lesson. The presentation screen is planned in three stages.

- At first stage, just the figure describing the volume in 3-D is presented in Figure 3-(a) and talks about the area on x-y plane and the volume above this area up to the surface represented by z=f(x,y) is described to the students by marking on the 3-D image using IWB.

- In the second stage, the volume is written as a finite Riemann sum S_n and its limit is taken while n goes to infinity, which is presented as double integral. Later on, it is shown as volume under the surface z=f(x,y) as pictured in Figure 3-(b).

- At the end, lecturer wants to demonstrate this limit by increasing n using an animation, which is proposed to help students to realize how the limit covers the whole volume under the given surface. To do this, lecturer plans to just press 'video icon' at the upper right corner of the screen and the animation gets start as presented in Figure 3-(c).

Three steps of the topic are described above. This presentation is totally depends on what lecturer wants to give to their students and how lecturer wants to present the topic. The lecturer prepares all of the empty spaces and their position at the preparation step and edits the figures by himself during presentation. Also, an animation is located on the same screen to make the topic interesting and more understandable for students.



(a) (b)

(c)

Figure 3: Example screen captures about the double integral as volume in three steps.

By giving this example here, it is addressed that, lecturer's imagination and ability to describe the lecture plays the key role. This depends not only to the lecturer, but also to the group of students and the topic. When all of these factors are considered together, a good presentation which can be used interactively can be built and used. Taking into account the feedbacks, instructors can improve their presentations by editing. If lecturer record and send these notes to the students, even including sound, then students can replay and strengthen their understand of the lectures. These are the benefits of presentations prepared using smart educational tools.

This example lecture is applied to a group of 25 first year engineering students. After this lecture is presented, a questionnaire is applied to this group of students. Selected questions and students replies are presented in Table 4.

Table 4: Questionnaire applied to engineering students to learn their opinion about the use of IWBs.

Questions	**Percentage of favorable answers**
When IWBs used in lessons, the things I have learned are getting more permanent.	%72
Through interactive whiteboards I can access information quickly and easily.	%72
When interactive whiteboards are used in lessons my focus is scattering.	%20
I like to use the board and the interactive whiteboards together.	%88
There is sufficient course content prepared for the use of the IWBs.	%60
I think the course contents should be prepared in a professional manner.	%96
I give importance to the presentation style of the lecturer rather than the course content.	%76

The results of the questionnaire show %96 of the students think that the lectures for IWBs should be prepared by professional manner. In addition, %88 of them think that IWBs should be used together with the classical boards. Just %20 of them say that the use of IWBs make them lose their focus on the lesson. Also %60 percent of them think that there is sufficient course content available for IWBs. When the questionnaire analyzed, the result shows that the students in engineering departments are eager to use IWBs during the lectures. They already understood the benefits of this technology and their opinions point out the importance of the preparation of the contents used with IWBs. At

the end of this questionnaire, a place in the sheet is left empty for students to write their own ideas and offers. Most of them request that the scope and the rate of the presented knowledge on IWBs should be carefully arranged. Otherwise, students do not follow the lecture after a while. In addition to the students ideas and offers, lecturer's opinion are asked after the presentation. The lecturer who gives this lecture in different classes in classical way says that, the questions from this group and the other groups are different. The students which took the lecture using IWBs ask more difficult and deep questions while the other group which took the lecture in classical way still try to understand the topic. This shows us the importance of using animation and visual tools while presenting science and engineering topics.

5. Conclusion

The aim of this paper is to describe "How the smart educational technology should be used in today's classrooms?" in higher education. Smart educational technology should be used considering both its benefits and drawbacks. If it is used just to project a sheet of paper on the screen in the classroom with classical manner, the mentioned problems in section 4 may be encountered and as a result student attendance to the class decreases. If the instructor plans their lectures to use IWBs interactively, then its benefits can be felt by students and positive feedbacks returns to the instructors. Otherwise, these technologies could be just a waste of money and time for both sides in higher education.

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GENERALIZATION OF A UAV LOCATION AND ROUTING PROBLEM BY TIME WINDOWS

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Abstract

In this study we extend and generalize a locating and routing problem for UAVs, with an objective of maximization of the total score collected from interest points visited. By solving the problem we determine simultaneously take-off and landing stations and visit order of interest points for each UAV. The problem is defined by an integer linear programming (ILP) formulation. An ant colony optimization approach is altered for the introduced problem. Computational experiments are performed to compare CPLEX solver and the heuristic. We observe that the heuristic performed well on the experienced instances.

ÖZ

Bu çalışmada İHA'lar için kullanılan, ziyaret edilen noktalardan toplanan puanlarıençoklamayı amaçlayan bir yerleştirme ve rotalama problemi geliştirilerek daha genel bir problem haline getirilmiştir. Bu problemin çözümü ile her bir İHA için kalkış ve iniş istasyonları ile noktaların ziyaret sıraları eşzamanlı olarak belirlenmektedir. Problem tamsayılı doğrusal programlama modeli olarak formüle edilmiştir. Bir karınca kolonisi optimizasyon yaklaşımı problem için modifiye edilmiştir. Sayısal denemelerde CPLEX çözücüsü ile sezgisel yaklaşım karşılaştırılmış, sezgisel yaklaşımın tecrübe edilen problem örnekleri üzerinde iyi performans gösterdiği tespit edilmiştir.

Keywords: *Location and Routing Problem; Ant Colony Optimization;UAV.*
Anahtar Kelimeler: *Yerleştirme ve Rotalama Problemi; Karınca Kolonisi Optimizasyonu; İHA.*

1. INTRODUCTION

In recent years we have witnessed that UAVs can increase the capability of military power by achieving difficult tasks that are unsafe for pilots. More specifically, small UAVs are employed by navies and used as surveillance drones by launching from small platforms.

For a navy, having mobile platforms and changing interest points, most surveillance tasks require a predetermined plan for stationing and routing the UAVs. A problem for optimal planning such an operation is defined by Yakıcı [1], and named as prize collecting location and routing problem (PCLRP). In PCLRP, it is assumed that identical UAVs are allocated to bases. Each UAV takes off from its base follow a route and land on its base where each UAV is limited by a maximum flight time. Optimal solution to this problem maximizes the collected scores (considered as importance factors) from visited interest points. Since the Integer Linear Programming (ILP) solvers provide poor solutions or no solution in reasonable period of times, an Ant Colony Optimization method is suggested by the author.

In this study, this basic problem is generalized to allow UAVs to take off and land at different bases, and to include time windows for assigned tasks to interest points. To the best of our knowledge, this problem is not introduced before. We give a formulation of this new PCLRP generalized with time windows. We also propose some modifications to the solution method suggested by Yakıcı [1] to employ it in solving new PCLRP which we call PCLRPTW from now on.

Since PCLRPTW and solution method proposed in this study are similar to PCLRP and its solution method, we do not give a detailed literature review here. For this purpose we refer to the literature review given by Yakıcı [1]. However, here we should at least specify the most relevant paper which is introduced by Ahn et al. [2]. It is defined in the context of planet exploration missions. The details of the solution method are presented by Ahn, DeWeck, Geng, and Klabjan in another paper [3]. Their problem is a rich version of PCLRP. However, it does not consider time window for each site visit as we do in PCLRPTW.

The readers are referred to recent survey papers by Drexl and Schneider [4] and by Prodhon and Prins [5] for a general review of the LRP literature.

In the following sections, we introduce the problem, explain the suggested metaheuristic method and present the result of our computational experience. Finally, in the last sections we provide concluding remarks.

2. PROBLEM DEFINITION

In our problem, we assume a fleet composed of identical UAVs. Therefore, we only specify one maximum flight time, one required time for each interest point visit and one cruising speed. Although we assume sufficient number of platforms, a limit may be introduced on the maximum number of active stations where platforms are stationed. The interest points and their time windows are assumed to remain fixed.

A solution to the problem is a number of routes, which is equal or less than the total number of UAVs, each takes off and lands in the allowed time and without violating time windows defined for interest points.

Below, we present indices, sets, parameters, variables and ILP formulation for the problems PCLRP and PCLRPTW. PCLRP and PCLRPTW are defined by the equations and inequalities (1-13) and (1-4, 7-22), respectively.

$u \in U$	set of UAVs.
$i, j \in I$	set of interest points.
$i, j \in S$	set of stations.
d_{ij}	expected elapsed time in flight between i and j.
p_i	importance of interest point i.
t_i	expected elapsed time on interest point i.
y_{max}	maximum number of active stations allowed.
t_{max}	maximum time between takeoff and landing for UAV.
b_i	beginning time for time window of interest point i.
e_i	ending time for time window of interest point i.
X_{iju}	binary variable indicating if UAV u has a leg from point i to point j, or not.

Y_i binary variable indicating if station i is activated, or not.
F_{iju} a continuous variable.
A_{ui} arrival time of UAV u to interest point i.

$$\max z = \sum_{j \in I \cup S} \sum_{i \in I} \sum_{u \in U} p_i X_{jiu} \quad (1)$$

subject to

$$\sum_{i \in S} Y_i \leq y_{\max} \quad (2)$$

$$\sum_{j \in I} \sum_{u \in U} X_{iju} \leq Y_i \ |I| \quad \forall i \in S \quad (3)$$

$$\sum_{i \in S} \sum_{j \in I} X_{iju} \leq 1 \quad \forall u \in U \quad (4)$$

$$\sum_{j \in I} X_{iju} = \sum_{j \in I} X_{jiu} \quad \forall i \in S, u \in U \quad (5)$$

$$\sum_{i \in I \cup S} \sum_{j \in I \cup S} X_{iju}(d_{ij} + t_j) \leq t_{\max} \quad \forall u \in U \quad (6)$$

$$\sum_{i \in I \cup S} X_{iju} = \sum_{i \in I \cup S} X_{jiu} \quad \forall j \in I, u \in U \quad (7)$$

$$\sum_{i \in I \cup S} \sum_{u \in U} X_{jiu} \leq 1 \quad \forall j \in I \quad (8)$$

$$\sum_{i\in I\cup S}\sum_{u\in U} F_{jiu} - \sum_{i\in I\cup S}\sum_{u\in U} F_{iju} \leq \varepsilon * \sum_{i\in I\cup S}\sum_{u\in U} X_{iju} \qquad \forall j \in I \qquad (9)$$

$$F_{iju} \leq X_{iju} \qquad \forall i \in I \cup S, j \in I \cup S, u \in U \qquad (10)$$

$$\forall u \qquad \varrho\, 1$$

$$\forall i \in I \cup S, j \in I \cup S, u \in U \qquad (11)$$

$$Y_i \in \{0,1\} \qquad \forall i \in S \qquad (12)$$

$$F_{iju} \geq 0 \qquad \forall i \in I \cup S, j \in I \cup S, u \in U \qquad (13)$$

$$\sum_{j\in I}\sum_{u\in U} X_{jiu} \leq Y_i\, |V| \qquad \forall i \in S \qquad (14)$$

$$\sum_{j\in I}\sum_{u\in U} X_{jiu} \leq \sum_{j\in I}\sum_{u\in U} X_{iju}\, |U| \qquad \forall i \in S \qquad (15)$$

$$\sum_{i\in S}\sum_{j\in I} X_{jiu} \leq 1 \qquad \forall u \in U \qquad (16)$$

$$\sum_{i\in S}\sum_{j\in I} X_{iju} = \sum_{i\in S}\sum_{j\in I} X_{jiu} \qquad \forall u \in U \qquad (17)$$

$$A_{uj} \leq \left(1 - \sum_{i\in I\cup S} X_{iju}\right) M + E_j \qquad \forall j \in I, u \in U \qquad (18)$$

$$A_{uj} \geq \left(\sum_{i \in I \cup S} X_{iju} - 1 \right) M + B_j \qquad \forall j \in I, u \in U \qquad (19)$$

$$A_{uj} \geq A_{ui} + X_{iju} t_i + d_{ij} + (X_{iju} - 1) M \qquad \forall j \in I, u \in U \qquad (20)$$

$$A_{uj} + t_i + X_{jiu} d_{ij} + (X_{jiu} - 1) M \leq t_{\max} \qquad \forall i \in S, j \in I, u \in U \qquad (21)$$

$$A_{uj} \qquad \forall j \in I, u \in U \qquad (22)$$

The function (1) represents total importance values collected from interest points. Constraint (2) limits the number of stations that can be activated. Constraints (3, 4) force each UAV to start its route from only one station to which it is assigned, while Constraint (5) force each UAV to return back to its departure point. Constraint (6) limits flight time. Constraint (7) serves as flow conservation. Constraint (8) limits the departures from interest points to one. Constraints (9, 10) prevent infeasible tours, where ε is a small positive real number. Constraints (11-13) identify the sets for decision variables. The objective function and these constraints (2-13) collectively define PCLRP.

We extend PCLRP by implementing two new features. One of them is allowing each UAV to land on any one of the active stations and the other is adding time windows for the task can be started on interest points. Removal of constraints (5, 6), and employing the constraints (14-22) provides the extended problem PCLRPTW.

Constraint (14) ensures that if station is not active, UAV cannot land on that station. Constraint (15) restricts that landing on a station can occur if a takeoff is realized at that station. Constraint (16) forces each UAV to land on at most one station. Constraint (17) ensures that if a UAV takes off, it must land. Constraints from (18-20) provide the satisfaction of time window restrictions. Constraint (21) ensures that all UAVs should return to a station before the

given time. Constraint (22) declares the domain for variable A_{uj}. The constant M, used in Constraints (18-21), represents a positive real number greater than t_{max}.

3. HEURISTIC SOLUTION APPROACH

In this section we refer to the Ant Colony Optimization (ACO) metaheuristic tailored for PCLRP by Yakıcı [1].This heuristic algorithm includes two main procedures, one is related to solution construction and the other is related to pheromone update. Robust design of ACO algorithm allowed us to utilize it for our problem with a minor modification to the probability distribution employed in the routing phase of solution construction in the study of Yakıcı [1]. Since only the construction procedure is affected by the change from PCLRP to PCLRPTW, here we do not mention the procedure related to pheromone update. However, to keep the integrity of this article, we will define the parameters used in the construction phase of the algorithm, without explaining details.

The proposed heuristic technique is similar to MMAS (MAX-MIN Ant System) [6, 7]. In this method, ants represent UAVs and the collection of routes by ants constructs one solution. The algorithm repeats iterations of solution construction and pheromone trail update to converge to a good solution.

The visibility component η_{ij} is a measure of importance of interest point j per unit time elapsed both in transition between the points i and j and in executing the task at j. Two learned knowledge components $\tau^{gl}_{i,n_i,j,k}$ and $\tau^{sl}_{i,n_i,j,k}$, reflects the contribution of solution component experienced in prior solutions. A solution component identified by the indices i, n_i, j and k relays the information that i is the station, n_i is the count of UAVs assigned to station i, j and k are the current and the next location of UAV, respectively. A solution must be formed by feasibly integrated solution components.

The superscripts, *gl* and *st*, used for identifying two different pheromone trails, represents the words “global” and “stationary”. Please refer to Yakici [1] for detailed explanation about pheromone trails.

Separate probability distributions are employed for assigning UAVs to stations and routing them between points. The probability distribution for assignment is given in Equation 23. Any UAV not assigned to a station has a probability to depart any station *i’* to reach any interest point *j’*.

$$p^{a}_{i'j'} = \frac{\left(\gamma^{gl}_{i'j'}\right)^{\alpha gl}\left(\gamma^{st}_{i'j'}\right)^{\alpha st}\left(\eta_{i'j'}\right)^{\beta a}}{\sum_{ij}\left(\gamma^{gl}_{ij}\right)^{\alpha gl}\left(\gamma^{gl}_{ij}\right)^{\alpha gl}\left(\eta_{ij}\right)^{\beta a}} \qquad (23)$$

γ^{gl}_{ij} and γ^{st}_{ij} are cumulative pheromone trails reflecting total of pheromones on the leg from station *i* to interest point *j* with greater number of UAVs at station *i* (compared to current UAV count). (Please see Yakici [1] for details about γ parameters). The power parameters, to which terms are raised in the formula, affect the relative importance of these terms. The superscript *a* identifies the “assignment” phase.

Equation 24 defines the routing probability of a UAV stationed at *i’*, from its current point *j’* to *k’*, given exactly $n_{i'}$ UAVs stationed at station *i’*.

$$p_1(i'' \; [\![n_\perp(i'') \; j]\!]'' \; k'')''r = ((\tau_1(i'' \; [\![n_1(i'') \; j]\!]'' \; k'')'gl)^{\wedge}(\alpha' gl)\,(\tau_1(i'' \; [\![n_1(i'') \; j]\!]'' \; k'')^{\wedge}st)^{\wedge}(\alpha' st \qquad (24)$$

Note that this probability is set to zero if problem constraints are violated by correponding routing. The superscript *r* identifies the “routing” phase.

Differently from PCLRP, here we define the parameter $\theta_{j'k'}$, which is employed to decrease the probability of a UAV to arrive at an interest point too early before its time window. With the utilization of this function, the probability

decreased proportional to the waiting time before time window. Calculation of θ_{ij} value is given in the following expression:

$$\theta_{ij} = 1 - \frac{max(0, b_i - \omega - d_{ij})}{b_i} \quad (25)$$

where ω is the current time of UAV.

Pseudocode for solution construction phase is presented in Figure 1.

4. EXPERIMENTS

Keeping all of the experiment settings same as in the experiment of PCLRP, we have experienced the algorithm on the extended problem PCLRPTW for 9 instances reported by Yakıcı [1]. To activate time window constraints, a number of interest points are randomly chosen and visits to those points are restricted with certain time windows. Table 1 provides these numbers and assigned time windows (beginning and ending times).

```
1: procedure ConstructSolution(iter)
2:     while any u ∈ U is not assigned to a station i ∈ S do
3:         for ∀i ∈ S do
4:             if ( Σ_{i|i∈A} 1 < y_max) ∨ (i ∈ A) then        ▷ A|A ⊆ S is set of assigned stations
5:                 Calculate γ^gl_{i,j} and γ^st_{i,j} ∀i ∈ S, j ∈ I
6:             end if
7:         end for
8:         for ∀i ∈ S, j ∈ I do
9:             Calculate p^assignment_{i,j}
10:        end for
11:        Choose the assignment component (i, j) randomly
12:    end while
13:    Σ_{i,n_i,j,k} (τ^gl_{i,n_i,j,k})^{α^gl} (τ^st_{i,n_i,j,k})^{α^st} (η_{j,k})^{β^r} ← 1    ▷ sum is set to a positive number arbitrarily
14:    while Σ_{i,n_i,j,k} (τ^gl_{i,n_i,j,k})^{α^gl} (τ^st_{i,n_i,j,k})^{α^st} (η_{j,k})^{β^r} > 0 do
15:        for ∀i ∈ S, j ∈ {i} ∪ I, k ∈ I do
16:            Calculate p^routing_{i,n_i,j,k}
17:        end for
18:        Choose the routing component (i, n_i, j, k) randomly
19:    end while
20: end procedure
```

Figure 1. Pseudocode for Solution Construction Phase [1].

Table 1. Time Window Restrictions

Instance number (as given in Yakıcı [1])	Number of points restricted with time windows *x* Assigned time window
1	16 *x* (300-600)
2	10 *x* (200-600), 12 *x* (400-600)
3	10 *x* (100-300), 12 *x* (200-300)
6	24 *x* (300-600)
7	15 *x* (200-600), 24 *x* (400-600)
8	15 *x* (100-300), 24 *x* (200-300)
11	32 *x* (300-600)
12	20 *x* (200-600), 36 *x* (400-600)
13	20 *x* (100-300), 36 *x* (200-300)

Table 2 provides the results. The columns indicate instance number, best and worst heuristic solution value, gap between best CPLEX (version 12.6.2.0) solution obtained in one hour and best heuristic solution ((*C-H)/H* where *C* and *H* are best CPLEX and heuristic solution, respectively), and average solution time for one run. The experiments have been conducted on a PC with 4 GB RAM and 1.9 GHz processor.

Table 2. Experimental Results

Instance number (as given in Yakıcı [1])	Best heuristic solution (*H*)	Worst heuristic solution	Gap between best CPLEX solution and *H*	Average run time of heuristic (in sec.)
1	110	105	-65,7 %	108
2	125	121	-66,4 %	195
3	87	82	-18,4 %	162
6	116	107	-81,9 %	190
7	140	133	-77,9 %	334
8	84	76	-71,4 %	252
11	149	132	-50,3 %	316
12	194	181	-100 %	485
13	108	102	-57,4 %	396

In all of the experienced instances, we observe a significant difference between heuristic solutions and CPLEX solutions. CPLEX performs very poor in this hard combinatorial problem, while it cannot find any positive value in one of the problem instances (instance 12). On the other hand, heuristic method provides significantly better solutions in very short periods.

5. CONCLUSION

In this study, we generalize a variant of LRP, which maximize collected importance points from visited locations, introduced by Yakıcı [1]. A fleet of identical UAVs is assumed. UAV routes are constrained by allowed sortie time

and the requirement of same takeoff and landing station. We enhance the problem by removing the limitation of having same takeoff and landing station and by adding a practical characteristic, time windows for interest points.

Experiments show that altered ant colony optimization metaheuristic provides the best solutions in a few minutes.

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IMPLEMENTATION OF A DISTINCT RGB ENCODING TECHNIQUE FOR DATA HIDING IN IMAGES

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ABSTRACT

A new R−weighted Coding Method (RCM) is improved in this study. This Method offers high data hiding capacity and PSNR values. Experimental results show the usefulness and advantage of the proposed method over its classical counterparts, providing high performance, in terms of PSNR and particularly data hiding capacity. RCM has been adopted from an earlier study that well known the LSB (Least Significant Bit) coding technique. This information hiding/embedding method can be used for protecting of any secret data.

Keywords: Data embedding, data hiding, steganography, RGB Image coding.

ÖZ

Bu çalışmada yeni bir R ağırlıklı kodlama tekniği geliştirilmiştir. Bu metod yüksek veri gizleme kapasitesi ve PSNR değeri sağlar. Deneysel sonuçlar özellikle gömme kapasitesi ve PSNR açısından çalışmanın klasik rakiplerine göre kullanışlılık ve avantaj sağladığını göstermektedir. RCM metodu LSB (Least Significant Bit ; En düşük değerlikli bir kodlaması) olarak bilinen kodlama tekniğinden geliştirilmiştir. Bu bilgi gizleme/gömme metodu herhangi bir gizli bilginin korunması amacıyla kullanılabilir.

I. Introduction

Data hiding methods have become increasingly more sophisticated and widespread. Which is a discipline that conceals data in a carrier to deliver secret messages. Embedding applications are mostly based on computer software where a vast variety of many complicated algorithms are improved and implemented [1]. Steganography is a technique that conceals the secret messages in innocuous cover objects by means of various information hiding methods. Data hiding, a form of steganography is a technique to embed the original secret image to another cover image by some encryption/encoding techniques, which has potential applications in multimedia and information security. The objective of this research is to propose a different data hiding method for secret data or critical information in images [2].

Any convenient digitized content (picture, audio, and video, etc.) can be used as carriers The digital images are often used as carriers as following reasons. First of all they can be easily delivered over the puplic or through a managed, private network, thus it may take attention with little suspicion when the secret information is embedded. Another reason is that, pixels are highly correlated for most natural images and therefore this situation is very suitable for hiding information. Also, digital images are much easier to be presented in documents than the other types of digitized content. [3]. Data hiding methods have recently made a challenging progress together with the new developments in computer technologies. A lot of data hiding methods and their applications have been proposed since the beginning of 1950s. On the other hand, their initial applications in many domain were unable to ensure a critical secure level of information in time. Thus, both new data hiding techniques and their development have always received ever−increasing interest in parallel to the emerging computer technologies and algorithms [4].

II. Digital Image and Data

In any digital image, a pixel is the smallest item of information in an image that is represented by a series of Y rows and X columns (Fig. 1). Pixels are normally showed in a 2−dimensional grid and are frequently represented using squares or rectangles for gray images. Each pixel is a part of an original image, where the more samples typically provide the more accurate representations of the original. The intensity of each pixel is variable; for example in color systems, each pixel has typically three components and 3−dimensions, e.g., RGB (red, green and blue) [2,5].

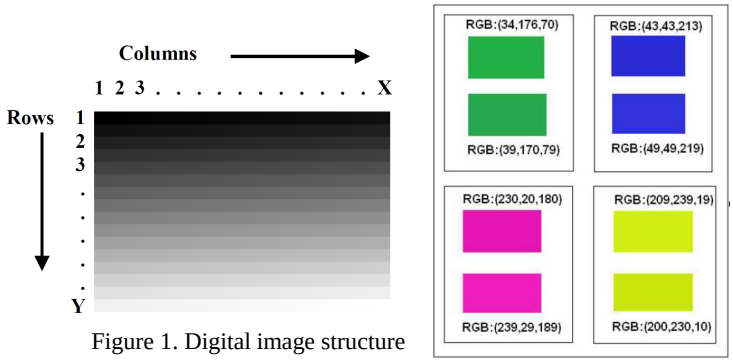

Figure 1. Digital image structure

In order to represent each pixel, number of bits assigns how many colors can be produced. For example, in an RGB color mode, the color monitor uses 24 bits each pixel (8 bits for each channel), allowing displaying 2^{24} (16,777,216) different colors. The number of colors can be obtained when bit depth is increased. This condition is an important circumstance and required for data hiding [4,5].

III Embedding a byte in a Pixel Cell

A pixel-cell constitutes the smallest building stone in an image. Image is occurred by means of uniting these pixels. The smallest color-cell occurs to uniting with three colors, those are called RGB; red, green and blue. These main colors constitute other intermediate colors with mixing a certain ratio. Each main color signify eight-bits (one byte) and so it has between 0 to 255 decimal numbers corresponding with its density. Accordingly, total size has equivalent three bytes or 24-bits. If a color-cell have a (RGB) weighted: (34,176,70) that indicates R=34, G=176, B=70. The obtained RGB dispersion and eight-bits equivalents are shown in Figure 2.

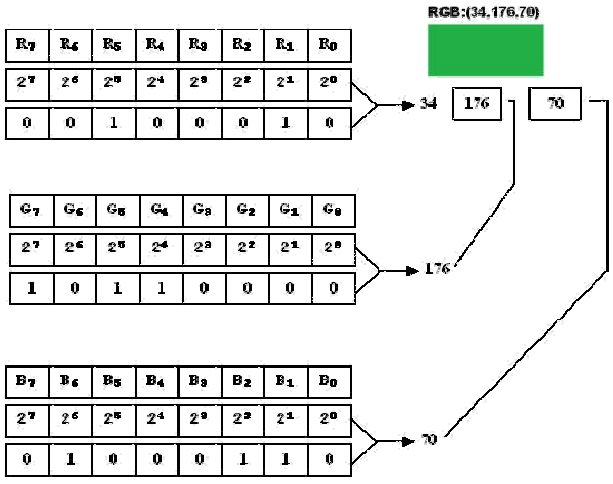

Figure 2. The obtained RGB dispersion as eight-bits equivalents.

For an ASCII code that has equivalent value "154" $(10011010)_2$ is embedding in a color-cell which have a (RGB) weighted (34,176,70). These processes are executed step-by-step in Fig. 3.

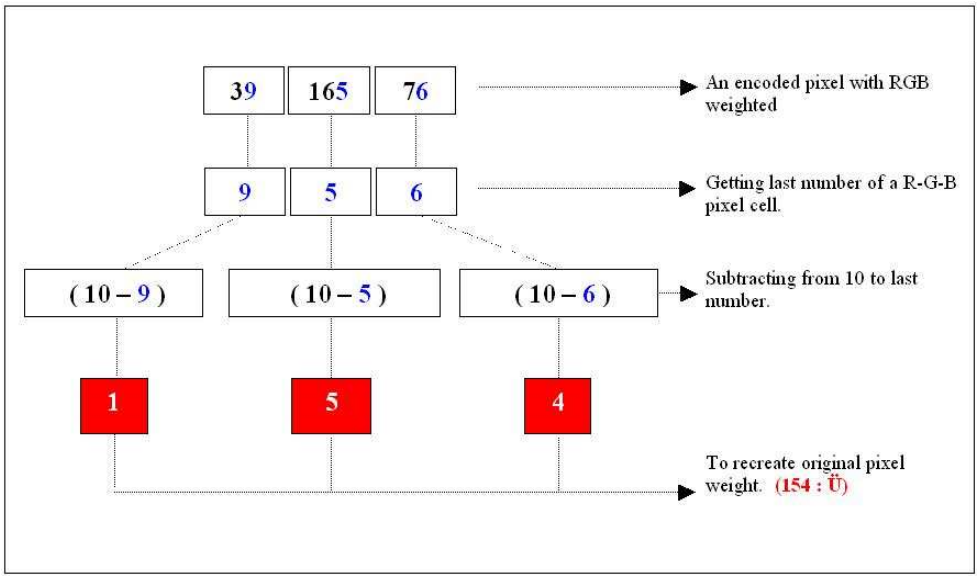

Figure 3. The Processes of Embedding an ASCII Code in a Pixel Cell

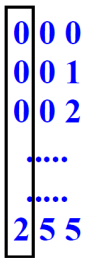

Figure 4. Recreating an ASCII Code where is Embedded a RGB Pixel Cell.

There are two different colors which have RGB: 34,176,70 and RGB: 39,165,76 for a pixel. These colors signify before and after of data hiding or embedding processes. The loss is available but it isn't perceived by the human sense. Now, our first privileged aim is that to provide an embedding without deterioration on the image. Furthermore, it has to embed in image as the biggest sized data. It can be stored to one-byte data for one pixel. Consequently, an image which has sized (310 × 220) pixel or (10,94 × 7.76) cm, that can be, stored (310 × 220) 68200 Byte, thus approximately 66.6 Kbyte data can be embedded in the image. The obtained capacity and the outcome are being quite satisfied for image, which has small sized.

IV. Changing of "R" Coding Weighted

The embedding process of last two-bit of part of eight-bit "R"

So far, we have discussed a novel embedding method that is changed all of RGB weighted with the same method. In this section we will discuss the other encoding way in which a data hiding can be embedded using last two-bits of R; R_1 AND R_0. It is necessary that must be minimal deterioration on the embedded image. Thus, the coded image become increasingly resembles original image. Because of this, it will apply a distinct encoding technique for part of R.

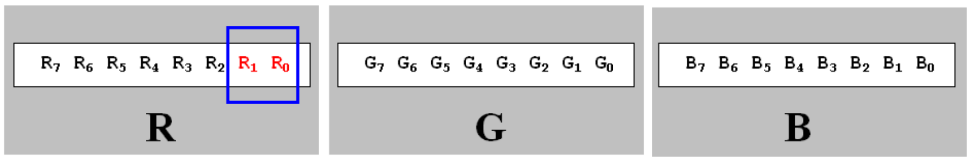

Figure 5. The embedding process of last two-bit of part of eight-bit "R"

In an extended ASCII, alphanumeric characters are represented by numbers ranging from 0 to 255 and are translated into an 8-bit binary code, hence first digit of 0 to 255 (MSB) can be 0 or 1 or 2. It can't be 3 to 9 numbers. This situation can be used as a useful advantage. In a data hiding application using RGB weighed coded technique that is constituted 3 distinct RGB colors weighed with each one 8 bit. The last two-bit of the first eight-bit (MSB), R1 and R0 are being used for this aim. Figure 5 illustrates this technique. For instance we assume a pixel that has RGB values (34,176,70) and "A", ASCII (065) character is desired to embed in this pixel. .Figure 5 graphically illustrates the concept of this novel technique. The operation process is as follows.

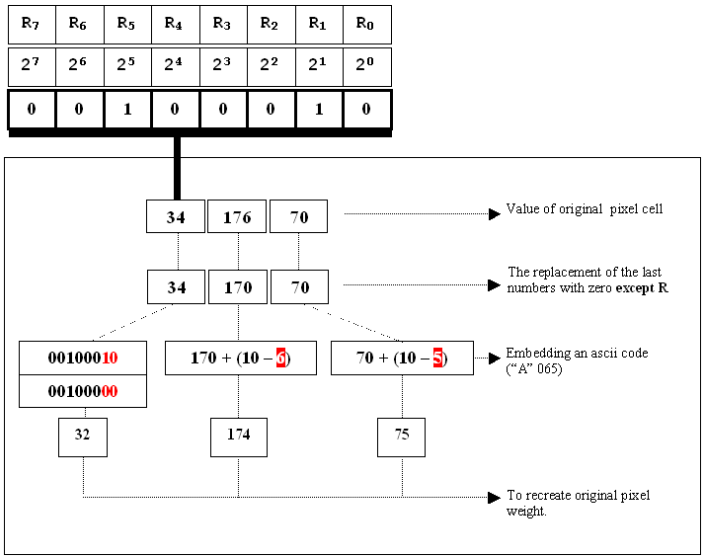

Figure 6. The Processes of Embedding an ASCII Code with R and GB in a Pixel Cell

A pixel that has RGB (34,176,70) value, its weight of R has 34. The value of BCD (34) has equal (00100010) as 8-bit binary. The last two-bit of the first eight-bit (MSB), R1 and R0 replace with "00" bits. Thus the result of new eight-bit is "001000 + 00". In an extended ASCII, first digit of 0 to 255 (MSB) can be 0 or 1 or 2. These equal "00", "01", "10". Character of "A" equals 065 values as ASCII; accordingly first digit of number of 065 is "0". The last two-bit of the first eight-bit (MSB), R1 and R0 are replace value of "00". In this way, value of eight-bit binary 00100000 is obtained. This eight-bit equal 32 as BCD; $32=(00100010)_2$.

Embedding technique of both G and B are applied same old method. Because, both can have zero-nine number in an extended ASCII. This method can be applied last four bits for G and B; merely this situation is caused a lot of deterioration in an image.

V. Reconstruction of embedded data of last two-bit of eight-bit "R"

Firstly, value of R: 32 convert to from BCD to binary form. $(32)_{10}=(00100000)_{2}$. Getting last two-bit of R, R1 and R0. (R1 R0 = 00) These binary numbers are equal "0" as BCD. The last digit of number of G: 174 is "4" and B: 75 is "5" . Both number are subtracting from 10. (10-4=6 and 10-5=5) Thus, number of 6 and 5 are obtained. Figure 7 graphically illustrates the processes of this technique On the whole, value of BCD (065=A) has attained.

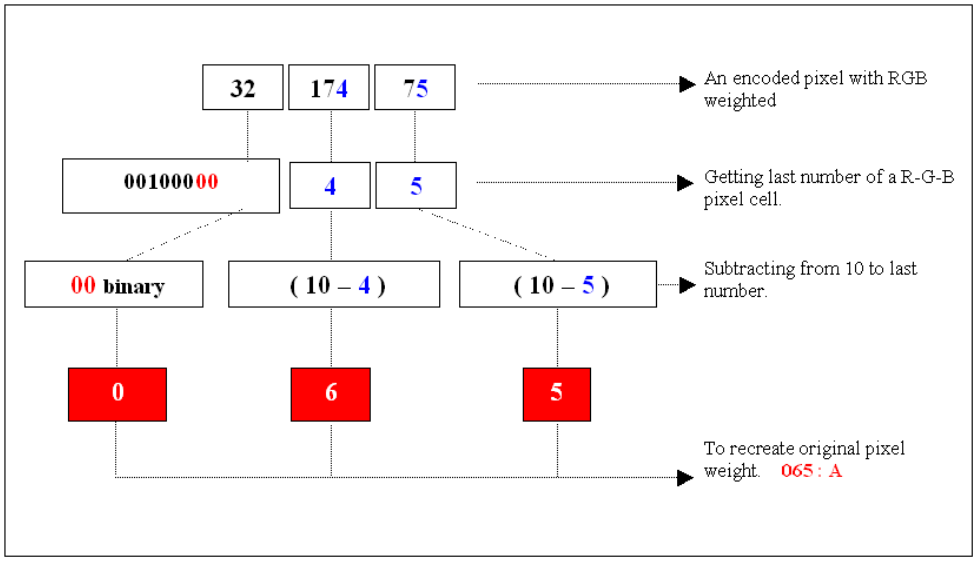

Figure 7. Recreating an ASCII Code where is Embedded a RGB Pixel Cell.

VI. Quality measures

In general terms "Peak Signal to Noise Ratio" (PSNR) and "Mean Square Error" (MSE) parameters are operated for statistical analysis of the

image embedding methods. The MSE should be figured out first as given in equation (1) and equation (2). As a second step PSNR can be derived as in equation (3) [12,13], where "O" and "S" are the original and stego image pixel values (binary) respectively to be compared and the image size is "X × Y". PSNR result of the stego images produced by all of the histogram−based data hiding techniques is guaranteed to be above the other classical techniques' performance in terms of statistical and perceptual invisibility. Note that the equations (1) and (2) are defined for only monochrome images, but for color images, the denominator of the equation (3) is multiplied by a factor 3. To compute the PSNR, the block first calculates the mean−squared error using the following equation [4]:

$$MSE = \frac{1}{m \times n} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \left\| O(i,j) - S(i,j) \right\|^2 \quad [1]$$

$$MSE = \frac{\sum_{m,n} \left[O(i,j) - S(i,j) \right]^2}{m \times n} \quad [2]$$

$$PSNR = 10 \log_{10} \left(\frac{MAX^2}{MSE} \right) \quad [3]$$

TABLE I. Comparison of other methods on bit rate and PSNR for Lena Image

Method	PSNR (dB)	Bit rate (bpp)
Goljan et al. [6]	39.00	0.092
Celik et al. [7]	38.00	0.284
Tai et al. [8]	37.98	0.493
Xuan et al. [9]	34.39	0.600
Tian [10]	34.80	0.671
Jung and Yoo [11]	41.46	0.766
Proposed	39.56	1.469 *

Table I shows that the proposed method not only has improved the data embedding capacity but also the PSNR for the well−known Lena image compared to its counterparts. Proposed method allows in much better the data embedding capacity compared to the classical methods. Data embedding methods are confirmed through well−known quality measures. PSNR value is the primary metric but it does not match with the HVS exactly. In addition to PSNR, some perceptual measures put forward such as Universal Image Quality Index (UQI) [14], Visual Information Fidelity (VIF) [15] and Mean Structural Similarity (M−SSIM) [14] in order to evaluate and analyze the data hiding methods. The UQI, VIF and the M−SSIM are measured as a quality result (Q) that ranges between [−1 and 1], between [0 and 1] and between [0 and 1] respectively, meaning that the best Q value can be 1 for all of them.

	RWB	LSB (2bits)	LSB	HSV	RWB	LSB (2bits)	LSB	HSV
	Lena				Baboon			
VIF	0.9798	0.9802	0.9981	**0.9993**	0.9823	0.9888	0.9930	**0.9997**
UQI	0.9237	0.9440	0.9988	**0.9995**	0.9724	0.9814	0.9945	**0.9998**
M−SSIM	0.9531	0.9654	0.9991	**0.9997**	0.9801	0.9890	0.9980	**0.9999**
	Peppers				Airplane			
VIF	0.9573	0.9786	0.9980	**0.9998**	0.9571	0.9325	0.9976	**0.9997**
UQI	0.9012	0.9435	0.9976	**0.9999**	0.8375	0.9390	0.9950	**0.9997**
M−SSIM	0.9366	0.9703	0.9986	**0.9999**	0.9422	0.9612	0.9980	**0.9998**

TABLE 2. Experimental results for different statistical metrics for different 512×512 gray images.

As mentioned above, only a PSNR analysis is not adequate for a complete quality assessment of any steganography method. In addition to

PSNR; VIF, UQI and M−SSIM visual quality measures are also used for the performance comparisons in this section (Table 2). Considering these parameters, the HSV method gives results that are closer the finest quality.

VIII. Conclusion

In this paper a novel R−weighted Coding Method (RCM) is discussed for protecting of any secret data. It is intended with this method that negligible deterioration in image and maximal storage of secret data. This Method offers high data hiding capacity and PSNR values. Experimental results show the usefulness and advantage of the proposed method over its classical counterparts, providing high performance, in terms of PSNR and particularly data hiding capacity. In this research particularly the deterioration of original image is decrease thanks to changing of “R” Coding Weighted technique.

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