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Preface

The publication process of the 'Inspiring Technologies and Innovations (INOTECH)' journal started with the decision numbered 261 taken at the session of the Senate of Kastamonu University dated 2.12.2021 and numbered 26, and with the coordination of Kastamonu University Technology Transfer Office.

Our journal named 'Inspiring Technologies and Innovations (INOTECH)' , which is a pioneer because it prioritizes R&D and innovation issues in multidisciplinary fields, is a peer-reviewed, open access, free publication policy and periodical research journal by Kastamonu University twice a year.

Our journal is in the presence of the academic community and you, our valuable readers, with its first issue. Aiming to develop in the way of presenting qualified works to national and international readers with the principle of scientific publishing, this first issue of our journal includes 5 original research articles from different disciplines and research fields.

We would like to thank all the academicians who contributed by sending their works, and all the referees who contributed in the evaluation process of these works; We hope that the interest and support for our journal from the national and international community will increase.

Regards.

Prof. Dr. Kasım YENİGÜN
Chief Editor

Takdim

"Inspiring Technologies and Innovations (INOTECH)" dergisinin yayın süreci,Kastamonu Üniversitemiz senatosunun 2.12.2021 tarih ve 26 sayılı oturumunda alınan 261 sayılı kararı ve Kastamonu Üniversitesi Teknoloji Transfer Ofisinin koordinasyonuyla başladı.

Multidisipliner alanlardaki ar-ge ve inovasyon konularını önceliklendirmesi sebebiyle ilklere öncülük etme niteliği taşıyan "Inspiring Technologies and Innovations (INOTECH)" isimli dergimiz, Kastamonu Üniversitesi tarafından yılda iki kez olacak şekilde hakemli, açık erişimli, ücretsiz yayın politikasına sahip ve süreli bir araştırma dergisidir.

Dergimiz ilk sayısıyla akademik camianın ve siz değerli okuyucuların huzuruna çıkmış bulunmaktadır. Bilimsel yayıncılık ilkesiyle nitelikli eserleri ulusal ve uluslararası okuyucuya sunma yolunda gelişim göstermeyi hedefleyen dergimizin bu ilk sayısında farklı disiplin ve araştırma alanlarından 5 adet özgün araştırma makalesine yer verilmiştir.

Eserlerini göndererek katkıda bulunmuş tüm akademisyenlere, bu eserlerin değerlendirme sürecinde katkıda bulunan tüm hakemlere teşekkürü bir borç biliyor, ulusal ve uluslararası camiadan dergimize yönelik ilgi ve desteğin artmasını ümit ediyoruz.

Saygılarımızla.

Prof. Dr. Kasım YENİGÜN
Baş Editör

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Content

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Research Article

Numerical Simulation of Convection-Diffusion Equation Using a Novel Flux Limiter

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ABSTRACT: CFD (Computational Fluid Dynamics) researchers encounter some substantial problems such as numerical dispersion and unphysical oscillation. The first order space discretization technique causes large numerical dispersion, leading to inaccurate prediction of the flow behavior of fluids. Therefore, numerical simulation engineers apply some high-resolution schemes such as QUICK (Quadratic Upstream Interpolation for Convective Kinematics) and TCDF (Third-order Continuously Differentiable Function) to reduce the impacts of the numerical dispersion. However, the higher order methods lead to undesirable and unphysical oscillations at large Courant number. First objective of this study is to propose a novel flux limiter obtained by modifying TCDF. The modified TCDF flux limiter function works at large Courant number without any unphysical oscillation contrary to the previously improved TCDF flux limiter. Second purpose of this study is to present a numerical simulator for solution of convection-diffusion equation. The Matlab codes and Google drive links related to this numerical simulator were included in the Appendix to make other researchers' works easy.

KEYWORDS: Finite difference method, High-resolution scheme, Flux limiter.

1. INTRODUCTION

In numerical solution of convection-diffusion equation (Peng et. al., 2013, Kurganov & Tadmor, 2000, Kamalyar et. al., 2014, Morton, 2019), there are two alternatives to minimize numerical errors. The first one is to decrease time step intervals, but it increases total simulation time. Secondly, higher-order techniques are recommended to reduce numerical errors (Wolcott et. al., 1996). Although, there exist a lot of higher-order techniques in literature, some of them lead to unphysical and unacceptable oscillation at large Courant numbers. For instance, third-order accurate QUICK (Quadratic Upstream Interpolation for Convective Kinematics) technique proposed by Leonard (Leonard, 1979), is an extremely good technique to diminish numerical dispersion. However, it causes unphysical oscillation at some critical points for large time step intervals.

In 2015, the TCDF (Third-order Continuously Differentiable Function) method was proposed by Zhang (Zhang et. al., 2015) in order to suppress the oscillations occurring in the QUICK method. TCDF is a smooth multi-component function and it consists of three different functions which are smoothly connected each other with same gradient. In spite of the advantage of TCDF over QUICK method, TCDF technique causes unphysical oscillation at flood front for large Courant number due to the upper limiter of TCDF flux limiter.

In this study, a new polynomial-ratio expression was developed to decrease upper limit of TCDF method. The sharper flood front and more accurate results without any unphysical oscillation were obtained using the modified TCDF technique. The main contribution of this study is the suppression of unphysical oscillation of previously developed TCDF method using this novel flux limiter. Second contribution of this study is the introduction of a numerical simulator in Matlab environment for numerical solution of convection-diffusion equation.

2. MATERIALS AND METHODS

The general form of convection-diffusion equation (Peaceman, 2000) includes diffusion, convection and accumulation terms. The unsteady convection-diffusion equation is shown in following Equation 1.

$$D\nabla^2 U - v.\nabla U = \frac{\partial U}{\partial t} \tag{1}$$

In Equation 1, U is variable of interest which can be supposed as concentration for miscible displacement fluid flow or it may be considered as temperature for heat transfer. D is diffusion coefficient (also called physical dispersion coefficient) and v refers to velocity of interested variable. The one dimensional form of convection-diffusion equation is given in Equation 2.

$$D\frac{\partial^2 U}{\partial x^2} - v\frac{\partial U}{\partial x} = \frac{\partial U}{\partial t} \tag{2}$$

The first, second and third terms in Equation 2 refer to diffusion, convection and accumulation terms respectively. The space discretization of Equation 2 is indicated in following Equation 3.

$$D\frac{U_{i+1}-2U_i+U_{i-1}}{\Delta x^2}-v\frac{U_{i+\frac{1}{2}}-U_{i-\frac{1}{2}}}{\Delta x}=\frac{\partial U}{\partial t} \quad (3)$$

In this study, explicit time discretization numerical technique (Versteeg & Malalasekera, 2007, Lundgren & Mattsson, 2020) was used to simplify calculations. The full discretization (time and space discretization) form of one dimensional convection-diffusion equation can be expressed in following equation.

$$D\frac{U_{i+1}^n-2U_i^n+U_{i-1}^n}{\Delta x^2}-v\frac{U_{i+\frac{1}{2}}^n-U_{i-\frac{1}{2}}^n}{\Delta x}=\frac{U_i^{n+1}-U_i^n}{\Delta t} \quad (4)$$

In Equation 4, i subscripts and n superscripts refer to space and time steps respectively. In numerical calculations, all grid block central values (..., Ui-1, Ui, Ui+1, ...) are calculated for each time step. On the other hand, there is no exact knowledge about grid block face values (..., Ui-1/2, Ui+1/2, ...). The main numerical errors arise from the approximation of these face values. Therefore, the problematic term in convection-diffusion equation is convection term especially for convection-dominated fluid flow. These face values must be predicted properly to obtain stable and accurate results. Otherwise, it causes large numerical dispersion and huge unphysical oscillation. There are some techniques in literature to predict grid block face values namely first-order method, QUICK technique and TCDF method.

2.1. FIRST ORDER METHOD

The conventional and simplest technique to approximate grid block face values is first-order method. The assumption of the face value as previous grid block central value can be defined as first-order method or first-order upstream technique (also called first-order upwinding method) (Ertekin et. al., 2001). Equation 5 shows mathematical expression of first-order method.

$$U_{i+\frac{1}{2}}^n\approx U_i^n \quad (5)$$

Despite the simplicity of first-order method, it causes large numerical dispersion. Nevertheless, first-order method never causes unphysical oscillation. Figure 1 shows numerical solution of convection-dominated flow equation using first-order method.

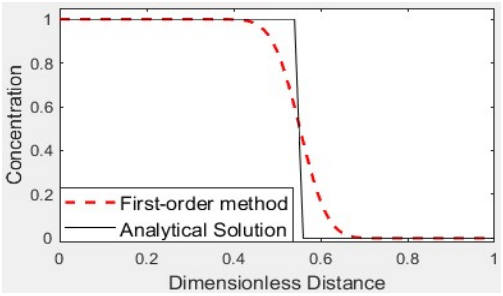

Figure 1. First-order method.

According to Figure 1, there is no unphysical oscillation of first-order method. It is an advantage of first-order upstream method, but numerical result of first-order method is far away from the analytical solution (Sarra, 2002) due to the large numerical dispersion. Therefore, the higher-order numerical solution should be used to minimize numerical dispersion.

2.2. QUICK METHOD

The QUICK method is a quite useful technique to decrease numerical dispersion because it has third order accuracy in space discretization. Equation 6 indicates QUICK method to approximate grid block right face value.

$$U_{i+\frac{1}{2}}^n\approx\frac{U_{i+1}^n+U_i^n}{2}-\frac{U_{i+1}^n-2U_i^n+U_{i-1}^n}{8} \quad (6)$$

According to QUICK method, face value depends not only on previous grid block central value but also on current and next grid block central values. Hence, it yields more accurate results compared to first-order upwinding technique. In spite of the advantages of QUICK method, it has a weakness. QUICK method causes large unphysical oscillation when physical dispersion coefficient approaches to zero and Courant number comes closer to one (Liu, 1993). It is

recommended to combine TVD (Total Variation Diminishing) method with the QUICK method to suppress this oscillation (Harten, 1984, Sweby, 1984). The general form of TVD formulation is given by following equation.

$$U_{i+\frac{1}{2}}^{n} \approx U_{i}^{n} + \frac{1}{2}\varphi(r)[U_{i}^{n} - U_{i-1}^{n}] \tag{7}$$

The first term at left-hand side in Equation 6 is upstream or upwinding term. The second term at left-hand side in Equation 6 is anti-diffusive term which prevents numerical dispersion. In Equation 6, φ is a flux limiter and it is a function of interested variable or concentration gradient ratio (r). The formulation of gradient ration is shown in Equation 8.

$$r = \frac{U_{i+1}^{n} - U_{i}^{n}}{U_{i}^{n} - U_{i-1}^{n}} \tag{8}$$

Equations 9 and 10 imply pure QUICK method and QUICK-TVD method respectively.

$$\varphi(r) = \frac{3r+1}{4} \tag{9}$$

$$\varphi(r) = min\left(2, 2r, \frac{3r+1}{4}\right) \tag{10}$$

Figure 2 shows general schematic of TVD area and relationship of flux limiter with gradient ratio for pure QUICK method and QUICK method with piecewise linear flux limiter function. The unphysical oscillations of pure QUICK method are suppressed thanks to this piecewise linear function. QUICK-TVD flux limiter consists of three parts. If concentration gradient ratio is small, the results are two times of gradient ratio. If gradient ratio so high, the results are restricted to 2 by limiter function so as to prevent oscillations. Otherwise, it's same as pure QUICK.

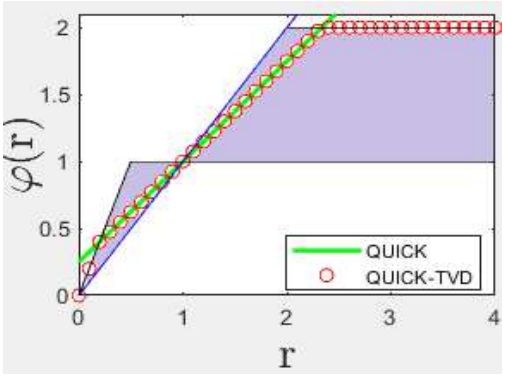

Figure 2. QUICK method and QUICK-TVD method.

The limiter functions must pass through the grayscale area of Figure 2 to obtain second order accurate scheme (Wolcott et. al., 1996). Numerical result of QUICK-TVD method is shown in Figure 3. The pure QUICK method doesn't give logical and meaningful numerical result for this condition (convection-dominated flow and high Courant number).

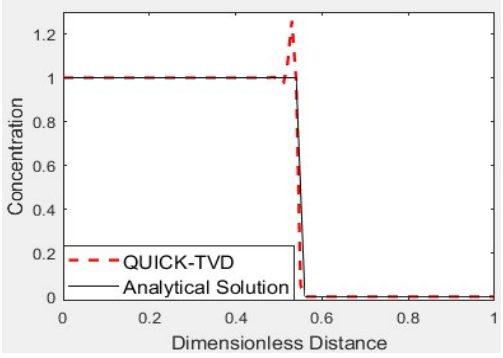

Figure 3. QUICK-TVD method.

In Figure 3, the QUICK-TVD technique decreases numerical dispersion, but it has some unphysical oscillation at flood front. Consequently, smooth flux limiter should be used instead of piecewise linear flux limiter to minimize the unphysical oscillations at flood front.

2.3. TCDF METHOD

The TCDF method is a smooth flux limiter function. It comprises three different functions which are linked each other with the same slope. The formula of the TCDF method is given in Equation 11 (Zhang et. al., 2015).

$$\varphi(r) = \begin{cases} r^3 - 2r^2 + 2r & if\ 0 \le r < 0.5 \\ 0.75r + 0.25 & if\ 0.5 \le r < 2 \\ \dfrac{2r^2 - 2r - 9/4}{r^2 - r - 1} & if\ 0 \le r < 0.5 \end{cases} \tag{11}$$

Firstly, the third-order QUICK scheme is stuck to over the interval $0.5 \le r \le 2$, which corresponds to the relatively smooth regions. Hence,

$$\varphi(r) = 0.75r + 0.25 \quad if\ 0.5 \le r < 2 \tag{12}$$

Secondly, in the region of $0 \le r < 0.5$, a cubic polynomial is selected to get a smooth function.

$$\varphi(r) = a\,r^3 + b\,r^2 + c\,r + d \tag{13}$$

It passes through two points: (0, 0) and (0.5, 0.625). The slope of TCDF method at the first point is 2 (two) and it has same gradient (0.75) with the third-order QUICK scheme at the second point. There are four equations and there are four unknowns, so this equation system can be solved (a=1, b=-2, c=2, d=0).

$$\varphi(r) = r^3 - 2r^2 + 2r \quad if\ 0 \le r < 0.5 \tag{14}$$

Thirdly, the general polynomial ratio expression is applied for the last part of the TCDF, $2 \le r < \infty$.

$$\varphi(r) = \frac{M\,r^2 + a\,r + b}{r^2 + c\,r + d} \tag{15}$$

In equation 15, M can be defined as maximum target of flux limiter. It is selected as 2 (two) for the TCDF flux limiter. In order to simplify calculation, c and d are selected as -1 (Zhang et. al., 2015). This last function passes through the point (2, 1.75) with the same slope of third-order QUICK scheme (0.75). There are two unknowns with two equations, so this equation system can be solved (a=-2, b=-9/4).

$$\varphi(r) = \frac{2\,r^2 - 2\,r - 9/4}{r^2 - r - 1} \tag{16}$$

Figure 4 shows the schematic for the TCDF method on TVD region using Equation 16.

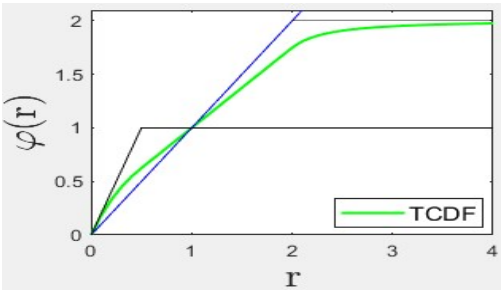

Figure 4. TCDF method and TVD region.

The numerical solution of convection-dominated fluid flow using TCDF method is shown in Figure 5.

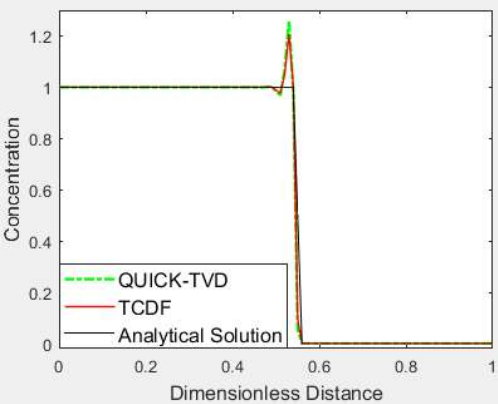

Figure 5. Numerical solution using TCDF method.

The oscillation of TCDF method is less than that of QUICK-TVD method, but still it is not acceptable. The TCDF method may be modified to suppress unphysical oscillations.

2.4. MODIFIED TCDF METHOD

In this study, it has been observed that unphysical oscillation of TCDF method arises from upper limit of the flux limiter. The last part of TCDF flux limiter has been modified to decrease upper limit of flux limiter and minimize unphysical oscillations. The new upper limit was selected as 1.6 instead of 2. It is assumed that, the new polynomial ratio expression passes through the two points (1.6, 1.45) and (5, 1.6) with the 0.75 and 0.1 gradients respectively. In that case, there are four equations and four unknowns, so this equation system can be solved. The modified part of the TCDF method is given by Equation 17. The modified TCDF method on TVD area is shown by Figure 6 using Equation 17.

$$\varphi(r) = \frac{1.6\,r^2 - \frac{292963}{28150}\,r + \frac{324943}{28150}}{r^2 - \frac{18256}{2815}\,r + \frac{20038}{2815}} \tag{17}$$

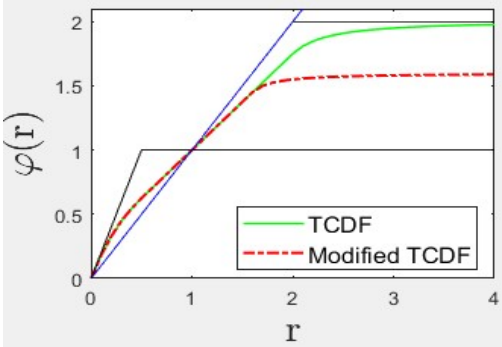

Figure 6. TCDF method and modified TCDF method.

3. RESULTS

In this study, it is supposed that Courant number is equal to 0.55, velocity is 1 and physical dispersion is 0 (zero) in order to compare all spatial discretization techniques properly. In addition to these assumptions, explicit time discretization technique is applied to all numerical technique. Figure 7 shows numerical results with exact (analytical) solution. According to the Figure 7, the first-order upstream method gives large numerical dispersion. The TCDF method has huge unphysical oscillation at flood front and it is not close to analytical solution. The modified TCDF flux limiter function has no oscillations and is the closest numerical solution to the analytical solution.

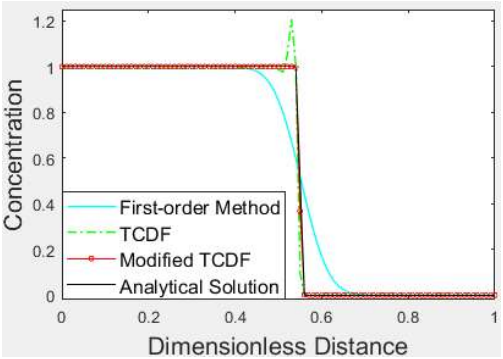

Figure 7. The numerical result of modified TCDF method.

It is important note that Courant number must be less than 1 (one) to get stable numerical solution due to the inherent of explicit scheme. The modified TCDF method works up to Courant number is equal to 0.55 without unphysical oscillation. This novel technique extends the limitation of explicit solution. If Courant number is greater than 0.55 and less than 1, the small unphysical oscillation may be observed. If Courant number is greater than 1, this numerical solution is unstable and unmeaningful results are obtained. This is the limitation of explicit numerical solution.

4. DISCUSSION AND CONCLUSION

There are two significant problems of the numerical solution for convection-diffusion equation: numerical dispersion and unphysical oscillation. The easiest way to solve convection-diffusion equation numerically is through the use of first-order upwinding space discretization technique. However, it gives rise to large numerical dispersion. The higher-order technique should be utilized to minimize the effect of the numerical dispersion. When the large Courant number and the low physical dispersion coefficient are used, some higher-order techniques (such as QUICK and TCDF methods) lead to huge unphysical oscillations. This study is to propose the modified TCDF technique to suppress unphysical oscillation of previously developed TCDF method. Secondly, this study is to present a numerical simulator for solution of convection-diffusion equation. The all open source Matlab codes and Google drive links related to this numerical simulator were provided in the Appendices. The developed numerical simulator is convenient for any grid dimension, any space interval, any time interval and some space discretization techniques.

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Appendix

Appendix A. Sub-function to run the numerical simulator.

```
function y=TVD(x)
% Select Space Discretization Method(SDM)
% For First Order Upstream Method -> SDO=1
% For Third Order Upwinding (Leonard-Quick) Method -> SDO=30
% For Third Order Upwinding (TVD with Leonard-Cubic) -> SDO=31
% For Third Order Upwinding (TVD with Leonard-Quick) Method -> SDO=32
% For TCDF Method -> SDO=33
% For Modified TCDF Method -> SDO=34
SDO=34;
if SDO==1%First Order Upstream
y=0;
elseif SDO==30%Third Order Upwinding (Leonard-Quick)
y=(3*x+1)/4;
elseif SDO==31%Third Order Upwinding (TVD with Leonard-Cubic)
y=max(0,min([2,2*x,(2*x+1)/3]));
elseif SDO==32%Third Order Upwinding (TVD with Leonard-Quick)
y=max(0,min([2,2*x,(3*x+1)/4]));
elseif SDO==33%TCDF
if 0<=x && x<0.5
y=x^3-2*x^2+2*x;
elseif 0.5<=x && x<2
y=0.75*x+0.25;
elseif 2<=x
y=(2*x^2-2*x-9/4)/(x^2-x-1);
else
y=0;
end
elseif SDO==34%Modified TCDF
if 0<=x && x<0.5
y=x^3-2*x^2+2*x;
elseif 0.5<=x && x<1.6
y=0.75*x+0.25;
elseif 1.6<=x
y=(1.6*x^2-292963/28150*x+324943/28150)/(x^2-18256/2815*x+20038/2815);
else
y=0;
end
end
end
```

Appendix B. The numerical simulator.

Note: In order to run Matlab codes in APPENDIX B, it's required to obtain "TVD.m" Matlab file. It can be designed using APPENDIX A. The name of the Matlab file have to be "TVD" without quotes. Secondly, generated TVD.m Matlab file and the numerical simulator mfile (in Appendix B) have to be at the same path. Thirdly, if you don't want to use Appendix A and B in order to run Matlab file, you can use Appendix C.

```
tic; clc; clearvars;
I=100+1;%Number of i-direction points
t=5.5;%Total simulation time
dx=0.1;%Space interval
dt=0.055;%Time interval
vf=1;%Velocity*(df/du)
L=vf*dt/dx;%Courant Number
D=0;%Physical dispersion
U00=0.5; Ui0=0;%Initial Condition
U0n=1; UIn=0;%Boundary Condition
Up(1)=U00; Up(2:I)=Ui0;
Un(1)=U0n; Un(2:I-1)=NaN; Un(I)=UIn;
for n=1:t/dt%Time iteration
%%Numerical Solution
for i=2:I-1
if i==2
rf=Up(i); lf=Up(i-1);
else
rf=Up(i)+0.5*max(0,TVD((Up(i+1)-Up(i))/(Up(i)-Up(i-1))))*(Up(i)-Up(i-1));
lf=Up(i-1)+0.5*max(0,TVD((Up(i)-Up(i-1))/(Up(i-1)-Up(i-2))))*(Up(i-1)-Up(i-2));
end
Un(i)=dt*(D*(Up(i+1)-2*Up(i)+Up(i-1))/dx^2-vf*(rf-lf)/dx)+Up(i);
end
Up=Un;
%%Analytical Solution
i=1; Ua(1:I)=NaN;
for x=0:dx:(I-1)*dx
```

```
if D==0
Ua(i)=1-heaviside(x-vf*dt*n); %Analytical Solution with Method of Characteristics
else
Ua(i)=0.5*erfc((x-vf*dt*n)/(2*(D*dt*n)^0.5))+0.5*exp(vf*x/D)*erfc((x+vf*dt*n)/(2*(D*dt*n)^0.5));
end
i=i+1;
end
% Plot Solution
set(gcf, 'Units', 'Normalized', 'OuterPosition', [0 0 1 1]);
plot(0:dx:(I-1)*dx,Un,'gv-','markerfacecolor','g');
hold on
plot(0:dx:(I-1)*dx,Ua,'k-','linewidth',2);
legend('Numerical Solution','Analytical Solution')
hold off
pause(0.001)
end
toc
```

Appendix C. Google Drive link.

In order to reach Matlab files, please use following Google Drive link:

https://drive.google.com/drive/folders/1e0MWNkUHjqJRpL7RrtJJdgLm73LciQoL?usp=sharing

Inspiring Technologies and Innovations

https://dergipark.org.tr/tr/pub/inotech

Research Article

Efficiency of Ensemble Learning Algorithms for Trend Analysis in Electricity Consumption in Turkey during Covid-19 Pandemic

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ABSTRACT:

Aim: We aim to analyze overall electricity consumption in Turkey starting from pre-COVID days until today to illustrate the illustrate efficiency of machine learning algorithms in trend changes.

Design & Methodology: We built machine learning models for the analysis such as AdaBoost (boosting), Random Forest (bagging) and Deep Neural Network (single-based algorithm).

Originality: The originality of this study is the determination of ensemble learning algorithms in the Analysis of Effects of Covid-19 Pandemic on Electricity Consumption in Turkey

Findings: Findings revealed that the proposed boosting (AdaBoost) ensemble algorithm (RMSE: 41848.7, MAE: 18574.3, R2 :0.89) is a significant contributory factor in the analysis of data related to electricity consumption.

Conclusion: As a conclusion, boosting (AdaBoost) ensemble learning algorithm is more preferable in the use of energy-related data than the bagging (random forest) and single-based algorithms (deep neural networks).

KEYWORDS: Ensemble Learning Algorithms, Adaboost, Electricity Consumption, Covid-19 Pandemic

1. INTRODUCTION

Machine Learning (ML) techniques have become increasingly popular in recent years. Machine learning provides a wide spectrum of uses in various industries, such as credit scoring in financial institutions, cancer diagnosis and pharmaceutical development, pattern recognition, audio, video, and image analysis, and electricity forecasting. Machine learning approaches have been used by people from numerous disciplines to address problems more efficiently and quickly (Nallathambi & Ramasamy, 2017). Researchers use machine learning for data processing solutions to build, optimize, and deploy effective prediction models that improve outcomes, and they rely heavily on machine learning for classification or prediction to analyze outcomes and pick up the best classification. With advantages that machine learning provided, ML has become popular in the energy community as well, as a way to forecast future consumption and market prices and has been widely used in different regression and classification problems (Sarker, 2021) (Viloria, Naveda, Palma, Núñez, & Núñez, 2020)(Tapas Ranjan Jena, Swati Sucharita Barik, 2020). A variety of machine learning algorithms have been proposed for the electricity consumption problems (González-Briones, Hernandez, Corchado, Omatu, & Mohamad, 2019) (Shaikh & Namdeo, 2021)(Sen, Tunç, & Günay, 2021).

Despite the fact that the offered research achieves impressive findings in terms of their objectives (Bashawyah & Qaisar, 2021),(Shaikh & Namdeo, 2021) the efficiency of ensemble learning and single-based algorithms for energy consumption problems has never been investigated. The objective of this research is to study and illustrate how powerful ensemble learning and single-based algorithms are for power consumption analysis.

2. MATERIALS AND METHODS

This section provides information about the proposed prediction approach for energy consumption in Turkey. In this study, the data is split into training (80%) and test (20%) sets. Then, 10-fold cross-validation is used in the training process of the AdaBoost, Random Forest, and Deep Neural Network algorithms. Python programming language was used in the implementation of these algorithms. Finally, the performances of the models are compared based on the test set.

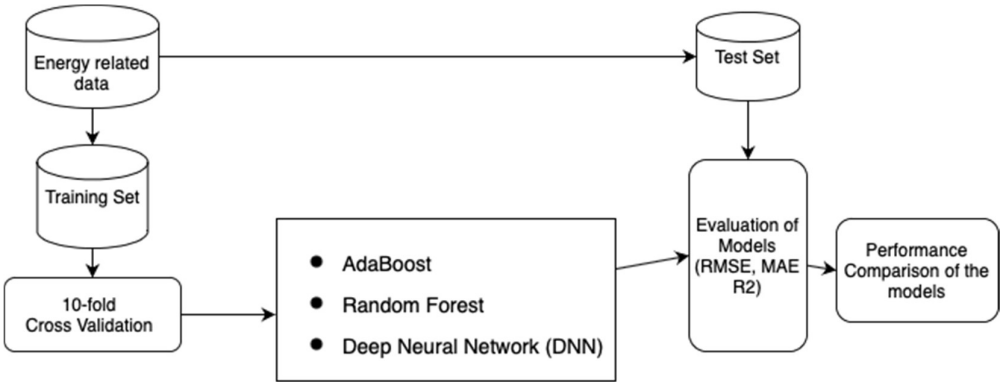

Figure 1. Prediction approach for the electricity consumption

2.1. Dataset

All energy-related data is collected from the Turkish Energy Transparency Platform (EPIAS) in Turkey. This platform provides the data essential for energy markets to operate in a transparent, reliable, fair, and predictable manner. EPIAS requests published data from institutions based on laws enacted by the Energy Market Regulatory Board. The relevant data owner companies are required to disclose the data on the Transparency Platform in a timely fashion, in the prescribed format, and with the correct content. Data is published on the web publicly for all parties to use.

Extracted data for hourly-based electricity consumption in Turkey belongs to all user profiles, including lighting, household, industry, irrigation, and commercial profiles., in MWh from EPIAS (EPIAS, n.d.). The data starts from January 1, 2019, to January 31, 2022, during which the COVID-19 Pandemic was in effect. The extracted data was further processed into daily data and summed up to get the overall electricity consumption of Turkey in MWh. All the analysis carried out has been performed using this EPIAS data.

2.2. Machine Learning Algorithms

Deep Neural Network

Deep neural network (DNN) is one of the popular machine learning algorithms. It can be used for both classification and regression problems (Fu, et al. 2020). The structure of any DNN consists of input, output, and at least one hidden layer (Buyrukoğlu, et al. 2021). In the study, different structures were tried such as DNN structures that were created with one, two, and three hidden layers for energy consumption. In the end, DNN created with one hidden layer performs better compared to the others. Therefore, one input, hidden, and output layers were used in the creation of the DNN as seen in Figure 2. Then, two, four, and six neurons were used in the hidden layer, and the best statistical score was obtained through the 4 neurons. Moreover, a variety number of epochs were used to create a robust and reliable DNN algorithm. In this sense, different epoch values were tried such as 50, 100,150, 200, 250, 300, 350, 400, 450, and 500. The maximum number of epochs was set to 400 because the best performance was obtained in the use of 400 epochs.

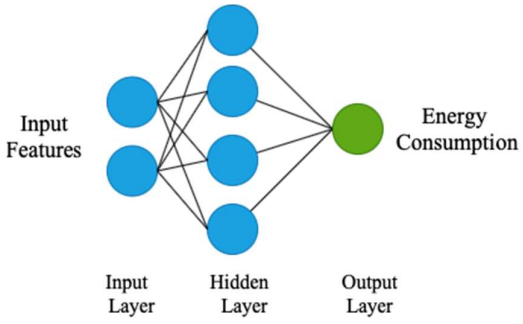

Figure 2. Structure of the Employed Neural Network

AdaBoost

AdaBoost is one of the popular boosting ensemble learning algorithms. Weak (simple) learners are used in the AdaBoost for classification or regression problems. In this sense, each weak learner is used in each estimator, and then a weight coefficient is assigned to this learner. This weighting coefficient is inversely proportional to the weak learner error. Finally, this model provides a solution based on weighted voting (Qu et al., 2021). A case study was also carried out to determine the optimal number of estimators in the energy consumption process such as 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100. In our study, 80 estimators were used in the proposed AdaBoost algorithm.

Random Forest

Bagging ensemble learning algorithm consists of two algorithms including decision tree and random forest (Fayaz, n.d.). The Random Forest algorithm is considered a more effective algorithm than the decision tree. The reason behind this is that the random forest algorithm consists of more than one decision tree. Average estimation of decision trees is used in the random forest for the prediction or classification problems (Nallathambi & Ramasamy, 2017). In our study, different numbers of trees were tried to determine the optimal number of trees such as 50, 100,150, 200, 250, 300, 350, 400, 450, and 500. In the end, the most beneficial statistical score is obtained through the 500 trees.

2.3. Evaluation Scores

In this study, MSE, MAE, and R2 statistical metrics are used to evaluate the employed algorithms in the energy consumption analysis. Equation 1, 2, and 3 gives the mathematical formula of these metrics (Chicco, D., Warrens, M. J., & Jurman, 2021).

$$MSE = \frac{1}{n}\sum_{i=1}^{n}\left(P_i - \hat{P}_i\right)^2 \quad (1)$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|P_i - \hat{P}_i\right| \quad (2)$$

$$R^2 = 1 - \frac{Unexplained\ Variation}{Total\ Variation} \quad (3)$$

where P_i is the actual value, $\hat{P}_i$ is the predicted value from the model and n is the number of observations.

3. RESULTS AND DISCUSSION

3.1. Prediction Results of Machine Learning Algorithms

Table 1 compares the results obtained from the employed machine learning algorithms for energy consumption. From the data in Table 1, it is apparent that the AdaBoost ensemble learning algorithm performs better than the other algorithms. Deep Neural Network (DNN) has the second-best RMSE, MAE, and R2 value for energy consumption. On the other hand, the random forest has the lowest statistical scores. These findings help us to highlight that Boosting ensemble learning algorithm (AdaBoost) provides significantly better results than the DNN and bagging algorithm (Random Forest). It means that boosting ensemble learning can be considered helpful for the prediction of energy consumption.

Table 1. Comparison of machine learning algorithms for the electricity consumption in Turkey

Model	RMSE	MAE	R2
AdaBoost (80 Estimators)	*41848.7*	*18574.3*	*0.890*
Random Forest (500 Trees)	*58253.4*	*23465.8*	*0.807*
Deep Neural Network (400 epochs)	*47456.4*	*19267.3*	*0.872*

3.2. The impact of different epochs in DNN

A case study was carried out to determine the optimal epoch number to be used in DNN for energy consumption. Figure 3 illustrates the MAE scores of DNN based on the use of the different number of epochs. The peak MAE score of DNN for energy consumption is 23858 (MWh) in the use of 50 epochs. In contrast to this, the use of 400 epochs in this DNN enables to reach the lowest MAE score (19267,3). Moreover, the MAE score is not changed during the use of 400, 450, and 500 epochs. Thus, it can be inferred from the results that the use of 400 epochs in this DNN has a significant impact on energy consumption.

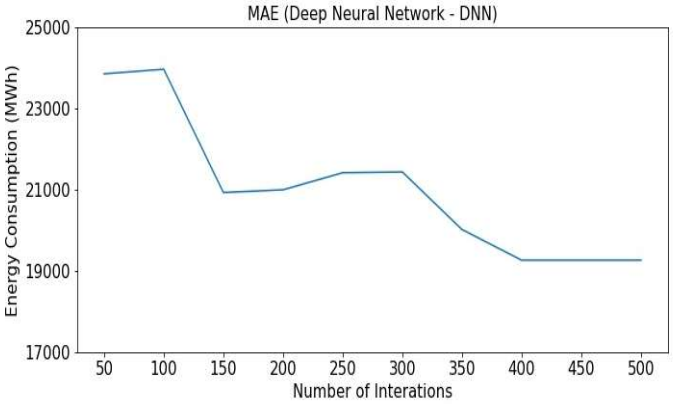

Figure 3. MAE scores of DNN based on different numbers of epochs

3.3. The impact of different iterations in AdaBoost

AdaBoost ensemble learning algorithm is one of the effective boosting algorithms as highlighted in Section 2.3. Figure 4 presents the MAE scores of AdaBoost based on the different number of estimators. What can be clearly seen in this figure is the highest MAE score (39958) of the AdaBoost algorithm is obtained with the use of 10 estimators. The score of MAE dropped sharply until 40 estimators (from 10 to 40 estimators). Then, the MAE score slightly decreased between the use of 40 and 80 estimators. In the end, the AdaBoost algorithm provided the best MAE score when the use of 80 estimators. Even if the MAE score remains the same when the use of 80, 90, and 100 estimators, the optimal estimator number of the AdaBoost algorithm is determined as 80. Thus, this proposed algorithm may provide more benefit in terms of time and cost in the prediction of energy consumption.

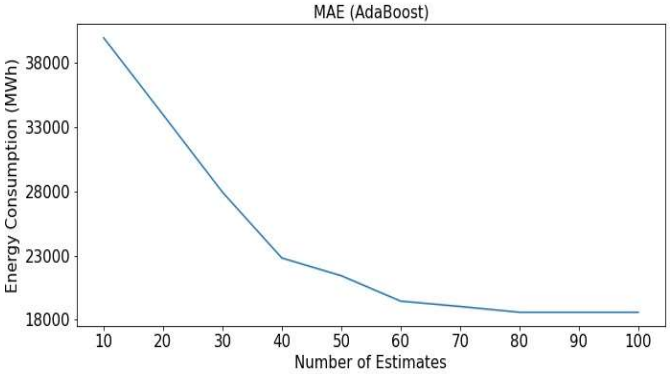

Figure 4. MAE scores of AdaBoost based on different number of estimators

3.4. The impact of different trees in Random Forest

Figure 5 shows the MAE scores of Random Forest based on the different number of trees. The MAE score (24944) rose to the highest point in the use of 200 trees. The MAE score fell to the lowest point of 23465,8 when the use of 500 trees. What is interesting in Figure 4 is the rapid decrease of MAE score between the use of 400 and 500 trees. The reason behind this is that the difference between the MAE scores is the use of 400 and 500 trees is 1049,4. In the end, the number of 500 trees is accepted as the optimal value for the proposed random forest algorithm in the energy consumption prediction.

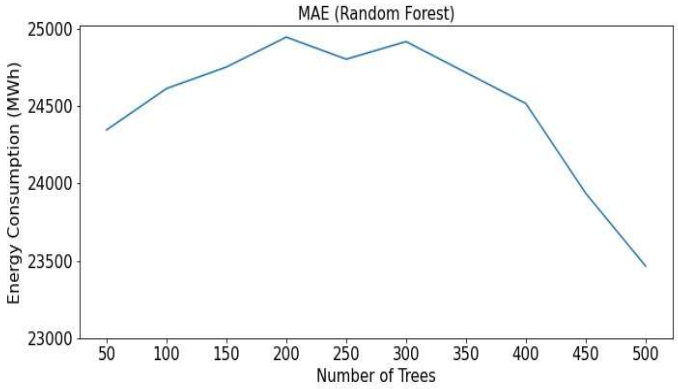

Figure 5. MAE scores of Random Forest based on different numbers of trees

3.5. Discussion of Electricity Consumption before and after Covid-19

In Figure 6, when total monthly electricity consumption was examined, it was discovered that consumption fell sharply during the lockdown period until May 2020, when average monthly electricity consumption peaked. The lowest value recorded was 26399 MWh in May 2020, after which electricity consumption began to rise as restrictions were relaxed, reaching a maximum of 43181 MWh once all industries resumed production.

Starting with the first announcement of the pandemic in March'2019, electricity consumption dropped below 1.000.000 MWh and fluctuated between 950.000 and 1.000.000 MWh due to frequent closures and restricted working hours of businesses. On June 1, 2019, due to the tourism season, restrictions have been loosened that burst electricity demand again. In the spring of 2020, lockdowns were effective in the decrease of consumption. With the application of vaccinations to millions of people, restrictions were largely lifted, which gave rise to a gradual increase in electricity demand.

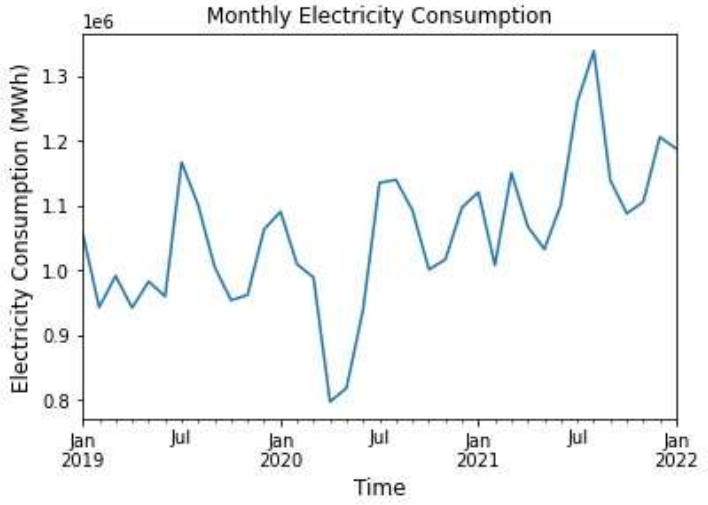

Figure 6. Monthly Average Electricity Consumption (MWh) in Turkey

4. DISCUSSION

This section discusses the performance of the employed algorithms in the electricity consumption and the electricity consumption from pre-COVID days until now, respectively.

As highlighted in Table 1, AdaBoost boosting ensemble learning algorithms achieved to provide the best statistical scores compared to the other employed algorithms including Random Forest and Deep Neural Network. Most of the studies in the literature have focused on comparing the base-learner algorithms with bagging algorithms (González-Briones, et al., 2019). The efficiency of Random Forest and Decision Tree bagging ensemble learning algorithms was compared with k-Nearest Neighbours, Support Vector Regressor, and Linear Regression base learner algorithms using the data belonging to a shoe store located in Salamanca, Spain. The linear regression algorithm provided the best accuracy score (85.7%) while the Random Forest algorithm was providing the lowest accuracy score (79.9%). A different study proposed by Nguyen & Nguyen (2019) predicts energy consumption employing a radial basis function neural network (RBF-NN). Due to the insufficiency of analytical and linear models for energy consumption, RBF-NN was employed in the study. Even if the studies proposed by González-Briones, et al., (2019) and Nguyen & Nguyen (2019) fulfilled their aim and objectives, they do not compare the bagging and boosting ensemble learning algorithms. In contrast to this, in a different study, Pinto et al., (2021) compared the efficiency of three ensemble learning

algorithms (AdaBoost, Random Forest, Gradient Boosting) in the energy consumption using a real data from an office building. The AdaBoost ensemble learning algorithm provided the best MAPE (5.34) score than the others. In the presented study, the employed AdaBoost ensemble learning algorithm is also achieved to provide the best statistical score compared to the DNN and RF as shown in Table 1. It can be inferred from the results that the AdaBoost ensemble learning algorithm seems more efficient than the other ensemble and base-learner algorithms in electricity consumption.

In Figures 3, 4, and 5, the MAE scores of the employed algorithms based on the different number of parameters (epochs, estimators, trees) are illustrated. In these Figures, the number of parameter values is set within a certain range. Moreover, a range is fixed for the number of parameters between which the model should be trained to predict the best possible results. In the end, the optimal parameter values were determined for DNN (400 epochs), AdaBoost (80 estimators), and RF (500 trees).

5. CONCLUSION AND FUTURE DIRECTIONS

In this study, the aim is to show the efficiency of ensemble learning (AdaBoost, Random Forest) and single-based (Deep Neural Network) algorithms for the prediction of electricity consumption. The MAE values are 18574.3, 23465.8, 19267.3 for AdaBoost, Random Forest, and Deep Neural Network, respectively. Also, the proposed AdaBoost ensemble model provided less satisfactory RMSE (41848.7) and R2 (0.89) values. These results revealed that ensemble learning algorithms may play a significant role in the prediction problems for electricity consumption. Additionally, the boosting (AdaBoost) ensemble algorithm is a significant contributory factor in the analysis of data related to electricity consumption in comparison to the bagging (random forest) and single-based algorithms (deep neural networks). On the other hand, the electricity consumption rises from July 2021 in the Covid-19 pandemic.

There are still more ML approaches to be investigated for a more efficient way of conducting the analysis of electricity consumption data. Our future research will focus on the combination of statistical feature selection techniques and deep learning algorithms to improve the AdaBoost algorithm for electricity consumption prediction.

Author's Contributions

Data were publicly available. Conceptualization, formal analysis, methodology, and writing – original draft was performed by Selim Buyrukoğlu and Ayhan Akbaş. Resources, software, supervision, writing – review & editing were organized by Selim Buyrukoğlu and Ayhan Akbaş.

Conflict of Interest

The authors claim no conflict of interest to declare.

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Research Article

Neutronic Performance Calculations by Using Suitable Molten Salt in Advanced Fusion Reactor to Produce Electric Energy

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ABSTRACT:

In this study,ARIES-RS fusion type reactor has been designed by using (MCNPX) code. The ARIES-RS study is investigating the use of free flowing liquid surfaces to form the inner surface of the chamber around a fusion plasma. Liquid wall concept has these important advantages compared to the traditional solid wall concept; with its feature of renewable wall it provides possibility for high power density. MHD equations consist of macroscopic transport equations and magnetic induction equation. Turbulent models based on NSM equations are suitable for two types of liquids, working fluid, molten salts operations are required. In this study, MHD balance is discussed in terms of radiation heat transfer conditions, current driving and nuclear performance. ARIES-RS reactor is essentially designed as ferritic steel and V - 4Cr - 4Ti alloy, self-cooled mild steel as the building material.

KEYWORDS: Advanced Reactor, Fusion, Mhd, Liquid Wall, Molten Salt

1. INTRODUCTION

For the last 25 years, the ARIES team has conducted research for various advanced fusion knockers and non-knock models and has investigated the operating performance and DT supply. The design could be based on the reverse knockout mode of the plasma cutting and using moderately advanced engineering concepts such as lithium, the average plasma with a large radius of 5,52m and a small plasma diameter of 1.38m, with a total thermal power of 2620 MW and a fusion power of 2170 MW, with a net output electrical power of 1000 MW. It is conceptualized [1,3]. It has emerged as a fusion power plant using the DT mix as the fuel type. Candidate liquid (LiBeF4, Li17Pb83, LiSn) solutions are used in various regions of the reactor, which are mild molten salts with various chemical properties that provide stable operation of the reactor.The torus type Aries-RS reactor seems to provide the best economic performance in terms of engineering and meeting the future energy demand with refrigerated vanadium alloy plasma surface components and steady state reversed truss buckle.It emphasized that the ARIES-RS engineering design process, in collaboration with the ARIES team, is reaching the high-level task requirements developed at the beginning of the study [1,4-7].Figure -1 show that the fusion power core-cross section 3D and table -1 summarizes the basic parameters for the design of the ARIES-RS moderate aspect ratio is the moderate aspect ratio is used in its design.

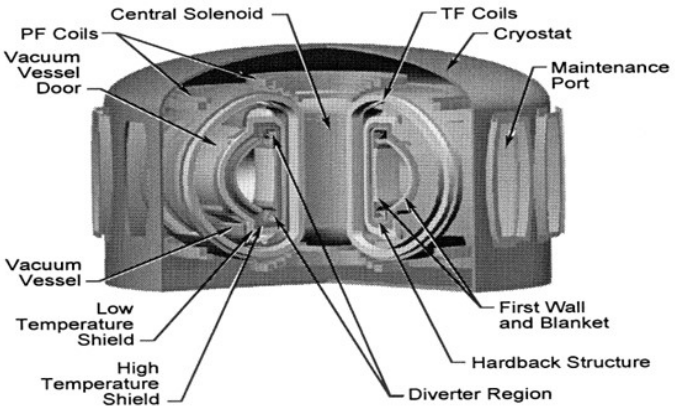

Figure 1. The ARIES-RS fusion power reactor segments [1,4-7].

ARIES-RS reactors are a hybrid model where fusion and fission reactions take place together. This reactor is a new fusion reactor design that uses a liquid wall between the fusion plasma and the solid first wall for tritium production or energy transfer. High-quality fissile fuel can be obtained by using the fast, energetic neutrons 238U and 232Th as a result of the reaction. In terms of these problems that can arise, the concept of liquid first wall (FW) in fusion reactors is a more appropriate choice. Neutrons emitted as a result of fusion reactions occurring in the plasma are captured by thorium and uranium in the blanket, resulting in fragmented fuel production. As with previous ARIES designs, the MCNP5X code is included for various simulations of this reactor.

The segments and plasma structure of the Aries-RS fusion power reactor are illustrated in Figure-1 by the Arıes team. Aries-RS reactor design, advanced commercial fusion power created by using liquids (LiBeF4, Li17Pb83, LiSn and LiNaBeF4) solutions for various candidate melt coolers with steel structure for both internal and external used The vapour pressure of the Li17-Pb83 and natural Li %, mole composition was calculated for the temperature range (200-1000K) containing a representative operating temperature range of the Aries-RS reactor. Li17-Pb83, LiNaBeF4 and pure Li phase diagram measured by Aries-RS suite [4-7]. Molten salts are used as high-temperature heat transfer medium in many industries. Table-1 shows the various physical properties and ARIES-RS parameters used in the design of the ARIES-RS fusion reactor It is the salt that is solid in the liquid phase at standard temperature and pressure due to the high temperature. The coolant pressure of the first wall is 12MPa and has a total surface area of 542 m2.The FW (First wall) has an average neutron wall load (NWL) 4.1Mw / m2 and an average heat flux of about 0.48Mw / m2.

2. Thick Liquid of Wall Concepts

In the ARIES-RS fusion reactor, we offer many advantages such as replacing the first liquid wall with thick liquids, high fusion power density, high control reliability and usability, and low failure reduced radioactive waste quantities and increased build a life [15-17].It contains structurally vanadium alloy self-cooling lithium design material. It by the ARIES team that was decided this blanket has the potential to perform better. Facility requirements with a moderate extrapolation of today's technology. V-alloy has low activation, low temperature, high temperature capability and can handle the high heat flux. In addition, this blanket provides excellent performance. At Figure-2 show that the ARIES-RS of view core 2D sector [12-15, 16-18].

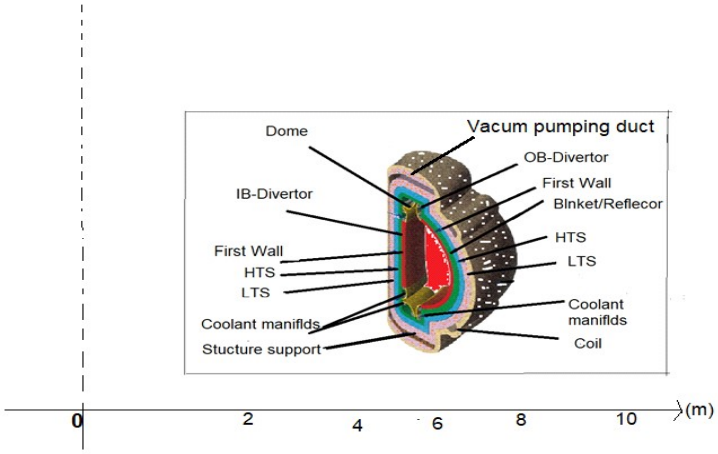

Figure 2. The ARIES-RS of view core 2D sector. [1,4-7].

In the ARIES-RS reference balance, the boot current fraction is 0.88 using density and temperature profiles characteristic of inverted shear plasmas. External non-inductive techniques are often required to drive off-axis currents in the plasma centre and near the axial cutting zone. A series of non-inductive current drive techniques have been considered for the inverted shear power plant. Depending on the reference balance, a combination of these techniques is required to drive currents in different parts of the plasma. Due to the tendency to radiate radially towards the plasma centre, the ICRF fastest waves are best suited for current propulsion on the magnetic axis. On the other hand, with a suitable launch spectrum, the low-hybrid wave can be made to move currents off-axis in the cutting reverse region. Scans of the plasma triangularity of 0,2 to 0,6 showed that a high over 0,4 was required for high β and β increased with increasing For ARIES-RS, internal deflector requirements (mainly adequate neutron protection for space requirements), is limited to 0,5. Plasma elongation improves b, but makes the plasma unstable to vertical movement. Maximum elongation is limited by passive stabilization conductive structure and feedback control system. Neutral rays can provide such plasma rotation rates. On the other hand, ARIES-RS only uses RF current drive [6, 9;15-19].

Table 1. ARIES-RS Reactors of Physical Scale Parameters [1,4-7]

Parameters	Scale
Major radius (m)	*5.52*
Minor plasma radius (m)	*1.38*
Aspect ratio	*4.00*
Plasma vertical elongation (x-point)	*1.70*
Plasma current (MA)	*11.32*
Bootstrap current fraction	*0.88*
Current-drive power (MW)	*81*
Toroidal field on axis (T)	*7.98*
Peak field at the TF coils (T)	*16*
Toroidal b	*0.05*
Average neutron wall load (MW/m^2)	*3.96*
Coolant inlet temperature (°C)	*330*
Coolant outlet temperature (°C)	*610*
Fusion power (MW)	*2170*
Total thermal power (MW)	*2620*
Net electric power (MW)	*1000*
thermal efficiency	*0.46*
Reactor Net efficiency	*0.38*
Recirculating power fraction	*0.17*
Cost of electricity (KWh/cent)	*75.79*
Plasma current, Ip (MA)	*11.3*
On-axis toroidal field (T)	*7.98*
Triangularity	*0.50*
Poloidal β	*2.28*
Toroidal β	*4.96*
Bootstrap current (MA)	*10.0*
Driven current, I_{CD} (MA)	*1.2*

3. MATERIALS AND METHODS

3.1. Numerical Calculations

The design and calculations of Aries-RS were carried out as a 3D torus by using the MCNPX code / Endf / VI library. The parameters of the first wall (FW) of the reactor examined different blankets and molten salt mixtures at Table-2 are shown valid driver requirements for ARIES-RS balance. Specially; tritium production rate, energy multiplication factor, fissile fuel breeding, radiation damage amount, initial installation cost (COS) and heat deposition rate, neutron wall loading (NWL) investigated. The compatibility between high- temperature materials is the transfer of fluid dynamics such as plasmas to the MHD model, including the effects of electromagnetic forces inside and inside the blanket.

Table 2. Valid Driver Requirements for ARIES-RS Balance[1,4-7].

System	Frequency (GHz)	N	Power (MW)	Launcher Position
ICRF Fastwave	*0,091*	*2.0*	*5.4*	*15*
High-frequency wave	*1,000*	*2.1*	*21.4*	*0*
Lower hybrid wave	*4,600*	*1.9*	*9.5*	*-15*

3.2. The ARIES-RS of Engineering Concept

The ARIES-RS design process due to the need and generally operates with an inverted plasma. Sufficient power needed to make a viable diver solution in the SOL and submersible areas. In this case, the sum of the particle and radiation heat flow does not exceed 6 MW/m^2. As a function of fuel density and temperature, the contours of the auxiliary power required for steady-state plasma power balance are displayed [2,20;23-28,31].9 ≤ I ≤15 KeV and fuel densities n≥2 x10^{20}/m^3. Transport and radiation losses in areas outside the ignition zone exceed fusion power and assist steady-state operation requires a medium aspect ratio (α = 4.0) and plasma current is relatively low (IP = 11.32 MA) and a preload current ratio (f = 0.88) is quite high. As a result, the auxiliary power required for the RF current driver is relatively low (80 MW). At the same time, the average beta (β = 5%) is high, which provides power densities close to practical engineering limits (peak neutron wall 5.7 MW/m2 High capacity such that the inlet temperature of the refrigerant into the reactor's heart is

approximately 330°C and the coolant outlet melt salt temperature from the reactor is approximately 610 °C It is designed as a vanadium alloy at the Table 4 shown that dimensionless some parameter flow in ARIES-RS reactors.

3.3.Tritium Breeding Rate (TBR) and Energy Multiplication Factor (M)

Tritium growth rate (TBR) is defined as the ratio of tritium production rate in the system to the burnt tritium ratio in plasma. To provide adequate tritium cultivation, there must be a medium containing liquid lithium flowing. By using MCNP5X simulation, the tritium production rates (TBR) resulting from the natural lithium 7.56 6Li and 92.44 7Li isotopes for various blanket layer thicknesses (15, 20, 25, 30 and 50 cm) of the ARIES-RS reactor [1-3,23-27,30-33]. In order for DT fusion reactor should be TBR ≥ 1,05 self-sufficient tritium. The amount of tritium was taken from the reproduction reaction of 6Li and 7Li isotopes in the blanket. Thermal neutrons with 6Li (n, α) T reaction and fast neutrons tritium produced with the help of 7Li (n, α, 'n). Exothermic and Endothermic neutron capture reactions of 6Li and 7Li, respectively, also affect M values. These reactions are given as follows,

$$^{6}Li + n \rightarrow {}^{4}He + T + Q(4.784)\ MeV$$

$$^{7}Li + n \rightarrow {}^{4}He + T + n + Q\ (-2.467)\ MeV$$

The overall TBR and M depend on the neutron coverage fractions (NCF) of regions surrounding the plasma and the blanket thickness in each region. The relative NCF for the inboard and outboard regions varies significantly with the aspect ratio. The Tritium breeding ratio (TBR) would be given, TBR =Tbr6 +Tbr7; where, respectively; Tbr- 6 and Tbr- 7 on Li_6 and Li_7 depended. The Tritium breeding ratio (TBR) can be given as follows;

$$Tbr_6 = \iint \emptyset . \sum n,\alpha)T\, dE\, .dV \qquad and \qquad Tbr_7 = \iint \emptyset . \sum (n,n',\alpha)T\, dE\, .dV$$

Another important neutronic parameter is the energy impact factor M. It is defined ratio of the ratio total energy deposited in the systems to the incident neutron kinetic energy. The energy produced in (D, T) reactor should be as high as possible than this energy produced by plasma Multiplication coefficient can be obtained by increasing the fusion neutron energy, mainly in the blanket with ^{233}U and ^{232}Th fission. In addition to the kinetic energy transfer of 14.1 Mev Fusion-induced neutrons resulting from the Fusion DT reaction also Li hopes to generate neutrons in the additional doped fission energy from a blanket of melt salts. In the Figure-3 per source neutron, local tritium breeding ratio TBR (atoms /Sec) and M (MeV) states of energy multiplication coefficient change versus % 6Li can be seen. In Figure 3, it is clear that enriching the Li result in a significant decrease in the TBR and a negligible increase M.

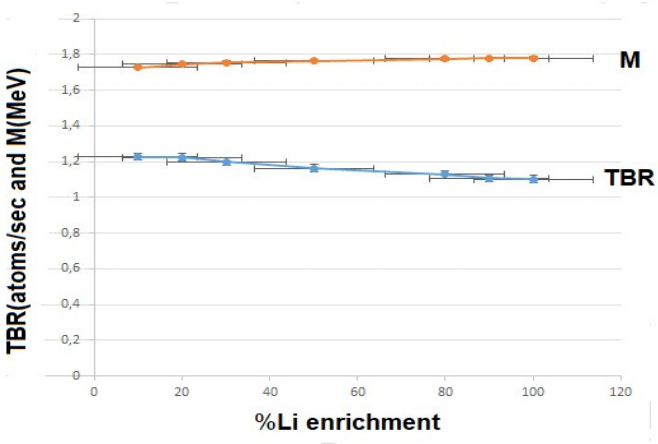

Figure 3. Local TBR and M exchange versus of % Li7+% Li6

3. RESULT AND DISCUSSION

For the full assessment of neutron wall loading, it is primarily necessary to determine the amount of radiation that interacts with the structural material of the ARIES-RS reactor. It is vital to design the various components of the neutron wall charge and fusion power core and evaluate the radiation environment and intensity around the torus geometry. Neutron wall loading, with the change of vertical distance from the middle plane, tritium production depends on the blanket structure. Plasma systems make up 10-20% of the first wall. In Figure-9 show the NWL of ARIES-RS reactor versus distance from the midpoint. ARIES-RS of diverter structure depending on the outboard (OB) and inboard (IB) NWL values are 5.67MW /m^2 and 4.03 Mw /m^2, respectively. Due to its asymmetric geometry, the upper half of the first wall and the diverter are modelled with the code MCNPX to create the poloidal distribution. The ARIES-RS forward power fusion reactor creates a maximum fusion power of 2,170 MW. The total surface area of the fire wall and resulting in the machine's average peak (4.1MW/m^2). The NWL value reaches a peak in the midpoint of the outboard FW with the outboard and the diverter plate and exchange outboard. In Figure-4 show the NWL of ARIES-RS reactor versus distance from the midpoint. ARIES-RS of diverter structure depending on the outboard (OB) and inboard (IB) NWL values are 5.67MW / m^2 and 4.03 MW /m^2, respectively.

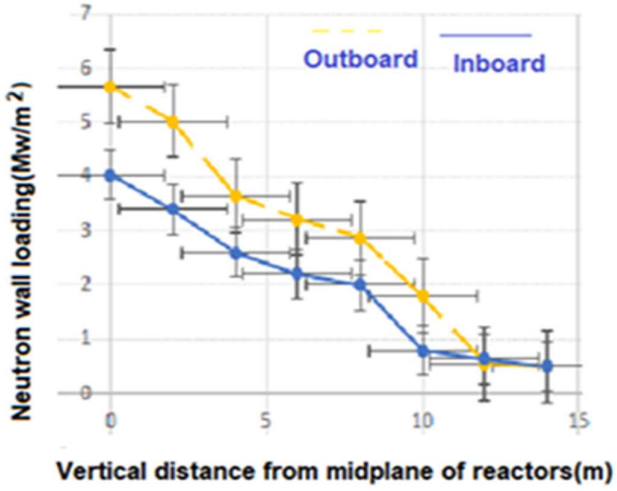

Figure 4. NWL of ARIES-RS reactor versus distance from midpoint

4. CONCLUSIONS

In this study, an advanced ARIES-RS fusion reactor demonstrated the advantages of using it in mixed mode by adding a fission zone to the system. In addition, the emergence of various energies arising from the plasma and the initial setup cost (COS) of the rector allowed the use of candidate solution salts of different thicknesses and spontaneous tritium capable of forming tritium [1-3,8-10]. The design and calculations of ARIES-RS were carried out as a 3D ball torus using the MCNP5X simulation code/ Endf -5B/VI library. In order to ensure the continuity of the operation of the reactors, one of the important tasks in Aries-RS is to provide tritium self-sufficiency. In particular, the $Li_{17}Pb_{83}$ composition is carried for nuclear heating. Blanket and harvest high-temperature $Li_{17}Pb_{83}$ composition is breeding material, important for both good tritium reproductive potential and self-cooling conditions. In the case of no additions to the blanket, TBR ≥ 1.20 values are observed for molten. In the case of no additions to the blanket, TBR ≥ 1.20 values are observed in a molten liquid such as plasmas have been enhanced by compatibility between high temperature materials, MHD model inside and outside the blanket, and the effects of electromagnetic forces. It will also assist in neutron activation analysis used in various sites. Due to the low fission rates in the fusion zone, among the types of fusion energy studied, the matrix material, ^{232}Th and ^{233}U, selected as fuel, was more efficient in terms of performance of the ARIES-RS reactor. The world's present thorium reserves are many times more than the uranium reserves, this type of ARIES-RS reactor or the use of less costly and ergonomic high performance will allow the efficient use of efficient thorium fuel to provide fissile fuel for conventional fission reactors.

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Research Article

Acceptance of E-Book Usage During COVID-19 Pandemic Using Technology Acceptance Model

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ABSTRACT: It has been observed that there has been an increase in the use of e-books, mainly because people prefer to store all their reading materials in the digital environment and carry these materials with them. The benefits of e-books are endless. In a device smaller than a book, hundreds of thousands of books can be stored, notes can be taken, countless bookmarks can be placed. However, there has been resistance to this important and very helpful technology, just like every other technology. In this study, we aim to determine the perceptions and attitudes of book readers towards this new technology using technology acceptance model. The data is collected with the help of an online survey and a 5-point likert scale is used to measure factors. The determined sample is Istanbul Technical University students. Structural Equation Model is used to understand the effect of factors on behavioral intention. We conclude that 9 out of 11 hypotheses are supported.

KEYWORDS: Technology Acceptance Model, E-Book Usage, Structural Equation Model.

1. INTRODUCTION

An e-book, also called an eBook or electronic book, is the digital version of traditional, printed books, consisting of text and/or pictures, displayed on a flat panels of electronics such as computers, tablets and various other devices (Gardiner, 2010). As the technology progresses, it has affected all aspects of our lives, even reading. Ever since the invention of writing in 3200 BC, the human kind has been reading handwritten materials, mostly written on cloth, paper, stone or any other medium. The next scientific breakthrough wasn't until 1440 when Johannes Gutenberg invented the printing press. Not only did his invention made copying materials easier, but it also made reading materials easier to access to the general public. The invention of personal computers served a similar purposes with granting people better access to reading materials and distributing them. However, while computers make reading more accessible, they are not portable like a traditional book. For this purposes, e-readers were invented.

An e-reader, also stylised as an E-reader or e-book reader, is any device that's capable of displaying texts in broad term, however, it usually refers to the mobile electronic devices specialized for reading e-books. Devices such as smart phones and tablets can act as e-readers, but in this paper, e-reader will strictly be referring to devices designed specially for reading purposes. An e-reader doesn't necessarily share the same display technologies with the previously mentioned devices. Usually, they feature a technology called electronic paper to make it easier to read even under the sunglight and reduce the eyestrain (Falcone, 2012).

However, the technological advancements and development of new devices would not be as useful as it currently is if it hadn't been for the Internet. Internet is what enables so much information to be transferred between users. As it became more integrated with our daily lives, services such as e-commerce became more common, too. This allowed traditonal, printed books to be sold in an alternative form.

While the fact that thousands of books can be stored in a device in the size of a single book is an enticing development for some readers, there's also resistance. This resistance is known as technology resistance and is known to be a reason for the failure of systems (Kim & Kankanhalli, 2009). Varios reasons might affect the technology resistance and the usage of e-books or any other technology. In order to figure out these reasons so they can be solved, researches have been made. Davis's Technology Acceptance Model is one of the methods of understanding the mentality behind usage of e-books and the factors affecting it. Ever since it was developed, Davis's Technology Acceptance Model has been tested and used numerous times to explain the factors affecting technology usage and acceptance ever since it was developed (Bagozzi, 2007). It is also what this paper used in order to investigate the usage of e-books. Figuring out the reasons behind technology usage is extremely important, because only then it is possible to eliminate negative causes and enhance positive ones. Otherwise, the failure of the system is inevitable.

Under the light of the events occurred in most of 2020, mainly the COVID19 pandemic, there has been many lockdowns. People have been hesitant with shopping for physical goods even if they were daily necessities. Most of the stores, including bookstores have been shut down for long durations during the pandemic, therefore the only way of obtaining new books were online shopping. Yet the reluctancy was prominent, especially because there has been news of COVID19 virus spreadinIndg faster on paper (money). In an environment where people have been growing apprehensive about the usage of traditional books, it is expected to see an increase in e-book usage.

2. LITERATURE REVIEW

With the increasing usage of electronic devices in daily life, especially the younger generations that adapt to technologies faster started to use e-books and e-readers even more in the last decade. The fact that e-commerce has became more common and of the norm plays a big part in this. As the population started to trust payments over internet more, it has become more common for the readers to buy e-books for their e-readers or e-reader substitutes.

There's disagreement upon the true inventor of e-books. Some cite Brown, due to his claims that it was time to get rid of printed books, and ascend into a new reading machine, one where you can read thousands of books in minutes, if you desire to (1930). This machine he talked about, however, was only the concept of e-books, it was a mere idea Brown failed to put into motion, but it triggered a change.

The first digitilazed text, in the form of an index of Thomas Aquinas' works was Index Thomisticus, it was started on 1946 and was completed only in the 1970s (Bryson, 2014). This text is accepted as the first examples of an e-book. However, the first device similar to today's ereader, Enciclopedia Mecánica, was patented by Ángela Ruiz Robles, his prototype aimed to reduce the amoung of books his students carried and was a mechanical device (Guillermo, 2013). It had several rolls stacked vertically with each roll containing a book. As the rolls on the left side turned and pulled the piece of paper in the middle, more of the book would be revealed, and one could have several of these books in a single device.

Most accept Micheal Hart's Project Gutenberg as the origin of e-book technology as we know today. Project Gutenberg aimed to digitize publications with expired copyrights in 1972, free of charge (Jin C. H., 2013). Project Gutenberg is still accessible today, and holds 60,000 e-books that has expired copyrights in the U.S. They are accessible for downloading or online reading. It also has a sister website, where independent authors or poets can publish their own books for the readers to access freely.

Technology Acceptance Model

E-books combine the familiar feeling of a reading instrument with today's technological developments. In this aspect, one can argue that traditional books and e-books share the common goal of communicating written works to the reciptor (Lam, Lam, Lam, & McNaught, 2009; Elyazgi, Nilashi, Ibrahim, Rayhan, & Elyazgi, 2016). The difference begins in the methodology. Due to e-books being a newer technology than traditional books, Technology Accceptance Model (TAM) has been chosen as the evaluation method due to its robustness in predicting behavioral intention or behavior (Limayem, Hirt, & Chin, 2001).

The basis of TAM is the Theory of Reasoned Action (TRA). TRA was developed by Martin Fishbeing and Icek Ajzen in 1967 and explores the relationship within attitude an action. In TRA, actual behaviour is conditioned in behavioral intention, which can be defined as a function of person's attitude and person's subjective norms with varying weights (Ajzen, 1985). TRA is a model that aims to figure out a person's voluntary behavious by undersanding what causes said person to perform an action (Doswell, Braxter, Cha, & Kim, 2011). In addition, social norms also affect a person's ultimate decision to perform an action of their intention to perform the action; and TRA reasons that action is not performed when there's lack of behavioural intention (Azjen & Madden, 1986).

22 years later, Davis specialized TRA model for the information systems and replaces some of the attitude measures as provided in Figure 1. In TAM, the preceding factor of behavioural intention, which is attitude, is formulated as a combination of perceived usefulness (PU) and perceived ease of use (PEOU) as well as outer factors. Both are influenced by external variables, and claims that behavioral intention to use is determined jointly by perceived usefulness and attitude towards using. Attitude, combined with perceived usefulness not only affect behavioural intention (BI), but they are also important to reduce user resistence in adoption (Lee, Hsieh, & Hsu, 2011). To paint a brief picture, external variables have affects on PU and PEOU. TAM also assumes that PEOU has an effect on PU, however, vice versa doesn't hold true necessarily (Jin C. H., 2013). PU's and PEOU's increse will increase attitute toward using, which in turn, increases BI, and increased BI results in increased actual system usage (Soto-Acosta, Ramayah, & Popa, 2013).

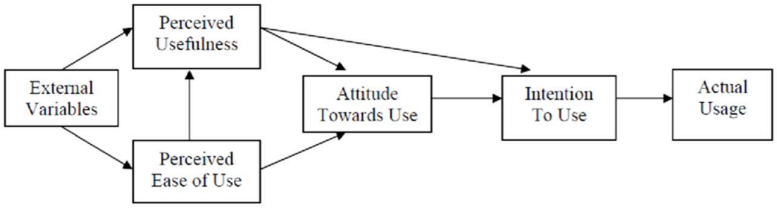

Figure 1. Technology acceptance model (Davis, 1989)

In the further extension of TAM, TAM2, the model includes social influence and cognitive instrumental processed in addition to the simple model; such as subjective norm, voluntariness, image, job relevance, output quality and result demonstrability. (Venkatesh & Davis, 2000). However, this model has been deemed to over-highlight user decisions by some (Agarwal & Karahanna, 2000; Bruner & Kumar, 2005; Gefen & Straub, 2000; Liao & Tsou, 2009).

Conceptual Model and Hypotheses

The external variables vary by the context of the information system that's being observed; different technologies ought to have different variables that affect the outcome. Some variables may affect only PU or PEOU, too. This paper focuses on relative advantage and self efficacy's relation towards PU and PEOU, and assumes e-book anxiety and brand and service trust to be closely related to attitude.

Relative advantage

Relative advantage is defined as "the degreet to which an innovation is perceived to be better than the ideas it supersedes" (Rogers, 2003). Compared to the alternatives of e-books, such as traditional books or audibooks, e-books are assumed to have relative advantage over them. Relative advantage is hypothesised to affect both perceived usefulness and perceived ease of use.

H1: "Relative advantage has a significant positive effect on perceived usefulness."

H2: "Relative advantage has a significant positive effect on perceived ease of use."

Self efficacy

There are multiple studies that suggest self-efficiacy can affect PEOU (Compeau & Higgins, 1995; Compeau, Higgins, & S.Huff, 1999). Self efficacy is defined as the person's ability to follow through a pattern of behavior (Bandura, 1997), and has been part of various acceptance models (Davis, 1989). Self efficacy is hypothesised to affect both perceived usefulness and perceived ease of use.

H3: "Self efficacy has a significant positive effect on perceived usefulness."

H4: "Self efficacy has a significant positive effect on perceived ease of use."

Perceived usefulness

Davis defines PU as "the degree to which a person believes that using a particular system would enhance his or her job performance." (Davis, 1989). Perceived usefulness is hypothesised to affect both attitude and behavioural intention.

H6: "Perceived usefulness has a significant positive effect on attitude."

H10: "Perceived usefulness has a significant positive effect on behavioral intention."

Perceived ease of use

Davis defines PEOU as "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989). Perceived ease of use is hypothesised to affect both perceived usefulness and attitue.

H5: "Perceived ease of use has a significant positive effect on perceived usefulness."

H7: "Perceived ease of use has a significant positive effect on attitude."

E-book anxiety

This study defines e-book anxiety as hesistance of using e-books or feeling nervous while doing so. Brand and service trust as a cognitive factor is defined as "the degree of influence that company reputation, website quality, and system security have on the behavioral intention of consumers to use e-books" (Tsai, 2012). E-book anxiety can also be consider part of resistence. It is hypothesised to affect attitude.

H8: "E-book anxiety has a has a significant negative effect on attitude."

Brand service and trust

Brand service an trust in this study measures whether or not consumers are more likely to trust the e-books if they obtain them from reliable sources. Brand service and trust is hypothesised to affect attitude.

H9: "Brand service and trust has a significant positive effect on attitude."

Attitude

Attitude is widely accepted as one of the major contructs that affect behavioural intention. The original technology acceptance model says that attitude combined perceived usefulness affect behavioural intention.

H11: "Attitude has a significant positive effect on behavioral intention."

Behavioural Intention

Behavioural intention to use is the step before actual use. This study does not measure actual use, and ends the calculations on behavioural intention. TAM model that's structured according to the hypotheses is provided in Figure 2.

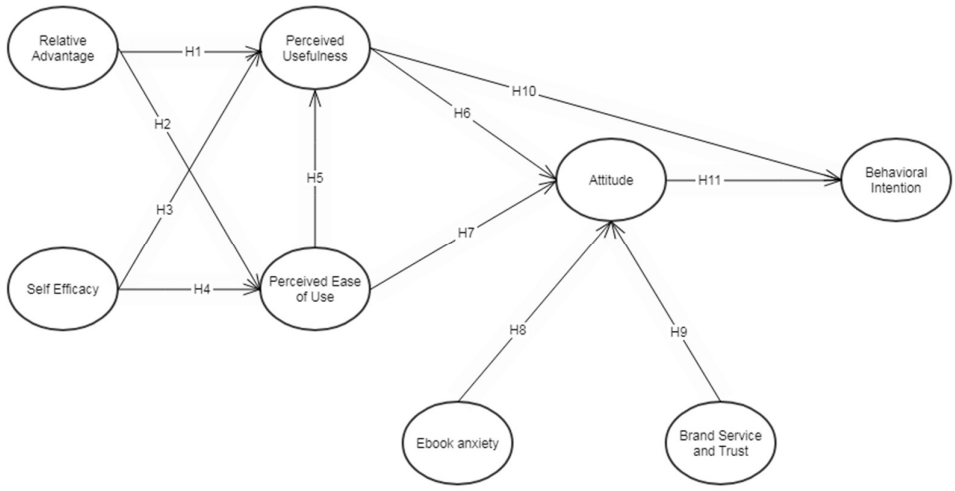

Figure 2. Conceptual model and hypotheses

3. MATERIALS AND METHODS

3.1. Design

This study uses undergraduate students from Istanbul Technical University to test the conceptual model's hypothesis. Survey was distributed by online channels. The goal is to confirm relative advantage and self efficacy have positive effects on perceived usefulness and perceived ease of use as well as proving e-book anxiety has a negative effect on attitude and brand service and trust has positive effect on attitude. The rest of the hypotheses are proven in the literature and are the basis of the TAM.
Survey is made of three parts. The first part includes a declaration that the given information will not be used for any purposes other than this research and a brief definiton of e-book. The second part includes demographic cahracterictics; such as gender, age, education level, how long the participiants have been reading e-books, and a question about the medium used for reading e-books. The third part is made of items of the constructions.

3.2. Data Collection

168 responses in total were received throughout the survey duration. 49.4% of the participants were female and 46.2% of the participants were male. The youngest participant was 16 years old and the oldest was 69, with the average age of 27. 19.6% of the participants had high school diploma, 12.7% had associate degree, 39.2% was undergraduate and 28.5% was post graduate. Of all the participants, 9.5% had less than a year of experience with e-books, 15.8% had between one and three years of experience, 23.4% had between three and five years of experience, and 51.3% had more than five years experience. Approximately 41.1% of the participants prefer tablet as a medium for e-books, 43% prefer e-readers, 68.4% prefer smartphone and 37.4% prefer computer.

3.3. Measurement Development

The items that create the constructs were taken from literature studies. Likert scale was used to rate the items: 1: strongly disagree, 2: disagree, 3: undecided, 4: sagree, 5: strongly agree. The 4 items for relative advantage (RA1, RA2, RA3, RA4) and 4 items for self efficacy (SE1, SE2, SE3, SE4) were taken from Jin (2014). 5 items of perceived usefulness (PU1, PU2, PU3, PU4, PU5) were developed by Davis (1985). Perceived ease of use had 4 items (PEOU1, PEOU2, PEOU3, PEOU4) and they were taken from Davis (1985), Davis et. al (1992) and Venkatesh and Davis (2000). E-book anxiety's 3 items (ANX1, ANX2, ANX3) were adapted from Venkatesh and Bala (2008) and Lee et al (2009). Brand service and trust has 4 items (TR1, TR2, TR3, TR4) and they were taken from Tsai (2012). Attitude has 4 items (AT1, AT2, AT3, AT4) and they were adapted from Venkatesh (2003). And lastly, 4 items of behavioural intention (BI1, BI2, BI3, BI4) were taken from Jin (2014) and Davis (1985). Construct and items are provided in Table 1.

Table 1. Constructs and items

CONSTRUCT	CODES	SOURCE	ITEMS
Relative Advantage	*RA1*	*Jin (2013)*	*I prefer e-books over paper books.*
	RA2		*E-books are more efficient than paper books.*
	RA3		*E-books are more helpful than paper books when doing something or studying.*
	RA4		*I believe using e-books has a more positive influence on me than using paper books.*
Self efficacy	*SE1*	*Jin (2013)*	*I will get used to obtaining the relevant technology for using e-books.*
	SE2		*I am able to understand the technical terms involved in e-book usage.*
	SE3		*I am able to explain the relevant functions of e-books.*
	SE4		*I am capable of explaning e-book usage to others.*
E-book anxiety	*ANX1*	*Venkatesh and Bala (2008), Lee et al (2009)*	*I have trouble using e-books.*
	ANX2		*I feel hesitation to use ebooks because I might make mistakes that I might not be able to correct.*
	ANX3		*I feel apprehensive about using e-books.*
Brand and service trust	*TR1*	*Tsai (2012)*	*I am comfortable with using well-known e-reader brands.*
	TR2		*I believe the transaction system of e-books is secure.*
	TR3		*I have confidence in e-books provided by enterprises.*
	TR4		*I prefer reading e-books purchased from well-known sellers.*
Perceived Usefulness	*PU1*	*Davis (1985)*	*I believe using e-books make my reading behavior more efficient.*
	PU2		*Using e-books is a convenient reading behavior.*
	PU3		*Overall, I believe ebooks are useful for me.*
	PU4		*Using e-books can make my academic and reading behavior more efficient.*
	PU5		*I expect that using e-books will improve my reading performance.*
Perceived Ease of Use	*PEOU1*	*Davis (1985), Davis et. al (1992), Venkatesh and Davis (2000)*	*Using an ebook is easy.*
	PEOU2		*I will become skillful at using e-books.*
	PEOU3		*I think it is easy to learn e-books without spending too much time.*
	PEOU4		*I find reading to be easy when using an e-book.*
Attitude	*AT1*	*Venkatesh (2003)*	*Using e-books is a good idea.*
	AT2		*I think it is very convenient to look up information using e-books anytime and anywhere.*
	AT3		*I like using e-books.*
	AT4		*I own a device that is an e-reader or can substitute one (Phone, tablet, etc...)*
Behavioural Intention	*BI1*	*Jin (2014), Davis (1985)*	*I want to use the services provided by e-books.*
	BI2		*I intend to buy or use e-books as much as possible.*
	BI3		*I have a strong tendency to continue using e-books.*
	BI4		*I intend to buy or use e-books in the future.*

3.4. Data Analysis

Partial least squares structutal equation modeling (PLS-SEM) statistical methodlogy is used to analyse the data. PLS-SEM is a multivariate analysis technique and it has many advantages, and some of these are "it makes no assumptions about the data; it requires no specific distributions for measured variables; it assumes the errors are uncorrelated; it works well with small samples; and it is better suited for analyzing complex relationships and models" (Sternad, Gradisar, & Bobek, 2011). SmartPLS 3.3.3 was used to conduct these calculations.

3.5. Measurement Model

In order to check the reliability and validity, convergent and discriminant validity were used. In order to analyse the data, Cronbach's alpha values, the values of factor loadings, composite reliability and the average variance extracted (AVE) were used. For factor loadings, 0.6 was taken as threshold value. When analysed, 7 of the 32 items (AT4, PEOU4, PU1, PU3, RA1, SE1, TR2) failed to pass the threshold, therefore the model was reconstructed after removing these items. Initial factor loadings are provided in Table 2.

Table 2. Initial factor loadings

ITEMS	AT	BI	TR	ANX	PEOU	PU	RA	SE
ANX1				*0.792*				
ANX2				*0.782*				
ANX3				*0.615*				
AT1	*0.81*							
AT2	*0.891*							
AT3	*0.858*							
AT4	*0.502*							
BI1		*0.81*						
BI2		*0.84*						
BI3		*0.883*						
BI4		*0.829*						
PEOU1					*0.852*			
PEOU2					*0.856*			
PEOU3					*0.564*			
PEOU4					*0.816*			
PU1						*0.527*		
PU2						*0.815*		
PU3						*0.539*		
PU4						*0.863*		
PU5						*0.824*		
RA1							*-0.212*	
RA2							*0.791*	
RA3							*0.804*	
RA4							*0.85*	
SE1								*0.586*
SE2								*0.802*
SE3								*0.853*
SE4								*0.758*
TR1			*0.807*					
TR2			*0.534*					
TR3			*0.813*					
TR4			*0.779*					

When analysed again, 2 items (ANX3, PEOU4) failed to pass the threshold again, so they were also eliminated. The model was finalised with 23 remaining items. Model's factor loadings are provided in Table 3.

Table 3. Model's factor loadings

ITEMS	AT	BI	TR	ANX	PEOU	PU	RA	SE
ANX1				*0.861*				
ANX2				*0.897*				
AT1	*0.828*							
AT2	*0.916*							
AT3	*0.861*							
BI1		*0.81*						
BI2		*0.844*						
BI3		*0.883*						
BI4		*0.825*						
PEOU1					*0.929*			
PEOU2					*0.92*			
PU2						*0.835*		
PU4						*0.865*		
PU5						*0.87*		
RA2							*0.782*	
RA3							*0.804*	
RA4							*0.872*	
SE2								*0.801*
SE3								*0.873*
SE4								*0.801*
TR1			*0.786*					
TR3			*0.839*					
TR4			*0.825*					

Cronbachs's alpha values indicate the degree of consistency, while composite reliability (CR) Cronbach's alpha and composite reliability values, show if the items are valid for measurement of a construct; both of them are required to be above 0.7 (Nunnaly, 1978). AVE, which shows the convergence of items, has the threshold of 0.5 (Fornell & Larcker, 1981). Cronbach's alpha, composite reliability and AVE values are provided in Table 4.

Table 4. Cronbach's alpha, composite reliability and AVE values.

ITEMS	CRONBACH'S ALPHA	RHO_A	COMPOSITE RELIABILITY	AVERAGE VARIANCE EXTRACTED (AVE)
Attitude	*0.837*	*0.841*	*0.902*	*0.755*
Behavioural Intention	*0.862*	*0.866*	*0.906*	*0.707*
Brand Service and Trust	*0.752*	*0.757*	*0.858*	*0.668*
E-book Anxiety	*0.707*	*0.716*	*0.872*	*0.773*
Perceived Ease of Use	*0.831*	*0.833*	*0.922*	*0.855*
Perceived Usefulness	*0.819*	*0.821*	*0.892*	*0.734*
Relative Advantage	*0.759*	*0.778*	*0.86*	*0.673*
Self Efficacy	*0.765*	*0.767*	*0.865*	*0.682*

After these steps, discriminant validity is evaluated. In order for this to be valid, squareroot of AVE, which stand on the diagonal of the table needs to be the largest in respective rows and columns (Chang, Chou, Yin, & Lin, 2011). Dicriminant analysis is provided in Table 5.

Table 5. Discriminant analysis

ITEMS	AT	BI	TR	ANX	PEOU	PU	RA	SE
Attitude	*0.869*							
Behavioural Intention	*0.979*	*0.841*						
Brand Service and Trust	*0.733*	*0.765*	*0.817*					
E-book Anxiety	*0.527*	*0.568*	*0.431*	*0.879*				
Perceived Ease of Use	*0.961*	*0.925*	*0.705*	*0.444*	*0.925*			
Perceived Usefulness	*0.862*	*0.926*	*0.775*	*0.583*	*0.752*	*0.857*		
Relative Advantage	*0.529*	*0.542*	*0.591*	*0.217*	*0.495*	*0.504*	*0.82*	
Self Efficacy	*0.757*	*0.775*	*0.708*	*0.602*	*0.736*	*0.759*	*0.501*	*0.826*

3.6. Hypotheses testing

SmartPLS software was used to conduct the following results and test the validity of hypotheses. According to the results, relative advantage does not have a significant positive effect on perceived usefulness ($p > 0.05$, H1 not supported) but it does have a significant positive effect on perceived ease of use ($p < 0.05$, H2 supported). Self efficacy has a significant positive effect on perceived usefulness ($p < 0.05$, H3 supported), and it has a significant positive effect on perceived ease of use ($p < 0.05$, H4 supported). Perceived ease of use has a significant positive effect on perceived usefulness ($p < 0.05$, H5 supported). Perceived usefulness has a significant positive effect on attitude ($p < 0.05$, H6 supported). Perceived ease of use has a significant positive effect on attitude ($p < 0.05$, H7 supported). E-book anxiety does not have a significant positive effect on attitude ($p > 0.05$, H8 not supported). Brand service and trust has a significant positive effect on attitude ($p < 0.05$, H9 supported). Perceived usefulness has a significant positive effect on behavioral intention ($p < 0.05$, H10 supported). Attitude has a significant positive effect on behavioral intention ($p < 0.05$, H11 supported). Supported and non-supported hypotheses are provided in Table 6.

Table 6. Hypotheses

CODE	HYPOTHESES	SUPPORTED?
H1	*Relative advantage has a significant positive effect on perceived usefulness.*	*No*
H2	*Relative advantage has a significant positive effect on perceived ease of use.*	*Yes*
H3	*Self efficacy has a significant positive effect on perceived usefulness.*	*Yes*
H4	*Self efficacy has a significant positive effect on perceived ease of use.*	*Yes*
H5	*Perceived ease of use has a significant positive effect on perceived usefulness.*	*Yes*
H6	*Perceived usefulness has a significant positive effect on attitude.*	*Yes*
H7	*Perceived ease of use has a significant positive effect on attitude.*	*Yes*
H8	*E-book anxiety has a has a significant negative effect on attitude.*	*No*
H9	*Brand service and trust has a significant positive effect on attitude.*	*Yes*
H10	*Perceived usefulness has a significant positive effect on behavioral intention.*	*Yes*
H11	*Attitude has a significant positive effect on behavioral intention.*	*Yes*

4. RESULT AND DISCUSSION

With the recent developments in technology, information and communications technologies became a part of our daily life. While there aren't scientific breakthroughs in e-book technology everyday, it's a stable technology that more people start using every day. With e-books, people can enjoy hundreds of thousands books just on their fingertips. However, as it is with every technology, there's a resistance, too. This paper investigated the possible factors that affect the e-book adaptation in order to prevent implementation failure.

By utilizing TAM, this paper investigates the determinants of attention and behavioral intention. The model presented in this paper includes self efficacy, relative advantage, e-book anxiety and brand and service trust. At the end of the analysis, 9 hypotheses out of 11 of them were supported. Relative advantage is proven to have a significance positive effect on perceived ease of use, while it doesn't have any on perceived usefulness. This means that while being an advantageous choice, e-books still don't ensure usefulness. A possible reason for this is the fact that our sample was mostly consistent of students, and some students gave such a feedback that they prefer traditional books while they study if it's a viable option, especially because it's more troublesome to flip several pages in an e-reader. Self efficacy has a significant positive effect on both perceived usefulness and perceived ease of use; it means people that people find it easier and more useful when they can handle the system on their own. Perceived ease of use has a significant positive effect on both usefulness and attitude. Both perceived usefulness and brand service and trust have a significant positive effect on attitude, but e-book anxiety's negative significant effect on attitude is not proven. And lastly, both attitude and perceived usefulness have a significant positive effect on behavioral intention.
It's important to note that this study was conducted in a single country; Turkey. Doing the same study with similar constructs might yield different results, especially if there's significant cultural difference or the sample is chosen differently. It's advised for the upcoming studies to conduct researches with more diverse audiences with various background in order to develop the model further. Further studies will undoubtedly manage to explain the factors affecting e-book usage better.

The effects of self efficacy, relative advantage, e-book anxiety, brand and service trust, PU and PEOU on attitude and behavioral intention to use e-books in Turkey is studied in this paper. The number of questionnaires collected was 168. The proposed model is analyzed with structural equation modeling using partial least squares. The data is analyzed with SmartPLS 3.3.3 software, which is a popular choice in this kind of analyses. As mentioned before, 9 out of 11 hypotheses were supported. Aside from providing theoretical grounds, this study also supplies practical implications for e-books, which is becoming more and more common. This paper is the first study which brings together aforementioned constructs in understanding factors of attitude and behavioral intention of using e-books in Turkey.

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Research Article

Interactive Virtual and Augmented Reality Mobile Application For Museums

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ABSTRACT: Augmented reality technology is a technology that can be used in all areas of life and will make our lives easier. With the innovation brought by technology, it is possible to use this technology in many areas. In this study, a mobile application was developed using Unity 3D Game Engine, which supports augmented reality and virtual reality technologies and provides an application development environment for these technologies, for museums that are losing their attractiveness and the number of visitors is decreasing day by day. In addition, augmented reality technology has been included in the application by utilizing the Vuforia Engine, which is a Unity plug-in. Asian, Egyptian and Greek civilizations have been successfully modeled in experiments.

KEYWORDS: Augmented Reality, Virtual Reality, Unity, Vuforia Engine, Museum.

1. INTRODUCTION

Virtual reality is a realistic computer-generated simulation of a real or imaginary world (Uçar, 2021). The person navigates through a virtually created mini-world. In other words, virtual reality distances people from the real world but allows them to watch this world enriched with virtual elements (Slater et al., 2016). Augmented reality, on the other hand, is a technology that tries to integrate the virtual world and the real world. In other words, instead of bringing the person into the virtual world, it enriches the sound, text, picture, and three dimensional (3D) models in the virtual world with visual effects and brings them to the real world (Berryman, 2012). It is clear that these technologies have significant potential, since augmented reality and virtual reality strengthen interaction with the virtual world, making the sense of perception close to the physical environment. Since they are open spaces for development, the continuity of studies related to these technologies is important.

In the literature, there are many studies based on virtual reality and augmented reality, especially in recent years. For example, Gargrish et al. presented a study based on augmented reality technology for the learning difficulties of 3rd-grade high school students in a geometry course. In their study on application design and coding with Unity Game Engine, the authors aimed to overcome the learning difficulties of children with 3D models, to attract their attention, and, moreover, facilitate their learning (Gargrish et al., 2020). Chang and his friends have presented an interactive solution with augmented reality for the application of augmented reality technology to motor skill learning in

physical education (Chang et al., 2020). Zhang et al. developed augmented reality-based astronomy simulation software for students to experience interactive learning (Zhang et al., 2014). Kamarainen et al. have developed an application based on augmented reality technology to address the ecosystem science learning goals of middle school students and help them understand and interpret water quality measurements (Kamarainen et al., 2013) Efstathiou et al. examined the contribution of augmented reality technology in improving the historical empathy and conceptual understanding of 3rd-grade students in an inquiry-learning environment (Efstathiou et al., 2018). Rohil and Ashok carried out a study involving augmented reality technology to assist urban planning. In the application developed by the authors, 3D layout plans of critical places for urban development are presented to the user (Rohil and Ashok, 2022). Menon et al. designed an augmented reality simulation to complement existing content in the nursing physical assessment course and improve both psychomotor skills and clinical competence (Menon et al., 2022). Pimentel has developed a mobile augmented reality app called 'Penguin Rescue' to facilitate interaction with wildlife and support biodiversity conservation. In their study, the authors help the penguin by rehabilitating a virtual penguin (Pimentel, 2022). Smith and Friel developed an augmented reality application for mental transformations from two-dimensional representations to three-dimensional cognitive understanding in the field of chemistry. Students can view 3D models with augmented reality with their mobile devices, and they can also examine the model by making changes with touch screen movements (Smith and Friel, 2021). Nakamoto et al. presented a SPECT/CT augmented reality study for intraoperative localization of sentinel lymph nodes in head and neck melanomas (Nakamoto et al., 2022). Finally, Smith et al. discussed the effect of the spatial position and movement of the augmented reality graph on driver behavior. SensoMotoric Instruments eye-tracking glasses and iView ETG 2.6 software were used to record the gaze position of the individuals and analyzed the gaze of the individuals with the SensoMotoric Instruments BeGaze 3.6.40 software (Smith et al., 2021).

In today's world, especially museums are faced with the problem of increasing the number of visitors and sustainability. The decrease in the number of visitors to museums is seen as a negative result in terms of financial, social, and educational impact (Aytekin, 2016). Although there are many reasons, the most important factor is that museums find themselves in competition with the products of the entertainment industry. Unable to continue this competition,

many museums have had to close or are about to close. In addition, there are not enough guides for visitors to museums. For this purpose, museums that are considered guides of a certain period and region should interact and communicate with their visitors in accordance with the requirements of the era and developing technology in order to maintain their existence. In this study, it is aimed to make the historical monuments that we cannot reach and the people who left their mark in history suitable for the present day by using virtual reality and augmented reality technologies. In addition, it is aimed to make it an attraction for museums that have fallen into oblivion and whose visitors are decreasing. It is believed that the application developed in this study will make a great contribution to the tourism sector of our country.

Especially in the augmented reality-based studies carried out in the field of tourism, it was seen that only one problem was addressed. For example, Sites in VR application (Sites in VR, 2016) offers the opportunity to travel in virtual reality to museums, and natural attractions. An application developed for the Geneva Museum of Art and Museum History (Geneva Museum of Art and Museum History, 2020) has a 3D model of the Achille and Penthésilée Statue only. An application, that was developed using Wikitude Studio for a literature museum about the famous Italian novelist Italo Svevo living in Trieste, has only 2D images come to life and there are no virtual guides and 3D models (Fenu and Pittarello, 2018). In the above studies in which augmented reality and virtual reality technologies are used, there are no stages that are visiting with a virtual guide or visiting virtual exhibitions using augmented reality and virtual reality. Our study differs from these studies in this respect.

2. MATERIALS AND METHODS

2.1. Unity 3D Game Engine and Unity Virtual Reality

Unity is a game engine developed by Unity technologies. It can be used to develop games, augmented reality and virtual reality applications, simulations, and animated films for computers, mobile devices, and consoles. An important feature of Unity is that it gives the developer the ability to write program code during the game development stage. Graphics and code work together with Unity. This working logic provides flexibility to the developer and reduces the application development time. Figure 1 presents the Unity application development screen. Since Unity is a cross-platform game engine, a game can be compiled for different platforms without the need for any infrastructure changes. With this ease of use, a game prepared for PC can be made to work for Mac with a single click without the need to change the code (Venture Beat, 2022). In addition, with the "Virtual Reality" feature in it, virtual reality applications can be developed without the need to use any external plug-ins (Unity Game Engine, 2016).

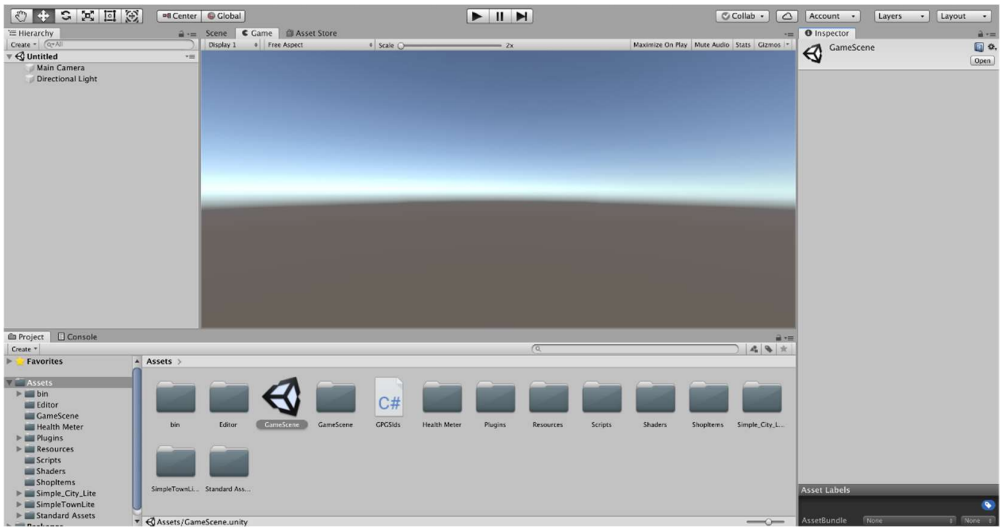


Figure 1. Unity 3D application development screen

2.2. Vuforia Engine

Vuforia Engine, introduced by Power to Create a company, is a software platform where augmented reality applications are developed. In order to use it in Unity, it must be downloaded as a plugin and added to Unity. It is highly preferred in augmented reality and virtual reality studies, as its ease of use and in-app optimization are at a high level. Vuforia; Area Target, Model Target, Image Target, etc. It enables the active use of augmented reality technology with services (Vuforia Engine Library (a)).

2.3. Vuforia Area Target

It is an environmental monitoring feature that allows applying augmented reality technology to specific interiors, spaces, and monitor spaces. An accurate model of the field is required to create the field target database. These models are created using 3D scanners. In this way, interactive games with the environment, navigation applications, and spatial instructions are created. It can be applied to offices, apartments, museums, hospitals, and many more (Vuforia Engine Library (b)). In order to take advantage of the Area Target feature, first of all, it is necessary to scan the interior with 3D scanners and

extract the 3D model of the space by the reverse-engineering method. The created model is converted into a Unity Package with the help of Vuforia and imported into the Unity environment (Vuforia Engine Library (c)).

2.4. Vuforia Image Target

Vuforia Engine target refers to the image that it can detect and monitor with the help of the source. When the application is made and the phone camera is accessed, a target source is needed for the objects to come to life on the phone. The system detects the image by comparing the image with a known target source database. When the image target is detected, the object comes to life on the mobile phone. The target image needs to be uploaded to Vuforia Engine's website. Vuforia issues a special license key for the uploaded target image. It is necessary to import this license key and the image uploaded to the site into Unity by downloading the customized package for Unity (Vuforia Engine Library (d)). At this stage, Unity recognizes the target image and detects it every time it sees it. In this way, when the image target is detected, the object is displayed on the mobile phone.

2.5. Developed Application

3D models have been taken from the Unity Asset Store (Unity Asset Store (Unity Asset Store(a)) website which is a store created by Unity Technologies. Anyone who is a member of the Unity community can publish the project examples, animations, and models they create in this store (Unity Asset Store (b)). A virtual museum consisting of artifacts from Asian, Egyptian, and Greek civilizations has been created in the Unity environment for a museum tour with virtual reality. While creating the museum, first of all, the works were placed in the museum and the museum design was carried out. In this way, the user can enter the application and walk around the museum with virtual reality glasses and a phone in the virtual reality section. In other words, when the visitor enters the "Virtual Exhibition with Virtual Reality" section within the application, he/she can examine the museum in virtual reality by putting his/her mobile phone on virtual reality glasses.

When the mobile phone camera is turned on, the target images have been added to the "Target Manager" section of the Vuforia Engine website so that the phone can recognize the artifacts, and the Vuforia Engine plugin has been imported into Unity. Afterward, 3D models of artifacts in different museums around the world were added to the mobile application for the virtual exhibition of Asian, Egyptian, and Greek civilizations. Thus, 3D models of the images determined by the mobile phone come to life on the user's screen. Figure 2 presents the workflow chart of the developed application.

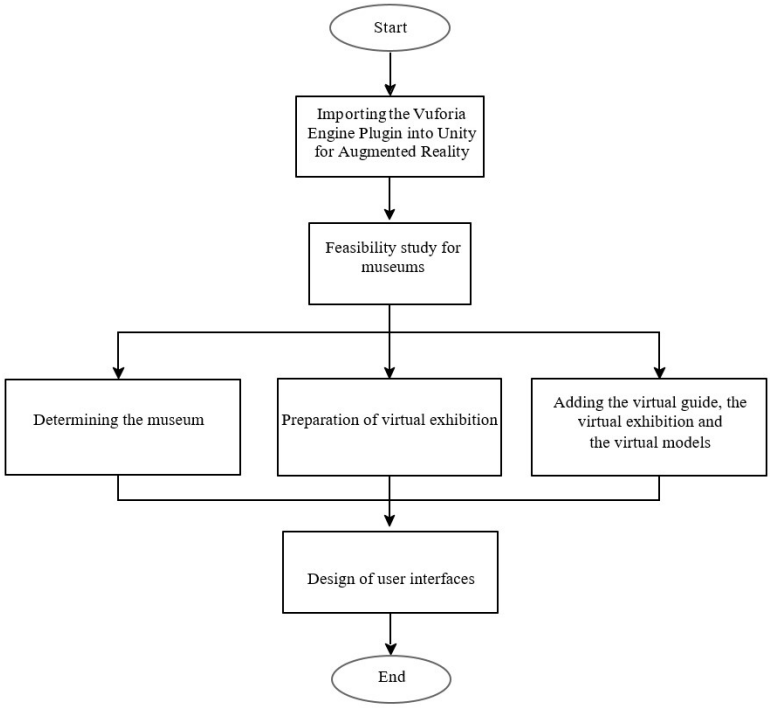
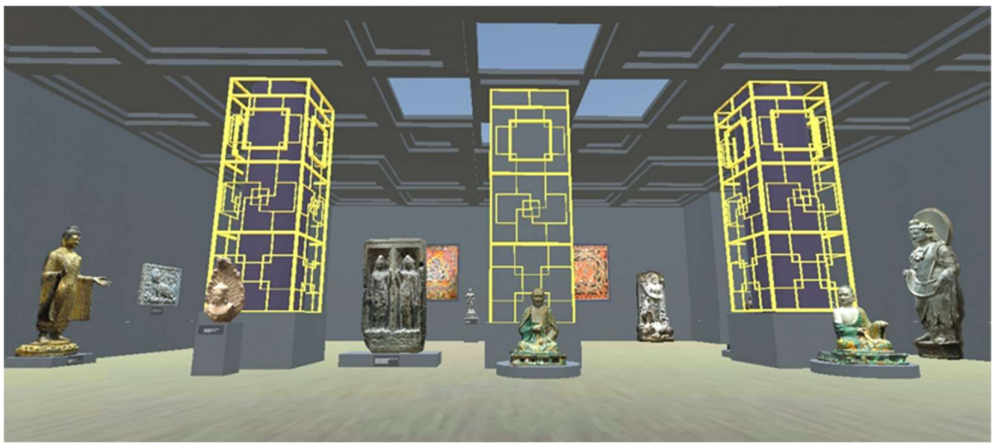
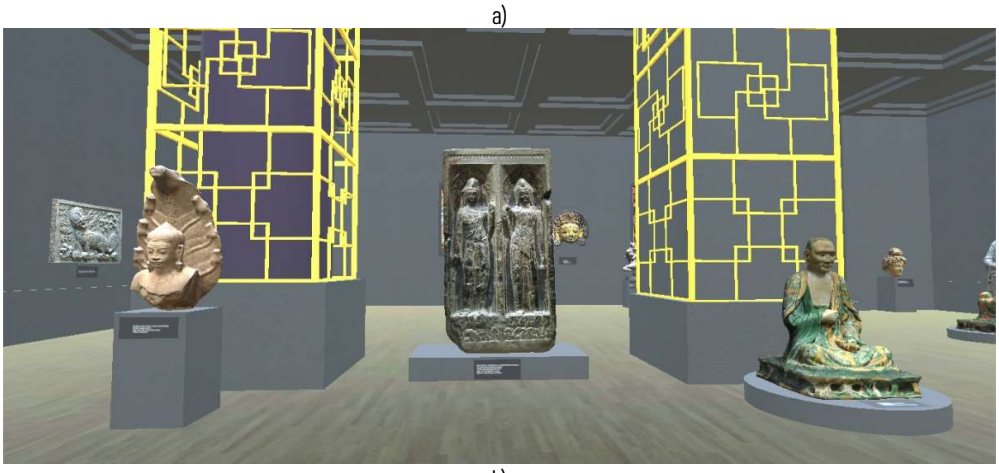


Figure 2. Workflow diagram of the study

The section "Virtual Exhibition with Virtual Reality" consists of works belonging to the Asian, Egyptian and Greek Civilizations. In this section, the visitor will be able to see the works from his/her location with the virtual reality application without going to the museum. Figure 3 presents sample screenshots containing he stages of the developed application.



a)



b)

c)

d)

Figure 3. Virtual Reality application's user interfaces; a) In-museum virtual exhibition with Virtual Reality, b) In-museum virtual exhibition with Virtual Reality, c) In-museum virtual exhibition with Virtual Reality, d) A bird's eye view of the virtual exhibition inside the museum with Virtual Reality

In addition, when the visitor uses the application within the museum and holds his camera in the space reserved for the virtual exhibition, he will be able to view the works of museums located in different countries as a virtual exhibition within the museum with augmented reality. The virtual exhibition section consists of 3 civilizations: Asian Civilization, Egyptian Civilization, and Greek Civilization. There are 8 works for each civilization and 24 works in total. With the help of buttons, it Dec possible to switch between civilizations and artifacts. Information and descriptions about the works are written in the fields located under the works. The screenshots of the virtual exhibition section of the mobile application animated with augmented reality taken from within the application are presented in Figure 4.

a)

b)

c)

Figure 4. Screenshots of the augmented reality part; a) a screenshot of "Stone Funeral Statue of an Officer" of Asian Civilization, b) a screenshot of "Statue of Dancing Heavenly God" of Asian Civilization, c) a screenshot of In-app image of "VII. Cleopatra Statue" of Egypt Civilization.

Moreover, the visitor chooses the museum he will visit by going to a museum and opening the mobile application from his phone, a short 5-question questionnaire is conducted about that museum. According to his answers to the questionnaire, his interests are determined and a virtual museum tour is created. After that, the camera on the individual's mobile phone turns on and a virtual guide modeled in 3D with augmented reality appears in front of him. A person can follow the virtual guide and visit the museum and get information. In addition, when he examines works related to his camera, the relevant objects come to life on the screen of his phone in three dimensions. In addition, artifacts in different museums can be viewed and virtual tours can be made with augmented reality in the virtual exhibition section.

4. RESULT AND DISCUSSION

In this study, virtual and augmented reality-based mobile application has been developed for museums. The application has been developed with the ease of interface provided by Unity and the augmented reality support of the Vuforia Engine plugin. The virtual exhibition feature of the application consists of carefully selected works from museums that we could not find the opportunity to visit for various reasons. In the future, it is aimed to include features such as hiding some treasures in the museum with augmented reality in order to provide more interaction with the visitor, gaining points by finding these treasures and using these points in the developed application. Virtual reality and augmented reality technologies, which are very popular today with their features, should be used especially in the defense and medical fields.

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