

Shortest Path Approach in Pedestrian Transfers Application in Unity

Mustafa GÜNEŞ^{*,a}, Hakan DİLİPAK^b

^{a,*} Gazi Üniversitesi Kazalrın Çevresel ve Teknik Araştırılması Bölümü, 06560, ANKARA, TÜRKİYE

^b Gazi Üniversitesi İmalat Mühendisliği Bölümü, 06560, ANKARA, TÜRKİYE

ARTICLE INFO

Received: 02.04.2020
Accepted: 03.08.2020

Anahtar Kelimeler:

Unity, A Yıldız
Algoritması, En Kısa
Yol Problemi, Arazi
Modelleme, Yapay
Zekâ

^{*}Sorumlu Yazar:

e-posta:
mustafagunes5365@
hotmail.com

ABSTRACT

In the past 15 years, terrorist organizations have made tactical changes in their attacks, while the defense elements have continuously improved their doctrines. In some parts of all operations, especially the Homeland Security Operation, the troops were forced to move from one point to another in the field as pedestrians. In the present study, a visual application showing the shortest route to the target was made to the troops acting as pedestrians in the field. First of all, three-dimensional model of a certain region was created by using height maps in Unity Game Engine. A Star algorithm and Navigation Mesh help to move pedestrian elements in the terrain. As a result of the study, a decision support system was developed showing the direction in which troops move during the transfer to the field by using a star algorithm and navigation mesh.

<https://dx.doi.org/10.30855/gmbd.2020.02.03>

Yaya İntikallerde En Kısa Yol Problemi Unity İçerisinde Uygulama

MAKALE BİLGİSİ

Alınma: 02.04.2020
Kabul: 03.08.2020

Keywords:

Unity, A Star
Algorithm, Shortest
Path Problem, Terrain
Modeling, Artificial
Intelligence

^{*}Corresponding

Authors

e-mail:
mustafagunes5365@
hotmail.com

ÖZ

In the past 15 years, terrorist organizations have made tactical changes in their attacks, while the defense elements have continuously improved their doctrines. In some parts of all operations, especially the Homeland Security Operation, the troops were forced to move from one point to another in the field as pedestrians. In the present study, a visual application showing the shortest route to the target was made to the troops acting as pedestrians in the field. First of all, three-dimensional model of a certain region was created by using height maps in Unity Game Engine. A Star algorithm and Navigation Mesh help to move pedestrian elements in the terrain. As a result of the study, a decision support system was developed showing the direction in which troops move during the transfer to the field by using a star algorithm and navigation mesh.

<https://dx.doi.org/10.30855/gmbd.2020.02.03>

1. INTRODUCTION (*Giriş*)

Technology is developing and changing very fast today. This change and development have affected the

ability and capability of terrorist groups, while allowing countermeasures to be developed. From this perspective, terrorist organizations have made tactical changes in the last 15 years in order to minimize their

Bu makaleye atf yapmak için: M. Güneş and H. Dilipak, "Shortest Path Approach in Pedestrian Transfers Application in Unity," *Gazi Journal of Engineering Sciences*, vol. 6, no. 2, pp. 111-119, August, 2020, doi: <https://dx.doi.org/10.30855/gmbd.2020.02.03>.

losses and avoided close contact as often as possible, using long range shots and mines and Improved Explosives Devices (IED) in their attacks and actions. On the other hand, security units are subject to such attacks as they must necessarily act as pedestrians in some of the tasks.

In this context, it has been evaluated that the content of the study can contribute to different fields such as operations research, military literature, serious game, gamification and simulation and information systems, 3D modeling, virtual reality, game engines, artificial intelligence. [1]. Therefore, similar studies can be used for training purposes in the military field.

From a military perspective, gamification has a history that dates back a thousand years. In this context, the physical world should be reflected dynamically, and if necessary, the educational environment in which city plans and architecture were added should be added to the game environment. Modern computers provide the same objective in this respect. Sometimes it can be said that the simple games people play at home are based on some very old military tactics. [2].

Today, it is necessary to talk about game engines in order to present the physical environment in a realistic way. Especially the engines in different capacities, performances, licenses and price levels make it difficult to decide which engine you will choose for your project. Patrasitidecha (2014) developed a comparison matrix to be able to determine an appropriate game engine in terms of different ranges of features, performance, license, and cost [3].

Similarly, Petridis et al. (2018), evaluated the game engines based on the five elements for the analysis of engines such as visual benefit, functional benefit, integrity accessibility, networking, and multi-platform support issues [4].

Different applications are used to make the model and the environment realistic and different package programs are used when necessary. For example, in a study conducted in 2016, buildings on the Ahmet Necdet Sezer Campus (ANS) were modeled within the context of environmental modeling, and this model was placed in the Google Earth program to be used. [5]

Similarly, Gürkan et al. (2016) In another study, Mustafa Kemal University campus was modeled and CAD and SkecthUp programs were used in the application. In this study, pre-processing of data, transferring CAD data to SkecthUp, scaling and modeling of 3D buildings, optimization of building photographs, processing of building colors and textures, campus design with SkecthUp and integration with digital terrain model were applied. [6]

In a study prepared by Indraprastha and Shinozaki in 2009, the technical data of a sample settlement was converted to 3D with the help of CAD and then transferred to the Unity game engine. In this study, the advantages and limitations of the engine are specified. [7].

In 2012, Aziz et al. A workshop was created in a virtual reality environment and an application was made showing how a wheel interacts with the user, the order of the gears and the working methods. CAD data was used in the study and the application was intended to be user-friendly [8].

Mathematical programs are also used in this field. For example, in a different study conducted in 2018, the data created via MATLAB was transferred to Unity in order to direct unmanned aerial vehicles and directed within the engine[9].

In addition, new technologies are being developed within the Unity game engine. In 2014, Jangrawa et al. A system has been designed to create new objects in the user-facing area within an open source application [10].

Assigning material to 3D models as well as the modeling of the environment or the arrangement of the textures, realistic representation of the model are important issues. It is aimed to present the models better with different photogrammetric methods used especially in serious games [11]. In a similar study conducted at Unity in 2015, a virtual drone was used to model complex surfaces such as forests and shrubs [12].

Modeling with photographs was carried out in a military study in 2009 by Koyuncu and Bostanci. In this way, the existing terrain and enemy conditions were modeled, and a decision support system was created for the commander using the photos taken on the battlefield. [13].

The aim of this research is to enable the personnel to adapt to the terrain more easily in the tasks performed by the security elements. Thus, to facilitate the pedestrian transfer activities that the units have to perform at every stage of the operation. With this study, the units working in the field will see the route they will be transferred to in three dimensions in computer environment before the assignment, will discover the terrain structure of the region and will be able to determine the shortest route to their destination. It is understood that the content of this study is an interdisciplinary issue. There are many areas of the study that are related to the field of defense sciences, as well as many areas corresponding to areas such as operations research and computer graphics. For this reason, it has been evaluated that the study will contribute to different fields such as operations research, defense industry literature, serious game, gamification, 3D modeling, virtual applications, game engines, artificial intelligence.

In this study, a real piece of terrain will be modeled, and a movable area will be created on it. In this field, the shortest path problem will be solved with A star algorithm. In this context, there are many examples of A * application in the literature. Examples of route planning of a robot can be prepared [14], or an algorithm for determining paths for modeling virtual human movements [15] can be used.

2. METHODOLOGY (YÖNTEM)

The study consists of different stages. According to the content of the project, as shown in a study conducted in 2005 [16], it is possible to create different rankings. The exemplary steps shown in Figure 1 should be performed sequentially or simultaneously.

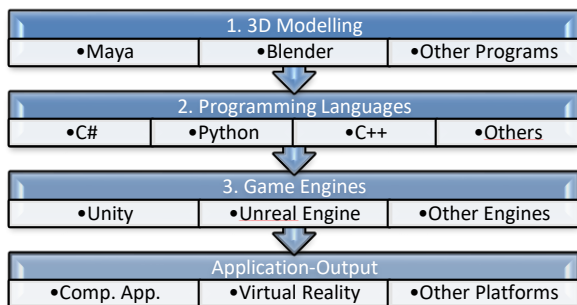


Figure 1. Sample serious game process (Örnek ciddi oyun süreci)

2.1. Operator Modeling (Operatör Modellemesi)

Modeling the character to be used in serious game can be done with different package modeling programs. However, this modeling requires both considerable skill and technical knowledge. There are many different stages for modeling, constructing and moving a human being [17]. In humanoid modeling:

- Modeling of solid or organic human model,
- Preparation of tissues,
- Fitting a skeleton system to the model,
- Determining the boundaries of this skeletal system,
- Determining how much body part will be affected for each movement,
- There is a need for processes such as the creation of methods for muscle group movements and the preparation of the controller.

Although the mentioned steps are feasible, utilities are used in this section for the subject integrity of the study.

2.2. Editing Height Maps (Yükseklik Haritalarını Düzenleme)

One of the most important features that distinguishes serious games from other games is that environmental conditions overlap with reality. For this purpose, height maps can be used to benefit from real data. The height maps are black and white maps that give a vertical view of the terrain. Each pixel in these maps has a tone between 0-255 and is transformed into terrain by transferring these data to game engines with modeling programs (example height maps [18]). In this study, elevation map of the relevant region will be provided from Terrainparty website [19].

2.3. Game Engines (Oyun Motorları)

There is also a need to manage these models and rules through a program. For this reason, software called game engine is used. In this way, models and other objects can be associated with codes and the application can be prepared.

In today's conditions, many engines are used. However, in game development, users prefer Unity and Unreal engines more often [20] [21]). There are many studies in the literature on the evaluation of game engines. Considering the increasing number of

publications, [1] it was decided that it would be appropriate to use Unity in this study.

2.4. Some Regulations in Unity (Unity İçinde Bazı Düzenlemeler)

Another important element is that all interactions used in the virtual world are bound to the rules. Transferring things like movements, conditions, other environmental elements, user interface to the game objects can be done in a relatively simple way in Unity. With the drag-and-drop method, many game objects can be defined in programs. Due to the use of the C # programming language in Unity, such assignments can be assigned as variables within the code block.

2.5. Example of Artificial Intelligence Applications in Unity: Shortest Path Problem with A Star Algorithm (Unity'de Yapaya Zeka Uygulamalarına Örnek: A Yıldız Algoritması ile En Kısa Yol Problemi)

Unity uses the Navigation Mesh editor for artificial intelligence applications in order to move the characters autonomously in the terrain prepared in the Unity. Similar examples are found in the literature [22]. With this editor, the so-called agents can move through the created terrain with certain abilities and restrictions. For example, agents can advance to their destination at a certain speed, through a depth, bump or slope at a distance. Or, by placing certain limitations on these elements, their mobility may be limited. Unity game engine creates a Navmesh with the specified features. Similar examples can be examined in the literature. [23]

2.5.1. Shortest path problems with navmesh (Navmesh ile en kısa yol problemleri)

Some of the problems encountered in practice can be solved by artificial intelligence applications. One of these areas is the problem of trying to find the shortest path between two points. These problems are often called the Shortest Path or Path Finding Problems. In this context, it may be desirable for an object to move to a desired location within the stage, to move around obstacles and to proceed autonomously from the lowest cost route by evaluating the costs of the routes. A * (A Star) algorithm is one of the algorithms used for this purpose and is used by Unity in some artificial intelligence applications. and many resources describing the implementation of this algorithm are available.

Uses of A Star Application [24]:

1. Path finding problems,
2. Determining the route that the character will follow towards the target in games,
3. Traveling salesman problem solution,
4. Finding the shortest exit from the maze, can be counted.

Graphs are used in A * algorithm. In this way, graphs can be unidirectional or bi-directional and weighted. In some cases, the cost of returning from the same route may be different.

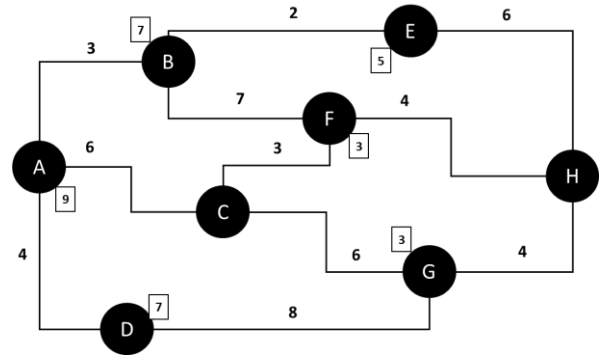


Figure 2. Graph display example (Örnek graph gösterimi)

Finding the shortest path can also take much time, depending on the solution process, the number of nodes and paths. Heuristic algorithms can be used to calculate the shortest path, due to the fact that there is already a lot of workload when calculating games. [25]

In short, the A * algorithm is the best (heuristic) nesting algorithm to find out which nodes to navigate from one node to the destination node in the shortest way. This is due to the distance calculation function used in the algorithm:

$$f(n) = g(n) + h(n) \quad (1)$$

$f(n)$ = Heuristic function that performs the calculation.

$g(n)$ = Cost from initial node to current node

$h(n)$ = Estimated distance from the current node to the target node.

The implementation of the algorithm is usually carried out at the following stages [26]:

1. At each step, the lowest value takes the node and removes that node from the queue.
2. The values of all other neighboring nodes are updated according to the node visited.
3. The algorithm repeats the above steps until you reach the target or there are no nodes in the queue.

This application will show you how to make the application that finds the shortest path in a field with real height and slope values.

3. APPLICATION (UYGULAMA)

In the application, the basic aspects of modeling the operator and terrain and creating some Navmesh (Navigation Mesh) in Unity will be mentioned.

3.1 Operator Modeling (Operatörünün Modellenmesi)

Firstly, the character was modeled in detail with Adobe Fusion [27] package program as desired (Figure 2.) and then the character was transferred to Mixamo site [28] to transfer the skeletal system to this model. Mixamo application can be created for the model only skeletal system or if desired, different animations can be transferred to the model. In this study, the skeletal system of the model was prepared and a simple walking animation was added to the model.

An animator has been added to the model in Unity so that the animation attached to the created model can work, and it is allowed to work from the beginning of the application without waiting for any condition (Example: Adding animators [29]).

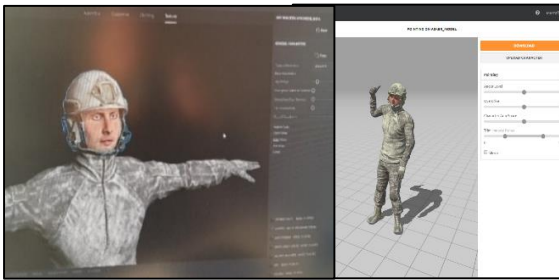


Figure 3. Character modeling and adding animation (Karakter modellenmesi ve animasyon ekleme)

3.2 Terrain Modeling (Arazinin Modellenmesi)

Terrain Party was used to provide the elevation map of the terrain to be created. After obtaining the 10

× 10 km elevation map of the Tunceli Region, the relevant parts of this map were arranged in the photo editing programs (Fig. 3) and transferred into Unity with PNG format.

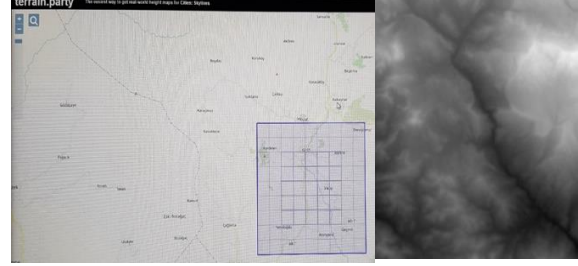


Figure 4. Editing the elevation map of the land (Arazinin yükseklik haritasinin düzenlenmesi)

Subsequently, the selected standard terrain was converted into the desired 3D terrain environment by selecting the elevation map obtained in the previous step with an extension into Unity. Simple C # code was used during this translation process. This modeling process can be done via Terrain Editor without the need of any software in current Unity versions.

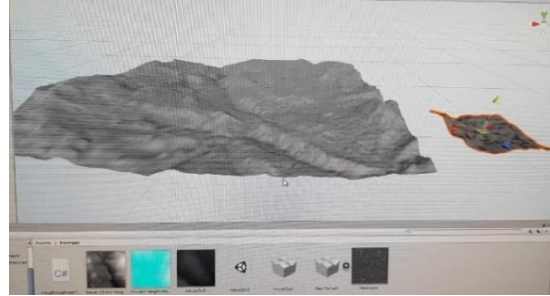


Figure 5. Land scaling and material assignment in unity (Unity'de arazinin ölçeklenmesi ve materyal ataması)

As seen in the study, there is a significant size difference between the 10 × 10 km land and the 2 × 2 km land. With the optimization of the model, the time to be spent on the modeling of the land was evaluated and it was decided to continue the study on 2 × 2 km of land. Subsequently, the material assignments to these lands were made with the Terrain-Stratum-Painter extension [30] based on altitude information and the land was made ready for use.

3.3 Preparation of Other Elements in Unity (Unity içerisinde Diğer Unsurların Hazırlanması)

One of the most important elements in the preparation of terrain and environmental conditions is the correct adjustment of the light. The fact that the

light source to be formed in the Unity at the right angle and intensity will make the application more realistic. Directional Light was used and daylight values were tried to be obtained.

Similarly, factors such as moving the vegetation created by the wind in the environment or hearing the environmental sound are the elements that enhance the sense of reality within the unity. For this reason, standard functions in Unity are utilized.

3.4. Artificial Intelligence Application in Unity (Unity'de Yapay Zeka Uygulaması)

A C # script is written that takes the coordinate of the point when clicked and assigns that coordinate to its destination so that the animated character can move to the desired point within the generated terrain.

```
void Update()
{
    if (Input.GetMouseButtonDown(0))
    {
        RaycastHit hit;
        if
        (Physics.Raycast(Camera.main.ScreenPointToRay
        (Input.mousePosition), out hit, 1000))
        {
            agent.destination = hit.point;
        }
    }
}
```

Thus, with the character walking animation, it is aimed to advance to the desired point in the field by taking into consideration obstacles, angles and heights.

At this stage, some settings of the application's Navigation Mesh and Agent system have been made. While the Agent's settings were made, measurements close to a normal person were used and the length of the character was set as 2 m width 0.5 m, maximum step height 40 cm and angle 30 degrees. In this context, the Navigation Mesh of the generated land is as follows.

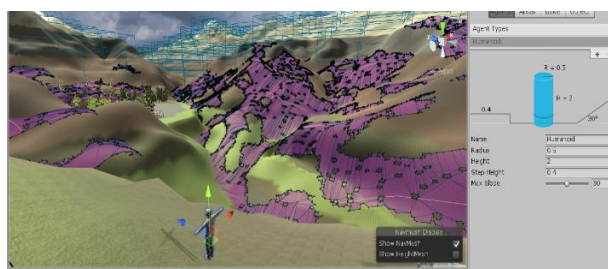


Figure 6. NavMesh creation and agent settings in Unity (Unity'de navmesh oluşturma ve agent ayarları)

After this stage, our character has been appointed as an agent. The variable assignments of the script prepared for the progression to the clicked points were made on the Unity editor. Thus, a soldier model in the field goes to the clicked point by using the shortest path algorithm.

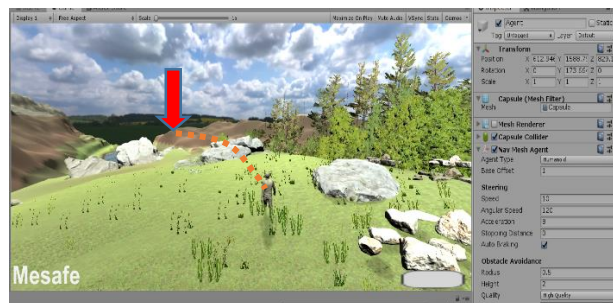


Figure 7. Moving on terrain with a star algorithm (A yıldız algoritması ile arazi üzerinde hareket etme)

4. RESULT AND DISCUSSION (SONUÇ VE DEĞERLENDİRME)

In this study, a piece of land was created by using real map and altitude data and this piece of land was arranged in Unity. A soldier was modeled by using package programs and animation was added to this model and imported into Unity. NavMesh was then assigned to the terrain, the prepared model was set as Agent, and the Agent was able to move through the shortest path (within certain limits) using the A * Algorithm.

It is considered that this study can be used especially by the pedestrian elements (soldiers, hunters, etc.). Thus, a decision support system has been prepared for the elements that are assigned to go from A to B and how to reach the destination by the shortest way. In addition, the personnel who will perform this task have been able to see the land in 3D and make risk assessment when necessary.

It is considered that in the following studies, arrangements can be made in which the user can move the model or insert some control points in between by using an interface, not by clicking. In addition, some important notes on the land (eg “ a handmade explosive mechanism at this point” or “attention falls rock”) can be taken to support the user. Or some obstacles, zones that slow down or increase the speed

of walking may be added. Thus, it is considered that the application can be made more realistic and useful.

CONFLICT OF INTEREST STATEMENT (ÇIKAR ÇATIŞMASI BİLDİRİMİ)

The authors reported no potential conflict of interest.

REFERENCES (KAYNAKLAR)

- [1] Y. Daineko, M. Ipalakova, R. Muhamedyev, M. Brodyagina, M. Yunnikova, B. Omarov, "Use of Game Technologies for the Development of Virtual Laboratories for Physics Study," *Development of Virtual Laboratories for Physics Study*, vol. 6, no. 42, pp. 422-428, November, 2016, doi: 10.1007/978-3-319-49700-6_42.
- [2] R. Smith, "The Long History of Gaming in Military Training," *Simulation Gaming OnlineFirst*, vol. 41, no. 1, pp. 6-19, 2010, doi: 10.1177/1046878109334330.
- [3] A. Patrasitidecha, "Comparison and evaluation of 3D mobile game engines", M.D. dissertation, Chalmers University of Technology University of Gothenburg, Sweden, 2014.
- [4] P. Petridis, I. Dunwell, D. Panzoli, S. Arnab, A. Protopsaltis, M. Hendrix, S. de Freitas, "Game Engines Selection Framework for High-Fidelity Serious Applications," *International Journal of Interactive Worlds*, vol. 2012, no. 1, pp. 1-19, April, 2012, doi: 10.5171/2012.418638.
- [5] İ. Tiryakioğlu, M. Uysal, S. Erdoğan, M. Yalçın, N. Polat, A. Suat, "3 Boyutlu Bina Modelleme ve WEB Tabanlı Sunumu: Ahmet Necdet Sezer Kampüsü Örneği," *Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi*, cilt. 16, sayı. 1, s. 107-114, Nisan, 2016, doi:10.5578/fmbd.10042.
- [6] A. Gürkan, A. Salıcı, M. K. Yıldırım, M. Yıldırım, "Üç Boyutlu Yerleşke Modelleme; Mustafa Kemal Üniversitesi Tayfur Ata Sökmen Yerleşkesi Örneği," *CBÜ Fen Bil. Dergi*, cilt 12, sayı 3, s. 511-515, Aralık, 2016, doi: 10.18466/cbayarfb.280672.
- [7] A. Indraprastha, M. Shinozaki, "The Investigation on Using Unity3D Game Engine in Urban Design Study," *ITB J. ICT Vol*, vol. 3, no. 1, pp. 1-18, 2009, doi: 10.5614/itbj.ict.2009.3.1.1.
- [8] E. S. Azız, Y. Chang, S. K. Esche, C. Chassapis, "A Multi-User Virtual Laboratory Environment for Gear Train Design," *Game-Based Gear Train Laboratory*, vol. 22, no. 4, pp. 788-902, February, 2012, doi: 10.1002/cae.21573.
- [9] C. Altın, O. Er, "İnsansız Hava Araçlarının (İHA) Sanal Gerçeklik Yazılımı ile Modellenmesi ve Farklı Kullanıcılar için Performans Analizleri," *Sakarya University Journal Of Computer And Information Sciences*, cilt 1, sayı 2, s. 1-13, Ağustos, 2018, doi: 10.35377/saucis.01.02.447931.
- [10] D. C. Jangrawa, A. Johri, M. Gribetza, P. Sajdaa, "NEDE: An open-source scripting suite for developing experiments in 3D virtual environments," *Journal of Neuroscience Methods*, vol. 2014, no. 235, pp. 245-251, September, 2014, doi: 10.1016/j.jneumeth.2014.06.033.
- [11] G. Kontogianni, A. Georgopoulos, "Exploiting Textured 3D Models for Developing Serious Games," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. 40, no. 1, pp. 249-255, August, 2015, doi: 10.5194/isprsarchives-XL-5-W7-249-2015.
- [12] W. Meng, Y. Hu, J. Lin, F. Lin, R. Teo, "ROS+unity: An efficient high-fidelity 3D multi-UAV navigation and control simulator in GPS-denied environments," In *IECON2015-2015-41st Annual Conference of the IEEE Industrial Electronics Society*, 9-12 Nov. 2015, Yokohama, Japan [Online]. Available: IEEE Xplore, <https://ieeexplore.ieee.org/document/7392488>, [Accessed:Oct.12,2019].
- [13] B. Koyuncu, E. Bostancı, "Using Web Services to Support Battlefield Visualization and Tactical Decision Making" In *International Conference on Computational Intelligence, Modelling and Simulation*, 7-9 Sept. 2009, Brno, Czech Republic. [Online]. Available: IEEE Xplore, <https://ieeexplore.ieee.org/document/5349971>, [Accessed:Oct.12,2019].
- [14] F. Duchoň, A. Babinec, M. Kajan, P. Beňo, M. Florek, T. Fico, L. Jurišica, "Path Planning with Modified a Star Algorithm for a Mobile Robot," *Elsevier Procedia Engineering*, vol. 96, no. 1, pp. 59-69, 2014, doi:10.1016/j.proeng.2014.12.098.
- [15] J. Yao, C. Lin, X. Xie, A. J. Wang, C. Hung, "Path Planning for Virtual Human Motion Using Improved A* Star Algorithm," In *2010 Seventh International Conference on Information Technology: New Generations*, 12-14 April 2010, Las Vegas, USA. [Online]. Available https://www.researchgate.net/publication/242499880_Seventh_International_Conference_on_Information_Technology_New_Generati

ons_ITNG_2010_Las_Vegas_Nevada_USA_12-14_April_2010. [Accessed: Oct.12, 2019].

[16] S. E. Kirkley, S. Tomblin, J. Kirkley, "Instructional Design Authoring Support for the Development of Serious Games and Mixed Reality Training" *In Interservice/Industry Training, Simulation, and Education Conference (IITSEC) 6-9 December 2005, Las Vegas, USA.* [Online]. Available: <https://pdfs.semanticscholar.org/abeb/00c31a0cbc8920c37493f7922b95f333bc4c.pdf>. [Accessed: Oct.12, 2019].

[17] Autodesk Maya, "Autodesk Maya 2018 - Simple Character Rigging Part 1 of 3," youtube.com. para. 1,2018. [Online]. Available: <https://www.youtube.com/watch?v=cOokoFED7QE&t=2s>. [Accessed: Oct.12, 2019].

[18] Google, "Greyscale-Height-maps," Google.com. para. 1,2019[Online]: Available: https://www.google.com/search?tbm=isch&sxsr=ALeKk03etJCOV854h3dse1mo_68YYz6EXw%3A1595583268758&source=hp&biw=853&bih=746&ei=JKsaX9WaLMyNlwSu8ZSoAw&q=Greyscale-Height-maps&oq=Greyscale-Height-maps&gs_lcp=CgNpbWcQAzoHCCMQ6gIQJ1DfB1jfb2DQC2gBcAB4AIABcYgBcZIBAzAuMZgBAKABAqABAa0BC2d3cy13aXotaW1nsAEK&sc=client=img&ved=0ahUKEwjVvMTvyuXqAhXMxoUKHa44BTUQ4dUDCAc&uact=5. [Accessed: Oct.12, 2019].

[19] Terrainparty, "The easiest way to get real-world height maps for Cities," Terrain.party. para. 1,2019. [Online]. Available: <https://terrain.party/>. [Accessed: Oct.12, 2019].

[20] Unrealengine, "Unreal Engine is a complete suite of development tools for anyone working with real-time technology," Unrealengine.com para. 1,2019. [Online]. Available: <https://www.unrealengine.com>. [Accessed: Oct.12, 2019].

[21] Unity, "Unity Real-Time Development Platform," Unity3d.com. para. 1,2019. [Online]. Available: www.unity3d.com/. [Accessed: Oct.12, 2019].

[22] J. Hu, W. gen Wan, X. Yu, "A pathfinding algorithm in real-time strategy game based on Unity3D," *In 2012 International Conference on Audio, Language and Image Processing, 16-18 July 2012, Shanghai, China* [Online]. Available IEEE Xplore, <https://ieeexplore.ieee.org/document/6376792>. [Accessed: Oct.12, 2019].

[23] Unity, "Building a NavMesh," Unity User Manual.com para. 1,2019. [Online]. Available: <https://docs.unity3d.com/Manual/nav-BuildingNavMesh.html>. [Accessed: Oct.12, 2019].

[24] F. Can, "A* Algoritması (A yıldız arama algoritması)," farukcan.net.para.2, [Online]. Available: <https://www.farukcan.net/2016/05/a-algoritmasi-a-yildiz-arama-algoritmasi/>. [Accessed: Oct.12, 2019].

[25] A. Güleç "A* algoritması ve temelinde yatanlar," www.alpgulec.com, para. 1, 2019. [Online]. Available: <https://www.alpgulec.com/documents/33-a-star-algoritmasi-ve-temelinde-yatanlar>. [Accessed: Oct.12, 2019].

[26] S. E. Seker "A Yıldız Arama Algoritması (A Star Search Algorithm, A*)," sadievrenseker.com, para. 1,2019. [Online]. Available: <http://bilgisayarkavramlari.sadievrenseker.com/2009/03/02/a-yildiz-arama-algoritmasi-a-star-search-algorithm-a/>. [Accessed: Oct.12, 2019].

[27] Adobe, "Fusion 360 for Educational Institutions," autodesk.com, para. 1, 2019. [Online]. Available: <https://www.autodesk.com.tr/education/free-software/fusion-360-for-educational-institutions>. [Accessed: Oct.12, 2019].

[28] mixamo "Get animated," mixamo.com, para. 1,2019. [Online]. Available: <https://www.mixamo.com/#/>. [Accessed: Oct.12, 2019].

[29] D. Dino, "How to get started with Unity - Using the Animator," Youtube.com, para. 1,2019. [Online]. Available: https://www.youtube.com/watch?v=gON_hhhvhel. [Accessed: Oct.12, 2019].

[30] Magcat, "Terrain Stratum Painter," assetstore.unity.com, para. 1,2019. [Online]. Available: <https://assetstore.unity.com/packages/tools/terrain/terrain-stratum-painter-60201>. [Accessed: Oct.12, 2019].

Mustafa GÜNEŞ

Mustafa Güneş was born in 1983 in Istanbul, Turkey. He graduated from the Turkish Military Academy System Engineering Department in 2005. In 2016, he completed his master's degree from the Command School Command, Defense Sciences Institute, Supply And Logistics Management and in 2019, Hacettepe University, Information Institute, Computer

Animation And Game Technology. Since 2016, he is a PhD student at Gazi University / Institute Of Science, Environmental And Technical Research Of Accidents (Interdisciplines), Environmental And Technical Research Of Accidents. He has been working within the Ministry of National Defense since 2005 and has been conducting research and managing projects on Information Technology Education, Supply Chain and Logistics Management and Occupational Health and Safety.

Hakan DİLİPAK

Associate Professor. Hakan DİLİPAK Born in Kahramanmaraş in 1971, Hakan DİLİPAK completed his primary, secondary and high school education in 1989 in Kahramanmaraş. In the same year, he gained Gazi University Technical Education Faculty Mechanical Education Department and graduated in 1993. He did his master's degree at Gazi University Science Institute between 1995-1997 and PhD in the same Institute between 1998-2001. He worked as a Technical Teacher at Erzincan Technical and Industrial Vocational High School between 1993-1995. He worked as a Research Assistant at Gazi University Technical Education Faculty, Department of Mechanical Education between 1995-2001, as a Lecturer between 2001-2003 and as Assistant Professor from 2003 onwards. Since October 2013, he has been working as an Associate Professor in Gazi University Faculty of Technology Manufacturing Engineering. He is married and has 3 children. Work areas, machinability, CAD, CAM, CAE, CNC, formability, Sheet metal molding, expert systems, programming in manufacturing and design..