Literature Review

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Abstract

Augmented reality (AR) is an enhancing area that is getting more and more used in different areas. This is a literature review that searches the previous works about augmented reality applications in some specific areas, and its combination with onboarding process. The purpose of this literature review is to be informed about the main two research areas which is augmented reality and onboarding, for our project named "Augmented Reality Based Continuous Onboarding Framework". Aim of our project is combining Augmented Reality (AR) and software development workflow process and providing continuous onboarding to software practitioners while performing their daily tasks. We believe that software developers should be interactively guided using AR technology on the onboarding process continuously. Similar to a GPS device that can guide you through point A to point B, our goal is to create software artifacts like navigation components, software teams may benefit from digitally enhanced working conditions provided using AR. After researching many different articles and sources, we deduced that there is lack of research about the combination of augmented reality, software engineering disciplines and onboarding processes. In this paper, we explained the current projects and usage areas of augmented reality, and examples of onboarding with their brief explanations.

1.Introduction

Regarded as one of the emerging technologies, Augmented Reality (AR) enriches the real world with digital information and media should reshape the ways we interact with our world. According to Azuma [1], AR is a technology, combines physical world with virtual objects for a new kind of visualization that promises spatial interaction in real time. Even though studies about AR were initiated in the 1960s [2], the interest of people to this technology increased after the success of the Pokemon GO [3] game. Within the last two years, social media conversations about AR have gone up to the rate 33% [4]. Recently, AR becomes a promising technology is used in various fields such as education, industry, entertainment, military. Yet, the current AR market can still be considered as newly growing, meaning that technology and market maturity are still in their early adolescence [4]. AR technology still continues to progress. Up to now, it has valuable effects on the fields in which it is used. In the light of positive feedbacks, this technology can have positive impacts on different domains as well.

2. Augmented Reality in Literature

2.1 AR in Education

Thus, far, research has been conducted to explore the benefits of AR in education. One study is by Wojciechowski & Cellar [5], highlights that students tend to collaborate AR objects with real objects by using simple and cost-effective devices. Freitas & Campos [6] developed an AR application called SMART (System of Augmented Reality for Teaching) to visualize and introduce the objects such as cars, airplanes, and animals to primary school students. Application was experimented upon 54 students in three different schools, and the results showed that SMART improved their ambition about learning. AR is not only used for primary level students; but also for higher level educated students in universities and colleges to embody complicated theories and systems [6]. In biology lessons, an AR application that simulates the organs in human body with their names and explanations is used to demonstrate to the students for more realistic experience in classroom [6].

2.2 AR in Tourism

As AR technology widely spreads, there can be seen many examples of AR applications in wide variety of fields. One of the fields that AR can be used efficiently is tourism. Kounavis et al. [7] mention some of the AR applications for this field in their research. Tuscany+, the first AR application, is a digital tourist guide on Tuscany region. Augmented Reality for Basel which is also a special tourist guide for the city of Basel, gives its users valuable information about the city, and users can find information about museums, hotels, shopping centers, restaurants, events, etc. Urban Sleuth is one of the examples of AR applications for tourism field but it is remarkably distinctive from the others because it requires user participant in order to solve mysteries and accomplish missions while touring in the city and challenging with other teams. Last application is specially designed for demands of Museum of London and it is called The StreetMuseum. It makes users able to view historical places and information about them [7]. Han et al. [8] highlight the importance of AR

technology in tourism by emphasizing that industry of tourism needs to draw attention of people and nowadays the most efficient way to achieve this is usage of mobile devices, therefore tourism industry must be kept updated by new investments.

2.3 AR in Entertainment

Carmigniani et. al. [9] express that using AR in entertainment industry may bring a breath of fresh air into it especially for the gaming applications, for instance, animations can be displayed when playing a board game. With AR technology, user experience of players can be improved. Augmented onboarding can be beneficial as a main component of a game, e.g. presenting how to play, showing tactics that are available, displaying ongoing characteristics of other players. Such a visual improvement makes games more attractive and interactive. As an example, Gandy [10] developed AR Karaoke game. Game allows player to play a scene from a movie. HMD (head-mounted display) was used for getting into the environment of the scene with virtual objects. Gamer can experience the movie scene in first-person perspective. Moreover, Santiago and Romero [10] developed a game with the theme about collecting pieces and solving puzzles. In this game, players collect virtual objects and the more object players collect, their chance for solving the puzzle increases. Entertainment sector has a tremendous advantage in AR because of the fact that borders of applying entertaining features to AR is not as limited as the other fields.

2.4 AR in Marketing

Yuen et al. [11] touched on the point of AR technology in marketing with giving the example of automotive companies, which use real size AR virtual cars in their showrooms. With virtual buttons, customers can observe virtual model vehicles by opening doors, rotating them. They indicate that customers can gain more definite impression about the product with using the virtual models on their mobile phones. Augmented reality is commonly used for online advertising. As an example, car company MINI [12], developed an AR application advertised on some German magazines. In this special form of advertisement, readers show the related page to their webcams and a virtual MINI car appears on the screen [9]. Magic mirror is also an application about AR technology developed for marketing. In addition to this, Cisco's fitting room is another development for retail sales which AR technology is involved. In these two applications, customers are allowed to try on virtual clothes instead of real products. With AR technology, they see how such clothing might look on them. This helps customer to make more accurate decisions during shopping [9]**.** Höllerer and Feiner [13] mentioned that there may be virtual billboards appear on the street according to user's profile and interests to advertise a product. In the light of these examples and tendency to using mobile technologies in every area like shopping, marketing is one of the fields that have a significant potential for AR technology investments.

2.5 AR in Military

AR can be used for training the military personnel. One usage of AR for military is tracking the medical issues on a battlefield. Authorized commander on a combat can get the information about the health status of a soldier whether he is injured, and visualize the view and conditions of the field using AR [13]. Special AR helmets that contains 360 cameras and sensors are in developing phase to

help ground soldiers to experience a real life combat conditions with the warnings about the battlefield conditions such as an enemy or a danger spot warnings [11]. In their study, Fenier and Henderson [14] developed an AR system that provides maintaining the systems and equipment in a bulletproof vehicle more quickly and securely, by a military mechanic wearing special AR glasses.

2.6 AR in Automotive Industry

Automotive industry is one of the sectors that AR is used. Many of the companies, especially car and airplane producer companies, work with some big, costly, fast changing and time consuming products. Consequently, producing this kind of products and training people to learn and assemble the parts of products require large amount of time and money. Reiners et al. [15] mentioned that since the products change faster and companies need to keep pace with the new technologies, AR can be used for training the service personnel in assembling and fixing the parts of a product. In their study, they worked with BMW Company in assembly of a doorlock into a car door. As a result, their work enlightened prototyping and conducting tasks in a specific part of a car. Furthermore, Azuma [1] stated that a 3D model that simulates the real components of equipment is easier and more practical rather than manuals and pictures while following the instructions. Boeing, one of the largest airplane companies, used AR technology to guide the technicians about the electrical system of an airplane. Moreover, Feiner [16] claimed that architects can use AR to visualize the installation of a building by showing the electric cables and pipe systems inside the walls. Also, it can be used to display what would it be the view from the window if a new building is built for the architect to see and analyze. For different sectors on the industry, AR can be implemented and adapted according to the different demands of the sectors.

3. Onboarding

Onboarding is the process of incorporating new employees into an organization [17]. Onboarding, in other words adaptation process of getting used to the company culture, new colleagues, and new projects, take some time; however, it is becoming easier with some methods and tools [18]. Unmistakably AR gives entrepreneurs boundless potential for putting learners in true situations and circumstances. Numerous representatives learn best by doing as opposed to seeing. AR is a glad medium between perusing about something in a book and doing the genuine article [20]. A new approach to onboarding process is continuous onboarding which the adaptation period never stops, it continues as the employee works in the company and it keeps him engaged to the working process. According to Leaman, the employees whom had a successful onboarding experience are more likely to stay with a company for a long period [19]. Yates [20], explained in her highly extensive Ph.D. thesis about software engineering and onboarding that onboarding process is really crucial for both developers who work individually or work in a team in order to understand the techniques, culture and the code based work on the company. It is better to get the information about co-workers, documentation, codes and code artifacts by new employees to make the onboarding process more qualified. Also, it is more beneficial to ask for help.

3.1 AR for Onboarding

Business world is living and changes very fast. So business agility and adaptability is crucial for being afloat in the sector. Taking this facts into consideration, companies work on real-time

continuous training [21]. Software development industry is one of the most challenging industries for employee adaptation to job. Technology giants like Google, Apple, Microsoft are aware about this issue and work for creating solutions to this problem. Recently, Apple created an AR application in which while walking around campus they orient their new employee with showing how each department works using AR [22].

4. Conclusion

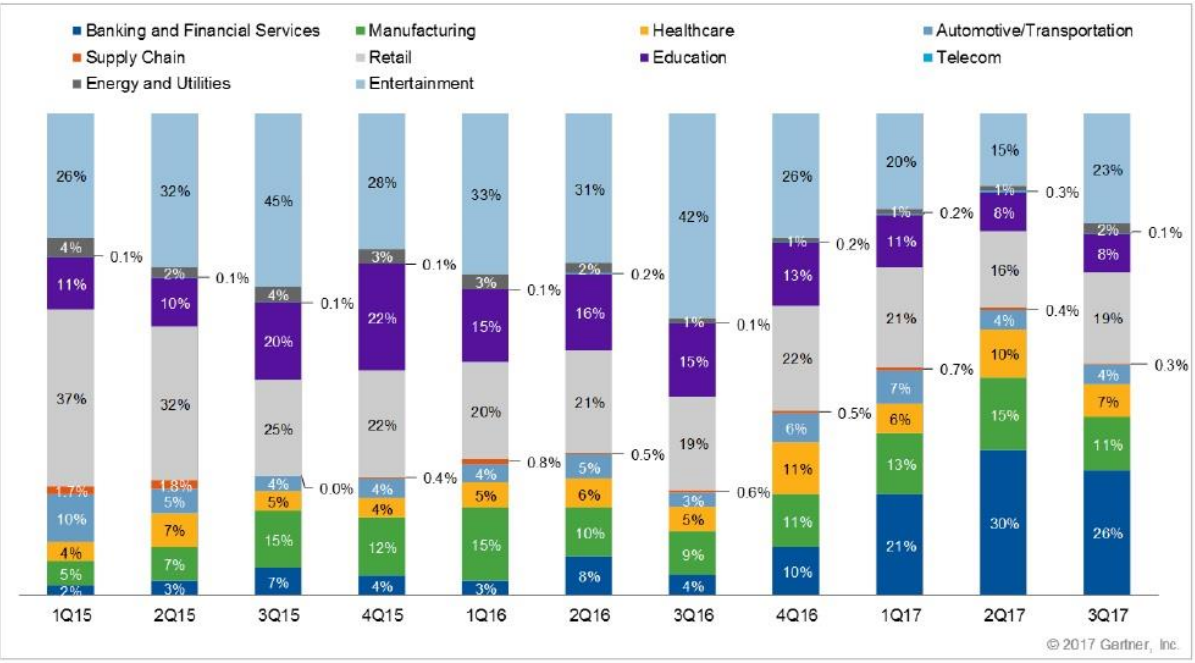

Figure 1: Verticals Driving the Social Media Conversations in AR [23]

To sum up, AR technology has a great potential in many different fields, such as education, tourism, entertainment, marketing and sales, military, and automotive industry as it can be seen in Figure 1. It shows how the conversations in AR has changed from 2015 to 3rd quarter of 2017 in various fields. Regularly, technology is evolving and applications are getting more visualised and interactive. AR technology provides extended experiences to its users and instead of flat screens, keyboards, and external components, it more deeply connects people to the data they want to reach [24]. The ever-increasing evolution of mobile technology and the fast adaption to these devices by people have allowed AR to become reachable to the public [25]. At this point, AR technology has a considerable and promising role about recent advancements in application market. When all these workings about AR are taken into consideration, there is certainly, a lack of academic and scientific research about the combination of AR and Software Engineering disciplines, and also AR using for onboarding processes. The purpose of this project is to provide continuous onboarding to software practitioners while performing their daily tasks by creating an enhanced version of spatial reality enriched by digital information and media so as to improve the software development workflow. We believe that software developers should be interactively guided using such an AR technology. Therefore, we characterize an environment includes AR for software development teams.

References

1. R. Azuma, "A Survey of Augmented Reality", *Presence: Teleoperators and Virtual Environments*, vol. 6, no. 4, pp. 355-385, 1997.
2. R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier and B. MacIntyre, "Recent advances in augmented reality", *IEEE Computer Graphics and Applications*, vol. 21, no. 6, pp. 34-47, 2001.
3. "Catch Pokémon in the Real World with Pokémon GO!", *Pokemongo.com*, 2017. [Online]. Available: http://www.pokemongo.com/. [Accessed: 22- Oct- 2017].
4. T. Nguyen, A. Jump and M. Resnick, "Three Key Development Practices to Implement Effective Enterprise Augmented Reality Applications", *Gartner*, 2017.
5. J. Cabero Almenara and J. Barroso Osuna, "The educational possibilities of Augmented Reality", *Journal of New Approaches in Educational Research*, vol. 6, no. 1, pp. 44-50, 2016.
6. K. Lee, "Augmented Reality in Education and Training", *TechTrends*, vol. 56, no. 2, pp. 13-21, 2012.
7. C. Kounavis, A. Kasimati and E. Zamani, "Enhancing the Tourism Experience through Mobile Augmented Reality: Challenges and Prospects", *International Journal of Engineering Business Management*, vol. 4, p. 10, 2012.
8. Z. Xiang and l. Tussyadiah, *Information and Communication Technologies in Tourism*. Rome: Springer, 2017, pp. 511-523.
9. J. Carmigniani, B. Furht, M. Anisetti, P. Ceravolo, E. Damiani and M. Ivkovic, "Augmented reality technologies, systems and applications", *Multimedia Tools and Applications*, vol. 51, no. 1, pp. 341-377, 2010.
10. B. Thomas, "A survey of visual, mixed, and augmented reality gaming", *Computers in Entertainment*, vol. 10, no. 3, pp. 1-33, 2012.
11. S. Yuen, G. Yaoyuneyong and E. Johnson, "Augmented Reality: An Overview and Five Directions for AR in Education", *Journal of Educational Technology Development and Exchange*, vol. 4, no. 1, 2011.
12. "The Official MINI Website | MINI UK", *The Official MINI Website | MINI UK*, 2017. [Online]. Available: https://www.mini.co.uk/en_GB/home.html. [Accessed: 22- Oct- 2017].
13. T. H. Höllerer and S. K. Feiner. Mobile Augmented Reality. In H. Karimi and A. Hammad, editors, *Telegeoinformatics: Location-Based Computing and Services*. CRC Press, Mar. 2004. ISBN 0-4153-6976-2.
14. S. Henderson and S. Feiner, "Exploring the Benefits of Augmented Reality Documentation for Maintenance and Repair", *IEEE Transactions on Visualization and Computer Graphics*, vol. 17, no. 10, pp. 1355-1368, 2011.
15. D. Reiners, D. Stricker, G. Klinker, and S. Müller, "Augmented Reality for Construction Tasks: Doorlock Assembly," *Proc. Int'l Workshop Augmented Reality (IWAR '98)*, pp. 31-46, 1999.
16. S. Feiner, A. Webster, T. Krueger, B. MacIntyre and E. Keller, "Architectural Anatomy", *Presence: Teleoperators and Virtual Environments*, vol. 4, no. 3, pp. 318-325, 1995.

17. "What Is Onboarding? - Best Practices & Process - White Paper", *Icims.com*, 2017. [Online]. Available: https://www.icims.com/resources/white-paper/onboarding. [Accessed: 08- Dec- 2017].

18. M. Kosa and M. Yilmaz, "Gamifying the Onboarding Process for Novice Software Practitioners", in *Systems, Software and Services Process Improvement*, 2016, pp. 242-248.

19. "3 Tips To Redesign Your Onboarding Process Into A Continuous Experience - eLearning Industry", *eLearning Industry*, 2017. [Online]. Available: https://elearningindustry.com/redesign-your-onboarding-process-into-a-continuous-experience-3-tips. [Accessed: 08- Dec- 2017].

20. R. Yates, "Onboarding in Software Engineering", 2014.

21. D. Newman, "Hyper-Training And The Future Augmented Reality Workplace", 2017. [Online]. Available: https://www.forbes.com/sites/danielnewman/2016/09/20/hyper-training-and-the-future-augmented-reality-workplace/#33650a2728b0. [Accessed: 09- Dec- 2017].

22. B. Beus, "How Augmented Reality Can Revolutionize Employee Onboarding and Retention". [online] Business 2 Community. Available at: https://www.business2community.com/tech-gadgets/augmented-reality-can-revolutionize-employee-onboarding-retention-01921335#shajp8sgjDJrGDKB.97 [Accessed 9 Dec. 2017].

23. M. Resnick, "Best Practices for Using Augmented Reality in Mobile Apps", *Gartner*, 2017.

24. B. Blau, B. Burke, S. Searle and D. Cearley, "Top 10 Strategic Technology Trends for 2017: Virtual Reality and Augmented Reality", *Gartner*, 2017.

25. T. Nguyen and B. Blau, "Market Guide for Augmented Reality", *Gartner*, 2017.

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Augmented Reality Based Continuous Onboarding Framework

Software Requirement Specifications
Version 3

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Table of Contents

1. INTRODUCTION

This document is the software requirement specification document for the project titled as “Augmented Reality Based Continuous Onboarding Framework”. This system is an application that assists developers to adopt more easily to their working environment, and ultimately improve the software development process and work more efficiently.

1.1. Purpose

The purpose of this document is describing the Augmented Reality Based Continuous Onboarding Framework. Aim of the project is combining Augmented Reality (AR) and software development workflow process and providing continuous onboarding to software practitioners while performing their daily tasks. This document contains particularized information about the project and requirements of the project. The document indicates the recognized constraints and requested software functionalities. Furthermore, the SRS document explains how users collaborate with the application, and explains how concerns of the stakeholders are met.

1.2. Scope of Project

Software development is a process which has deep background consisting of various phases. Even though, there are different methodologies used in software development, it has never been a straightforward process. Developers should always be highly motivated and continuously focused on the project. Otherwise, they can easily be disoriented during the development process. All developers including juniors should always keep the pace of the process.

Software process is set of activities that is implemented with a structure to develop a system [1]. There are different software development models according to requirements and characteristics of a software. Some of the most used models are traditional and agile models. The traditional approach can be illustrated with the waterfall model which consisting of project phases which are performed in decided time interval and all of them follow each other after one phase is completed [2]. Pfleeger and Atlee [2] confirm that waterfall method consists of the activities which are requirement analysis, design, implementation, testing, operation and maintenance. This model is a static and linear model, in other words it is lack of agility which is a problem about waterfall model. On the other hand, agile software development provides more flexibility and changeability during the process of a software. It uses short timeboxes which last 1 to 4 weeks and it minimize the risks during the development phase [3]. The project is more likely to be used by agile methodology developers, since the process is dynamic and employees tend to be disoriented if they miss an iteration or a meeting.

By creating a combination of augmented reality (AR) with software development workflow process, the goal of this project is to provide continuous onboarding to software practitioners while performing their daily tasks. Onboarding is the process of incorporating new employees into an organization [4]. Onboarding, in other words adaptation process of getting used to the company, new colleagues, and new projects, take some time; however, it is becoming easier with some methods and tools [5]. A new approach to onboarding process is continuous onboarding which the adaptation period never stops, it continues as the employee works in the company and it keeps him engaged to the working process. According to Leaman, the employees who had a successful onboarding experience are more likely to stay with a company for a long period [6]. We believe that software developers should be interactively guided using AR technology on the onboarding process continuously. Similar to a GPS device that can guide you through point A to point B, our goal is to create software artifacts like navigation components, software teams may benefit from digitally enhanced working conditions provided using AR. In addition, our plan is to visualize the profile of software practitioners, their skills, their performance and progression using AR technology. Ultimately, an aim is to collect information from a set of different sources and visualize it using AR and creating a virtual dashboard by putting all key stakeholders in a AR enhanced room with the motivation of producing usable software in a short amount of calendar time. This approach enables clear and quick communication/collaboration among teammates by having multiple resources to feed in war room, creates a multiple data-feeding environment where software development issues can be quickly identified and resolved with less distraction with personalized enhancement of workflow.

1.3. Glossary

Term	**Definition**
Augmented Reality (AR)	Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are "augmented" by computer-generated or extracted real-world sensory input such as sound, video, graphics, haptics or GPS data [7]
Stakeholder	A person who has interest or concern in the project
War Room	A term represents the decision and development phase in a meeting room while a software is producing by a team.
Onboarding	The process of incorporating new employees into an organization [4]
Scrum	Scrum is a management and control process that cuts through complexity to focus on building products that meet business needs [8]
Workflow	The series of activities that are necessary to complete a task [9]
Agile Development	Agile software development is a conceptual framework for undertaking software engineering

	projects by minimizing risk and using short timeboxes 1 to 4 weeks [3]
Software Management	Managing software processes by planning and leading. [10]
Dashboard	An interface that monitorize some tools and information from multiple sources [11]
Framework	A real or conceptual structure intended to serve as a support or guide for the building of something that expands the structure into something useful [12]
Scrum Board	Visual display of the progress of the Scrum team during development process [13].

1.4. Overview of the Document

This SRS is divided into subsections with numbers. Part 2 is Overall Description and it has the general concept, user types, and constraints of the system to understand it more specifically.

Section 3. Specific Requirements defines both functional and performance requirements of the system in more detail. In order to understand the functions that the different users use, use-case diagrams are shown in this section. Also, this section contains the design constraints and software attributes of the system.

At last, section 4 is the References where resources are stated.

2. OVERALL DESCRIPTION

The following section presents an overall description of the Augmented Reality Based Continuous Onboarding Framework. In particular, the product has been put into perspective through a detailed assessment of the system, user, and hardware interfaces.

2.1. Product Perspective

Augmented Reality Based Continuous Onboarding Framework is an augmented reality based application project that has the purpose of adopting new software developers to their working environment, assisting developers to work more efficiently and making them able to keep pace of their projects and meeting digitally.

2.1.1. Development Methodology

During development process of this project we are planning to use scrum which is an agile development methodology. Due to volatile requirements, agility is important for project development. In contrast to traditional software development, scrum is an agile methodology which is incremental and iterative. Development process consists of sprints which includes its own task to be performed. Each sprint has equal iteration time 30 days on average. In daily, development team has meeting less than 15 minutes which is called daily stand up meeting. In scrum, there are three main roles which are product owner, scrum master and development team. Product owner demands requirements, scrum master manages the process and development team. And the development team has the role of working on project according to plan. The advantages of scrum can be summarized as follows; First of all, as a result of agility, changes that happened in development process can handled easily. In addition to that, problems which occur during process can be negotiated immediately due to daily stand up meetings [14]. In the light of these facts, Scrum is suitable for development of this project.

2.2. User Characteristic

In Augmented Reality Based Continuous Onboarding Framework, there is only 1 type of users interact with the system: developers.

Developers must be employees of HAVELSAN A.Ş., they must read and understand English language due to system language is English and must have knowledge of software development and company culture. They can use the system for onboarding and analyzing meeting histories. Developers must be registered to the system in order to use it.

3. REQUIREMENTS SPECIFICATION

3.1. External Interface Requirements

3.1.1. User interfaces

The user interface will be worked on mobile devices.

3.1.2. Hardware interfaces

The system will work on mobile devices, tablets, and AR compatible devices.

3.1.3. Software interfaces

There are no external software interface requirements.

3.1.4. Communications interfaces

System shall communicate with Team Foundation Server, Microsoft Outlook, and Exchange Server via an internet connection. Data shall be transferred from these servers to the mobile device that uses the system.

3.2. Functional Requirements

3.2.1. Home Screen Use Case

Use Case:

Login to the application

Exit from application

Diagram

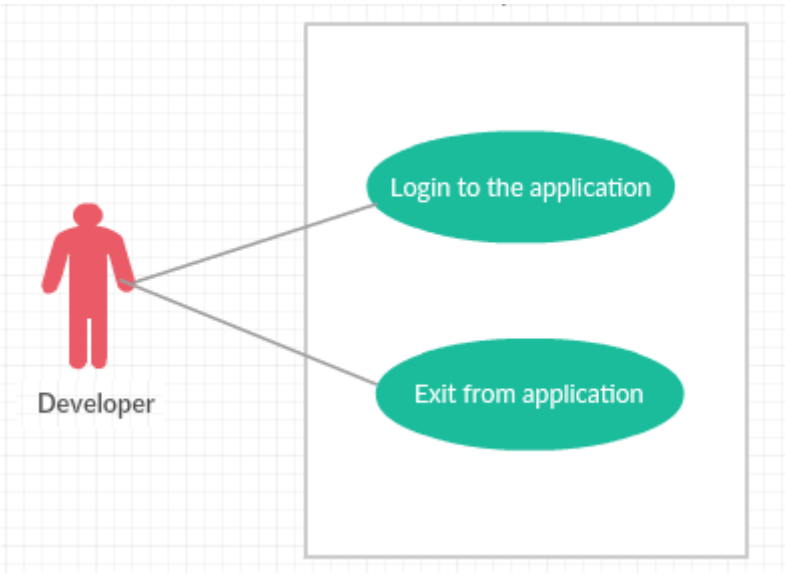

Figure 1: Home Screen Use Case Diagram

Brief Description

1. Application opens, and the Home Screen welcomes all users.
2. User enters username and password to login to the system.
3. If username and password match, user logins to the system successfully.
4. After a successful login operation user is routed to the Main Menu.
5. If user selects " Exit " option, application will close.

3.2.2. Main Menu Use Case

Use Case:

Switch to the Orientation Mode

Switch to the Operation Mode

Logout

Exit

Diagram

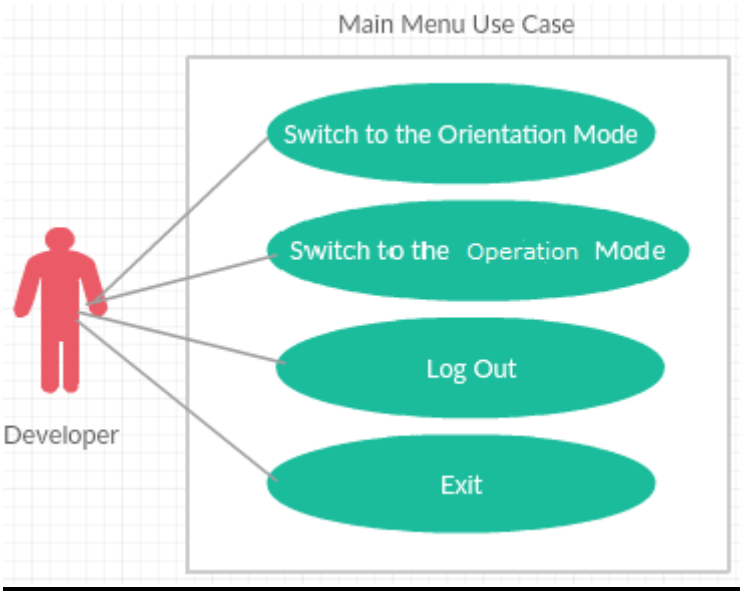

Figure 2: Main Menu Use Case Diagram

Brief Description

After successful login operation, developers can start to use system by choosing the related mode. System allows developers to choose the " Orientation Mode" or "Operation Mode". Also developers can choose "Logout" or "Exit".

1. Main Menu is displayed.
2. User selects "Orientation Mode", "Operation Mode", "Logout" or "Exit".,
3. If "Orientation Mode" is selected, Orientation Mode is opened.
4. If "Operation Mode" is selected, Operation Mode is opened.
5. If "Logout" is selected, user is logged out from the system and application is directed to Login Screen.
6. If "Exit" is selected application will close.

3.2.3 Pause Menu Use Case

Use Case:

Resume

Main Menu

Exit

Diagram

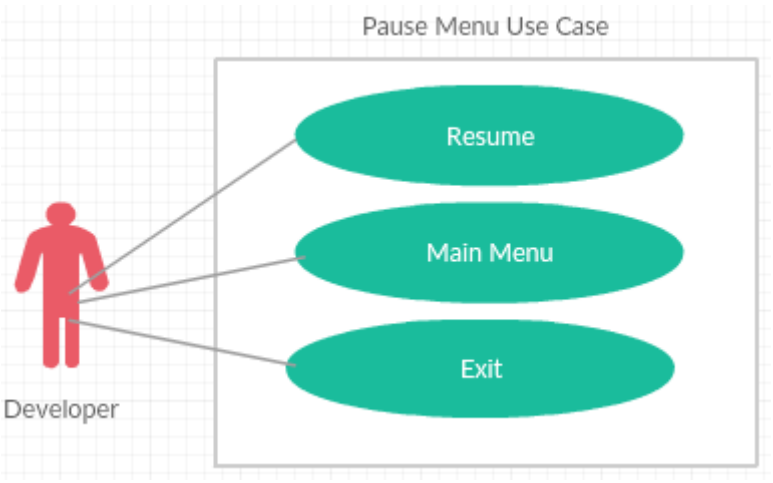

Figure 3: Pause Menu Use Case Diagram

Brief Description

After selecting "Pause" button in any mode user can go to main menu, exit from application or go back to his last scene.

1. "Pause" button is selected in any mode screen.
2. If "Resume" is selected, user goes back to his last scene.
3. If "Main Menu" is selected, user goes to main menu.
4. If "Exit" is selected, application will close.

3.2.4. Orientation Mode Use Case

Use Case:

Scan image (includes get information)

View related information

Exit from orientation

Diagram

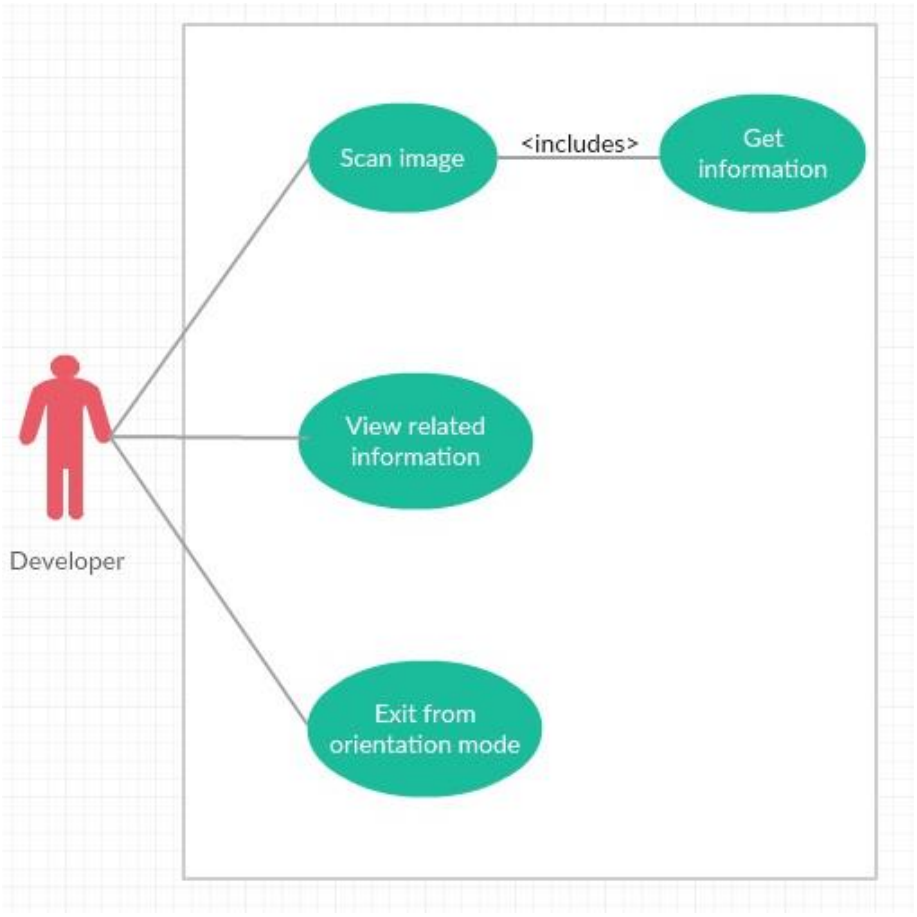

Figure 4: Orientation Mode Use Case Diagram

Brief Description

In this mode, user can access the profile information of the developer by scanning the unique image which belongs to selected developer. For every developer, a unique image is defined and exists in the system database and the information of the corresponding developer is reached from the data source servers.

1. Camera screen is opened.
2. If an image of a developer is detected by the camera, photograph/video, team information, and development ability of the chosen developer appear on the camera screen as an AR component.
3. If user selects exit, screen turns back to developer mode.

3.2.5. Operation Mode Use Case

Use Case:

Scan image (includes get information)

View related information

Exit from operation mode

Diagram

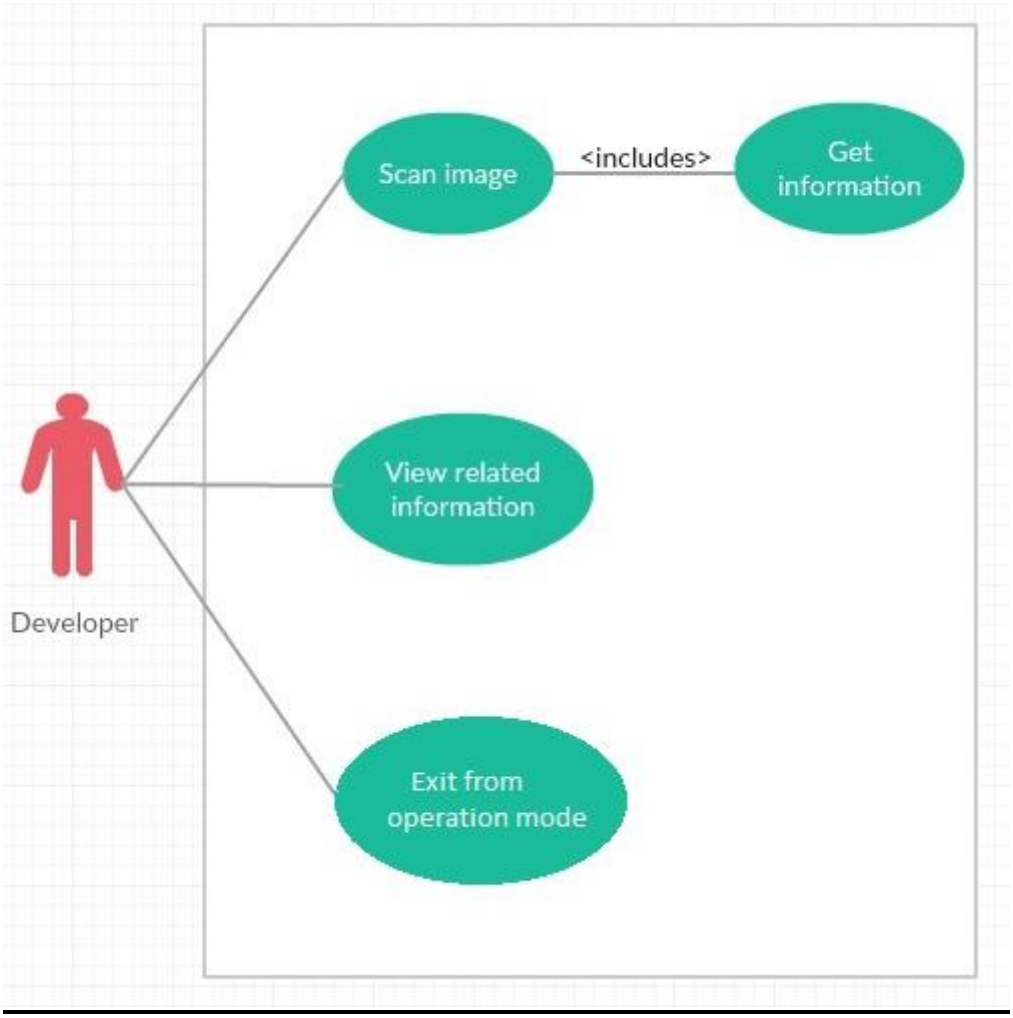

Figure 5: Operation Mode Use Case Diagram

Brief Description

In this mode, user can access the information about the work items which are defined in current sprint by scanning the unique image which belongs to selected task. For every task, a unique image is defined and exists in the system database. By scanning the related image, data about the task will be displayed on the camera screen. If user wants to see more detailed information about task, s/he can open TFS(Team Foundation Server) link of selected task on the web browser. In addition to task status, user can observe his team mates' current task information by scanning the unique person image. Current task information of a developer includes statistical data about task types which he works on as feature, improvement or bug and total workload of identified developer. Also, in the situation of task sharing, system shows shared tasks of current user and selected developer.

1. Camera screen is opened.
2. If camera detects a unique image of a task, the information of that task is displayed as summarized.
3. If camera detects a unique image of a developer, current workload and task status information is displayed.
4. If user selects exit, screen turns back to developer mode.

3.3. Performance Requirement

System's visual must run smoothly without any latency to keep the level of immersion high. This requirement is depended on many aspects of the user mobile device/tablet. System will be developed by using Unity3D and Vuforia; therefore, versions of Unity3D and Vuforia must support the mobile devices'/tablets' OS. Unity3D version must be the latest version (2017.2+). For Vuforia to be worked on mobile devices/tablets; Android OS must be 4.1.x+, IOS must be 9+ [15].

3.4. Software System attributes

3.4.1. Portability

Augmented Reality Based Continuous Onboarding Framework is designed for mobile devices/tablets using Unity3D and Vuforia. Unity3D supports many of the mobile devices/tablets, so system can be used mobile devices/tablets if their OS versions are supported.

3.4.2. Performance

The distance between the camera and the image shall not be more than 0.5 meters to scan. Scan operation shall not be last more than 10 seconds.

3.4.3. Usability

The software is planned to be used by software engineers whom are expected to be experienced mobile device and application users. Even so, the usability should be as simple as possible since the screen of a mobile device is not big enough to place many information. New users are able to learn using the system in 5-15 minutes.

3.4.4. Availability

System shall be available to all its users in the company building. As long as the Team Foundation Server and Outlook server of the company are operational, system shall be able to collect with the accurate data from these servers. The servers and the internet connection of the device that uses the system shall be available while the system is working.

3.4.5. Scalability

Multiple users can use the system with their own mobile devices, tablets and AR compatible devices. The first version of the system is planned to be used by a team of 4-6 people.

3.4.6. Security

Security is one of the key elements of the project, since HAVELSAN works on defense industry, therefore company has strict rules about confidentiality. There shall be no login to the system other than the employees of the company. Also, standard users shall not access to the admin authorization pages.

3.5. Safety Requirement

Since the system is working on mobile devices/tablets and AR devices, user must be careful while they are moving around. System may show them virtual objects or images or texts which are not real but these virtual objects, images and texts may appear on real objects. While using the system, users may not notice the real objects and these object can cause injuries. Therefore, while looking at the screen and moving, user should watch out the area and take his eyes off the screen in every few seconds to check the real environment .

As it is known, too much mobile device exposure can cause occurrence of some symptoms of radiation such as headache, insomnia, tiredness, sleep disruption, eye strain and many more [16].

4. REFERENCES

[1] "Life cycle and process models", *Coursehero.com*, 2017. [Online]. Available: https://www.coursehero.com/file/p1bkcfg/A-structured-set-of-activities-required-to-develop-a-software-system/. [Accessed: 08- Dec- 2017].

[2] A. Adenowo and B. Adenowo, "Software Engineering Methodologies: A Review of the Waterfall Model and ObjectOriented Approach", *International Journal of Scientific & Engineering Research, , Issue 7,*, vol. 4, no. 7, 2013.

[3] "Software Development Methodologies", *Itinfo.am*, 2017. [Online]. Available: http://www.itinfo.am/eng/software-development-methodologies/. [Accessed: 08- Dec- 2017].

[4] "What Is Onboarding? - Best Practices & Process - White Paper", *Icims.com*, 2017. [Online]. Available: https://www.icims.com/resources/white-paper/onboarding. [Accessed: 08- Dec- 2017].

[5] M. Kosa and M. Yilmaz, "Gamifying the Onboarding Process for Novice Software Practitioners", in *Systems, Software and Services Process Improvement*, 2016, pp. 242-248.

[6] "3 Tips To Redesign Your Onboarding Process Into A Continuous Experience - eLearning Industry", *eLearning Industry*, 2017. [Online]. Available: https://elearningindustry.com/redesign-your-onboarding-process-into-a-continuous-experience-3-tips. [Accessed: 08- Dec- 2017].

[7] Schuettel, Patrick (2017). *The Concise Fintech Compendium*. Fribourg: School of Management Fribourg/Switzerland.

[8] "What is Scrum?", *Scrum.org*, 2017. [Online]. Available: https://www.scrum.org/resources/what-is-scrum. [Accessed: 08- Dec- 2017].

[9] "What is workflow? - Definition from WhatIs.com", SearchCIO, 2017. [Online]. Available: http://searchcio.techtarget.com/definition/workflow. [Accessed: 08- Dec- 2017].

[10] J. Münch, O. Armbrust, M. Kowalczyk and M. Soto, *Software process definition and management*. [Place of publication not identified]: Springer, 2014.

[11] "What is dashboard? - Definition from WhatIs.com", *SearchCIO*, 2017. [Online]. Available: http://searchcio.techtarget.com/definition/dashboard. [Accessed: 08- Dec- 2017].

[12] "What is framework? - Definition from WhatIs.com", *WhatIs.com*, 2017. [Online]. Available: http://whatis.techtarget.com/definition/framework. [Accessed: 08- Dec- 2017].

[13] Bowes, J. (2018). *Agile concepts: the Scrum Task Board - Manifesto*. [Online] Manifesto. Available at: https://manifesto.co.uk/agile-concepts-scrum-task-board/ [Accessed: 1-Mar- 2018].

[14] M. Villavicencio, E. Narváez, E. Izquierdo and J. Pincay, "Learning Scrum by doing real-life projects", *IEEE Global Engineering Education Conference (EDUCON)*, pp. 1450-1456, 2017.

[15] “Vuforia Supported Versions”, *Vuforia*, 2017. [Online]. Available: https://library.vuforia.com/articles/Solution/Vuforia-Supported-Versions. [Accessed: 4 December 2017].

[16] Suhag AK, Larik RS, Mangi GZ, Khan M, Abbasi SK, et al. (2016). Impact of Excessive Mobile Phone Usage on Human. *Journal of Computer Science & Systems Biology*, 9, 173-177. DOI:10.4172/jcsb.1000235.

ÇANKAYA UNIVERSITY

CENG408
Innovative System Design &
Development II

Augmented Reality Based Continuous Onboarding Framework

Software Design Document
Version 3

Advisor: Assist. Prof. Dr. Murat YILMAZ
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Table of Contents

1. INTRODUCTION

1.1. Purpose

The purpose of this Software Design Document is to provide the details of project titled as “Augmented Reality Based Continuous Onboarding Framework”.

The target audience is software developers and teams in HAVELSAN A.Ş. Our approach will make them able to adapt new working environment easily in terms of knowledge, skills and behaviors and reach their projects’ information digitally. The newcomers to a software process will need to learn the team’s tools, processes, culture, and the existing codebase to be maintained. They must take in a great deal of social and technical knowledge in the company. Therefore, some tools and guidance can make the onboarding process more efficient.

The goal of the project is to provide continuous onboarding (i.e. organizational socialization) to software practitioners and enhance the daily workflow of software organization which make them effective members of software development organization.

While performing their daily tasks, practitioners should collect information from a variety of different sources. Here, our aim is to visualize this information using augmented reality (AR) technology by creating a virtual system dashboard for stakeholders. Consequently, we improve the software development process in a AR enhanced room with the motivation of producing software artifacts in a short amount of calendar time. This approach enables clear and quick communication/collaboration among teammates by having multiple resources to feed in war room creates a multiple data-feeding environment where software development issues can be quickly identified and resolved with less distraction with personalized enhancement of workflow.

1.2. Scope

This document is the description of the design of the project Augmented Reality Based Continuous Onboarding Framework.

Software development is a process that has deep background consisting of various phases. Even though, there are different methodologies used in software development, it has never been a straightforward process. Developers should always be highly motivated and continuously focused on the project. Otherwise, they can easily be disoriented during the development activities. All developers including juniors should always keep the pace of the process. By creating a combination of augmented reality (AR) with software development workflow process, the goal of this project is to provide continuous onboarding to software practitioners while performing their daily tasks. Onboarding is the process of incorporating new employees into an organization [1]. Onboarding, in other words adaptation process of getting used to the company, new colleagues, and new projects, take some time; however, it is becoming easier with some methods and tools [2]. A new approach to onboarding process is continuous onboarding, which the adaptation period never stops, it continues as the employee works in the company and it keeps him engaged to the working process. According to Leaman [3], the employees who had a successful onboarding experience are more likely to stay with a company for a long period. In addition, our plan is to visualize the profile of software practitioners, their skills, their performance and progression using AR

technology. Ultimately, an aim is to collect information from a set of different sources and visualize it using AR.

For the development, we have chosen Vuforia [4] integrated with Unity 3D platform [5] which is a game engine with 3D graphics and it is compatible with all different platforms and devices. Vuforia has been shown to be one of the leading augmented reality tools by developers, due to its remarkable features such as compatibility with popular gadgets, visuals of different kinds, perception of objects. For the coding of the project, C# language is used in Visual Studio 2017 integrated with Unity 3D.

1.3. Glossary

Term	Definition
Augmented Reality (AR)	Augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are "augmented" by computer-generated or extracted real-world sensory input such as sound, video, graphics, haptics or GPS data [6]
Stakeholder	A person who has interest or concern in the project
War Room	A term represents the decision and development phase in a meeting room while a software is producing by a team.
Onboarding	The process of incorporating new employees into an organization [1]
Scrum	Scrum is a management and control process that cuts through complexity to focus on building products that meet business needs [7]
Workflow	The series of activities that are necessary to complete a task [8]
Agile Development	Agile software development is a conceptual framework for undertaking software engineering projects by minimizing risk and using short timeboxes 1 to 4 weeks [9]
Software Management	Managing software processes by planning and leading. [10]
Dashboard	An interface that monitorize some tools and information from multiple sources [11]
Framework	A real or conceptual structure intended to serve as a support or guide for the building of something that expands the structure into something useful [12]
Technical Debt	The consequence of implementing partial or quick

	software development solutions instead of time-consuming, yet more effective, long-term solutions [13]
Scrum Board	Visual display of the progress of the Scrum team during development process [14].

1.4. Overview of Document

The SDD is divided into subsections with numbers. Chapters and their brief content is explained below.

Section 2 is the Architectural Design that explains the general architecture of the system by class diagram, activity diagram and design elements of the system.

Section 3 demonstrates the Use Case Realizations. It contains the general GUI design of the system, block diagram of the use cases that is described in the SRS document.

Section 4 contains Graphical Interface Design which explains the design of the system which the user uses.

Section 5 is the references that are used in the document.

1.5. Motivation

As computer engineering students who are enthusiastic about the new technologies and new aspects in today's fast changing technology world, we started to encounter with the term augmented reality more. While researching about augmented reality, we find out this technology is emerging in many different areas. Since we all will work in software development phases in our career, we want to make development process more easy and more functional for software developers, especially for the ones who are new to the environment. After our research about augmented reality, we realized there is lack of study about AR and onboarding of software engineers and decided that combining these two areas will make the software engineers more motivated and more engaged to their work when they start to work in a new environment or a new project. Our aim is making onboarding process more efficient with the use of augmented reality by making some virtual visualization in the office environment.

We have chosen Vuforia which is the tool that has the most resources online in augmented reality are recently. Also, it has a plugin to Unity 3D platform which is the most popular game engine with its 3D graphics and compatibility with all different platforms and devices.

2. ARCHITECTURE DESIGN

2.1. System Design Approach

During development process of this project we are planning to use scrum, which is an agile development methodology. Due to volatile requirements, agility is important for project development. In contrast to traditional software development, scrum is an agile methodology, which is incremental and iterative. Development process consists of sprints that include its own task to be performed. Each sprint has equal iteration time 30 days on average. In daily, development team has meeting less than 15 minutes, which is called daily stand up meeting. In scrum, there are three main roles that are product owner, scrum master and development team. Product owner demands requirements; scrum master manages the process and development team. And the development team has the role of working on project according to plan. The advantages of scrum can be summarized as follows; First of all, as a result of agility, changes that happened in development process can handled easily. In addition to that, problems, which occur during process, can be negotiated immediately due to daily stand up meetings [15]. Furthermore, agility is a high priority for our AR application, since AR is a new technology for industry. The examples and resources are not enough to analyze or observe the development phase of an AR application**.** Therefore, many problems can occur during development process due to lack of experience. Instead of getting the fully worked product at the end of the development phase, producing small working parts of the system will be more beneficial to decrease the technical debt [13]. In the light of these facts, to take the advantage of early diagnosis of problems, and control the process properly, scrum is suitable for development of this project.

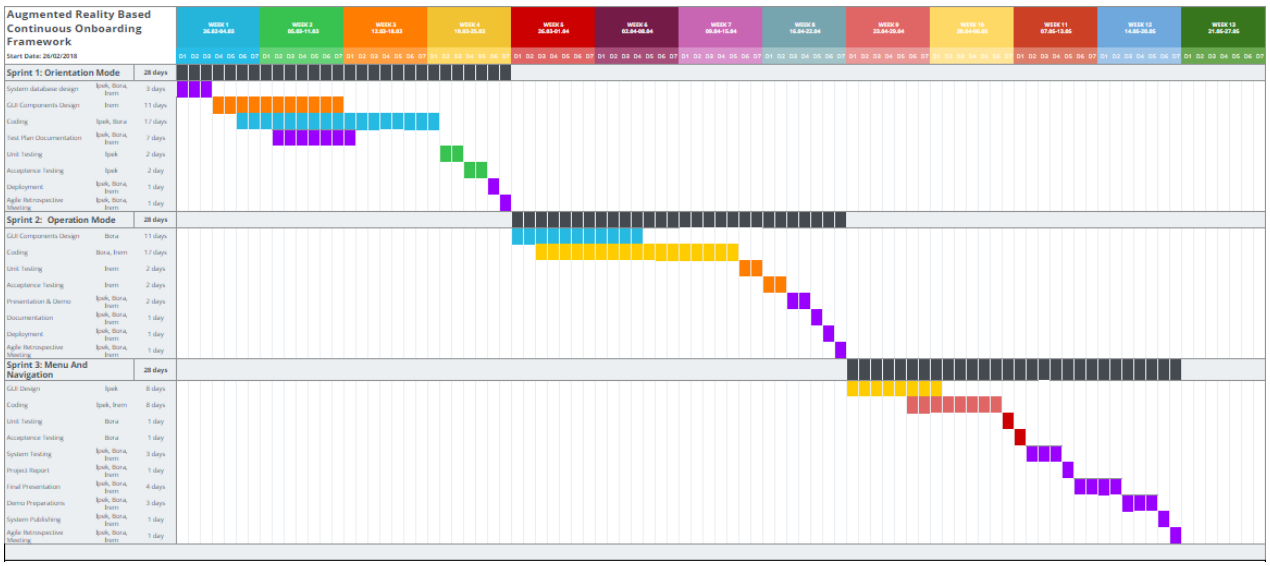

Figure 1 Work Plan

The tasks in the work plan (Figure 1) as follows;

The first process, which is not included in this work plan, was the researching and project specification phases. In that process, information about the related issues and projects related to this subject was investigated. We investigated: augmented reality in education, augmented reality in tourism, augmented reality in defense, automotive, entertainment fields, in marketing-sales, three-dimensional modeling, features of Vuforia and Unity3D software. After these investigations, we worked on feasibility of this project.

We conducted meetings with company employees to determine the basic functions and specifications about project. After those meetings, we prepared documentations about requirements and design of the project.

After field researching and requirement analysis phases, with sprint 1, we will start to develop our project. In sprint 1, mainly we will work on “Orientation Mode” of our project. Firstly, we design system database. After that, GUI components will be designed. Coding will follow the design. Then, current working product will be tested. When tests are also done, product will be deployed. After all these steps, at the end of the sprint we will conduct agile retrospective meeting to improve development process. With sprint 1, we will get a version of the application that can perform orientation mode.

In sprint 2, mainly we will work on the “Operation Mode” which is another main screen of our project. In this sprint, first job is again designing GUI components of the screen. Coding will follow the design. Then, current working product will be tested. When tests are also done, product will be deployed. After all these steps, at the end of the sprint we will conduct agile retrospective meeting to improve development process. With sprint 2, we will get a new version of the application that can perform orientation mode and operation mode.

Last of all, in sprint 3, we will implement menu and navigation components such as login screen, pause menu, main menu of our application. To do this, first job is designing GUI components of the screens. Coding will follow the design. Then, current working product will be tested. This sprint is the last one, therefore when it is completed, we will have final product. Before finish the process, we test whole system and after these tests succeeded and completed we publish our application. And last of all we will conduct agile retrospective meeting to discuss what we have done with good and bad sides.

2.1.1. Class Diagram

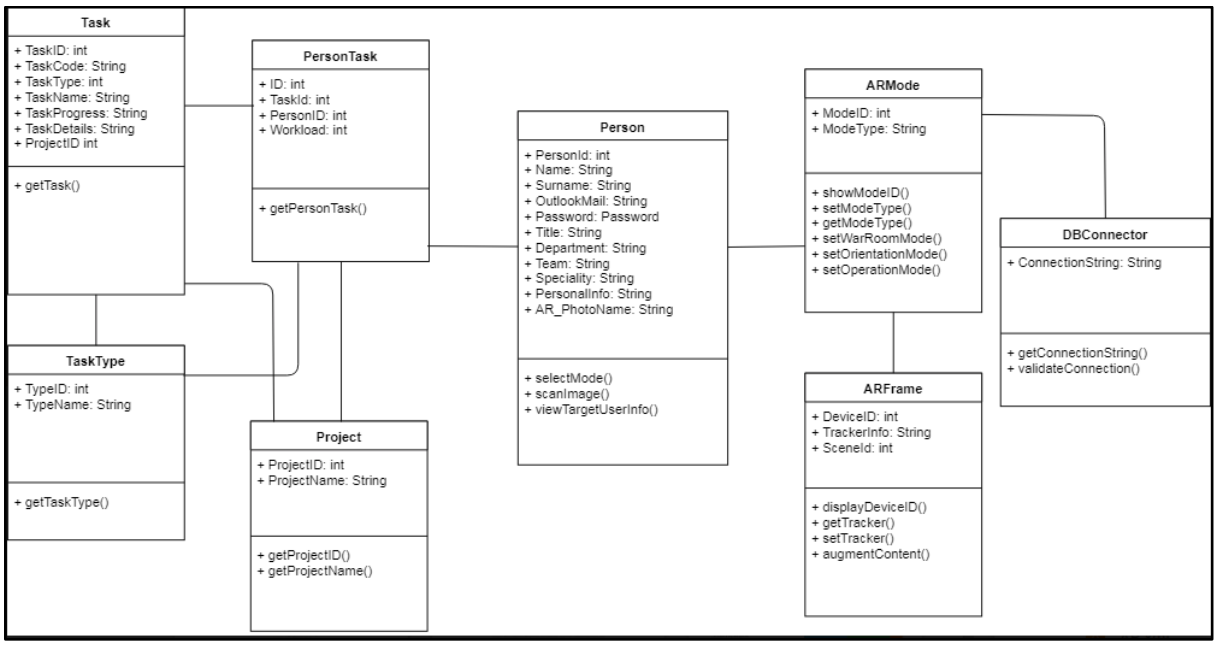

Figure 2 Class Diagram

Figure 2, displays the information about the connections between system attributes. System performs the task according to the modeID in AR Mode class. AR Mode class manages the mode that the system will work according to user's selection. Person class is the class that represents functions of the actor of the system. User selects a mode and views the information about the object according to the type of the objects which are either another user or a meeting room. AR frame tracks environment in both modes. This class gets the information about scanned image and creates the augmented content. AR Anchor class is incorporated with AR Frame and according to the augmented content from AR Frame, it locates the content according to world location.

2.2. Architecture Design of System

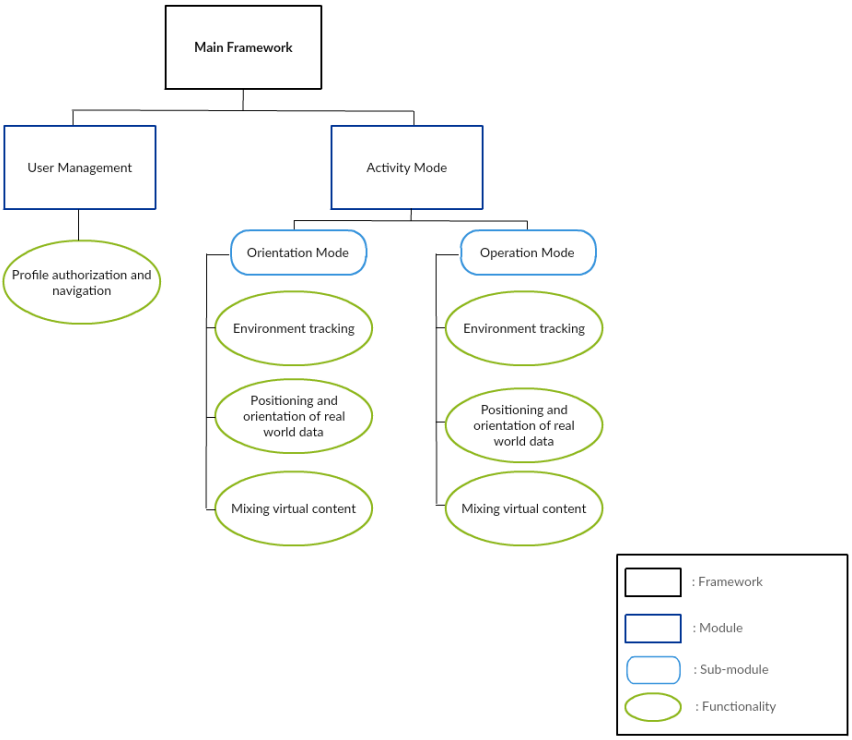

Figure 3 Modularization of System

According to structured modularity in figure 3, system consists of two main modules which are user management module and activity mode module. User management module contains the functionality of profile authorization which controls and navigates users through system usage lifetime. The second module is activity mode module which comprises orientation mode and the operation mode of the system. These two submodules have their own functionalities as environment tracking, positioning and orientation of real world data and mixing virtual content.

In augmented reality, we change the real world data with adding some virtual data and represent this mixed content to user. AR mechanism begins to work with getting the real world data through camera or sensors. After that, positioning and adaptation are done and data is ready to processing. Processing of the data is the most crucial part for developing an AR application. Changing the real world data is done in this step and mixed with virtual information. In the last step, content of mixed reality is represented to the user as video output.

2.2.1. User Management

This system is available for company workers only. Standard users are the developers who working on software development. Developers can login, use orientation and operation mode, and exit from the system. First, user should run the application and login page is opened first. User is expected to be registered to the system by system coordinator who manages the database of the company so that he/she can login to the system. By inputting a valid username and password, user logins to the system and navigated to related page according to her/his authorization rights. Developers are navigated to moda selection page and from there they can continue with orientation mode or operation mode. Users can exit from the system with selecting exit option. When there is a database connection error, system can fail to login with giving an exception error with description.

2.2.2. Activity Mode

2.2.2.1. Orientation Mode

This screen is available for developers only. In this mode, user can access the profile information of the developer by scanning the unique image which belongs to selected developer. User must be logged in and switched to the orientation mode before accessing. Camera screen is opened and environment is observed from the screen and application does environment tracking functionality. User basically tries to determine an AR target to get an information about a person. After determining a target, user scan the unique image which belongs to the target developer to get information about her/him. User sees these information on the screen mixed with augmented reality components. After information is seen, user can scan a new image or can exit from the orientation mode by selecting exit option. When there is a database connection error, system can fail to login with giving an exception error with description.

2.2.2.2. Operation Mode

In this mode, user can access the information about the work items which are defined in current sprint by scanning the unique image which belongs to selected task. User must be logged in and switched to virtual system dashboard mode before accessing. Camera screen is opened and environment is observed from the screen and application does environment tracking functionality. By scanning the related image, data about the task will be displayed on the camera screen. If user wants to see more detailed information about task, s/he can open TFS(Team Foundation Server) link of selected task on the web browser by clicking the task code. In addition to task status, user can observe his team mates' current task information by scanning the unique person image. Current task information of a developer includes statistical data about task types which he works on as feature, improvement or bug and total workload of identified developer. Also, in the situation of task sharing, system shows shared tasks of current user and selected developer. User can exit from the operation mode by selecting exit option.

2.3. Activity Diagram

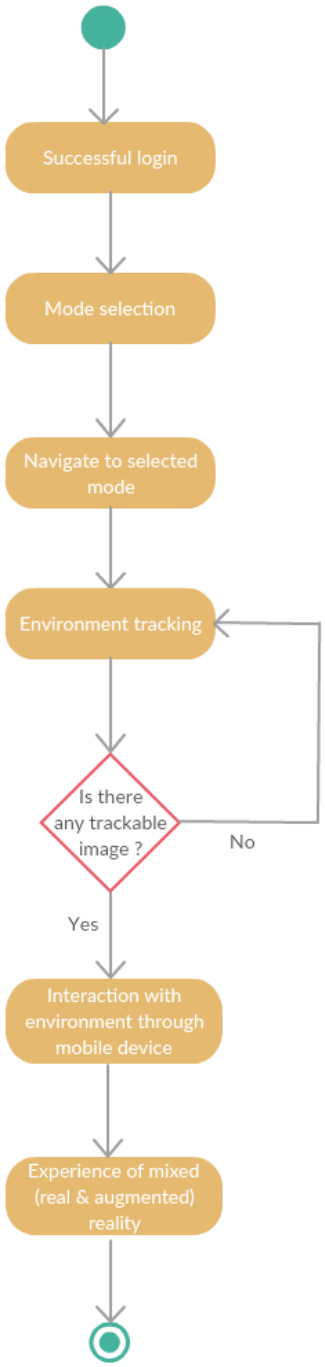

Figure 4: Activity Diagram

Figure 4 shows how the system works as an activity diagram. When the user open the application, login form will open. After a successful login, user chooses the mode to use the system whether Orientation Mode or Operation Mode. After the mode is selected, user navigates the system according to selected mode. After the mode is selected, AR functions are involved. Environment tracking is started. The environment that the camera sees is seen on the screen until a a unique trackable image that is in the AR database is detected. If the trackable image is detected, interaction with the mobile device and the environment is started.

Corresponding data is retrieved from the servers and these data is placed to the environment by the AR anchors which gets the world location and place the components into that location. After that, mixed reality experience is started and user sees the real environment with the augmented reality components through the camera screen.

3. USE CASE REALIZATIONS

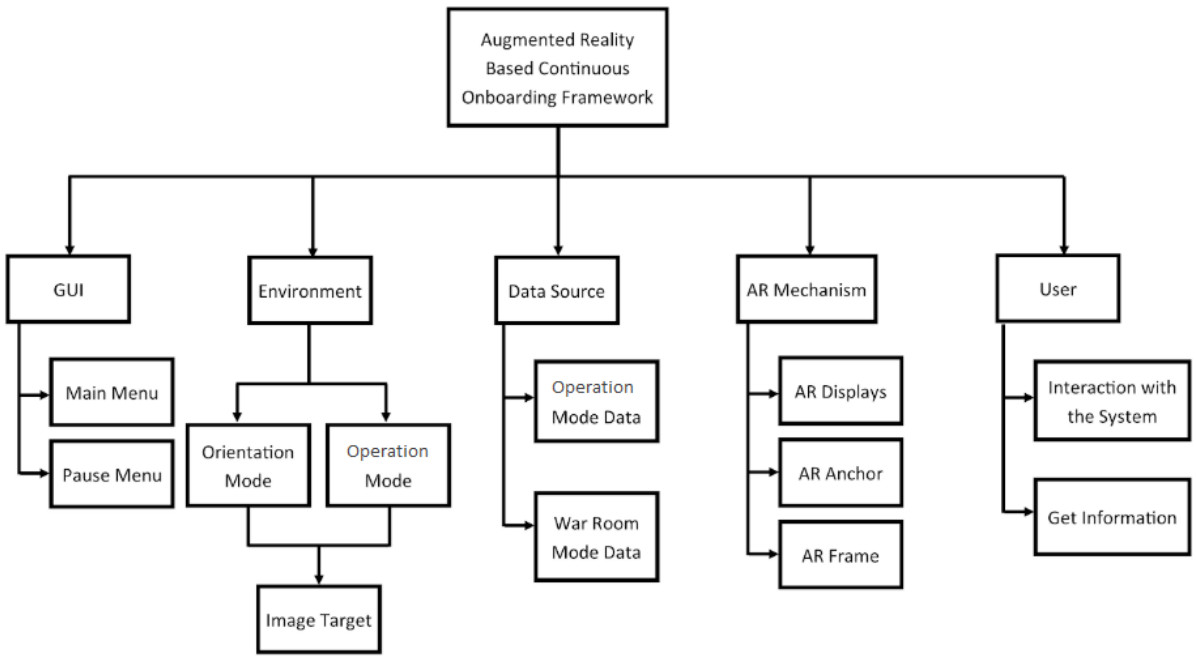

Figure 5 Use Case Realization Diagram

3.1. Brief Description of Figure 5

Components of Augmented Reality Based Continuous Onboarding Project are shown in Figure 5. The designed systems of the simulation are displayed in the block diagram in the figure. There are five main components of the system and their sub-modules.

3.1.1 Graphical User Interface (GUI)

GUI module consists of the general design of the system. It manages and guides the user interactions with the system. There are two submodules of it and these are Main Menu that guides the user in the system, and Pause Menu that when the system is waiting for the response of the user.

3.1.2 Environment

Environment module represents the environment that the application is used. There are two submodules of environment and these are Orientation Mode and Virtual System

Dashboard Mode. Orientation Mode takes place in the office environment and Virtual System Dashboard Mode takes place in meeting room. Also their submodule is Image Target which is placed in the real environment for AR frame to detect and get the information.

3.1.3 Data Source

Data source module consists of the data that the system retrieves from servers to use in the two modes of the system. These modes are Orientation mode and Operation Mode. The data that is needed changes according to these modes. Therefore there are two submodules of Data Source module.

3.1.4 AR Mechanism

AR Mechanism module is responsible for the functionalities of an augmented reality system. Its submodules are AR Frame, AR Anchor, and AR Displays. AR Frame tracks environment to detect an AR target. AR Anchor gets the locations and locates the AR displays according to world location.

3.1.5 User

User module is to determine the abilities of user. User can interact with the system using the functions of its class. After these interactions user gets the desired information from the system.

4. GRAPHICAL INTERFACE DESIGN

In this project, some augmented reality based virtual objects, texts, and etc. are placed on the screen of a device via the camera as if the objects were in the real environment.

4.1. Overview of Interface

User enters to the system from his/her account. After login, the camera screen opens and the actual environment is seen through the camera on the screen. There are some instructions on the screen to guide the user. First, user chooses whether the application will be on “Orientation Mode” or “ Operation Mode” by touching the screen. User follows the office environment from the screen.

4.1.1 Orientation Mode Design

If the system is on the Orientation Mode, user looks for the identifier image on the employees desks. When an image has matched from the database of the system, there will be seen a virtual button to extend the information about the owner of the desk. If the user presses that button to extend, first thing user sees is photograph, name, position, team, some personal information, speciality and current works of the person, that is the owner of the identifier image and position and department that he works on.

4.1.2. Operation Mode Design

If the system is on the Operation Mode, user can scan the identifier image of a work item on the scrum board or a unique person image. The panel which appears on the screen differs according the recognized image. If the image belongs to a task, screen panel shows the summarized information about the task as text through camera screen. In addition, if user wants to see more detailed information about task, s/he can open TFS(Team Foundation Server) link of selected task on the web browser. If the image belongs to a developer, the summarized information about to current task status of the developer will be displayed through camera screen.

4.2. Screen Images

Picture 1: Sample interface from the Orientation Mode

In the Orientation Mode, when user scans the unique image of some colleague and continues with the show information button, a window like Picture 1 that has the entries about selected developer's photograph, name, title, department, team, some personal information, speciality and current works of the person. Picture 1 is an interface sample that we planned to use as the general screen design when the target image of a developer is scanned and identified in Orientation Mode.

Picture 2: Sample interface from the Operation Mode Mode

Picture 3: Sample interface from the Operation

In the Operation Mode, there two possible screens, one of them includes data about task, and the other one includes data about current task status of a developer. When the recognized image belongs to a task, screen panel shows the summarized information about the task (Picture 2). When the recognized image belongs to a developer, the summarized information about to current task status of the developer will be displayed through camera screen (Picture 3).

5. REFERENCES

[1] "What Is Onboarding? - Best Practices & Process - White Paper", *Icims.com*, 2017. [Online]. Available: https://www.icims.com/resources/white-paper/onboarding. [Accessed: 08- Dec- 2017].

[2] M. Kosa and M. Yilmaz, "Gamifying the Onboarding Process for Novice Software Practitioners", in *Systems, Software and Services Process Improvement*, 2016, pp. 242-248.

[3] "3 Tips To Redesign Your Onboarding Process Into A Continuous Experience - eLearning Industry", *eLearning Industry*, 2017. [Online]. Available: https://elearningindustry.com/redesign-your-onboarding-process-into-a-continuous-experience-3-tips. [Accessed: 08- Dec- 2017].

[4]“Vuforia Supported Versions”, *Vuforia*, 2017. [Online]. Available: https://library.vuforia.com/articles/Solution/Vuforia-Supported-Versions. [Accessed: 4 December 2017].

[5]"Unity - Products", *Unity*, 2017. [Online]. Available: https://unity3d.com/unity. [Accessed: 18- Nov- 2017].

[6] Schuettel, Patrick (2017). *The Concise Fintech Compendium*. Fribourg: School of Management Fribourg/Switzerland.

[7] "What is Scrum?", *Scrum.org*, 2017. [Online]. Available: https://www.scrum.org/resources/what-is-scrum. [Accessed: 08- Dec- 2017].

[8] "What is workflow? - Definition from WhatIs.com", SearchCIO, 2017. [Online]. Available: http://searchcio.techtarget.com/definition/workflow. [Accessed: 08- Dec- 2017].

[9] "Software Development Methodologies", *Itinfo.am*, 2017. [Online]. Available: http://www.itinfo.am/eng/software-development-methodologies/. [Accessed: 08- Dec- 2017].

[10] J. Münch, O. Armbrust, M. Kowalczyk and M. Soto, *Software process definition and management*. [Place of publication not identified]: Springer, 2014.

[11] "What is dashboard? - Definition from WhatIs.com", *SearchCIO*, 2017. [Online]. Available: http://searchcio.techtarget.com/definition/dashboard. [Accessed: 08- Dec- 2017].

[12] "What is framework? - Definition from WhatIs.com", *WhatIs.com*, 2017. [Online]. Available: http://whatis.techtarget.com/definition/framework. [Accessed: 08- Dec- 2017].

[13] "What is Technical Debt? The History and Definition", *Praxent*, 2017. [Online]. Available: https://praxent.com/blog/brief-history-technical-debt. [Accessed: 28- Dec- 2017].

[14] Bowes, J. (2018). *Agile concepts: the Scrum Task Board - Manifesto*. [Online] Manifesto. Available at: https://manifesto.co.uk/agile-concepts-scrum-task-board/ [Accessed: 1-Mar- 2018].

[15] M. Villavicencio, E. Narváez, E. Izquierdo and J. Pincay, "Learning Scrum by doing real-life projects", *IEEE Global Engineering Education Conference (EDUCON)*, pp. 1450-1456, 2017.