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The Usability Evaluation of the ARDroneSim Application for Augmented Reality-Based Drone Flight Training Simulator

Abstract: **-** Drone technology has grown rapidly in recent years, with a wide range of applications in various industries, including military, commercial and recreational sectors. There is a high demand for drone pilots in the industries and it is expected to grow more than 50 percent over the next five years. Nevertheless, the growth of domestic and commercial usage of drones has raised the issues of laws violation in terms of surrounding safety and privacy issues. Therefore, effective training is crucial for drone pilots to ensure safe and efficient operation. Motivated by these issues, we have designed and developed an affordable simulated environment via augmented reality for drone flight training. We implemented the main key aspects of effective simulation-based learning in the development. A survey questionnaire was distributed to assess the usability of the application. The findings of the evaluation indicated that the application achieves the total SUS score of 72.12 and adjective ratings are good.

Keywords: augmented reality (AR), drone, simulation, virtual training, Unmanned Aerial Vehicle (UAV).

I. INTRODUCTION

The Industrial Revolution 4.0 (IR 4.0) through the application of technologies such as Internet of Things (IoT), robotics, virtual reality and Artificial Intelligent (AI) is accelerating the global technological advancements with the goal of enhancing operational effectiveness, productivity and automation [1][2][3]. In line with the IR 4.0, unmanned aerial vehicles (UAVs), which are commonly known as drone, are gaining popularity and showing significant potential for the future. Drones are increasingly utilized to increase the productivity and efficiency for complex tasks such as building inspection, surveillance, maintenance, security, and crop monitoring [4]. The primary advantage of using drones is due to their ability to cover large areas without touching the ground, making then an excellent solution for these application [5].

The application of drones in agriculture, power management, law enforcement, delivery, and transportation are prominent and expected to escalate in thirty years from now [4]. In agriculture, farmers can utilize the drone by monitoring their crop easily from a different perspective. Meanwhile, in law enforcement the drone can be equipped with X-ray camera, infrared sensor, and metal detector when undergoing public surveillance to maintain peace and safety of the community. For oil and gas sector, infrared and gas sensor are mounted on the drone to detect any gas leakages and chemical with volatile concentration on the site during the inspection. However, for delivery and transportation, it still has some constraints as there is the limit of weight that the drone can carry which affects the drone's flight duration and distance.

There are many popular companies that manufacture very high-quality drones like Da-Jiang Innovations (DJI), Parrot, Autel, and Skydio. These companies offer drones not only for consumers, but also for professionals,

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enterprise and agriculture. Drones have a lot of technological components, including camera, GPS module, accelerometer, altimeter, and positioning sensor. Drone pilots control the drone through a remote controller that send signal to the drone using either radio waves or Wi-Fi. The drone can be controlled as far as 10km from the operator, depending on frequency power that emitted by the controller. As the technological rise, the component of the drone becomes much cheaper and owning a drone is more affordable for anyone.

However, the issue emerges when there are many incidents reported regarding the misuse of drones. Based on Holland Michel & Gettinger [6], there are six categories of incidents covered in their study, which include the invasion of privacy, drone use, smuggling, close encounters with manned aircraft, crashes, and shoot down. Another report by Jackman A., and Hooper L., [7] categorized the potential threats associated with drone into four categories: 1) image and video capture, 2) transport and carrying, 3) data collection and 4) disruption. The details of the threats are listed in Table 1. A lot of drone accidents and crashes have occurred for several reasons. One of the biggest mistakes drone owners can make is flying a drone without having any understanding of how to operate it properly. Therefore, effective training is crucial for drone pilots to ensure safe and efficient operation. Furthermore, many drone pilots are also unaware of rules and regulations that had been enforced by local authorities. Over the years, the rules and regulations of drone piloting has been tightened due to problems that were caused by several people. Some countries require a pilot license to operate a drone, and others just require a permit to fly at a certain location.

Table 1: Potential Threats Associated with Drones

Category	Example of Threats
Image and video capture	• Of critical and sensitive infrastructure (e.g. government and military facilities) • Of commercial sites and activities (e.g. sporting events, TV and film set, rural farms) • Of emergency service operations (e.g. by media or members of the public) • Reconnaissance to facilitate further actions (e.g., burglary) • Intrusion of privacy • Spying, stalking and domestic abuse of individuals (e.g., ex partners)
Transport and carrying	• Outfitted with weaponry (such as explosives, handguns, tasers and chainsaws; assassination attempts of political leaders; gang attacks on police and security forces) • Modified to transport, carry and/or drop contraband or potentially harmful items (e.g., into prisons; across borders; by drug cartels)
Data collection	• Cyber-attacks and/or corporate espionage (e.g., corporate facilities, networks and technology)
Disruption	• Flown by criminal actors and citizens at particular sites, spaces and events, with the aim of disrupting proceedings (e.g., airports, political events, sporting events, emergency service operations). • Such

Currently, there are several drone flight simulators in the market that are commonly used to train a new drone pilot such as DJI Flight Simulator and Zephyr Drone Simulator. However, these simulators come with high range of prices that only affordable for a large company. It also required powerful computer hardware with a graphic processor as a system requirement for the simulator to operate smoothly. A drone remote control needs to be

connected to the computer to use the simulator. An affordable simulator is necessary to be developed, so it is suitable to be used by everyone. According to Mairaj et al. [8], a good UAV simulator requires the following characteristics: easy to use, should run on general-purpose hardware, less complex, and easy graphical user interface (GUI).

Therefore, this project is aimed to design and develop the drone flight simulator in a 3D environment using augmented reality (AR) named ARDroneSim to provide the users with a virtual and safe experience of flying a drone. By utilising AR, this simulator can offer an immersive experience that enables the user to control the drone in the simulator that closely resembles the real-world environment. We applied the simulation-based learning theory into the development of this simulator, which emphasizes the importance of realistic, interactive environments for effective skill and knowledge transfer. This simulator also incorporated with educational component that teach user about rules and regulations of drone piloting, and how to fly a drone properly through this simulator. This feature aligns with the simulation-based learning theory which emphasis on comprehensive learning experiences that encompass both technical skills and contextual knowledge. By integrating regulatory guidelines and compliance checks into the simulation, users can gain a thorough understanding of legal requirements and best practices in a controlled, risk-free environment. By leveraging the immersive capabilities of AR, this project aims to enhance the effectiveness of drone training, ensuring that users acquire the necessary skills and knowledge to operate drones proficiently and responsibly.

The upcoming sections of this paper begin with Section 2 that outline the background of the study that focuses on the overview of the drone, the introduction of simulation-based learning, some history and implementation of simulation, simulation using AR and some related works on drone flight simulator. Subsequently, Section 3 presents the design and development of the drone flight simulator, Section 4 elaborated on the results and discussions, while Section 5 concludes the paper.

II. BACKGROUND OF STUDY

A. Drone

The term “drone” usually refers to an unmanned aerial vehicle (UAV) that operates without an onboard pilot. Instead, it is controlled remotely from a ground control system or were able to fly autonomously using pre-programmed flight plans and advanced on-board sensors and GPS system [7][9]. Initially, a drone is specifically developed for the military purposes, primarily to serve as weapons and for intelligence resource gathering. These early military drones provide strategic advantages by allowing for operation in hazardous environments without endangering human lives. Now, as technology advances, drones are increasingly available in a variety of non-military applications such as for personal, commercial, and industrial uses.

There are two main types of drones, which come in various shapes and size: fixed-wing and multirotor systems as shown in Fig. 1. A drone with a fixed-wing system has a static wing. Instead of vertical lift rotors, fixed-wing drones have wing-like aircraft that need to move forward to generate lift. This type of drone is suitable for long-distance operation such as aerial mapping and surveillance due to less power consumption, faster, and much lighter. The drone usually uses fuel as its power source. However, the cost of the drone is expensive and harder to take-off and land, which required more training. Another type of drone is a multirotor system, which uses rotary wings to fly. Multirotor drones come with at least four rotors and can have maximum to eight rotors. Its ability to hover make it easier to control especially for the beginner. Because of its multiple rotors, this type of drone required much more energy to fly. This type of drone usually has limited flight time, which is around 20-30 minutes only, depending on its battery capacity, size, and weight. It has flight coverage of up to 30 kilometers. Compared to fixed-wing drone, multirotor drone is much quieter. Table 2 shows the comparison between fixed-wing and multirotor drone systems.

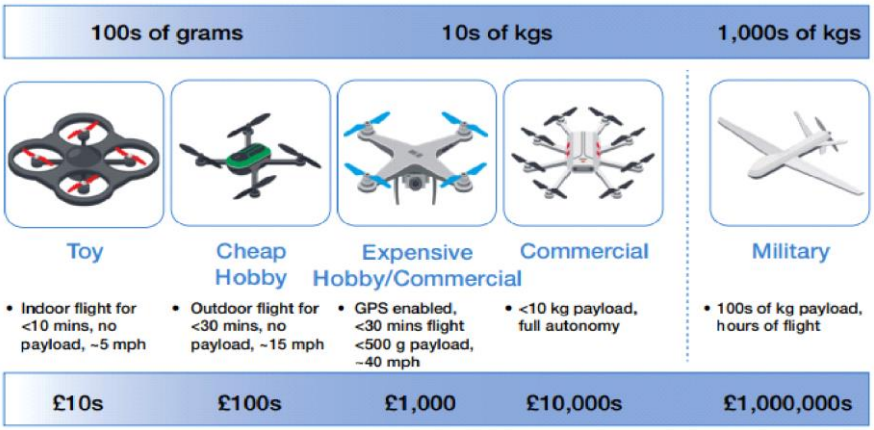


Fig. 1: Range of Drones [7]

A drone is equipped with numerous components including camera, Global Positioning System (GPS), sensors, flight controller, accelerometer, and much more. Some drones that used by military and enterprise have more advanced components such night vision camera, heat sensor, biological sensor, and chemical sensor. The technology in the drone makes it suitable to be used in a wide variety of applications. Beyond surveillance and delivery applications, drones are utilised in drone journalism, search and rescue, disaster response, asset protection, wildlife monitoring, firefighting, communications relay, healthcare and agriculture [4].

Table 2: Comparison between fixed-wing and multirotor drone system

Drone Type / Features	**Fixed wing**	**Multirotor**
Ability to Hover	No	Yes
Applications	Aerial mapping, surveillance, agriculture	Emergency response, law enforcement, inspection, videography/photography
Power Source	Battery, fuel	Battery
Wind Resistance	High	Low
Cruising Speed	High	Low
Flight Range	Up to 100 km	Up to 30 km
Flight Time	More than 60 minutes	20-30 minutes
Take-off/landing Area	Large	Very small

Drones have become an integral tool in various industries, offering numerous benefits. They provide real-time data and high-resolution imagery, enabling informed decision-making and timely interventions. Drones also improve safety by performing tasks in hazardous environments, thereby reducing the risk to human workers. Furthermore, their ability to cover large areas quickly and efficiently makes them invaluable in applications such as environmental monitoring and infrastructure maintenance. Despite their advantages, the widespread adoption of drones faces several challenges. Regulatory issues, privacy concerns, and the need for skilled operators are significant barriers that need to be addressed. Moreover, ensuring the reliability and security of drone systems, particularly in urban environments, remains a critical concern [10].

B. Drone Flight Simulator

Drone crashes usually caused by a fatal system failure, human error, and uncontrolled environment is the most critical issues that raised the concern for a safer drone flight. Drone operators can use a drone flight simulator to practice and get familiar with flying the drone in the virtual environment before using it in real life, hence, minimizing the error and mistake that could lead to any unwanted incidents [11]. A drone flight simulator is needed by drone enthusiasts, designers, and researchers for a variety of purposes, including practicing and improving their flying skills. The simulator serves three major purposes: implementing new technology, providing low-cost training, and enhancing research and development (R&D). Besides practicing and training, researchers are also able to develop and test a wide range of drone designs and configurations using the simulator. According to Qi S., Wang F. and Jing L. [12], both theoretical and simulator training should be included in drone operator training. Qi et al. stated that theoretical training involves the understanding of safety and regulations when operating a drone as well as the basic knowledge of how a drone works. The theoretical training is capable of providing relevant guidance to minimize the accidents caused by human factors and avoid the violation of drone regulations. Qi et al. also mentioned that drone simulator utilized computer technology to train the drone operator in a safer virtual environment. Guidance by professional instructors is necessary to ensure that the drone operator gets proper training, especially for operating skills. The operating skills involve basic drone operation, take-off and landing, simulating emergency circumstances, and mission planning.

C. Simulation using Augmented Reality

Augmented Reality (AR) technology is a piece of technology that mixes the virtual environment with the real world [13]. The technical means it uses include Multimedia, 3D-Modelling, Real-time Tracking and Registration, Intelligent Interaction, Sensing, and more. AR technology first appeared in 2015. Even though AR has come a long way in the last 20 years, there are quite some technological issues. AR became increasingly popular when Niantic, Inc. collaborate with Nintendo and The Pokémon Company to develop and publish an AR game named Pokémon Go for Android and iOS devices.

The Augmented Reality technology has many possible applications in a wide range of fields, including entertainment, education, medicine, engineering, and manufacturing [14]. In the field of entertainment, AR can be used as an interactive tool for video games, advertisements, exhibitions, and much more. AR in education can offer an interactive and immersive learning approach that help students to understand and remember information more quickly. For medicine, by allowing a patient to wear appropriate equipment, AR can be used by the doctor to alert patients to take their medication on time. Engineering implements AR by allowing engineers to model the objects virtually by using Computer-Aided Designs (CAD) before building it in the real world. Finally, AR can include an interactive training manual, which can be supplemented by diagrams and videos for manufacturing purposes.

The great majority of training alternatives for drone pilots are performed in entirely virtual simulators, which detaches people from the feeling of piloting a real drone with a real controller in a real environment. This motivates the combination of UAVs and augmented reality (AR) to create training experiences that enhance the real world with virtual elements [15]. Most AR simulators can be installed on smartphone, which is affordable because of its low-cost and can be use anywhere. It is ideal and can be a good start for beginners who want to learn how to fly a drone.

Other than AR, most drone simulators are computer-based applications which means that computer is needed to play the simulation [16]. While AR uses virtual joystick to control the drone, computer-based simulator requires external controller. DJI Drone Simulator, Zephyr Drone Simulator, and DroneSimPro Drone Flight Simulator are some examples of computer-based simulators. These simulators are usually expensive and specially designed for enterprise and professional training.

III. DESIGN AND DEVELOPMENT

The project development methodology is important to ensure that the project development is following the plans and expectations. ADDIE model is one of the most common models used in the instructional design field as a guide to producing an effective design [17]. Instructional designers usually use this model for technology-based education. The model is a popular choice to develop e-learning and training tools that matched the learner's needs.

Educators, instructional designers and training developers find this approach very useful because having stages clearly defined facilitates implementation of effective training tools.

Instructional design aims for a learner-centered rather than the traditional teacher-centered approach to instruction, so that effective learning can take place. Since ARDroneSim is a training tool, it can be categorized for Instructional System Design (ISD). So, the ADDIE model is a suitable methodology to be used for project development because it is proven to be effective for developing training and learning materials.

ADDIE is an instructional system design model for building an effective instructional system development (ISD). The word ADDIE itself is the acronym of the five phases involved in this model, which are Analysis, Design, Development, Implementation, and Evaluation as shown in Fig. 2. Each phase is related to each other and must be completed before going to the next. The ADDIE model also offers a well-established and useful framework for developing a successful ISD, as well as ensuring that the ISD's requirements are fulfilled effectively. In addition, evaluation phase is very important for each step to be evaluate in order to ensure that the objectives are achieved by using the instructional design and resources to fulfil the needs of the learners [18].

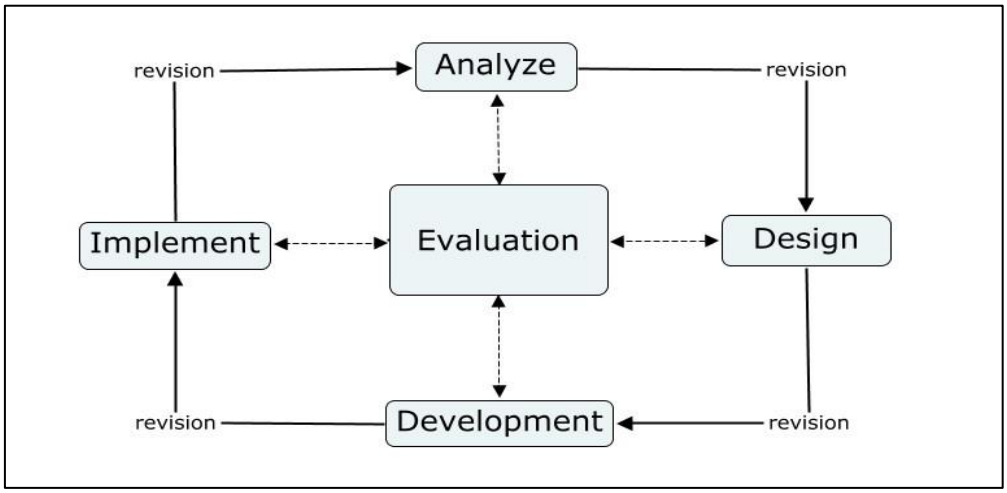


Fig. 2. ADDIE Model

A. Design

In the design phase, the flowchart and the storyboard were designed to give a clear view of the project. The developer shall figure out how to design instruction that can really be effective in ways that facilitate people's learning and interaction with the materials that they create and provide. Fig. 3 is the flowchart that shows step-by-step process that involves in the ARDroneSim simulator. The storyboard provides a simple illustration of the simulator environment as a blueprint when developing the simulator. Fig. 4 shows the storyboard for one of the flight trainings in the ARDroneSim apps.

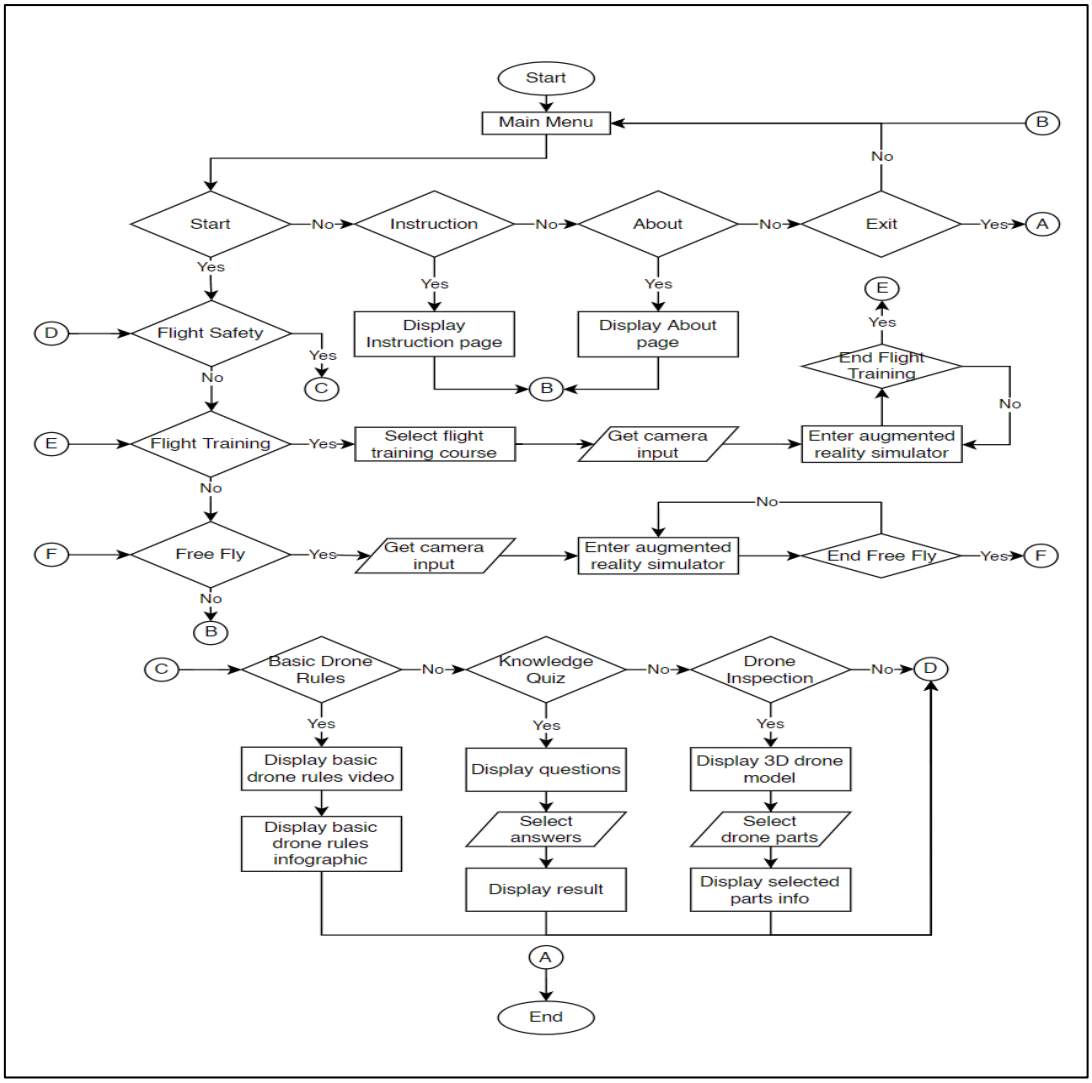
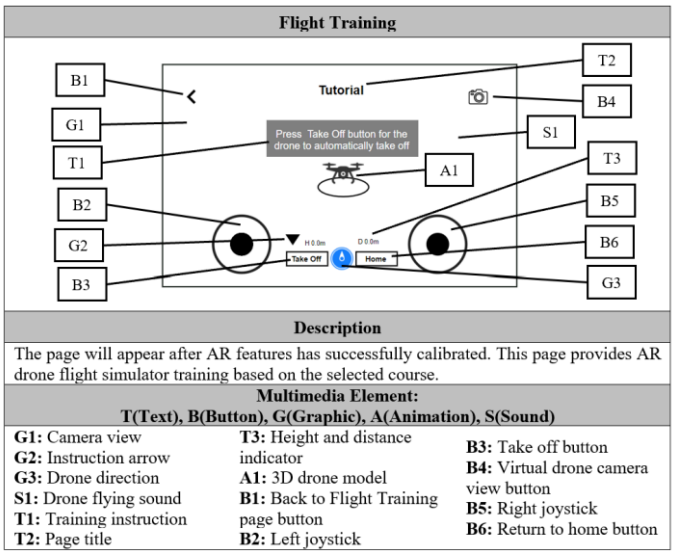


Fig. 3. The Flowchart of ARDroneSim



Description

The page will appear after AR features has successfully calibrated. This page provides AR drone flight simulator training based on the selected course.

Multimedia Element:
T(Text), B(Button), G(Graphic), A(Animation), S(Sound)

G1: Camera view
G2: Instruction arrow
G3: Drone direction
S1: Drone flying sound
T1: Training instruction
T2: Page title
T3: Height and distance indicator
A1: 3D drone model
B1: Back to Flight Training page button
B2: Left joystick
B3: Take off button
B4: Virtual drone camera view button
B5: Right joystick
B6: Return to home button

Fig. 4. The Storyboard of ARDroneSim's Flight Training Tutorial

B. Development and Implementation

In the development phase, the previous flowchart and storyboard are referred to ensure the project development follows the right path. The application is developed using the Unity game engine. The files such as drone model, graphics illustration, video, and audio created using 3Ds Max, Adobe Premiere Pro 2020, and Adobe Illustrator 2020 are then imported into Unity to be combined. The appropriate scripting using C# programming language for drone controller, scene manager, level manager, and input manager are scripted to make the application functioning as it should.

The selected type of drone model implemented in this project is the multirotor drone. The animation for the drone propeller is animated in 3Ds Max. Each propeller rotation is based on the real drone configuration. Front right and back left propellers rotate counterclockwise while front left and back right propellers rotate clockwise. There are three types of animation for the propellers, take-off, flying, and landing. These animations are then exported into FBX file format to be used in Unity. Fig. 5 shows the animating process for the propeller's animation.

Fig. 5. Animation Process for the Propeller

The ARDroneSim is mainly developed for mobile devices. Due to this, the application is receiving three inputs to make it function appropriately. The input from the camera (Fig. 6) is utilized for augmented reality features and input from the mobile device's touch screen is used for the user to navigate through the application. The third input is the gamepad, specifically for Xbox Controller (Fig. 7). The drone movement inside the simulator can be controlled using the gamepad or on-screen joystick (Fig. 8). The gamepad input is optional, but it is highly recommended to use as it can give the feels like the real drone remote controller.

Fig. 6. Camera Input for Augmented Reality Feature

Fig. 7. Xbox Controller Input

Fig. 8. On-screen Joystick Input

IV. RESULT AND DISCUSSION

We have conducted a usability evaluation using the System Usability Scale (SUS) to evaluate the developed project. The questions given cover a wide range of the application usability aspects, including the need for support, training, and complexity, and hence have a high level of face validity for evaluating the application's usability [19]. The usability evaluation is important for evaluating the finished product to ensure the goals are achieved using the instructional design and materials to meet the learner's needs.

The target participants for this evaluation are beginners who are interested to learn how to fly a drone. The SUS questionnaire was distributed online using Google Form. The participants were required to install the application and then answer the questionnaire that was included in the form. After testing the application, the participant was required to answer the provided questionnaire to evaluate the usability of the developed application.

The questionnaire was distributed and made available online for a month. Within this period, the application has been downloaded 185 times. However, only 52 participants responded to the questionnaire. Table 3 summaries the demographic information of the respondents who participated in the evaluation. The majority of the participants were aged 18 to 24 years old with a total number of 30 respondents (57.7%), followed by 12 respondents (23.1%) were aged 35 to 44 years old, 6 respondents (11.5%) were aged 25 to 34 years old and the rest were below 17 years old. 34 out of 52 respondents (65.4%) were male, and the rest are female which 18 respondents (34.6%). The majority of the respondents (59.6%) have no experience at all in drone piloting, and only 4 respondents (7.7%) have more than five years of experience in drone flight. Meanwhile, Samsung is the most smartphone brand used to test the application by the respondents. iPhone is not included since the application test is available for Android smartphones only.

Table 3. Respondent Demographics Information

No	Question	Range	Frequency	Percentage (%)
1	What is your age?	Under 12 years old	1	1.9
		12 - 17 years old	3	5.8
		18 - 24 years old	30	57.7
		25 - 34 years old	6	11.5
		35-44 years old	12	23.1
		45-54 years old	0	0
		55-64 years old	0	0
		65-74 years old	0	0
		75 years or older	0	0
2	What is your gender?	Male	34	65.4
		Female	18	34.6
3	Where are you from?	Northern Region Malaysia	8	15.4
		Central Region Malaysia	18	34.6
		East Coast Region Malaysia	6	11.5
		Southern Region Malaysia	17	32.7
		Sabah	0	0
		Sarawak	3	5.8
4	What is your level of education?	Primary School	1	1.9
		Secondary School	5	9.6
		Pre-University	6	11.5
		Undergraduate	30	57.7
		Postgraduate	3	3.8
		Preferred not to say	7	13.5
5	Drone flight experience	Less than 1 years	11	21.2
		1 to 5 years	6	11.5
		More than 5 years	4	7.7
		No experience at all	31	59.6
6	Smartphone brand	Google	2	3.8
		Huawei	10	19.2
		OnePlus	2	3.8

		Oppo	7	13.5
		Realme	2	3.8
		Samsung	14	26.9
		Vivo	3	5.8
		Xiaomi	12	23.1

The next section of the questionnaire consists of 10 questions based on the SUS instruments [19] to determine its usability. Each question must be evaluated by user from the scale of 1 for strongly disagree to 5 being strongly agree. To make it easier for the user to understand, the questions are available in dual language, English, and Malay language. The list of questions is included in the Appendix A. Table 4 shows the result obtained from the SUS evaluation that has been done through Google Form. SUS has a total score of 100. Strongly disagree, somewhat disagree, neutral, somewhat agree, and strongly agree are the five-scoring weight for each of the 10 questions. The score weight range is from 1 for strongly disagree to 5 for strongly agree. To get the raw SUS score, the total score for all odd number questions (X), is added together and subtracted by 5 (X-5). The total score for all even number questions (Y), is added together and 25 is subtracted by the total (25-Y). The total score for odd and even number questions is summed up (X+Y) to get the raw SUS score. The final SUS score is calculated by multiplying the raw SUS score with 2.5 ((X+Y) * 2.5)). The average final SUS score is 72.12 and calculated by dividing the total final SUS score with 52 (((X+Y) * 2.5) / 52). Fig. 9 shows the grading score for SUS.

Table 4. SUS Evaluation Result

Respondent	**Question Score**										**SUS Score**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Raw**	**Final**
1	5	1	5	1	5	1	4	1	4	1	38	95
2	3	4	4	5	4	3	3	3	3	2	20	50
3	4	2	3	3	3	2	4	2	3	3	25	62.5
4	4	3	4	2	4	3	4	2	3	3	26	65
5	3	2	5	1	4	3	4	1	5	3	31	77.5
6	5	1	5	1	5	2	4	1	5	1	38	95
7	5	2	5	3	5	2	4	2	5	2	33	82.5
8	4	3	4	4	4	4	4	4	4	4	21	52.5
9	4	5	4	5	5	5	4	5	4	4	17	42.5
10	5	2	5	5	5	1	5	1	4	5	30	75
11	5	1	5	1	5	1	4	1	4	1	31	77.5
12	3	4	4	5	4	3	3	3	3	2	29	72.5
13	4	2	3	3	3	2	4	2	3	3	19	47.5
14	4	3	4	2	4	3	4	2	3	3	24	60
15	3	2	5	1	4	3	4	1	5	3	30	75
16	5	1	5	1	5	2	4	1	5	1	29	72.5
17	5	2	5	3	5	2	4	2	5	2	23	57.5
18	4	3	4	4	4	4	4	4	4	4	34	85

19	4	5	4	5	5	5	4	5	4	4	29	72.5
20	5	2	5	5	5	1	5	1	4	5	32	80
21	5	1	5	1	5	1	4	1	4	1	37	92.5
22	3	4	4	5	4	3	3	3	3	2	32	80
23	4	2	3	3	3	2	4	2	3	3	27	67.5
24	4	3	4	2	4	3	4	2	3	3	21	52.5
25	3	2	5	1	4	3	4	1	5	3	28	70
26	5	1	5	1	5	2	4	1	5	1	34	85
27	5	2	5	3	5	2	4	2	5	2	20	50
28	4	3	4	4	4	4	4	4	4	4	25	62.5
29	4	5	4	5	5	5	4	5	4	4	28	70
30	5	2	5	5	5	1	5	1	4	5	35	87.5
31	5	1	5	1	5	1	4	1	4	1	27	67.5
32	3	4	4	5	4	3	3	3	3	2	31	77.5
33	4	2	3	3	3	2	4	2	3	3	39	97.5
34	4	3	4	2	4	3	4	2	3	3	26	65
35	3	2	5	1	4	3	4	1	5	3	30	75
36	5	1	5	1	5	2	4	1	5	1	20	50
37	5	2	5	3	5	2	4	2	5	2	20	50
38	4	3	4	4	4	4	4	4	4	4	30	75
39	4	5	4	5	5	5	4	5	4	4	33	82.5
40	5	2	5	5	5	1	5	1	4	5	31	77.5

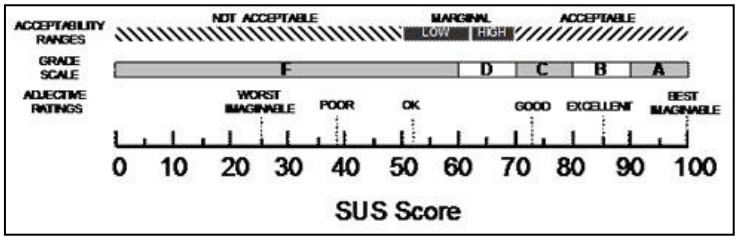


Fig. 9. System Usability Scale Grading Score

The SUS grading score is divided into three categories, acceptability ranges, grade scale, and adjective ratings based on the total score [18]. Acceptability ranges consist of not acceptable, marginal, and acceptable. The grading scale is from grade A to F. Accepting range is categorized the score as worst imaginable, poor, ok, good, excellent, and best imaginable. The SUS score obtained for the project during the evaluation is 72.12. As the result, the ARDroneSim is acceptable in the acceptability range, graded C for grade scale and adjective ratings is good. A SUS score of 70 is close to the average of 68, indicating that it is in the upper half percentage of the range [19].

V. CONCLUSION

ARDroneSim is an AR-based application that target to help new drone pilots to practice maneuvering drone before flying the real one. The AR features implemented in this simulator is capable to enhance the training experience in the real world with virtual elements. This application is suitable to be used by anyone because it can be easily installed on a smartphone and consume less space for storage. By using this application, the risk and cost of drone flight training can be reduced, and improper operation that may cause damage when training with the real drone can be prevented. It also provides information regarding the basic drone rules that every drone pilot needs to follow when flying a drone.

The users' evaluations are used to determine the accomplishment of the objectives. The evaluation utilized System Usability Scale to obtain the usability of the application according to the targeted audience feedback. According to the result, the application achieves the total SUS score of 72.12, which is in the acceptable range, graded C, and good in adjective ratings. This result considered that the application is usable as effective learning and training tool for drone flight training.

The development of this application is a great solution for a new drone pilot to training flying the drone by themselves or guided by an instructor in a safer virtual environment before controlling the real one. The application also provides proper guidance about the rules when flying a drone which every drone pilot needs to follow to prevent any consequences including penalties, fines, and jail as the consequence of breaking the law.

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APPENDIX A

SUS Evaluation Questions

1. I think I would like to use this application frequently. / Saya rasa saya ingin menggunakan aplikasi ini dengan kerap.
2. I found the application unnecessarily complex. / Saya mendapati aplikasi ini amat rumit.
3. I thought the application was easy to use. / Saya fikir aplikasi ini senang digunakan.
4. I think that I would need the support of a technical person to be able to use this application. / Saya berpendapat bahawa saya memerlukan sokongan orang teknikal untuk menggunakan aplikasi ini.
5. I found the various functions in this application were well integrated. / Saya dapati pelbagai fungsi dalam aplikasi ini digabungkan dengan baik.
6. I thought there was too much inconsistency in this application. / Saya fikir terdapat terlalu banyak ketidakselarasan dalam aplikasi ini.
7. I would imagine that most people would learn to use this application very quickly. / Saya membayangkan bahawa kebanyakan orang akan belajar menggunakan aplikasi ini dengan cepat.
8. I found the application very cumbersome to use. / Saya mendapati aplikasi ini sangat sukar digunakan.
9. I felt very confident using the application. / Saya berasa sangat yakin menggunakan aplikasi ini.
10. I needed to learn a lot of things before could get going with this application. / Saya perlu belajar banyak perkara sebelum dapat menggunakan aplikasi ini.