UNIVERSITI UTARA MALAYSIA
SCHOOL OF COMPUTING
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STTHK2123 INTERACTION SYSTEMS & TOOLS

ASSIGNMENT 1(PROPOSAL)

Prepared By:

No.	Name	Matric No.
1.	Daniel Jakson	301153
2.	Tan Hou Ren	301235
3.	Muhammad Azri Asnawi Bin Kamal Arifin	301027
4.	Lim Wei	300827
5.	Maithilly Partiban	300927

Instructor:

Ts. Dr. Juhaida Binti Abu Bakar

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Table of Contents

Executive Summary/Abstract

The fantastic arcade game Space Shooter was a seduction for many in the 19th century. However, with the advent of new and better modern games, its glory is no longer visible. This project will be directed to modernize Space Shooter through implementation of hand gesture recognition, level-up systems, as well as a competitive leaderboard. These features serve to draw players' psychological needs for competence, autonomy, and relatedness in order to create an immersive and yet rewarding experience.

In the first place, the project begins by Discover, Define, Develop, and Delivery using the Double Diamond methodology. Outdated gameplay and lack of engagement are two major concerns that the project should focus on in the Discover phase. According to Manuj (2023), space shooter games may fail to bring new features or gameplay mechanics, making them feel outdated and uninteresting. The Define aspect of this focused better definition of modernized features. The Develop aspect was characterized by feature implementations, such as gesture controls through the webcam, levels of increasing difficulty, and a leaderboard that functions in real-time. The last Deliver phase involve user testing and feedback collection through A/B testing and structured questionnaires.

The target user groups include casual gamers between 13 to 34 years of age who can physically use hand gestures. According to Hoffman (2023), gamers in this age range show strong and diverse spending behaviours and social interaction. Furthermore, hand gesture recognition can help those with poor motor coordination or with a person that are recovering from physical rehabilitation. Chen, J., Zhao, S., Meng, H., Cheng, X., & Tan, W. (2022) proved that an interactive game using gesture recognition could become a supportive tool with 99.03% accuracy in hand gesture detection and generating interest among users with coordination problems. In this regard, our game also aims to have a simple and engaging hand interaction which could then be promoted for increased the use in accessibility design.

Basic statistical methods will assist the analysis to compare between the traditional and enhanced versions. The entire project lasts for 14 weeks, from proposal writing to the final presentation and document compilation. The expected output is an enhanced Space Shooter game that is made more relevant through hand gesture control implementation, with a dynamic ranking system using leaderboards. There is also a tutorial and gesture calibration system to ensure accuracy and user-friendly manipulation of these features. This game promises to be appealing, engaging, and emotionally rewarding to both novice as well as returning players.

By combining nostalgic gameplay with modern technology, this project not only revives a classic but also emphasize innovative approaches to game design. It highlights the incredible value of gesture-based interactions, while also stepping toward exploring new immersive and intuitive user experiences in game design.

Introduction

Background Study

Space Shooter is a classic childhood game for most people. It was a game in which the player controlled the main character (space ship) and shot the enemy (space ship or meteorite). The game's scores are computed depending on the number of enemies shot down by the main character and the amount of time the main character lives. It now has several power ups such as shield to increase the space ship life and bolt to increase the shooting ability of the space ship. This space shooter game now uses the keyboard such as left arrow button and right arrow button to control the movement of the space ship; space bar to control the fire of the bullets and esc button for quit game. However, Space Shooter now become more and more boring and less interesting compare to other game in this era. Therefore, this study is plan to improve the Space Shooter and attract more player play this game.
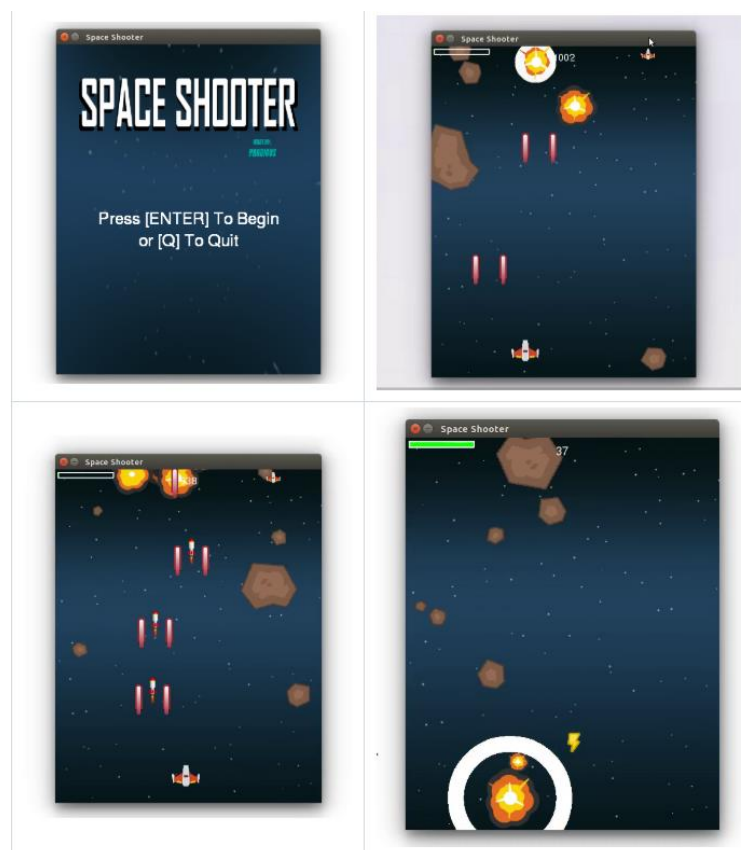

Figure 1: The Existing Space Shooter game

Figure 2: Keyboard control for currently Space Shooter game

Problem Statement

Space Shooter was a highly popular arcade game during the late 19th century, evoking a strong sense of nostalgia among players of that era. Based on Kent, Steven L. (2001), in 1978 Midway (i.e. American video game company) was manufactured and sold more than 60,000 Space Invader (i.e. similar game for the Space Shooter) machine in United States within a year. Based on Figure 3 and Figure 4, however, the game has become outdated and largely forgotten by modern audiences over time. This decline is unfortunate, as Space Shooter once held a special place in the hearts of many gamers. The primary reason for its lesser popularity is the rapid innovation in gaming technology. Modern games have far superior graphics, smoother animations, better storylines, and more interactive gaming experiences. All these advancements make modern games far more attractive and intriguing for players, especially the younger generations. As such, old games like Space Shooter cannot keep pace with the latest gaming world.

Figure 3: The number of current players play the similar Space Shooter game in Steam
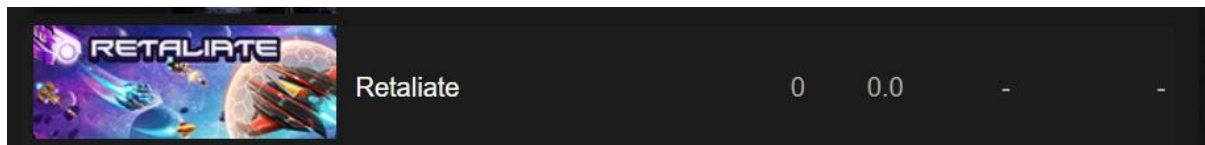
Figure 4: The number of current players play the similar Space Shooter game in Steam

Project Objective(s)

In this study, the project objectives are as below:

1. To identify user requirements for enhancing Space Shooter with hand movement detection, a level-up system, and a leaderboard to create a more engaging gaming experience.
2. To develop a proposed game system that integrates hand gesture-based controls, a progression-based level-up mechanism, and a leaderboard to fulfill players' psychological needs, such as competence, autonomy, and relatedness.
3. To evaluate the performance of the proposed game system using the Gaming Skill Questionnaire.

Scope of the Study

This study focuses on the evolution of an interactive Space Shooter game controlled mainly through hand gesture recognition. The game is designed to improve four key aspects of user experience: cognitive engagement, social interaction, emotional involvement, and overall user engagement. From a cognitive perspective, the game will let players control the spaceship by using specific hand gestures (see Figure 5), which promotes attention, learning, and memory. It helps to improve the player's mental focus to pay attention to the game, where they need to know where to shoot, and their responsiveness when playing. Players also need to learn and memorize the gestures. Gradually, player involvement and immersion can also be increased. To enhance emotional engagement and maintain user interest, the system features a level-up system that upgrades the spaceship as the player progresses. It aligns with studies conducted by Huang, Jasin, and Mamchanda (2019), who indicated that player motivation is closely linked to skill development and structured reward systems. In order to boost social interaction, player achievements will be tracked. It will then display on a high-score leaderboard. In this case, it motivates players to challenge themselves and their friends. It also helps to promote healthy competition and peer interaction.
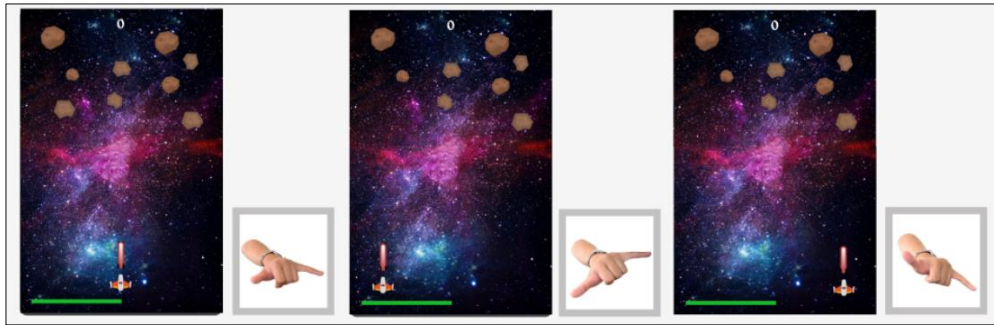
Figure 5: Low-fidelity design illustrating the core interaction of the advanced Space Shooter game, where hand gestures control spacecraft movement (stay, move left, and move right).

We will use Python along with its libraries such as OpenCV, MediaPipe, and Pygame to build the system. The software will be developed for desktop platforms only. It is designed for casual gamers between 13 to 34 years of age. Players must be able to perform the required hand gestures to control the game. All text, instructions, and user interface elements will use English. This will help keep the game simple and easy to understand.

The scope also covers the basic user interface design, including main menu, tutorial mode, leaderboard view, visual or audio feedback interfaces, and the detailed gameplay guides. Despite integrating gesture-based controls, the game will remain single-player mode. In this case, it will not include features such as online or multiplayer modes, user login systems, or remote gesture interaction. However, it will support local data storage for necessary in-game functions.

Limitation of the Study

One of the significant constraints of the system is the system's dependance on ambient lighting conditions. Testing revealed that the system reaches a smooth performance of 15-20 frames per second (FPS) under a bright and well-lit environment. This allows the game to provide accurate real-time recognition of user gestures. However, when lighting is poor or hand movements are too fast, the system may struggle to keep up, leading to lag or incorrect gesture detection. Tests also showed that running background applications can cause FPS to fluctuate, which further affects gameplay performance (Rajhaga et al., 2024). Additionally, since the game relies on a functional camera to detect gestures, it may be inaccessible on devices without a functioning camera.

Moreover, this project will support only predefined gestures for basic actions such as moving left and right. While this ensures system stability and simpler development, it also

limits the variety of user interactions. As Modaberi et al. (2024) noted, although expanding gesture diversity can boost user engagement it could introduce challenges such as increased recognition errors and user fatigue especially in long gaming sessions.

Furthermore, the system is implemented as a desktop-based application, and is not compatible with mobile or touchscreen devices. As a result, only users who have access to a computer with a functioning webcam can access it.

Besides, the gesture calibration process is designed to be simple, quick and straightforward. It learns the movements fast but does not fully account for every hand size, angles, or positions. In consequence, some users may experience slightly different levels of accuracy.

Significance of the Project

This game will use hand gesture recognition as a creative interaction approach to manipulating a Space Shooter. Creating a unique and modern play experience, this removes the reliance on dedicated controllers or keyboards which may not be available for everyone—especially those that have motor limitations or are in physical recovery situations. Using hand gestures or gestures in general allows a more accessible, intuitive, and natural manipulation of electronic/digital spaces to provide gaming opportunities to more people.

Recent work by Chen et al. (2022) discussed the rehabilitative and therapeutic implications of gesture recognition systems. In their study, a gesture-based rehabilitation game improved users' hand–eye coordination and motor control showing promise towards being useful not only for gaming and entertainment but for physical therapy, and cognitive recovery. The game we create will use a similar concept to Space Shooter and revamp the way classic arcade-style games are designed with the notion of using modern interactions whilst also keeping the nostalgic elements.

This project combines entertainment and rehabilitation into a dual-function system that can evoke reflexes and motor responses and could even be beneficial in coordination training for individuals undergoing recovery. Gesture-based control of the game mechanic is not entirely new to the gaming space, but it remains to be fully embraced within modern gaming.

Another worthy addition to the gesture-based interaction is the level-up system and leaderboard. These psychological aspects are mainly concerned with competence via progression, autonomy via gesture control, and relatedness via competitive leaderboards, thereby satisfying the needs as examined by Przybylski et al. (2009). Neglecting the fulfillment

of these needs translates to neglecting and therefore leaving the user unmotivated and dissatisfied. Modaberi et al. (2024) highlight competition and social connection as retention drivers. These mechanisms keep players engaged, alert, and immersed within the experience. The level-up system and leaderboard encourage friendly competition and foster community. These systems will increase replicability and maintain the game's long-term engagement. Altogether, they create a fun and emotionally rewarding gameplay experience.

Gesture control is not yet commonly utilized in most games as of today, as much of the contemporary games still rely mainly on input controls from devices like keyboard, mouse, or even in some cases, touch controls. This is what this project will further delve into, finding new avenues in terms of game control using one's hands. Movement-tracking games can be made more easily accessible to be played and enjoyed as well. Certainly, it will be beneficial to players who find it difficult to play games using standard input devices. Another option will be available for users who prefer motion-based interaction.

In the long run, this project not only brings new life to Space Shooter but also opens up possibilities for more immersive and gesture-controlled game development.

Expected Output

The project deliverable output is a modern and interactive version of the classic Space Shooter game. The game will be coded with Python and include a hand gesture recognition system. The deliverable will have a user-friendly and minimalist interface. The main menu will enable players to begin the game, choose keyboard controls or gesture controls, and view the leaderboard. A simple head-up display (HUD) will show the score, and power-ups on the screen. A health bar will also be displayed to indicate the spaceship's status. For the gesture option, players will be enabled to control the spaceship's movement, allowing it to stay, move left or move right using hand gestures. According to the study by Shanthakumar et al. (2020), there is the need for simple gestures to avoid errors. This idea is parallel to the choices for this project. For example, to navigate the spaceship, players use the Shaka sign gesture, extending the thumb and little finger while folding the other fingers. Tilting the hand to the left or right moves the spaceship in the corresponding direction, while maintaining a neutral position keeps it stationary. The spaceship fires bullets automatically during gameplay. For the gesture control, it is reversible and can be enabled or disabled. Players can choose their control of choice.

As implied by Modaberi et al. (2024), there is going to be a gesture calibration screen in the game where users can learn and practice performing each gesture correctly and calibrate their movement. This way, hand gestures are more accurate and general user experience can be improved. For newcomers, they are required to go through a tutorial mode to guide them step by step in a relaxed way, so that they are ready prior to jumping into the actual game.

Moreover, there will also be the presence of a level-up system in the game. The player's difficulty will be gauged on the score and how long one survives in the game. As a player levels up, the visuals of their spaceship change and introduce new perks for that spaceship. Such perks may include the fast-firing rate, enhanced defense, or size enlargement. New levels would provide fiercer enemies, which it will need more shots to destroy, more hindrances in the form of meteors, power-ups that include shields or rapid fire. These upgrades show clear evidence to the players of their advancement. Therefore, it makes the gameplay fun in addition to a challenging and rewarding experience.

The game will also contain a leaderboard and high score-tracking system that will keep players interested and provide an environment for friendly competition. Scores will be assigned based on meteorites killed, survival time, and the achievements earned during gameplay. The leaderboard will show a player's name, ranking and score. Hence, players can see their scores and challenge themselves to beat them or even try to beat other players' scores.

Related Works

Literature Review Overview

Topic 1: Gesture-Based Interaction in Gaming and HCI

1. <u>Real Time Hand Gesture Recognition System For Dynamic Applications</u>

Gesture recognition involves significantly from hardware-dependent solutions to vision-based techniques. In the early systems they used wearable devices like data gloves (e.g., CyberGlove) for precise tracking which are expensive and cumbersome. Advancement of technologies in computer vision and machine learning, non-contact vision-based approaches emerged as a more practical alternative.

Some vision-based techniques have been explored for gesture recognition. The Viola-Jones algorithm and Haar-like classifiers are widely used for real-time object detection due to their robustness against noise and lighting variations. Hidden Markov Models (HMMs) have been employed for dynamic gesture recognition, as demonstrated by Marcel et al. and Chen et al., though they require complex training. This work utilizes contour and defect analysis to recognize static gestures, analyzing hand convexity defects to detect finger positions.

Gesture recognition has been used broadly in HCI across different domains. In virtual reality and gaming, gesture-based interaction has enabled avatar control, as explored by Freeman and Konrad et al. that become famous commercials such as PlayStation's EyeToy. In assistive technologies, these structured gestures further communication for hearing-impaired through sign language recognition. It has also been implemented for slide control and media interaction, such as Ahn et al.'s work on gesture presentation control and other applications in VLC media control.

Despite its advantages, gesture recognition meets some risks. The system robustness remains an issue, as lighting conditions, occlusions, and background noise can impact accuracy. Scalability also becomes a risk when extending the system to support multi-gesture and multi-user environments. Real-time efficiency must be stable with additional cost. Finally, user tolerance needs improvement that focuses on reducing errors in the recognition part and improves feedback mechanisms.

2. <u>Development Of Hand Gesture Detection Application For Slap Mosquito Game Based On Image Processing</u>

Gesture recognition technology is increasingly used in gaming and human-computer interaction, thanks to its intuitive and natural control mechanisms. Early research has concentrated on static image-based gesture detection (Naufal et al.,2023); however, there are new systems that focus on real-time recognition to facilitate dynamic interactions. Current methodologies range from sensor-based approaches that give high precision, to vision-based techniques that assert accessibility and become user friendly.

Various image processing techniques give different convincingness in gesture recognition. For example, YOLO-v3 achieves impressive performance, boasting over 90% accuracy in real-time object detection. Other popular methods include Haar-like features and MediaPipe, which are enforced for tracking hand landmarks and gestures (Mujahid et al.,2021). Additionally, edge and corner detection algorithms are devoted to increasing classification accuracy. These techniques sustain the robustness of gesture recognition systems (Saputra & Hariyanto, 2024).

Rapid Application Development (RAD) has become a recommended way for creating gesture-based systems to give out performance in prototyping and incorporating user feedback (Wulandaei et al.,2020). RAD application in real-time recognition project proving its adaptability for iterative development process cycles. This allows developers to gain opportunities to improve gesture interactive in user testing and performance.

At the same time, gesture interaction counters few challenges like lightning conditions that cause accuracy of detection leading to diminished performance (Oudah et al.,2020). There also background processes consume high computational power that affect system responsiveness and real-time processing for optimization to ensure a easy gameplay in gaming and application. These challenges are important for future improvement of gesture recognition (Saputra & Hariyanto, 2024).

3. <u>Design and evaluation of a hand gesture recognition approach for real-time interactions</u>

Gesture-based interaction represents a powerful system alternative to traditional input devices

in Human-Computer Interaction (HCI). It gives users a natural way to interact with digital systems. Shanthakumar et al. (2020) proposed a real-time hand gesture recognition system in their study. The methodology adopted for this system is based on detection of static and dynamic hand gestures by measuring angular velocity. It was designed for high accuracy, fast response, and smooth performance.

Their method collects data from motion-tracking gloves fitted with inertial measurement units (IMUs). These gloves track the 3D movements of hand and finger joints in real time. The researchers created a set of eight natural gestures for the system. These gestures include swipe, stop, pinch, come, go, drop-in, trash-out, and pointing. Each gesture is defined by joint angles, palm direction, and angular velocity.

The team tested these gestures in two interactive applications. One was a gesture-controlled video game called "Happy Ball." The other was a virtual reality image categorization tool. The system performed very well. It reached a gesture recognition accuracy of 97.3%. Users gave mostly positive feedback regarding the system. According to System Usability Scale (SUS) scores obtained on this system, a score above 90 falls into the classification of "Excellent" (Shanthakumar et al., 2020, p. 17722).

The detection logic of this system can be applied to vision-based systems even though it uses motion-tracking gloves instead of a camera. The method relies on reading vector directions, angle changes, and timing. All of which can also be captured using camera-based tools like MediaPipe. This shows that the method could fit well into the webcam-based system planned for this project.

The study also proves that gesture-based systems can deliver smooth, responsive, and fun user experiences. This is especially true in games, where quick reactions and immersive controls matter most. Remodeling classic games into modern classics using gesture controls has made great strides in gamifying such games and making them more enjoyable and accessible. This trend correlates with the objectives of this project, the revival of the classical Space Shooter game. The plan is to use gesture-based controls to create a modern, interactive, and player-friendly gaming experience.

4. <u>The Role of Gesture-Based Interaction in Improving User Satisfaction for Touchless Interfaces</u>

Among the most inspiring domains of the last decade Human-Computer Interaction (HCI) is gesture-based interaction. A digital system's user experience is vital to naturalize and maximize using gestures, particularly in touchless spaces. Modaberi et al. (2024) confirm that gestures can properly replace traditional input methods like keyboards and touchscreens with developing technology towards more stimulating and natural-like interfaces.

Hand gestures feel more natural to users because they mirror real-world actions. Modaberi et al. have indicated that such control not only enhances usability but also helps in developing a stronger emotional connection between the user and the system. This is especially so in fields like gaming, smart homes, and healthcare where smooth and effortless interaction is vital. Their work would guarantee incorporating gesture controls into the Space Shooter game as a way of reviving it. A more tactile and interactive method of playing may once again evoke interest in new as well as experienced players.

The success, though, of any gesture system to a great extent depends on how accurately a gesture is detected. Modaberi et al. (2024) concentrated on the fact that if the system falsely misreads a gesture, then players get frustrated and the satisfaction level takes a big hit. The observation itself clearly indicates why it is important to include a calibration screen and an intuitive tutorial in the Space Shooter project. Instructing the players on how the system identifies gestures at the beginning will prevent initial frustration and encourage them to play the game further.

The study also raised a positive effect of fatigue on the part of the user. The players would typically be tired after performing large or repetitive motions while playing (Modaberi et al., 2024). That is why there is a need to redesign the Space Shooter to remain true to loose, basic gestures. Basic and little movements like swiping or pointing can maintain the controls active and fun without tiring the players.

Modaberi et al. also showed that people prefer gesture systems that are easy to learn and remember. Simple and direct short gestures like swipes and taps were the base of apps and games that were significantly higher in satisfaction than full-body or long movement-based systems (Modaberi et al., 2024). This is consistent with the objective of having simple gestures for Space Shooter, for example, using an extended hand to control the spaceship and a fist to fire. Simple gestures like these render the game simple enough for anyone to play, including children or individuals who are not familiar with gesture controls.

Lastly, the research highlighted that gesture systems also enhance convenience and hygiene. As no hand contact is required with common hardware, they are particularly convenient in public places (Modaberi et al., 2024). Although Space Shooter is designed in particular for desktop computers, even this hands-free operation remains convenient and renders the game more up-to-date and versatile.

In brief, Modaberi et al.'s research presents satisfactory evidence to deploy gesture controls in the Space Shooter project. When a game is clear, seamless and accurate in gestures, fun, new, and engaging experiences can be expected. That would likely make Space Shooter not only more appealing to experienced players but also for new players searching for something fresh and interactive.

Topic 2: Design Frameworks for Hybrid and Iterative Game Development

1. <u>Human-Centered Design Based on the Double Diamond Model for Optimizing Hybrid Game Design</u>

In 2005, the UK Design Council began the dissemination Define, Develop, and Deliver. The model has been one of the most recognized and structured approaches to design of the Double Diamond model, which mentioned four phases of the design process: Discover, and has since been applied here and there across several design disciplines. However, when it comes to game design-in-particular hybrid games that contain a blend of digital and physical elements- applying the model poses specific challenges.

In hybrid game design, the linear path of the Double Diamond model does not properly portray the iterative and dynamic characteristic of game development. To overcome this limitation, Liang et al. (2024) proposed an integrated framework combining the Double Diamond model with systems thinking, user-centered design (UCD), agile methods, and heuristic evaluation. This hybrid procedure aims to enhance design process flexibility and responsiveness in attaining a more complete integration of both digital and physical components of hybrid games. The intention of this framework is to create iteration cycles with user involvement at every stage to increase overall player engagement and satisfaction in hybrid game contexts.

The hybrid game development models are becoming complex and old models need to rethink and adopt a more flexible, people-centered, iterative approach to meet contemporary demands imposed by player behavior, as elaborated in this literature.

2. <u>The First Diamond is Service Design and the Second is UX/Interaction Design: the Double Diamond Model and Team Roles in Making a Mobile Service Application Using Cross Disciplinary Teamwork</u>

The researches of Suoheimo et al. (2022) explore using the Double Diamond not just as a design process framework but as a collaborative medium that supports team role clarity and interaction in cross-disciplinary service development. They interpret it uniquely, the first diamond is for service design, which emphasizes understanding user needs and defining service objectives, while the second diamond applies to UX/interaction design that emphasizes designing and delivering user interfaces and experiences. This involved creating a mobile application for supporting school principals, calling on such diverse fields as education, service design, software development, and visual communication. The duality of the roles, according to the authors, increases the effectiveness of each design phase through clarity of roles and expectations along competent lines of the team.

Through the prism of role theory, and utilizing visual tools such as persona cards and co-design sessions, the study makes the argument that the early definition of roles and constant communication greatly helped the teamwork, preventing misunderstandings and siloed thinking so often seen in interdisciplinary projects. Suoheimo et al. (2022) suggest that using structured frameworks such as the Double Diamond can help in bridging the disciplines, especially where digital and human-centered design elements are tightly integrated. The results obtained are consistent with the premise that design tools are useful not only for structuring workflow but also for social coordination and knowledge sharing, which become essential for a successful co-creation of digital service applications.

Topic 3: Competitive Dynamics and Player Segmentation in Games

1. <u>Designing Leaderboards for Gamification: Perceived Differences Based on User Ranking, Application Domain, and Personality Traits</u>

Leaderboards have become popularized as a way of getting people to use and become involved with applications and games by appealing to their natural spirit of competition. Research shows that they work best when standards of improvement are easily gauged, like fitness apps where people's step counts yield clear rankings or work settings where productivity can be examined. However, studies warn about the downside of leaderboards. This happen because when people see themselves at the bottom, they may lose motivation rather than be spurred on by possible competition. This means that developers have to be careful about their implementation of these ranking systems.

In terms of effectiveness, the context or application has very unique influences on the operation of leaderboards. The fitness apps seem to benefit most from such systems in that people sort-of enjoy sharing their workout stats with their friends in a healthy manner. Leaderboards tend to fail in social media, as most users do not wish for a competitive environment while trying to socialize. A work environment presumably falls somewhere in between where the best is pushed to better performance by such means, but the underperformers may lose self-esteem even more.

The people's personalities could also influence how they react to leaderboards. For instance, an outgoing natural competitor would love to see their name up in some ranking for everybody to see, while a more reserved person would likely prefer a way to keep track of his or her progress without making too much a fuss about it. This should lead one to conclude that an ideal leaderboard system would then allow different ways of engagement that would include ranking for can be, and to those who do not want competition, progress reports instead. Thus, some interpretation for game developers would emerge in terms of developing flexible systems intended for spurring various types of players, with no one feeling excluded.

2. A Dynamic Model of Player Level-Progression Decisions in Online Gaming

Dynamic decision-making as well as motivational engines have emerged as important aspects of player engagement in progression within online games. (Zhao, Yang, Shum and Dutta (2021)) contribute to this field by modelling how learning processes and risk preferences can influence decisions that players make regarding level progression. It reveals that overconfidence about one's own abilities, along with risk-seeking behavior, tends to be prevalent. This agrees with

earlier investigations in player motivation, such as Huang, Jasin, and Mamchanda. (2019), who revealed that engagement is heavily tied to skills acquisition and reward structures. Incremental content updates also serve the purpose of holding a player interest within an online game. This statement aligns to Albuquerque and Nevskaya (2012), who state that visible and meaningful progression such as character upgrades can enhance retention in games.

The segmentation of players into "Experiencers" and "Achievers" (Zhao et al., 2021) emphasize the necessity of customized progression systems. For instance, Experiencers would rather have many small-scale upgrades that add variety to gameplay, while Achievers would be more appreciative of milestone rewards tied to goal completions. This distinction shows the important of game designers in terms of different playstyles of progression mechanics for enhanced engagement.

The implications for the game design are clear where progression systems would balance uncertainty and predictability in order to leverage the different player risk preferences, along with upgrades (character size, improvements on attack, and defence). This should be made apparent and rewarding for the players. Future research would therefore pursue how dynamic levelling mechanics influence long-term retention and satisfaction of players since, in games where progression is tied to the visible development of a character. Therefore, it plays a critical role in the dynamic levelling mechanics.

Topic 4: Psychological and Motivational Foundations of Game Engagement

1. A Motivational Model of Video Game Engagement

Przybylski et al. (2009) propound a motivational model of video game engagement based on the Self-Determination Theory. This theory argues that three core psychological needs-competence, autonomy, and relatedness- must be satisfied for the player to be engaged positively. Their study reveals that video games capture audiences by addressing these internal needs, thus providing entertainment and lasting commitment.

Competence, the need to feel effective and skilled, is reinforced in games where challenge and player ability are matched. The study reveals that game mechanics promoting skill mastery and progression contribute to long-term engagement. Autonomy, the need for personal control and choice, is supported by aspects that allow players to personalize gaming experiences and

decision-making. Relatedness, the need to connect with other people or socialize, is fulfilled by the multiplayer and co-play by others in the same game, forming social ties or collective experiences shared with them.

The study also examines violent video games in the format of engagement and claims that even when violent in form, the apparent value of such video games is not, in itself due to the content of the violence but rather that the video games usually satisfy that dimension of psychological needs. It may happen that players scoring high on trait aggression are naturally inclined to prefer more violent games, but, according to the present study, violence in itself will not increase fun or immersion.

Through incorporating self-determination theory in relation to engagement with video games, Przybylski et al. (2009) have introduced a theoretical framework through which to understand motivations of players and the success of an ideal game design. Their work underlines psychological needs development in the creation of engaging gaming experiences thus shedding light on researchers and game developers as regards empowering user engagement.

2. <u>Why People Continue to Play Online Games: In Search of Critical Design Factors to Increase Customer Loyalty to Online Contents</u>

The study found that the importance of interaction in online gameplay in retention of the participants and loyalty of the player. It is such that Choi and Kim (2004) argue that repeated engagement with gaming is largely dependent on the effectiveness of interaction that the game offers. The theory proposed by their research presents that the best gaming experiences and subsequently, greater customer loyalty originate from two basic dimensions of interaction which are personal interaction (between players and game systems) and social interaction (among players).

Personalized engagement in an online game can be defined as the problem-solving approach and goal attainment by very good communication between the game system and the gamer. According to Choi and Kim (2004), there are three core elements in such a type of effective personal interaction:

Goals clearly defined objectives help players understand what they need to achieve. Well-informed background, character explanation, and precise goal-setting do not only give a

direction to the player but also a context for the evaluation of progress. This clarity helps maintain focus and contributes to an immersive experience.

Operators are the tools and mechanisms available to players to achieve their objectives. Whether through customizable controls, game mechanics that allow players to make strategic decisions, or systems that enable smooth transitions (such as resuming play from a previous point), effective operators empower players and enhance their sense of control.

Immediate feedback from the game system and accuracy are important. Such aspects of knowledge, such as reward systems, sound effects, and visual cues, give players information on their progress or performance. When feedback is timely, it gives players a more in-depth experience of interaction with the game, increasing their engagement and thus commitment to the game.

These create an environment where an individual can remain challenged as well as constantly informed and guided. It results in a flow state, deep optimal engagement, which is critical to the long-term engagement of the people in the game .

At the same time, Choi and Kim (2004) highlight that effective social interaction can significantly enhance the overall gaming experience by incorporating the following components:

Communication spaces are the virtual places in a game where players go to hang out, talk, and build a community. Immersive nature—3D graphics—realistic or detailed visual environments make one feel as though he or she is in a shared space, which is otherwise mimicking real-life social experience.

A further requirement for online games is providing effective communication tools, in addition to the provision of space for gamers to hang out. Through chat, bulletin boards, and community forums, players can brainstorm, build alliances, and cooperatively accomplish tasks that are part of the game. These tools allow for continuous dialogue from time to time and help render social support, thereby increasing the player's attachment to the game.

Literature Review Table Summary

Authors	Country	Purpose	Type of source	Summary points
Przybylski, A. K., Rigby, C. S., & Ryan, R. M. (2010). A motivational model of video game engagement.	USA	To examine how video games fulfill psychological needs based on Self-Determination Theory (SDT)	Journal Article	The study found that competence, autonomy, and relatedness engage players more immersed in the video game. Games with balanced challenges enhance competence, player choice supports autonomy, and multiplayer features foster relatedness. The appeal of violent games is linked to need satisfaction rather than violence itself.
Choi, D., & Kim, J. (2004). Why People Continue to Play Online Games: In Search of Critical Design Factors to Increase Customer Loyalty to Online Contents.	South Korea	To identify critical design factors that increase customer loyalty in online games	Journal Article	Found that game interactivity, network externalities (social connections), and character competency significantly impact player retention. Players remain engaged when they feel a sense of belonging and progression. Social aspects, such as guilds and teamwork, increase loyalty.
Mr. Siddharth Swarup Rautaray & Dr Anupam Agrawal. (2012). Real Time Hand Gesture Recognition System for Dynamic Applications	India	The purpose is to show system design of vision-based hand gesture recognition for human-computer interaction (HCI) in virtual world	Journal Article	From hard-based transformation to vision-based gesture recognition, give new natural interaction in a virtual environment. Future research focusing on improving accuracy of recognition and wide range of gesture vocabulary. The integration of deep learning models such CNNs, RNNs with advanced 3D depth sensing like Kinect and LiDAR will significantly increase robustness while expanding application in VR, robotics, etc.

Rajhaga Jevanya Meliala, Nur Indah Chasanah, Jonser Steven Rajali Manik, Anggito Rangkuti Bagas Muzaqi, Syah Bintang, Endang Purnama Giri & Gema Parasti Mindara. (2024). Development of Hand Gesture Detection Application for Slap MosquitoGame Based on Image Processing	Indonesia	The purpose is developing an interactive game called "Slap mosquito" that uses gesture recognition through image processing that give a natural and greater gaming performance with computer vision technique like OpenCV and real- time detection.	Journal Article	Simulate gesture recognition is an approach used in interactive gaming that comes with high performance in exchange for optimization of lightning condition and system performance. The future approach such as deep learning models improved adaptability, depth-sensing (Kinect) to increase robustness and expanded gesture vocabulary for complex interactions. These improvements could overcome the gap between gesture-based control and human-computer interaction that expands gaming to broader domains.
Yuan Jia, Yikun Liu, Xing Yu & Stephen Voida. (2017). Designing Leaderboards for Gamification. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*.	USA	To examine user preferences and perceptions of the leaderboard in gamified systems depend on either their own ranking position or the ranking of others.	Journal Article	The study found that leaderboards are a gamification tool that motivate users through social comparison. However, the effectiveness depended on the user's ranking and personality type, and the domain of the application. Users with high scores and users with more extroverted traits showed positive reactions toward the leaderboard feature.

Zhao, Yi, Sha Yang, Matthew Shum & Shantanu Dutta. (2021). A Dynamic Model of Player Level-Progression Decisions in Online Gaming.	USA	To develop a dynamic rational bounded model for predicting players' decision-making processes in play-or-quit situations during level progressions in online games, as well as their risk preferences.	Journal Article	This study proposes a dynamic structural model according to which online gamers take decisions regarding level progression on the basis of expected utility, learning, and bounded-rationality. The model also differentiates the two player segments which is "Experiencers" and "Achievers". In addition, the model provides design recommendations towards audience participation and revenue enhancement.
Risheng Liang, Sauman Chu, Debra Lawton, Guobin Pan (2024). Exploring the application of the Double Diamond design model in hybrid game design: Integrating human-centered design principles to enhance user experience and gameplay.	USA (University of Minnesota Twin Cities)	The objective is to explore the application of the Double Diamond design model in hybrid game design, focusing on the integration of human-centered design principles in enhancing the user experience and gameplay.	Journal Article	This study explores the Human-Centered Design (HCD) principles that govern the Double Diamond Model-stages of Discover, Define, Develop, and Deliver-for the further improvement of hybrid game development by focusing upon iterative enhancements, user-centered insights, and interdisciplinary cooperation. In this context, it highlights the real and virtual blend in hybrid games. It further outlines design chapters, challenges, and best practices in order to achieve an enjoyable experience for the player.
Mari Suoheimo, Saana Korva, Tuija Turunen, Satu Miettinen.	Finland & Norway	The Double Diamond model and visual tools explore how they enhance	Peer – Reviewed Conference Paper	The Double Diamond model with the first diamond containing Service Design and UX/Interaction Design in the second; thus,

(2020). The Double Diamond model and visual tools: How they enhance role clarity and collaboration in cross-disciplinary teams.		role clarity and collaboration in the cross-disciplinary team concerned with the design of a mobile service app.		making it a structured framework for multidisciplinary teamwork. And, using role theory, the cross-disciplinary team dynamics are studied, while visual tools like persona cards can be used to improve communication and understanding across disciplines. Design phases and roles become more visible so that co-creation is encouraged with collaboration throughout the process.
Vaidyanath Areyur Shanthakumar, Chao Peng, Jeffrey Hansberger, Lizhou Cao, Sarah Meacham, Victoria Blakely. (2020). Design and evaluation of a hand gesture recognition approach for real-time interactions.	United States	To provide a comprehensive review of hand gesture recognition systems based on computer vision techniques, focusing on recognition algorithms, implementation challenges, and real-world applications.	Journal Article	The study introduces a gesture recognition method using sensor-based motion tracking and an angular-velocity approach. It overcomes common vision-based issues like hand occlusion and environmental limits. The system, designed for motion-tracking gloves, shows 97.3% accuracy and low latency. Its ability to recognize static and dynamic gestures makes it suitable for gaming and virtual environments, which relates to the project's webcam-based gesture control.
Majid Modaberi. (2024). The Role of Gesture-	Iran	To examine how gesture-based interaction affects user satisfaction in	Journal Article	The study explores gesture-based interaction in touchless user interfaces. It shows that well-designed gestures improve usability, reduce effort, and increase user

Based Interaction in Improving User Satisfaction for Touchless Interfaces.		touchless interface systems, focusing on factors like usability, intuitiveness, and emotional engagement.		satisfaction. The results highlight that gesture controls offer a more natural experience and boost engagement, effective for improving human-computer interaction especially in interactive and accessible systems.

Summary

This literature review had examined the main aspects on the development of hand gesture recognition systems, gamification strategies, modeling engagement processes for players, and human-centered design methodologies with a focus on framework of interactive gaming applications. Recent advancements in vision-based gesture recognition demonstrate efficient capabilities on the way natural user interaction adopts, using different techniques such as Haar-like classifiers, MediaPipe for real-time hand tracking. However, limitations of these systems arise from environmental factors such as lighting conditions and background interference. The complementary research on IMU-based glove systems (Shanthakumar et al., 2020) gives very high accuracy values of 97.3% and utility scores of more than 90 in SUS. Thus, showing great potential for synergies with the other one based on the camera. Regarding the user experience (Modaberi et al. 2024), it shows that gesture-based interfaces enhance engagement through intuitive interaction. Still, they have to emphasize critical design criteria such as gesture simplicity, recognition safety, and fatigue mitigation.

The review discusses the psychological and behavioral aspects of player engagement. The leaderboards have varying effectiveness on the context and seem to have a most impactful effect in fitness applications, whereas they may demotivate lower-ranked players in some contexts. Player motivation studies have identified distinct behavioral type, with "Experiencers" derive satisfaction from gameplay processes while "Achievers" focus on goal completion (Zhao et al., 2021). These findings align with Self-Determination Theory (Przybylski et al.), which identifies competence, autonomy, and relatedness as fundamental drivers of sustained engagement. In addition, social interaction and responsive feedback systems (Choi & Kim, 2004) are key factors for player retention emphasized in the research.

In terms of design, the Double Diamond model shows a valuable framework, although its classical linear structure that require modifications in a hybrid game development setting. Recent work by Liang et al. (2024) proposes an integrated framework to coordinate the Double Diamond model with systems thinking, user-centered design (UCD), agile methods, and heuristic evaluation to handle the complexities arising from the digital-physical integration. Complementary studies on cross-disciplinary collaboration (Suoheimo et al., 2022) illustrate how structured design processes can improve teamwork efficiency and output quality in complex projects.

One major insight that the studies provide is in the development of gesture-controlled gaming systems. The main recommendations include developing robust gesture recognition with easy calibration for users, building progression systems that appeal to various player motivations, and employing flexible design methodologies within iterative processes. Future advancements could benefit from integrating machine-learning technologies to enhance gesture recognition and developing adaptive gamification features responding to the actions and preferences of the individual player. Thus, this research synthesis provides a very strong theoretical basis for making engaging, entertaining, yet accessible forms of gesture gaming.

Methodology

Project Methodology

Double Diamond design methodology has been used to structure this project, which comprises four simple yet efficient steps: Discover, Define, Develop, and Deliver. In the Discover phase, the original Space Shooter game is explored to identify factors that caused its reduced appeal for the modern player, including outdated control schemes and engaging mechanics. The phase focus on examining the current trends in gesture-controlled games, limitations of existing space shooter titles, and the user needs and expectations. The data of this discovery will be sourced from various platforms like the online forums, academic research and similar initiatives that utilized AI-based hand gesture recognition. Moreover, a preliminary survey will be distributed to potential users in order to identify which features and control options would most appeal to them. Define phase involved setting the objectives for modernizing features like hand gesture controls and level-up systems as well as a leaderboard, making gameplay much more interactive and rewarding for players.

Figure 6: Low-fidelity design showcasing improvements and newly added features such as level-up, leaderboard, and hand gesture control options.

In Develop phase, these features are built and integrated into the game. This includes gesture detection using a webcam, designing the required progressive system through which players can level up, and adding a leaderboard to check high scores recorded. Testing the new version by real users and collecting their feedback to modify the final product completes the Deliver phase.

Target users are casual players between the ages of 13 and 34 who are able to use hand gestures physically. Sample from 5 to 7 individuals will be selected and assigned into treatment groups familiar with basic gaming. These users will participate in A/B testing, by completing the whole game sessions with both the original keyboard-based version and advanced gesture-based version of the game.

A structured questionnaire will collect data from participants after they play the enhanced Space Shooter game. Player evaluation will be measured on a Likert scale on different game issues such as control accuracy, ease of use, enjoyment, level of challenge, and representation of overall satisfaction. The study will aid in understanding the sentiments of players toward the new and evolving gesture control system, level-up feature, and leaderboard. The questions are also supposed to check whether or not improvements in the overall gaming experience have occurred with the new features compared to the previous version.

Lastly, basic statistics like averages and frequency counts are used in analyzing the results. Two versions of the game will be compared to see which version players would choose. All participants shall give informed consent, so their data will be anonymous and secure. System lags and hardware limitations sometimes occasionally pose hurdles, but in the end, the project results in a more modern thrilling twist to a classic game. The whole project anticipation is that it would last around 3 to 4 months.

Project Timeline
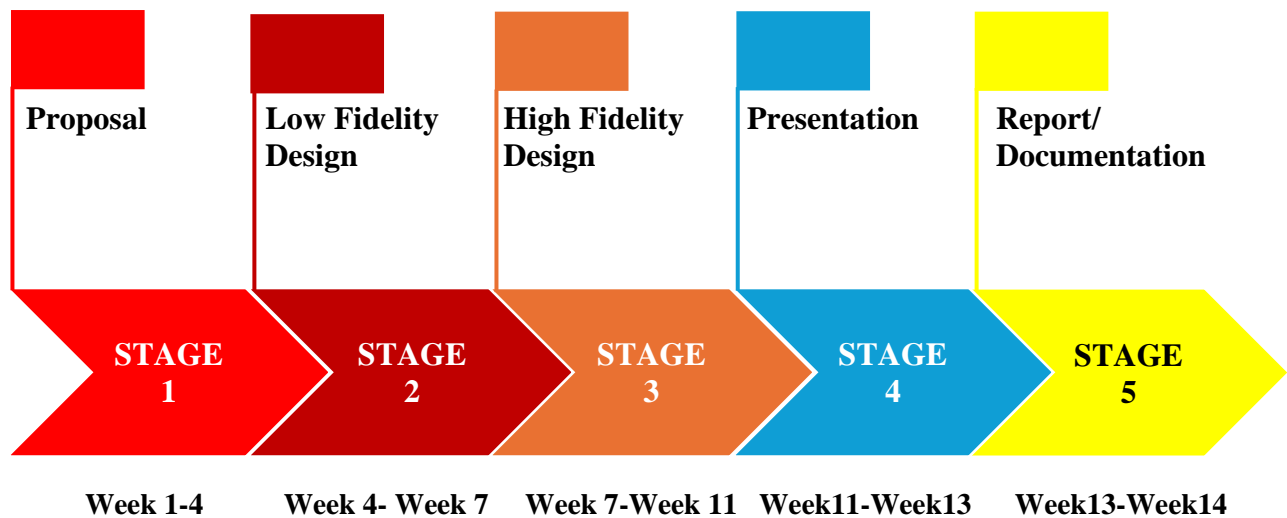
Stage 1: Proposal:

Identify the problem, define the target users, and outline the goals and features to improve the previous system.

Stage 2: Low Fidelity:

Create simple sketches or wireframes to visualize the basic layout and user flow of the game interface.

Stage 3: High Fidelity:

Design a detailed and visually complete prototype showing the game interface's final look, feel, and interactions.

Stage 4: Presentation:

Prepare and deliver a visual pitch explaining the problem, solution, design process, and improvements.

Stage 5: Report/Documentation:

Compile a formal write-up covering all stages, justifying improvements, and reflecting on the overall process.

Task Distribution Table

Name	Stage	Task
Daniel Jakson	Proposal	- Executive Summary - Project Methodology - Project Timeline - Read and write 2 Literature Review
	Low Fidelity Design	- Sketch wireframe for Main Menu & Gesture Setup Interface (UI where player enables/configures hand movement detection) - Run an interview session for 3 users to gather the feedback using A/B testing
	High Fidelity Design	- Design detailed interface for Gesture Setup and Main Menu
Tan Hou Ren	Proposal	- Background Study, Problem Statement & Project Objective - Read and write 2 Literature Review
	Low Fidelity Design	- Sketch wireframe for Gameplay Interface with Level-Up UI - List out the functional and non-functional requirement
	High Fidelity Design	- Design full Gameplay screen with visual assets for level progression
Muhammad Azri Asnawi Bin Kamal Arifin	Proposal	- Development (Project risks and payoffs & Project cost & Evaluation) - Read and write 2 Literature Review - Design Use Case Diagram

	Low Fidelity Design	- Sketch wireframe for Leaderboard Interface and Game Over Screen
	High Fidelity Design	- Design detailed Leaderboard and Game Over screen with animation or effects to show rank changes, etc. - Add head-up display (HUD) will show the player's level, health status, score, and power-ups during gameplay
Lim Wei	Proposal	- Scope and Limitation of the study - Significance of the report - Expected Output - Read and write 2 Literature Review
	Low Fidelity Design	- Ensure consistency across all wireframes (fonts, layouts, flow) - Add Accessibility Options Wireframe (e.g., hand detection sensitivity, colour modes) - Do summary and analysis based on the interview session responses.
	High Fidelity Design	- Design Settings & Accessibility Screen with toggle controls for gesture calibration and visual/audio options
Maithilly A/P Partiban	Proposal	- Development (Users & Methodology – Double diamond) - Read and write 2 Literature Review
	Low Fidelity Design	- Create User Flow Diagram from gesture setup → gameplay → level up → leaderboard

		- Build Interactive Prototype (Figma) showing gesture-based transitions (e.g., swipe to shoot, move to navigate. - Design an activity diagram
	High Fidelity Design	- Design a hand gesture icons or indicators to guide the user before the game start

For Stage 4 (Presentation) & 5 (Report/Documentation), the whole group member will work together collaboratively.

Development

Users

The target demographic for this enhanced Space Shooter game primarily includes casual gamers, students, and technology enthusiasts who are interested in innovative interaction techniques such as gesture controls. Typically, these users are aged between 13 and 34, enjoy brief yet immersive gameplay experiences, and are open to discovering new gaming formats that move beyond traditional input methods.

In addition, gesture-based controls provide an alternative for those with accessibility barriers that becomes necessary when using physical controllers or complicated keyboard setups. Insights gleaned from this vastly varied population of users just might hold the key to designing intuitive controls, game mechanisms that are entertaining, and poner improvement in overall usability.

The surveys, usability testing, and A/B tests are used as tools throughout the course of development using a given methodology that will therefore enable the design to meet the expectations of the users soon after launch to sufficiently collect feedback on the likelihood of having an impact on user experience.

This project uses the Double Diamond Design Methodology, under which there is a diversely segmented four phase activities of Discover, Define, Develop, Deliver. This framework ensures that the design process is user iterative focused and leads to the production of finer products.

Methodology
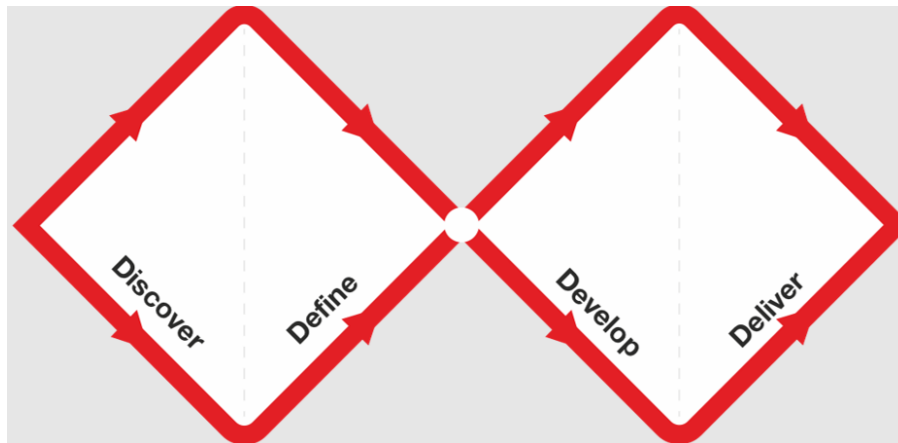
1. Discover

Research was conducted, during this phase, on gesture-controlled gaming trends, limitations of current space shooter titles, and the changing user expectations. The data sources were academic journals and publications, gaming forums, and earlier projects with AI-driven hand gesture recognition. It also sent out a preliminary survey to potential users aged 13-34 for providing insights into desired gameplay features, usability expectations, and preferred methods of control. This information fueled the identification of user pain points and helped in prioritizing the features.

2. Define

Insights into this period of discovering which were analyzed and synthesized into one central design question: "How can we engage users better and provide more interaction with a classic arcade-like space shooter through gesture controls based on artificial intelligence instead of traditional input methods?" This then led to core objectives around and success metrics, including:

- Real-time hand gesture recognition using a standard webcam.
- A progressive difficulty system to maintain player challenge.
- A real-time leaderboard for competitive motivation.
- Ensuring fluid, uninterrupted gameplay with natural, intuitive controls across different devices.

The success criteria were defined by responsiveness, user satisfaction, system stability, and gameplay enjoyment.

3. Develop

This phase focused on the implementation and integration of key features. The following components were developed:

a) Hand Gesture Recognition System:
Real-time webcam captures using OpenCV in tandem with MediaPipe or some equivalent AI-based hand-tracking frameworks are utilized for accurate gesture detection. Certain key gestural commands (like rotation of the hand to the left and right to move the spaceshoot) were mapped to in-game action. Calibration tools were added to suit individual hand sizes and lighting conditions.

b) Game Mechanics Integration:
The gesture control module was embedded in the Python engine of the Space Shooter game. The above work involved creating logic for signal processing to maintain low-latency input response like the promptness of conventional controls.

c) Low and High-Fidelity Prototypes:
The low and high-fidelity prototyping was done using Figma to give a clear picture of the bare-bones structure and user flow through the game. These prototypes were identified in terms of main screens-from the main menu to the gesture setup interface, display of gameplay, level-up notifications, and leaderboard. These were intended to show the way players will move around the game-from configuring gesture controls through engaging in gameplay and then reviewing their progress.

d) User Testing (A/B Testing):
Both gesture and keyboard control versions of the game were played by the participants. Due to the structured feedback formats used for data collection, several qualitative and quantitative measures were collected, including control accuracy, ease of learning, and levels of engagement. Feedback from this phase was then used to adjust gesture recognition thresholds, UI layout design, and animation response buildup time for an even better player experience.

4. Deliver

In the final stage, the refined version of the game was deployed for broader testing and evaluation. Specific deliverables and evaluations included:

a) Final Survey and User Evaluation:

The participants were involved in a structured questionnaire measuring satisfaction, usability, and immersion in gameplay, with emphasis on gesture systems as methods of specific evaluation compared to traditional controls.

b) System Testing and Optimization:

The test was carried out over several devices so that performance does not vary with varying quality of cameras or computation power. Adjustments have been made for minimum lag with fallback mechanisms for recognition failure.

c) Cost-Benefit and Feasibility Analysis:

An overview cost analysis was performed as a first step to investigate the feasibility of integrating gesture controls into mainstream games. Webcam gesture input was found to be inexpensive and quite compatible; nevertheless, the variance among hardware and lighting conditions could be potential drawbacks.

d) Gesture Implementation Summary:

The finalization of the gesture control system allowed total integration, thereby enabling players to navigate using intuitive movement of their hands. Instructions were superimposed on-screen, along with feedback icons to guide potential players unfamiliar with gesture input.

Project payoffs

The project we are developing is a system that can enable users to control the game using hand gesture movement with integration of AI which is pattern recognition and a model to train user hand gesture. This can help users from using the keyboard for too long that can damage over the time when they click frequently. Users also can compete with other users with their score points to achieve in the leaderboard with different levels and character.

Project risks

The project comes with multiple risks which can lead to system failures. One of them is performance limitations caused by old CPUs or GPUs that are outdated which can cause lag because our system applies real-time image processing that consumes a lot of resources like delayed character movement and unresponsive controls. There are also hardware constraints that interrupt the game which is a poor-resolution camera that reduces gesture detection accuracy.

Project cost

The project cost is RM 0. It is because developing the entire system, we are using open-source resources. All code was written from publicly available documentation from open-source platforms such as GitHub, YouTube tutorials and official project websites. This website can be accessible to all developer communities which is effective for development. Additionally, there is AI documentation at official websites such OpenCV and TensorFlow that give a guide to complete the project.

Evaluation

The project evaluates based on Gaming skills questionnaire where it is designed to check player's skills and engagement with six different video games genres that ask player's how **frequently they play** and **self-assessed skill level** in the game. These questionnaires give out user strategic thinking in game situation, technical skills to game's settings and tools while examining teamwork and communication in progress and self-assessment.

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