

## Endure: Augmented Reality Fitness Mobile Application

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**Abstract**—An alarming fact that surprisingly not many locals are aware of is that Malaysia has been labelled as Asia’s fattest country in the year 2015 up until now. With abundance of food comes immense responsibility to take care of our health, however that is not the case for Malaysians. Based on the survey distributed, not many integrate exercising as a part of their weekly routine as they prioritize their work/study over a 20-minute workout session. The repercussions of this unhealthy habit are severe, and may cause a global pandemic of obese-stricken populations in the future. With that being said, ‘Endure’ is an application proposed to aid in mitigating the issue mentioned. It is a fitness application that incorporates a gaming environment enabling the user to be the first-person player in a horror-themed game. Using immersive technology such as Augmented Reality (AR), users are able to play this chapter-by-chapter application whilst outdoors or indoors. Endure encourages users to challenge themselves by increasing the distance for each level while limiting the time required to complete each one of them. With the aid of an AR game object, users will be pushed to keep their virtual-selves alive by increasing their pace with regards to the countdown timer. In short, the application is developed to motivate users to keep their feet moving by creating a virtually fun environment for the players.

**Keywords**—augmented reality; game; fitness; mobile

### I. INTRODUCTION

Fueled by the need for a better healthcare system that could potentially bring about a significant change in our overall wellbeing, the Malaysian Ministry of Health (MOH) has transpired numerous methods in tackling this predicament. Nevertheless, there seem to be a recurring issue when it comes to the prevalence of chronic diseases related to excessive weight gain especially obesity, followed by heart conditions, that has been observed to increase the mortality rate of Malaysians over the years.

A recent study by The Lancet, a British medical journal, proved that Malaysia holds the number one spot as the most obese country in Asia. This alarming fact was later supported by a survey conducted by the National Health and Morbidity in 2015 that revealed almost half of the local population aged 18 and above (47.7%) were overweight as well as obese [1]. Despite the availability of various fitness applications designed to motivate users and keep track of their health status, it appears that there is no traction when it comes to

the features they provide which could keep the users engaged and committed till it brings about significant changes as most millennials are easily bored with applications that do not have a fun factor incorporated in them, consequently, the applications are uninstalled in a mere month as they fail to discipline the user.

As one of the top Asian food paradise, the local culinary diversity plays an important role in Malaysia’s travel and tourism sector. However, this has brought about several adverse effects to our community whom have yet to inculcate a healthy lifestyle despite knowing the repercussions of detrimental eating habits.

The very core of obesity in young adolescence is the way they carry out their lifestyle as well as the lack of exercise involved in their daily routine. A research shows that from a sample of 122 people, only 39.3% were reported to have taken the initiative of trying to lose weight [2]. Additionally, most of them preferred quicker methods such as slimming products over a healthier regime or a change in their diet.

As food is abundant, many are still unaware of the negative implications of unhealthy dietary habits [1]. By taking a look at our closest relatives, friends or even ourselves, not many can agree that they were introduced to a casual workout routine since young. Consequently, most of us come to a realisation when the effects have manifested into a more severe chain reaction of chronic diseases.

Various fitness or running applications that are available on the market have yet to tap the fun factor in order to promote physical activities in an exciting manner. Oftentimes, users are required to take the initiative to run, jog or walk while solely depending on their own will to push forward. The applications do not provide sufficient incentives that are able to encourage users to consecutively use the application to actualize their weight goal.

As the statistics have bought to light a critical issue that could eventually affect all of our wellbeing if not dealt with promptly, there is a need for an alternate approach to tackle this national disease. Henceforth, Endure, an application that creates a dynamic videogame setting for users to experience in real life, is a solution that is able to motivate users to assimilate endurance activities – running, jogging and/or walking – in their day-to-day lifestyle.

This paper is structured as follows: Section 2 reviews on several related work with comparisons. Section 3 explains the methodology and findings from questionnaire survey.

Next, section 4 discusses on features of Endure. Lastly, Section 5 presents conclusion and future works.

## II. RELATED WORKS

In this section, the review of the similar mobile applications developed by others are discussed. Many mobile applications that serves the purpose of keeping the user fit and healthy via endurance activities is available in the market such as Runkeeper [3], Couch to 5K [4], and Zombies, Run! [5], which will be discussed next. The review discussed will be based on distance calculator, augmented reality, countdown timer, audio input, and motivational factor features.

### A. Runkeeper

Runkeeper is an application that basically encourages their users to run by enabling them to set goals and keep track of their progress along the way. This application utilizes the GPS function for users to view their training efforts by comparing the distance covered on the map provided [3].

Runkeeper helps user to track workouts, set goals, follow a running plan, stay motivated, and see their progress in an easy-to-use interface [6]. One of the main features of Runkeeper is tracking activities, allows user to track and display their attempt at running, walking, jogging and/or cycling daily. The user is able to set a certain goal to achieve and the application will assist them in reaching their target in terms of distance covered, weight or pace. It also helps runners of all levels including beginners [7]. Through a personalized plan, the application customizes the user's workout routine in order to accommodate their busy schedule. A motivation feature is also embedded in this application by allowing user to join challenges, obtain rewards, and share achievements with friends.

### B. Couch to 5K

The Couch-to-5K encourages users to work out 3 times a week for just 30 minutes and in a mere 9 weeks, users are said to be able to complete a 3.1-mile run. As the application is used, the runner's time and distance are tracked via GPS and recorded onto their website, active.com. The distance and pace run by the user are calculated using the GPS function.

The users are also motivated by a virtual coach who gives constant cues verbally about the ongoing training [8]. It runs in the background and only chimes in to tell user when to walk, jog, or briskly walk [9]. This feature will guide the user throughout the workout session.

The user also able to set their own playlist with music provided by their in-app song player. This feature might influence their mood while working our session takes place. This application has an option for the user to share their workout progress on Facebook.

### C. Zombies, Run

Zombies, Run! is an application that integrates an immersive storyline by placing the user as a runner who needs to collect supplies to live in a zombie infested world

[5]. As the user runs, small portions of the plot in the form of announcements are provided via periodical interruptions.

With the Zombie Chase feature, a siren sound is initiated to push the user to quicken up their pace in order to outrun the zombies. Through a plot-based game, the user is a runner whom which hundreds of lives are counting on in order to get supplies and avoid the zombies. User picks a mission before they start their run and let it play [10].

The game progress is recorded in the form of graphs to enable users to get a clearer picture of their development. Users can register online for free on their ZombieLink website and they will be allowed to share their progress online together with their run history.

Similar with Couch to 5K, a personal playlist feature is available in this application that allow users to customize their own playlist before running. There is also an option to upgrade the application to a Pro version. The Pro version consists of 200 sets and more missions which can be unlocked for the price of RM16 per month or RM100 per year [11].

Table 1 shows the features comparison of the existing mobile applications based on selected specifications as follows:

- Distance Calculator (DC) – A feature that computes the distance run by the user and records it on a daily basis for the user to view their progress
- Augmented Reality (AR) – An interactive feature that will keep the users wanting to continue running and not get bored easily in order to achieve their goal.
- Countdown Timer (CT) – A feature that pushes user to complete a specific distance within a set amount of time.
- Audio and Vibration Input (AVI) – Continuous audio feed such as music or additional sound effects to prevent the user from being distracted as well as maintaining their pace.
- Motivational Factor (MF) – A feature that provides a reward-like feeling for the user by incorporating bonuses and/or store function in which users can customize or utilize their rewards.

TABLE I. FEATURES COMPARISON

Features	Mobile Application			
	Runkeeper	Couch to 5K	Zombies, Run!	Endure
DC	√	√	√	√
AR				√
CT				√
AVI		√	√	√
MF	√	√	√	√

## III. METHODOLOGY

In collecting insights and evaluating information for this project, two methods have been reviewed and chosen, that

are, document review and questionnaire under the qualitative and quantitative research categories respectively.

#### A. *Document Review on Obesity in Malaysia and Benefits of Physical Activity on Health and Fitness*

A newspaper article reviews the analysis conducted and deductions conjured by the Economist Intelligence Unit in their “Tackling Obesity in Asean” report [12]. It has been inferred since 2014 that Malaysia has the highest obesity rate in the whole of Southeast Asia. Based on their study, 38.5 percent of Malaysians were overweight while the overall pervasiveness of obesity was at 13.3 percent. In the year 2016, this predicament has cost the country approximately RM4 billion to RM8 billion. This figure was depicted as almost a quarter of the Malaysia’s expenditure on healthcare. Due to this growing condition, females of age seven to twelve were already said to have developed the symptoms of obesity, thus causing a huge decline in the future productivity of Malaysians. Furthermore, it was reported that only a third of Malaysians carry out a proper exercise routine. Ultimately, most locals do not take obesity seriously as they assume it is only a physical issue and not a morbid disease.

Another article studies the benefits of physical activity in terms of health and cardiorespiratory fitness [13]. Basically, an increase in workout and exercise are said to be correlated with lower susceptibility of cardiovascular diseases. Plus, physical activities may mitigate the possibility of contracting high blood pressure, stroke, diabetes and even cancer. Currently, it is suggested that a minimum of 150 minutes of moderate to strenuous physical activity per week in sessions of 10 minutes may possibly lower the risks of acquiring chronic diseases. In short, the perks of exercising can be depicted in a “dose-response” relationship that is, the more frequent physical activities are carried out, the greater the positive impact is on one’s health and wellbeing.

#### B. *Questionnaire Analysis*

As user’s requirement is a crucial part in determining the functionalities of a system, questionnaire is one of the two choices of data gathering methodology in this project. This technique is able to cover a large number of respondents as it is distributed online via social media platforms, besides being cost-effective and eco-friendly as no papers were wasted in acquiring the necessary data.

This survey is divided into several sections, each consisting questions of related topics, some of which participants are presented with based on their answer in the previous section. The questionnaire begins with demographic questions regarding the respondent’s personal information and perception of their own fitness level, followed by questions regarding the respondent’s daily activities and frequency of carrying them out, their method of maintaining a healthy lifestyle as well as their opinion on the existing applications on the market and the significance of several features that will be implemented in the proposed application.

The questionnaire distributed garnered 105 responses, and the analysis of the answers in each section are evaluated sequentially. Out of the 105 responses, 59 were females, making them the majority population of respondents while

the remaining 46 were males. The majority respondents were of age 20 to 29 years old, followed by respondents of age 50 and above, with a sum of 58 and 20 responses respectively. There are 20 responses from the age group of 12 to 19 and 30 to 39 years old. Only 7 responses were recorded by the age group 40 to 49, making them the smallest population of respondents in regards to their age. Based on this data collected, this survey consists of a widely distributed age group enabling a more holistic analysis to be conducted.

Majority of the respondents are students and this information tallies with the previous question on the age group as the largest number of respondents are of age 20 to 29 years old. Second to that is the employed/self-employed group, making up a total of 32 responses out of 105, followed by a tie between unemployed and retired at 7% each. Knowing the occupation of respondents is vital in order to understand the intensity of their day-to-day activities as students and employed participants are guaranteed to carry out some form of exercise, be it running to catch a bus or walking from one place to another, to an extent that is, whether at school or work.

Based on the respondents’ input on their weight (in kilograms) and height (in meters), the highest weight in relation to height is 157.3kg (with a height of 1.78m) while the lowest weight recorded is 42kg (with a height of 1.76m). These data are crucial in determining the Body Mass Index (BMI) which can be utilized in order to analyze the criticality of an average person’s weight status.

BMI is calculated by dividing one’s weight in kilograms by the square of height in meter. By referring BMI calculations derived from Centers for Disease Control and Prevention [14], the survey reveals that majority of the respondents weigh within the average range. However, the second highest range appears to be between 24.9 to 29.9 which is considered as overweight on the BMI scale. This is followed by the underweight category and finally the obese fraction which sums up to a total of 12 and 10 respondents respectively. By comparing their input and the standard BMI scale, 23 out of 105 respondents were inaccurate about their size and 22% of the respondents considered themselves as average-sized while actually being either overweight or obese.

Respondents are also required to rate their current fitness level on a scale of 1 to 5, with ‘1’ being ‘fit’ and ‘5’ being ‘unfit’ in this question. Majority of the respondents, making up 41% of the total responses, rated 3 indicating that they are at an average fitness level. On the other hand, 18.1% rated ‘4’ and ‘5’ equally implying that they are either close to being unfit or agree to an extent that they are unfit based on their personal judgement. The remaining 22.9% rated themselves as close to being fit or fit, indirectly indicating their confidence about their health and well-being. Based on this, more people acknowledge the fact that they are unfit and this indicates a positive sign to begin their journey in improving their lifestyle via the proposed application.

Another question elicits respondents’ method of transportation in order to distinguish the extent of movement one carries out on a day-to-day basis. From the result, it clearly indicates that the most popular way of commute is by

car or motorcycle, making up 76.2% of the total responses. Second to that is by walking, in which 18.1% of the respondents chose, indicating that more people travel via vehicles as compared to by foot. The least preferred methods are by public transportation and bicycle, having a total of 8.6% responses for each.

Based on the responses on the frequency of exercise, almost half of the respondents do not exercise regularly, indicating that they either rely on their daily movement from one place to another as a form of exercise or have no regards at all in ensuring a proper exercise routine. Interestingly, 22.9% of the respondents claimed to exercise 2 to 4 times a week, which is a higher percentage as compared to the 19% of those whom workout about once a week. The least number of respondents were recorded for exercising 5 to 7 times a week, in which only 8.6% respondents conduct on average. Discerning the regularity of exercise enables us to determine the perseverance of the general public in maintaining a healthy lifestyle.

In rating respondents on their current motivation level to exercise on a scale of 1 to 5, with '1' being 'high' and '5' being 'low'. Majority of the respondents rate a '3', indicating that 41% of the total are motivated to an extent but neither too high nor too low. This is followed by lowly motivated respondents making up 17.1% of the total responses, while 16.2% of them have between medium to low level of motivation. Only a mere 11.4% of the respondents rated '1', implying that they have the right amount of motivation stemming from several personal factors that enable them to exercise consistently on average.

A large number of respondents, 42.9% specifically, claim that they only exercise less than 20 minutes on average whereas the smallest group claim to exercise 20 minutes a day. This vast difference implies that many people are unaware of the positive impact exercise can bring about when carried out at the recommended regularity of 20 minutes a day for 3 days per week.

Another question elicits the most familiar activities respondents carry out whether it is regular sports (e.g. football, badminton, etc.), jogging and/or running, swimming, dancing, hitting the gym or none, as they prefer to sleep instead. Majority of the respondents answered jogging and/or running, making up 38.1% of the total responses. This supports the intention of the application proposed as it encourages users to get their feet moving via endurance activities as mentioned. The least popular activity carried out by the respondents is dancing followed by swimming and regular sports.

Respondents are also required to rank three activities that are, walking, jogging and running with its regularity whether they are carried out every day, regularly, sometimes or not at all. For walking, majority of the respondents answered every day, while jogging and running are carried out sometimes. Based on these findings, it can be said that people lack of motivation and purpose in order to inculcate simple activities as mentioned above into their daily routine.

Regarding respondents' discipline towards healthy exercise habits via application, majority of the respondents answered 'no', making up 40% of the total responses. This

indicates that either a large number of people are unaware of the various fitness application that are available on the market or the existing application are not interesting enough to be used routinely.

In responding to the purposes of utilizing the fitness application, majority of the respondents (56.5%) use the application or method in order to increase their current fitness level. Second to that is to lose weight, covering 47.8% of the responses. The least popular reason is to compete with friends, making a total of 11.9% and 8.7% respectively in each graphs above.

Respondents ranked the existing application in terms of user interaction, motivation factor, accuracy (GPS, distance calculator) and fun factor. They are required to rank each element with either excellent, good, fair or poor. For user interaction, majority ranked "good" followed by "fair", indicating that the current appeal of application is at mediocre level. For motivational factor, most respondents also ranked "good" and "fair" with "excellent" being the least ranked, implying that the existing application are not functioning at its prime in terms of encouragement.

On the other hand, majority of the respondents ranked "good" for accuracy and this proves that the present technology that is readily available can be said to be reliable as the calculations and calibration are close to being precise. As for the fun factor, most respondents ranked "good" and "fair" indicating that the current exercise application provide only average excitement for users to persist in achieving their fitness goals. Based on the results, we can deduce that the existing application in general is lack certain important elements mentioned in this question in order for users to persevere and continue utilizing the application.

Respondents are required to rank a number of features which are, distance calculator, game challenges and scoreboard that will most likely be implemented in the proposed application. They may choose to rank each feature with "very important", "important", "moderately important", "slightly important" and "not important". Based on the number of respondents recorded in the range of necessity for each feature, it is clear that majority of the ranking falls under "important" and "very important" indicating that every feature stated has a level of significance in contributing to a dynamic application.

### C. Prototype Development

For the development, Unity3D is chosen to develop the AR elements of this project, which includes the cannibals and collectibles. This software aids in incorporating "markerless" AR images using their Simultaneous Localisation and Mapping technology in order to place the said images at random locations.

## IV. FEATURES IN ENDURE

As discovered through reviews, there is no doubt that the existence of fitness application is plentiful with a common goal of motivating users and improving their health status. However, most application fail at bringing about changes and keeping the users engaged for a short period of time, thus, becoming obsolete in a mere number of months. As the

statistics have brought to light several critical issues revolving around weight gain and its consequences that could eventually affect all of our wellbeing if not dealt with promptly, there is a need for an alternate approach to tackle these problems.

Besides mitigating the issues mentioned, ‘Endure’ is proposed to encourage users to get their feet moving via an immersive audio adventure, packed with contemporary technology using AR. This application provides users with a dynamic videogame setting for them to experience in real life as well as a solution in motivating users to assimilate endurance activities – running, jogging and/or walking – in their day-to-day lifestyle.

Endure is developed on the idea of entertainment sports, in which the application can provide a massive load of fun, just like one would experience whilst playing a virtual game, with an added benefit of improving their health. Primarily, the application functions on a chapter-by-chapter basis in which the user has to run a certain distance that would gradually increase as the game progresses to the consecutive chapter. This concept can be said to be the rewarding factor for the user as they will be able to experience a sense of accomplishment once they have reached the goal of each chapter.

Endure consists of several functionalities all in which works in relation to one another to create a gaming environment for the user. When initiating the chapter, for instance, if the user selects Chapter 1, he or she would have to cover 500 meters in order to reach the goal of the chapter. The chapters’ increase in difficulty in terms of distance with regards to a set countdown timer respective to each chapter. The countdown timer is set to 350 seconds based on a calculation done by dividing the average speed of a person walking per second by the distance in each chapter, and in this example of Chapter 1, it has been calculated to be the said amount of time. This timer increases as the difficulty of chapter increases.

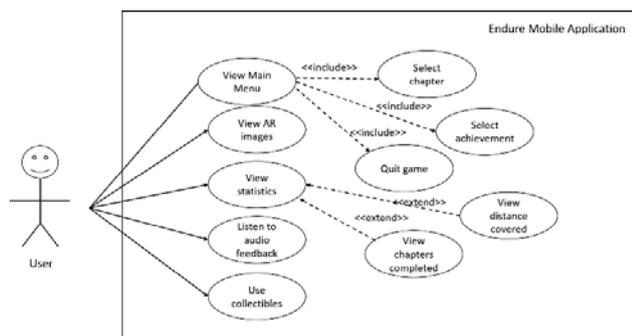


Figure 1. Endure: Use case diagram.

Nevertheless, game objects in the form of AR chicken legs are programmed to spawn at limited number of times for each chapter which can be utilized to buy time whenever required by the user. As the user collects these game objects, it will be stored and displayed on the “chicken leg” button to indicate the amount of chicken legs left. When the “chicken leg” button is selected, the application will automatically

deduct the number of chicken legs displayed indicating that they have used their collectable item while increasing the amount of time in the countdown timer by 5 seconds. In the case of when the objects have stopped spawning and the user has used all the chicken legs collected, they would then be required to speed up their pace in order to catch up with time and not lose the challenge. There is only 1 actor involved in this system, as shown in Figure 1.

### A. Game

The screenshot of the game scene as shown in Figure 2 that appears when the user taps on “Chapter One” on the home page. The back camera of the smartphone is activated when the game starts and projects the input as the background for the game. The chicken leg is an AR game object that spawns randomly but with a limited number. The bottom left indicated the distance run by the user in comparison with the required distance to achieve the chapter’s goal while on the bottom right is the countdown timer that presents the amount of time left to end the game.



Figure 2. Endure: The game.



Figure 3. Endure: Achievement.

## B. Achievement

The Achievement feature is dependent on the Game feature as the latter consists data that is vital for the Achievement operations. This feature is also dependent on the information from Challenges that comprises of chapter information which will be required by the Achievement class in order to compute the user's efforts and accomplishments. It records the user's accomplishments in terms of distance run, and bravery points for gaining boosts and utilizing the grenades in order to ward off the cannibals. Figure 3 shows the achievement page in which users may view their total distance run as well as the chapters that have been completed. The data is stored in the internal memory of the smartphone the application is installed on.

## C. Challenges

This feature is associated with the game through composition as the game would not be able to run if there were no challenges. It comprises of information concerning the chapters and its details. Figure 4 shows challenges page by chapter.



Figure 4. Endure: Challenges.

## V. CONCLUSION AND FUTURE WORKS

Endure has been successfully developed as one of the first fitness application that integrates AR as a game whilst involving the user themselves as the first-person player. As proposed in the beginning, the user is able to partake in a virtual game with functionalities that encourages them to get their feet moving in a more engaging and interactive way.

Additionally, as the game revolves around a chapter-by-chapter basis, users can opt for a chapter of their choice which comes with a distance goal as well as a countdown timer to push the user to complete the chapter. The storyline which characterizes the user as a survivor who needs to

outrun the cannibal hoard provides a more personal feel for the user to win the game while subsequently improving their health in the long run.

A helping factor, the AR chicken legs that can be collected, aids the user in completing the chapter successfully and can be said to be a "motivational factor" in order to provide users hope to accomplish their distance target. Finally, users can view the total distance they have covered as well as the chapters completed all in one page.

Several enhancements are taken into consideration to improve the application such as adding a pulse rate monitor that can detect the user's pulse rate and send real-time feedback to the application, a calorie counter will come in handy as the user will be able to have a clearer overview of the changes taking place in their body whilst utilizing the application, and a statistic view that able users to obtain a bigger picture of their progress throughout their journey of improving their wellbeing.

## ACKNOWLEDGEMENT

Work presented in this paper forms part of the research on Exploring Usability and Security Components of Mobile Learning Applications, which was partially funded by Universiti Tenaga Nasional Internal Research Grant scheme (UNIIG).

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