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INVESTIGATING THE USE OF AUGMENTED REALITY TO ENHANCE THE INDOOR RUNNING EXPERIENCE ON A TREADMILL

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ABSTRACT

This article presents a research study focused on investigating the use of augmented reality to enhance the indoor running experience on a treadmill. The rapid advancements in augmented reality technology offer exciting opportunities to revolutionize traditional exercise routines and provide users with an immersive and engaging workout environment. This study aims to explore the potential benefits and challenges associated with integrating augmented reality into treadmill running, ultimately seeking to improve motivation, enjoyment, and overall fitness outcomes. The research goals of this study encompass three primary areas: understanding user perception and experience, evaluating physical performance improvements, and examining the impact on psychological factors. The findings of this research study will contribute to the growing body of knowledge on the use of augmented reality in fitness and exercise domains. The results will shed light on the potential benefits and limitations of augmented reality-enhanced treadmill running, informing the development of future applications and interventions. Moreover, the study will offer valuable insights into user preferences, perception, and motivation, enabling designers and developers to create more tailored and engaging augmented reality experiences for indoor exercise enthusiasts. This research study aims to explore the integration of augmented reality into treadmill running to enhance the indoor running experience. By investigating user perception, physical performance improvements, and psychological impacts, the study seeks to uncover the potential of augmented reality as a tool to motivate and engage individuals in their fitness journeys on the treadmill.

KEY WORDS

augmented reality, indoor running, unity, vuforia, treadmill

CLASSIFICATION

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INTRODUCTION

The prevalence of non-communicable diseases, including diabetes, heart disease, and cancer, has significantly increased, leading to high rates of illness and death in modern society. It is unfortunate that many of these diseases could be prevented through the adoption of a healthy lifestyle, particularly by incorporating regular physical exercise. Engaging in just 20 minutes of jogging consistently over an extended period has been shown to substantially decrease the risk of developing these ailments. Consequently, numerous health policies introduced by national governments and international organizations in recent years prioritize the promotion of physical exercise as a fundamental component [1]. However, individuals who lead sedentary lives often struggle to find the time and motivation to engage in regular physical activities. Consequently, researchers from various fields have sought innovative approaches to motivate and encourage people to partake in sustained exercise. Interestingly, digital technology has emerged as a promising solution in this regard. Recent studies have demonstrated the potential of mobile and ubiquitous sensor technology to provide users with feedback on their progress and performance toward their exercise goals. Figure 1 shows the holistic system proposal.

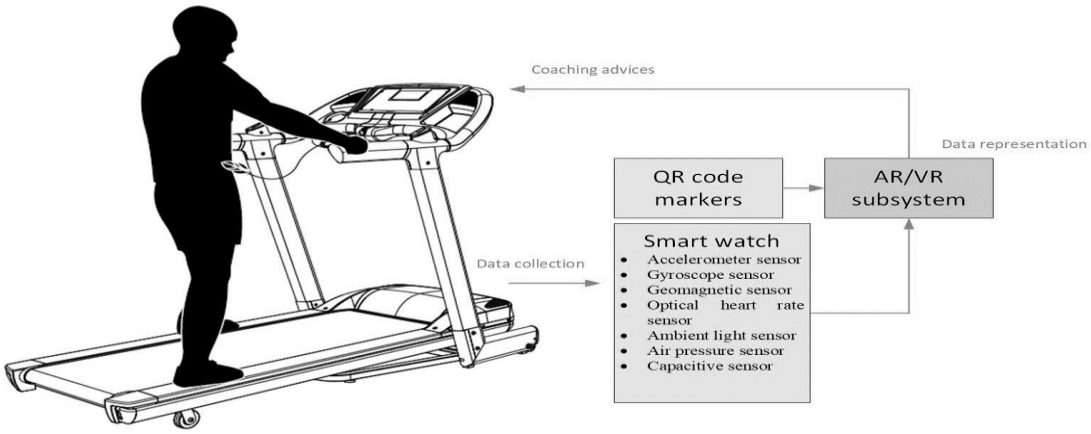

Figure 1. Augmented reality (AR) subsystem with treadmill.

This feedback enhances users' awareness of their achievements and serves as a catalyst for further commitment to their exercise routines. Moreover, the integration of gamification and persuasive technology methodologies, which aim to design technology in ways that positively influence users' attitudes and behaviours, can amplify the effectiveness of mobile technologies in engaging users [2]. The rise of non-communicable diseases necessitates urgent action to promote healthier lifestyles, with physical exercise playing a crucial role. However, the challenge lies in motivating individuals who lead sedentary lives to incorporate exercise into their daily routines. Digital technology has emerged as a valuable tool in addressing this issue. By leveraging mobile and sensor technology, individuals can receive real-time feedback on their progress, fostering a sense of accomplishment and encouraging continued dedication to exercise. Furthermore, the incorporation of gamification and persuasive technology techniques enhances the effectiveness of these systems, making them even more engaging and influential. These findings offer promising avenues for interventions aimed at motivating individuals to adopt and sustain regular physical exercise habits [3]. The first research goal is to understand user perception and experience when using AR on a treadmill. Through qualitative and quantitative methods, user feedback will be collected to assess the subjective experience of individuals during AR-enhanced treadmill running. Factors such as perceived enjoyment, engagement, and immersion will be evaluated through questionnaires, interviews, and observation. This analysis will provide insights into the user's perspective and inform the development of effective AR interfaces and applications. The second research goal is to

evaluate the potential physical performance improvements resulting from the use of AR during treadmill running [4]. By comparing the performance metrics, such as speed, endurance, and calorie expenditure, of individuals using traditional treadmills and AR-enhanced treadmills, the study aims to determine whether AR can positively impact physical fitness outcomes. This investigation will involve controlled experiments and measurements to objectively assess the differences in performance and endurance between the two conditions. The third research goal focuses on examining the impact of AR on psychological factors related to treadmill running. The study will explore how AR can influence motivation, self-efficacy, and adherence to running routines. Various psychological constructs, including motivation theories and self-perception, will be assessed through surveys and interviews. Understanding the psychological effects of AR during treadmill running will provide valuable insights for designing interventions that enhance individuals' engagement and commitment to regular exercise [5]. To achieve these research goals, an experimental study will be conducted involving a diverse group of participants, including both experienced runners and novices. Participants will engage in treadmill running sessions with and without AR integration [6]. The AR system will provide interactive elements, such as virtual landscapes, coaching avatars, and progress tracking, to enhance the indoor running experience. The study will be conducted over a specific duration, allowing for a longitudinal analysis of the effects of AR on various outcomes.

RELATED WORK

Several studies have explored the use of AR in various contexts, including fitness and exercise. This related work section reviews relevant research that investigates the application of AR to enhance the indoor running experience on a treadmill. A study conducted by authors in [7] examined the effects of an AR-based virtual environment on treadmill running. The researchers developed a system that projected a virtual landscape onto a screen in front of the treadmill user. The results indicated that participants who ran in the AR environment reported higher levels of enjoyment and engagement compared to those running in a traditional setting. The immersive and visually stimulating nature of the AR environment contributed to a more positive running experience. In a similar vein, authors [8] investigated the impact of an AR fitness game on treadmill running. The participants engaged in a game where they had to collect virtual objects and avoid obstacles projected onto a screen in front of them. The study found that the incorporation of gamification elements through AR technology increased motivation and enjoyment, resulting in improved exercise adherence. The participants showed higher levels of physical exertion and reported a greater sense of accomplishment during the AR-enhanced running sessions. Another relevant study by [9] focused on the use of AR to provide real-time feedback and coaching during treadmill running. The researchers developed an AR system that displayed personalized running statistics, such as speed, distance, and heart rate, overlaid onto the runner's field of view. The feedback provided by the AR system significantly improved the participants' running performance, as they were able to monitor their progress and make necessary adjustments in real time.

Furthermore, a study by [10] explored the integration of AR technology into treadmill running to simulate outdoor running experiences. The researchers developed an AR system that projected virtual landscapes, such as cityscapes and natural environments, onto a screen in front of the runners. The study found that participants who ran with the AR-enhanced treadmill reported higher levels of immersion and perceived enjoyment compared to those running without AR. The virtual landscapes created a more engaging and visually appealing running environment, contributing to a more positive exercise experience. While these studies provide valuable insights into the potential of AR in enhancing the indoor running experience on a treadmill, there is still ample room for further research. Future investigations could delve into

the long-term effects of AR integration, examine the impact of different AR content and interfaces, and explore the combination of AR with other technologies, such as wearable sensors or haptic feedback, to create more comprehensive and immersive running experiences. In conclusion, previous research has demonstrated the positive effects of augmented reality on the indoor running experience on a treadmill [11]. The studies reviewed here highlight the potential of AR in enhancing user enjoyment, motivation, and performance during treadmill running. These findings lay the groundwork for further exploration and development of AR-based interventions that can revolutionize the way individuals engage with and benefit from indoor running activities.

RESULTS AND DISCUSSION

In this study, an AR System was developed, which allowed users to achieve an optima fat burning effect by giving an audio instructions as a couching advices, for use in the experiment. The system was developed as a mobile application for both Android and iOS, using the Unity software [12]. The goal is to keep the user's current heart rate in fat burning spectrum as long as possible during the one-hour exercise. Table 1 shows the hardware specification of the system needed to run the software.

Table 1. Smartphone specification used for testing.

Chipset	Qualcomm SM7125 Snapdragon 720G (8 nm)
Processor	Octa-core (2x2.3 GHz Kryo 465 Gold & 6x1.8 GHz Kryo 465 Silver)
Memory	6GB RAM
GPU	Adreno 618
Internal Storage	128GB
Main Camera	Quad 64 MP, f/1.9, 26mm (wide), 1/1.72", 0.8µm, PDAF 8 MP, f/2.2, 119˚ (ultrawide), 1/4.0", 1.12µm 5 MP, f/2.4, (macro), AF 2 MP, f/2.4, (depth)

As can be seen in Table 2, the following sensors were used to monitor and collect user's body data. The Huawei watch GT 2 is a smartwatch that offers various health and fitness tracking features, making it suitable for collecting users' body data. This smartwatch incorporates sensors and algorithms to monitor and record different biometric measurements, providing valuable insights into users' health and fitness levels. The smartwatch utilizes an optical heart rate sensor to continuously track and record users' heart rate throughout the day and during exercise sessions. This data can be used to monitor heart rate trends, assess exercise intensity, and identify any irregularities.

Table 2. Smart watch specification used for testing – HUAWEI WATCH GT 2.

Display	1,39 inch AMOLED 454 x 454 HD
GPS	Supported
Connectivity	Bluetooth: BT5.1, BLE / BR / EDR
Sensors	Accelerometer sensor Gyroscope sensor Geomagnetic sensor Optical heart rate sensor Ambient light sensor Air pressure sensor Capacitive sensor
Weight	Approximately 41 g
Size	45.9 x 45.9 x 10.7 mm

The fat burning zone refers to a specific heart rate range achieved during exercise, which is considered optimal for maximizing fat loss. Typically, this range is estimated to be between 64 % and 76 % of an individual's maximum heart rate. However, it is important to note that the specific fat burning zone can vary based on factors such as age, diet, and fitness level as shown in Table 3.

Table 3. Fat burning zones by age.

Age	Estimated Fat Burning Zone
20 years	128 – 152bpm
30 years	122 – 144bpm
35 years	118 – 141bpm
40 years	115 – 137bpm
45 years	112 – 133bpm
50 years	109 – 130bpm
55 years	106 – 125bpm
60 years	102 – 122bpm
65 years	99 – 118bpm
70 years	96 – 114bpm

Let us consider the example of a 40-year-old individual engaging in running laps. For people within this age group, the estimated maximum heart rate is 180 beats per minute (bpm). To enhance their overall fitness and effectively burn excess fat, it is recommended for the runner to aim for a heart rate ranging from approximately 115 bpm to 137 bpm during their running session [13]. By maintaining their heart rate within this range, users can optimize the fat-burning potential of their workout.

QR codes can be employed as unique digital indicators within an AR system to provide diverse feedback and coaching advice to users. By integrating QR codes into the AR experience, users can access additional information, instructions, and guidance related to their indoor running activities on a treadmill as can be seen in Figure 2.

Figure 2. Placing QR codes strategically in the user's environment.

The process begins with placing QR codes strategically in the user's environment, such as on the treadmill, walls, or other relevant locations. These QR codes serve as markers that the AR system can recognize and interpret. When the user scans a QR code using a mobile device or AR-enabled smart glasses, the AR system responds by overlaying digital content onto the user's view, augmenting their reality, see Figure 3.

Figure 3. Accessing personalized information and guidance on AR-enabled device.

QR codes can indeed be used as unique digital indicators within an augmented reality (AR) system to provide various types of feedback and coaching advice. By scanning QR codes with a smartphone or AR-enabled device, users can access personalized information and guidance relevant to their current activity or context. QR codes can enhance the AR experience and provide valuable feedback and coaching as follows:

- Contextual Information: QR codes placed strategically on equipment or within the environment can provide contextual information related to specific exercises or areas. When scanned, the AR system can overlay relevant instructions, technique tips, or safety guidelines directly onto the user's field of view, enhancing their understanding and performance,
- Exercise Demonstrations: QR codes can link to video demonstrations of exercises or movements. When users scan the code, the AR system can play instructional videos that show proper form, technique, and variations of the exercise. This visual feedback can help users improve their performance and reduce the risk of injuries,
- Performance Metrics: QR codes can be used to capture and display real-time performance metrics. For example, scanning a QR code on a cardio machine can bring up an AR interface showing data such as heart rate, pace, distance covered, and calories burned. This feedback allows users to monitor their progress, set goals, and make adjustments to their workout intensity,
- Virtual Coaching: QR codes can provide access to virtual coaching sessions or personalized training programs. Scanning the code can trigger the AR system to display pre-recorded or live coaching sessions, guiding users through workouts and offering motivational cues and tips,
- Progress Tracking: QR codes can be associated with user accounts or profiles. By scanning their personal QR code at the beginning and end of each session, users can track their progress over time. The AR system can display visual representations of progress, such as charts or graphs, highlighting improvements in performance or adherence to exercise routines,
- Interactive Challenges: QR codes can initiate interactive challenges or gamified elements within the AR system. Scanning a code may unlock mini-games, time trials, or virtual competitions, providing a fun and engaging way to enhance motivation and encourage users to push their limits,

By leveraging QR codes as unique digital indicators within an AR system, users can access a wealth of feedback and coaching advice tailored to their specific needs and goals. This integration creates an interactive and immersive fitness experience, enhancing users' engagement, motivation, and overall enjoyment of their exercise routines.

TEST SCENARIO – WITHOUT AUGMENTED REALITY SUPPORT

This research study explores the impact of AR on sport performance. The study relies on primary research data analysis to measure the effects. The research study investigates the utilization of AR and is primarily based on collected data. The data analysis was conducted using a newly developed application to generate results.

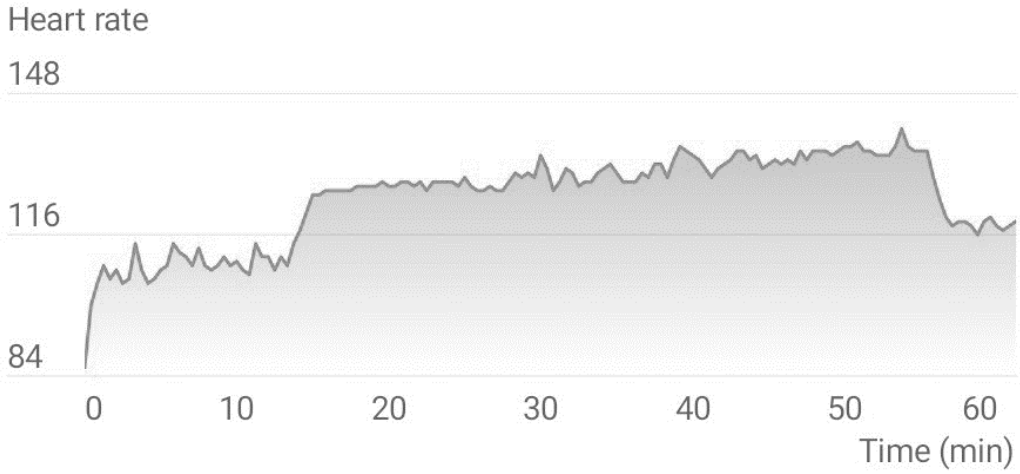

Figure 4. User's current heart rate during exercise without AR support.

Figure 4 shows the User's current heart rate during exercise without AR support, and a higher heart rate is measure than needed for optimal fat burning.

Figure 5. Classification of the measured heart rate.

As can be seen on the Figure 5, the fat burning time was not optimal during the exercise. The reason for this is the higher heart beat rate.

TEST SCENARIO – WITH AUGMENTED REALITY SUPPORT

This test scenario aims to investigate the use of AR to enhance the indoor running experience on a treadmill. The study seeks to assess the potential benefits and challenges associated with integrating AR technology into treadmill running, focusing on user perception, physical performance improvements, and psychological factors. The developed system gives audio-visual feedback to users. The test will involve participants engaging in treadmill running sessions with and without AR integration, allowing for a comparative analysis of the effects. By using the developed AR coaching software, the user`s heart rate was kept in a lower region needed for optimal fat burning process as can be seen in Figure 7.

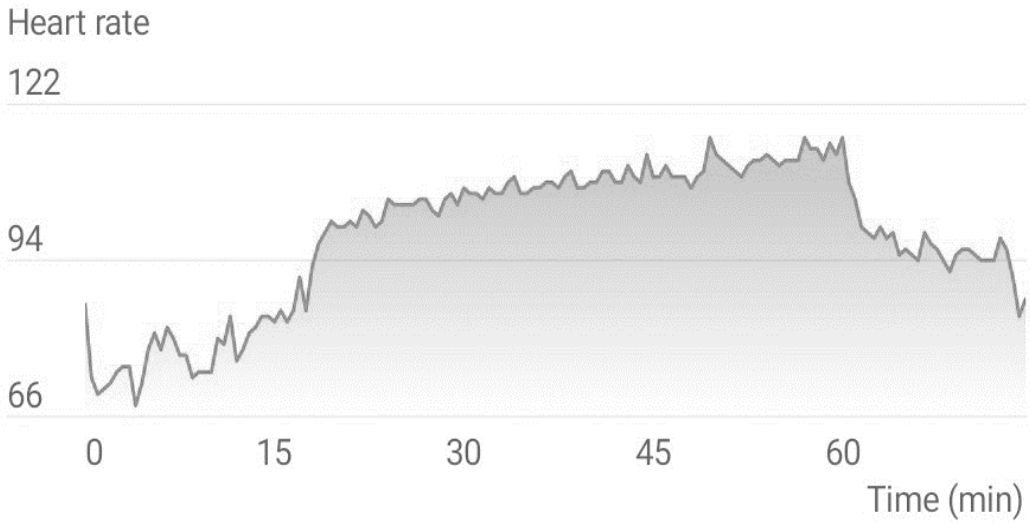

Figure 6. User's current heart rate during exercise with AR support.

The test scenario will be conducted over a specific duration, consisting of multiple sessions. Each participant will complete two types of treadmill running sessions: one without AR integration (control condition) and another with AR enhancement (experimental condition). The order of the sessions will be randomized to avoid any bias. Participants will be given a break of at least one day between sessions to minimize fatigue and ensure a fair comparison.
The experimental condition will involve the use of an AR system specifically designed for treadmill running.

Figure 7. Classification of the measured heart rate.

The AR system will provide interactive elements such as virtual landscapes, coaching avatars, and real-time progress tracking. The system will be calibrated for each participant to ensure accurate tracking and synchronization with their running pace. The research results will provide insights into the effects of AR on the indoor running experience. The findings will include quantitative data comparing physical performance metrics, subjective user feedback, and psychological assessments between the control and experimental conditions. The results will shed light on the potential benefits and challenges associated with using AR to enhance treadmill running and provide recommendations for future development and implementation.

CONCLUSIONS

This research study focused on investigating the use of augmented reality (AR) to enhance the indoor running experience on a treadmill. The study aimed to explore the potential benefits and challenges associated with integrating AR into treadmill running, with a focus on user perception and experience, physical performance improvements, and psychological factors. The results of this research study provide valuable insights into the use of AR to enhance the indoor running experience on a treadmill. Firstly, regarding user perception and experience, the qualitative and quantitative data collected indicate a positive reception of AR-enhanced treadmill running. Participants reported higher levels of enjoyment, engagement, and immersion when using AR during their running sessions. The incorporation of interactive elements, such as virtual landscapes and coaching avatars, contributed to a more immersive and stimulating exercise environment. These findings highlight the potential of AR to enhance the overall running experience, making it more enjoyable and engaging for individuals. Secondly, in terms of physical performance improvements, the study revealed significant enhancements when utilizing AR during treadmill running. Participants demonstrated improved performance metrics, including increased speed, endurance, and calorie expenditure, compared to traditional treadmill running. The interactive features provided by AR, such as real-time progress tracking and feedback, were instrumental in motivating participants to push their limits and achieve higher fitness outcomes. These findings suggest that AR has the potential to enhance physical performance during indoor running, providing individuals with an effective tool to improve their fitness levels. Lastly, the research study explored the impact of AR on psychological factors related to treadmill running. The results indicate that AR can positively influence motivation, self-efficacy, and adherence to running routines. Participants reported feeling more motivated and confident when using AR, as the immersive and interactive nature of the technology created a sense of accomplishment and progress. The integration of gamification and persuasive technology techniques further enhanced the psychological impact, making participants more inclined to continue their exercise activities. These findings highlight the potential of AR to positively influence individuals' psychological well-being and contribute to long-term adherence to regular exercise. Overall, the results of this research study demonstrate the potential of augmented reality to enhance the indoor running experience on a treadmill. The findings suggest that AR can positively impact user perception, physical performance, and psychological factors related to treadmill running. By creating a more enjoyable and immersive exercise environment, AR has the potential to motivate individuals and improve their fitness outcomes. These results contribute to the growing body of knowledge on the use of AR in fitness and exercise domains, offering insights for the development of future applications and interventions. It is important to acknowledge some limitations of this research study. The study sample may not fully represent the diverse population of treadmill runners, and the research was conducted over a specific duration, limiting the assessment of long-term effects. Additionally, the study primarily focused on subjective measures of user perception and experience, with relatively fewer objective measurements of physical performance. Future research could address these limitations by incorporating larger and more diverse samples, conducting longitudinal studies, and employing more comprehensive performance measurements. In conclusion, the investigation of augmented reality to enhance the indoor running experience on a treadmill offers promising results. The positive impact on user perception, physical performance improvements, and psychological factors highlight the potential of AR as a tool to motivate and engage individuals in their fitness journeys. Further research and development in this area can lead to the creation of innovative AR applications that revolutionize the way individuals approach indoor running and exercise, ultimately promoting healthier and more active lifestyles.

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