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ABSTRACT
The decreasing hardware cost makes it affordable to pair Immersive Virtual Environments (IVR) visors with treadmills and exercise bikes. In this paper, we discuss the application of different gamification techniques in IVR for supporting physical exercise. We describe both the hardware setting and the design of Rift-a-bike, a cycling fitmersive game (immersive games for fitness). We evaluate the effectiveness of such techniques through a user study, which provides different insights on their effectiveness in designing such applications.

Author Keywords
Gamification, Immersion, Virtual Reality, Fitness

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION
Aerobic physical exercises, such as running or cycling, are often combined with entertainment activities when carried out indoors. Nowadays, consumer-level immersive Virtual Reality (IVR) devices (e.g., the Oculus-Rift) provide an affordable solution for creating IVR settings at home or at the gym, which can be used for entertaining people while training.

In this paper, we evaluate the effects of gamification techniques in IVR environments for fitness that, from now on, we call *Fitmersive Games*. We describe both the hardware setup and the design of a bike fitmersive game (Rift-a-bike), and how we applied the different gamification techniques. After that, we report on a user study, where we registered an increased enjoyment in the users' physical activity through the gamification approach. In addition, we collected qualitative feedback on the different gamification features, according to three dimensions (usefulness, motivation and fun) together with an overall evaluation of the game experience. Finally, we discuss the qualitative feedback on the gamification techniques, which provides hints for selecting them in other fitmersive games.

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RELATED WORK
The introduction of devices for recognizing the user's gestures (such as the Wiimote or the Microsoft Kinect) opened the market for the active video games [1]. Even if they cannot be considered a real substitute for a proper physical exercise [6], they have a positive impact on different physical abilities [5]. Unsurprisingly, these settings have been enriched also with other gym equipment, such as exercise bikes. For instance, Ranky et al. [7] created a rehabilitation system embedding sensors inside an exercise bike. Playing video games, with some level of control depending on the physical effort (e.g., the racing speed of a car) has a positive impact on the affective attitude and the adherence to the physical exercise for inactive people, even if it was not created specifically for that purpose [8].

More recently, the availability of consumer-level HMD enabled the development of immersive VR experiences for exercise games (the fitmersive games). Bolton et al. [2] demonstrated a paper delivery videogame with a setting similar to the one discussed in this paper. We further develop this approach applying the different gamification techniques and studying their impact on the overall user experience.

RIFT-A-BIKE
We created a prototype implementation of a fitmersive game, called Rift-a-bike, whose goal is to have a bicycle ride in a digital city along a predefined path. The user focuses on keeping the appropriate speed for the training phase. The hardware setting includes only consumer-level devices and it is easily replicable at home or at gym. We used a normal exercise bike, which we instrumented with a Raspberry PI for sensing the user's cycling speed. In order to explore the environment, the user wears an Oculus Rift head mounted display (HMD), which provides a stereoscopic view on the virtual world and a set of earphones for the audio. In addition, we used a Kinect for Windows V2, for tracking the user's movements and replicating them in the VR environment through the avatar. Figure 2 shows the user's avatar in the game environment, while figure 1 shows the hardware configuration for playing the game.

From the software point of view, we created the virtual city using CityEngine, a procedural city environment generator.

Figure 1. Rift-a-bike hardware setup.

We imported the city model in Unity 3D and we built the bike tour simulation. We added the gamification features on top of this environment.

In figure 2 we included a set of screenshots of the different game features, while a demonstration video is available online [9]. In the rest of this section we describe the gamified elements in the VR environment. We tried to adapt the different techniques in order to contribute to both the user's physical activity and entertainment.

Levels

In many videogames, levels indicate the user's progresses. They should set goals both difficult and reachable, making them challenging but not frustrating for the average user [10]. Through the different levels, the user increases her playing skills and follows the game plot. In Rift-a-bike, we included three different levels during the virtual city bike tour, each one corresponding to the phases of a physical work-out. In the *Warm-up*, the user pedals at a medium-low speed; in the *Exercise*, the user pedals at the speed required for the training; in the *Cool-down*, the speed gradually decreases until the end of the exercise.

From the users experience point of view, the partition helps them in gaining confidence with the system before starting the real exercise, and entertains them while showing the different phases in a playful way. From the physical exercise point of view, the first phase prepares the user to the physical strain, while the last one relaxes the body and guides it to rest phase in a gradual and controlled manner [3]. It is possible for the user to set-up the duration of the different phases autonomously (e.g., 5 minutes for warm-up, 15 for the exercise and 5 for the cool-down, 25 minutes in total).

Points

The points are virtual rewards that stimulate the users in performing a set of actions. In addition, they provide also a quantitative measure of their performance, according to different metrics. For instance, the user gradually gains Experience Points (XP) completing quests, or she increases her Skill Points (SP) if she is able to complete a certain action, or she is rewarded with Karma Points (KP) if she helps other players.

We included in Rift-a-bike a skill point system, which rewards the user if she is able to maintain the correct speed. The user gains points collecting the coins positioned by the game engine along the path. The number of coins depends on the user's speed: the more the pace is closer to the correct one, the more coins the user will collect.

Challenges

The challenges (or missions) represent particular tasks or quests that the user has to complete for gaining experience. For instance, at the very beginning of a game the users are requested to complete very simple challenges, such as breaking a box or jumping an obstacle, in order to become familiar with the game mechanics. Later in the game, challenges are related with the development of the plot (e.g., finding a treasure), or they may be optional (and more difficult) parts of the game, which usually attract the more eager and skilled players.

In Rift-a-bike, the whole training exercise is represented as a challenge: the user's objective is to follow a rabbit, trying to keep-up with him as long as possible (see figure 2). In this way, the player gains a precise objective during the training. This strategy has a twofold goal: it distracts the user from fatigue while motivating her in continuing the exercise. In addition, the rabbit is an implicit feedback mechanism: the user is able to evaluate her performance simply considering the distance from the rabbit.

Badges and Prizes

Badges are special rewards for different achievements in the game. For instance, when the user finds 100 diamonds, she may be rewarded with a treasure finder badge, which acknowledge her ability in such particular activity. Badges increase the reputation of the player in the community and also her self-esteem. In addition, they provide additional motivation for playing. It is usual in a videogame that a single achievement may be split in different sub-activities that the user should complete to receive a prize. When she collects all the prizes, the achievement is unlocked.

In Rift-a-bike we included both badges and prizes. The badges are represented through a set of trophies that the user receives at the end of the training (see figure 2). Their value is related to the overall evaluation of the training session. In addition, the user collects three different prizes during the session, one for each phase. Their value is related to the user's performance in the considered phase. If the user gets the best prize in each phase, she will get the most valuable trophy.

USER STUDY

We have carried out a user study for evaluating two different aspects of our fitmersive game prototype. The first objective is to establish whether the users enjoy more the physical activity with gamification elements while interacting with IVR environments. The second one is to provide a qualitative assessment of the different gamification techniques used in our

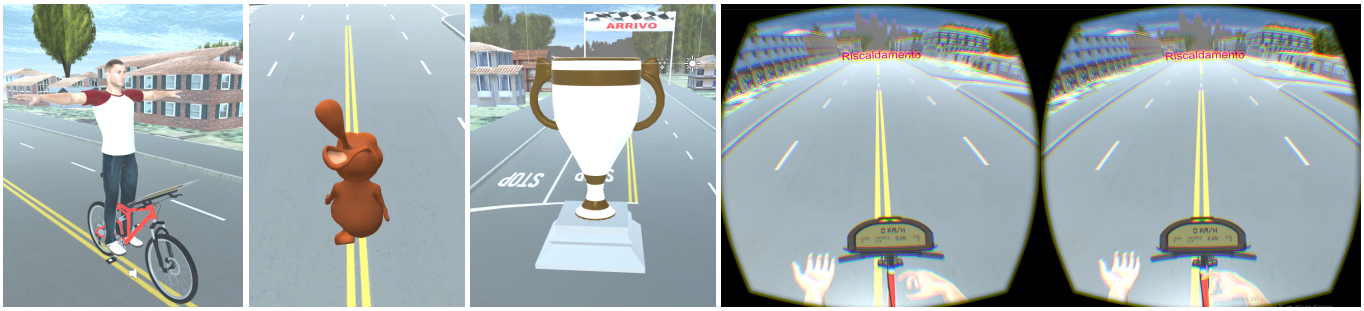

Figure 2. Rift-a-bike fitmersive game environment. From left to right: the user's avatar, the "follow the rabbit" challenge, a session final trophy (badge) and the stereoscopic view for the Oculus Rift.

prototype, according to three dimensions: usefulness, fun and motivation.

Method

The test consists of two 10-minute sessions at the exercise bike, in which we vary the environment condition between two nominal values: Baseline (B) and Game (G). In the B condition, the user pedals in the virtual environment without any gamification feature. She is still able to observe the virtual city with the HMD and the avatar replicates her movements. In the G condition, the user pedals in the same virtual environment, enhanced with the gamification techniques. Each user carried out the test in both conditions, half of them started from the B condition, while the other half started from the G condition.

Before starting the two sessions, the users completed a demographic questionnaire, useful for collecting information on their physical activity habits, experience level with virtual environment and other data that characterises the sample population. After each session, we requested the user to fill the Physical Activity Enjoyment Scale (PACES) [4], a standard questionnaire for evaluating the level of users' enjoyment during the physical activity. At the end of the test, the users filled a qualitative questionnaire for evaluating the overall usability of the environment and the different gamification techniques according to their contribution to the usefulness, fun and motivation.

Results

Twenty-two users participated in the test, 19 males and 3 females. The average age is 23 years old ($\bar{x} = 23.18$, $s = 3.0$, $min = 16$, $max = 23$), with different levels of education: junior high school (1), high school (13), bachelor (4) and master (3). Only three users exercise once a day, the majority of users performs physical activity once a week (10), the others are uniformly distributed among the lower levels of activity: 4 once a month, 3 once a year and 2 less than once a year. The experience with virtual environments varies among the users: 3 uses them more than once a day, 2 once a day, 3 once a week, 6 once a month, 6 once a year and 1 never used them before. In addition, most of them already tried an HMD (18), while for three of them it was the first time. Our sample has a limited age range and an unbalanced gender ratio, which represent a limitation for the study results. However, their experience with HMDs helps them in evaluating the experience, limiting the influence of the hardware setting novelty on their ratings.

The PACES [4] test consists of 18 questions in a 1 to 7 Likert scale, and defines how to aggregate the scores for the different questions. Figure 3 summarises the results for all questions, showing the ratings for the G condition are consistently higher with respect to the B condition. In particular, the mean score for the B condition is $\bar{x}_B = 91.76$, $s_B = 15.52$, which is already high, but for the G condition is even higher ($\bar{x}_G = 106.90$, $s_G = 10.53$). After performing a normality test on the scores ($W_B = .98$, $W_G = .95$, $p_B = .49$, $p_G = .20$), we compared the two means with a paired t-test ($\alpha = 0.05$) and we found a significant difference; $t(20) = 5.57$, $p = .001$. The 95% confidence interval is $[6.83; 23.45]$. Therefore, we can conclude that our users perceived a difference between the two conditions and that using the gamification techniques positively affects the physical activity enjoyment in IVR settings.

In the post-test questionnaire we asked the users to evaluate the gamification features according to three different aspects: usefulness, fun and motivation using a 1 to 7 Likert scale. Figure 4 summarises the questionnaire results. Through the analysis of variance and the post-hoc analysis we noticed that the *Challenge* received consistently the higher score, and such difference is significant with the *Prize* feature for all aspects (respectively $p = .002$, $p = .001$, and $p = .002$). Considering the usefulness aspect, we found a significant difference also between the *Levels* and *Prizes* ($p = .01$), while between *Points* and *Levels* there is a practical significance ($p = .06$). The feature that has the most relevant impact on the users' motivation is the *Challenge*, followed by *Points* and *Badges*. The impact of *Levels* and *Prizes* is less relevant.

DISCUSSION

The **Challenge** was the most relevant gamification feature in the fitmersive game: the majority of the user explicitly cited the rabbit challenge as the most entertaining and useful feature of the game, since it both motivates the exercise and provides a good feedback on the user's performance. It both motivated users and for helping them in completing the workout correctly. Challenges are also important for the overall experience, since the main objective of the user is not any longer a boring exercise, but a challenge inside a game, which provides a higher motivation for completing the activity.

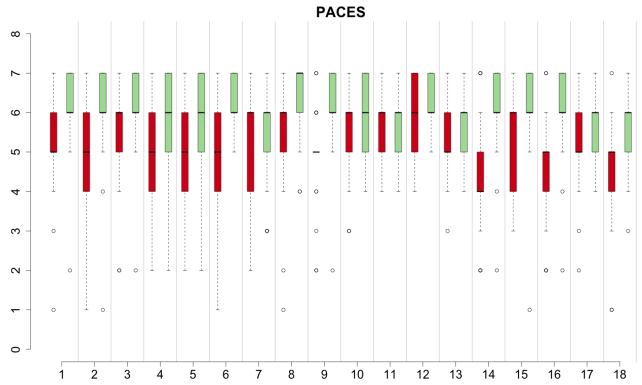

Figure 3. Paces questionnaire results. Red boxes are related to the Baseline (B) condition, while green ones to the Game (G) condition. We reversed the scores for questions with a negative connotation.

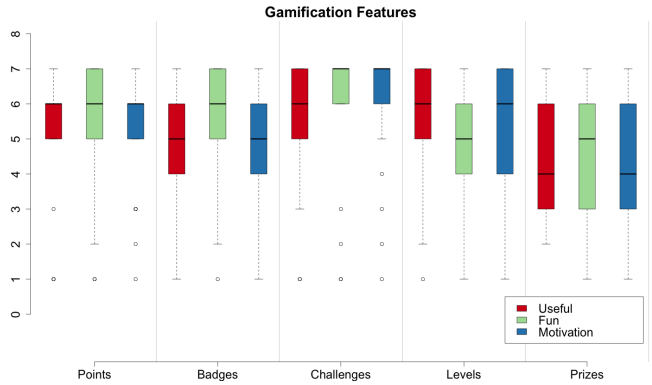

Figure 4. Qualitative assessment of the gamification features included in Rift-a-bike. Red boxes represent the usefulness rating for each feature, the green boxes the fun scores and the blue boxes the motivation scores.

Levels guided the user inside the physical training system and helped them in maintaining a consistent progress plan. In addition, they supported the user in understanding how difficult will be the current task. Completing a level provides them a sensation of fulfilment, which facilitates their permanence in the fitmersive game.

Collecting **Points** provided an immediate goal for the users and, even if they are virtual rewards, they positively affected the motivation and the fun during the exercise, distracting the users from the physical strain. According to the user's comments, we suggest to select a point system able to maximize the exercise objective, such as the regularity of speed for the endurance, the precision of the movement for a particular muscle training and so on.

Badges provide an indication on the overall player status. Considering that we evaluated a single-player game, their impact was limited. However, we recognize that including a social network support in our prototype would have lead to different results. Therefore, we suggest to give priority to other features in single-player settings.

Including **Prizes** as intermediate rewards does not seem to have a particular influence on users with respect to the other gamification features. On the other hand, they do not degrade the user experience. Our suggestion is to include them only if needed, but to give priority to all the other features first.

Besides the gamification fatures, the users appreciated also the immersion in the environment, and the possibility to change the viewpoint moving the head. The negative aspects are related to the motion sickness. Six of them have had a slight nausea, especially in bends at high speeds. This is an open issue for HMDs in general and for Oculus Rift applications in particular. However, we should try to mitigate the problem also while designing the city paths.

CONCLUSION AND FUTURE WORK

In this paper we discussed application of gamification techniques in Immersive Virtual Reality environment for supporting physical exercise. We describe the implementation of Rift-a-bike, a fitmersive game that enhances the exercise bike experience with challenges, levels, points, badges and prizes. Through the results of a user test, we show that the gamification elements increase the user's enjoyment during the physical activity and we provide a set of guidelines for applying gamification features for fitmersive games. In future work, we aim to evaluate the system with more users and hopefully with a more gender-balanced sample. In addition, we will add the multiplayer and social support in Rift-a-bike, in order to stimulate the competition among the members of a social network. In addition, we will analyse the gamification effect in the long term.

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