Designing Group Fitness Swimming Exergames: A Case Study

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Abstract
Recently, HCI-related communities have explored ways to enhance conventional group fitness through interactive technologies. As one such approach, we considered how to design exertion games (exergames) for group fitness. In this poster, we examined group fitness swimming as a case study, and designed SwimTrain, an exergame for this group activity. Our game focuses on helping multiple swimmers set and maintaining an appropriate exercise intensity through both competition and collaboration. We also explored several implementation issues, such as device settings, input methods, and game feedback.

Author Keywords
Swimming, exergame, social interaction

ACM Classification Keywords
K.8.0 [Personal Computing]: General-Games; H.5.3 [Group and Organization Interfaces]: Synchronous interaction

Introduction
Since being introduced in the late 1960s, group fitness has become one of the most popular types of exercise. Today's group fitness includes most forms of exercises which are performed by a group of people and guided by an instructor [10]. We can see this type of exercise almost everywhere, such as group spinning, swimming, and yoga classes. The key benefits of group fitness include learning

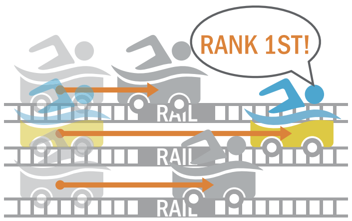

Figure 1: Visual presentation of Compartment Ordering

Figure 2: Visual presentation of Train Running

Figure 3: Visual presentation of Train Stop

new skills, adherence to a training regimen, and increased enjoyment and engagement.

Advances in interactive technologies have spurred researchers to explore augmentation of conventional group fitness. One approach is to design a self-quantified tool that delivers individual/group exercise information; for example, Mauriello et al. proposed a wearable display for group running that shows running pace or duration to a group of runners [4]. In this work, we consider group fitness exertion games (exergames) that enable multiple exercisers with different fitness levels and workout goals to perform a set of exercise activities at the same time.

We examine group fitness swimming (e.g., swimming lessons/clubs) as a case study. Fitness swimming is a very popular aerobic exercise, as it provides a comprehensive full-body workout. Furthermore, this is a challenging case, as there are limited opportunities for social interaction in the swimming pool environment [8]. Based on the observation of group swimming and well-known exergame design guidelines [5, 6], we designed an exergame for group fitness swimming, called SwimTrain.

We mainly focus on supporting multiple swimmers who have different fitness levels and workout goals. To this end, our game design involves collaboration and competition. In particular, we employ a competitive aspect to facilitate users' engagement with social competition, as well as to help determine the target exercise intensity. In the collaborative period, swimmers are represented as train compartments that are overlaid on a virtual circular lane. The aim is to avoid collisions between compartments by collaboratively maintaining their individual target intensity. We also consider what is required to implement SwimTrain, such as estimation of physical intensity and method of delivering social presence to users.

SwimTrain

To design SwimTrain, we first observed group swimming. When swimming in a lane, each swimmer maintains an appropriate distance from those nearby (i.e., swimmers ahead and behind) to avoid contact [8]. Thus, one swimmer's pace influences others; for example, if one person swims slowly, the swimmer behind is also forced to swim slowly to keep their distance. This changes the swimming pace of all swimmers sharing the lane. Therefore, swimmers choose different lanes according to their skill levels and swimming speed [8].

The main concern of our game design is to balance different fitness levels and workout goals; thus, we augmented conventional group swimming in a virtual shared space [6]. Especially, the observation of 'swimming in a lane' is analogous to the motion of linked compartments in a train; each compartment of the train must maintain an appropriate distance from adjacent compartments to avoid collisions. Hence, we used a train metaphor that maps each swimmer to a compartment of a virtual train. In a virtual space, each swimmer maneuvers a compartment using their own physical intensity.

In addition, we incorporated competitive and collaborative aspects into the game for users' enjoyment and engagement. SwimTrain is comprised of multiple rounds, with each round following the same three-part structure: a short competitive phase, called *Compartment Ordering* (see Figure 1); a longer collaborative phase, called *Train Running* (see Figure 2); and a short rest phase, called *Train Stop* (see Figure 3).

Compartment Ordering During this phase, each swimmer's current physical intensity is estimated and aggregated (e.g., mean intensity). The game determines the order of compartments with individual aggregated intensities, and informs the players of the current orders (i.e., the rankings of swimmers). This competitive aspect

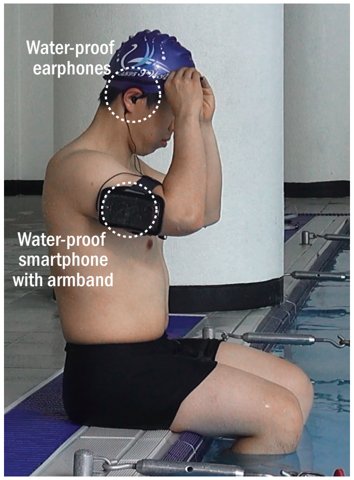

Figure 4: A device setting for SwimTrain

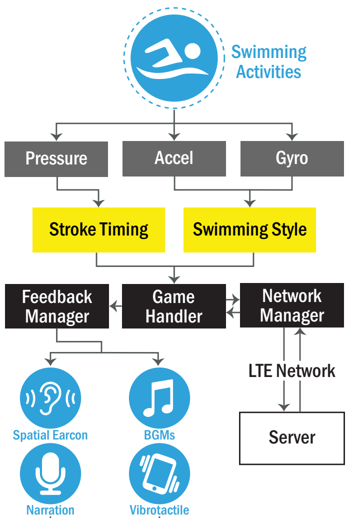

Figure 5: An expected overall architecture of SwimTrain

promotes players' engagement, and encourages higher intensity [9]. At the end of the phase, the aggregated intensities of each swimmer becomes their *target intensity* for the following phase, and they are given points according to their final rankings.

Train Running The goal of this phase is for each swimmer to continuously match their intensity with their target intensity established in the Compartment Ordering phase. The difference between current and target intensities for each swimmer shifts their compartment accordingly; a compartment shifts backwards when the current intensity is lower than the target, and forwards when it is higher. In addition, a compartment collides with an adjacent compartment if this difference exceeds an allowable range. Each swimmer's game points correspond to the length of time they go without compartment collisions throughout the phase.

Train Stop In this phase, every swimmer takes a rest. The game determines total rankings of swimmers from the previous round by summing points of previous two phases (i.e., Compartment Ordering and Train Running). In addition, information about the next round, such as the duration of each phase and optional rules of the round is announced to swimmers.

Furthermore, we incorporated some additional features into the game. Swimmers can score bonus points if they perform a given swimming style (i.e., freestyle, backstroke, butterfly, or breaststroke) throughout the round. We also varied the duration of each phase so that swimmers can apply different strategies to achieve a higher rank. For example, when the Compartment Ordering period is longer and the Train Running period is shorter, swimmers might focus on the former period, even if they overexert themselves. Both the target swimming style and the durations for a round are announced during the Train Stop of the previous round. These features might provide opportunities for unskilled swimmers to win the game.

Implementation Consideration

To play SwimTrain, we assumed that each swimmer secures a water-proof smartphone on their upper arm with an armband, and wears water-proof headphones (see Figure 4). Swimming motions are recognized using built-in sensors of the smartphone, and the game's progress is delivered to users in forms of auditory and tactile feedback. Each device communicates with a server using LTE (Long Term Evolution) network, which is the most robust electromagnetic-based technology under water [2]. An expected architecture of SwimTrain is shown in Figure 5.

As mentioned earlier, SwimTrain mainly uses physical intensity as a game input. Previous work has suggested heart rate to estimate physical intensity [7]. Instead, we considered the stroke rate (the number of strokes per unit time) as a measurement of a swimmer's physical intensity, because an increase in stroke rate is correlated to an increase in energy cost, which is defined as required energy to move a unit distance for a unit mass body [3]. To estimate the stroke rate, it is required to detect every single stroke timing. In addition, swimming styles should be recognized to determine whether players are performing the target swimming style throughout a round. We note that Choi et al. have suggested a real-time stroke detection module which recognizes stroke timing and swimming styles using an accelerometer, a gyroscope, and a barometer [2].

To inform players of the game's progress and presence of other players, we considered tactile feedback and a variety of sound resources, such as spatial earcons, narrations, and background musics. For example, when a player is swimming slower than their own target intensities, the spatial earcon delivers warning signals that sound as if it is coming from behind. An in-game narrator can also announce the situation (e.g., *"You are too close to the compartment behind"*), and the game progress (e.g., *"Start the Train Running phase"*). To help players distinguish phases, the game provides different background music at each phase.

Future Work

We are planning to implement a prototype of SwimTrain and conduct a user study iteratively. We will evaluate whether our game design balances different fitness levels and workout goals. For example, we can allow novices and competitive swimmers to play SwimTrain at the same time, and investigate user experiences.

In addition, we will carefully consider the limitations of human sensory capabilities during swimming. Our game provides a variety of sensory feedback, such as spatial earcons, narrations, and background music. However, swimmers' compounded exhaustion may hinder recognition of multiple feedback from the game [2]. They might also have difficulty distinguishing a direction of the spatial earcon, especially the front and the back [1].

We are also interested in applying our game design to other group fitness domains. Our train metaphor is based on the observation of 'swimming in a lane', which can extend to 'exercise in a line (or lane)'; for example, jogging or cycling in a line. We expect that such a group fitness can be transformed into a SwimTrain-like game.

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