GameLight - Gamification of the Outdoor Cycling Experience

Desheng Zhao
University of Glasgow
Singapore
zdsdesheng@gmail.com

Songjia Shen
University of Technology Sydney
Sydney, NSW, Australia
songjia.shen@uts.edu.au

Jeannie S.A. Lee
Chek Tien Tan
Singapore Institute of Technology
Singapore
jeannie.lee@singaporetech.edu.sg
chektien.tan@singaporetech.edu.sg

Florian 'Floyd' Mueller
Exertion Games Lab
RMIT University
Melbourne, VIC, Australia
floyd@exertiongameslab.org

Alexandru Dancu
Simon Lui
Singapore University of Technology and Design
Singapore
alex@ahlab.org
simonlui@sutd.edu.sg

DIS '19 Companion, June 23–28, 2019, San Diego, CA, USA
ACM 978-1-4503-6270-2/19/06.
https://doi.org/10.1145/3301019.3325151

Abstract
GameLight is a smart bicycle light that overlays a virtual game projected on the ground, within the user's natural field of view while cycling. The system aims to enhance the cycling exertion experience by augmenting it with various game elements presented in two game modes: (1) an "Arcade" mode that implements a virtual coin collecting mechanic, and (2) a "Challenge" mode that provides timed effort challenges. The system consists of a pico-projector and mobile phone wirelessly connected to cadence, speed and heart rate sensors that serve as input to the virtually projected game to achieve a fun and playful effect while cycling in a controlled environment. This demo will be appealing to attendees interested in designing playful technology to support exertion.

Author Keywords
human computer interaction; exergames; serious games; projector; bicycle; mobile phone; cycling

CCS Concepts
•**Human-centered computing** → **Interaction paradigms; Mixed** / **augmented reality;** *Ubiquitous and mobile devices;*

Figure 1: GameLight setup on a bicycle

Introduction

Increasing the adoption of cycling for exercise provides well-known benefits to the individual by improving both physical and mental health. However, the widespread adoption of cycling may be a challenge due to issues such as sustaining long-term motivation.

Exergames [9] that aim to transform exercise into game-like experiences have been active areas of research (e.g., [5]). Commercial mobile games such as [7] and motion-based gaming platforms (e.g., the Microsoft Kinect and the Nintendo Wii Fit) have also demonstrated the potential of games for health, where it was shown that individuals enjoyed exergaming more than the exercises in their original forms [6].

Specific to cycling, limited prior exergaming research has been demonstrated thus far. For example, PaperDude [1] is a remake of a classic arcade game, PaperBoy, with a virtual reality head mounted display (HMD) and an indoor bike trainer. Existing commercial cycling indoor platforms such as Zwift (www.zwift.com) and TrainerRoad (www.trainerroad.com) also enable virtual cycling experiences. Their popularity offers much promise in cycling exergames, and studies of such systems [8] suggest improvements in the cardiovascular fitness of participants. However, these systems have two major shortcomings: (1) they mainly serve performance-oriented avid cyclists, and (2) they can only be used in an artificial indoor setting.

For outdoor cycling, Smart Flashlight [3] explored the use of the environment surrounding the bike as a projection display, for the purpose of navigation guidance. It showed that projected images on the ground, in the line of sight of cyclists, improved safety on the road versus a traditional handlebar mounted mobile screen interface. However, Smart Flashlight did not investigate whether such projections were suitable for outdoor exergaming.

This demonstration presents GameLight, an improved projection-based system for exergaming. It uses low cost off-the-shelf components to overlay virtual games projected on the ground within the user's natural field of view. The projection allows for an improved view and interface for outdoor cycling and an opportunity to provide an outdoor exergaming experience in controlled environments. This system is potentially useful in improving motivation for outdoor cycling. As the safety aspects have not been thoroughly investigated, we recommend the system to be only used in controlled environments, e.g., fixed bike paths in outdoor parks.

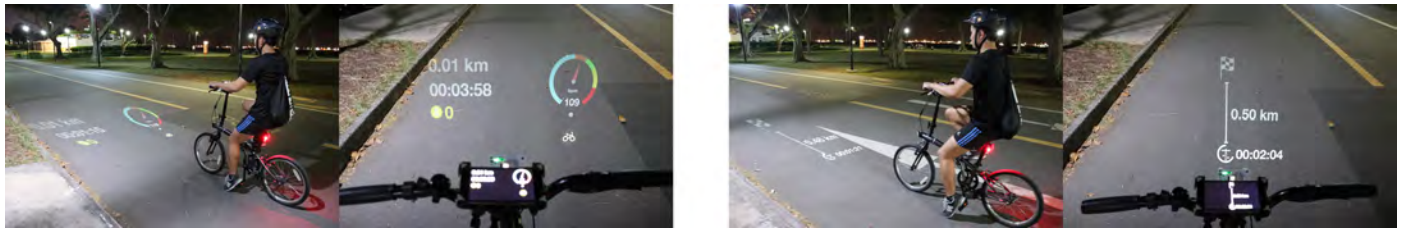

Figure 2: Game modes: "Arcade" mode (left) and "Challenge" mode (right)

Level	XP Needed
1	50
2	125
3 onwards	(*prev level XP* * 2) + (25 * *curr level*)

Table 1: Experience points required for each level

Level	Coin Frequency
$\leq$ 20	Every 30 meters
20 to 40	Every 40 meters
40 to 60	Every 50 meters
60 to 80	Every 60 meters
$\geq$ 80	Every 70 meters

Table 2: Frequency of the virtual coin

Setup & Implementation

Figure 1 shows the setup of GameLight on a bicycle. The setup includes a pico-projector and mobile phone mounted on the head-tube and handlebars respectively. The mobile phone contains the GameLight app, streamed wirelessly to the pico-projector. The cadence and speed sensors are attached on the crank and spokes of the bicycle respectively. The Bluetooth smart sensor, which connects both the cadence and speed sensors, is attached onto the chain stays of the bicycle.

The GameLight app was developed on the iOS platform in Swift. The hardware used by the app include a Wahoo chest strap heart rate sensor and Wahoo speed and cadence sensors. They are connected to the app using Bluetooth. The Wahoo API was used to access the cycling metrics that was collected from the sensors. GameLight uses Firebase[4] as the backend service and calls the cloud functions that was written on the realtime database to retrieve, store and amend data.

Gameplay Design

There are two game modes: (1) an "Arcade" mode, with the aim of collecting as many virtual coins as possible, and (2) a "Challenge" mode, with the objective of cycling a certain distance within the allocated time. Players can use either mode to accumulate experience points (XP), which is used as a quantitative measure to determine the player's progression through the game. Table 1 describes the level progression design.

Arcade Mode

In Arcade mode, the objective of the player is to collect as many virtual coins as possible within the distance cycled. The virtual coins are converted into XP. The frequency of the coins appearing is dependent on the player's level (Refer to Table 2). A distinct sound effect is played when a coin is collected.

Training within specific heart rate (HR) zones helps to achieve the desired goals of particular workouts. Therefore, these zones are also translated into gameplay mechanics. The value of the virtual coin is dependent on the player's current HR zone and level. The higher the player's HR and level, the greater the value of the virtual coin (Refer to Table 3).

Based on Burke's recommended HR zones [2], the four HR zones are derived using the maximal HR (MHR) of the player. MHR is the highest heart rate where one achieves to the point of exhaustion. An approximation of MHR can be

	Heart Rate Zone				
Level	*≤1*	*1*	*2*	*3*	*4*
1-5	1	2	3	4	5
6-10	2	3	4	5	6
11-15	3	4	5	6	7
16-20	4	5	6	7	8
21-30	5	6	7	8	9
31-40	6	7	8	9	10
41-50	7	8	9	10	11
51-60	8	9	10	11	12
≥ 60	9	10	11	12	13

Table 3: Value of the virtual coin

calculated using a simple popular formula, **220 - <Player's age>**. To determine the true MHR, the player has to go through a sports-specific or laboratory maximal stress test. As the MHR is only used within a game context, it was calculated using the simple formula in the implementation.

Challenge Mode

The Challenge mode aims facilitate the flow [10] experience with curated progressive levels. In this mode, the objective of the player is to beat the distance goal within the allocated time. Each challenge is locked initially, and unlocked progressively upon completion of each successive challenge. The player gains XP when he/she completes the challenge. As the player progresses, the difficulty of the challenges increases.

Conclusion

By enabling an outdoor cycling exergame, GameLight aims to improve the cycling experience through playful technology to motivate exertion. As future work, a more compact and battery-efficient hardware is currently being designed to integrate all components into a single-device form factor, in preparation for a larger scale user study in-the-wild.

References

[1] John Bolton, Mike Lambert, Denis Lirette, and Ben Unsworth. 2014. PaperDude: a virtual reality cycling exergame. In *Proc CHI'14 EA*. ACM, 475–478.

[2] Ed Burke. 1998. *Precision heart rate training*. Human Kinetics.

[3] Alexandru Dancu, Zlatko Franjcic, and Morten Fjeld. 2014. Smart Flashlight: Map Navigation Using a Bike-mounted Projector. In *Proc CHI '14 (CHI '14)*. ACM, New York, NY, USA, 3627–3630.

[4] Firebase. (????). `https://firebase.google.com/`. [Accessed 25 March 2018].

[5] Florian Floyd Mueller, Martin Gibbs, Frank Vetere, and Darren Edge. 2017. Designing for Bodily Interplay in Social Exertion Games. *ACM Transactions on Computer-Human Interaction* 24 (05 2017), 1–41.

[6] Alex C. G., Birgitta L. B., and Melinda A. S. Emily K. B. 2012. What Are the Benefits of a Commercial Exergaming Platform for College Students? Examining Physical Activity, Enjoyment, and Future Intentions. *Journal of Physical Activity and Health* (2012).

[7] Amrit K. Kamboj and Somashekar Krishna. 2017. Pokemon GO: An innovative smartphone gaming application with health benefits. *Primary Care Diabetes* 11 (04 2017).

[8] Shannon Knights, Nicholas Graham, Lauren Switzer, Hamilton Hernandez, Zi Ye, Briar Findlay, Wen Yan Xie, Virginia Wright, and Darcy Fehlings. 2016. An innovative cycling exergame to promote cardiovascular fitness in youth with cerebral palsy. *Developmental neurorehabilitation* 19, 2 (2016), 135–140.

[9] Hannah Marston and McClenaghan . 2013. *Play yourself fit: Exercise + Video games = Exergames*. 241–257.

[10] Penelope S. and Peta W. 2005. GameFlow: A Model for Evaluating Player Enjoyment in Games. (2005).