Biotic games: Integrating real living cells into digital game play

Honesty Kim, Daniel Chiu, Seung Ah Lee, Lukas Gerber, and Ingmar H. Riedel-Kruse
Department of Bioengineering, Stanford University
318 Campus Drive
Stanford, CA 94305, USA
ingmar@stanford.edu

ABSTRACT

The advancement of biotechnology enables the novel medium of "biotic video games". Biotic games are the playful interaction with living microscopic cells. In this conference contribution we will give a live demo of a low-cost biotic game kit that we developed which enables the wider distribution of biotic games. We present a 3D-printable microscope containing four LEDs controlled by a joystick that enables human players to provide directional light stimuli to the motile single-celled organism *Euglena gracilis*. The cells' behavior is displayed on the integrated smart phone. Real time cell-tracking couples these cells into interactive biotic video game play, i.e., the human player steers Euglena to play soccer with virtual balls and goals. The player's learning curve in mastering this fun game is intrinsically coupled to develop a deeper knowledge about Euglena's cell morphology and phototactic behavior. This kit is educational via construction and via play; its low cost and open soft/hardware should enable easy, wide adoption and further development. We invite the community to develop other games on this platform for education and entertainment.

INTRODUCTION

Biological technologies are becoming increasingly relevant in societies, creating a need for improved training and education. Interactive play and construction kits have been effective in steering student interest and engagement towards nurturing an interest in science [1], such as with video games and robots [2], [3]; integrating artistic and design aspects is also educationally important, hence the acronym STEAM (Science, Technology, Engineering, Art, Math) [4]. Equivalent activities in the life sciences are underdeveloped. We will give a live demo of a low-cost biotic video game [5], [6] kit (Fig.1) that we have developed in order to allows humans to playfully interact with living microorganisms.

IMPLEMENTATION

Biology – Euglena: As biological organism we chose *Euglena gracilis*, which are single-celled motile protists that are photosynthetic and phototactic (Fig. 2). Euglena are attracted or repelled by light based on its intensity (Fig.2C). This allows the player to control the orientation and direction of the *Euglena* via directional light stimuli. Euglena are widely used in educational settings. They are safe to use, educators are familiar with the organism, and many curricula exist for teaching students about *Euglena*. They are very popular as they are comparably large, have a vivid red eyespot and green cell body (Fig. 2B), and can survive multiple weeks without any care.

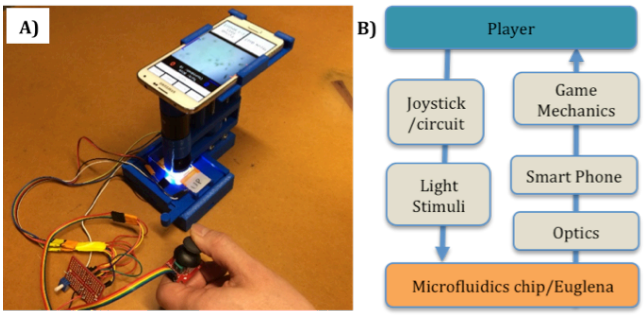

Fig.1: We developed a biotic video game design kit that enables humans to playfully interact with single celled Euglena. A) Overview of the game-kit with a player applying light stimulus via joystick; smart phone displays video game environment. B) Schematic of components enabling human-biology interaction.

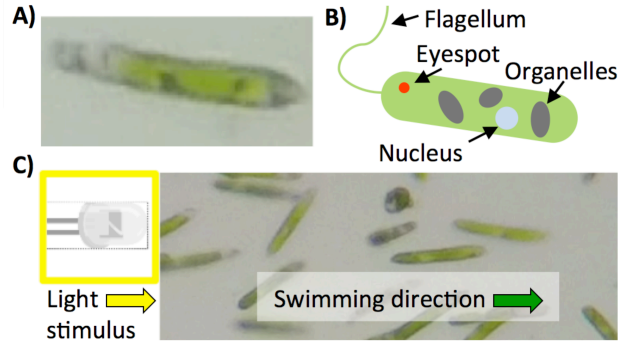

Fig.2: The game play features the phototactic behavior of the single-celled organism Euglena. A) Subcellular details of the organism are visible. B) Schematic of Euglena highlighted. C) Upon application of directional light stimuli, the player is able to induce collective motion away from the light (Note: all cells oriented to the right). (Scale: Length of Euglena ~50 µm)

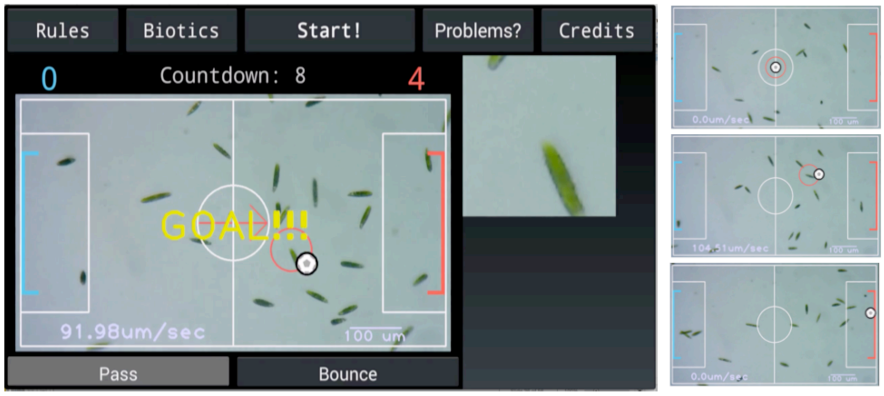

Fig.3: The smart phone game app for biotic game play with real living cells: (Left) Menu options, game states, timer, and player scores on top; screen with microscope image representing the play field including virtual goals and ball in center; tracked cell magnified on right; buttons for passing and bouncing ball on bottom. (Right) Game sequence: Ball pick-up with one Euglena (red circle), guidance of Euglena towards the goal via joystick-controlled light, and finally scoring a goal.

Microscope – Electronics – Microfluidics: We developed a custom DIY microscopy kit with integrated light stimulus (Fig.1A). The sample holder accommodates four LEDs. These LEDs are controlled by an analog joystick and are pointed towards the center of the sample holder, providing the directional light stimuli for the cells inside the microfluidic chamber, which contains the Euglena cells. Euglena cultures in the chambers are viable for 2-4 weeks, ultimately enabling a "plug and play experience" as with conventional electronic video games.

Smartphone - Object Tracking: We developed our game on an Android phone (Samsung Galaxy S5). The image recognition and game development was done using OpenCV and Android Studio.

GAMEPLAY

We developed a two-player turn-based soccer-like game (Fig.3). The objective of the game is to get a virtual "ball", into the goals at the two ends of the field. The player controls the system via external joystick (Fig.1) and two buttons at the bottom of the screen (Fig.3). The Euglena can "catch" the ball using image recognition. A circle is drawn around the region where image recognition is being performed. When a Euglena enters the region the software detects the Euglena and determines its center of mass. The ball then follows the Euglena's center of mass as it moves away from the light (Fig.3).

Game mechanics: At the start of a game, the ball is placed in the center of the field. Once a Euglena touches the ball it gets picked up. Using the joystick to control the directional LEDs, the player can direct the Euglena towards the goal. If the ball is carried beyond the bounds of the screen the player loses possession of the ball, and the other player takes a turn. The game ends after three turns and the player with the most points wins.

EDUCATIONAL POTENTIAL

This biotic video game-kit has multipronged educational potential, primarily via play and via building to target groups in middle school to college. From a biological perspective, the game allows players to spend a lot of time observing and also interacting with Euglena, which is the fundamental basis of discovery. Real time in-game feedback on speed and size (Fig.3) provide quantitative knowledge. Players are also able to discover subcellular details resulting in familiarity with the building blocks of life. The learning curve to excel in this game is directly coupled to an increasing understanding of Euglenas response to light stimuli. Hence the player learns first hand about the complex behavior of even organisms. This biotic video game device is a lush intersection of multiple scientific disciplines beyond biology such as optics, computer science, electronics, and even arts, all of which we expect people to learn in an integrated manner by building such game devices, which provides a motivational basis for corner and capstone (bio-) engineering devices classes [7].

CONCLUSION

We provide a live conference demo of a biotic video game-kit we developed, which incorporates biological phenomena into the gameplay mechanics. This medium has great potential for nurturing interest and teaching biology and device design. All components of this low-cost design are easily fabricated. An upcoming full paper will provide design instructions and first user assessment. We invite the community to develop games on this platform and to explore the educational and entertainment potential more deeply. We also envision significant future technological and commercial synergy between the game and biotech industry – similar as has happened over the past decades for conventional electronic video games [5].

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