VR-Electrocardiogram: Performing and Understanding ECGs in VR

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Principal Investigator: Brian Anthony; Sponsorship: MIT.nano Immersion Lab

The electrocardiogram (ECG) is a common, safe procedure used by cardiologists to diagnose a plethora of heart conditions. It consists of placing a set of voltage-sensing leads onto specific locations on the body which record the electrical activity of the heart.

In order to perform an ECG and see the resulting graphs, you need a live human subject. But unfortunately, in a large class, getting practice for every student can be time-consuming and require numerous live subjects. Tools already exist in virtual reality for learning where to place leads when performing an ECG. The drawback of these programs is that they give no active feedback to the student on the outcome of incorrect placement of leads. Rather, these programs follow a simple 'point-and-click' style of placing the leads, and the program ends. The VR ECG program addresses these issues by virtualizing the process and simulating the function of a real human heart.

The VR ECG program developed by VR/AR@MIT replaces the need for a live human by replicating the electrical action of a real heart. The program uses reverse-engineered real clinical ECG data to simulate electric signals in the heart, which can then be read by the virtual leads to generate ECG plots dependent on where the students place their leads. As a result, users can learn how the electric function of the heart works, and how their performance of an ECG affects their resulting graphs in real time. It allows for total freedom of the student to place the leads wherever they want, and draw conclusions about how each lead correlates to new outcomes in the resulting plots.

VR ECG is replayable infinitely, and requires only a small playspace. This allows the program to be used in any layout of the classroom, or used as a homework assignment for students. As a virtual tool, it can be used worldwide by anyone in healthcare with a VR headset. VR/AR@MIT hopes that VR ECG will enhance medical training and improve patient outcomes around the world.

Figure 1: Mannequin used for performing ECG in virtual environment.

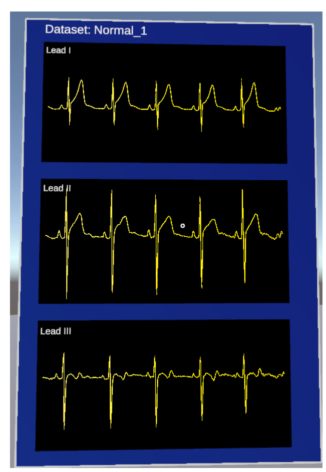

Figure 2: Generated ECG graphs in virtual environment

VR-Frogger: Improving Locomotion Immersiveness in VR

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In virtual reality, the user is bound by their physical playspace, but in many cases it is necessary to explore a larger area within the virtual environment than the user's physical playspace allows. Virtual movement to traverse these environments often limits immersion. There is currently no solution for natural, user-friendly locomotion in VR. VR-Frogger addresses this need by capturing vertical physical movement and translating it to locomotion in the virtual space.

There are two mainstream workarounds to the problem of virtual locomotion. First is pressing a button or joystick to move in a direction. This allows for a continuous view of the game, but feels unnatural to the body due to the combination of seeing movement but not physically moving, which can cause nausea and dizziness. The second method is point and click teleportation. This avoids the nausea problem caused by joystick movement, but causes a choppy and disorienting experience.

The goal of VR-Frogger is to determine the validity of jumping as a mechanism of movement for virtual reality. In the game, the user crosses roads and evades moving cars by physically jumping up and down in their playspace in order to move forward in the VR environment. Vertical movement, or jumping, solves the problem of limited playspace area. We expect that by linking the user's vertical movements in real life to horizontal movement in the virtual environment will be less jarring and feel more natural to the body.

Users are able to playtest the game using both jumping and button based locomotion systems. After testing, users are encouraged to fill out a user survey comparing their experience using each of the locomotion systems. In it, questions relating to comfort, ease of use, performance, and more are given. Using these metrics, VR/AR@MIT hopes to analyze quantitatively the effectiveness of this new locomotion form in the virtual reality space.

Figure 1: First person VR view inside Frogger environment

FURTHER READING

- VR-Frogger GitHub - Source Code and APK Download. https://github.com/trentpiercy/VR-Frogger

Templated crystallization of silk fibroin in nanostructured materials

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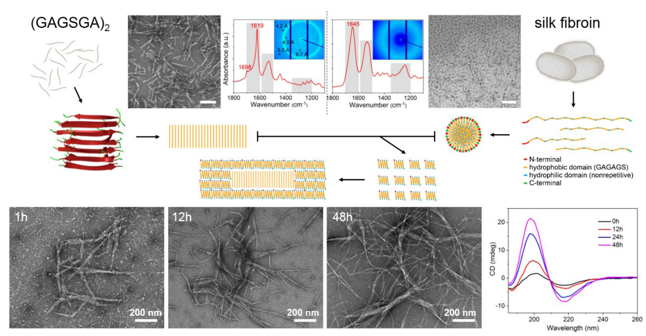
Sponsorship: NSF Career, ONR YIP

Naturally occurring biopolymers are promising building blocks for a new generation of multifunctional materials that can work at the biotic-abiotic interface and better interact with the environment. Particularly, silk fibroin – a structural protein extracted from Bombyx mori silkworm cocoons, has attracted a lot of attention in the recent decades due to the potential use as technical material in a broad range of applications, encompassing drug delivery, regenerative medicine, food coating, printable sensors and optoelectronics etc. As more manufacturing methodologies with silk fibroin are being developed, a key question yet to be answered is how to endow silk fibroin-based bulk materials with complex nanoscale features.

In this work, we introduce templated crystallization of silk fibroin as a process to nanofabricate hierarchically structured materials up to centimeter scale. The process involves the use of ordered peptide supramolecular assemblies as templates to drive a phase transformation of silk fibroin from unordered to ordered conformations, thereby enabling further assembly of the silk fibroin chains into β-sheeted nanofibrils (Figure 1). Multiple parameters including the relative concentration between silk fibroin and peptide seeds, silk fibroin molecular weight, pH and peptide conformation are investigated to fine tune the assembly kinetics, silk polymorphs and nanomechanical properties. Combining the templated crystallization with various top-down fabrication such as soft lithography and printing enables formation of different silk polymorphs at selected areas, generating a free-standing patterned silk film, where the different molecular structures can be used to store or encrypt information (Figure 2). Together, these results pave the way for nanofabrication of a new generation of smart and adaptive materials built from the bottom up.



▶ Figure 1: Schematic of templated crystallization of silk fibroin on β-sheet nanowhiskers assembled from a dodecapeptide (GAGSGA)2. TEM imaging and circular dichroism spectroscopy are used to verify and characterize the templated crystallization process.

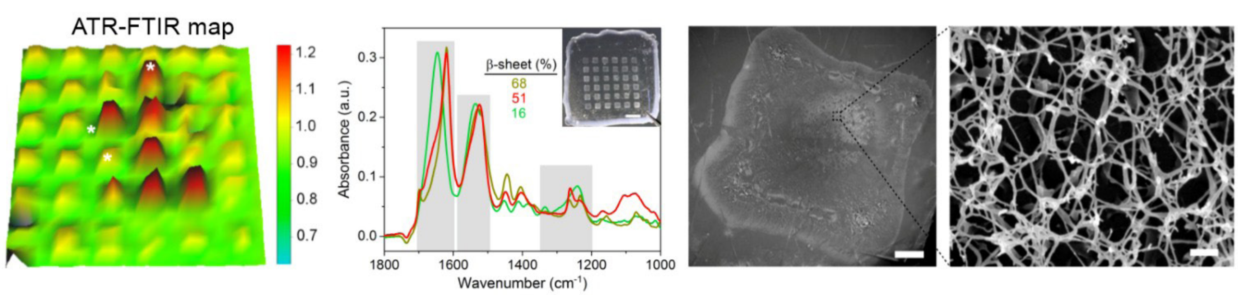


Figure 2: Nanofabrication of a free-standing silk film that is selectively crystalized into different polymorphs through templated crystallization on different peptide seeds. ATR-FTIR is used to reveal the hidden numeral in the patterned silk film.

FURTHER READING

- H. Sun, B. Marelli, "Polypeptide templating for designer hierarchical materials," Nature Communications, vol. 11, no. 351, Jan. 2020.
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- Asylum Research. A Smooth Route to Hierarchical Materials: Peptide Templating of Silk [Online]. Available: https://www.oxinst.com/learning/view/article/a-smooth-route-to-hierarchical-materials, Aug. 2020.