Sweat-Atoms: Crafting Physical Objects with Everyday Exercise

Rohit Ashok Khot
Exertion Games Lab,
RMIT University, Australia
rohit@exertiongameslab.org

Figure 1: A 3D printed object created using the heart rate pattern can be used as a souvenir of the invested effort.

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Abstract
In this paper, we introduce a novel idea of associating physical exercise with the creative process of crafting physical objects. Our aim is to harness physical exercise as a source for self-expression. We present Sweat-Atoms, a 3D modeling and printing system, which generates abstract 3D designs using the heart rate patterns of individuals engaged in a physical activity. The crafted physical objects can act as souvenirs and be testimony to the invested human efforts in performing the physical activity. The preliminary responses to the system have been encouraging. Participants liked the crafting of their exercise patterns and they were eager to experiment our system with different physical exercises.

Author Keywords
Physical exercise; 3D printing; crafting; exertion.

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation]: User Interfaces - Miscellaneous.

General Terms
Design, Human Factors

Introduction

Regular physical exercise is the key to maintain and regain personal health [1, 12]. Despite knowing the benefits of physical exercise, number of people who regularly exercise is relatively low [10]. We find two issues with physical exercise that makes the exercising experience non engaging. The first issue is the monotonous nature of most physical exercise. For example, in order to achieve the desired health benefits, the user should not only exercise regularly, but also at the appropriate level of intensity [1]. This would involve setting up an exercise routine, obeying the rules instructed by the physician, coach or fitness DVD program. This repetitive nature of the exercise activities coupled with perceived control of the external factors on our actions make physical exercise a boring and non-engaging experience [2]. The second issue with physical exercise is the lack of meaningful feedback. Unlike our usual daily activities where the results of our invested energy are visible immediately, the outcomes of the physical exercise are not comprehensible and visible immediately. For example, the effect of an exercise to burn our body fats is visible only after a certain period of time. This shortcoming can often make exercise a purposeless activity and thereby demotivating users from doing it [9]. As a result, it has been pointed out that with health goals alone it is often challenging to engage people in doing physical exercise [12]. Therefore, it becomes necessary to couple exercise with some engaging activity.

The intention of this work is to make physical exercise an engaging experience through the process of crafting. We believe that crafting is one of the supreme examples of an autonomous activity where actions are often guided with self-interested (motivated) outputs [5]. Our idea is to craft a physical object in tandem with the physical exercise using the exercise patterns. We define exercise patterns in terms of various bodily movements that happen during the exercise as well as the exercise intensity, which is measured in terms of the heart rate and breathing rate. Currently, these exercise patterns are mainly utilized to show accurate statistics on individual's exercise performance and to prompt the user to aim for the next achievable health goal [7]. We believe there is an opportunity of using exercise patterns as a source for self-expression and creativity. Crafting physical objects that resemble the exercise patterns can not only be a new way of visualizing these exercise patterns, but the crafted physical object can also serve as a souvenir or a testimony to the efforts invested in performing physical exercise. We also believe that the coexistence of crafting activity with physical exercise can inspire the user to be more creative with her exercise activities. This can possibly help her to change the monotonous nature of the physical activity, leading to more sustained engagement.

As a proof of concept, we present Sweat-Atoms, a 3D modeling and printing system, which generates abstract 3D designs using heartbeats of the individual engaged in a physical exercise. While the user is exercising, she wears a heart rate monitor around her chest, which records and sends changes in the heartbeats to Sweat-Atoms application. The Sweat-Atoms program then builds an abstract 3D model using the received heartbeat patterns, which is subsequently printed using a 3D printer. The preliminary responses to the system have been positive. Participants appreciated the approach of 3D modeling with their

exercise patterns. They were very eager to print different shapes by using different exercise patterns.

Related work

Recently, attempts have emerged with the aim of tackling the above-mentioned issues about exercise using the digital technology. For example, devices such as pedometers and heart rate monitors provide accurate and real time feedback on the exercise activity and thus make understanding of the exercise goals easier. Secondly, to address the monotonous nature of physical activity, people have tried to couple the exercise activity with activities that are known to be fun. For example, exertion based games facilitate intense body movements through engaging game based narratives [6]. Similarly, gamification based exercise systems provide virtual rewards and points on successful completion of exercise activities [11].

Majority of the existing works have focused on virtual engagement, which are also vicarious in nature. The exercise experience is often tailored by the designer of system and most often the user is rewarded only when she correctly follows the preset exercise instructions. For example, in most exertion-based games, there is a predefined mapping between bodily movements and actions inside a game. If the player does not make the correct body movement at the correct time, there will not be any action within the game. As a result, many of the unmapped bodily movements go unnoticed inside a game. Moreover, the virtual points and rewards do not hold much material and cherishable value in real world. For example, a score of 10,000 virtual points might be satisfying for a moment, but it is not as memorable as any real world physical reward. We believe, this instilled vicarious nature of exercise experience limits autonomy [2] and fails to provide users with options for self-expression and creativity within physical exercise. Interestingly, it has been observed that when an activity does not provide users with any option for creativity, they often alter their due courses of actions to make themselves feel autonomous and creative. For example, many runners in the UK tried to be creative with their running patterns, tracked by a mobile phone app on a virtual map by deliberately running in a pattern that resulted in a running route representation in the shape of a penis [8]. Another example is of Farmville based pixel art where the game players use their virtual farms as a canvas to create pixel-based art [3], with no particular advantage in the game except as a tool for self-expression. And there are also people who instill self-expression in physical sports, for example see body sculpting and performance-based arts such as dance. Drawing inspiration from the performance based arts, where creativity and physical activities are interlinked, we ask the following research question,

"*In order to make the experience more engaging, can we incorporate creativity and self-expression within different forms of physical activities?*"

Approach

To answer our research question, we note that the way of doing exercise differ for every individual, even if they do the same exercise. For example, the bodily movements and the body response of one person to a physical exercise will vary from others, even if only by a slight deviation. We draw on this fact that each person brings her own unique flavor to exercise, in particular how the body responds to the activity over time. However, these nuances within the exercise

activities are not easily noticeable. Fortunately, technology can measure these nuances, and we see this as an opportunity to support our endeavor.

We propose the idea to capture and utilize exercise patterns to fabricate a physical object in response to the physical activity. Our intention behind choosing a physical object over a digital one is that we believe it could provide a better testimony of the invested physical effort than virtual rewards. Moreover, physical objects are cherished more than virtual objects because of their better visibility in the surroundings and lower probability for replication [4]. In order to understand how physical exercise and personal fabrication are related to each other, we elaborate on these two activities: energy expenditure during a physical exercise and the additive manufacturing process of 3D printing. Physical exercise involves stepwise investment (subtraction) of energy to achieve the desired health goal. On the other hand, in additive manufacturing, a 3D model is constructed (printed) by adding materials layer by layer. We see a synergy between the two activities. For example, the continuous subtraction of energy while doing a physical exercise is similar to the continuous addition of materials to print a 3D model. This synergy between the two activities inspired us to think about interlinking them together. For example, what if the obtained patterns of the exercise activities are fed into additive manufacturing process; can it result into interesting abstract designs? Motivated by this thought we present below a creative exertion approach, we call as Sweat-Atoms.

Sweat-Atoms

Sweat-Atoms is a 3D modeling and printing system where the nuances (measured patterns) of exercise activities are utilized in the modeling process of 3D printed object. In the current prototype we have utilized heart rate patterns in creating the 3D model. We now explain the working of the system (Figure 2).

Step 1: Exercise: While performing a physical exercise, the user wears a heart rate monitor which records her heart beats per minute. In the current prototype, we have utilized the Zephyr heart rate monitor.

Step 2: Measure: While the user is performing the physical activity, the heart rate monitor attached to her body, records the exercise intensity levels in the form of increase in the heart beats. This recorded data is then sent over Bluetooth to the Sweat-Atoms application, installed on the computer. Sweat-Atoms is a 3D modeling application developed in Processing.

Step 3: Model: After receiving the heart rate data, the Sweat-Atoms software starts the 3D modeling process. In the current prototype, the constructed 3D design consists of triangular prisms of varied volume joined together to create an abstract shape. For every large increment in the heart rate (± 10 beats per minute), a new triangular prism is added to the model. The size of the triangular prism depends upon the reading of the heart rate. For example, for a higher reading of the heart rate, we insert triangular prisms of higher volumes (Figure 3). The modeling process continues as long as the user is exercising (or as long as the heart rate monitor is sending the data). The process stops when the user stops the heart rate monitor manually. The user can also manually stop the process in between the exercise if required.

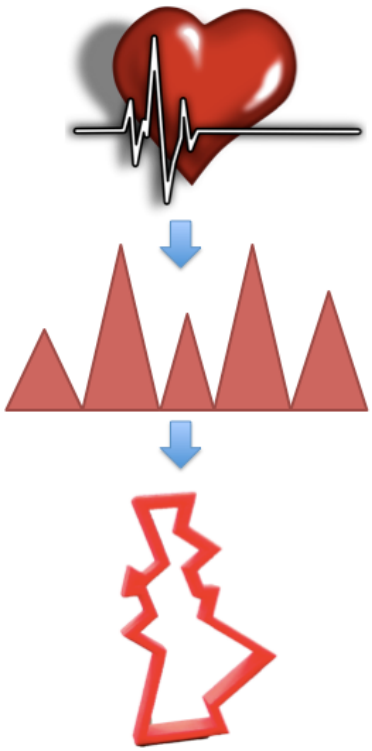

Figure 3: The 3D modeling process inserts a triangular prism of different volumes for each significant (+- 10bpm) variation in the heart rate. All the inserted prisms are then assembled together to represent an abstract 3D shape.

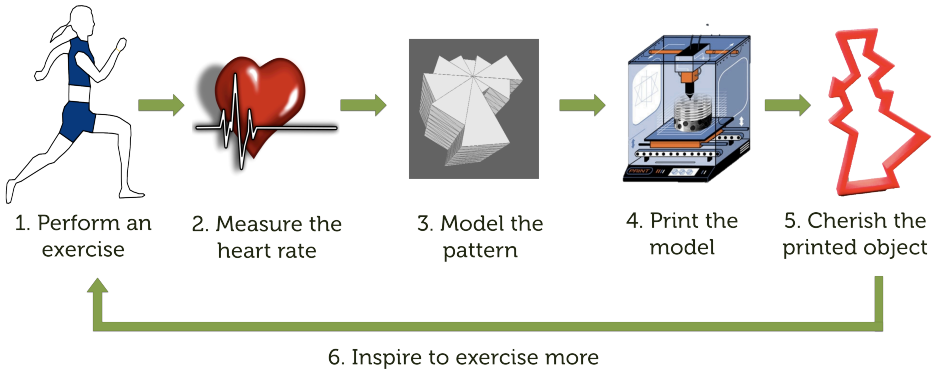

Figure 2: The Sweat-Atoms loop in actions: 1) user performs a physical activity. 2) The heart rate is measured 3) A 3D model is created based on the pattern 4) The 3D model is printed 5) The user cherishes the printed object 6) The cherishing and ability to create new, novel patterns hopefully inspire the user to exercise again and in different ways.

Although in the present prototype, we have preconfigured the geometrical shape as well as the mapping between the heart rate readings and the design, users can also utilize different geometric shapes for modeling and they can also define a different set of mappings between the measured readings and the 3D design.

Step 4: Print: When the user has finished her physical exercise, she stops the Sweat-Atoms application. The resultant 3D model is then saved into a STL file and the file is fed to the 3D printer for printing. Users can choose the printing material of their choice as well as alter the dimensions (size) of the 3D model before printing.

Step 5: Cherish: The printed object not only acts as a souvenir to the efforts invested in performing the physical activity but it can also be used for a utility purpose such as sending it to someone as a gift. Figure 4 shows some of the printed objects in different materials and design patterns.

Step 6: Inspire: The design of the physical object is based on the exercise patterns. In order to get different physical object as an output, the user might get inspired to do exercise differently and to try out new forms of exercise [10]. For example, user might be interested in figuring out how the pushup exercise would reflect in the design compared to jogging or what if I increase the speed of my running, would it have any impact on the constructed 3D model? We believe questions like these would inspire the user to exercise more and be creative with her exercise. As a result, we envision that it would lead to an engaging experience.

Preliminary feedback

We report the observations from a preliminary study conducted with five university students taking treadmill as an example of physical exercise. Each participant

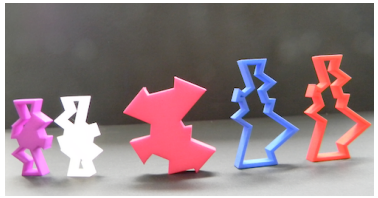

Figure 4: Some of the objects printed using the exercise pattern of the participants are shown.

wore a Zephyr heart rate monitor and its readings were fed to Sweat-Atoms program installed on their computers. We mentioned a partial design of our system to them that we were willing to create 3D models from their heart beat patterns. We intentionally did not inform the participants about the 3D printing of the souvenir made out of their heart rate. Our motive behind this was that we wanted to see their reactions on getting a 3D object as souvenir of their invested time in our study as well as the physical exercise. Participants liked modeling of their heart rate in the form of 3D printed objects: "*Oh man! It is so interesting. I should have run for 10 more minutes. I wonder what would be my object by then!*" They found these objects as a beautiful and interesting way of experiencing exercises and were very eager to produce different designs by doing different exercises.

Limitations

Currently the system is designed with predefined algorithms to measure heart rate patterns and to generate 3D models out of them. One might argue that this designer-oriented view may not fully capture self-expression. We acknowledge this and therefore, in the future, we are planning to structure the system as a creative toolset to allow users to define their own modeling process and to take up the designer's role. Our focus for now is on everyday physical activity, as this can significantly contribute to positive health. In future, we will also look at physical sports.

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