ProjectLive: An Augmented Reality System For Stress Relief via Guided Tai Chi Exercises

Jennifer Lu
Stanford University
jenylu@stanford.edu

Exan Nixon
Stanford University
enixon1@stanford.edu

Peter Washington
Stanford University
peterwashington@stanford.edu

Abstract
We have developed an augmented reality (AR) system, codenamed ProjectLive, intended to provide instantaneous stress relief and improve mental health of users. The system provides this stress relief in the form of short, interactive games that prompt the user to exert themselves in ways that approximate Tai Chi exercises. Tai Chi has been well documented to encourage stress relief and lower blood pressure. ProjectLive encourages the user to make relaxing body movements in their environment through interactive instructional activities delivered through a HoloLens device. Unlike in traditional Tai Chi, where there is a single human instructor, ProjectLive uses butterflies as the "instructor" which provide the user with hand movement guidance. The user is given positive feedback if they correctly follow the butterflies. The activities are further customized to the user by taking into consideration the user's biometric markers, primarily heart rate, using the Microsoft Band. We have conducted a small pilot user study to determine the effectiveness of the ProjectLive system in providing short-term stress relief to users.

Author Keywords
Augmented Reality; Biofeedback; Mental Health; Wearable Computing

ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction

Why Augmented Reality?

Prior work has shown that Tai Chi can reduce stress in users, as measured by reduction in heart rate, blood pressure, and changes in salivary cortisol levels [3]. During Tai Chi, it is necessary and helpful for users to be able to see their arm movements while also enjoying (or at least being aware of) their environment. For users to currently self-learn Tai Chi, they would most likely watch a video on their laptop while following the instructions in the video. This can be inconvenient and also distracting from a user's own movements since they will be fixated on a small screen.

While the literature on virtual reality to provide stress relief is dense [7, 8, 11], there is little work on using augmented reality to provide stress relief. In the case of virtual reality, users would not be able to enjoy the physical space they are in or see their actual arm movements as they do the exercises. Using augmented reality can solve these problems by allowing users to see the necessary physical elements of both their movements and the space they are in while easily following the augmented Tai Chi movements from the HoloLens.

Overview

ProjectLive focuses on providing stress relief to people, preventing anxiety, and promoting overall health. The system provides this stress relief in the form of short, interactive games that prompt the user to exert themselves in ways that approximate well-known Tai Chi exercises. Tai Chi has been well documented to encourage stress relief and lower blood pressure.

[UPDATE THE EXAMPLE ACTIVITY?] ProjectLive encourages the user to make relaxing body movements in their environment through interactive activities delivered through a HoloLens device. An example activity, which we have focused on in our implementation, prompts users to catch as many butterflies as they can in their environment, encouraging the users to be active while adding a sense of nature to their current environment. We have chosen the butterfly metaphor as a common theme throughout the various interactive games because butterflies fit with the imagery of nature that is known to relax users. Butterflies are also mobile and can therefore be used for gamification purposes (to prompt the user to move in a relaxing way). The system could be used in the clinical setting, where there is large and growing interest in providing effective innovative therapeutic technologies.

The system's **interaction** is as follows: the user's goal is to *follow* a flock of butterflies with their index finger. When the finger is detected hovering near a butterfly, the butterflies near the finger become surrounded by a green halo. The halo disappears when the user's finger is no longer near the butterflies. The halo provides positive feedback to the user indicating that they are moving in the correct motion. In this way, the user is given positive feedback if they correctly follow the butterflies.

Another dimension of interactiveness comes from measuring the users mental/physical state as a source of input. Specifically, we use the sensors on the Microsoft Band to continuously measure the users heart rate. The biofeedback triggers the user to put on the HoloLens headset and then lets the user know when it is okay for them to take it off. In this way, the micro-activities are customized to the users mental state.

This paper begins with a survey of related work. The paper then describes the general architecture of ProjectLive as well as a description of the various 3D, spatial, and interactive Tai Chi exercises that ProjectLive supports. We then describe a user study we conducted to determine the effectiveness of our system. We conclude with areas of future work for ProjectLive.

Related Work

Stress Relief Literature

A formal study has found that people find stress relief in natural environments and that they find more stress-relief from physical activities [2]. Because of this, ProjectLive encourages users to be more physically active when possible and uses the imagery of a butterfly (representative of nature). Our system also adheres to a set of design heuristics for calming technologies published by the Calming Technologies Lab at Stanford, namely relieving time pressure from activities, acknowledging human interpretations of time passing, and reducing feelings of being overwhelmed [4].

Other work has shown that Tai Chi, brisk walking, meditation, and neutral reading are all activities which have been shown to reduce stress in users, as measured by reduction in heart rate, blood pressure, and changes in salivary cortisol levels [3]. Furthermore, Tai Chi and balance training have been shown to improve health and prevent falls for older people aged 70 years and older. A study by Wolf [12] evaluated the effects of two exercise methods Tai Chi and computerized balance training on primary outcomes such as biomedical, functional, and psychosocial and secondary outcomes such as occurrence of falls over the course of 15 weeks. The results showed that blood pressure lowered after a 12-minute walk among Tai Chi participants. In addition, Tai Chi was seen to reduce the risk of multiple falls by 47.5%. Another study looked at the effects on blood pressure, lipid profile, and anxiety status on users after a 12-week Tai Chi Chuan exercise program [10]. The exercises were done 3 times a week over the course of the entire 12 weeks where each session included a 10 minute warm-up, 30 minute Tai Chi exercise, and a 10 minute cool-down. The results of the study showed a significant decrease in blood pressure and serum total cholesterol level. Trait anxiety and state anxiety were also seen to decrease as measured by the STAI evaluation. The conclusion showed that Tai Chi exercises are able to decrease blood pressure and improve lipid profile changes and anxiety levels. Patients with mild hypertension would benefit greatly from Tai Chi exercises.

One related project Tai Chi augmented reality system is a Tai Chi Virtual Tutor Mobile application for Elderly parks [5]. This system creates an augmented reality application within a park where others can look at a large screen and follow this Tai Chi tutor when they stand in front of it. Our project differs in that there is no traditional instructor. Rather, the butterflies are the "instructor" and provide the user with hand movement guidance.

In response to this work, ProjectLive encourages users to make movements similar to those in Tai Chi and will motivate the user to be active. With augmented reality, our project serves as a self-tutorial for Tai Chi while allowing the user to enjoy the physical space they do their exercises in. Comparatively, when learning Tai Chi normally, most people are focused on watching the instructor or video they are following. With our augmented reality application, users are able to focus on and notice their own movements while being guided by virtual butterflies. In addition, they are able to enjoy the physical surroundings they are in as they follow the

exercises.

Virtual and Augmented Reality for Stress Relief
While there is very little prior published research in using augmented reality for stress relief, the literature for using *virtual* reality (VR) for stress relief is quite dense. There are over 50 published case studies of using VR for mental health; in general, these studies identify advantages in delivery and disadvantages in side effects of the VR systems [1]. Many of these studies focus on the use of VR for treatment of post-traumatic stress disorder through exposure therapy [7, 8, 11].

System Architecture

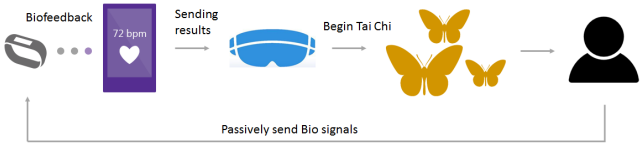


Figure 1: Architecture displaying communication between the user, Microsoft Band, Smartphone, and Microsoft HoloLens

As shown in Figure 1, the ProjectLive system architecture consists of a Microsoft HoloLens, a Microsoft Band, and a smartphone device (Android). Due to the limited processing power of the Microsoft Band, it needs to be paired to a smartphone device. The biometric sensors detected on the Band are sent to the Android device, which then forwards the measurements to an Amazon EC2 instance which the HoloLens reads from. The HoloLens then updates the interactive game being played based on the user's biometric data. A detailed description of the various interactive games that ProjectLive supports is contained in the next section.

Interaction

Unlike in traditional Tai Chi, where there is a single human instructor, ProjectLive uses butterflies as the "instructors" that provide the user with hand movement guidance. The activities are further customized to the user by taking into consideration the user's biometric markers, primarily heart rate, using the Microsoft Band.

The application begins with a message prompting the user to "Follow the butterflies with either hand." and a flock of butterflies flying in front of their view as seen in Figure 2. When the user's finger is detected hovering near a butterfly, the butterflies near the finger become surrounded by a green halo as seen in Figure 3. The halo disappears when the user's finger is no longer near the butterflies. The halo provides positive feedback to the user indicating that they are moving in the correct motion. If the halo is always present, the user is making the right movements.

Figure 2: Starting prompt displayed on the HoloLens.

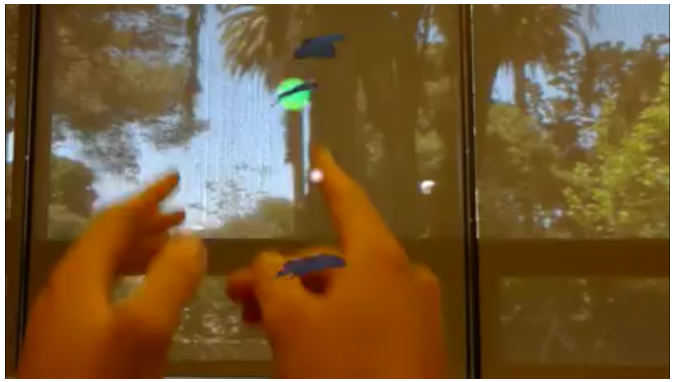
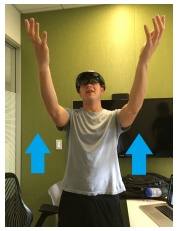


Figure 3: A green halo is shown over the butterflies when a user hovers their hand over the butterfly.

Microsoft Band
The user wears the Band on their wrist continuously throughout the activity. When the user selects an activity on the Android device, the band prompts the user to get ready for the activity with both a haptic notification and text displayed on the Band.

Interactive Tai Chi Exercises
All of our designed interactions (developed with Unity Game Engine) encourage the user to either move in ways that are shown to provide stress relief or to provide imagery of the user's current scene that are shown to provide stress relief. We have chosen the butterfly metaphor as a common theme throughout the various interactive games because butterflies fit with the imagery of nature that is known to relax users. Butterflies are also mobile and can therefore be used for gamification purposes (to prompt the user to move in a relaxing way).

We implemented five beginner Tai Chi exercises which users can either individually choose or automatically run one after the other. The first exercise, shown in Figure 2, involves an up and down arm movement by the user encouraging a sink and breath out action. The second exercise, shown in Figure 3, has the user bringing their arms out and above their head then back down. This also encourages breathing out as the user goes through. In the third exercise, shown in Figure 4, the user brings their arms out to the side, up, towards themselves, and then back out in a circular motion while facing the side. This focuses on a pushing movement along with breathing out and is to be done on both sides. The fourth exercise, shown in Figure 4, has the user breathing in and out deeply where the butterflies will pulse along with the user's breathe and heartbeat. Finally, in the last exercise (shown in Figure 6), the user brings both arms up and around their head and body in a large circular motion while facing forward. This last one focuses on Rise and breathing in.

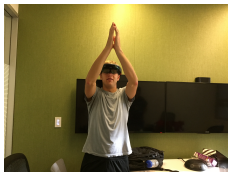


(a) Raising arms up, breathing in

(b) Lowering arms down, breathing out, sink

Figure 4: Tai Chi Exercise 1- Sink

(a) Raising arms up to side, breathing in

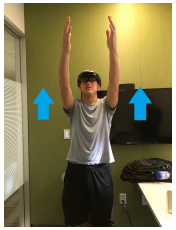


(b) Raising arms above, breathing in

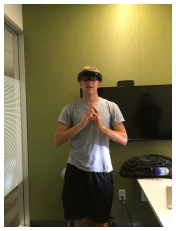
(c) Lowering arms down, breathing out

Figure 5: Tai Chi Exercise 2- Arms out

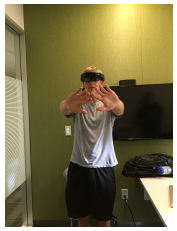
(a) Starting Position



(b) Raise arms up

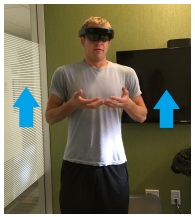


(c) Bring arms in

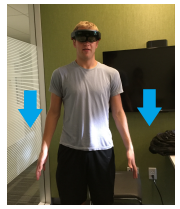


(d) Push arms forward

Figure 6: Tai Chi Exercise 3- Push

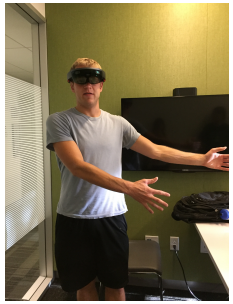


(a) Breathing in

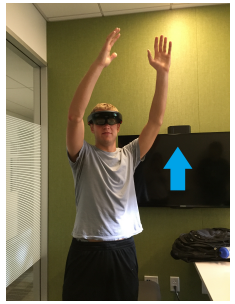


(b) Breathing out

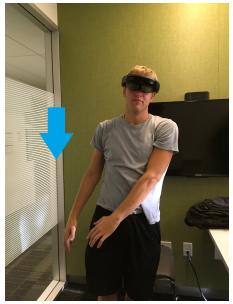
Figure 7: Tai Chi Exercise 4- Breathing



(a) Starting position



(b) Raising arms up



(c) Bring arms around other side and down

Figure 8: Tai Chi Exercise 5- Circular Movement

User Study

In this section, we describe a small-scale user study that we conducted with 7 users to evaluate the potential effectiveness of our prototype. In addition to receiving qualitative feedback about using the device, we measured the blood pressure and heart rate of each participant. The blood pressure was measured immediately before users put on the HoloLens for the first time, immediately after completing the activity, and 3 minutes after use (in order to allow the users' heart rate and blood pressure to achieve a resting state). The heart rate was measured on the Microsoft Band and was continuously monitored throughout the study.

BP (Before)	BP (Right After)	BP (3 Minutes Later)
102/61	99/65	100/68
125/76	128/79	139/83
106/70	109/67	124/93
116/80	114/79	118/80
108/74	97/66	106/68
102/71	100/68	102/78
102/77	104/76	110/60

Table 1: Blood pressure of users immediately before putting on the HoloLens for the first time, immediately after completing its use, and 3 minutes after use.

HR (Before)	HR (Right After)	HR (3 Minutes Later)
61	69	62
42	52	52
75	75	49
62	68	65
71	71	73
58	57	54
69	67	61

Table 2: Heart rate of users immediately before putting on the HoloLens for the first time, immediately after completing its use, and 3 minutes after use.

Interestingly, there was not a significant increase or decrease in heart rate or blood pressure before and after using the device, as demonstrated in Tables 1 and 2. This could have resulted from many factors. For example, the users were only asked to interact with ProjectLive for 3 minutes; this may not be enough use to see statistically significant changes in biofeedback markers.

Despite the inconclusive quantitative results, there was a good amount of positive feedback about the effectiveness of the device. We observed that users moved their hands according to the pre-determined Tai Chi movements that we were testing for, which supports the idea that augmented reality can guide and instruct users to move their bodies in relaxing ways in any environment.

3 out of 7 users said they felt more relaxed after using ProjectLive, while 2 out of 7 said they felt the same and 2 out of 7 said they felt less relaxed. The participants who felt less relaxed complained about having to constantly move their heads to keep the butterflies in their field of view as well as the burden of having to wear a heavy device while trying to relax. 5 out of 7 users were comfortable with the device. 5 out of 7 users would definitely use ProjectLive if it were fully fleshed out and production quality.

Future Work

There are many areas of future work for ProjectLive. The interactions explored were a start, but more complex butterfly movements and a more gamified experience may help to relax users even more. The system itself can be expanded to incorporate more biofeedback sensors. For

example, while heart rate is a good indicator of stress, there are other well-documented biofeedback mechanisms, such as Galvanic Skin Resistance, which is a good indicator of a users stress level [6, 9]. While there was little change in heart rate or blood pressure in our user study, this may not be the case with galvanic skin response (which is provided only on the Microsoft Band 2 - ProjectLive currently uses the Microsoft Band 1).

The feedback we received from the user study was immensely useful for determining future areas of study. Users pointed out that deploying to a more lightweight and comfortable device is critical, as the HoloLens is too heavy for practical relaxation activities that involve movement. We would like to conduct a more thorough user study that measures the longitudinal effects of using ProjectLive to see if there is change in user's stress over time through daily use of the system.

Conclusion

We have developed an augmented reality (AR) system, codenamed ProjectLive, intended to provide instantaneous stress relief to users. ProjectLive encourages the user to make relaxing body movements in their environment through interactive activities delivered through a HoloLens device. Unlike in traditional Tai Chi, where there is a single human instructor, ProjectLive uses butterflies as the "instructor" which provides the user with hand movement guidance. The activities are further customized to the user by measuring the user's heart rate and other biometric markers. Our qualitative user study found that ProjectLive has the potential to provide stress relief to users, and more broadly, that augmented reality has the potential to be used to gamify relaxing exercises.

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References

[1] Gregg, L., and Tarrier, N. Virtual reality in mental health. *Social psychiatry and psychiatric epidemiology 42*, 5 (2007), 343–354.

[2] Hansmann, R., Hug, S.-M., and Seeland, K. Restoration and stress relief through physical activities in forests and parks. *Urban Forestry & Urban Greening 6*, 4 (2007), 213–225.

[3] Jin, P. Efficacy of tai chi, brisk walking, meditation, and reading in reducing mental and emotional stress. *Journal of psychosomatic research 36*, 4 (1992), 361–370.

[4] Moraveji, N., and Soesanto, C. Towards stress-less user interfaces: 10 design heuristics based on the psychophysiology of stress. In *CHI'12 extended abstracts on Human factors in computing systems*, ACM (2012), 1643–1648.

[5] Nugroho, H. A., and Rhee, K. H. Design thinking: Tai chi virtual tutor mobile application for elderly park in augmented urban planning.

[6] Perala, C. H., and Sterling, B. S. Galvanic skin response as a measure of soldier stress. Tech. rep., DTIC Document, 2007.

[7] Rothbaum, B. O., Hodges, L. F., Ready, D., and Alarcon, R. D. Virtual reality exposure therapy for vietnam veterans with posttraumatic stress disorder. *The Journal of clinical psychiatry 62*, 8 (2001),

1–478.

[8] Shaw, C. D., Gromala, D., and Seay, A. F. The meditation chamber: Enacting autonomic senses. *Proc. of ENACTIVE/07* (2007).

[9] Shi, Y., Ruiz, N., Taib, R., Choi, E., and Chen, F. Galvanic skin response (gsr) as an index of cognitive load. In *CHI'07 extended abstracts on Human factors in computing systems*, ACM (2007), 2651–2656.

[10] Tsai, J.-C., Wang, W.-H., Chan, P., Lin, L.-J., Wang, C.-H., Tomlinson, B., Hsieh, M.-H., Yang, H.-Y., and Liu, J.-C. The beneficial effects of tai chi chuan on blood pressure and lipid profile and anxiety status in a randomized controlled trial. *The Journal of Alternative & Complementary Medicine 9*, 5 (2003), 747–754.

[11] Wiederhold, B. K., and Wiederhold, M. D. Virtual reality for posttraumatic stress disorder and stress inoculation training. *Journal of CyberTherapy & Rehabilitation 1*, 1 (2008), 23–35.

[12] Wolf, S. L., Barnhart, H. X., Kutner, N. G., McNeely, E., Coogler, C., and Xu, T. Reducing frailty and falls in older persons: an investigation of tai chi and computerized balance training. *Journal of the American Geriatrics Society 44*, 5 (1996), 489–497.