The Development of the Sati Interactive System: A Computer-Based Interactive System that Creates a Sense of Deep Engagement in the User

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Abstract. In this paper we discuss the development of the Sati Interactive System, including: the interaction design framework, hardware, software, testing, and results. The Sati Interactive System is a computer-based interactive system that creates a sense of deep engagement in the user by integrating colour, sound, and movement. The expression, 'sense of deep engagement' is derived from the Buddhist concept of 'Sati': being aware of and paying attention to the present moment. Experiencing a sense of deep engagement, being relaxed, focused, and not feeling the passing of time may have mental and physical health benefits. An evaluation of the system was based on data collected from 30 participants. 71% of participants provided positive responses to using the system, indicating that the Sati Interactive System was effective in creating a relaxed, focused state, and not feeling the time passing while using the system and afterwards.

Keywords: Computer-based interactive systems · Interaction design

1 Introduction

This paper discusses the development process of a computer-based interactive system that creates a sense deep engagement in the user. Here, a sense of deep engagement is considered as experiencing being relaxed, focused, and not feeling the passing of time, Goodall [1, p. 159] referenced John Cage, describing this as the "vanishing point of time and space". The expression, 'sense of deep engagement' is derived from the Buddhist concept of 'Sati': being aware of and paying attention to the present moment. To create a sense of deep engagement the Sati Interactive system integrates colour, sound, and movement, the main elements of an artwork.

Most computer-based interactive artworks have, as their main goal, entertaining the participants and often creating a sense of excitement, for example, DJ Light created by CinimodStudio [2], Yeosu Spanish Pavilion project created by Zappulla, Toribio [3], and Voice Array created by Lozano-Hemmer [4]. The main goal of computer-based interactive systems such as: Lange et al.'s [5] Interactive game-based rehabilitation using

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the Microsoft Kinect, Jaume-i-Capó et al.'s [6] Interactive Rehabilitation System for Improvement of Balance Therapies in People With Cerebral Palsy, and the Augmented Chemistry: Interactive Education System by Singhal, Bagga [7], are focused on learning and developing or improving physical characteristics.

The focus of the Sati Interactive System is to create a sense of deep engagement in the user, rather than creating an artwork, or an interactive system towards entertainment, education, training, or healthcare purposes. It does not provide the user with achievements or level-ups, such as in a first-person shooter game, and does not provide options to increase the difficulty; nor does it attempt to educate people.

2 The Sati Interactive System

The Sati Interactive System setup that was used for testing was installed in the Immersive Space 1 at the University of Melbourne (Room 202, Level 3, Arts West–Building 148). This setup was equipped with a computer, a projector, an external webcam, and external speakers. Figure 1 below shows the diagram of the Sati Interactive System setup used for testing.

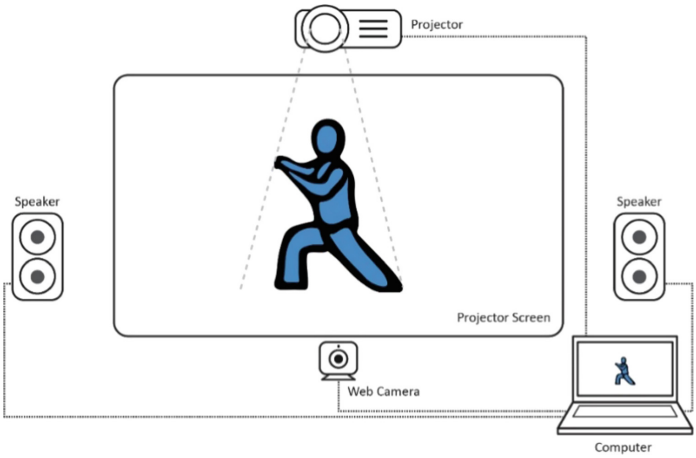

Fig. 1. The Sati Interactive System diagram

2.1 The Interaction

An outline of a person performing Tai Chi movements is displayed through the projector. The user copies the projected movements and moves their body. These body movements trigger various nature sounds. For example, moving the right hand up may trigger sounds of the ocean waves and moving the left hand down may trigger bird sounds from the forest. When the user's movements are accurate with the projected movements, the projected outline is filled with a color. When the user's movements are not accurate, color fades away. This is shown in Fig. 2 below.

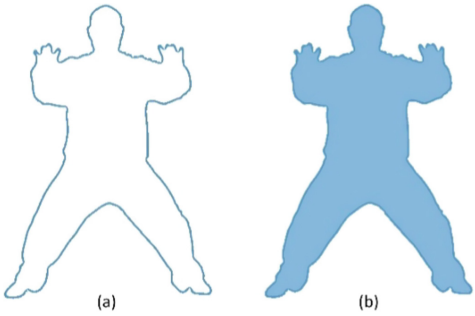

Fig. 2. (a) user movements are not accurate (b) user movements are accurate.

Figure 3 below shows a participant interacting with the Sati Interactive System.

Fig. 3. A participant interacting with the Sati Interactive System.

Sati Interactive System Setup Used at the University of Melbourne. We used an isolated environment to tests the Sati Interactive System with participants because,

- There are no distractions/no external influence–This allows the user to focus on the activity without being distracted, which is an important factor that helps the user achieve a sense of *sati* [8, 9].
- A discrete environment might provide a more immersive experience, easing the process of achieving a sense of deep engagement.

Hardware. The Sati Interactive System setup used at University of Melbourne consists of the laptop that we used to develop the system, an external webcam, a projector, and external speakers. The system was tested in the Immersive Space 1 at the University of Melbourne (Room 202, Level 3, Arts West - Building 148). The laptop specifications are i7 2.8 GHz processor, 16 GB of ram, and a 4 GB dedicated GTX 1050 video card.

Software. Max is used to design the Sati Interactive System. The system is designed to do tasks such as: analyzing the webcam data (body movement), comparing it with the reference video, playing audio clips according to different body movements, and projecting various visual elements according to the analyzed data. The system runs on Windows and MacOS.

2.2 Software Development

Here, I am using Fig. 4 below to describe the development of the Sati Interactive System software.

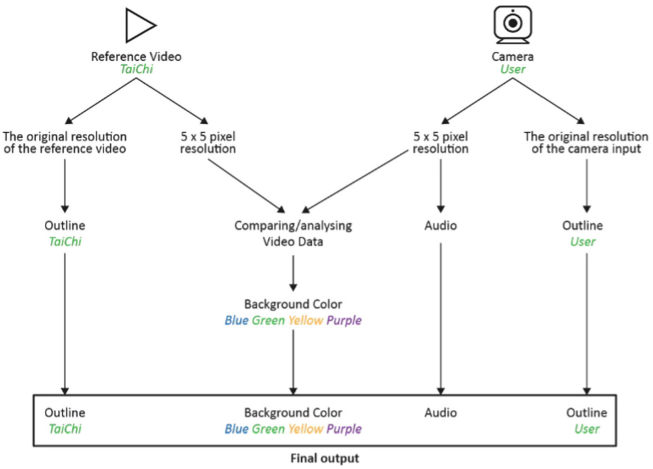

Fig. 4. Diagram of how the Sati Interactive System software works.

As shown in Fig. 4, the Sati Interactive software has two inputs: the reference video[1] (Tai Chi) and the Camera (User). First, the Tai Chi reference video is duplicated to create two outputs. The first output processes the original resolution of the video and creates an outline of the Tai Chi Master. The second output reduces the resolution to 5 by 5 pixels. The same process is done to the input from the camera. The first output uses the original resolution from the camera to create an outline of the user. The second output uses a reduced 5 by 5-pixel resolution. The 5 by 5-pixel is used to ease comparison to the reference video movements (Tai Chi Master's movements) with the user movements and because here we did not attempt to create a 100% accurate comparison. This resolution was enough to detect and compare the user movements and it gave a fast and smooth response. A 100% accurate comparison is not necessary because the purpose of this interactive system is not to make the user move exactly as the projected image. However, if an accurate comparison is needed, it can be accomplished by applying a higher resolution to the second output.

This comparison of the two videos is used to compare the user's movements with the reference video movements to see if the user is in sync with the reference video

[1] We have used a Tai Chi video as the reference video here, however, the user can select their own video. In the examples presented here, the ability to add different reference videos have been disabled. The recommended video resolution is 480 p with a frame rate of 30 fps because the application will only output a maximum resolution of 480 p. The resolution is limited to 480 p because it is more likely to work on low-cost computers. The reference videos must have a plain background and the character in the video must be dressed in a colour different from the background colour.

movements. For example, as shown in Fig. 2, when the user movements and the Tai Chi Master's movements are in sync, the Tai Chi Master's outline image will be filled with color (b), when it is not in sync the color will fadeout (a).

The audio changes according to the user movements. Each movement triggers different nature sounds such as: ocean waves, birds, creeks, and waterfalls.

3 Development of the Interaction Design Framework

The development of the framework is based on Forlizzi, Ford, and Battarbee's [11, 12] approaches. This framework is used to develop the Sati Interactive System, its user interface, user-product interactions, backend design program resulting in the product. The framework takes an interaction-centred perspective that includes aspects of user experience.

3.1 Factors that Influence Experience

The first step of designing the framework is to understand what influences experience. Figure 5 shows a summary of the factors that influence user experience, developed using Forlizzi and Ford's influences on experience [12].

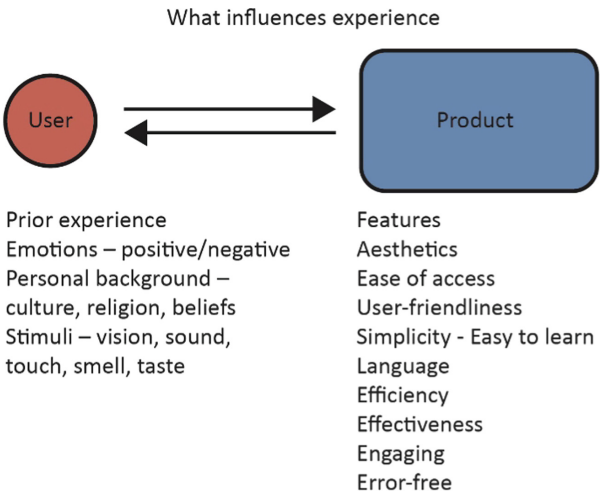

Fig. 5. User and product factors that influence user experience.

Here, we have added additional factors combining aspects specific to HCI usability that affect user experience, such as: efficiency, effectiveness, engaging, error-free, and easy to learn [13]. For example, a product that includes these features has a better chance of creating a positive user experience when competing with similar products. Understanding what influences experience can help develop an interactive system that promotes a positive user experience.

3.2 User-Product Interaction and Experience of the Sati Interactive System

According to the framework of user-product interaction and its relation to user experience presented by Forlizzi and Battarbee [11, p. 263], The Sati Interactive System can be categorized as a product with an expressive interaction that creates an experience with aspects of co-experience.

Expressive interaction–Sati Interactive System consist of functions that enables the user to customize certain aspects of the software to the preference of the user. For example, the user can change the color of the visuals, adjust volume levels, adjust the speed, and adjust the sensitivity of the camera.

An Experience–Using the Sati Interactive System is an activity that provides an experience. This activity has a beginning and end and it influence emotional changes. For example, this activity can be named as 'relaxing' or 'learning tai chi' experience, and the interaction might influence positive or negative emotional changes.

Aspects of Co-Experience–The Sati Interactive System does not inherently allow Co-Experience. However, the Co-Experience is created when individual user experience is verbally shared among others.

3.3 The Interaction Design Framework for Sati Interactive System

The interaction design framework for Sati Interactive System is shown in Fig. 6 below.

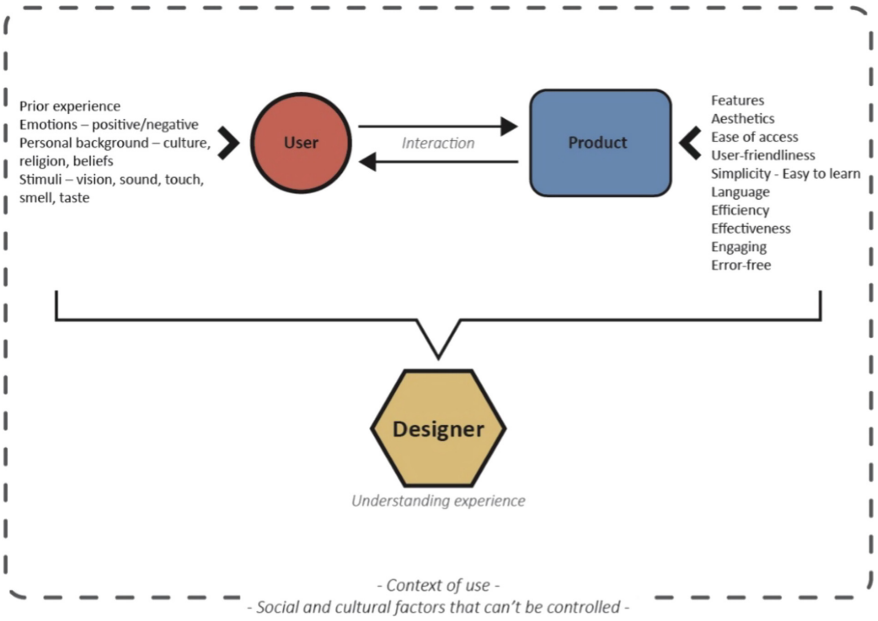

Fig. 6. Interaction design framework for the Sati Interactive System.

The above figure shows the interaction between a user, a product, in this case the Sati Interactive System, and the designers' role of understanding user experience. Here,

the designer's role includes understanding both user and product-based aspects that influence user experience. This framework can be used to create any interactive system.

Using the Framework

Initially, according to the framework, the designer does not have control over factors such as social and cultural influences, prior experience of the user, and the personal background of the user. Understanding these limitations is the first step of using the framework.

In Table 1 below, we analyze each component of the Interaction Design Framework and discuss how it is used in the design process of the Sati Interactive System.

Table 1. Using the interaction design framework.

Aspects that influence experience	How it is used in the Sati Interactive System
Emotions–positive emotions	Using variations of color and sound to enhance positive emotions
Stimuli–vision, sound	Positive emotions are stimulated through vision and sound using color, sound, body movement techniques, and real-time interactive motions
Product features	Ability to change the color of the visuals Ability to adjust the speed, camera sensitivity, and volume Ability to plug in various cameras
Aesthetics	Simple graphical interface Interactive smooth visuals Interactive sounds
Ease of access	The Sati Interactive System can be copied to any computer with the required specifications and played Small file size
User-friendliness simplicity	Direct and short instructions Simple user-interface design that includes direct instructions
Efficiency	The software is programmed using simple algorithms and coding techniques to deliver a smooth interaction, using resources efficiently
Effectiveness	The system is designed only focusing on the end goal. The user interface is designed to be user-friendly and simple to be understood by anyone. The system is designed to deliver smooth interactions, quality visuals, and sounds
Engaging	The system is using visuals and sounds to create an attractive environment to engage the user
Error-free	Sati Interactive System is tested in both windows and mac systems

Applying the Principles/Concepts of Computer-Based Interactivity

Here we are focusing on the principles/concepts of computer-based interactivity and how this can be linked to arts-based interactivity. This link is important because we are using an arts-based approach, to develop the Sati Interactive System. An artwork is inherently designed to create a sense of deep engagement/transformative experience; this is what we want the user to experience when they interact with the Sati Interactive System.

Table 2 on the following page gives an explanation of concepts/principles of interactivity in a computer-based and an arts-based approach and how these two approaches are linked in making of the Sati Interactive System. The first column shows the concepts/principles of computer-based interactivity, the second column shows the explanation of the concept/principle in computer-based interactivity, the third column shows the explanation of the concept/principle in arts-based interactivity, and the last column shows how these two approaches are linked in making of the Sati Interactive System.

Table 2. The use of the principles/concepts of computer-based interactivity in the Sati Interactive System.

Principles/Concepts	Explanation in computer based (CB) interactivity	Explanation in art based (AB) interactivity	How these two approaches are linked in making of the Sati Interactive System
Directionality	Typically, two-way bi-directional stream of communication–typical for all computer-based interactions	Typically, uni-directional, but this is developing with the advent of computer-based arts and art making	The Sati Interactive System provides 'bi-directionality' as it communicates with the user in real-time by providing feedback. For example, color and sound is generated according to the user movements
Responsiveness	The ability to respond to current and previous communications and the response speed	Typically, non-responsive, but this is developing with the advent of computer-based arts and art making	Sati Interactive responses to the user immediately using visuals and audio
Awareness	Understanding of context and meaning	An artwork is not typically aware or not responsive to its context or meaning. However, this is developing with the computer-based interactive artworks	Sati Interactive is aware of the user's actions such as movements and input via the user interface. However, it does not have an awareness of its context or meaning. The user can understand the context and meaning of the Sati Interactive System

(*continued*)

Table 2. (*continued*)

Principles/Concepts	Explanation in computer based (CB) interactivity	Explanation in art based (AB) interactivity	How these two approaches are linked in making of the Sati Interactive System
Selectivity	The availability of choices for the user	The creator may have the ability to select the medium used to design the artwork, however the user does not. But the user can select which artwork they engage with	'Selectivity' is achieved by providing choices to the user. Sati Interactive gives the choice to use both color and sound. For example, the user can select different colors, adjust the speed of the interaction, adjust the responsiveness of the interaction, and to adjust the volume. The Sati Interactive user interface consists of a 'help' button that provides information on using the system. Additionally, the user interface also provides clear and detailed information for each available option such as 'play' button, various sliders, 'full screen' button, and audio controllers
Being interchangeable	Communication roles can be interchangeable	Communication rolls cannot be interchangeable. Typically, an artwork does not communicate with the user	'Being interchangeable' is achieved by providing the user with the opportunity to control certain factors of the Sati Interactive System to meet their needs according to the feedback provided by the system. Here, the user communicates with the Sati Interactive System and the communication roles are interchanged by the feedback
Real-time communication	Interactive media should be an instant exchange	An artwork can create real-time communication. For example, an artwork can create a transformative experience in the user at that moment	This is achieved by providing real-time feedback to the user. For example, the user receives feedback from the system in real-time through color and sound. This can also be seen as a way of communication between the user and the system

4 Testing the Sati Interactive System

The testing was conducted in the Immersive Space 1 at the University of Melbourne (Room 202, Level 3, Arts West - Building 148) on four separate days within two weeks. The laptop that was running the Sati Interactive System was connected to the projector and the sound system in the Immersive Space. A Dell XPS 15 9560 laptop was used to run the Sati Interactive application.

Participants. The test consisted of 30 participants who were asked to try the Sati Interactive System, these included: university staff members, students from different universities, and people not related to the university. All participants were above the age of 18. However, age will not be taken into consideration because it is not relevant to the process.

Task and Procedure. The initial plan was to conduct 30 trials of the Sati Interactive System. However, we noticed that three out of the first five participants are only focusing on trying to align them self with the Tai Chi master outline and they try to adjust them self during the movement. We felt like this interferes with what the Sati Interactive System is trying to create, a sense of deep engagement, because the user lost focus, while trying to make adjustments to their pose, rather preventing them from relaxing and enjoying the color and sounds. The participants said that it was hard to keep up with the Tai Chi master's movements.

As a result of this observation, we decided to conduct two types of trials: (1) the user can only see the Tai Chi master (no user image outline) and (2) the user can see their image and the Tai Chi master on the screen (with user image outline). There were 15 participants for each type of trial.

The Fig. 7 below shows the difference between (1) no user image outline and (2) with user image outline.

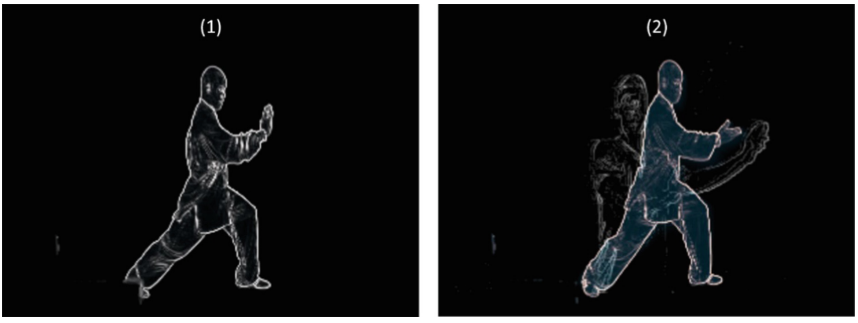

Fig. 7. (1) no user image outline (2) with user image outline

Immediately after engaging with the Sati Interactive System the participants were asked to answer 15 questions, regarding how relaxed and focused they felt, and whether they enjoyed using the system. Each participant engaged with the Sati Interactive System for 5–10 min. All 30 participants completed the questionnaire, and a few provided additional comments on the questionnaire itself.

Measures. The Sati Interactive System is evaluated using the three coding methods used in Grounded Theory: Open coding, Axial coding, and Selective coding [14]. Firstly, the raw data is analyzed using Open code and Axial code, measuring the total amount of positive, negative, and neutral experiences. Later, this data is used to choose the Selective code 'Core category', which will provide the final evaluation.

5 Results and Discussion

According to the results, both trials show an overall positive response, and negative responses are lower than neutral responses. Only two participants showed different results to the trends, these were participant 14 and 27. The highest amount of negative responses, five, is made by participant 14, who also made 8 neutral responses. Participant 27 has six positive responses and nine neutral responses but no negative responses. I consider these responses as anomalies. Twenty-five participants have at least one neutral response and seven participants have more than five neutral responses, which indicates that neutral responses are common among participants.

Overall, there are 71% positive responses, 8% negative responses, and 21% neutral responses. This indicates that the Sati Interactive System is successful in its goals. Most participants providing a positive response suggest that the system helped them become relaxed and focused. However, there was no significant difference in the responses to the questions between the 15 users that saw their outline and the 15 users that did not see their outline when using the Sati Interactive System.

Using the adapted Grounded Theory process, this analysis shows that most participants felt that the Sati Interactive System helped them achieve a sense of relaxation and the ability to focus on that specific moment, a sense of deep engagement. While only one testing process, with a limited number of participants, was carried out, we can surmise that similar responses would occur if we were to do more testing in different environments. The questions were designed to be interpreted by the user.

While the responses to the questionnaires show that the Sati Interactive System is successful in creating a sense of deep engagement in the participants, this success may be argued due to the comparatively small number of respondents. However, this number of respondents, or fewer is not unusual in this field, for example: Castellano, Villalba [15] had only 10 participants when recognizing human emotions from body movement and gesture dynamics, Dow, Mehta [16] had only 12 participants when exploring the impact of immersive technologies on presence and engagement in an interactive drama, and Yang, Bernardo [17] had only 23 respondents when considering the effect of yoga on type 2 diabetes.

6 Conclusion

Here we have discussed the development and the testing process of the Sati Interactive System. The Sati Interactive System is developed using a user-product interaction design framework focusing on the user's prior experience, emotions, and stimuli. We also focused on aspects of the product such as its: features, aesthetics, ease of access,

user-friendliness, simplicity, language, efficiency, effectiveness, engaging, and error-free. This process resulted in the Sati Interactive System, which has features developed from the framework that we designed based on Forlizzi, Ford, and Battarbee's approaches as their ideas are flexible and have formed a basis for other interaction designs. These include: features designed to enhance user experience; an application that works on Windows and Mac operating systems; a system that is easy to setup and is of low-cost, and can integrate with a home entertainment system.

The program uses sounds of nature, Tai Chi movement technique, and four types of colors. Nature sounds and colors are used to create positive emotions. Tai Chi movement technique is used as a visual guide to help engage the user in an activity, not for its ability to calm and relax the mind and body.

Results of the Sati Interactive System trials show that it can create an experience of being relaxed, focused, and not feeling the passing of time, a sense of deep engagement. This experience may not be easily expressed in words, similar to how the experiencing of art may not be easily expressed in words. These results also indicate that the interaction design framework can be used to develop similar computer-based interactive systems.

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