The Light: Exploring Socially Improvised Movements Using Wearable Sensors in a Performative Installation

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ABSTRACT

This work explores the potential of a set comprised of wearable sensors, a performative lighting installation, and a public museum space, to inspire performative and collaborative social behavior among members of the public. Our installation, The Light, was first exhibited as part of the Late at Tate Britain event in 2019. In this paper we discuss the concept and technological implementation behind the work, and present an initial qualitative study of observations made of the people who interacted with it. The study provides a subjective evaluation based on people's facial expressions and body language as they improvise and coordinate their movements with one another and with the installation.

CCS CONCEPTS

• Human-centered computing → User studies • Applied computing → Arts and humanities → Media arts • Hardware → Sensor applications and deployments

KEYWORDS

Data embodiment; Wearable computing; Body movement; Installation; Motion sensors

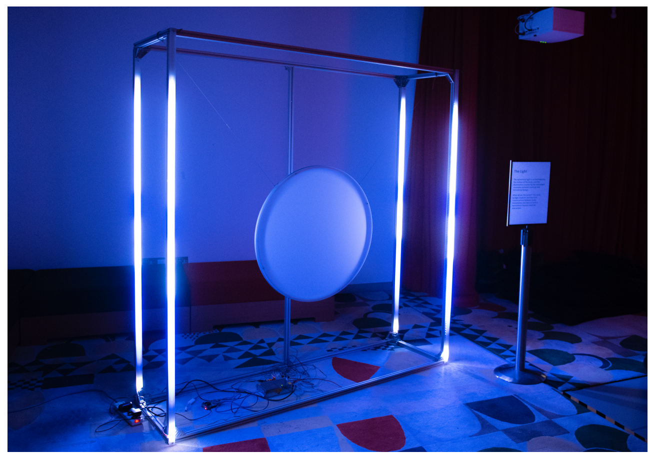

Figure 1: *The Light* by Friendred. Photographed by Natalia Janula. Exhibition held at Tate Britain / Late at Tat

1 Introduction

In this paper we exemplify how socially improvised movement can be driven in a performative lighting installation, *The Light*. Similarly, Alaoui et al. exemplified how movement quality (MQ) interaction can bring richer and more engaging experiences than position-based (PB) interaction [1]. To do so, they created a lighting installation, *A Light Touch* where light effects were controlled by hand gestures via Kinect. MQ interaction refers to how the body moves according to a dancer's interpretation of three categories ('Breathing', 'Expanding', 'Reducing'), whereas PB interaction means direct mapping such as mapping light intensity with a hand moving vertically. We incorporated MQ interaction into our approach and explored the social relationship between participants. We hypothesize that wearable sensors promote a greater level of expressiveness as they enable greater freedom of movement. Reeves et al. questioned how spectators can experience the interaction among machines and performers [2]. Reeves categorized the relationship into 'manipulation' (how users/performers interact) and 'effect' (the perceivable results). These studies helped us to understand the perspective of seeing the participants as performative bodies. Building on this, we propose that participant's bodies can be choreographed by, as well as influence, the set. We placed emphasis on playfulness and expressiveness among the participants when they were interacting with *The Light*.

Wearable sensors, incorporating Inertial Measurement Units [1] (IMU), are widely used to measure people's body movement (e.g. commercial fitness trackers), and are increasingly used to capture social interactions [3]. Such devices aid and enlarge the possibilities for interaction in creative applications. Schlegel et al. attached Twiz, a wireless IMU sensor, to various objects, such as tree branches, wheels and balls etc. This had the effect of giving inanimate objects new characteristics for interaction [4]. In a similar way, we proposed that IMUs, worn by exhibition visitors and configured to interact with an installation, could create an environment in which participants' expressivity was augmented. In this way a predetermined set helps to conduct how each body moves, and, crucially, encourages social coordination between bodies.

To connect theory with practice, we produced an installation, The Light, at Tate Britain, curated by Tate Collective. Over the course of a three-hour long exhibition, members of the public got the chance to wear wristband-like sensor devices that would let them interact with the installation. The piece revealed an emergence of collective movements driven by the environment.

In the following we describe the essence of the artwork. We then give an overview of the work's construction, and the implementation of the sensor technology. Using recordings from the day, we present a post-hoc qualitative analysis of participants facial and body expressions. Drawing on our findings, we discuss potential applications of the work and future uses of socially improvised movements.

2 The Light

The Light is a participative lighting installation aimed at orchestrating participants' movements while the ever-shifting ephemeral light becomes the embodiment of the data. The juxtaposition of inertness and motion elicited audiences to engage with the installation. This work allows participants to move and interact freely with minimal instructions on the usage of the devices, thus bridging a harmonious human-machine interaction where the set comprised of artifacts are the central driven elements.

Five wristbands with wireless, IMU-based motion sensors were provided for participants. As shown in Figure 2, individuals, or groups of two or more people, could wear one or more sensors. The sensors controlled different lighting patterns on the installation. The interaction was designed to be MQ based. Multiple free-form gestural inputs, such as shifting position, fast and slow movements, and changes in rhythm, led to dynamic lighting effects. Users' behaviors were implicitly connected to the visual representation of the installation. Crucially, different sensors were programmed to control different parts of the installation. This had the effect of encouraging sensor-wearing participants to spontaneously coordinate between one another to create novel effects.

Figure 2 (a) In this image, a group of users wore four devices simultaneously, and were trying to synchronize with one another. (b) Here one user wore two devices on her feet (marked by red circles), while interacting with another user, who was holding a device. Photo (c) Friendred.

2.1 The Light - Fabrication

The geometrical installation was made of 13 aluminum bars, four led light strips were incorporated individually inside standing support structures. Four customized translucent fine-cut frost acrylic strips were mounted in front of the light strips to create and intensify etherealness of the lights (figure1). The middle circle was also fabricated from lightweight aluminum and mounted with the same frost materials to scatter the light.

2.2 Technological Intervention

We used a wireless, wearable motion sensor device (the Mbient R) that includes an IMU and basic data processing capabilities. The appearance of the devices is Fitbit-like, and it was encouraged to be worn on any part of the body possible in order to maximize the modalities of the input. We configured each of the 5 devices to

[1] IMUs include force sensing accelerometers, gyroscopes and magnetometers.

transmit information on movement energy (calculated by combining the 3-axis accelerometer data). Data from all sensors was sent via Bluetooth Low Energy (BLE) to a central Raspberry Pi 4 hub, where the signals were converted into control signals for the lighting effects (see Figure 3).

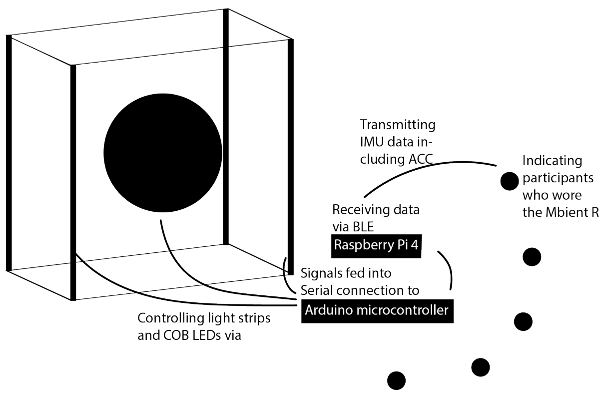

Figure 3 Technical diagram

All lighting effects were controlled by the data that was mapped through 3-axis ACC converted from participants' body movement. However, the various gesture mappings are resultant of a shared action (lighting effects) created by multiple participants simultaneously. The 5-gesture mappings were devised as user 1 mapped to 4 blue "raindrop" effects; User 2 mapped to 4 white "raindrop" effects; User 3 mapped to 2 COB LED gradient of illumination effects; User 4 mapped to 4 Blue reversed "raindrop" effects; User 5 mapped to 4 white reversed "raindrop" effects.

These signals were fed via a serial connection to an Arduino microcontroller, which in turn controlled the four led-light strips, and the central orb consisted of two Chip on Board (COB) LEDs. The high voltage LEDs were controlled via MOSFET with Arduino to create a gradient of illumination in synchronization with participants movements.

3 Qualitative Study of User Experience

Can socially improvised movements be formed in a performative installation? We defined the properties of social expression and used these categories to analyze people's movement. We made a qualitative assessment based on videos of 30 participants interacting with the installation. The intention was to identify different user experiences and the shifting behaviors of the participants throughout the exhibition. 17 video sources were selected and analyzed by 4 assessors (3 males, 1 female, aged 20-70). A list of properties of expressions (see left column) were targeted in the course of choosing excerpts. Assessors were given the definition of each category, and simple instructions to assess individuals as well as their relationship to the surroundings. The length of each video is relatively short, with a total length of 9"44'. We asked assessors to view the videos and rate a subset of expression properties on a Likert scale from 1 (strongly disagree) to 5 (strongly agree) based on the observed participant's behavior when they interact with the installation and the other participants. The median ratings for each participant are then counted for each measure to produce the results shown in Figure 4.

Measures:

- **Collective Expressiveness (CE)** – Interaction among participants
- **Playfulness** – Seeking creative ways to interact with surroundings
- **Discomfort** – Confusion and noticeably unappealing
- **Control and being controlled (C&BC)** – trying to work out mapping between actions and display
- **Observation** – wearing device but mostly watching others

3 Preliminary Results

A majority (~57%) of participants expressed control and being controlled (C&BC) social behavior in which participants seemed focused on deciding what lighting patterns to generate and the level of aggressiveness. Granting trust and incorporating their own personal experience with the sense of control may instigate a novel experience [5]. The next most prevalent are Playfulness (43% combined agree and strongly agree) and collective expressiveness (CE, 37%).

One clip shows the highest score for both CE and Playfulness with unanimous agreement between assessors. Two users who controlled four wearables chose to wear the sensors on various body parts, such as their neck and feet (see figure 2). Additionally, the interaction shifted from individual with installation to between two individuals. Not only were they engaged with the installation with various movements initiated by the body, but also collectively shared experience socially with each other.

One participant appeared to experience anxiety caused by the multi-interactive modalities, not knowing which lighting effects to link back to their movement or failing to control the sensor instinctively. As mentioned, movement-based interactions can engender greater expressivity, but in trade-off can also lead to collateral results such as users' confusion and not understanding interaction modalities, as they are given minimum instructions or implicit guidance. The discomfort users felt, from another perspective, can provoke ambiguity and implicit interaction, and therefore lead to positive design outcomes such as creative effects generated by variable interpretations [6]. Sengers et al. also conveyed the tendency of heterogeneous interpretation in interactive works [7]. To do so, an implicit relationship between participants and interactive systems were required. For example, users might express views from the perspective of utilities ('Low

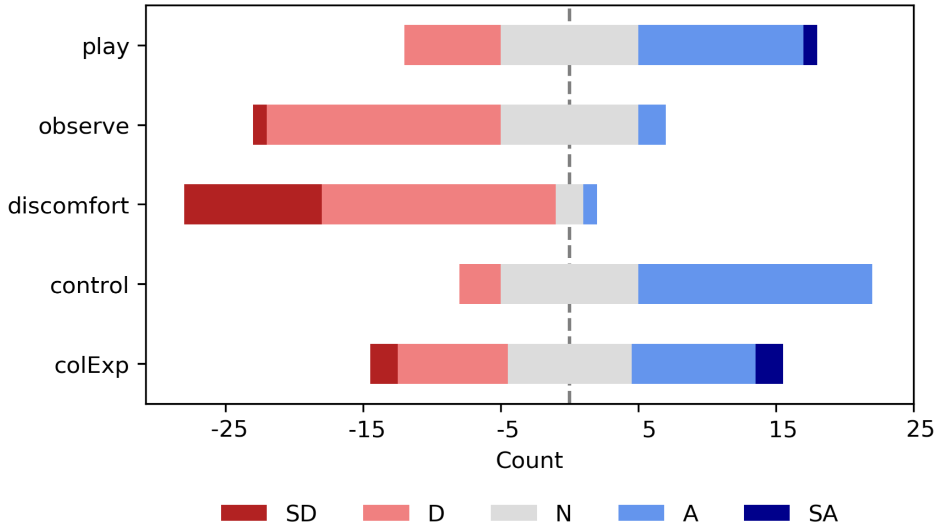

Figure 4 Likert measures of expression for 30 participants, averaged over 4 independent assessors. Scores range through Strongly Disagree (SD), disagree (D), Neutral (N), Agree (A), and Strongly Agree (SA).

level') and personal experiences ('High level'). This incorporation of multiple interpretations from users can be beneficial to design process and evaluation methods.

About 7% of participants were categorized as observation. Interestingly, several participants started to participate after observing what the others were doing. We have previously discussed Stuart Reeves' and other's approach of designing a spectators' experience. Wherein, Reeves proposed a taxonomy which highlighted the interchangeable role of spectators and "performers". Sometimes spectators will attempt to shift their position from observing to interacting with the installation (system). This implicit interaction and guidance could have helped to raise a suspenseful experience for spectators. We hope to collect more data for this part in the future to further explore this.

4 Conclusion

We have used The Light to accentuate the importance of environment driven interaction, as well as socially improvised movements. We measured a number of underlying properties of expression to quantify the expressivity participants might encounter when interacting with The Light. By defining the properties of social expression and quantifying qualitative measures, the preliminary results suggest that the set generated strong responses, most notably 'control and being controlled', 'playfulness' and 'collective expressiveness' among participants. We will develop this work further to study the synchronicity and collective behaviors of larger numbers of participants and explore how this relates to social expression.

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