SIGCHI: Magic Mirror - Embodied Interactions for the Quantified Self

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Abstract
Over the past few years, there has been a tremendous advancement in fitness tracking systems such as pedometers and heart rate monitors; and collecting and interacting with personal health or wellness data, is a growing research topic within the Human Computer Interaction (HCI) community. While fitness tracking systems have advanced into on-body sensing modalities, the process of data reporting and intervention is still largely done through mobile and web applications, using traditional methods of data visualization such as graphs and charts. This has resulted in a disconnect between data and its context. This work-in-progress, “Magic Mirror”, explores how to retrieve and visualize health data using the body as a reference frame.

Author Keywords
Quantified Self; Embodied Interaction; Multi-Modal Interfaces; Ubiquitous Computing;

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Self-tracking devices are becoming increasingly popular, largely thanks to the growing Quantified Self

(QS) movement, and in the healthcare domain, these devices help individuals monitor various aspects of personal health, including heart rate, calories burned, steps walked and sleep duration [1]. From smart watches, to chest-straps and head-bands, these devices are assuming on-body roles in an attempt to preserve context and interaction mechanism during the process of data collection. But a majority of these devices simply transfer data to mobile phones and tablets, which then display summary statistics using graphs and charts. This transfer results in a disconnect between data and its context, and as a result these tools present factual data in a form where the objectiveness of numbers and graphs is far less effective for reflection and interpretation[2].

There is ongoing research on visualizing and presenting QS data in more meaningful ways, but a majority of these focus on data alone. Huron et al. have proposed a new paradigm to create flexible, and tangible visualizations using physical building blocks that are dynamic and enable non-experts to create novel visualizations [3]. Another work by Epstein et al., titled "Taming Data Complexity in Lifelogs", defines cuts or subsets of collected data with shared features such as location or physical activity, and visualizes those cuts using a variety of presentation techniques including graphs, tables, and Sankey diagrams [4].

In order to connect QS data with the individual self, an understanding of "context" from a human centered perspective is essential. Alnanih et al. define context as the user's "physical, social, emotional or informational state, or as a subset of the physical and conceptual state of interest, to a particular entity" [5]. With existing QS tools such as mobile apps, this physical state of "context" is lost. Furthermore, these graphical representations lack detail and specificity, which may be essential to support cognitive reasoning and understanding [6]. Human cognition involves both top-down and bottom-up processing of information, but being unable to see the data within its context, the user is forced to translate the information shown on the display into a mental representation or cognitive map [7]. Ball and North argue that this not only increases the time and effort spent in navigating data, but also results in a distorted cognitive map.

In embodied interaction, there is a theory that the cognitive mind is not separate from the physical body. Every individual develops a body schema, through which they establish their knowledge about the self; a psychological picture of the physical self, which often extends into the environment and external objects such as clothing and shoes [8]. Schilder defines this schema as "a picture of our body we form in our minds as tridimensional units, including interpersonal, environmental and temporal factors" [9]. A study conducted by Ball and North examines how physical navigation and physically interacting with large scale visualizations, affects user performance times on analytical tasks. They propose that, by expanding visualizations to human scale, we can take advantage of not only the eyes and cognition, but the entire body including motor memory, peripheral vision, optical flow, focal attention, and spatial memory [7]. The motor, peripheral vision, and proprioceptive cues that come from walking and moving, help in forming a cognitive map that is often absent in small display environments.

Since people tend to carry their mobile phones with them everywhere, there is a risk of user fatigue due to frequent assessment. Ramanathan et al. argue that for some domains, daily or weekly reports are sufficient for effective self-monitoring [10]. These devices are also oblivious to the situation and surroundings. They cannot discern what information is relevant or when it is appropriate to present such information [11].

Related Work

Research has shown that faster speed or greater accuracy for object identification requires that the object is presented within a coherent real-world scene. An experiment conducted by Elting et al. proved that icon based display produced a higher level of decision making accuracy, and that sensory and perceptual processing occurs within a context of top-down influence that involves the search for meaningful interpretation of stimulation[6].

'Watch Your Steps' is a semi-public display that promotes physical activity through social play and collective awareness. It displays visualizations about step count of a group of players in near real-time. The findings show that such displays promote new conversations among players without producing privacy issues [12].

Angesleva et al. developed a body mnemonics interaction design concept that uses body space as the interface. The system consists of a handheld mobile device, which employs the proprioceptive sense to store and retrieve information from the body space, and provides device generated vibrotactile feedback to indicate the outcome of the action [13].

A study conducted by Cacioli et al. on avatar body dimensions and men's body images showed disparities between avatar and actual body dimensions, which is a manifestation of the difference between one's self-perceived body and one's ideal body [14]. Another experiment showed that people who watched an avatar that looked similar to themselves(in regards to body weight, height and age) who ran on a treadmill for approximately 5 minutes, exercised more the next day than people whose avatars were not similar in appearance to themselves [15].

Magic Mirror

David England describes whole body interaction as "the integrated capture and processing of human signals from physical, physiological, cognitive and emotional sources to generate feedback to those sources for interaction in a digital environment" [16]. Based on this definition of whole body interaction design, and drawing from the concepts of body schema and body mnemonics, "Magic Mirror" is an attempt to provide context to personal health data. Specifically, the system explores how to retrieve and visualize health data using the body as a reference frame.

Design and Implementation

In order to design movement based interactions, one has to become an expert in movement, by practicing and experiencing movement while designing, according to a paper by Hummels [17]. She recommends an interaction design approach which integrates sketching and physical modelling with sensor technology and dataflow modelling programs.

For this work, in order to understand the technology and gesture tracking mechanism, an initial prototype of the "Magic Mirror" system was built using the Cinder Framework and Kinect. The system tracked four

Figure 2: Magic Mirror Display

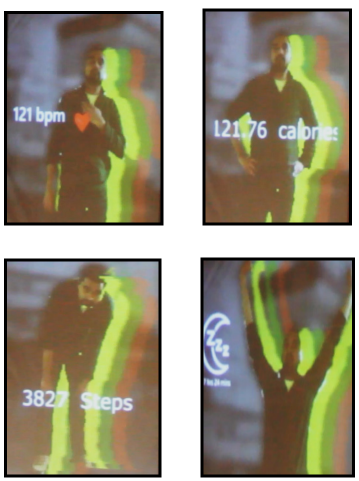

Figure 3: (Clockwise from top-left) Visualization for a. Heart-Rate, b. Calories c. Steps and d. Sleep

different gestures to retrieve heart-rate, calories, steps and sleep data. Through random intercepts, participants were presented with this initial prototype, and were asked about visual encoding for data and feedback. Based on their inputs, a set of sketching alternatives were generated to design the final set of gestures and visual encodings for expressiveness and effectiveness of the visualization.

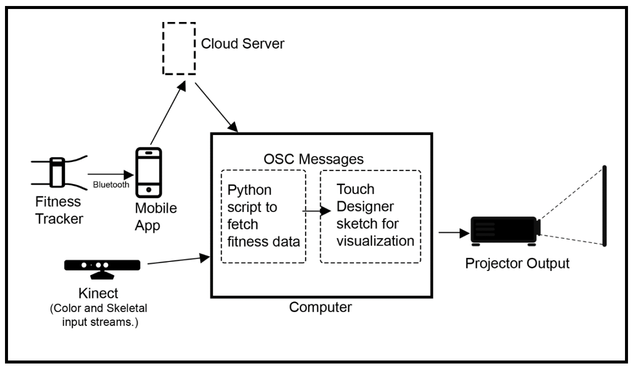

Figure 1: Schematic representation of the setup for Magic Mirror

The setup for Magic Mirror is fairly simple, and it consists of a Kinect Sensor that is connected to a computer, which in-turn sends real time data to a projection display (Figure 1). The software module combines Kinect input with real-time fitness data, and generates a visualization that is projected onto a large scale display (Figure 2). The Withings-Pulse-O2 fitness wrist band was selected to generate real-time fitness data because of its public web developer APIs, and its ability to measure several parameters including heart rate. The Withings-Pulse-O2 sends data via Bluetooth to an iOS application, which sends this data onto the cloud server. A python script running on a local machine, queries this data every 30 seconds (the time interval is mainly due to the restrictions posed by Withings.), and broadcasts it using the Open Sound Control (OSC) protocol.

Kinect video processing and visualization is done using Touch Designer. The Touch Designer code listens for OSC data, from which it extracts measurements for heart-rate, steps and calories. The skeletal input stream from Kinect is used to extract the body dimensions of the person being tracked, which is then processed along with the video camera feed to blur the background while keeping the person in focus. The skeletal joint positions are used to monitor for gestures. When an intended gesture is detected, the corresponding value from the OSC input is overlaid onto the processed video stream, using a combination of text and graphics, and is projected onto a mirror display.

The interaction for this system is modelled on the behavior of individuals, when in front of a mirror, to check or fix themselves by adjusting their outward appearance. Analogous to using the hand to fix a crease on the shirt or adjusting a tie, this system employs body centered natural user interactions to check various aspects of personal health. Four main gestures are tracked and visualized by the system:

1. **Heart Rate:** Retrieving information about heart rate is done by placing the right palm over the chest, slightly inclined towards the left shoulder. This gesture draws a virtual beating heart at the point where the right hand is, and also displays the real-time-heart-rate, measured in beats per minute

(Figure 3a). The joints that are tracked for this gesture are the tip of the right hand and the shoulder center.

2. **Calories:** The gesture to retrieve information about the calories burned involves placing both hands over the hips. Performing this gesture displays a value indicating the number of calories burned. (Figure 3b). The joints tracked for this gesture are tips of both left and right hands, and also the left and right hip joints.
3. **Steps:** The third gesture is to retrieve the number of steps walked, which involves placing the left or right hand on the respective knee. This action displays a value representing number of steps walked, over the knee (Figure 3c). The joints tracked are left and right hand tips and also left and right knee joints.
4. **Sleep:** The last gesture tracked is to retrieve sleep information, and involves stretching the arm(s) upwards and outwards. Performing this action displays duration of sleep to the right of the face along with the sleep icon (Figure 3d). The joints tracked are the left and right elbow joints, and the left and right shoulder joints.

Performing any of the aforementioned gestures, not only displays real-time data, but also creates a series of reflection images of the body frame, as a silhouette, color coded based on wellness quotient, in order to represent wellness from the past three days. Wellness quotient is an aggregation of all parameters being tracked and is color coded such that yellow-green indicates a positive value while orange-red represents negative values.

Observations

Once instructed, participants were able to perform the gestures with ease, and appreciated this new way of visualizing body data. The blurred background helped them focus on the context, their own body, and understand the significance of the parameters being displayed. They were particularly intrigued by the animated heart, whose beating rate encoded the heart-rate value in beats per minute.

Discussion and Future Work

All of the gestures presented in this system attempt to preserve the context, in this case the part of the body that the data can be most associated with. By using a mirror like display, the interaction expands upon natural mirror behavior, i.e. to check one’s outward appearance. Next steps would involve integrating data from life-logging wearable cameras, designing novel representations for high level, and historical aggregation of data, and also evaluating the effectiveness of the Magic Mirror interface interface when compared to other forms of body data visualizations. Future work may also involve exploring how such an interface can be used to make wearable devices more accessible to the elderly or those who are technology novices.

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