Shoe-Friend: An Interactive way to induce emotional bonding for longevity of shoes

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ABSTRACT

It is believed that human beings tend to care more about their possessions whenever there is an emotional attachment created. These kinds of bonds can be invoked through mutual interactions between the user and the product in use. In this paper, we propose a smart shoe system called Shoe-Friend that actuates an emotional bonding between users and their shoes, with a sole purpose of lengthening their lifespan. The shoe is based up off sensors that measure several physical quantities when in use. Depending upon the sensor readings, the system interacts with the user with messages and LED signals indicating whether the shoes are used in a proper manner. We try to complement the happy time of the shoe with the behavioral nature of the users. Results from an experiment show that the system can accurately correlate affective traits of the users.

CCS CONCEPTS

•Human-centered computing → Smart-shoes;

KEYWORDS

smart shoes, human computer interaction, shoe-emotion

1 INTRODUCTION

The market for consumer products is increasing day by day because of their booming demand. Despite of the competition, cost of manufacturing is skyrocketing. Factory line manufacturing process requires utilization of exhaustible raw materials, which are getting scarcer. We often hear news about the use of consumer products not being wise and there is an over exploitation of natural resources. There is an outcry amongst experts working for sustainable development goals that we should be wise in using our products. People should reduce the improper use of commodities such that they last longer. We can take a pair of shoes as an example of such product, which is used by human being for variety of purposes.

Different types of shoes are manufactured catering specific needs. While shoe companies make tremendous amounts of profit through their extravagant sales, very little thought is put into the resources that are needed in the manufacturing process. If shoes are not used fully up to their useful lifetime, manufacturers will continue to produce large quantities of shoes, which will ultimately exhaust the natural resources. We believe that shoes are not being used in proper way as they should be, hence resulting in a shorter lifetime. As long as people take their shoes as mere objects created solely for comforting purposes, they will be negligent about how the shoes should be properly worn and well maintained.

It is intuitive that people tend to care more about their products if there is an emotional bonding between them. Due to the bonding, people use their products wisely, which will in turn increase their lifespan. Mutual interaction is one of the ways to entice bonding, which can clearly be depicted through the attachment that humans have with their pets. It is interesting how people care about every aspect of their pets' lives. The reason behind the utmost care is mostly due to the emotional bond that humans develop with their pets. This emotional bond is a result of the reactions pets give in response to their owner's actions and characteristics. We seek a novel way to create an interactive relationship between users and their shoes such that shoes respond to their users based on how they are being treated. By making the shoes responsive, we believe that we can create attachment between the shoe and the owner. This attachment can provide necessary feedback information to the owner to treat the shoe in proper way, which will in turn prolong the lifetime of the shoes.

The remainder of the paper is organized as follows: in the next section, we build up a background of the concept. Then we discuss about the related work done on smart shoe technology as well as highlight the novelty of our research. Then we briefly outline the discuss system model. This section is followed by experimental set up and data collection methods used. After that, we analyze the data for results before providing concluding remarks.

2 BACKGROUND

The upsurge of advanced technology has improved human lives by leaps and bounces. The amalgamation of technology with human needs is pioneering avenues to render better

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services. Affordance in Human Interface Technology refers to the interaction between the user and device where the latter caters the needs of the former [5]. Many actions can be performed on the device, which necessarily are not limited to physical interactions. Alongside physical and functional affordances, there are designs that invoke users perception, which induce a form of emotional interaction between the entities [3].

We intend in creating an interactive relationship between humans and their shoes through quantitative measurements of time. The data is gathered through sensors, which are located within or in the vicinity of the shoe. The data will then be used for analyzing the general behavioural pattern of users with their shoes. We believe there are certain metrics and conditions, such as weight inserted into the shoe, time duration that the shoe is worn, temperature inside the shoe, etc. can be used in determining exactly how the shoes are being treated.

Figure 1: Prototype of the shoe.

2.1 Related Work

With the growing interest in the field of Human Computer Interaction (HCI), a lot of research work has been done developing feet and locomotion interfacing devices, specially shoes. Besides, there has been tremendous amount of work in conceptualizing smart shoes. Some of the manufacturing companies have already launched smart shoes through their production lines using variety of technologies to fulfill human requirements [9]. These shoes are catered to be used for specific purposes, especially related to sports, where the users can get constant feedback on their actions to improve their performance. Connectivity with smart phones and other handheld devices also give better usability to the shoes. Altra-IQ, IOFIT, Hype8Kicks, Digitsole are some of the examples of such smart shoes that are commercially available [9].

Authors in [1] have developed a low-cost shoe system that monitors human gaits using Force Sensing Resistor (FSR). The system was used in collecting locomotion data from several activities through wireless interface. The authors were able to differentiate the characteristics of various human postures and were able to recommend a healthy gait behaviour. Similar work was done by authors in [8], where a wireless smart shoe system was designed to study gait behaviours in elderly people to decrease their tendancy of falling by providing early warning. Authors in [13] propose a fuzzy logic in smart shoe to better estimate human gaits for proper locomotion using FSR while the work done in [6] employs the same logic in detecting major gait abnormalities by measuring improper foot pressure patterns. The system shown in [7] uses a smart shoe to sense motion by collecting acceleration and pressure values from the bottom of the feet to the detection firmware. Authors in [15] have investigated the different phases of a walk-cycle by identifying the characteristics associated with each phase using touch sensors in the shoe insole. [10] proposes a system that recognizes physical activities through the use of two force sensors placed at the front and back side of the shoe insole. Similar kind of work has been reported in [11] as well.

Some of the other researches on smart shoes are aimed at specific applications. There are research papers that have presented the use of shoes for navigation purposes. [2] and [12] present different technologies which have been used in creating maps to locate and track users through smart shoes. There is some work done in determining the emotional states of a user by listening to the footstep sounds. There is more advance work done in [14] where authors have a devised a shoe system for sensing abnormal affective status by tracking gaits. The shoes obtain signals with gait information which are then mapped to different affective states.

Most of the work discussed above is centered around the technologies that utilize shoes for health monitoring, enhancing gaits, finding appropriate bodily movements, navigation, etc. The solutions are heavily tilted towards physical and functional affordance of shoes, which is obviously of paramount importance. However, the emotional aspect of the shoe affordance is merely touched. The measurements obtained from sensors are not tied up closely with affective states of human beings. Besides, there has not been any research done for lengthening the life of shoes through mutual interaction between users and their shoes. Our research is aimed at building a materialistic relationship between the entities through constant interaction.

3 SYSTEM DESIGN

Our system constitutes of three major components: sensors, microprocessor-based data gathering module and output modules. We have put together a single shoe for this research. The system is based on the principles of designing wearable electronics for shoe insole as described in [4]. The outlook of the prototype can be seen in Figure 1.

Figure 2 shows the block diagram of the system model. We have used four types sensors in our implementation, FSR, Load Cell, IR sensor and Temperature sensor, which measure

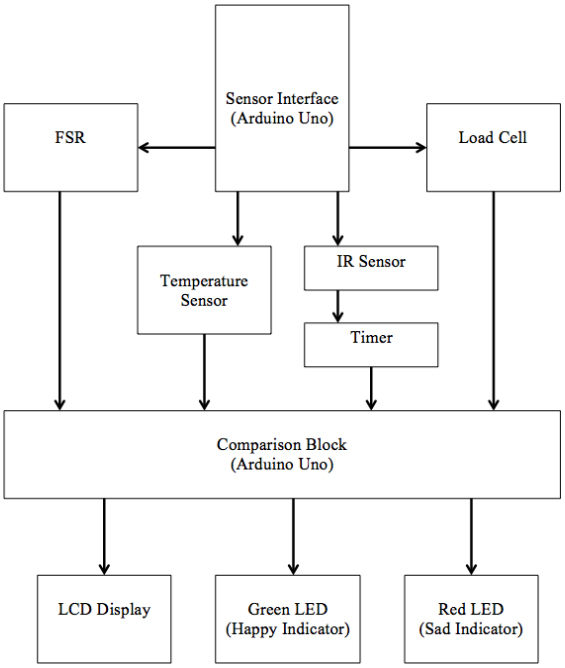


Figure 2: Block diagram of the system model.

four different types of physical quantities. FSR is used to measure pressure on the outer surface of the shoe while a Load Cell pad placed on the shoes insole measures the weight exerted by the user. We track the time when the shoe is being used through IR sensor. It is located at the anterior tip of the shoe and senses whenever foot is placed inside. As the name suggests, the temperature sensor measures the temperature inside the shoe.

The Arduino Uno Rev3 module is used to interface the sensors together. It collects as well as stores data from individual sensors and sends information over to the output device for display. It is programmed to push different outputs based on the readings obtained from the sensors. This unit is housed in a separate box and is connected to the shoe through wires. There are two kinds types of output display modules used. We have used two LEDs, one green and other red, to show the state of the shoe. If the green LED is lit up, then the shoe is happy while on the contrary if the red LED is lit up, then it means that the shoe is sad. There is also an LCD screen mounted on the shoe to display messages depending upon the sensor readings.

The sensor readings drive the Arduino module to send output on the display modules. All the readings are compared with their respective threshold values and an output is lodged whenever the reading is greater than the threshold. In addition to light in red and green LEDs, there are 15 different messages that show up in the LCD for different combination of sensor readings. Table 1 shows the messages linked

Table 1: List of different conditions and messages

Time-in	Temperature	Pressure	Weight	Message
$<$Th	$<$Th	$\geq$Th	$\leq$Th	Im under pressure!!
$\geq$Th	$<$Th	$<$Th	$\geq$Th	I wanna breathe!!
$<$Th	$\geq$Th	$<$Th	$\geq$Th	Hot and heavy!!
$\geq$Th	$\geq$Th	$<$Th	$\geq$Th	Heavy!!I need fresh air!!
$<$Th	$\geq$Th	$\geq$Th	$\geq$Th	Wow!! Help! Im dying!!
$\geq$Th	$<$Th	$\geq$Th	$\geq$Th	Very heavy!! Help!!
$<$Th	$<$Th	$\geq$Th	$<$Th	Ouch!! It hurts!!
$\geq$Th	$<$Th	$<$Th	$<$Th	Let me breathe!!
$<$Th	$\geq$Th	$<$Th	$<$Th	Very Hott!! Help!!
$\geq$Th	$\geq$Th	$<$Th	$<$Th	Very Hot!! Can't breathe!!
$<$ Th	$\geq$Th	$\geq$Th	$<$Th	It hurts!! Very hot!!
$\geq$ Th	$<$Th	$\geq$Th	$<$Th	It hurts!! Can't breathe!!
$\geq$ Th	$\geq$ Th	$\geq$ Th	$\geq$ Th	Wow!! Im dying!!
$<$Th	$<$Th	$<$Th	$\geq$ Th	Very heavy!!
$\geq$ Th	$\geq$Th	$\geq$Th	$<$Th	Its hot and hurts!!

Table 2: Data Collection

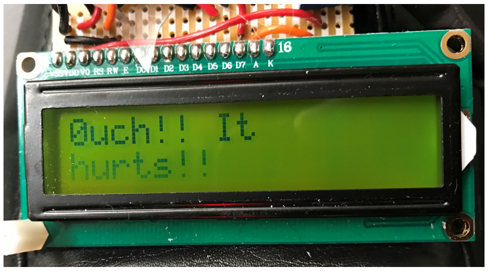
	Average Score from Questionnaire	Happy time (minutes)	Normalized score (from happy time)
User1:Day1	3.4	40.5	3.4
User1:Day2	3.4	45.3	3.8
User1:Day3	3.4	37.8	3.2
User2:Day1	2.2	20.2	1.7
User2:Day2	2.2	40.2	3.4
User2:Day3	2.2	27.6	2.3
User3:Day1	4.6	52.3	4.4
User3:Day2	4.6	57.4	4.8
User3:Day3	4.6	55.7	4.7

with different sensor readings[1]. Figure 3 shows four different messages displayed in the LCD during the experiment.

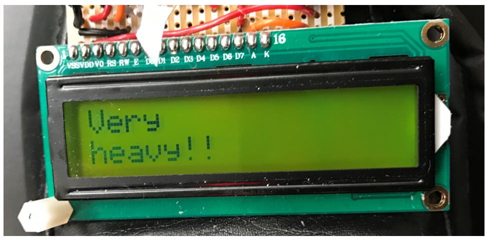
4 EXPERIMENTAL SETUP AND DATA COLLECTION

For the evaluation of our system, we performed an experiment with three different users. We let the users wear our prototype shoe in their indoor household environment for one hour. The shoe was used while the user was active, as in performing some chores, such that there are ample chances of having interactions. After completion of each experimental session, we requested the users to record the happy time in minutes, out of the sixty minutes provided in the session. We repeated the experiment three times with each user on separate days. Figure 4 shows a user wearing the prototype of the shoe.

For comparison, we provided a questionnaire to each user. Each question had to be answered with a score from 1 to 5, 1 being the worst and 5 being the best. From their answers to the questions in the questionnaire, we calculated an average score for each one of them.



(a)



(b)

(c)

(d)

Figure 3: Message displayed in LCD.

5 RESULT

In Table 2, we have listed the data collected from different users. Specifically, we have listed the average score of each user calculated from the answers in the questionnaire, total happy time of the shoes, in minutes, for different users in different days and the normalized score calculated from the happy time[2].

Figure 4: A user wearing the prototype of the shoe.

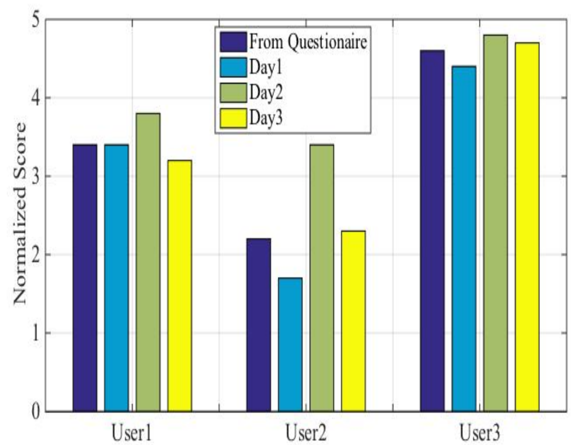


Figure 5: Comparison of average score obtained from questionnaire, with normalized score obtained from the experiment in different days for different users.

In Figure 5, we plot the bar chart comparing the normalized score obtained by each user from the questionnaire and from our experiment on Day 1, Day 2 and Day 3. From the graph, we see that for User 1 and 3, the normalized score provided by our experiment is close to the score calculated from the answers of the questionnaire. This shows that our system is closely reflecting the behavior of the user. However, for User 2, we see a spike in Day 2 and the result obtained from our experiment is deviated highly from the

[1]Th stands for Threshold value. Please refer to technical documentation for exact threshold values of different sensors

[2]We normalized score as $\frac{x}{60} * 5$ where x is the happy time of the shoes in minutes such that the normalized score is in the range of 0 to 5 for comparison with the score calculated from the questionnaire.

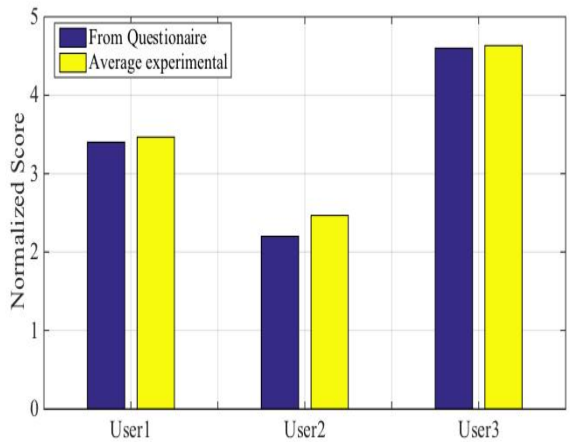


Figure 6: Comparison of average score obtained from questionnaire, with average normalized score of each user.

score calculated from the questionnaire. This could have happened due to unpredictable behavior of the user or a momentary glitch in the system. Therefore, we also calculate the average normalized score obtained over three days and plot the average normalized score with the score obtained from the questionnaire in Figure 6. We observe that the average normalized score of all users are relatively close to the scores calculated from the questionnaire.

6 CONCLUSION AND FUTURE WORK

In this paper, we presented a system that prolongs the lifetime of shoes by creating an interactive emotional bonding between the users and their shoes. The main motto of the paper was to ensure that people use their shoes in a proper manner such that the chances of them being in operation are increased. The sensor based smart shoe measured several physical quantities like weight, temperature, pressure, etc., which were used to depict whether the shoe was used properly. Interactive messages and displays indicated how the shoe felt when in use. With the help of a simple experiment, we were able to correlate the behavioral pattern of the users with the perceived emotion of the shoe.

The extension of the system could be done by incorporating more sensors that would even contextualize the environment. The electronics used in the shoe can be made more robust to support outdoor activities for conducting experiments. The use of shoes in outdoor activities is more involuntary in nature such that emotions of the users towards theirs shoes would be depicted in a much better way. Similar experiments can be done with multiple shoes and provide recommendations to the users based upon their gait patterns. Furthermore, the scope of the work can be widened by experimenting on the transfer of emotions from old pair of shoes to a new pair.

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