i-m-Walk : INTERACTIVE MULTIMEDIA WALKING-AWARE SYSTEM

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Abstract: *i-m-Walk* is a mobile application that uses pressure sensors in shoes to visualize phases of footsteps on a mobile device in order to raise the awareness for the user´s walking behavior and to help him improve it. As an example application in slow technology, we use *i-m-Walk* to help beginners learn "*walking meditation*," a type of meditation where users aim to be as slow as possible in taking pace, and to land every footstep with toes first. In our experiment, we asked 30 participants to learn *walking meditation* over a period of 5 days; the experimental group used *i-m-Walk* from day 2 to day 4, and the control group did not use it. The results showed that *i-m-Walk* could effectively assist beginners in slowing down the walking speed and decreasing the incorrect rate of pace during *walking meditation*. To conclude, this study may be of importance in providing a mechanism to assist users in better understanding of his pace and improving the walking habits. In the future, *i-m-Walk* could be used in other application, such as walking rehabilitation.

1 INTRODUCTION

Walking and jogging is an integral part of our daily lives in terms of transportation as well as exercise, and it is a basic exercise can be done everywhere. With the rapid growth of smartphones and the development of human-computer interaction design, many research projects have studied walking-related human-computer interfaces on mobile phones. For example, there is research evaluated the walking user interfaces for mobile devices (Kane et al., 2008), and proposed minimal attention user interfaces to support ecologists in the field (Pascoe et al., 2000). In addition, there are several walking-related systems developed to help people in walking and running. Nike uses touch sensor attached to users' shoes to track the jogging information and plays appropriate songs to user while jogging (Nike+, 2009). adidas uses a accelerometer to detect user's pace and heartbeats while jogging, and provides the jogging information audibly, such as jogging time, distance, and calories burned (miCoach, 2010). Wii fit uses a balance board to detect user's center of gravity, and there are several games, such as yoga, gymnastics, aerobics, and balancing (Wii Fit, 2009). In addition, walking is a gentle, low-impact exercise that can ease people into a higher level of fitness and health. There are some research uses walking as the rehabilitation exercises and an essential exercise for elders (Femery et al., 2004).

Besides, the concept of "slow technology" is proposed in recent years. Slow technology aims that users should have more time to think and reflect while learning, understanding and healing (Hallnäs et al., 2001). The technology of ambient light and biofeedback were some kinds of slow technology and were widely used in the field of rehabilitation and healing application now. Therefore, "*walking meditation*" is one kind of meditation, and is also the application of slow technology. Although many research projects have focused on meditation, showing benefits such as enhancing the synchronization of neuronal excitation (Lutz et al, 2004) and increasing the concentration of antibodies in blood after vaccination (Davidson, 2003), most projects have focused on meditation while sitting. There is little relevant research which uses technology to help user learn the *walking meditation*.

Figure 1: A participant is using *i-m-Walk*.

In this paper, in order to develop a system that can help users improve the walking habit. We use the training of *walking meditation* as an example application to evaluate the effectiveness of *i-m-Walk*. Traditional training of *walking meditation* demands on one-on-one instruction, and there is no standardized evaluation. It is challenging for beginners to self-learn *walking meditation* without feedback. We have designed experiments to test the effect of walking awareness by using *i-m-Walk* during *walking meditation*. Participants were asked to do a 15-minute practice of *walking meditation* for five consecutive days. During the experiment, participants using *i-m-Walk* will be shown real-time pace information on the screen. We proposed two hypotheses: (a) *i-m-Walk* could help beginners walk slower during *walking meditation*; (b) *i-m-Walk* could help users use correct walking method while *walking meditation*.

This paper is structured as follows: The first section deals with the introduction of walking system. The second section of the article is a review of walking detection and multimedia-assisted walking applications. This is followed by some introduction of *walking meditation*. The forth section describes the system design. After which experimental design is presented. The results for the various analyses are presented following each of these descriptive sections. Finally, the discussion and conclusion are presented and suggestions are made for further research.

2 RELATED WORKS

The first concept of wearable computing and smart clothing system included an intelligence cloth, glasses, and an intelligence shoes, and the intelligence shoes could detect the walking condition (Mann, 1997). Then, in past decade, there were many studies researched on this field, such as a study used pressure sensors and gyro sensors to detect user's feet posture, including heel-off, swing, and heel-strike (Pappas et al., 2004), and a research embedded pressure sensors in the shoes to detect the walking cycle, and used vibrator to assist users while walking (Watanabe et al., 2005). Besides, there were many different methods on walking detection, such as used bend sensor (Morris et al., 2002), accelerometer (Crossan et al., 2005), ultrasonic (Yeh et al., 2007), and computer vision technology (Quek et al., 2008) to analyze pace.

However, with the development of ubiquitous computing, there are many studies combined the technology of multimedia, feedback, and walking detector to assist people in different applications. Drobny designed an intelligent shoe that can detect the timing of pace, and play the music to help beginners learn the ballroom dancing. While it detected missed pace while dancing, it would show some warning messages to the user. (Drobny et al., 2009). Paradiso developed a system which can detect dancers' pace and applied them to interact with the music (Paradiso, 2002). Mann developed a system which can writes out the music on a timeline along the ground, and each pace activates the next note in the song, it can train the ability of musical tempo and rhythm training for children (Mann, 2006). Reynolds designed a system which used visual information to adjust foot trajectory during the swing phase of a footstep when stepping onto a stationary target (Reynolds, 2005).

In the application of walking in psychological field, Montoya used lighted target was used to load onto left side and right side of walkway, and stroke patients could follow the lighted target to carry on their pace. The results pointed out that stroke patient might effectively get help by using vision and hearing as guidance (Montoya, 1994). Also, an fMRI study on multimedia-assisted walking experiment showed that increased activation during visually guided self-generated ankle movements, and proved that multimedia-assisted walking is profound to people (Christensen et al., 2007).

In the application of pace analysis in healthcare field, Noshadi developed a system which can detect the walking stability of elderly and thus to prevent falling down. The system monitored walking behaviours and used a fall risk estimation model to predict the future risk of a fall (Noshadi et al., 2008). Intiso used electromyography biofeedback system to evaluate the effect of biofeedback on stroke and rehabilitation patients, and the results showed that biofeedback could help patients recover the swing phase of foot-drop after training (Intiso et al., 1994). Moreover, in the application of pace analysis in entertainment, Nintendo published some walking-related games in recent years. Personal Trainer – Walking could detect users' pace trough accelerometer, and users were encouraged to walk and got better scores (Nintendo, 2009). Wii is a well-known game console, and there had some interactions that should detect user's pace information, such as jogging and dancing (Wii Fit, 2009).

However, none of related research in our survey has a complete study to use multimedia-assisted biofeedback and intelligent shoes to help users aware of their pace and improve it. In this study, a complete research on integrating walking-aware shoes and multimedia feedback for learning *walking meditation* was proposed. In this paper, we will describe the measurement of walking signal, the walking-aware shoes, the biofeedback mechanisms, the experimental design, and the experimental results.

3 WALKING MEDITATION

The mechanism of meditation has many kinds and different postures, such as meditation in standing, sitting, lying down on back, and walking postures. While the user is mediating with the posture of walking, he would tend to feel less dull, tense, or easily distract in *walking meditation*. In this paper, we focus on the meditation in the posture of walking, which is also named walking meditation. *Walking meditation* is a moving meditation which aligns the feeling of body inside and outside. Also, it would help people focus and concentrate on his mind and body. Furthermore, it can also deeply investigate our knowledge and wisdom.

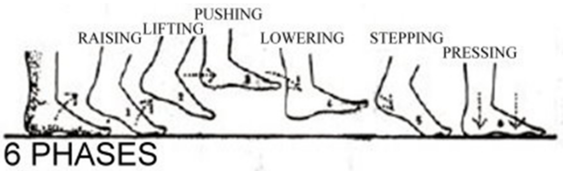

Figure 2: Six phases of a footstep in *walking meditation* (Thera, 1998).

The principle of *walking meditation* aims to be as slow as possible in taking pace, and landing each pace with toes first. The people could focus on the movement of his feet while walking. The movement can be divided into six phases, from the status of raising, lifting, pushing, lowering, stepping, to pressing. People should aware of the movement in each stage while *walking meditation* (see Figure 2). It is important to stay aware of the feet sensation.

Keep practicing of *walking meditation* is an effective way to align the mind and body, and to enhance the feeling of mindfulness. Mindfulness can be defined as careful, open-hearted, choiceless, present moment awareness. While feeling mindfulness, people will slow down the footstep while *walking meditation*. With long-term practice of *walking meditation*, it benefits people by increasing patience, enhancing attention, overcoming drowsiness, and leading to healthy body (Hanh et al., 2006).

The goal of this study is to help beginners aware of their mind and body, and to get healthier after *walking meditation*. Therefore, *i-m-Walk* system was developed to assist beginners in learning the walking methods of *walking meditation*,

4 SYSTEM DESIGN

i-m-Walk includes a pair of intelligent shoes, an ZigBee-to-Bluetooth relay, and a smartphone. Inside the intelligent shoes, there are three force sensitive resistor sensors fixed underneath each shoe insole, and the sensing values will transfer wirelessly through the relay to the smartphone. We develop the system that can analyze the pace information, and show the information through visual feedback. The system is running on HTC HD2 smartphone which running Window Mobile 6.5 and has a 4.3-inch LCD screen. The overview of the system is shown in Figure 3.

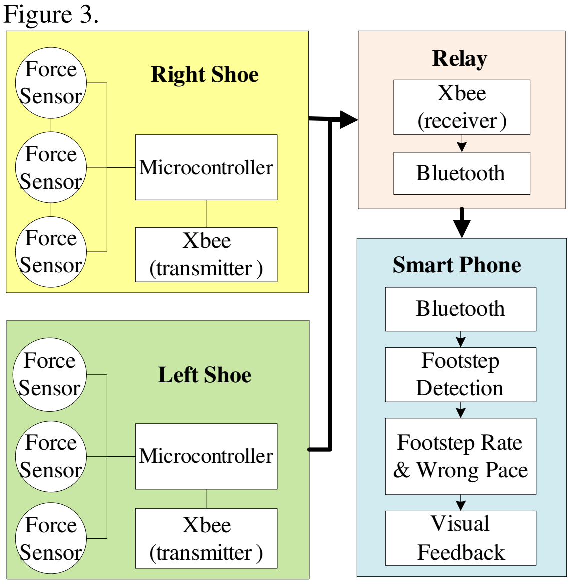

Figure 3: The flow chart of *i-m-Walk*.

4.1 *i-m-Walk* Architecture

The shoe module is based on Atmel's highperformance, low-power 8-bit AVR ATMega328 microcontroller, and transmits sensing values through a 2.4GHz XBee 1mW Chip Antenna module wirelessly. The module size is 3.9 cm x 5.3 cm x 0.8 cm with an overall weight of 185g (see Figure 4), including an 1800mAh Lithium battery can continuous use for 24 hours. We kept the hardware small and lightweight in order not to affect users while walking.

Inside the shoes, we use three force sensitive resistor sensors to detect the pressure distribution of user's feet while walking. The sensing area of each pressure sensor is 0.5 inch in diameter. The intelligent shoes would be used to detect user's walking speed and walking method of *walking meditation*. According to the recommendations of orthopaedic surgery in National Taiwan University Hospital, we use three force sensitive resistor sensors fixed underneath the shoe insole. The surgery recommended that there were three main sustain areas located at structural bunion, Tailor's bunion, and heel, seperately. (see Figure 4). Besides, the shoe module is put outside of the shoes (see Figure 5). With a fully charged battery, the shoe module can be used continuous for 24 hours or more.

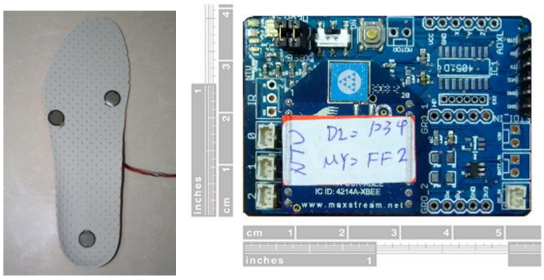

Figure 4: Shoe module. Right figure shows the micro-controller and wireless module. Left figure shows one insole embedded with three force sensitive resistor sensors.

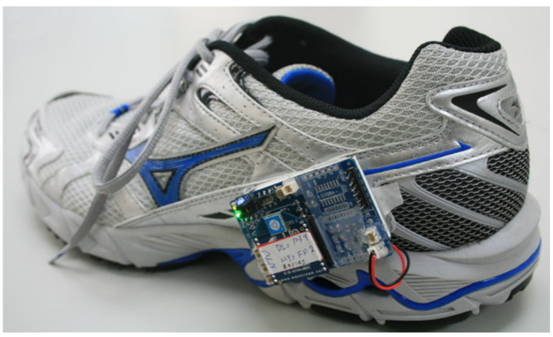

Figure 5: Intelligent shoes. A sensing module is attached onto the side of the shoe. The sensing values will transfer wirelessly through the XBee module.

4.2 Walking Detection

According to different applications, there are many sensing technologies and detection algorithm on the field of walking detection (Pappas et al., 2004 & Long et al., 2008). In our system, we use six pressure sensors to sampling the pressure distribution of user's feet while walking. The sample rat of our system is 30 times per second. In order to detect whether the user lands each footstep with toes first or not, the pressure distribution is divided into two parts, front part and heel part. The sampling value in front part is the average of two force sensors which underneath at the position of structural bunion and Tailor's bunion. The sampling value of heel part is a force sensor underneath at the position of heel. Therefore, there are four sampling values in our system to represent his walking status. Then, we took an experiment to find out the most appropriate threshold value which could categorize whether the sampling value in these parts is pressed. The experimental result showed that this method can accurately detect the landing moment during the weight of participants from 40 kg to 90 kg. Also, this method can also detect that the user lands with toes first or heel first. The definition of the beginning of each gait cycle is in the moment while the heel is lifting while walking. The end of the gait cycle is in the moment while another foot's heel is rising while walking. Figure 6 shows an example of our detection method. In this example, the system detects that the user lifts his left foot in fifth second because that the sensing value in heel part is less than the threshold. Also, the system detects that the user lifts his right foot in 10.7 second because that the sensing value in heel part is less than the threshold. Besides, if the sensing value in front part is less than the threshold before front part, it means that the user land this footstep with heel first.

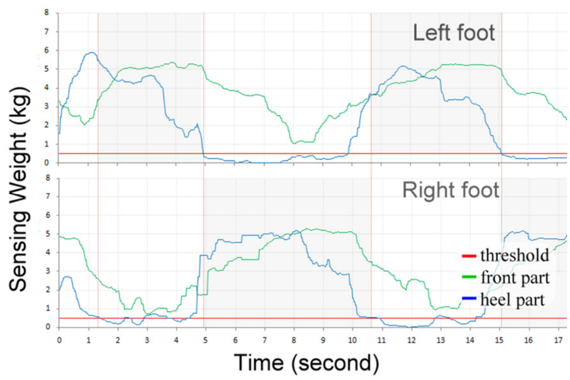

Figure 6: Signal processing of walking signals. Blue line indicates the sensing weight (kg) of heel, and green line indicates the sensing weight of toes over time. Red line is the threshold to activate the landing events. Gray block means that which foot is landing.

4.3 USER INTERFACE

Multimedia assisted system can be effectively applied in preventive medicine (Hu et al., 1994), and it can also assist patients in walking easily (Femery et al., 2004 & Woodbridge et al., 2009). In our study, *i-m-Walk* is developed to assist beginners in learning the walking methods of *walking meditation*. The user interface of *i-m-Walk* includes three components: warning message, footstep awareness, and walking speed (see Figure 7). In this section, we describe the user interface and the design principles of our system.

4.3.1 Walking Aware

The main function of *i-m-Walk* is to reflect the walking conditions on the mobile phone, and user can aware of his walking conditions by watching the context in real time. A pair of footmark is in the center of the user interface, and it shows user's walking phases by using the movement of color blocks. The color blocks show the center of gravity in both feet separately, and the transparency will change according to the volume of landing force. Also, the color block will move top-down while the user is landing with toes first. The color block will move bottom-up while the user is landing with heel first. Besides, while the user uses incorrect pace while walking meditation, the color block will change from green to red to remind the user to land footstep with toes first in next footstep. In our study, the correct walking method is defined that the user lands every pace with toes first, and the color block will show represent in green. On the contrary, while the user lands footstep with heel first, the system would recognize that he is using incorrect walking method, and the color block would represent in red.

4.3.2 Walking Speed and Warning Message

During *walking meditation*, people should stabilize his walking pace at a lower speed. *i-m-Walk* provides the user interface that shows the walking information in real time, and provides the mechanism to remind user while he is walking too fast. The walking speed is shown on the bottom of the screen, and the speed is visualized as a speedometer. In the speedometer, the indicator will point to the corresponding walking speed such as the speedometer for car. For example, if the indicator points to the value "30", it means that the user walks thirty footsteps per three minutes. Therefore, the speedometer also provides the function to remind the user while he is walking too fast. According to the experiment, we defined the lower-bound of the walking speed as 40 footsteps per three minutes. While the walking speed exceeds the speed, the indicator will point to the red area, and the screen will show a warning message "too fast" on the top of the screen. The warning message would disappear while the walking speed is less than 40 footsteps per three minutes.

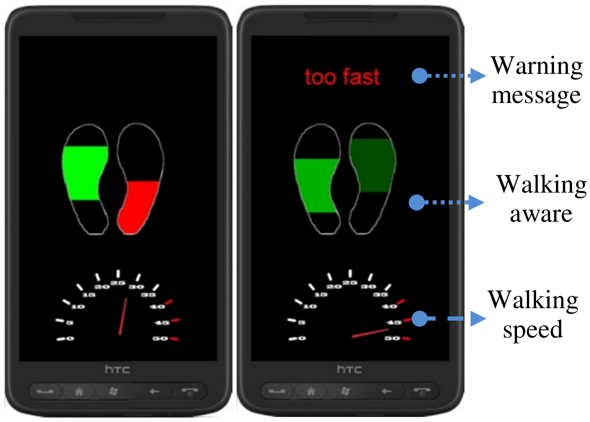

Figure 7: The user interface of *i-m-Walk*. The user interface shows three components: warning message, walking-aware, and walking speed. Left figure shows that the user uses incorrect walking method on right foot. Right figure shows that the walking speed is too fast (46 footsteps per three minutes), and the warning message appears on the top of the screen.

5 EXPERIMENT DESIGN

Two experiments were designed to evaluate the effects of walking-aware system during *walking meditation*. The first experiment was a pilot study. In this study, we evaluated the effect of visual feedback which showed six sensing curves which projected on the wall. The second experiment evaluated the effects of *i-m-Walk*.

5.1 PILOT STUDY

Before the development of *i-m-Walk*, a pilot study was held to test whether the visual feedback of user's walking information could help user walk better while walking meditation. Eight master students volunteered to participate in this pilot study. Participants' average age is 26.3 (*SD*=0.52). All participants have the experience of sitting meditation before, but all of them do not have the experience of *walking meditation*. There were four participants (three male and one female) in experiment group (with visual feedback), and four participants (four male) in control group (without visual feedback). Participants would take ten minutes each day and for three consecutive days in this experiment. Before the experiment, participants were taught the methods and principles of *walking meditation*. The experiment was a 4 × 2 between-participants design. In the experiment group, participants were asked to watch the walking information which projected feet's pressure distribution on the wall. In the control group, participants were asked to walk without watching the walking information. All participants walked straight in the seminar room. The results showed that there was a significant main effect that experimental group had lower walking speed than control group ($p<0.05$) during the three days. Also, the median value of incorrect pace in experimental group was less than control group, too. The incorrect pace was defined in this study landing footstep with heel first. As the results from the pilot study, we concluded two preliminary conclusions: (a) visual biofeedback could help beginners slow down the walking speed during *walking meditation*; (b) Multimedia guidance could usefully help user aware of his pace during *walking meditation*, and could decrease the number of incorrect pace. However, we also observed a problem that participant's perspective would change over time while walking, and it might influence the effect of learning. Based on the results and recommends, we developed a mobile application, i-m-Walk, to visualize the walking information on a mobile device, and designed a experiment to evaluate the effect of it.

5.2 USER STUDY

5.2.1 Participants

Thirty master and PhD students in the Department of Computer Science volunteered to participate in this experiment. Participants' average age is 25.2 (SD=3.71). The results of questionnaires showed that twenty-seven participants have the experience of sitting meditation, and three participants do not. Also, all participants do not have the experience of *walking meditation*. 83.3% of the participants carry mobile phone all the time, and 63.3% of the participants have the experience of using smartphone. There were fifteen participants (eleven male and four female) in experiment group (with visual feedback), and fifteen participants (eleven male and four female) in control group (without visual feedback). Because the feet size would differ to each participant, we prepared two pair os shoes with different sizes for participants to choose a comfortable one.

5.2.2 Location

Meditating in a quiet and enclosed area would be easier to bring mind inward into ourselves and may reach in calm and peace situation. In this experiment, we selected a corridor in the faculty building as the experimental place for *walking meditation*. The corridor is a public place at an enclosed area and few people would conduct their daily activities like standing, walking, and interacting with one another there. The surrounding of corridor is quiet and comfortable for participants to reach their mind in calm. The length of the corridor is thirty meters, and the width is three meters. The temperature is 21~23 Celsius degree.

5.2.3 Procedure and analysis

Before the experiment, participants were asked to walk alone the corridor in casual walking, and we recorded the walking speed. We would like to ensure that all participants are under the same condition before the training of *walking meditation*. The result showed that the average walking speed is 95.97 footsteps per minute (SD = 4.67). Then, we taught the methods of *walking meditation* to all participants. The guideline of the *walking meditation* which we provided to the participants was as follows:

"Walking meditation is a way to align the feeling inside and outside of the body. You should focus on the movement of footstep while walking. Each footstep would include six phases, from the phase of raising, lifting, pushing, lowering, stepping, to pressing. Besides, you have to land every footstep with toes first and then slowly land your heel down. During walking meditation, you should stabilize your walking pace at a lower speed as possible. You have to relax your body from head to toes."

The experiment was a 15 × 2 between-participants design. Participants would take fifteen minutes each day and for five consecutive days in this experiment. Table 1 shows the procedure of this experiment. In the experimental group, participants were asked to use *i-m-Walk* from day 2 to day 4. In the control group, participants were asked to walk without any feedback during *walking meditation*.

Table 1: Experimental procedure: ● means that participants were asked to use *i-m-Walk* and ○ means that participant do not use *i-m-Walk* during *walking meditation*.

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Experimental Group	○	●	●	●	○
Control Group	○	○	○	○	○

While learning of walking mediation, all participants were asked to walk clockwise around the corridor and hold the smartphone. In control group, there was no visual feedback on smartphone although they still needed to hold. In experimental group, participants were informed that they can decide not to see the visual feedback while they did not need it. The participants in experimental group were asked to complete a questionnaire after each task from day 2 to day 4. Besides, we asked all participants the feeling and impression after the experiment in day 5. However, all participants could write down any recommends and feelings after the experiment, and we will discuss the issues in the discussion section.

5.2.4 Results

We analyzed the walking speed and incorrect pace both in experimental group and control group. In the results of the walking speed, figure 8 shows the average stride time on experimental group and control group from day 1 to day 5. In day 1 and day 5, all participants learned *walking meditation* without using *i-m-Walk*. Following t-tests revealed significant difference ($p < 0.005$) that the experimental group had longer stride time than *control group* from day 2 to day 4. In experimental group, the average of stride time increased from 4.5 seconds in day 1 to 10.9 seconds in day 5. In control group, the average of stride time increased from 3.2 seconds (day 1) to 5.1 seconds (day 5). The results showed that the participants in experimental group had significant main effect ($p < .005$) in slowing down the walking speed after the learning of *walking meditation*. On the contrary, the participants in control group had no significant main effect ($p > .1$) in slowing down the walking speed after the learning of *walking meditation*. Therefore, the results showed that *i-m-Walk* could help participants in slowing down the walking speed during *walking meditation*.

In our experiment, the definition of correct walking method is that users should land every footstep with toes first during *walking meditation*. If participants landed footstep with heel first, it was an incorrect pace. Figure 9 shows the median values of total incorrect pace in 15 minute learning of *walking meditation* on *experimental group* and *control group* from day 1 to day 5. In experimental group, the median value of incorrect pace decreased from eight in day 1 to one in day 5, and it decreased over day. In control group, the median value of the incorrect pace decreased from seven pace in day 1 to five ace in day 5, but the incorrect pace decreased only in the first three days. The results showed that *i-m-Walk* could effectively reduce incorrect pace during *walking meditation*.

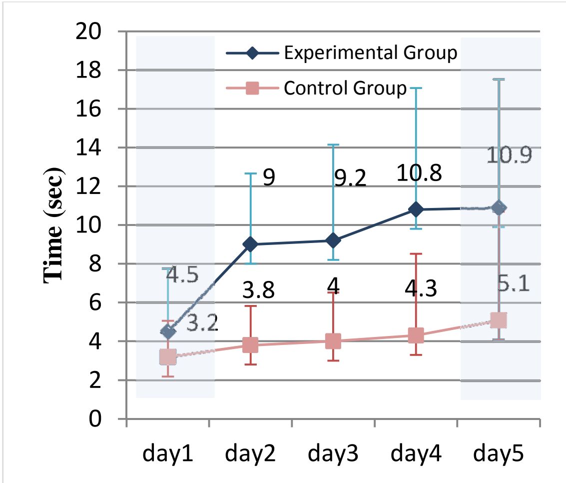

Figure 8: The comparison of average stride time on experimental group and control group from day 1 to day 5. Error bars show ±1 SE.

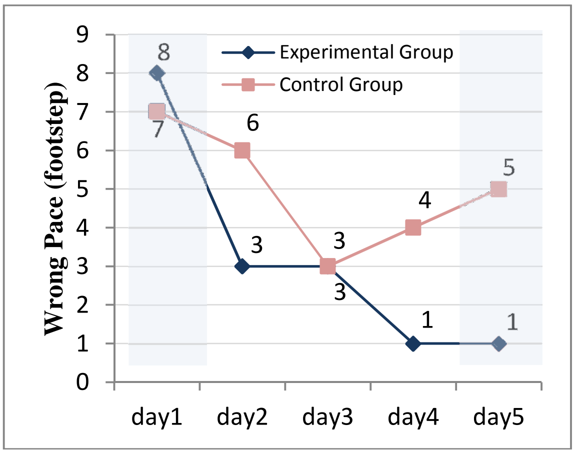

Figure 9: The comparison of the median of incorrect pace numbers on experimental group and control group from day 1 to day 5.

The experimental group was asked to complete a questionnaire after using *i-m-Walk* system from day 2 to day 4. There are two questions in the questionnaires, and the content was the same in each day. Figure 10 shows the results of questionnaires. We asked two questions: (1) what is the degree of *i-m-Walk* to help you aware of the walking pace? (2) what is the degree of *i-m-Walk* to help you slow down the walking speed? There were five options, including "1: serious interference", "2: a little interference", "3: no interference and no help", "4: a little help", and "5: very helpful", and participants should fill the answer. The results of questionnaires showed that all participants in experimental group gave positive feedback both in question 1 and question 2, and almost all participants in experimental group liked the system.

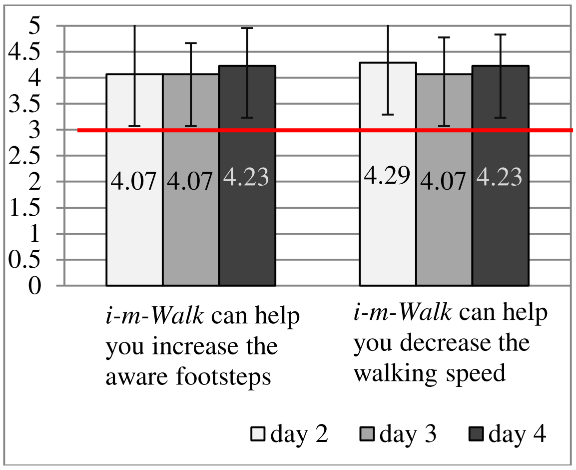

Figure 10: The results of questionnaires which were filled by experimental group from day 2 to day 4. The red line means the baseline of the satisfaction. Error bars show ±1 SE.

6 DISCUSSION

The aim of this section is to summarize, analyze and discuss the results of this study and give guidelines for the future development of applications.

6.1 User Interface

The user interface of *i-m-Walk* provides the walking information, including walking speed, incorrect pace, and the center of feet. The experimental results showed that *i-m-Walk* could help beginners decrease the walking speed while *walking meditation*. There is a participant's comment from experimental group:

User E6 in day 3*: "I always walked fast, but when I saw the dashboard and the warning message "too fast" on the screen, it was helpful to remind me to slow down the walking speed.*

The experimental results also showed that *i-m-Walk* could effectively reduce the rate of incorrect pace for beginners while *walking meditation*. One of the participants from experimental group said that:

User E1 in day2: *"While the color block changed the color from green to red, I knew that I used incorrect pace* immediately. *Then, I would pay attention on my pace deliberately in the next footstep.*

The mechanism of remind function likes a personal couch to remind user while using incorrect pace in *walking meditation*. We concluded some design principles of the user interface: (a) *i-m-Walk* used the form of dashboard to represent the walking speed. The value of walking speed is easy to watch, and user might aware of the change of walking speed while he slowed down or speeded up; (b) *i-m-Walk* provided additional alarm mechanism, a warning message "too fast", while walking too fast. The mechanism could remind user when he is distraction; (c) *i-m-Walk* could effectively reduce the rate of incorrect pace for beginners. Besides, two participants said that they always forgot to breathe while concentrating on the user interface. It is possible to provide the guidance of breathing rhythm with the rhythm of walking during *walking meditation*.

6.2 Human Perception

Vision, sound, smell, taste and touch are five main perceptual modalities for human beings. The most use in human-computer interaction is visual modality and audio modality now. There was a comment from a participant from experimental group:

User E3 in day 2*: "If I can listen to my pace during walking meditation, I do not need to hold the smartphone".*

In cross-modal research, visual modality is always considered superior than auditory modality in spatial domain. In our case, *i-m-Walk* needs to show the walking information, walking speed and incorrect pace in the same time. Therefore, *i-m-Walk* uses visual feedback as the user interface. The advantage of visual feedback is that users could choice to watch the information or not, but the shortcoming is that users cannot receive the information while they do not watch it. Therefore, it is possible to provide more interaction methods to remind users, such as tactile perception and acoustic perception. On the other hand, the mechanisms of multimedia-assisted feedback might attract user's attention in some case. Too many inappropriate and redundant events might disturb user. In our system, *i-m-Walk* provides visual feedback all the time during *walking meditation* because we do not know whether the user needs the information or not. Therefore, we informed all participants that they could choice not to watch the screen while they could aware of their pace well. By this way, it could minimize the interference while *walking meditation*.

6.3 Beginner vs. Master

In recent years, the concept of "slow technology" was applied in many mediate systems. The design philosophy of "slow technology" is that we should use slowness in learning, understanding and presence to give people time to think and reflect. In our study, *walking meditation* is a form of slow technology. There are two main parts in *walking meditation*, inside condition and outside condition. The inside condition means the meditation of mind and the outside condition means the meditation of walking posture. All participants were beginners in our experiment because we would like to focus on the training of the walking posture first. The difference between beginner and master in *walking meditation* is that the beginner does not familiar to *walking meditation* and needs to pay more attention on the control of walking posture; on the contrary, the master familiar to it and could pay more attention to align the mind and walking posture in the same time. *Walking meditation* is a way to align the feeling inside and outside of the body. The beginner should familiar the walking posture before the spiritual development. In this paper, the goal of our experiment is to evaluate the learning effects of *i-m-Walk* system. The experimental results showed that experimental group could slow down the walking speed and decrease incorrect pace after five days. Six participants in experimental group felt that the experimental time in day four was short than first day although the experimental time was the same. However, there was no such comment from the participants in control group. The results showed that *i-m-Walk* could help user in training the walking posture of *walking meditation*.

6.4 Reaction Time

Reaction time is an important issue in human-computer interaction design. If the reaction time is too long, it is hard for user to use it. According to the observation, the delay time of *i-m-Walk* is about 0.2 second. However, the delay time do not affect the user because the application in this experiment does not need fast reaction time. The average pace speed is 10.9 seconds in experiment group in day five. The results of questionnaires also showed that participants felt that the visual feedback could reflect their walking status immediately.

7 CONCLUSIONS AND FUTURE WORK

In this paper, we present a mobile application that uses pressure sensors in shoes to visualize phases of footsteps on a mobile device in order to raise the awareness for the user´s walking behaviour and to help him improve it. Our study shows that *i-m-Walk* can effectively assist beginners in slowing down the footstep frequency and eliminating the error rate of pace during *walking meditation*. Therefore, *i-m-Walk* can be used in other applications, such as walking rehabilitation, fitness, and entertainment applications.

Despite the encouraging results of this study as to the positive effect of *i-m-Walk*, future research is required in a number of directions. First, the experiment in this study showed that *i-m-Walk* could help beginners aware of their footsteps, but we did not know the learning effect in the long-term. How long a beginner can familiar to the essence of walking meditation is an interesting issues. In the future, we will record user's learning status day by day, and to find out the learning curves of walking meditation. Second, *i-m-Walk* only used the mechanism of visual feedback to assist users, and it did not include the mechanism of auditory feedback and tactile feedback. In the future, we would like to compare the effect of visual feedback, auditory feedback, and tactile feedback while walking. Third, breathing method is important while walking, jogging, and running. We are developing system named *i-m-Treadmill*, which investigates the relationship between jogging and breathing. Finally, we will develop a system which integrates the technique of breath detection, walking detection, and multimedia-assisted biofeedback to develop a health care system, and toward to the ideal of preventive medicine.

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