Psychology State Acquiring Device Based on Sitting Postures for Implicit Interaction

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Abstract: Context-aware is very important for implicit interaction. User’s psychology state as a kind of user context can be used in the interaction to improve quality and to make the service more individual. In this paper, a psychology state acquiring device based on sitting postures for implicit interaction is developed. The device consists of two parts: pressure sensor matrix and micro control unit. The former is made up of 40 pairs of pressure sensor node to sense pressure distribution on it, and the latter has a power supply module, first/second level CD4051 parts, operational amplifier LM324, AD0804, and STC89C52RC mainly to realize sampling control and analysis. With this device, several experiments are carried on. It can be seen that the effect is good enough in single set testing, area (palm/sitting) testing and the actual environment testing. So it can be used in implicit human computer interaction researches and applied in another area. Copyright © 2013 IFSA.

Keywords: Implicit interaction, User context, Affective computing, Psychology state, Sitting posture.

1. Introduction

On November 28, 2011, the Chinese Internet of things "twelfth five-year" development plan was announced formally, which pointed out a development direction for the new type of Internet of things (IoT) industry heating up in recent years. Its industry was pointed out that there is a huge market potential. The plan clearly put forward that China by 2015, has made significant results on the core technology research and development and industrialization and key standards of research and development, establishment and perfect industry chain, major application demonstration and promotion etc and formed preliminary a innovation drive, applications traction, collaborative development, safe and controllable Internet of things development pattern. With the development of technology, the meaning of the Internet of things is also tending to perfect gradually, and has outlined scenarios of a better life in the future for us based on Internet of things.

The Internet of things said at present, through the information sensing equipment, is a comprehensive network of implementation from person to person, the people and things interconnection, according to the agreed protocol. So it improves the perception of the material world and realizes the intelligent decision and control. Under the target, the researches of interactive technology and the development of related equipment is particularly important.

The rest of the paper is organized as follows. In Section 2, a brief literature review is provided on implicit interaction, psychological state acquiring and human pressure measuring. Section 3 presents the development of our psychology state acquiring device based on sitting postures. Section 4 carries on some experiment and analyzes the real results. Section 5 provides the conclusions and the future work.
2. Related Works

2.1. Implicit Interaction

Interaction process, depending on the difference of object and methods, can be divided into three types: explicit/implicit interaction of person to person, person to thing, and thing to thing. At present, the research mainly concentrated on the direction of human computer interaction (HCI), which belongs to the second type. With the development of theories and technologies of the pervasive computing and the multimode interaction, researches on HCI gradually draw more attention from explicit interaction to implicit one [1-3]. Studies have shown that implicit interaction can replace the explicit one effectively in the interactive process, though implicit interaction is not as accurate as the explicit one [4]. In fact, the recent researches suggest that if taking full advantage of user behavior contexts as the implicit interactive information, we can do better in the interaction than using explicit information [5, 6].

Implicit human computer interaction (ICHI) is the frontier of the HCI [7]. Nicole Kaiyan, coming from Australia Swinburne University of technology, has put forward the concept of ICHI in 1996, but do not study in detail [8]. Since 2005, universities and institutes in the United States, Germany, China, Austria and so on, have concentrated on the ICHI theories, technologies and applications. Albrecht Schmidt, coming from Karlsruhe University, carried out related researches on ICHI earlier. Given that two elements of the implicit interactions are perception and reasoning, he proposed that context information was extremely important to the interactive process, and modeled the interaction process with XML language at the same time [9]. Andrew Wilson and Nuria Oliver, coming from Microsoft research in the United States, have developed four systems based on the machine vision to study the implicit interaction technology. Since 2007, Tao, coming from Tsinghua University in China, has developed an adaptive visual system to detect and understand user behaviors in order to apply on the implicit interactions [11]. Meanwhile, Tian, coming from Institute of Software in Chinese Academy of Science, studied the characteristics of the implicit interactions in the view of the WIMP user interface [12]. The development of ICHI at home and abroad was reviewed as shown in the Fig. 1.

2.2. Psychological State

Accessing user psychological state implicitly can be divided into two kinds: non-contacting and contacting. Non-contacting method is mainly based on vision and voice, and contacting method collects and analyzes the users' physiology and interaction information. Relevant methods are shown in Table 1.

Although the visual and auditory is the main non-contacting method for accessing psychological state, there are many problems, such as processing difficulty brought by large amount of information, unstable of information collecting, and so on. Contacting method is based on a variety of sensors, and directly measure the user's emotional state in real-time. By carrying on the sensor data fusion and fuzzy reasoning, Seong - Joo Kim judged the user's emotional state by measuring the sweat, pulse, body temperature, blood pressure and other physiological information [10]. Nguyen Thuy Le reduced the sensor type, only by measuring the pulse and body temperature to determine the user emotional state [11]. Arapakis suggested acquiring person’s psychological state by face expression [7].

![Fig. 1. Development of ICHI.](image-url)
addition, it can be also based on the questionnaire or other types to measure the person’s psychological state indirectly. Gustavo Gonzalez applied emotion quotient test table on surveying users’ emotional state. And Ai Thanh Ho used a more convenient form to solve the problems of disliking questionnaire by showing the user a different set of colors for the choice. And according to the selected item, the user’s current emotion can be accessed. The characteristics of such methods are shown in Table 2. Among them, B, M and G denote poor, general and good respectively.

### Table 1. Implicit accessing method of psychological state.

<table>
<thead>
<tr>
<th>Method</th>
<th>Portability</th>
<th>Continuity</th>
<th>Sensibility</th>
<th>Comfort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expression</td>
<td>B</td>
<td>B</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Voice</td>
<td>M</td>
<td>B</td>
<td>M</td>
<td>G</td>
</tr>
<tr>
<td>Eye movement</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>B</td>
</tr>
<tr>
<td>Brainwave</td>
<td>B</td>
<td>G</td>
<td>G</td>
<td>B</td>
</tr>
<tr>
<td>Behavior</td>
<td>B</td>
<td>B</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Physiological information</td>
<td>G</td>
<td>G</td>
<td>G</td>
<td>M</td>
</tr>
</tbody>
</table>

According to the feature comparison in Table 2, the physiological information to accessing user’s psychological state is more obvious, portable, continuous, sensitive, and comfort. So developing physiological information acquiring device, acquiring user's psychological state implicitly, specially based on contacting method and physical information, is necessary and significant to improve the quality of HCI and realize seamless interaction. This paper states the realization of a sitting posture acquiring system.

### 2.3. Human Pressure Measuring

Tekscan Company in the United States studies on human pressure measurement system (BPMs). With unique sensor technology, measure the body pressure distribution. Qinetiq Company researches on an intelligent seat. It can recognize passenger’s psychological states, and predict potential danger to inform crews on an airplane.

However, these productions use special material, such as air bag or conductive rubber, and so on. In addition, they are usually difficult to product and costs too much. So it is not easy to use widely.

### 3. Design and Implementation

#### 3.1. Overview

The schematic diagram and the physical connection of our device for accessing Users’ psychological information implicitly are shown in Fig. 2.

The distributed pressure is detected by the pressure sensor matrix, and integrated with status information acquired by gyroscope devices. Then
data package is sent to the micro control unit to compute and analyze, which is helpful to the subsequent processing.

3.2. Pressure Sensor Matrix

The size of our pressure sensor matrix is designed as $41 \times 44$ cm$^2$ (Fig. 3). It consists of 40 pairs of pressure sensor node with the size of $2.80 \times 2.80$ cm$^2$. They are ranged to 7 lines and 6 columns. Line 1 is placed with 4 groups of sensors, and from line 2 to 7 each row is placed with 6 groups. Their number increases gradually. The interval between two groups is 20 mm ($\pm 5$ mm) to ensure the integrity of user’s physiological signal, and to improve the resolution of the signal.

As the minimal signal acquiring unit, the pressure sensor node consists of two weighing sensors, which are half-bridge type resistance strain gauge (Fig. 4). They are installed into two ‘E’ shape holders. It is noticed that the two pressing points of weighing sensors should be 2-3 mm higher than the surface of holders to leave enough space for increasing the pressure measurement range.

3.3. Hardware Connection

With a microcomputer as the processor, micro control unit is responsible for data collection, analysis and simple communication. By adopting the wireless serial port module NRF24L01, Communication is realized to transmit important data to computer.

Moreover, reconfigurable sensing module is helpful to intelligent management and prolonging the life cycle of sensors. Hardware connection is shown as Fig. 5.

![Fig. 3. Pressure sensor matrix](image)

![Fig. 4. The minimum signal acquiring unit.](image)

The micro control unit consists of a power supply module, first/second level CD4051 parts, operational amplifier LM324, AD0804, and STC89C52RC mainly. When pressure sensor matrix is working, MCU STC89C52RC controls the first and second level CD4051 parts separately to make pressure signals be sampled one by one. After the analog signals collecting, operational amplifier LM324 works. And then AD0804 module converts the analog signals to digital one. So the MCU processes these signals, and transmits them to PC by the wireless module NRF24L01.

1) CD4051 analog switch.

CD4051 is equivalent to a single pole eight throw switch.

The input address code ‘ABC’ determines which channel is selected. The ‘IN H’ is enable port. If setting it to zero, each channel is in the connecting state continuously. The power port ‘VEE’ of CD4051 is used for power level shift, which can make digital signal provided by COMS circuits to control this multi-channel switch directly under the condition of a single set of power supply.

2) AD0804 module.

ADC0804 belongs to continuous incremental (Successive Approximation Method) of A/D converter, resolution: 8. The convert values change from 0 to 255. Conversion time: 100 us
(fCK = 640 kHz). The range of the sensor output voltage signal used in this project is 0 ~ 5 V. Its minimum output voltage is 5 V / 256 = 0.01953 V, which represents the minimum voltage value of ADC0804 can converting. When using AD0804, we must pay more attention to the time of reading and writing. Time is very important. Adding a longer time delay between WR statements (20 millisecond), LED connected with the AD0804 will be slightly brighter, and the light of digital tube will jump. When removing the time delay, LED does not light, and the light of digital tube will keep stable. In the actual application, if the analog switches are turn off or on too fast, the AD0804 will be affected greatly. It can be solved, if we add delay of 1 millisecond.

3) Operational amplifier LM324.

Operational amplifier used in this project is consisted of four parts: Biasing circuit, Input stage, Intermediate stage, Output stage. The differential amplifier circuit (restrain power) is used in the input stage. Intermediate grade adopts emitter load circuit with active load to improve magnification. Output stage adopts the complementary symmetry output stage circuit to improve the driving-load ability of the circuit. The purpose of this module is mainly to amplify the small signal undistorted outputted by sensors which can not be identified by Micro programmed Control Unit.

4) The wireless module.

When sending data, the address of receiver and the pressure data are sent into NRF24L01 + according to the time sequence, configure CONFIG register into transceiver model. The microcontroller gives CE a high level signal (at least 10 us) and inspires NRF24L01 + launches in Enhanced ShockBurstTM. Then power the RF, package the data (plus word head, CRC check code). At last, launch packets at a high speed. When received, firstly, we must configure the address of the machine and the packet size what you want to receiving, configure CONFIG register so that make it goes into receiving mode, and give the CE a high level signal. After 13 us NRF24L01+ comes into the monitoring state, waiting for the arrival of the data packet. When receiving correct data packets (correct pressure data and CRC check code), NRF24L01 + wipe off the prefix, address and CRC checksum automatically; then, NRF24L01 + send message to the micro controller by setting the RX_DR of STATUS register (STATUS generally caused interrupt of the micro controller). Finally, micro controller read out the pressure data from nRF24L01 and then clear the STATUS register.

3.4. Software Implementation

Micro control unit receives the pressure acquisition from distributing data by the pressure signal acquisition nodes on different locations through timesharing strobe and shutdown. The software processes is shown in Fig. 6.

4. Experiment

Running the system after Power supplied, we can obtain user sitting pressure distribution data, by means of serial debugging tools sscom32. It can be shown in Fig. 7.

There are 40 data at each set of transmission because that the emotional cushion is designed 40 pressure sensors (hexadecimal). The start bit of data by the FF is the beginning flag of transmission. These data is transmitted by every 3 seconds. We can configure the transfer mode based on the needs: continuous transmission mode and a single transmission.

When transmitted to the upper computer, the pressure data is displayed, processed and analyzed in the upper computer software. We can analyze the psychological state by sitting posture so it is the acquisition of pressure data that really Vital.

In order to test the system for pressure data acquisition process, and according to the pressure area, we do the following tests: 1) Single set testing of pressure sensors; 2) Area (palm) testing of pressure sensors; 3) Area (sitting) testing of pressure sensors; 4) The actual environment testing.
1) Single set testing of pressure sensors.
First, three sets of pressure sensors were tested. They are in line 5 column 3, line 4 column 5 and line 6 column 6 respectively. The tested results are shown in Fig. 8.

(a) The set of pressure sensor in line 5 column 3.

(b) The set of pressure sensor in line 4 column 5.

(c) The set of pressure sensor in line 6 column 6.

Fig. 8. Single set of pressure sensors testing.

2) Area (palm) testing of pressure sensors
In this section, 10 participants place their right hands on the pressure collection area of our device respective. The palm pressure distribution testing results of two subjects of them are shown in Fig. 9.

According to the pressure range represented by different colors, the fingers of the first subject press lightly. Conversely, his palms press more heavily, which is displayed with pink color.

(a) Palm pressure distribution of subject 1.

(b) Palm pressure distribution of subject 2.

Fig. 9. Palm pressure testing.

It is seen that the second subject’s fingers point to the left upper part of area testing from Fig. 9(b). His fingers press heavily, demonstrating with a deeper green area. In addition, the sensor set of row 3 column 1 is also detected a certain pressure due to the external disturbance.

3) Area (sitting) testing of pressure sensors
In this section, the number of subjects involved in the testing is 10. Sitting pressure distributions of three subjects are shown as Fig. 10. It can be seen that the waist bones are relatively obvious from the change color in this picture. Although the overall detective effect is good, the sensor set of line 3 column 1 still exists certain interference detection.
4) The actual environment testing.
When the car turns sharp right or left, driver’s sitting posture changes because of the centrifugal force. The distribution of sitting pressure gets imbalanced. Fig. 11 shows changing results of the driver’s sitting pressure respectively when he faces two types of turn.

From the changing color shown in the Fig. 11, the pressure of driver’s left leg is bigger when the car turns right. On the contrary, the pressure of driver’s right leg is bigger when the car turns left. Furthermore, this application can be used in the drive assistant in the future.

Fig. 10. Sitting pressure testing.

Fig. 11. The actual environment testing.
5. Conclusion

It is of great significance and very necessary that to develop the equipment of obtaining psychological state which provides an experimental platform for the following-up implicit interactions research and improve the quality of human-computer interaction for realizing seamless interaction. This project has the following features:

1) With adopting the upper and lower computer system, our project overcomes the technologies difficult problems of data transmission and inconvenience of the traditional products using. Moreover, considering the using convenience of human-computer interaction when it is designed, we adopt a wireless connection way, which reduces the communication complexity greatly.

2) Fully merged the concepts of energy conservation and environmental protection, our system adopts the "nobody - power dormancy, anyone - detection on electric start" intelligent mode, which makes up for the defect of the resources waste of the traditional technology, achieving the energy conservation and environmental protection.

3) Tested in different environment, hardware and software system can run effective. Therefore the system has good robustness, which also makes up for the defects of single application of traditional technology.

4) In this project, taking the subsequent expansion into consideration in the design process, we make good prepare for that the separation of chair cushion and analogue switch CD4051 of pressure sensors are increased to 64 pressure sensor groups for overcoming difficulties of traditional technology expansion.

References