Haptic Shoes: Representing Information By Vibration

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Abstract

This paper undertakes a new approach transferring and representing the requested information by the design and implementation of haptic shoes. Different from the traditional method of visualisation, stock market data are conveyed to the users via the haptic shoes they wear. With the vibration devices installed inside the haptic shoes, information is communicated to the investor by wireless system. This paper describes the architecture and the operation of the whole system as well as the implementation methods.

1 Introduction

The method to transform information into easily understandable message has become more and more crucial today. Different types of visualisation technologies have been developed to help people understand certain kind of information in an easier way. An information visualisation process in the computer normally starts with a step of analysing the input data sets and finishes with a drawing step.

As a result of the rapid development of computer technology and network in recent years, information visualisation has faced the challenge of the growing amount of data, which leads to the insufficient display on the computer screen. Many attempts have been taken to display such huge amount of data properly.

However, display is not the only way to represent information. Although the seeing is the most popular way to receive information among the five senses of human being, it is also possible for human body to use other senses, such as the sense of touching, to perform the duty. This paper aims to undertake a different approach to meet the above challenge by using vibration to represent the data.

A pair of haptic shoes with the feature of vibration have been designed and produced to transfer the information in the stock market. Traditionally, the investors rely on the analysis of visual interpretation of transactions such as the graphs or charts. Although it is an easy way to obtain the information, it could not well alert the change of transactions. For example, when facing minor-change data diagram for a long time, most people will fell bored that they may miss the tremendous changes followed by. The haptic shoe can be used as an alarm to alert the user in this case.

In the early stage, the capacity of this approach may not be as powerful as visual method. However, it is another domain to represent information, which can overcome the shortage of visualisation, or can be combined with traditional visualisation methods to bring a better outcome.

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2 Design Principles

Similar as information visualisation, in order to fit the characters of haptic approach, an analysis process is needed before vibration. During the analysis, the raw transaction data will be parsed, so that the size of data can be significantly reduced.

The second step will be transforming the data into vibration. Since the vibrating device must be close to human's body. There are some special requirements for the system.

- Easy to wear, so the system is implemented as a pair of shoes.
- Small enough to be installed in shoes.
- Light enough, otherwise people will not use it.
- Self-contained, which means the system should consist all the peripheral including battery.
- The connection with outside (getting data) must be wireless.

Different from the visualization method that can display a large amount of data at the same time, this haptic approach has its own characters:

- Touching is not as sensitive to human as sight; it is hard for normal people to judge two adjacent (less than 5cm) vibrators. Thus more space is needed for each information point.
- Normally, it will take people some time to notice the vibration. Thus the variety of input data cannot be very fast.
- People are easy to feel tired or bored when facing with a seldom change graph for a long time. As for vibration, it is likely that people will get used to it, so that the effect of vibration looks like the 'background music". But when such vibration changes suddenly, people will be much more sensitive to it than to a peak in the diagram.

2.1 Haptic and Vibration

Haptic is hard to define term since it has so many different meaning in different application domain. Although not quite a lot, there are still some researches in this area, for instant, a research (Priplata, Niemi, etc. 2003) was carried in Boston University to improve balance for elderly people through randomly vibrating insole. But most of these researches used special haptic or vibration devices, which will lead to a high cost thus make the system impractical.

However, vibration has been used to represent information for years though its existence is not aware by many people. The most remarkable example is the mobile phone, of which vibration is used as an alternative option to substitute the function of ringing. In some models of mobile phone, different types of vibration can represent different type of call. Such application has proved that vibration is a convenient and practical way to represent information.

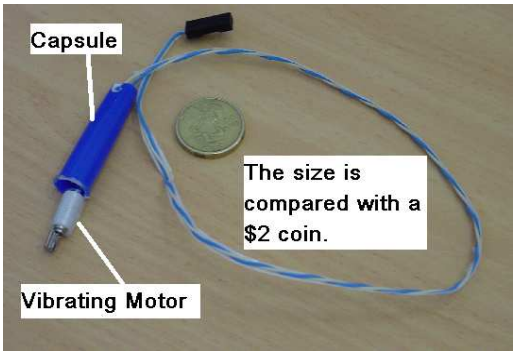

Figure 1: A vibrator used in the haptic shoes

Since mobile phones are very popular now, it is valuable to adopt the its vibration devices and put them into new application. The (*vibrator*) developed and used here consists of a vibrating motor and a capsule outside. Figure 1 shows the size and structure of the vibrator.

The motor,which is driven by a electronic circuit, is the acting device. The capsule is essential since it converts the rotation of the motor into vibration. Without the capsule, rotation of motor may be hold by human body.

The motor is adopted from existing mobile phone, so it is small enough and the power usage is within the system limitation. Besides, the performance of the motor was already proved. Most important of all, it is an off-the-self part so the cost of customizing a special motor can be saved.

2.2 Data Handling

On visualisation of stock market information, many commercial software can gather stock market data through either Internet or Intranet, and draw corresponding charts on the computer screen for users. Actually, such charts are essential tools for investors. But in order to fit the character of vibration, the data need to be analysed further.

Normally, the stock trading data can be got from internal IP-based network of some data providers. The following figure shows an example of a received data packet.

Because people are not very familiar and sensitive with vibration information, it is impossible to represent all this information at the same time. In fact,

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AMEND: 13:40:49 03/11/2003 b0: MGW Bid 800537652:  x1097 at $4.89 by ;

TRADE: 13:40:49 03/11/2003 b0: MGW x1097 at $4.89;    [Bid:800537652] [Ask:800355360]
id=70403567  Bi TK
ENTER: 13:40:50 03/11/2003 b0: Ask 800603441:  x15,000 FCO  at $0.23 ;
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Figure 2: An example of input data

too many information will become garbage and will be ignored by user.

Although only the trade transaction is concerned, there is still a problem when trying to represent the data properly. The key issue is the transaction does not occur all the time. Since the stock market data is the projection of investor's behaviour, it is very likely that there will be no trade transaction during some period, while lots of transactions in a single stock happened at a certain time. That is to say, the price curve will has great fluctuations.

Thus a *smoothing* mechanism is developed to solve this problem. In such a mechanism, the average value of price in a period, such as 10 seconds, is used to draw the price curve instead of the original price value, so that a smoother curve can be got.

$$Average\ Price = \frac{Sum\ of\ price\ of\ all\ received\ trade\ transaction\ data}{Number\ of\ all\ received\ trade\ transaction\ data}$$

Similarly,the vibrators inside the shoes will only take action according to the change rate, rather than representing whole the real-time data curve. The approach, with an implication of another data-mapping scheme, meets the design philosophy: use the vibration to "alert" the user at critical moments as well as to provide general idea during normal time.

But coin always has two sides; using average value instead of true value of price will cause some negative effects. For example, tiny changes in a sampling period may be neglected. But, for this application, that degrade of system will acceptable.

2.3 System Architecture

The central theme this project address is the processes to get data, analyse data, transmit data and represent data. So the system is designed according to these functions.

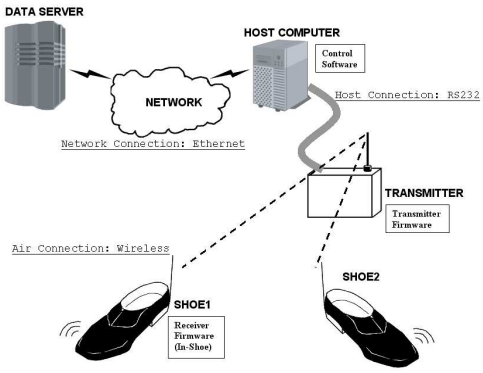

Figure 3: System Architecture

With the understanding of system architecture shown in Figure 1, the operation of the system is straightforward. The Host Computer is the key actor of the whole system, when running the control

program, it establish a network connection with Data Server, through which it can get the stock transaction data continuously. The control program will analyse the received data of certain interested company set by the user. The analysis process will generate average prize information, which will be used in this system. The control program will then send such data to the transmitter.

When the transmitter gets the data, it will translate them into the vibration command, that is, decide which vibrator will take action. Then this decision will be send to the receiver through air connection.

When the receiver gets the information, it will drive the vibrating motor through electronic circuits according to the command, so that the end user will feel the vibration.

3 Implementation

A design process of a real system is full of compassions and decisions. A lot of techniques, modules and devices sound good; only few of them are suitable for this project. As there are so many factors need to be considered, such as budget, time and complexity, the final result is undoubtedly a trade-off of them all.

3.1 Host Computer

The *Host Computer is* a standard PC. It communicates with Data Server through standard Ethernet interface, communicates with the transmitter through PC serial port, which is a standard RS232 interface. Using of standard interface can reduce the cost of special hardware design.

There is a Control Software running on the host computer to communicate with Data Server through network to get input data, analyse the input data, draw the analysis result as a curve on the screen; and send control data to the Transmitter through serial interface as well. The control software was designed with the help of UML modle and was implemented in Visual Basic.

3.2 Protocols

Although relatively simple, three communication protocols are needed for this system to define the logical relationship between two sides in a connection.

Network Protocol Since working on an IP-based network, this protocol is a simple example of TCP connection, defined in special PORT number. Simple methods, such as Telnet, can be used to establish the connection.

Host Communication Protocol Host Communication Protocol is based on the RS232 standard. Both the physical and logical levels are adopted, so that the transmitter can communicate with normal PC.

Wireless Communication Protocol(Air Protocol) Wireless Communication Protocol adopts the serial communication and UART ideas from RS232 standard, while transfers the serial communication frames through radio frequency wireless module. The information contains in the frame are the commands for the vibrator, which can be decoded by the receiver.

3.3 Embedded Systems

Both transmitter and receiver in this system are implemented as an embedded system powered by a micro controller.The goal of *Transmitter* is to become an interpreter between the wired and wireless network. Briefly, the transmitters consists a radio frequency *Transmitter Module* and a *Transmitter Control Board*. The transmitter control board aims to communicate with the host computer and translate the wired data into wireless command. While the transmitter module focuses on establishing an air connection with the receiver.

Figure 4: Vibrators installed in shoe

Like the transmitter, the *Receiver* also contains a *Radio Module* and a*Control Board*. One more module needed for the receiver is the *Motor Driver*, which is used to control and drive the motors inside the vibrators.

Figure 1 shows the installation positions of the vibrators. One shoe contains 3 of them.

On building an embedded system with small size, a lot of researches have been done and a lot of products are available on the market. Devices applied in this filed varies from general-purpose micro-controller (μC), to Field Programmable Gate Arrays (FPGA). But since embedded systems are usually application-oriented, especially when a reality system is concerned. A new system has to be built for nearly every project. New design methods, such as UML,have been ported into the real-time domain, so that the design process can be accelerated.

Same as embedded system, wireless connection is also one of the most active research areas in recent years. Low power, small size and reliable modules emerged, which make it possible to use certain off-the-shelf modules for this project.

4 Conclusion

This project designs and implement a haptic shoes system, which can obtain haptic stock market data from network and transform it into the vibration signal inside the shoes. This system applied a wide range of computer technologies including data analysis, network connection, embedded system and wireless communication.

The system has proved to function properly and the purpose of its design and implementation has been archived. Furthermore, this system can be used in some other aspects such as reflecting the price of some other data sets besides stock market. Wireless receiver and vibrators can also be installed in other devices such as pants or shirts.

This system proved that, it is possible to represent information with different kind and different position of vibrations, and implement such system in cheap price, with proper usage of existing modules come from other applications.

Future improvement of the system are proposed as following:

- Perform usability test to study end-user's reaction to vibration, so that better positions for the vibrators can be found.
- Optimize the data-mapping scheme according to further study on haptic, so that more data can be represented and understood by human through vibration.

References

Attila A Priplata, James B Niemi, Jason D Harry, Lewis A Lipsitz, James J Collins (2003),Vibrating insoles and balance control in elderly people, Vol 362,The LANCET