Context-Awareness on a Hoodie:
Knowing When the Hood is Taken Off the Head

John Sunwoo[1], Kyoung Ju Noh, Hyung Sun Lee and Il-Yeon Cho
Wearable Computing Research Team, Electronics and Telecommunications Research Institute
{bistdude,kjnoh,hslee77,iycho}@etri.re.kr

Abstract

Development of conductive yarns have accelerated the natural integration of wearable computers into garments. However, the application to various types of clothing needs to be explored individually. A hoodie is one type of clothing that may be suited to interact with the head. For its operation, it is important to know when a user has put the hood on the head, or has taken it off the head. We introduce a hoodie that can automatically recognize the hood's position, not by equipping it with a dedicated sensing hardware, but by utilizing a conductive yarn based network that is built into the hoodie. Fabric Serial Bus (FSB) protocol is used to detect the change of electrical characteristic on the communication yarn, when the hood position changes.

1. Introduction

Various smart hoodies have been introduced in the past years [1][2]. Such hoodie products and prototypes demonstrate how hoodie-type clothing pieces can interact with humans, as a form of wearable computer. One advantage of having a smart hood on a piece of clothing is that the hood itself can directly interact with organs on the head, comprising a variety of interactions. After putting on the hood, it may start: monitoring brain activities, playing music in a comfortable setup, or recognizing head gestures (such as a nod or a gaze toward a certain direction). Another advantage of having a computerized hood is due to its natural on-the-go form factor. Since the hood is a natural and easily accessible part of a hoodie, users do not have to hassle carrying around conventional headphones, microphones, hats, or any other devices that may interact through the head.

For various hoodie applications, different types of electronic modules are required to form a network. A number of researches have shown the need for a new communication protocol that are suited for fabric based platforms, such as garments [3][4][5]. The Fabric Serial Bus (FSB) proposed in [3] show the appropriate network scheme needed for such platform; one that uses conductive yarn or ink as the communication medium. In garments, various conditions including abrasion can alter the electrical characteristic of the communication medium. FSB analyzes the signal delay that appears on the communication line to detect the change of the electrical characteristic. Network parameters can be dynamically switched using the information. As a result, FSB in a garment can be used to deliver information among many kinds of electronic modules in one complete organic network [3][4].

In the point of context-awareness, having a hoodie that knows itself of when the user has put on or taken off the hood, will let more diverse applications be operated in an efficient manner. For instance, when the hood is taken off the head, some functionalities would no longer be useful, thus they could be powered off. However, proposed smart hoodies have not solved the principle problem. Most of proposed hoodies have some kind of controller to activate the functional hardware on the hood, which does not give more convenience and interactions to the wearer. Some are equipped with optical or inertial sensors on the hood, but they are easily confused by the environment or activities [2][6].

In this paper, using FSB which is capable of measuring the signal delay of the network, we suggest a context-aware hoodie prototype that does not require additional sensing hardware.

2. Design of a Smart Hoodie

For our study, we implemented FSB modules that are connected to sensors and interface with them. The hoodie would have at least two different FSB modules that are routed across the hood and the back of the hoodie. In order to detect when a user has taken off the hood, we have designed various versions of line pattern to produce intentional stray capacitance, as the hood and the back of the hoodie overlaps. As illustrated in Figure 1, D+ and D- line can act as two separate conductors. If they form a certain amount of area and stay in a close distance, it generates the C component in the network that helps to increase delay.

[1] Present address: Department of Biomedical Engineering, Cornell University, 101 Weill Hall, Ithaca, NY 14853

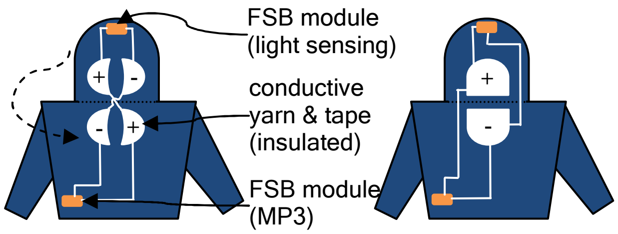

Figure 1. Designs of FSB based hoodie

The overlapped area would produce enough capacitance to create a noticeable change in network delay, but would not affect the network performance. The plate patterns are insulated from one another in order to prevent unwanted shorts between two differential lines. It is also important to have a certain amount of resistance on the signal line itself, for they are another factor on generating RC time (delay).

3. Implementation and Results

The final prototype hoodie was implemented to have FSB network, capable to attach any functional node on the hoodie via snap buttons (Figure 2). For this study, we have implemented two FSB modules and attached them on the hoodie. The FSB modules interface with a light/temperature sensor and a MP3 player module via SPI, respectively. Also, the FSB modules include transceiver hardware, as well as the data link and application software embedded into a FPGA and a microcontroller. We have sewn on the hoodie using a conductive yarn across the two terminals for a D+ and D- route. Conductive tape was used to form a plate in the middle of the route. The plate patterns can be replaced by embroidering conductive yarn, so that it is similar to a plate. The measured resistance of the conductive line, between electronic modules placed on the top of the hood and the pocket, was around 1K ohms. The stray capacitance generated from overlapping the hood and the back of the hoodie was measured to around 200pF.

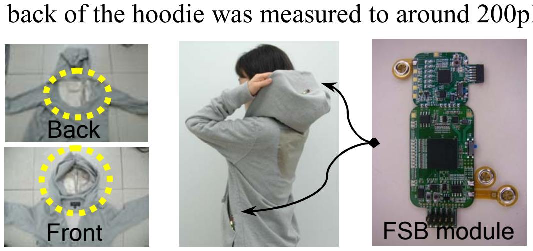

Figure 2. Final prototype of FSB hoodie and a FSB module

Application software was implemented to detect the delay between two communication modules, then to change network parameters accordingly to activate functions as needed. The targeted operation was to stop playing music when the hood was taken off, and start playing music again when the hood was put back on. At the same time, by using the light/temp sensing module, the volume of the music would be dynamically adjusted as the surrounding luminance changed.

The implemented hoodie was worn and tested by a person. When the hood was taken off, we observed the delay of 200nsec to 400nsec [3]. The FSB network was aware of the change and the music stopped being played. As the user put the hood on his head, the signal delay observed on network decreased to 20nsec (the minimum possible value). Then, the MP3 module was self-activated to play music on the hoodie. As the person went into dark, the volume of the music decreased. The volume level went back to normal as the person escaped from the dark.

4. Conclusions and Future Work

In this paper, we introduced a novel method of wearable context awareness through the attached hood of a hoodie. Using the delay measurement functionality provided in FSB and the wire structure that amplifies the effect, taking off the hood and putting it on can be dynamically detected on the hoodie. Such actions affect and change the stray capacitance of a specially patterned FSB network on the hoodie. Any kind of additional sensing hardware was unnecessary in the approach. The hoodie prototype demonstrated the possible approaches of implementing FSB network to serve as a wearable context-awareness in a garment.

The future work would include 1) stabilizing the hoodie prototype as the capacitance tends to fluctuate on a rapid movement, 2) extending applications; such as to combine Brain-Computer-Interface (BCI) capabilities to the hoodie, or to equip motion sensing modules, so that the hoodie can recognize head movements.

5. References

[1] ___, "Audex Wearable Electronic Collection," 2006. (available at www.burton.com)

[2] ___, "NapCap", "Hoodlum" and "Neighbourhoodie," *Blog of Wearable Electronics*, 2010. (available at www.talk2myshirt.com)

[3] H.S. Lee, J. Sunwoo and D.W. Han, "Fabric Serial Bus: A Serial Bus Network for E-Textile Platform," *Conf. of Korean Institute of Next Generation Computing*, 2009, pp. 238-241.

[4] H.S. Lee, C.B. Park, K.J. Noh, J. Sunwoo, H. Choi and I.Y. Cho, "Wearable Personal Network based on Fabric Serial Bus using Electrically Conductive Yarn," *ETRI Journal*, 2010. (accepted for publication)

[5] E. Wade and H. Asada, "Conductive-Fabric Garment for a Cable-Free Body Area Network," *IEEE Pervasive Computing*, vol. 6, no. 1, 2007, pp. 52-58.

[6] A. Schmidt, H.W. Gellersen and M. Beigl, "A Wearable Context-Awareness Component: Finally a good reason to wear a tie," *Proc. of IEEE ISWC,* 1999, pp. 176-177.