A Gestural Input through Finger Writing on a Textured Pad

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ABSTRACT
We describe a new input method that utilizes patterned vibration that is generated through the finger writing on a textured pad. Using a flexible or a foldable textured pad which can be worn by the user can bring more diverse applications than conventional input interfaces such as a touchpad or tablet screen. Through this paper, we present a prototype system that implements this new method and discuss the advantages of the method. Finally we suggest a number of possible interface scenarios that can be beneficial from the new input method.

Author Keywords
gesture recognition, textured pad, finger writing/stroke

ACM Classification Keywords
H.5.2 User Interface, B.3.2. Input/Output Devices

INTRODUCTION

An electronic device typically incorporates a user interface for the operative control. Demand on making the user interface more simple and natural is increasing as functions of the electronic devices become complicated. This results in active development of new interface technologies that can control electronic devices or perform text input with using simple methods such as gesture recognition.

Besides, graphical user interface of electronic devices including computer-based devices are evolving into a simpler and more natural interface. This applies to most of the electrical appliances that serve as information terminals so that users can control and input texts in a simpler way.

Touchpads or tablet input systems are useful for inputting text because they use gestural writing method such as Graffiti [2]. However, these conventional devices are built with hard and firm electric circuits. So they are difficult to wear on a body and this prevents from easy carriage such as by folding them.

We often use our finger to make writing gestures (or strokes) on a flat surface to help memorize particular information such as a phone number. This gave us an idea to start thinking about the finger writing on a textured pad and we believe it has advantages over the other conventional input methods.

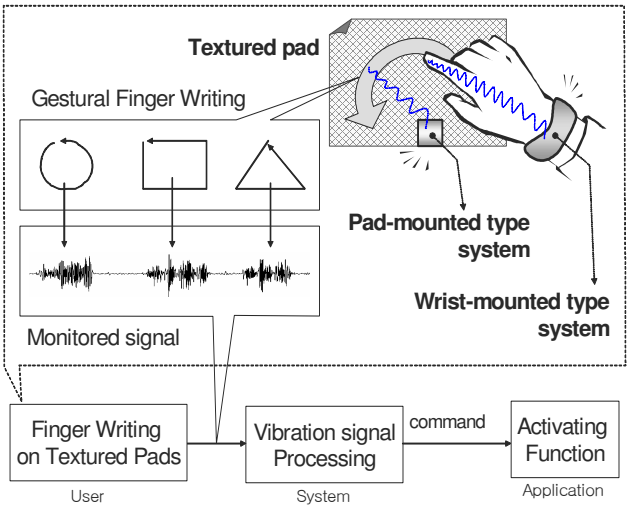

Figure 1. Diagram of a finger stroke on a textured pad

This interface technology that we are suggesting through this work can be extended to various applications. As shown in Figure 1, our pad is where the vibration signal is being generate with finger. The pad has a patterned texture and it is physically flexible that can be in any kind of shape. This can be useful for wearable computer users who probably want to control their wearable computers by attaching our textured pads and utilize it. It can be folded or rolled so that users can carry it conveniently which we think it is one of the advantages from using our system.

The paper begins with an overview of related works which have motivated this study. Then we introduce our novel input mechanism that is based on finger writings on textured pads. Next, we explain our prototype hardware and software modules including textured pad, finger stroke actions based on typical pen writing gestures, and system overview. We finally describe our sample scenarios that are currently under investigation followed by the discussions of future work.

RELATED WORK

Most of conventional user interfaces for typical electronic devices employ mechanical/touch buttons and stylus. One drawback of using these user interfaces is that the user must

aim the finger (or stylus) carefully to the buttons (or input screen) of the portable electronic device.

In the case of voice-controlled systems, they may alleviate the problem, however the major disadvantage of the voice-controlled interface is that the user must speak openly and other people nearby may hear. And still, the voice controlled systems are extremely sensitive to environmental noise and interference.

Seeking of new interfaces that can control electronic devices and perform text input results in inventions of a number of simple and natural gesture recognition interfaces.

Palm Graffiti [2] is a pen-gesture interface based on a touchpad sensor. It defines various letters that are written in a single stroke using a stylus to be recognized through the touchpad sensor. AIR-Remote [3] is a hand-gesture interface device consists of 3 gyroscopes and 3 accelerometer sensors. It associates with a 3-dimensional space to move hand and make gestures.

Brian [4] suggests fingertip gesture interface that is based on a wrist-mounted bio-acoustic sensor. Their Wristband senses sounds that are generated internally from the hand produced by the gentle fingertip gestures such as tapping, rubbing, flicking and snapping. They use a small piezo-electric microphone as a bio-acoustic sensor. However, fingertip gesture interface has a small gesture set. Furthermore, users are required to repeat the same movements frequently in order to obtain the sufficient signal that can cause stress in the hand and wrist.

GestureWrist and GesturePad [5] are a hand-gesture interface device based on a 2-dimentional tilt sensor, a piezo-actuator, a transmitter electrode and receiver electrodes. GestureWrist is a wristwatch-type input device that recognizes human hand gestures by measuring capacitances that are different and distinguishable according to the changes of wrist-shape. And it also measures forearm movements through a 2-dimentional tilt sensor. GesturePad is a module that consists of a layer of sensors that can be attached inside of clothes. It provides convenient input interfaces, however it utilizes a small amount of current flow through the body. It means the clothes need to be equipped with electric devices including power supply, which the clothes are not easy to make. And washing those equipped clothes is not easy as well.

Through our work, we suggest a new input interface and provide a user to control electronic devices by making a natural finger stroke action on textured pads as if the user is writing or scratching something. We believe that it can lead the most natural interaction between human and electronic devices with a number of advantages over the related works. They are:

-Our system can be used in the pocket without taking it out.
-Textured pad itself is not an electronic device; the pad does not have any electrical elements. Clothes attached with the pads are washable.
- Attaching the pads on clothes can be an artistic decoration.
- Our input method incorporates with pen-gestures that help to shorten the user learning period.

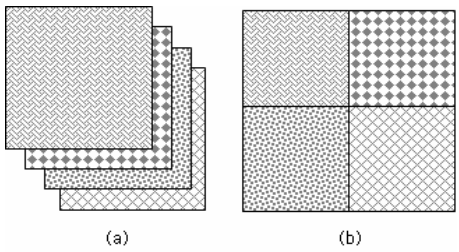

Figure 2. (a) Single pads and (b) a Patchwork pad.

OVERVIEW OF TEXTURED PAD

A textured pad is a flexible writing pad with textured surface. This texture on the pad surface consists of uniformly distributed grooves that are small and fine just enough for finger to be stroked smoothly as illustrated in Figure 2. One textured pad can have a unique tactile quality and profile over the others. We then use our finger to make writing or rubbing actions on the pad. If finger strokes the groove part on the pad, its tactility is strongly delivered through the hand and pad.

If one uses a regularly-textured pad, perceptible signals are produced by the finger stroke as illustrated in Figure 1. The pad generates monotone vibratory signals for the normal finger strokes for one direction (e.g., finger stroke of horizontal from left to right). Finger stroke on a finely-textured pad generates a signal of high frequency. Finger stroke on a loosely-textured pad generates relatively low frequency signal. A striped, diagonal, zigzag, lattice, geometric, embossed, and corrugated patterns can be considered to form the texture in our pads.

We define the following rules and requirements of the textured pads.

-When using a single pad, different finger strokes are classified and recognized. (Four different single pads are illustrated in Figure 2-a.)
-Between the different single pads, the same finger strokes are classified and recognized differently.
-More than two single pads can be assembled to one patchwork pad
-In the patchwork pad, a finger stoke input can be started in any pad and may be finished on other adjacent pads.

OVERVIEW OF GESTURAL FINGER WRITING

In this work, we adopted Palm Graffiti in such way that one gestural finger writing (this can be finger drawing or finger stroke as well) follows the uni-stroke rule [2]. Exemplary gestural finger strokes on the textured pads that are detected through our system include:

-2D writings of gestural alphabets, numbers, figures and signs

-User-defined 2D writings
-Manufacturer-defined 2D writings

Although it is not finger writing, fingertip gestures that are defined in work [3] such as tapping, rubbing and flicking actions are also detectable through our system. Each gestural finger writing is mapped to the corresponding action command of the application.

OVERVIEW OF SYSTEM CONFIGURATION AND TYPES

Our developed system consists of a receiving module to monitor resultant vibration from the finger writing, and a signal processing module to translate the vibration signals into the corresponding device commands. Meanwhile, the location of sensor that monitors the vibration can be attached to our wrist or the textured pad itself as illustrated in Figure 1. This configuration can be implemented in various forms and here we suggest two possible types among them.

1. Wrist-Mounted Type

This type of method detects the vibration through the bone conduction from finger to wrist. Sensor needs to be placed and attached to a wrist area.

2. Pad-Mounted Type

This type of method detects the vibration through the textured pad itself. Sensor needs to be placed and attached to the pad surface.

Both the wrist-mounted type and pad-mounted type can be applied and embedded to our clothes, accessories and general electronic appliances.

OVERVIEW OF PROTOTYPE SYSTEM

We are not focusing on a user evaluation or showing recognition rate of the system under the certain control factors (at least for this stage of development). Instead, we are more focusing on introducing our new input method through showing our prototype system and applicable scenarios.

Scenario:

A user is equipped with a wearable system that consists of a wireless media player, headset, Head-Mounted-Display (HMD) and our wrist-mounted type input device as shown in Figure 1. Textured pads are attached to the clothes and they are placed where the user can reach them easily. They made out of flexible material that are easy to be attached or taken off. The user listens to his or her favorite song using "PLAY", "STOP", "PREVIOUS", "NEXT", "SCROLL", and "INDEX" commands.

Figure 3 shows how the conventional media player look like (3-a) and how this interface can be mapped to our gestural commands using finger stroke on a textured pad (3-b).

Media Player Control

The textured pad can be left attached to our clothes and be used anytime. For a fixed place such as our office environment, the pad can be taken off from the clothes. In that case, it can be used by attaching it on the desk similar to a conventional mouse pad.

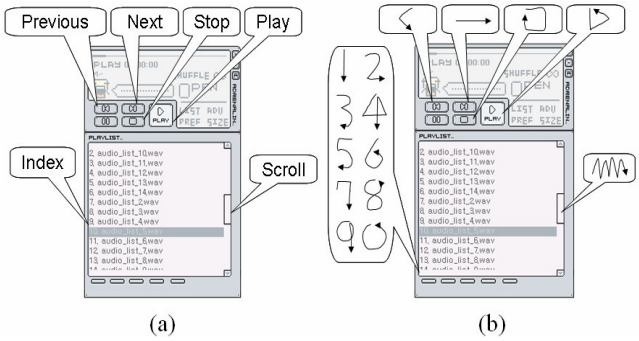

Figure 3. (a) Graphical interface of a typical media player describing commands and (b) Gestural finger stroke defined for each command

As shown in Figure 3-b, we define the gestural finger stroke commands in such way that they are similar to conventional media player commands to make the control easy. They are as follows:

- (Triangular finger stroke) for "PLAY"
- (Rectangular finger stroke) for "STOP"
- (<) for "PREVIOUS"
- (→) for "NEXT"
- (Arabic-number-like finger writing) for "INDEX"
- (A zig-zag finger stroke) for "SCROLL"

Fingertip shown in study [3] selects a file by rubbing fingers, which the gesture is defined as a scrolling gesture. Our method of scrolling through the files is more similar to the scrolling action using a conventional mouse. Thus we think our way of making gestural finger stroke command has more potential to have advantages over the other previously invented methods.

Most of other wearable input interface such as in [5][6][7], for instance, have to repeat the "NEXT" command multiple times in order to select the 10^{th} file if the current system cursor (or placeholder) is on the 1^{st} file of the list. This is not the case for our developed system because the textured pad is designed to recognize Arabic numbers in an easy way (Figure 3-b), similar to jump between different TV channels by entering the channel numbers.

Signal Processing

As illustrated in Figure 4, our prototype system consists of a piezo-electric microphone embedded within the wristwatch type device to maximize the contact with our hand. The piezo-electric microphone is to sense and receive the vibration signal generated from the finger strokes on the texturized pads. It is the same mechanism that is used in the Fingertip in [3] where the piezo-electric sensor utilizes the internal sound conducted from the bones of the hand and wrist to the ulna below the wristband sensor.

We use the Hidden Markov Model (HMM) based recognition technique by utilizing the HMM Toolkit (HTK) that is available from Cambridge University HTK homepage [8].

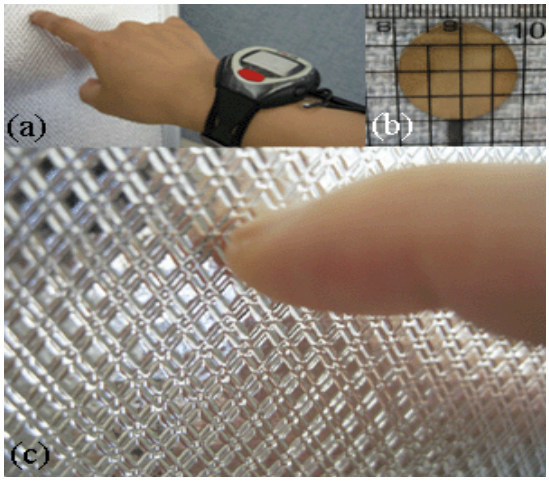

Figure 4. (a) Our prototype of a wristband-type device (b) A piezo-electric microphone inside of a wristband-type device. (c) Finger stroke on a textured pad of the regular lattice pattern.

With a fixed pad, we gathered training data to train the recognition engine. Each gestural finger stroke command is made for 5 times and the signal monitored by the piezo-electric microphone is collected as a training data. Our set of training data is collected once a day for 5 days.

When a user makes gestural finger writings on the pad, a resultant command is retrieved from the HMM based recognition engine. The command is then sent to the user's media player to be executed.

POSSIBLE APPLICATION SCENARIOS

Our proposed input method can be applied to various devices and situations. Applications associate with portable device, car and security are beneficial from our method because the textured pads are versatile and flexible that can be attached (embedded) freely on (in) any surface (device). Especially, their characteristic of the flexibility and freedom from electrical circuits shows that it can be useful in wearable computing environment. Since our method only uses the propagation of vibration signal as an input, our complete receiver module that includes sensor and other electrical circuits can be sealed up which gives us a water-proof device. We think this would bring us robust device that can endure harsh environment. The following are the application scenarios that we suggest through this paper.

Portable Device: Our textured pads can be attached to general MP3 players. It enables simple control of the MP3 player by scratching the MP3 player unit or by making figure stroke on the surface. Users are free from unwanted button pushes while the MP3 player is in the pocket.

Interface with Automobiles: Our textured pads can be attached to the face of any steering wheel. It provides a safer driving environment to the driver. While controlling conventional electronic devices during driving can be dangerous, simple gestural finger writings on the pad-ready steering wheels make easy control of electronic devices in the automobile.

Security-related Applications: It is possible to apply our input method to an authentications field where verifies people's identity through the personal features such as their hand signature. One's handwriting reflects unique features such as strength and weakness, speed and direction of the pen-stroke. Our method of eliminating the use of pen still carries those unique features which can be used as secure authentication. And also, signatures that are written with bare finger do not make marks, thus invisible. Our method also can be used when sending encrypted signals or messages and decrypt them. We think using this can solve numbers of security issues in the communications field.

DISCUSSIONS AND FUTURE WORK

We have presented a new input method that uses gestural finger writing on a textured pad. And we have suggested possible applications that can be beneficial from our method.

We are currently on a development stage. We have run the signal processing algorithm and recognition engine on a PC system in order to investigate the potential of our input method. From now on, we are starting to implement them into a mobile-gateway-type embedded system.

Possible applications including that we have suggested through the paper require more gestures. Thus, we are planning to increase the size of our gesture set. New gestures will be defined by analyzing number of targeted applications and the verifications of the newly defined gestures will be followed as well. We will consider other various kinds of texture patterns on the pads. Finally we will consider other possible types of patchwork pads that are composed of more than one textured pads.

REFERENCES

1. Rabiner, L.R. A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition. Proc. *IEEE 1989*, Vol.77, 257-286.
2. Wikipedia, Graffiti(Palm OS). http://en.wikipedia.org/wiki/Graffiti_(Palm_OS)
3. Brian A. The Sound of One Hand: A Wrist-mounted Bio-acoustic Fingertip Gesture Interface. In Proc. *CHI 2002*, ACM press(2002), 724-725
4. Sang-Hwan, K., Joonho, O., Hyun, J.K., Min-Chul, K., Mijeong K., An Interaction and Product Design of Gesture Based TV Remote Control, In Proc. *CHI 2004*, ACM press(2004), 1548
5. J. Rekimoto, GestureWrist and GesturePad:Unobtrusive wearable Interaction Devices, *ISWC 2001*, 21-27
6. Fukumoto,M., Tonumura, Y., UbiButton: A bracelet style fulltime wearable commander, IPSJ Journal, 40, 2(1999), 389-398(In Japaness)
7. Kokji, T., Michiaki, Y., Ubi-Finger:A Simple Gesture Input Device for Mobile and Ubiquitous Environment, In Proc. *AISL 2004*, 1-10
8. HTK Hidden Markov Model Toolkit homepage, http://htk.eng.cam.ac.uk/