A wearable unistroke textile touchpad

Make first letters caps in the title

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Media Computing Group
Prof. Dr. Jan Borchers
Computer Science Department
RWTH Aachen University

by
Christian Schmidt

Thesis advisor:
Prof. Dr. Jan Borchers

Second examiner:
Prof.Dr.Martina Ziefle

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Abstract

Acting as a spacer

Resistive

That can be

This bachelor thesis describes the development of a ~~wearable~~ 2D textile touchpad able to be embedded into everyday clothing. It is a wearable, bendable, washable, and breathable touch sensor designed for eyes-free interaction. ~~The touchpad is~~ It is ~~basically~~ composed of 3 ~~textile~~ layer, two ~~perpendicular~~ layers of fabric with conductive stripes, separated by a non conductive material. All materials used for manufacturing are low cost and lightweight. The prototype is based on resistive touch, hence it is limited to sensing touch at a single location. The touch coordinates are continuously sent to a gesture recognizer allowing the prototype to detect unistroke gestures. With these gestures can be used to control several applications in a mobile scenario. ~~The physical limitations are evaluated in an informal user study by testing the performance under various conditions.~~

The touch pad is made of low cost materials that are flexible, breathable, and washable, like any other piece of fabric.

The touchpad can detect a set of 15 unistroke gestures reliably.

In this thesis we describe the construction of the textile touchpad, and the evaluation of its robustness under extreme conditions.

Überblick

In dieser Bachelorarbeit wird die Entwicklung eines tragbaren, biegsamen, waschbaren und atmungsaktiven 2D Touchpads beschrieben. Der Sensor besteht aus aus zwei Schichten Stoff, der mit leitfähige Bahnen versehen ist, und Schaumstoff, der die beiden orthogonalen Stoffschichten trennt. Alle benutzte Materialien sind leicht und kostengünstig. Der Prototyp basiert auf der resistiven Methodik eine Berührung zu erkennen. Das heißt, dass der Sensor auf eine einzige Position beschränkt ist. Diese Positionen werden kontinuierlich an ein Programm, dass aus den einzelnen Punkten Gesten erkennt, geschickt. Damit können dann diverse Anwendungen insbesondere im mobilen Bereich gesteuert werden. Außerdem haben haben Benutzer den Prototypen unter verschiedenen Bedingungen getestet, um die physikalischen Einschränkungen zu bestimmen.

Acknowledgements

Thank you!

Conventions

Throughout this thesis we use the following conventions.

Text conventions

Definitions of technical terms or short excursus are set off in coloured boxes.

Definition:
Excursus

EXCURSUS:
Excursus are detailed discussions of a particular point in a book, usually in an appendix, or digressions in a written text.

Remove

Source code and implementation symbols are written in typewriter-style text.

`myClass`

The whole thesis is written in Canadian English.

Download links are set off in coloured boxes.

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Chapter 1

Introduction

Motivation and well known wearables

More

Electronics are getting smaller, lighter and powerful every year and we reached a point where they have actually become wearable. Therefore the research in the field of wearable computing increased over the last decade. The ultimate goal is to make life easier and more comfortable by integrating controls and sensors even more in ~~your~~ Our daily life. Health tracking devices are the leading wearables at the moment. Smartwatches are even capable of various smartphone features such that it is less often necessary to take your smartphone out of your pocket.

Smart clothing

One of the first contributions to the field of wearables were made by Post and Orth [1997]. They emebedded easy to build, washable textile based sensors, buttons, and switches into a jacket. Rantanen et al. [2002] integrated a computer including screen and battery into an arctic suite to provide the wearer with information about the surrounding conditions, their location, and controls for the integrated heating system. Brewster et al. [2003] investigated the opportunities of eyes-free hand gestures on a PDA attached to the waist, supported by audio feedback. They found that gestures were performed more accurate when acoustic feedback is provided.

The focus of this thesis lies on wearable textile input That can be devices ~~for eyes-free interaction int~~egrated into everyday clothing. Devices for eyes-free interaction are primary designed for a mobile context where the visual channel is occupied by the environment. While driving a car, changing the radio station, skipping a song, Or ~~and~~ answering a call ~~including~~ activating the Eyes ~~hands~~-free feature on your Devices ~~mobile phone~~ is ~~one example where~~ a wearable touchpad on your thigh would be helpful. Various approaches were presented aiming to create wearable input devices over the last decades. The most used technique for sensing a touch is capacitive touch sensing. [Holleis et al., 2008] built textile prototypes by sewing conductive thread Into ~~in~~ fabric creating touch sensing buttons. The buttons are discrete input elements and not continuous. However, their research on ~~conductive~~ resulted in several guidelines applicable for this field in general. ~~We try to refine them further with the knowledge we gathered with this thesis.~~

And interacting with a textile sensor embedded in your sleeve, for example, will reduce your division of attention.

Limitation and improvements

Most of the textile touchpads today are based on capacitive touch and rather prone to noise. The number of gestures they are able to distinguish Reliably ~~reliable~~ is quite limited Due to ... Body water ~~not to mention multitouch~~. To improve their performance the influence of the human body has to be minimized. Another possibility is to use another approach which is not affected by that noise at all. Resistive ~~touch is a technology used~~ in PDAs ~~and early smartphones~~.

Improved shielding techniques

Our contributions

In this thesis we present our ~~novel~~ wearable, ~~bendable, washable, scalable~~, resistive textile 2D touchpad. We provide a detailed description how to build this sensor with low cost materials. We show that our prototype is able to reliably detect various unistroke gestures and evaluate its robustness under several conditions. The software for operating the sensor is provided here Schmidt [2016].

These techniques, however, are not accessible today. Alternatively, in this thesis we use resistive technology ....

Chapter 2

Related work

This chapter reviews related research in the area of interactive textile. We divided this review into two parts: interactive textile technology and textile touch pads. In the first part we give an overview of ways to integrate and activate textile in everyday objects. In the seconds part we look at research that investigated different techniques to fabricate textile surfaces that can detect user touches and gestures.

2.1 General overview

2.1.1 Resistive vs. capacitive touch

The two most popular touch input technologies are resistive and capacitive. Both serve the same purpose but the underlying principle differs making them more or less suited for wearable computing.

Characteristics of Capacitive Touch

Capacitive touch uses a non-conducting material with conductive material underneath. The capacitance of the human body changes the electrical field of the sensor which is measurable. The advantages of capacitive touch is the easy support for multi-touch input and high resolution. These touch screens only need a slight touch without force. The main disadvantage is the human body itself, since it generates its own capacitive field which makes it hard to detect intentional touches. This flaw is intensified by the body movement continuously changing the proximity between the sensor and the human body. Therefore complex isolation techniques are required to isolate the sensor and the human body which is unfeasible for fast prototyping.

Characteristics of Resistive Touch

Resistive touch technology uses two separated layers of striped electrodes such that it is arranged to a matrix. The spacing material in ordinary resistive touch screens is either an air filled chamber or a non-conductive material which separates both layers while no external force is applied. Therefore one can operate it with a stylus or with gloves since no conductivity is required. On the one hand this solves the main disadvantage of the capacitive method regarding wearable computing, on the other hand it does not support multi-touch and is still prone to deformation and thus to unintentional contacts.

2.1.2 Textile interaction techniques

Holleis et al. [2008] presented several textile prototypes based on capacitive sensing. They embroidered conductive wires to a phone case, a glove, and an apron resulting in small conductive buttons. Besides that, they used conductive foil for buttons on a helmet as well. Their user study however only evaluated the apron with three different button layouts with different visibility. Based on the results they present guidelines for wearable controls such as locating and identifying controls must be quick and easy.
Speir et al. [2014] built two prototypes, a wristband and a glove. The wristband prototype uses a circular conductive fabric surrounded by resistive linqstat. A conductive finger cap connects both of them and generates a value which is used to determine the location and the movement of the touch. The glove works on the same principle. They evaluated their prototypes as remote controls for an iPod using one- and two-handed interaction and have found that the users have no clear preference.

Ubiquitous drums

A different application is presented by Smus and Gross

[2010]. They used force-sensitive resistors and pull-down resistor circuits to sense percussive touch. They taped the sensor into the inside of a pair of jeans and to the sole of a shoe. They created a program that translates the sensor values to different parts of a drum.

Time Domain Reflectometry

[Wimmer and Baudisch, 2011] created 13 prototypes based on time domain reflectometry (TDR). For this approach only one pair of wires is needed. The change in capacitance caused by conductive objects close to the pair of wire is measured and the location determined. Distance between the wires and their shape have significant influence on reliability. Their prototypes include stretchable, curved, and arbitrary shaped surfaces. They can sense touch at a distance up to 20m but TDR is prone to radio interference of mobile phones.

2.2 Textile touch pads

Pinstripe

Pinstripe is a continous textile input prototype created by Karrer et al. [2010]. It detects pinching and rolling of clothing by connecting conductive thread sewn on it. However, it is an unidimensional input device and not a touch pad. Nevertheless, when they introduced the participants to the sensor the users intuitively expected a touch pad.

Grabrics

Grabrics by Hamdan et al. [2016] is a fold-based textile sensor that can detect the axis of a pinch and the displacement and direction of the user's thumb over the fold. It, however, cannot detect complex gesture because of the limited resolution.

GesturePad

Rekimoto [2001] presented GesturePad which is a capacitive touch pad integrated in clothing. They propose slightly different architectures consisting of the upper fabric, receiver, transmitter, and a shield layer to reduce the influence of the human body. However, their work was not further evaluated.

PocketTouch

Another capacitive approach was developed by Saponas et al. [2011]. PocketTouch is an eyes-free, calibrateable capacitive touch pad which can sense the proximity of a finger through a wide range of fabrics. They used a touch sensor of a touch screen and attached it to a base which makes

Prototype	Touch technology	Gesture detection
Pinstripe	capacitive	detects size of pinch and movement of pinch in 1D
GesturePad	capacitive	not tested (theoretically able to detect 2D gestures)
Pocket touch	capacitive	multistroke gestures using N$ by Anthony and Wobbrock [2012]
FabriTouch	capacitive	swipes in 2D
Grabrics	resistive	detects axis of fold and movement of pinch in 2D

Table 2.1: Current textile touch pad technologies.

it not bendable. The reliability of PocketTouch was not further evaluated.

FabriTouch

FabriTouch is a flexible, capacitive textile touch pad presented by Heller et al. [2014]. It consists of lining, piezoresistive foil, spacing mesh, conductive fabric, and outer garment together integrated into a pair of trousers. FabriTouch is able to reliably detect simple swipe gestures on rigid surfaces rather than on the human thigh. Also movement has a negative impact on the performance of the sensor.

Going for Resistive Touch

After taking all characteristics into account we decided to go for the resistive touch technology, because we can drop all considerations of capacitive noise caused by the human body.

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abbrv, *see* abbreviation

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