





Human Dimensioning Lab Research

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Goals of the HDL

- The Wearable Product Design Center - established to explore methods and technologies related to wearable product design.
- A resource for University faculty and students.
- The National Science Foundation provided initial funding for the laboratory.
- Additional funding from 3M, Center for Translational Scientific Research, UMN Imagine Funds & more.



What's new in body scanner systems?



How do we measure activity with the scanner?



Learning, modeling & fabric fitting: how do we do it right?

Facilities

- VITUS Smart 3D Body Scanner System—Human Solutions.
- Occipital Structure Sensor.
- BTS Motion Capture system
- Motion Star system
- Polyworks Software
- OptiTex™ Software
- CAESAR Anthropometric Scans
- Production equipment for products

Past Research

- Relationship of Body Form and Bra Fit (Chin-man Chen): Extracted body angles from scans; used to analyze body shape related to bra fit.
- Variation of High Tech vs. High Touch Virtual "Fit Model" (Elizabeth Bye): Fit analysis on live models & 3D scanned images.
- Visualization of 3D Posture & Center of Gravity Throughout Posture Modifying Therapy (Karvin Ryan & Karen LaBat): To increase health care providers' visualization of posture in order to improve experience with posture modifying therapy.
- Postural Changes When Wearing a Baby Carrier (Samer) compared standing postures with and without baby carrier.
- Fabrication (Elizabeth Bye, Karen LaBat, Linsey Griffin, Heajoo Lee): Incorporated 3D textiles into designs & tested a sizing system.



How do we measure activity with the scanner?

Current Research

- The HDL have acquired new body scanning technology called the Structure Sensor. The Structure Sensor functions with an iPad and can go anywhere.
- The current research contains two parts:
 - ✓ First, we will compare anthropometric measurements taken with the new body scanning technology to measurements from the Structure Sensor, to measurements from the Human Dimensioning Lab, as well as traditional taking anthropometric measurements.
 - ✓ If this method proves to be successful, the Structure Sensor will then be used to gather anthropometric data from a targeted population in the metro area that require use of personal protective equipment.



How do we measure activity with the scanner?





University of Minnesota Wearable Technology Lab

Development of a Flexible Sensor Composite for On-Body Dynamic Measurement

Mary Ellen Berglund, Esther...

Introduction: Wearing sensors on the body is essential for a variety of applications... Method: Multiple generations were created... Results: The sensor composite...



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GIRAFFE - Garment Integrated Remote Awareness For Fluid Emission

Elther Koo, Robert M. Petryk Baker, Cary Dunner

Introduction: Multiple generations were created... Method: Multiple generations were created... Results: The sensor composite...



University of Minnesota Wearable Technology Lab

Toward Personal Microclimate: Sustainable Heating Through Smart Clothing

Lutz Dunne, Esther Koo, Nika Gagliardi, Nicholas Schell, Sophie Li et al.

Introduction: Wearing in the US, Energy Information Administration... Method: Multiple generations were created... Results: The sensor composite...



University of Minnesota

Toward "Good" Wearable Application Concept

Nika R. Gagliardi

Introduction: Wearing sensors on the body is essential for a variety of applications...

University of Minnesota Wearable Technology Lab

Design and Development of Valgus-Sensing Leggings

Mary Ellen Berglund, Crystal Conaghan, Sephka Utost-Ustad, Tahmidul Islam Molla, Marc Tompkins, Brad Holtsch, Lucy E. Dunne
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Introduction
Helping athletes and other exercisers that involve knee bending incorrectly can lead to severe damage of the knee and the Anterior Cruciate Ligament (ACL) [1]. A common at-risk movement is valgus, also known as knicked knee. Valgus refers to the medial collapse or rotation of the knee and can be characterized by greater hip adduction [2]. Finding a way to provide early intervention to detect and prevent these injuries can reduce harm of injury.

Objectives
Soft stitched strain sensors to the system of sensing valgus knee bends. Review and evaluate valgus-sensing leggings to determine sensor placements that optimize accuracy and differentiation between valgus and non-valgus knee bends.

Background
This research is based on prior work by Roberts, et al. [1], which demonstrated a way to create a textile-based strain sensor. The fifth sensor is made by a conductive thread that is woven into the knit in a looped overlock structure. The conductive thread has its own inherent resistance. As the legs of the knit structure are pulled in and out of stretch, the resistance of the stitch changes. When placed on during, the resistance changes as the sensor is stretched and compressed in response to the movements of the wearer [4].



Figure 1: Three sensor placements on leggings.

Method
Three prototypes of the leggings were developed. Two were knitted using a digital multiweaver (DMW). The first implemented an array of ten vertical sensors (Fig. 1 and Fig. 2). For the second prototype, five sensors were arranged following the anatomy of muscles with the exception of one full-leg vertical sensor. Five sensors were used (Fig. 3). Subjects were asked to perform ten squats (5 in non-valgus and 5 in simulated valgus) and sensor resistance data were collected and compared to rotation and flexion gathered through optical motion capture.

Results
Preliminary trials on two of the three prototypes were conducted and the difference in peak response for each sensor between non-valgus and valgus bends was recorded (Fig. 4). The different sensor placements showed different responses in general, with some sensors from the second prototype more distinct responses to diagonal sensor placement around the hip and knee. The sensors have the potential to measure response to valgus bends.

Conclusion and Implications
The preliminary results lead us to believe that strain sensors would be used to measure forces measured by the sensors and appear to be great placement wrap-ups. Moving forward, we will refine the sensor and further evaluate reference measure response differences and measure the leggings with no considerations on the timing or accuracy of sensor placement. Research should be

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Durability of Stitched Surface-Mount Electronics

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Introduction
Developing reliable manufacturing techniques for integration of electronic components into textiles is a key barrier to growth for garment-integrated electronics. We have developed a manufacturing method for a textile that integrates surface-mount electronic components. Stitched conductive thread forms the wires in a circuit board, allowing for more flexibility, mobility, and availability than traditional printed circuit boards. Implementation of surface-mount resistor systems verifies the suitability of printed circuit board manufacturing.

Objectives
The objective of this study was to evaluate the effect of the following variables on durability of conductive measurements:
• Size of the component package
• Thickness of the cover fabric
• Alignment of the ultrahigh fabric

Method
Stitched circuit development
• Using a Brother B4D-3430 programmable sewing machine and Brother PS-3000 software to create custom embroidered switches, 3 surface-mount LED packages (3mm, 5mm and 8mm) were attached to stitched conductive traces on a glass-weave cotton nylon fabric in two orientations: "vertical" (perpendicular to the package body) and "horizontal" (parallel to the package body) (Figure 1).
• Conductive traces were laid out using ultraviolet laser etched in the fabric and cotton in the reverse.

Component attachment
• LEDs were soldered to the attached traces using fine-tipped solder paste and a reflow oven to maintain even heating.
• A heat gun was used instead of the reflow oven for the 3mm LEDs for better control over the solder reflow direction.
• A total of 40 samples were developed using the same procedure, each containing 10 LEDs.
• For the 3mm and 5mm LEDs, 5 samples were made with C, E, and F stitch in place, while only 2 and 4 samples were used for the 8mm LEDs packages, respectively.

Durability Test
• All samples were tested to determine the effect on the air only (no heat, no humidity, and 5 samples were tested under even wear conditions).
• Samples were removed at multiple 1-minute, 5-minute intervals, 30 minutes, 60 minutes, 120-minute intervals.
• The total test time each wear condition was 840 minutes (14 hours).
• Condition of the solder joints was determined by evaluating LED function after each test. Any broken connections were documented and analyzed.

Results (Cont.)




Figure 1: Sewing Layout and LED

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Development of Elastomeric Sensors for On-Body Dynamic Pressure

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Introduction
Sensing pressure on the body is useful for a variety of aerospace applications. In extravehicular activity (EVA) suits, sensing pressure on the body is important to determine when and where a rigid suit structure comes into contact with the astronaut. In extravehicular activity (EVA) compression garments, which are used to combat orthostatic intolerance during landing (among other things), real-time pressure sensing could help improve current garment performance, or even enable new forms of compression therapy, such as developing an actively controlled compression garment that requires dynamic pressure.

Objectives
In this project, we developed a new elastomeric sensor capable of unobtrusively measuring pressure on the body.

Theoretical Framework
The sensor, which is sensitive to conductive changes with a compliant elastomeric substrate, was engineered to respond to pressure (i.e., pressure) by increasing its electrical resistance in a predictable manner. Conductive changes with applied pressure resulted in useful sensing capabilities.

Method
A parametric design and manufacturing methods were used to manufacture the sensor. The sensor was performed to assess the effect of these parameters on the sensor performance.

An "old" method of casting and sensors was used. The sensor is made of an elastomeric material. The technique is a combination of manufacturing saving and with state-of-the-art.

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Matched Surface-Mount Electronics

Development of a novel surface-mount electronics architecture for on-body devices.

Abstract

Figure 1

Figure 2

Development of a Novel Sensor Composite for On-Body Devices

Abstract

GIRAFFE - Garment Integrated Remote Awareness for Fluid Emission

Abstract

Smart Personal Microclimate Sustainable Heating Through Smart Clothing

Abstract

Toward "Good" Wearable Technology Application Concepts

Abstract

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