The Development of Soft Capacitive-based Pressure and Shear Sensor Arrays for Prevention of Pressure Injuries

Justin K. M. Wyss[1,2,3,4], Kieran Morton[1,3,4], Jian Gao[1,4], Sadan M. Wani[1,3,4], Huron Yin[1,4], Jacinta Li[1,4], Yiting Wu[1,5], Anindya L. Roy[1,4], Adriana Cowan[1,4], Junheng Zhao[1,4], Daniel Zhou[4], Jason Y. S. Chow[4], Berti Argun[4], Harsh Rajoria[4], Mika Nogami[6], John D. W. Madden[1,2,3,4]

[1]Advanced Materials Process Engineering Laboratory (AMPEL), The University of British Columbia, Vancouver, Canada
[2]International Collaboration on Repair Discoveries (ICORD), The University of British Columbia, Vancouver, Canada
[3]School of Biomedical Engineering, The University of British Columbia, Vancouver, Canada
[4]Department of Electrical & Computer Engineering, The University of British Columbia, Vancouver, Canada
[5]Department of Mechanical Engineering, The University of British Columbia, Vancouver, Canada
[6]Department of Integrated Engineering, The University of British Columbia, Vancouver, Canada

I. INTRODUCTION

Soft sensors are capable of detecting a variety of physical stimuli such as pressure, shear, proximity, etc. while being actively deformed. These devices open up a plethora of applications in sports, robotics and healthcare. One of the applications can be in the prevention of one of the most burdensome, costly and fatal secondary medical conditions, which are pressure injuries (PIs). This chronic wound develops due to prolonged pressure sufficient enough to occlude the blood supply to tissue regions (ischemia), resulting in ulceration and potentially fatal infections. The effect of pressure can be in combination with shearing forces, causing additional tissue damage. Most susceptible to PIs are individuals with restricted mobility and sensation, such as the spinal cord injury (SCI) and the elderly population, as well as hospitalized/bedridden patients.

II. PRESSURE & SHEAR SENSOR

We developed soft sensor arrays that are flexible and/or stretchable and designed for pressure and shear detection. These sensor arrays are scalable in size and resolution, and made out of silicone elastomer material, carbon black particles and fibres, and stretchable, conductive fabric. The working principle is based on capacitive sensing, where electrodes form an array of parallel-plate capacitors separated by a dielectric layer. When compressed or deformed, a relative change in capacitance is measured, which translates to pressure and shear.

III. RESULTS

The sensor arrays demonstrated their capabilities of measuring pressure within the desired range for PIs (0-200 mmHg) for short and long periods with low-repeatability error, creep and accuracy of $\pm$ 4%, as well as detecting directional shearing forces in 2-dimensional axes up to 1 N. Figure 1 highlights the performance in detecting pressure magnitudes, the repeatability error and creep of the sensor array.

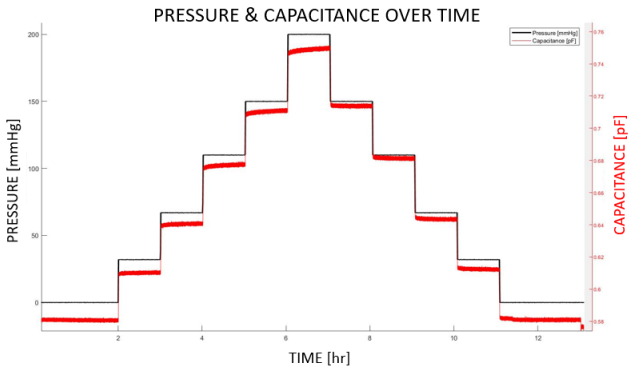

Fig. 1. Sensor performance in detecting pressure magnitudes ranging from 0 to 200 mmHg. Applied staircase sequence with incremental/decremental intervals of 1-hour, highlighting pressure (black) and capactiance (red).

IV. CONCLCUSION

The results suggest that the soft sensor arrays have the potential to be successfully used in PI prevention applications. Further work is required in characterizing the sensor arrays, testing them with human subjects in applicable real-life situations, as well as advancing the overall understanding of PI formation and adapting sensor designs to meet the requirements.

ACKNOWLEDGEMENTS

This study was supported by WorkSafeBC, MITACS, Praxis Spinal Cord Institute, ICORD, Rick Hansen Foundation and NSERC.