Wearable Textile Strain Sensor with Integrated Carbon Nanotubes

Jennifer Deignan[1*], Syamak Farajikhah[2], Ali Jeirani[2], Javad Foroughi[2], Shirley Coyle[1], Peter Innis[2], Gordon Wallace[2] and Dermot Diamond[1]

[1]*Insight Centre for Data Analytics, National Centre for Sensor Research, Dublin City University, Ireland.*

[2]*Intelligent Polymer Research Institute, AIIM Facility, University of Wollongong, Wollongong, Australia.*

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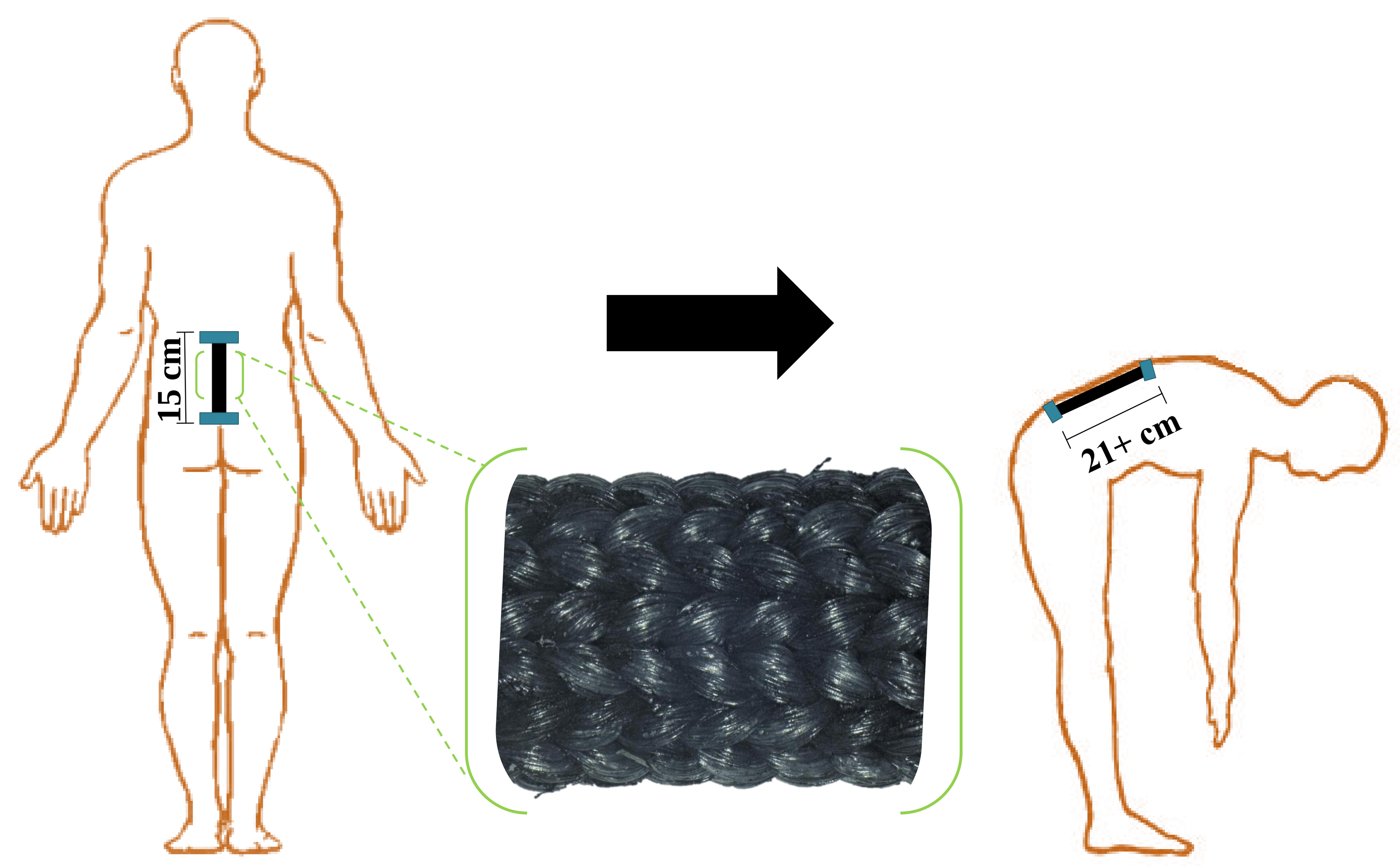
Introduction

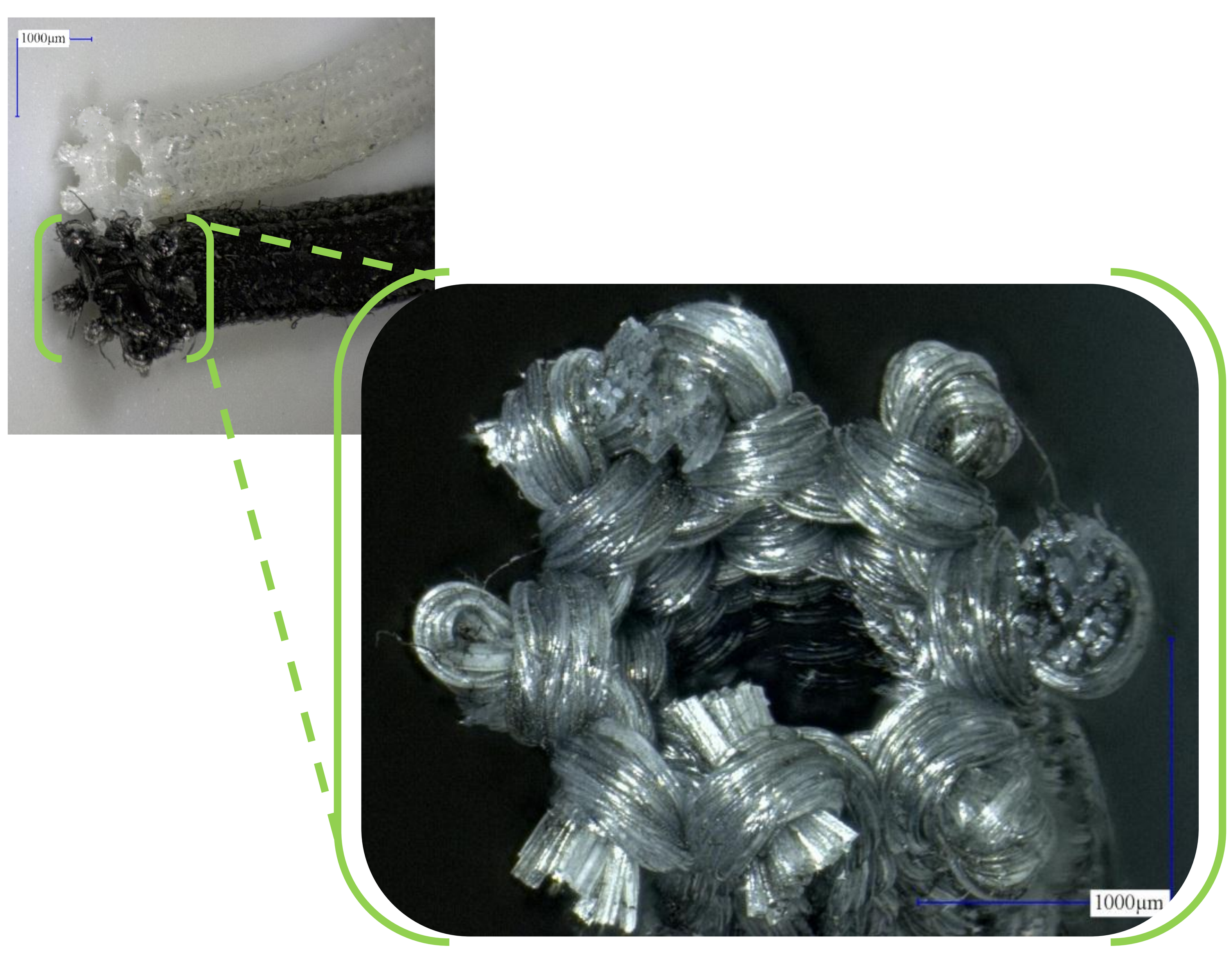
Wearable sensors have the potential to provide new methods of non-invasive physiological measurement in real-time. This work presents an alternative to the current clinical measurement of spinal flexion; the modified Schober's test. The accuracy of the test is determined by each clinician, which causes a large tendency towards error. Implementing wearable sensors and data acquisition software will not only improve the accuracy of the measurements, but the ability to analyze the data over time.

Background



We present an alternative to the current clinician measurement of spinal flexion: the modified Schober's test. By implementing a strain sensor in place of the measuring tape currently used, it is proposed that inter-observer error would be reduced and more consistent measurements would be provided over time.

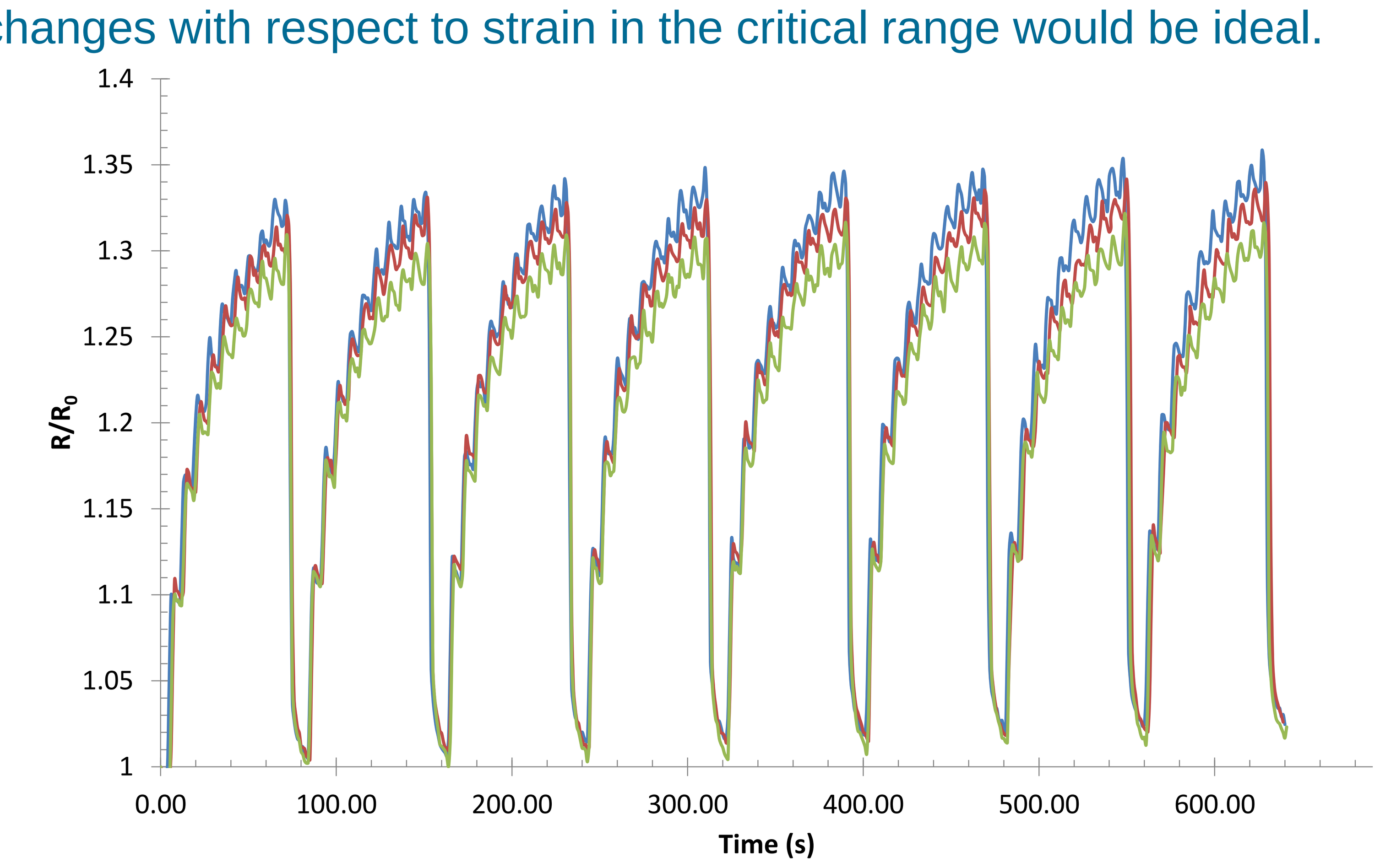
CNT Sensors



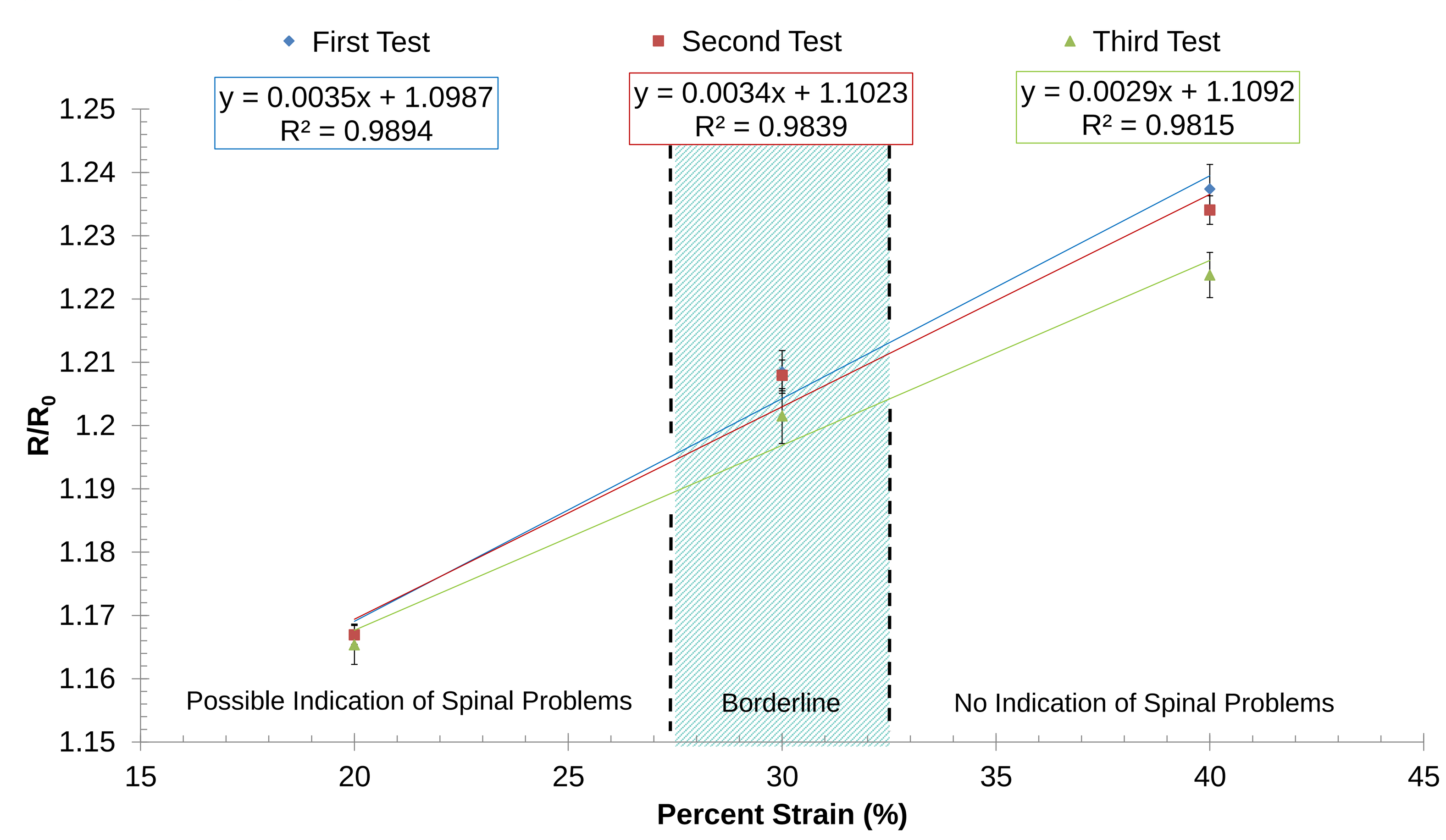
A knitted spandex cylindrical structure with integrated carbon nanotubes (CNT). A variety of sensors were produced with differing core sizes and sensor lengths. Each sensor was tested using the Schober's test as a guideline, focusing on strain percentages surrounding a 6 cm increase.

Sensor Testing

The purpose of this work was to select a sensor for use in a real-time wearable monitor for the flexion of the spine. With this in mind, the sensor data collection and analysis focused on the three crucial testing apexes; possible spinal complications, borderline, and healthy spine. For a 16.5 cm sensor these strain percentages are 30, 36 and 42 percent, respectively. Once the calibration was complete, all strain percentages could be extrapolated from the data, given the equation of the line was repeatable. Because of this, a sensor that showed linear resistance changes with respect to strain in the critical range would be ideal.



Each sensor was stretched with a linear actuator from 0% to 100% in 10% increases with a 5 second hold at each interval. Normalized resistance relative to percent strain of the sensor over time. A linear actuator was used to increase strain from 0-100% at a rate of 480mm/min.



Conclusions

While the critical percentage strains showed good separations with 3 repeat tests, the fibers showed very long relaxation times which would not be desirable in a clinical environment. It is believed that adding a core fiber could help decrease this time. The results of this work will be used in implementing in a real-time, wearable device for measuring the flexion of the spine. Such a device is believed to increase the accuracy of measurements and monitoring of diseases over time.

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