Weft Knit Smart Data Glove

Emmanuel Ayodele[1], SAR Zaidi[1], Zhiqiang Zhang[1], Jane Scott[2], Qingxiang Kong[1], Des Mclernon[1]

***Abstract*— The use of external attachments in connecting strain sensors to fabric in smart textiles reduces their reliability. In this paper, we illustrate how weft knitting and WholeGarment technology can be applied to create a smart data glove whose sensors and support structure are wholly textile thus lacking an external attachment. Furthermore, we validated the accuracy of the data glove with a reference device.**

I. INTRODUCTION

A smart data glove can help to drastically reduce the cost of rehabilitation for patients with impaired motor skills who cannot afford to employ therapists for home visits. Researchers have developed smart data gloves using a conventional design that leads to inaccuracies in the long term because of the deterioration of the external attachment that connects the sensors to its textile support structure [1]. However, we propose a weft knit internet of things (IoT) data glove prototype capable of measuring the flexion at the interphalangeal joints without any external attachment between its sensors and its support structure. Thus, ensuring therapists can accurately and efficiently observe the progress of the patients remotely.

II. MATERIALS AND METHODS

A. *Working Principle of a Weft Knit Sensor*

Weft knitting involves the interlocking yarn loops in a horizontal direction such that the feet of the loop legs lock with the head of the previous knitting cycle's loops [10]. Weft knitting conductive yarn creates a piezo-resistive sensor as a result of changes in the contact resistance between the loops of the sensor when strain is applied because the contact pressure between the loops is affected by the applied load. According to Holm's contact theory, the contact resistance between two conductors is defined as:

$$R_c = \frac{\rho}{2}\sqrt{\frac{\pi H}{nP}}. \quad (1)$$

Where, R_c is the contact resistance, ρ is the electrical resistivity, H is the hardness of the material used, n is the number of contact points and P is the contact pressure.

B. *Data Glove design*

The data glove was designed using SDS one apex apparel CAD software such that the sensors were placed at the distal and proximal interphalangeal (DIP and PIP) joints. Furthermore, the sensors were designed to be a combination of elastomer and conductive yarn to optimize their sensitivity. The conductive yarn used was a commercially available multifilament yarn comprising of 80% polyester and 20% stainless steel. Moreover, the glove was knitted with a Shima Seiki Mach2s 12-gauge knitting machine which deployed WholeGarment technology that fabricated the sensors and the elastomeric support structure in a single manufacturing process. Additionally, conductive thread was used to transmit data from the sensors to Arduino Lilypad which served as the glove's microprocessor. The data was then transmitted to Ubidots cloud, the online data storage and interface, via a Wi-Fi microchip, ESP8266, which served as the gateway.

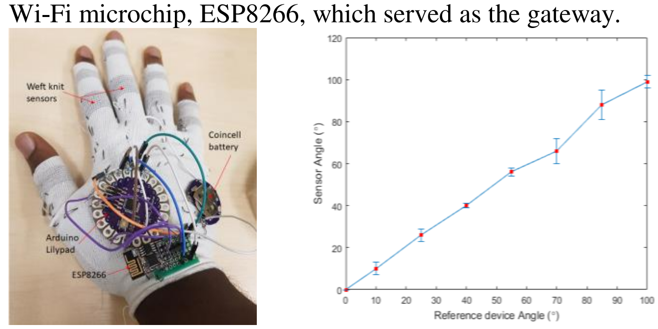

Figure 1. Weft Knit smart data glove (left) and Validation of its Sensor Accuracy (right).

III. RESULTS AND DISCUSSION

The accuracy of the glove was validated by comparing the results obtained with a digital angle ruler which acted as a reference device. The result of this experiment is illustrated in Fig. 1. The R-squared value and slope were calculated to be 0.9956 and 0.992857 respectively thereby signifying that the data glove produced accurate results. However, errors were observed in larger angles and can be eliminated by employing traditional filtering techniques.

IV. CONCLUSION

In this paper, we developed a prototype of a smart glove by weft knitting conductive yarn and an elastomer. In addition, we illustrated how WholeGarment technology can be used to create smart textiles that do not require external attachments between their sensors and support. Furthermore, we depicted the accuracy of the glove and its potential in rehabilitation.

1. School of Electronics and Electrical Engineering, University of Leeds. LS2 9JT. Syed Ali Raza Zaidi is the corresponding author: S.A.Zaidi@leeds.ac.uk
2. School of Design, University of Leeds.

REFERENCES

[1] H. Zhang and X. Tao, "From wearable to aware: Intrinsically conductive electrotextiles for human strain/stress sensing," in Biomedical and Health Informatics (BHI), 2012 IEEE-EMBS International Conference on. IEEE, 2012, pp. 468–471.

[2] D. J. Spencer, Knitting technology: a comprehensive handbook and practical guide. CRC press, 2001, vol. 16.