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Towards better measurement of joint stiffness in people with Rheumatoid Arthritis

Keywords: Range of Motion, hand evaluation, rheumatoid arthritis, goniometric measurement, data glove

Rheumatoid Arthritis (RA) is characterised by synovial inflammation resulting in pain, stiffness, swelling and deformity of the affected joints. The Disease Activity Score (DAS) is commonly used to measure RA disease activity (Van der Heijde et al. 1993), but this only quantifies joints that are tender and swollen rather than measuring stiffness. The symptom of joint stiffness is 'the perception of difficulty in moving a joint'. Simply recording the duration of stiffness in the morning does not reflect its intensity or its impact on movement and function. Although goniometers can be used to measure the Range of Motion (ROM) in each joint, this is laborious to perform and rarely recorded in the clinic setting. Since joint stiffness is often linked with disability, awareness of this problem will help to focus treatment strategies.

Data gloves capable of measuring finger joint kinematics can provide objective and dynamic information on joint movement which has the potential to help measure joint stiffness in an objective and clinically relevant manner.

Our work initially focused on using commercially available virtual reality gloves - the 5DT (Fifth Dimension Technologies 2004) and X-IST (Inition 2013). We developed a simple visual interface for the patient and a more detailed view for the analyst. Although this improved the ease of calibration and reproducibility of the data it was still time-consuming due to the need for frequent calibration. We therefore developed a bespoke dataglove using multiple accelerometers, bend sensors and force sensors to eliminate the need for calibration and offer improved accessibility to users with arthritis. We will be using these gloves in a clinical trial to study joint stiffness and movement in patients who have RA.

References

Fifth Dimension Technologies, 2004. 5DT Data Glove Ultra Series User's Manual 1.1 ed., 5DT.

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Data glove design improvements for finger joint Range of Motion measurement

Keywords: data glove design, Range of Motion, hand evaluation, rheumatoid arthritis

Data gloves are capable of measuring finger joint kinematics and can provide objective Range of Motion (ROM) information useful for clinical hand assessment and rehabilitation. Our work focuses on an intelligent system to analyse ambulatory movement of patients with Rheumatoid Arthritis (RA) and particularly focuses on the measurement of joint stiffness. The Disease Activity Score (DAS) measures RA disease activity, but it quantifies pain rather than measuring stiffness (Van der Heijde et al. 1993). Goniometric measurement quantifies static ROM, but it is laborious to perform. This system has been developed using 5DT (Fifth Dimension Technologies 2004) and X-IST (Inition 2013) standard off-the-shelf virtual reality gloves. Both gloves are designed to fit specific hand sizes. However human hands are not identical, resulting in the need for calibration of the gloves for each user. Patients with RA can also have limited ROM. This affects the glove calibration process and angular accuracy.

Development of a new bespoke glove containing multiple accelerometers, bend sensors and force sensors eliminates the need for calibration and offers accessibility to users with limited ROM. This glove has been designed using flexible PCB technology. Implementation of a meander-type PCB design between each finger joint greatly increases overall PCB flexibility.

Figure 1 provides a comparison of commercially developed data gloves to our glove. Systems are examined for the number and type of sensors used and their placement. Immediately noticeable is the inclusion of accelerometers and bend sensors on each finger joint to improve angular accuracy.

Physical attributes of the glove structure have been amended to allow easier donning and doffing and to protect glove circuitry from unintentional stretching. Figure 2(a) and Figure 2(b) demonstrate design concepts to facilitate easy glove removal.

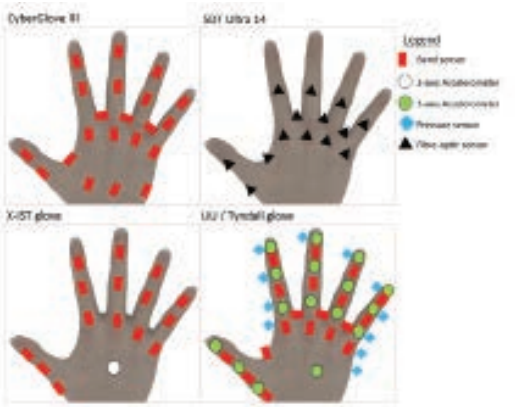

Figure 1: Graphical comparison of current start-of-the-art data gloves with the new glove. The glove contains bend sensors and accelerometers over each finger joint for dual movement determination. Additional force sensors demonstrate its suitability for rehabilitation.

Physical attributes of the glove structure have been amended to allow easier donning and doffing and to protect glove circuitry from unintentional stretching. Figure 2(a) and Figure 2(b) demonstrate design concepts to facilitate easy glove removal.

(a) (b)

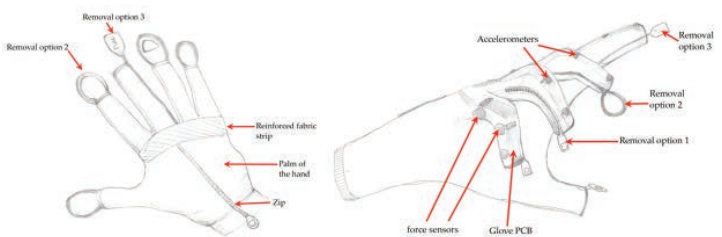

Figure 2(a): Sketch demonstrating design concepts implemented in the new glove design.
Figure 2(b): demonstrates the options considered to improve glove removal.

References

Fifth Dimension Technologies, 2004. 5DT Data Glove Ultra Series User's Manual 1.1 ed., 5DT.

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