Background

- Rheumatoid Arthritis (RA) is a disease that attacks the joints of the human skeleton (see Fig. 1).
- In 2011, RA affected up to 500,000 of the UK population and starts between the ages of 40-50. It is commoner in women [1].
- Around 20,000 new cases of RA are diagnosed every year in the U.K. [2].
- Four out of ten people give up their job within five years of diagnosis.
- Joint stiffness is a common complaint of RA sufferers.

RA is currently diagnosed by clinicians and therapists using x-rays and manual evaluation methods including a goniometer (Fig 2), tape measure and visual evaluation.

Measures flexion, extension, abduction and adduction of finger joints.

Joint Stiffness is currently measured using a Disease Activity Scale and the Health Assessment Questionnaire.

Difficult to record the onset of stiffness with this equipment as it occurs most frequently in the morning at home.

Materials and Methods

Digit-Ease project is a smart glove system integrating sensors, processors, wireless technology and algorithms to empirically measure Range Of Motion and assess the progression of joint stiffness.

Auto-calibrating

- New glove containing multiple accelerometers, bend sensors and force sensors eliminates the need for calibration (Fig. 3).
- Glove is automatically calibrated using Neural Network and accelerometer inputs from glove (Fig. 4)[3]

Patient access at home

- Clinician assigns objective from the objective bank to the patient or creates a new tailored one (Fig. 5).
- Patient attends clinic session and completes an objective routine. This is used as a baseline for comparison to future objectives.
- Patient logs into system and selects objective routine. Patient shown 3D hand movement during objective progression (Fig. 6)

Cloud-based analysis

- Clinician can compare individual repetitions from several objectives completed by the patient (Fig. 7).
- Objective routine is uploaded to a cloud database. Clinician can immediately view completed objective routine statistics and a 3D image as it happened at the patients home (Fig 8).

Glove structure design

- Physical attributes of the glove structure has been modified to allow easier donning and doffing and to protect glove circuitry from unintentional stretching.
- Using a zip on the underside of the glove relieves pressure across the knuckle joint.
- Using lightweight fabric strips along each fingertip reduces pulling force during removal.

Results

- Results show variance between repetition velocity (Fig. 13) and angular movement (Fig. 14) within objective.

Conclusion

- Digit-Ease is a Range Of Motion tool consisting of a wearable glove and a 3D interface.
- first ambulatory system to detect joint stiffness at home.
- Automatically calibrates glove using Neural Network and accelerometer data.
- Records minimum and maximum angular and velocity values during an exercise routine.
- Data is uploaded onto a database hosted in the cloud for immediate analysis by the clinician.
- Comparison of previous movement data provides indicators on improvement or decline.
- Determines the degree of deformity of the hand and stiffness of the moving finger joints.

References

[2] [Rheumatoid arthritis - joint up to like a year](http://www.nhs.uk/life-style/health-and-families/health-news/rheumatoid-arthritiscosts-up-to-£40bnayear-20130128.html).