Background

• Rheumatoid Arthritis (RA) is a disease that attacks the joints of the human skeleton.

• In 2010, RA affected up to 500,000 of the UK population and starts between the ages of 40-50.

• RA is currently diagnosed by clinicians and therapists using x-rays and manual evaluation methods.

• Manual methods are open to observer bias.

• This project focuses on an accurate hand measurement tool to detect hand Range of Motion (ROM) and joint stiffness.
RA affects the synovial tissue that lubricates the joints. This condition affects bones, joints, muscles and tendons.

Stiffness, swelling and deformity are common symptoms. Joints affected are:
- Distal interphalangeal (DIP)
- Proximal interphalangeal (PIP)
- Metacarpalphalangeal (MCP)

Swollen joints cause clicking sounds during movement and ‘trigger finger’.
Swelling and inflammation of the DIP and PIP joints cause both joints to bend. This creates:

- Boutonnière or hyperextended deformity
- Swan-neck or hyperextension deformity

**Current detection techniques**

- Occupational Therapists (OT) quantify joint range and determine hand function using the following methods and techniques.

**Goniometer**

- Measures flexion, extension, abduction and adduction of finger joints.
- The stationary arm of the goniometer is placed resting on the top of each finger.
- Fingers are bent towards the palm with the second goniometer arm. Flexion is measured in degrees.
- This is repeated for each finger and thumb.
• Measures finger flexion and extension - range of forward and backward digit movement.

• Measures abduction and adduction of finger joints.

• This is repeated for each finger & thumb.

• Goniometric measurement techniques have changed very little over the past 80 years. Average results within 7° in 62%-72% of trials.

A Health Assessment Questionnaire (HAQ) determines a patient's ability to perform daily tasks.

A Grip Strength Dynamometer measures the patient's grip of the intrinsic and extrinsic in kg.

Tape measure – measures thumb-index finger web space and distal phalanx-palm distance in centimetres.

Kapandji Score – grades the range of movement of the patient's thumb against each finger tip.
Current detection issues

- Outcomes are easily influenced by clinicians training and experience.
- All measurements are recorded in handwritten form.
- HAQ can be answered solely by patient or with a clinician. Answers may be more positive when answered with a professional.
- Joint stiffness is currently unmeasured.
- Current process is time consuming.

Digit-Ease Project

This project will provide the clinician with a ROM tool measuring:

- The degree of deformity of the hand and stiffness of the moving finger joints.
- Detection of creaking joints during movement.
- A shift in the position of the fingers in relation to the direction of the thumb by measuring web space.
- Recording the minimum, maximum and average values of a number of tests.
- Analysis of joint movement data to identify areas for Joint Protection benefits.
This project will initially use the 5DT data glove to measure joint ROM.

- Bend sensors will measure flexion and extension of each digit.
- Abduction sensors between fingers will detect adduction and abduction range.
- Abduction sensor will record Thumb-index finger web space.

A new glove is currently under design with added functionality.

- Additional bend sensors will measure flexion and extension on the three joints of each digit and detect Boutonnière and swan neck.
- Mote will store sensor data onto a flash card and will include wireless connectivity. An accelerometer will measure forearm supination and pronation.
- Wrist and thumb rotation sensors will measure ulnar and radial deviation.
Pressure sensors will measure Kapandji index.

The patient attempts to touch their thumb against various points on the hand.

Kapandji score increases as each point is touched.

Bespoke system under development.

Feedback of each sensor movement

Live 3D model of hand

Target achievement indicator

http://isrc.ulster.ac.uk
Additions to the software system will measure:

- Minimum and maximum flexion and extension ranges of each digit.
- Adduction and abduction range for each digit.
- Thumb-index finger web space.
- Amount of joint stiffness for each digit.
- Recording, storage and analysis of patient data.
- Analysis of historical patient movement.

The new system will be a data collection and playback tool.

- First ambulatory system to record joint stiffness at home.
- System will simultaneously record angles from multiple fingers and detect previously unidentifiable movement patterns.
- Record data offline for future analysis and playback.
- Problematic combinations of joint movement will be detectable and the benefits of Joint Protection recommended to patient.
- Glove system may be used in conjunction with emerging research in Mirror Imagery (MI) and Motor Imagery (MoI).
Conclusion

- To date, Clinicians use manual, time consuming techniques to quantify hand limitations.
- Current methods have the capability to detect hand ROM, with some issues.
- The proposed system will provide an automatic hand ROM measuring tool capable of measuring joint movement, joint stiffness and comparison analysis of historical movement data.
- Future work will provide additional joint movement for each finger and offline recording of movement at home.
- A new e-textile glove will provide a glove with low-weight, comfort, and high flexibility.

Questions?