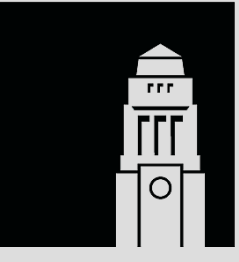


CAPTURING MOTION CAPTURE DATA FOR ANALYSIS OF MOVEMENT FOR STROKE PATIENTS

WHILST PERFORMING ROBOTIC REHABILITATION

ARRON J THOMPSON

JUSTIN F GALLAGHER



UNIVERSITY OF LEEDS

BACKGROUND CHECK

MULTIPLE MUSCLE GROUPS ARE REQUIRED TO MOVE A SINGLE BODY PART, RESULTING IN WIDESPREAD ACTIVITY ACROSS THE MOTOR CORTEX. A STROKE PATIENT MAY SUFFER A LACK OF ARTICULATION IN ONE BODY PART, CAUSED BY DAMAGE SPREAD THROUGHOUT THE CORTEX. THIS LEADS TO THE FACT THAT MOST POST-STROKE DISABILITIES ARE MOTOR IMPAIRMENTS.

IN VIRTUAL REALITY (VR) SYSTEMS, USERS ARE FITTED WITH A HEAD-MOUNTED DISPLAY (HMD), AS WELL AS ELECTROMAGNETIC SENSORS, WHICH TRACK THE POSITION AND ORIENTATION OF THE USER'S BODY IN REAL-TIME. THIS DATA IS USED TO DISPLAY CORRESPONDING MOTIONS BY AVATARS – A GRAPHICAL REPRESENTATION OF THE USER WITHIN THE VIRTUAL ENVIRONMENT (VE). IN A STUDY CONDUCTED USING THE VIDEOGAME FRANCHISE "SKYRIM", IT WAS FOUND THAT PLAYING IN VR INDUCES HIGHER LEVELS OF USER ENJOYMENT COMPARED TO ITS TRADITIONAL COUNTERPART. THIS IS DUE TO THE MAPPING OF MOVEMENT, AND THE SATISFACTION THAT COMES WITH THIS WHEN COMPLETING GAME ELEMENTS. THIS WOULD HENCE BE SUITABLE FOR INCREASING THE ENGAGEMENT OF STROKE PATIENTS UNDERTAKING REHABILITATION. HOWEVER, THE USE OF PHYSICAL EQUIPMENT ATTACHED TO USERS WITH MOTOR IMPAIRMENT MAY NOT BE SUITABLE FOR HOME USE DUE TO THE COMPLICATED NATURE OF THEIR SET-UP, AS WELL AS THE DISCOMFORT THESE SYSTEMS OFTEN CAUSE. NON-PHYSICAL BODY TRACKING IS FAR LESS DEVELOPED FOR THIS USE; HOWEVER, IT REQUIRES NO PHYSICAL USER SETUP, MAKING IT MORE PATIENT-FRIENDLY IN A HOME ENVIRONMENT THAN A VR SYSTEM USING SENSORS.

IT WOULD BE ADVANTAGEOUS TO DEVELOP A HOME REHABILITATION SYSTEM THAT ENCOURAGES REGULAR PROLONGED ENGAGEMENT, HAS ENTERTAINMENT VALUE BEYOND EVENTUALLY MUNDANE REPETITION, AND IS PHYSICALLY SUITABLE FOR STROKE PATIENTS UNDERGOING REHABILITATION.

RESULTS

BELOW ARE THE RESULTS COLLECTED IN THE EXPERIMENT DETAILED PREVIOUSLY. THE FIRST ROW REPRESENTS SMOOTH-MOVING PARTICIPANT MOTION DATA, AND THE SECOND REPRESENTS ROUGH MOTION. ONE CAN IMMEDIATELY SEE THE UNIFORMITY OR LACK THEREOF BETWEEN MODEL DATA (MJT) AND THE PARTICIPANT DATA ILLUSTRATED USING DASHED AND SOLID LINES. GRAPHS ON THE RIGHT ARE THE STATISTICAL MEASURES OF EACH RUN OF DATA, WHICH WAS USED TO DETERMINE A STANDARD OF MOTION AND THE USEFULNESS OF SAMPLES.

AIM OF THE GAME

THE AIM OF THE RESEARCH WAS TO UNDERTAKE A 'PROOF OF CONCEPT' ON MULTIPLE METHODS OF DATA CAPTURE, AS A BASIS FOR THE DEVELOPMENT OF HOME REHABILITATION. TWO MAIN METHODS WERE INVESTIGATED OVER THE 6-WEEK RESEARCH PERIOD:

- NDI'S OPTOTRAK SYSTEM, CONSIDERED THE GOLD STANDARD IN POSITION MEASUREMENT.
- MICROSOFT'S AZURE KINECT DEVELOPERS KIT, WHICH WOULD BE VALIDATED AGAINST THE 'GOLD STANDARD' AS A MEANS OF ACCURACY TESTING.

A SECONDARY GOAL OF THE RESEARCH WAS TO COLLECT DATA AND WRITE A PROGRAM COMPARING THE QUALITY OF USER MOTION TO A MATHEMATICALLY PERFECT MOTION PATH. THUS, ALLOWING FOR THE AUTOMATIC CATEGORIZATION OF PATIENT MOTION OUTSIDE OF REHABILITATION WARDS.

RESEARCH METHODS

IN ORDER TO COLLECT DATA FROM THE OPTOTRAK SYSTEM, A PYTHON PROGRAM WAS WRITTEN, WHICH EXTRACTS SETS OF DATA FROM THE OUTPUT EXCEL FILE OF THE OPTOTRAK SENSOR. THE PROGRAM THEN COMPARES THE COORDINATE MOTION DATA OF A PARTICIPANT TO THE MATHEMATICALLY PERFECT MOTION PATH; MINIMUM JERK TRAJECTORY OR MJT. THE MINIMUM JERK TRAJECTORY METHOD IS USED AS A MEANS OF PATH DEVELOPMENT FOR AUTOMATED WAREHOUSE OPERATIVES IN ORDER FOR PACKAGES TO BE TREATED WITH CARE, WHILST EFFICIENTLY MOVING THEM FROM POINT A TO POINT B.

THE EXPERIMENT ITSELF REQUIRED PARTICIPANTS TO MOVE THEIR HAND FORWARDS AND BACKWARDS, EXTENDING AND RETRACTING THE FOREARM AND ELBOW. DATA WAS COLLECTED AT 4 POINTS, 3 AT THE WRIST AND ONE AT THE ELBOW. THIS WAS REPEATED FOR 30 SECONDS, COLLECTING 6000 DATA POINTS FOR EACH OF THE 4 SENSORS.

AS ETHICS CLEARANCE IS REQUIRED FOR A FULL-SCALE EXPERIMENT, WHICH WOULD HAVE TAKEN APPROXIMATELY 8 WEEKS TO SOURCE, THE EXPERIMENT WAS RUN 4 TIMES, TWICE SMOOTH AND TWICE JERKY.

THE AZURE KINECT DK SYSTEM WAS TRIED AND TESTED OVER THE COURSE OF TWO WEEKS BUT TO NO AVAIL. THE LACK OF APPROPRIATE LEVEL GUIDES AND SOURCE MATERIAL MADE IT ALMOST IMPOSSIBLE FOR PROGRESS TO BE MADE BY AN INDIVIDUAL OF LOWER EXPERIENCE IN SUCH A RESTRICTED TIMEFRAME. IT WAS SIDELINED TO FOCUS ON DATA ANALYSIS USING OPTOTRAK.

CONCLUSIONS

TO CONCLUDE, IT WAS FOUND THAT:

- OPTOTRAK CAN BE USED TO MAP COORDINATE DATA OF MOTION USING COMPARATIVE TECHNIQUES SUCH AS MINIMUM JERK TRAJECTORY.
- THE STANDARDS OF MOTION ESTABLISHED WERE APPROXIMATELY <25% ERROR FOR SMOOTH MOTION, AND >25% FOR ROUGH MOTION.
- THE MODEL CANNOT BE USED AS A GOAL FOR WHICH THE AIM IS TO PERFECTLY REPLICATE, AS THIS ISN'T REQUIRED FOR EVERYDAY ACTIVITY.
- THE AZURE KINECT DK'S MANUALS AND ONLINE GUIDES WERE NOT SUFFICIENT FOR INDIVIDUALS OF LOWER EXPERIENCE LEVELS IN THE FIELD TO SUCCESSFULLY USE THE SYSTEM IN SUCH A SHORT TIMEFRAME.
- THE RESEARCH CONDUCTED CAN BE USED AND DEVELOPED FURTHER USING END EFFECTORS AND SWITCHES TO ELIMINATE THE NEED FOR HUMAN DATA ANALYSIS AND CONFIGURING. IN-HOME REHABILITATION SYSTEMS FOR STROKE PATIENTS CAN THEN BE DESIGNED, DECREASING RECOVERY TIME AND INCREASING RECOVERY QUALITY.

