

2007 CRA-W Canadian Distributed Mentor Project

**Graphical User Interface Development
For Robotic Stroke Assessment Data Collection**

Supervisor: Dr. Janice Glasgow

By

Mary Muir and Helen Xu

School of Computing, Queen's University

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1. Introduction

Stroke affects millions of people worldwide every year. It is the fourth leading cause of death in Canada today. For those that survive, only about 10% recover entirely, the rest usually suffer impairments of the limbs [1]. This leads to the importance in research to better understand the cause, effect, and treatment of strokes.

Stroke occurs due to the loss of blood flow to the brain. This generally happens in two ways: ischemic or hemorrhagic. In ischemic stroke, blood vessels become occluded and block oxygen supplies to the brain. Hemorrhagic stroke occurs when blood vessels rupture or bleed, impairing its ability to carry blood to target tissues. For example, when a blood vessel ruptures in the brain, blood clots can form and cause stroke. The interruption of blood supply to the brain causes oxygen depletion, which reduces or abolishes the brain's normal neural function. The effect of the stroke depends on what part of the brain was affected and how much damage occurred. Strokes can affect a person's ability to move, see, remember, speak, reason, and read or write [1].

Current clinical stroke assessments include physical assessment and visual observation by physicians. However, the clinical scores are subjective and offer little information about details of underlying impairments. Assessment of stroke impairments is therefore crucial as it greatly assists in rehabilitation therapy planning. [2]

Robots may aid the stroke assessment as they are being extensively used in rehabilitation. Dr. Stephen Scott of the Anatomy and Cell Biology Department at Queen's University developed a robotic exoskeleton called KINARM (Kinesiological Instrument

for Normal and Altered Reaching Movements). The device was initially developed to study the activity of neurons during various behavioral tasks in non-human primates. More recently, a human-sized KINARM was developed to study fundamental issues in motor control and learning in the upper limbs of humans. It is currently being used by clinicians at St. Mary's at the Lake Hospital in Kingston Ontario for upper limb impairment assessment. By permitting the arm to move in a horizontal plane to reach virtual targets on a semi-transparent mirror, information such as hand velocity, shoulder angles and torques are recorded. The vast amount of data collected allows greater analysis of various aspects of stroke [2].

2. Background

2.1 Clinical Stroke Assessments

Modern clinical assessments such as the Chedoke-MacMaster, Purdue Pegboard and Fugl-Meyer test all quantitatively measure the different stages of stroke and its recovery.

The Chedoke-McMaster Stroke Assessment is comprised of two components: the Impairment Inventory and the Activity Inventory. The Impairment Inventory (II) determines the presence and severity of physical impairments in the six dimensions of shoulder pain, postural control, arm, hand, foot, and leg. These are quantified in a seven point staging system. The Activity Inventory (AI) measures the client's functional ability. The score of AI depend on the amount of assistance needed by the client to complete the functional activity. The AI is comprised of the Gross Motor Function Index (with items including moving in bed and transferring to a chair) and the Walking Index (with items including walking on rough ground and climbing stairs). The maximum score that a client can obtain is 100 as there are 14 items with a seven-point scale and a two point score awarded for age-appropriate walking distance [3].

The Purdue Pegboard Test measures gross movements of hands, fingers and arms, and fingertip dexterity as necessary in assembly tasks. The test measures two types of activities: gross movements of upper limbs and fingertip dexterity. It involves sequential insertion and assembly of pegs, collars and washers [4].

The Fugl-Meyer test is a 226 point scale developed to evaluate patients recovering from hemiplegic stroke. It is divided into five domains: motor function, sensory function, balance, joint range of motion and joint pain. Each domain consists of many items and each item is scored on a 3 point scale. A scale of zero implies the inability to perform, a score of one implies partial performance and a score of two implies full performance. The test involves physical and observational assessment by clinicians [2].

2.2 Robotic Technologies

Since the measurement of these tests depend on the physicians' judgment, the results are often subjective and does not capture the minor changes in patient performance. Therefore, more advanced and objective robotic technologies are needed to assist and enhance stroke assessment. Many robotic technologies are used in stroke rehabilitation.

The MIME (Mirror-image motion enabler) robot is used to move the affected arm in straight lines or in complex patterns. The subject's forearm movements can be passive (movement provided by the robot) or active-assisted (subject initiates movement, the robot provides necessary assistance to the impaired arm to complete motion). MIME can take commands from the unaffected arm to help move the affected arm in a mirror-image pattern. Studies have shown that patients with MIME assistance showed faster recovery than those who without robotic assistance [2].

ARM Guide (Assisted Rehabilitation and Measurement Guide) was used to assist in recovery and investigate whether the mechanical assistance provided by the robot or

the repetitive movement attempts made by the patients was the primarily stimulated recovery. The experiment showed comparable results between subjects who performed free reaching and subjects that underwent robot assisted reaching [2].

Prior to the bilateral KINARM, unilateral KINARM is used in research. Control and stroke subjects were instructed to reach with their right arm to 16 peripheral targets from a center hold target as soon as the targets illuminate. 10 repeat trials were performed for each target (See Figure 2.1).

Differences in reaching between control subjects and stroke subjects with different lesion locations were observed. (See Figure 2.2) [2].

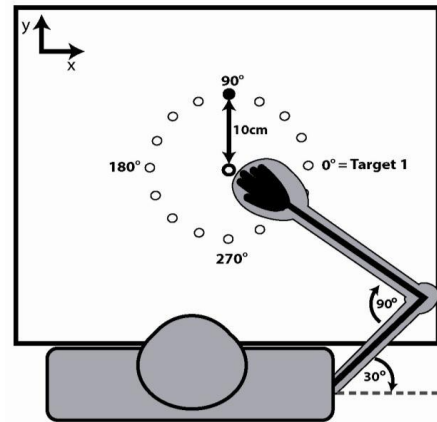
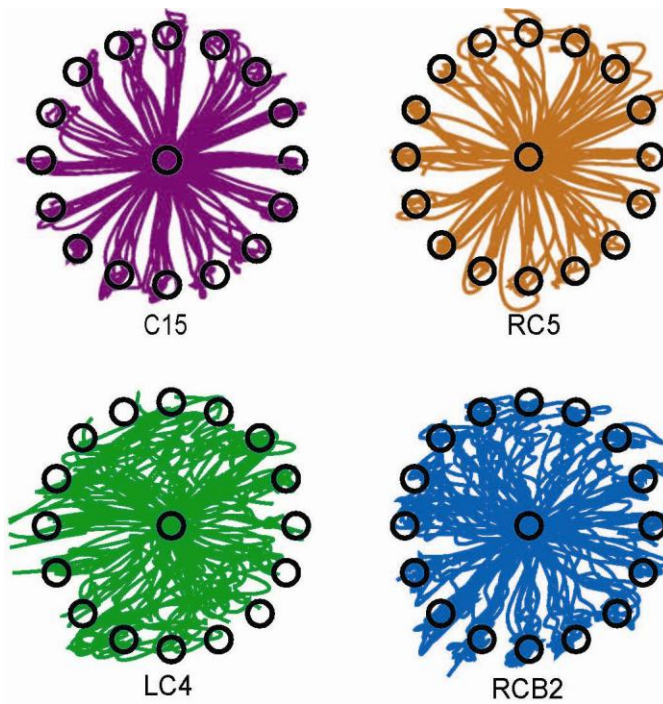


Figure 2.1

The unilateral-arm-KINARM reaching task: subjects are instructed to reach the 16 targets at a 10 cm distance from the center target with their right arm.



C15 = Control subject

LC4 = Left cerebral lesion

RC5 = Right cerebral lesion

RCB2 = Right cerebellar lesion

Figure 2.2

Different reaching profiles for subjects with different lesion locations. Subject RC5 with a right cerebral lesion presented smooth movements similar to control subject C15. This is because their left arm was affected by the lesion.

Different parameters such as *peak velocity* of the hand and *distance error* from the target were calculated and linearly compared across all targets for all subjects. Some parameters showed good separation between control and stroke subjects while others provided less separation. The parameters also presented good correlation to clinical scores such as the Purdue Pegboard and the Chedoke-McMaster score. [2]

3. Methodology

3.1 Project Description

Dr. Janice Glasgow's lab from the School of Computing is working with Dr. Stephen Scott's Neuroscience lab in developing computational methods to analyze the data generated by KINARM assessment sessions. Currently there have been approximately 100 subjects that have been tested in the system. Each subject has biographical, clinical assessment, and robotic assessment data that are collected by clinicians or the computer during the test. All data is added to the DB2 database through the combination of direct input in the DB2 Control Center, Excel Spreadsheets and Matlab scripts (See Figure 3.1).

Currently, the data collected from the subjects in the clinical assessments is handled in a multi-step procedure:

- 1) The physiotherapist that conducts the clinical assessment will fill out a long paper form that consists of general subject information (information that ends up in the subjects table) as well as scores from the various clinical assessments that are conducted.
- 2) These paper records are then given to another person who will either directly enter the data into the DB2 database using the built in DB2 Control Center or they will use an Excel spreadsheet where they will add data values. This excel file is then processed by Matlab to import the data into the DB2 database.

- 3) Someone else imports the KINARM data into the DB2 database using Matlab scripts

The following are some drawbacks of this process:

- It can take a long time for the clinical assessment data about the subject to be entered into the database.
- Due to the large size of the Assessment table, data can be put into the wrong field or the data can be added to the wrong subject because often more than one patient's details are visible.
- Too much tedious work is involved to correctly transfer the data from paper to the database.

The goal of our research project is to develop a software tool that would allow the clinicians to input biographical and clinical assessment data directly into the database from the stroke assessment sessions. This would effectively reduce the amount of time and work required for data collection.

Clinical (Human2) Database Structure

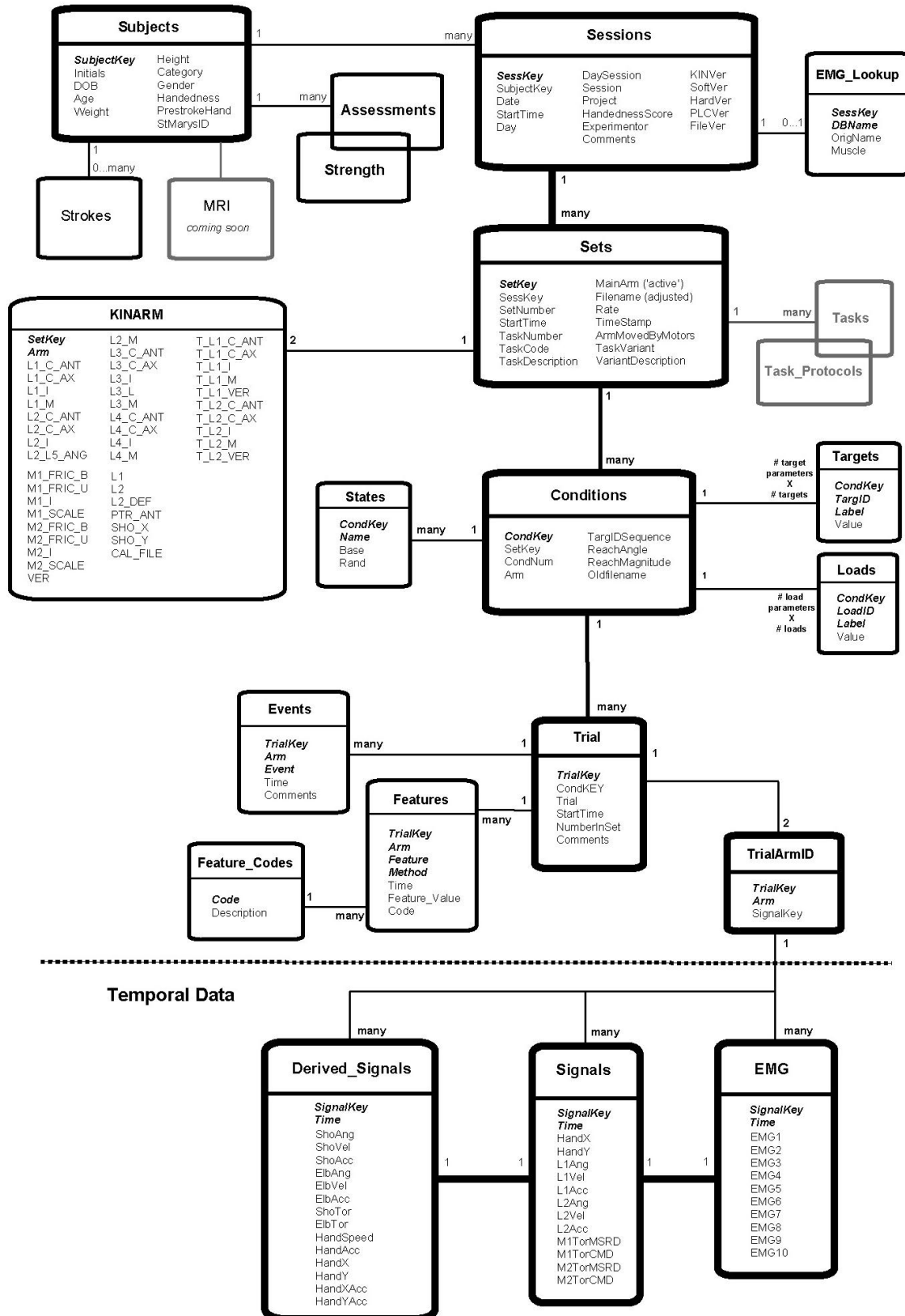


Figure 3.1 Layout of the Clinical Database

3.2 Project Design

It was determined to use Java as the programming language for the Graphical User Interface since some codes which allow the users to read and write to the DB2 database were already been developed.

It was also desired for clinicians to be able to input data even if the computer was not connected to the database. The records added would be saved and carried over on each running of the program. To allow for off-line access, classes were designed that replicated the affected tables in the DB2 database.

The DB2 database includes many tables. However, the ones that will be read and written to are Subjects, Assessments, Strokes, and Strength. In addition, the Stroke table used Lesion_Location and Vascular_Territories tables to describe the possible acceptable choices for Lesion Location and Vascular Territories of a particular stroke.

4. Results

4.1 Screen Shoots from GUI



Figure 4.1 The user login window.

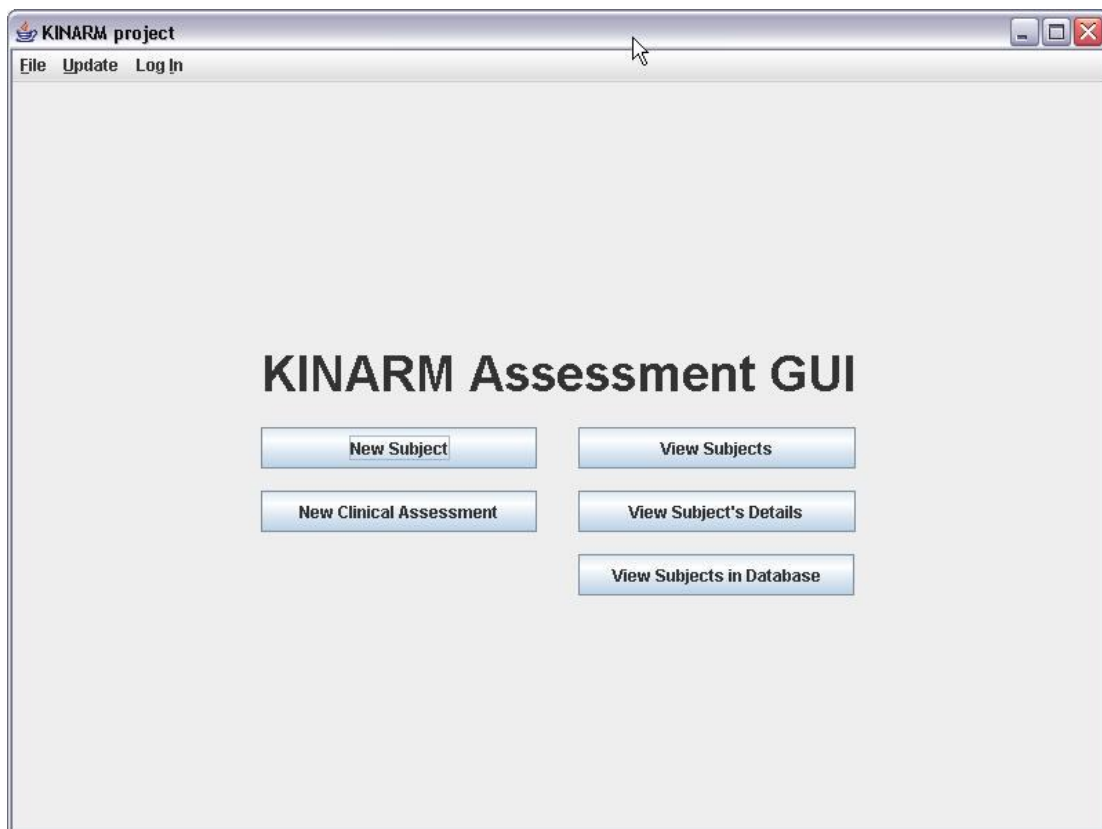


Figure 4.2 KINARM Assessment GUI homepage. Allows the user to add or view subjects and clinical assessments.

KINARM project

File Update Log In

Subject in Database List

Initials	Date of Birth	Category	Subject Key
RAM	1939-01-11	Control	375
RB	1945-01-01	Stroke	308
RBF	1958-10-31	Stroke	386
RD	2007-07-31	Dystonia	309
RGD	1944-01-01	Control	363
RGS	1946-01-01	Control	384
RJP	1938-01-01	Control	351
RLT	1933-01-01	Control	352
RRB	1939-04-21	Control	390
sb1	2007-07-31		310
sc1	2007-07-31		311
sc2	2007-07-31		312
sd1	2007-07-31		313
sd2	2007-07-31		314
sk1	2007-07-31		315
sr1	2007-07-31		316
SB	1957-12-28	Control	317
SJ	1984-05-13	Stroke	318
SL	2007-07-31	Stroke	319
SMC	2007-07-31	Stroke	320
SPD	2007-07-31	Control	321
SPE	1945-02-10	Control	322
SR	1982-01-01	Control	346
STM	1949-09-21	Stroke	394
SW	1940-09-17	Stroke	333
tb1	2007-07-31		323
tf1	2007-07-31		324

HOME Bring Subject into Local File

Figure 4.3 The list of subjects in the database. The subjects can be sorted by the columns by clicking on the tabs.

KINARM project

File Update Log In

Local Subject List

Initials	Date of Birth	Category	Subject Key	Uploaded	In Database
MATTY	Feb 1, 1934	Control	35	true	true
MAGGY	Oct 23, 1942	Control	34	true	true
MARTY	Aug 4, 1936	Control	32	true	true
MAMA	Dec 12, 1937	Control	28	true	true
MARG	Jun 4, 1934	Control	31	true	true
MARDY	Feb 13, 1945	Control	33	true	true
MARFY	Apr 11, 1910	Control	36	true	true
MAFFY	Jun 1, 1945	Control	37	true	true
MARSY	Feb 1, 1935	Stroke	38	true	true
MASSY	Mar 5, 1935	Stroke	39	true	true

HOME Add New Subject View Subject Details Upload Subject

Edit Subject Add Clinical Assessment Add MRI / CT scan Add Stroke Details

Figure 4.4 The Local Subject List. The subjects can be sorted by the columns by clicking on the tabs.

KINARM project

File Update Log In

KINARM - Subject Information

Subject Database Key: 32

(Required) Subject Code: MARTY

Date of Birth: (MMM DD, YYYY) Aug 4, 1936

Gender: ☒ Male ☐ Female

Age: 0

Category: Control

Dominant Hand:

St Mary's ID:

KGH ID:

Physician's Name: Dr. Phil

Physician's Phone Number:

Home Add New Subject Update Record Remove unsaved changes

Add New Assessment Add New Stroke View Subject Details View List of all subjects

Figure 4.5 Basic subject information window. Allows user to add or update a subject.

KINARM project

File Update Log In

Stroke Details

Stroke Key: 139

Date of Stroke: Aug 1, 2007

Affected Side: Left

Type of Stroke: Ischemic

Hemisphere of Lesion: Left

Lesion Location: Cerebellar

Vascular Territory: Posterior Cerebral Artery (PCA)

Structures Damaged:

Previous Stroke: ☐ Yes

Previous Stroke Description:

Comments:

Subject: MARTY - 32

☐ Date of Stroke Unknown

Home Save Reset

Figure 4.6 The stroke details of a particular patient.

KINARM project

File Update Log In

KINARM - Clinical Assessment Form

Assessment Key: 151

Examiner: Demers

Clinical Start Date: Aug 16, 2007

Weight: (kg) 0.0

Height: (cm) 0.0

Handedness: Right

Previous TIA: ☐

Number of Strokes: 0

Highest Level of Education? High School

Aphasia: ☐

Hemi-neglect: ☐

Physio after hospital: ☐

Physio sessions per week: 0

Subject (Key): MARTY - 32

Comorbidities & Medications

Edinburgh Handedness Score

Comments

CT or MRI

Folstein Mini Mental Score

MOCA Score

Strength Scores

Reflex Scores

Modified Ashworth Scores

Range of Motion

Thumb Localizing Scores

Purdue Scores

Dynamometer Scores

Health Survey 36

Chedoke Scores

Vision Details

BIT Score

FIM Scores

Barthel Index

Home
Save
Clear
Back to Subject Details

Figure 4.7 The KINARM Clinical Assessment form. It allows the user to enter patient assessment scores and other related information.


Health Survey 36
✕

Health Survey (Short Form 36) (SF-36)

Instructions:

This survey asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities.

Answer every question by marking the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

- In general, would you say your health is?
- Compared to one year ago, how would you rate your health in general now?
- How does your health affect your ability to do these activities? Activity Survey
- How does your health affect your work or other daily activities? Work Survey
- How has any emotional problems effect work or daily activities? Emotional Survey
- During the past 4 weeks, to what extent has your physical health or emotional problems interfere with your normal social activities with family, friends, neighbours, or groups?
- How much bodily pain have you had during the past four weeks?
- During the past 4 weeks, how much did pain interfere with your normal work?
- These questions are about how you feel and how things have been with you during the past 4 weeks. Feelings Survey
- During the past 4 weeks how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc)?
- How TRUE or FALSE is each of the following statements for you? True / False Survey

Total Score:

Calculate Score
Save Scores
Close

Figure 4.9 The Health Survey 36 window.



Figure 4.10 Comorbidities and Medications window. Allow user to enter patient's medical information.

4.2 Use of the System

Before any new assessments or strokes can be added to the system, the subject must be created first. From the main screen, the user can view the Subjects in the local database. If the subject has not been created locally, there are two ways this can be done. If the subject is already in the DB2 database then the user can from the main screen, view all subjects currently in the database. The user can then select that subject and the subject's information will now be viewable from the local View Subject list. Otherwise the user can create a new subject either from the View Subjects list view or from the main menu. The user then inputs the biographical information of the subject and saves it.

Once a subject is in the local list, the user can start adding assessments and strokes to the subject. When you create a new Assessment, it also creates the associated Strength Scores. The user can then go through the many screens that make up the

Assessment. The Clinical Assessment is made up of many different clinical tests that are used to describe the abilities of the subject to perform a series of tasks.

The strokes table is much simpler, consisting of only one screen for the input of details about the stroke.

5. Possible Future Development

A method should be added that will upload all subjects in the local list that have changed. This could be done by iterating over the subjects in the local list.

Currently a subject has a collection of strokes and assessments (with their corresponding Strength Scores) associated with him/her. It is also intended that the subject also has the MRI associated with him/her. However at the current time, the MRI table has not been designed, when this occurs, the MRI can be added to the person.

It would be useful if the system could detect when the computer is connected to the internet (and therefore able to upload data to the database). If this occurred, then the system could automatically update changed information when it can. It should also periodically update the Lesion Locations and Vascular Territories choices as these may change over time.

The system should also be able to remember where the file was last saved and open the last saved location. Currently it only opens and saves to the default location.

6. References

- [1] Heart and Stroke Foundation. *Stroke Statistics*. www.heartandstroke.ca (2007). Date Accessed: Aug 22, 2007.
- [2] Abu-Zeid, A. *Parameter Analysis for Robotic Assessment of Impairments in Reaching Due to Stroke*. (Master thesis, Queen's University, 2007).
- [3] McMaster University. *Chedoke-McMaster Stroke Assessment*. www.chedokeassessment.ca (2005). Date Accessed: Aug 22, 2007.
- [4] *Purdue Pegboard Dexterity Test*. www.wisdomking.com (2003). Date Accessed: Aug 22, 2007.