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Graphical User Interface Development

For Robotic Stroke Assessment Data Collection

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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 Perdue 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.

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.

C15 = Control subject
LC4 = Left cerebral lesion
RC5 = Right cerebral lesion
RCB2 = Right cerebellar 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.
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.
**Figure 4.3** The list of subjects in the database. The subjects can be sorted by the columns by clicking on the tabs.
Figure 4.4 The Local Subject List. The subjects can be sorted by the columns by clicking on the tabs.
Figure 4.5 Basic subject information window. Allows user to add or update a subject.
Figure 4.6 The stroke details of a particular patient.
Figure 4.7 The KINARM Clinical Assessment form. It allows the user to enter patient assessment scores and other related information.
Figure 4.8 The Folstein Mini Mental Score window.
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


