MOSKA: Software for Analysis of Motor Control

Marcelo da Silva Hounsell[1], Tânia Brusque Crocetta[2], Débora Cristine Xavier[3], Eloisa Volpato Heidemann[4], Alexandro Andrade[5]

[1] Santa Catarina State University
Department of Computer Science
Joinville – SC - Brazil

[2] Santa Catarina State University
Center of Health Sciences and Sports
Florianópolis -SC – Brazil

[3] Santa Catarina State University
Department of Computer Science
Joinville – SC - Brazil

[3] Santa Catarina State University
Department of Computer Science
Joinville – SC - Brazil

[2] Santa Catarina State University
Center of Health Sciences and Sports
Florianópolis -SC – Brazil

ABSTRACT— ***This paper presents a software application called MOSKA (MOtor SKill Analyser), which aims to help diagnosis and monitoring of patients with problems of fine motor control. The software uses various advanced interface methods and has various measurements as test results. The measures taken were defined and validated in a previous software proposal. These measures and all of the test section information are recorded into a database that allows the analysis of the patient evolution. Major features, software project structures and development steps of MOSKA will be detailed.***

Keywords— Motor Rehabilitation, Fine Motor Control, Interface

---

1. INTRODUCTION

We are living in the “information age”, in which Information Technology is increasingly used in many areas of human activity. The health sector is one of the areas that has benefitted from this technology, especially in seeking ways of support. Rehabilitation and diagnosis of motor control disorders are examples of sectors that can benefit. These examples are needed when there are losses of brain functions derived from several factors, such as those caused by stroke or accidents, in high-performance athletics or even common accidents in daily life. These disorders can lead to deficits in movement coordination [1], weakness of specific muscles, abnormal tone, abnormal posture adjustments, sluggishness, loss of precision, abnormal synergistic movement and lack of mobility between the structures of the shoulder girdle [2]. Professionals working in the physical therapy area, physical educators and therapists spend considerable time retraining their patients. This therapeutic intervention is usually directed towards amending the motion or the ability to move. Therapeutic strategies are designed to improve the quality and quantity of postures and movements essential for the function. Therefore, the understanding of motor control, and specifically, the nature of movement control, is essential for clinical practice [3]. The aim is to make a more precise diagnosis of the motor control problem to facilitate the patient treatment.

Although there exist proposals for diagnostic protocols developed in software, they are still considered to be proofs of concept in this area. Advanced techniques such as virtual reality (VR) or augmented reality (AR) have been used but little consideration has been given as to make the tests intuitive for the patient and especially to facilitate the therapist monitoring in daily practice through storage and retrieval of measures taken in several tests in order to evaluate the patient's evolution.

The MOSKA software (MOtor SKill Analyser) was developed in order to assist in the diagnosis and monitoring of upper limb fine motor control problems. By motor skills, we are referring to the intention behind the production of an organized and voluntary sequence of movements. All motor skills are acquired through practical experiences that are progressively refined through systematic practice. The possibility of using a computational tool that can measure this progress can help the areas of motor learning and rehabilitation [4]. The ACM software (Aprendizagem e Controle Motor - Motor Learning and Control [5, 6] was taken as the base and significant improvements were made on its facilities. In ACM, a particular patient performs a test by clicking on the starting point of a line and holding down the mouse up to the final point, which is at the other end of this straight line, following as close as possible to its path. Once this is done, the software calculates some metrics such as error and distance, providing the data to diagnose the severity and extent of the problem afflicting the patient's fine motor control. These protocols and metrics have already been the target of research aimed at their validation [7].

The MOSKA software performs the calculation of other metrics such as average speed, maximum error in area and percentage error, in addition to those already calculated by the ACM software. It allows the recording of the patient, tasks, tests, experiments and results and output data in text files. Another major improvement was performed by creating modules and windows that organize and change the interface including the use of Augmented Reality techniques [8], making the system easier to be understood and used.

The aim of this paper is to present the MOSKA software and its features, with emphasis on its structure and computational resources. The importance of developing projects of this nature consists in offering the development of increasingly precise, accurate and valid tools for the assessment of learning and motor control [9, 10].

2. MOTOR CONTROL AND ACM SOFTWARE

Motor control (MC) is a physical therapy characteristic coupled with the ability to coordinate movements generated by integrating a brain command and motor units of muscles and joints [5]. The MC analysis can be useful to assess a person´s fine motor skills in a given time as well as changes during motor rehabilitation treatments. These assessments of motor actions are useful for clinical diagnosis; they may provide information such as motor performance, time and severity of the injury that has occurred.

The evaluation of the MC can be defined as the gathering of data necessary to diagnose a problem or make decisions about the treatment to be used [7]. According to Eckhouse and Maulucci [11], the area of motor rehabilitation research addresses three specific goals. The first is to provide support mechanisms to enable individuals with disabilities in the execution of certain tasks in the environment to overcome their disabilities. The second is to provide quantitative data and evaluation measures to assess the degree of dysfunction of an individual. And the third is to offer treatment programs that allow that individual to improve his performance. Each of these goals requires a multi-sensory means of interaction and a computer system can provide accurate constant feedback about this performance, and quantitative analysis of results. These same authors have conducted extensive research on the use of multimedia resources in cognitive rehabilitation since 1988, and have emphasized the importance of using more precise tools for assessing and monitoring the progress of patients during rehabilitation. They also stress the need for accurate assessments regarding the control of fine motor skills that have the objective of quantifying the MC during the process of evaluating and treating patients.

The goal of diagnosis is to be able to develop strategies for measuring motor skills and improvement on the quality of a patient's movement. During the development of ACM tests proposed based on pre-defined tasks, each test consisted of a straight line drawn in a different direction and orientation in such a way that it is possible to study the patient's difficulty in each case that, in turn, was related to coordinated actions of muscles and bones in a harmonious group capable of predicting motor failures or limitations.

In the work of Sanches [7], a variety of these manual tasks were considered and among them, three were defined as basic standards for testing. They are: straight diagonal, horizontal and vertical (Figure 1). These tasks are purposely the most graphically simple, but involve complex movements that lead to greater ability to display and select fine motor restrictions. This work demonstrated the difficulty associated with the tasks, so that the first task is considered the most difficult one and the third task is the easiest one. The degree of difficulty was validated with 28 women diagnosed with fibromyalgia, which tested six different tasks. After the tests, calculations on average task performance supported the choice of the three standard tests.

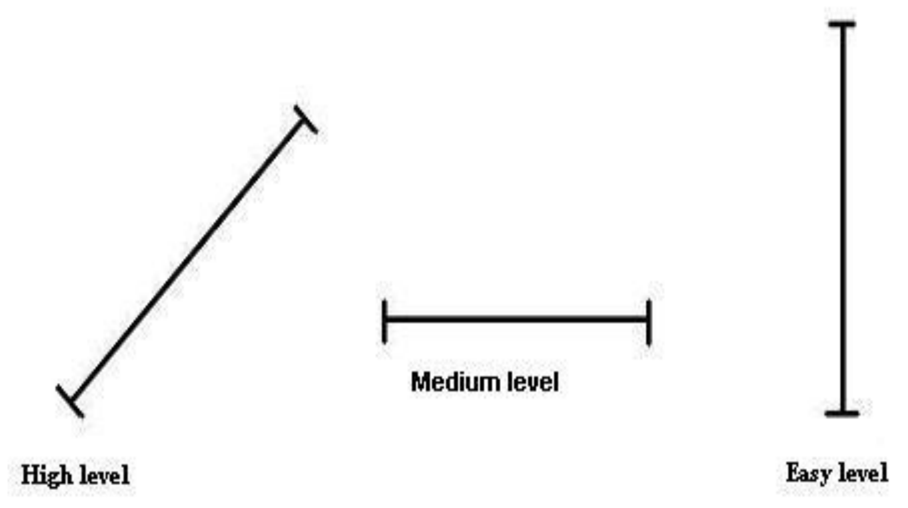

Figure 1: Task set for standard tests of motor control

The ACM software (Figure 2) is monolithic software developed with the Java computer language [12] which uses a simple mouse as the interactive device. It was developed in order to study and assess the patient's upper limb fine motor control.

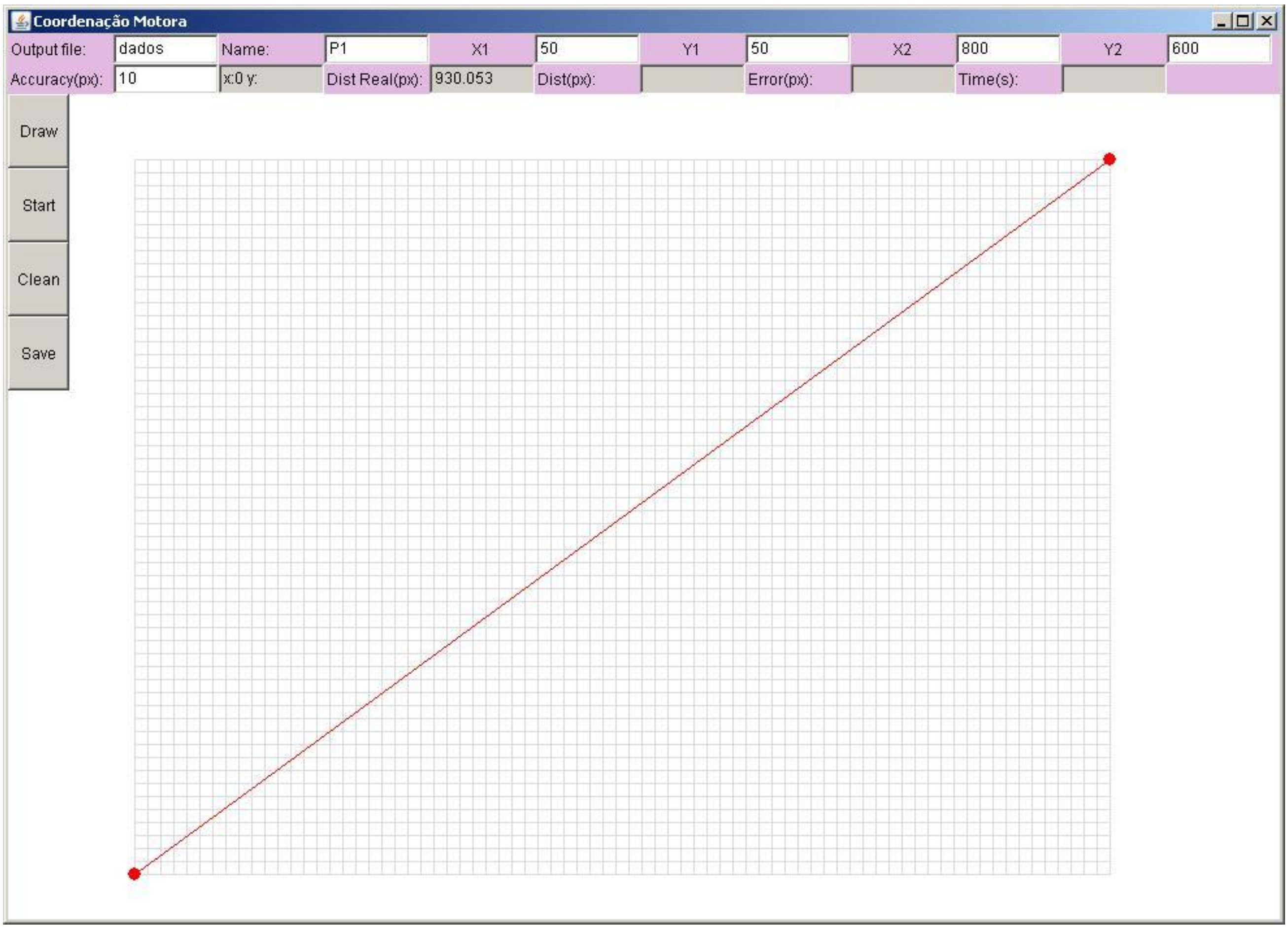

Figure 2: The ACM software

After the test is performed, these metrics are calculated: (a) the distance of the delineation of the patient, (b) the error (in pixels) for the actual distance between the points of the test, and (c) the execution time. All data are recorded in a conventional text file.

The ACM software is conceptually elegant since it proposes simple tasks that can reliably measure important variables for the analysis of fine motor control. However, some technological limitations undermine the spread of the software as a diagnostic tool for daily use: the need to define the tasks manually using coordinate points every time the software needs to be used, and the interpretation of the data on the interface requires a trained technician (keeping in mind that this is not documented or explained in the interface).

An analysis of the ACM software´s functionality limitations or problems was performed. Some of the problems found include: it accepts clicks after the end of the tests, which end up changing the values resulting from the calculations; it has no visual or audible feedback to inform the user that the test is over; there isn't the ability to set tasks or record the patients; there is a need to increase the number of metrics to be calculated in order to improve the wealth of information for diagnostics.

The solution for the problems listed above began to be seen as a prerequisite for the proposition of the new software, MOSKA.

3. THE MOSKA SOFTWARE

The The software is named MOSKA, an acronym for MOtor SKill Analyser and also a reference to the trajectories obtained in the tests, that may call to mind the erratic flight of flies (in Portuguese, MOSCA is a fly).

MOSKA (Figure 3) was also developed in Java because it allows the way ACM calculates the distance (that was the focus of previous studies) which avoids losing all the validation done for this metric. Also the software can be used on computers with different configurations, taking advantage of the easy portability that this language provides.

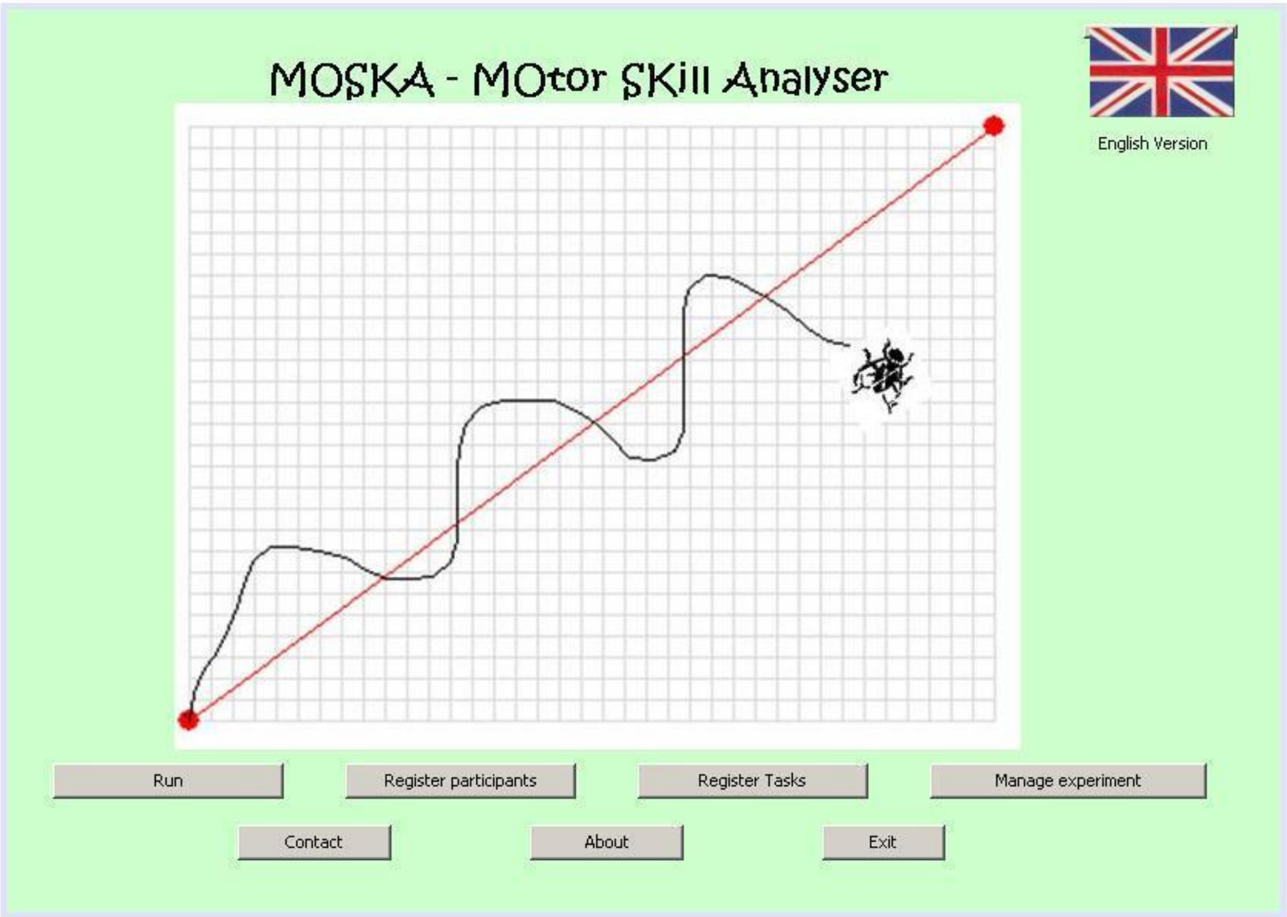

Figure 3: Main interface of MOSKA software developed in Java

For the development, the NetBeans tool (http://www.netbeans.org/features, retrieved march, 2009) IDE 6.1 on Windows 2000® platform was used, along with the JDK 6 library because the previous version of the JDK did not recognize some methods of the Java libraries.

For the database, we decided to use SQL along with the mySQL tool [13], since this tool is portable and easy to use. mySQL is open source software that enables a user to create, maintain and manage electronic databases. These technologies were chosen, primarily because they are free and open source tools.

Unlike ACM, which has only one screen, MOSKA was developed with multiple screens to improve usability and also because of the number of extra features. Figure 4 shows the design of MOSKA navigation screens where you can observe the flow of transitions between screens. For all developed screens, JFrames, a library of Java Swing was used, which are classes that extend the frame version of the AWT library. The frames are top-level windows, i.e., windows that are not contained within another window.

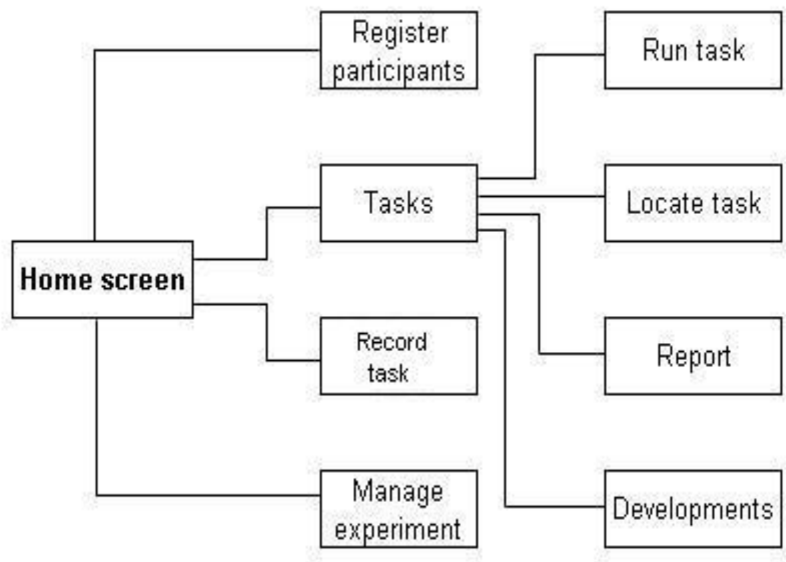

Figure 4: Screen navigation map in MOSKA

For MOSKA´s smooth functioning, it was necessary to define the terms "test", "task" and "experiment" and develop three screens for recording data: patients (Figure 5), tasks (Figure 6) and tests (Figure 7).

A "task" is the definition of a standard referential trajectory that the patient must execute which was defined and analyzed by the therapist based on the ability to measure the motor effort of a specific set of muscles and bones through the proposed trajectory. These tasks are the responsibility of the physiotherapy professional / researcher.

An "experiment" refers to a sequence of tasks selected for a "test" which, in turn, is a section of diagnosis where the patient tries to follow several trajectories (tasks) chosen for his type of problem injury, duly accompanied and / or supervised by a physiotherapist.

On the patient screen (Figure 5), the user should enter the patient's name, gender, date of birth and the experiments in which he must participate according to his problem. Therefore, this screen serves mainly to link a patient to a protocol of data gathering through a particular set of tasks. This protocol is the "experiment" and can have several different tasks recorded by the therapist according to the patient’s pathology.

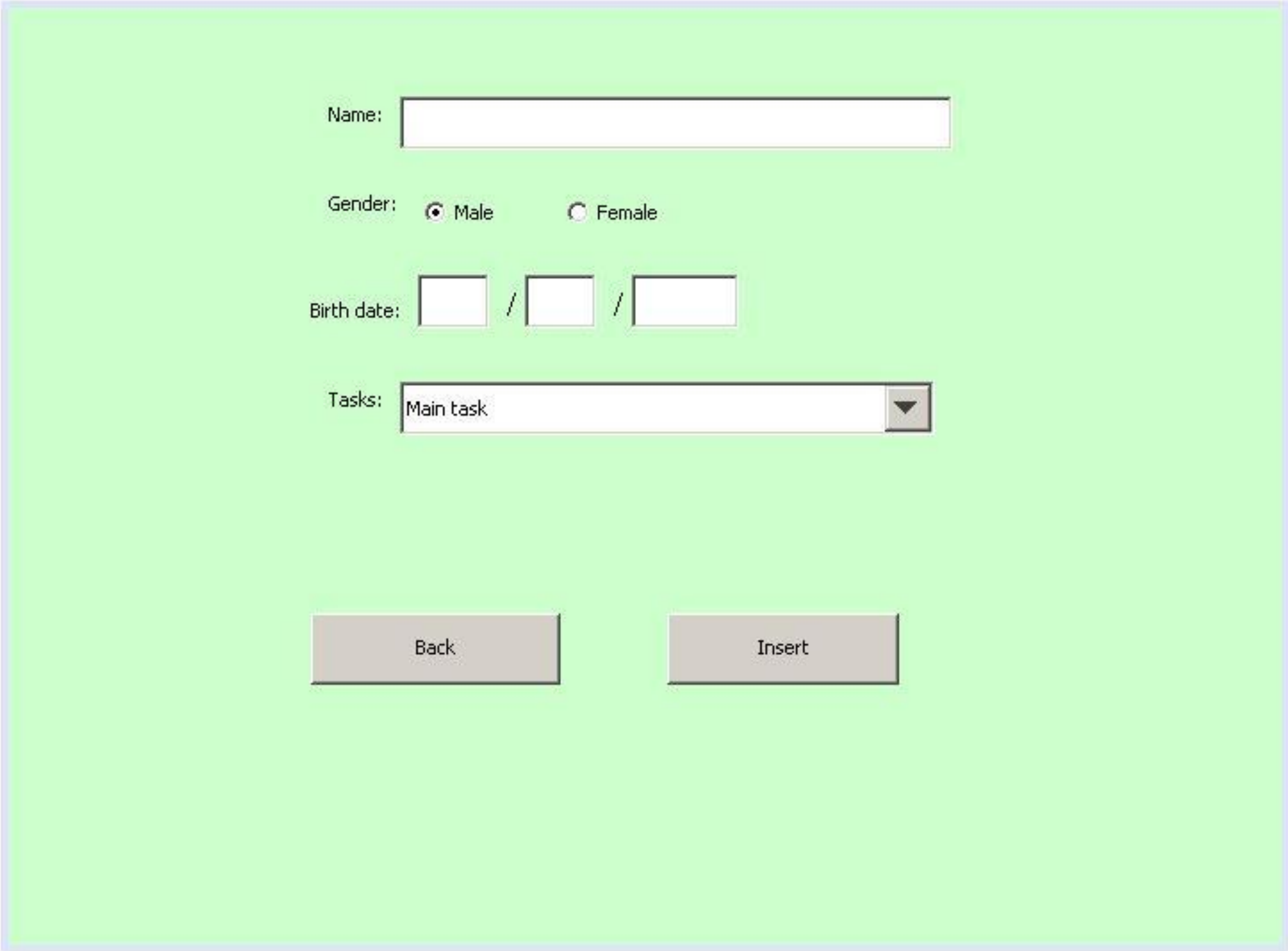

Figure 5: Display of the participant registration

The screen that adds extensibility to MOSKA is the task screen (non-existent in ACM). On the task screen (Figure 6) the user must enter: (a) a name for the task; (b) a textual description of the task or orientation so that the patient knows WHAT to do; (c) size of the terminal point thickness to be drawn (for an easier visual identification); (d) precision (granularity of the movement, in pixels, which is captured by the software - the default value of this parameter was 10 in ACM and was reduced to a 1 in MOSKA); (e) attraction radius (distance to the terminal point at which a task is considered started / finished); (f) number of samples (number of times that each task must be performed); and (g) location (x, y) of the terminal points.

For the latter parameter, the drag and drop method was implemented for the physiotherapist who is setting a task, which is easier than providing coordinates in a text box. Mouse events (MouseEvents) are generated as soon as the user clicks a mouse button. It was necessary to add a mouseListener in the constructor method so that the event functions can be executed.

You can also define if there is a point to be selected for beginning the task or if there should not be an initial / mandatory starting point. Remember that the tasks are trajectory patterns, studied and defined previously that relate to certain motor skills which can be (re) used in several different experiments, but their creation should be based on specific studies (such as those performed by Sanches [7]) and therefore they are not random.

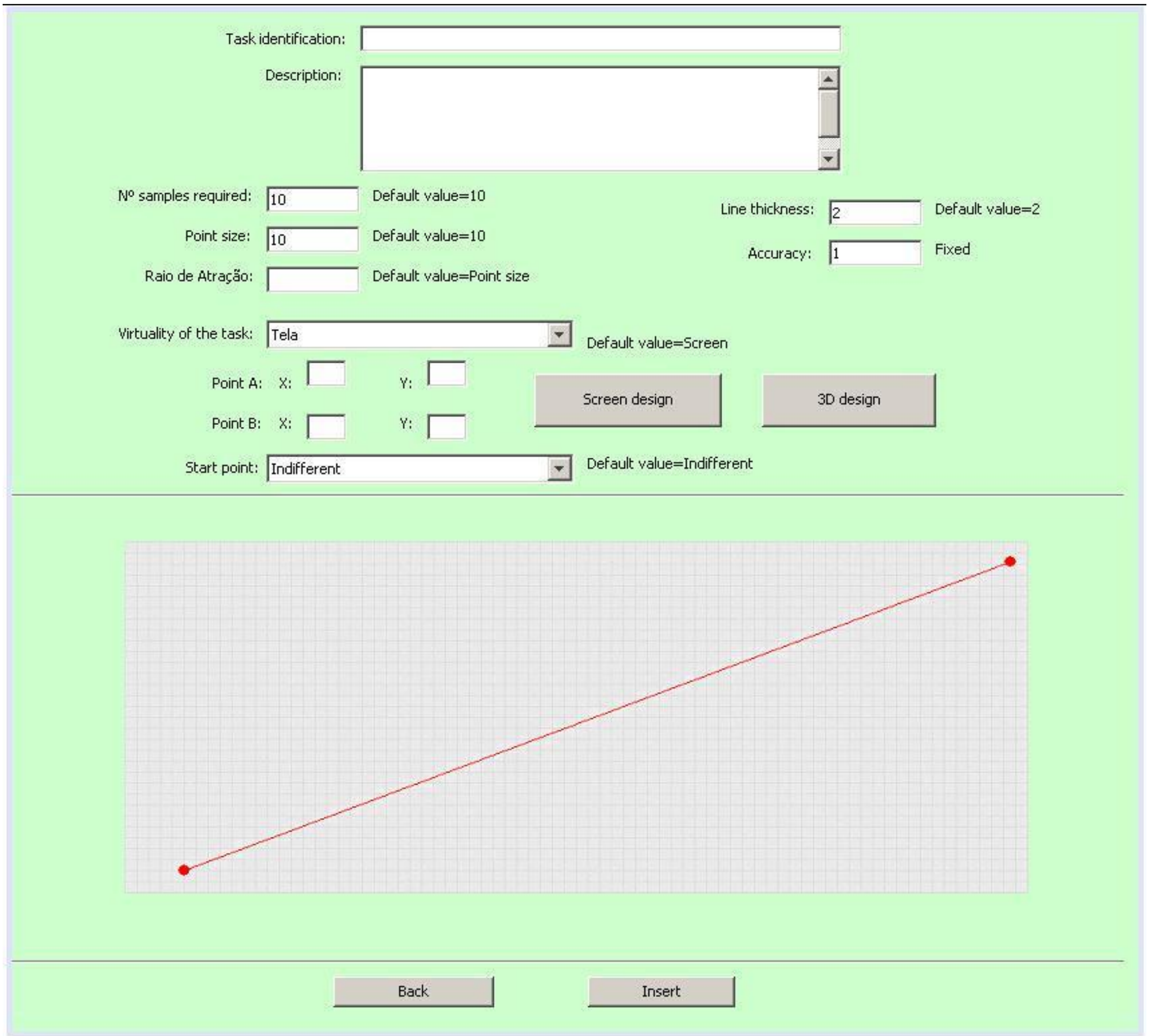

Figure 6: Task screen

Tests are events related to a patient at a particular date and indicate the day of execution of an experiment. To facilitate the association of a patient to a test, a search feature was included in the test screen so patients with similar names can be filtered and listed to narrow down all patients that use the system. It is from this screen that one has access to the test execution screen and to the reports for tests that were already taken.

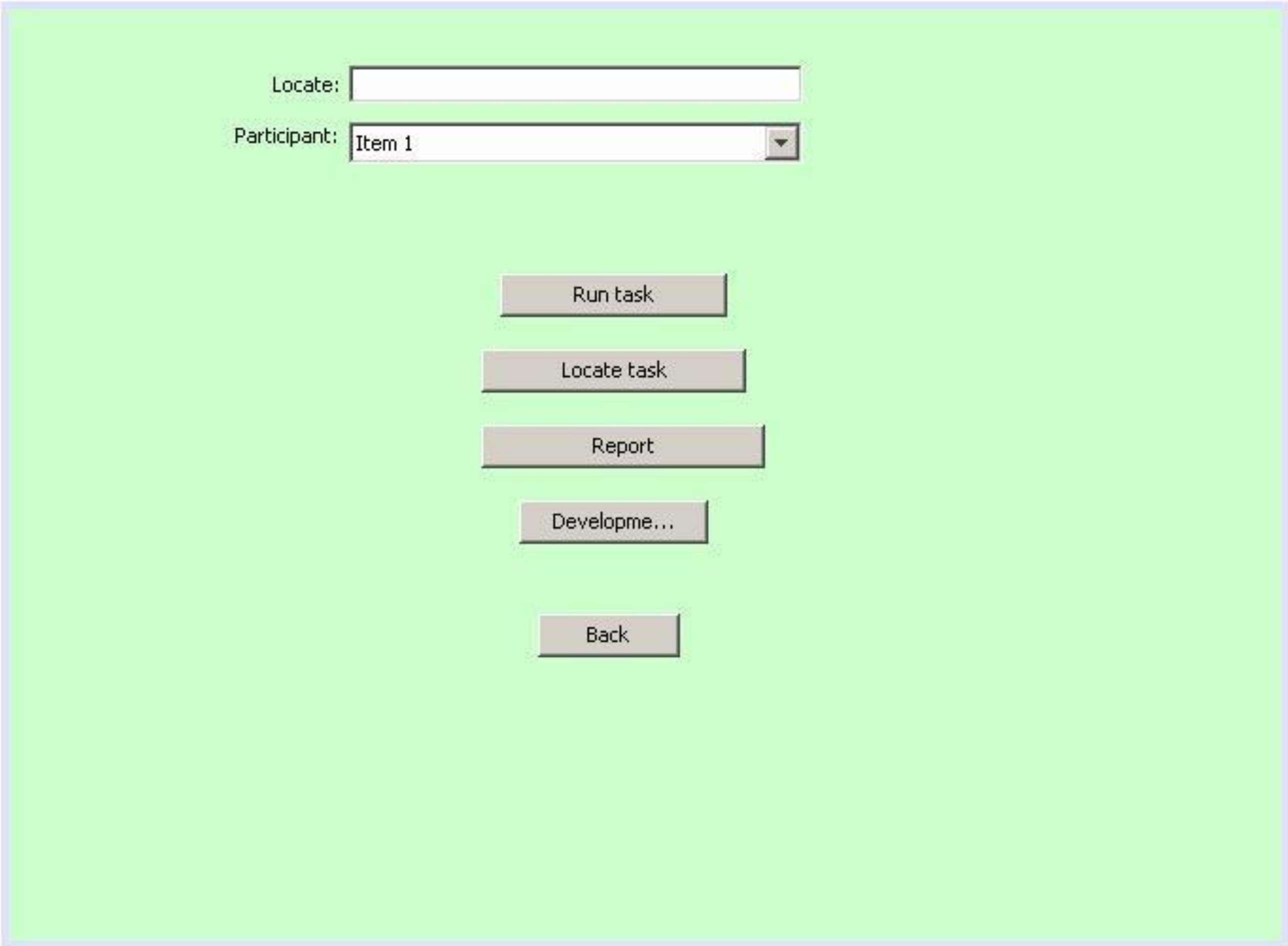

Figure 7: Test Screen

In the Test Execution screen (Figure 8), which accounts for all the functionality in the previous ACM, there is a text area at the bottom of the screen that shows the status of the test.

In Figure 8 the user can use the F1, F2 and F3 function keys to save, reboot and get help on the test (which is a description that was saved beforehand) respectively.

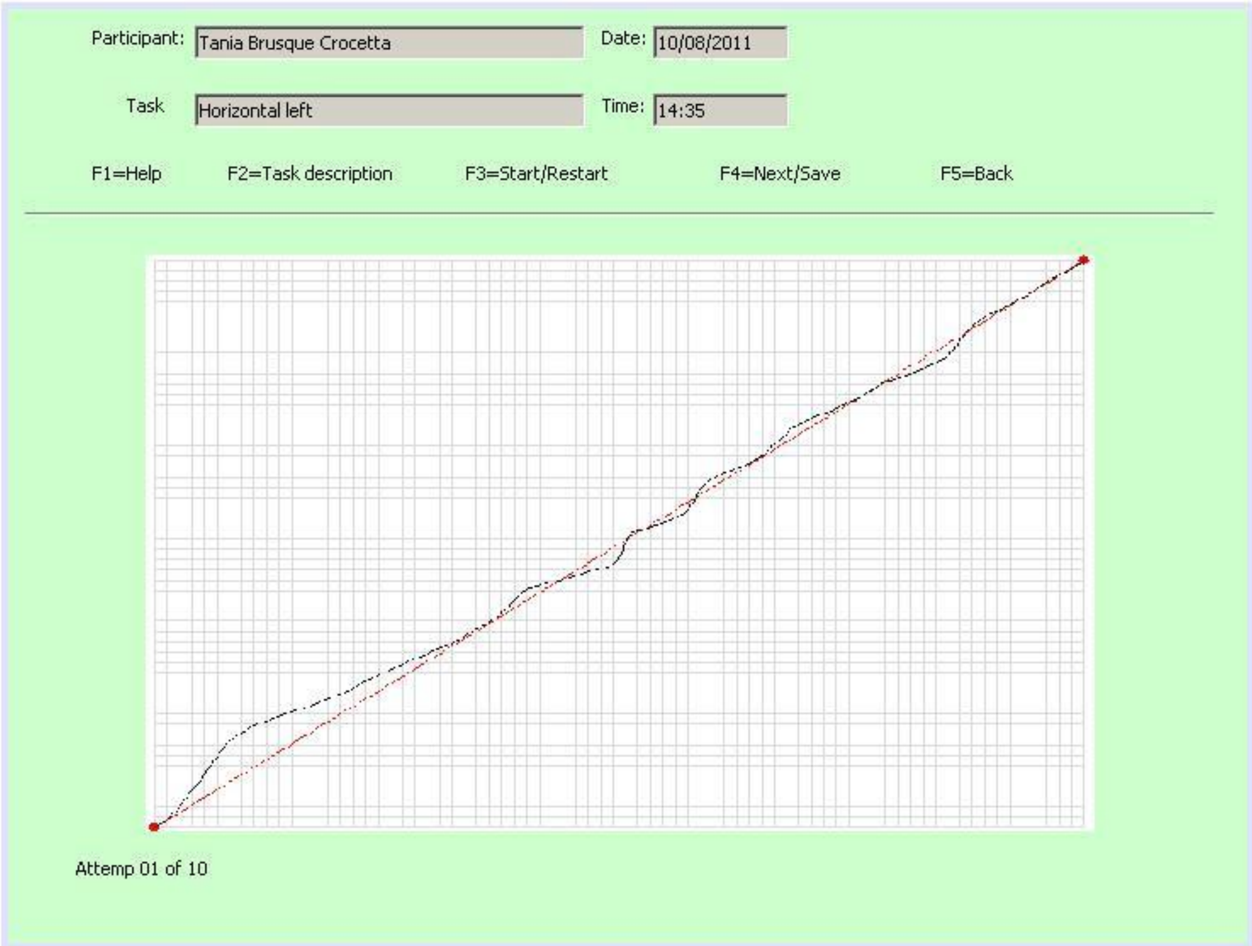

Figure 8: Test Run

The test requires the patient to select a point at the start of the line and follow the line as closely as possible with a selection button pressed down, up to the other end. When the user stops pressing the button, MOSKA calculates parameters such as average and maximum speed, distance traveled, percentage of error and time. These data are saved in the database and used to generate reports to assist in diagnosis but are not shown to the patient during the test.

To assist in the evaluation of patients, MOSKA generates reports with the data from the tests. The results of a patient for all tests on a particular date or task can be displayed. One can also access the data of all tasks that the patient performed on a particular date and also have the ability to view graphs related to his performance on a task with parameters such as average or maximum speed and errors he committed in relation to the straight line, which shows the evolution of the patient in that given task. Figure 9 shows the evolution of the speed parameter average over 10 tests on different dates (on the same task) to a fictional patient and data.

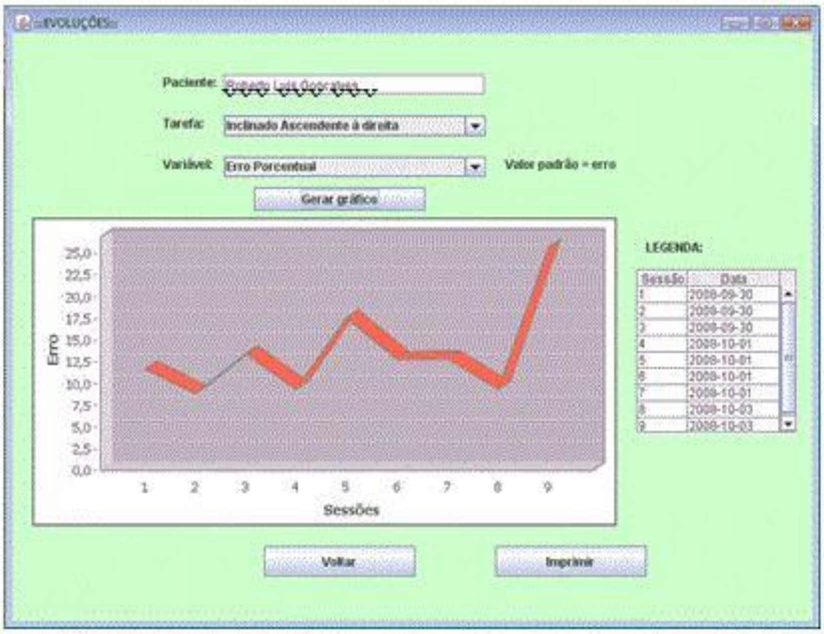

Figure 9: Progress screen

To maintain compatibility between ACM and MOSKA, the data are recorded in text files, as well as in a database.

To model the database, the tool used was brModelo 2.0 (http://sis4.com/brModelo/Default.aspx, retrieved September, 2008). This tool is freeware and used for teaching relational database modeling, and has easy usability. The data were modeled using the Entity and Relationship Model - ERM [14], in Figure 10. Note that the entities that relate many to many are experiments and tasks, because the same task can be in different experiments and each experiment can have multiple tasks. Patients however, may be inserted in only one experiment, even if one experiment may be related to several patients.

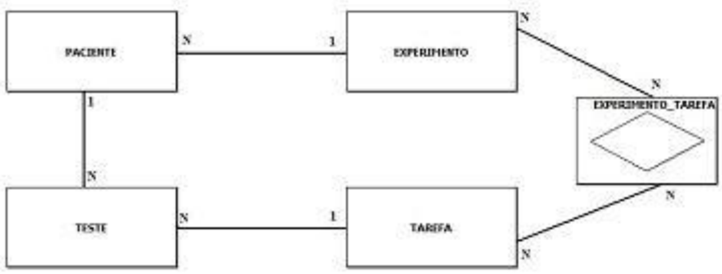

Figure 10: MOSKA´s ERM

The entities or tables created for the proper functioning of the software were: patient, experiment, test and task. A patient is the user who will do the tests; each experiment is recorded for each patient; for each task, different ways of exposing the lines on the screen are elaborated, and during the test the patient will perform different tasks in specific experiments. Each patient can also perform several tests, but each test will be performed by only one patient and each test will have only one task at a time; also, the same task can be performed several times in the same test.

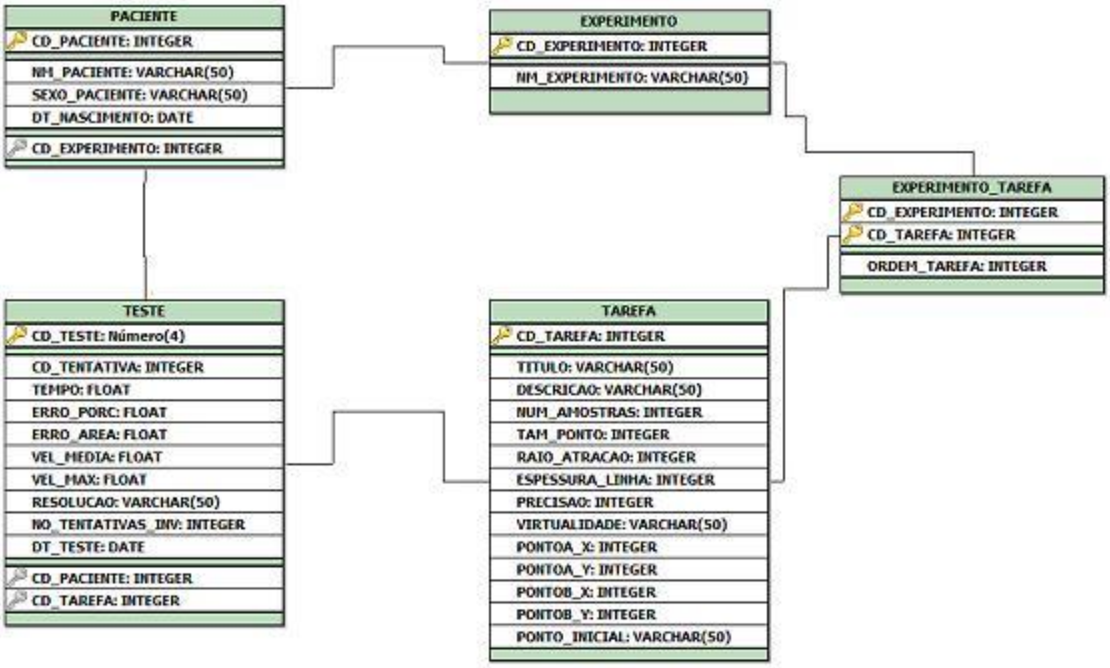

Figure 11: Logical model of database tables

For proper functioning, such as generating reports, a class called BD.java was developed, in which the code to connect to the database created in MySQL was inserted; also, various functions have been prepared for reading from and writing to the database. For each entity, the necessary attributes and what the primary and secondary keys would be were defined. Figure 11 shows the attributes of each entity and the relationship among them.

4. CONCLUSIONS

As motor control problems are increasingly common, the diagnosis and monitoring of these problems are increasingly needed in clinical tasks and there is a lack of a computerized system for this. This article has presented all the main features and structure of the MOSKA (MOtor SKill Analyser) software, which uses metrics proposed and validated previsously. Using MOSKA, devices and tasks (trajectories) are drawn by patients and these are used to measure parameters related to motor control. MOSKA also provides measurements for parameters such as average speed, maximum absolute error and percentage and time, all useful for the diagnosis of fine motor control problems and severity. All information is stored in a database for later retrieval or creation of evolutionary graphs.

Since the proposition of using computational means to obtain objective information about the patient's fine motor control condition has been validated by previous studies (in this case, the error in distance [7, 15]), it would be necessary now to research the contribution of new parameters given by MOSKA.

However, it is possible to say that MOSKA is configured as a modern, innovative solution for the daily monitoring and analysis of upper limb fine motor control problems.

5. REFERENCES

[1] Lewis GN, Byblow WD (2004) Bimanual coordination dynamics in poststroke hemiparetics. J Mot Behav, 36(2), 174-188.
[2] Cacho EWAC, Melo FRLV, Oliveira R (2004) Assessment of motor recovery of hemiplegic patients through the protocol of physical performance Fulg-Meyer. Revista Neurociências, 12(2), 94-102.
[3] Shumway-Cook A, Woollacott MH (2003) Motor control (M. d. L. Gianini, Trans. 2 ed.). Barueri, SP - Brazil: Manole.
[4] Teixeira LA (2006) Motor control. Barueri, SP - Brazil: Manole.
[5] Andrade A, Jardim LJL, Silveira CI, Borges Junior NG (2003) Learning and motor control evaluation software: application to discrete fine and closed motor skills. Paper presented at the X Congresso Brasileiro de Biomecânica, Ouro Preto, MG, Brazil.
[6] Jardim LJL (2008) Designing a system for evaluation of learning and motor control: application for fine discrete and closed upper motor skills. Santa Catarina State University, Florianópolis, SC - Brazil.
[7] Sanches SO (2007) Motor ControlDepression in Women with Fibromyalgia Syndrome. Santa Catarina State University, Florianópolis, SC - Brazil.

[8] Xavier DC, Crocetta TB, Andrade A, Hounsell MS (2009) Using Augmented Reality in Motor Control Analysis. Paper presented at the I Simpósio de Computação Aplicada, Passo Fundo, RS - Brazil.
[9] Magill RA (2000) Motor learning: concepts and applications (A. M. d. Costa, Trans.). São Paulo - Brazil: E. Blucher.
[10] Schmidt RA, Wrisberg CA (2010) Motor learning and performance (R. D. d. S. Petersen, Trans. 4 ed.). Porto Alegre, RS - Brazil: Artmed.
[11] Eckhouse RH, Maulucci RA (1997) A multimedia system for augmented sensory assessment and treatment of motor disabilities. Telematics and Informatics, v. 14, n. 1, p. 67-82. ISSN 0736-5853. Disponível em: < http://www.sciencedirect.com/science/article/pii/S0736585396000196 >.
[12] Horstmann CS, Cornell G (2001) Core Java 2 - Volume I - Fundamentals (Vol. I). São Paulo - Brazil: Makron Books.
[13] Yarger RJ, Reese G, King T (2000) MySQL & mSQL (V. P. Marinho, Trans.). Rio de Janeiro - Brazil: Ciência Moderna.
[14] Cougo PS (1997) Conceptual Modeling and Database Design (18 ed.). Rio de Janeiro - Brazil: Campus - Elsevier.
[15] Gonçalves VP (2008) Learning and motor control evaluation software to hemiparetic subjects: validity and reliability. Santa Catarina State University, Florianópolis, SC - Brazil.