

REMOTE REHABILITATION OF STROKE PATIENTS

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Abstract: In the paper we present a concept of remote rehabilitation of stroke patients. Rehabilitation plays a vital role in helping stroke survivors partly or fully recover their functions lost after brain injury. The duration of the rehabilitation plays a crucial role. We believe that many of common disabilities that result from a stroke can be treated at patients' homes with the use of a specially designed computer system. The architecture of the system is presented as well as its main goals and assumptions.

1 INTRODUCTION

Stroke may have a clear-cut negative impact on patients' psychosocial functioning. There are common disabilities that result from a stroke: decline in attention, selective attention deficits, decline in logical thinking, planning and reasoning tasks, comprehension, synthesis and analysis, weakening of short-term as well as long-term, verbal and visual memory, speech disorders (aphasia, dysarthria).

Rehabilitation plays a vital role as it helps the stroke survivors partly or fully recover their functions lost after brain injury.

Not only does the choice of proper exercises play a vital role as well as their correct and systematic performance but the duration of rehabilitation is generally of utmost importance. It should be as long as possible. On the other hand, prolonging rehabilitation in the rehabilitation centre is expensive and it takes another patient's seat. That is the reason for our claim that after the rehabilitation in the clinic the patient should undergo further rehabilitation at home.

The research presented in (Jack et al., 2001; Broeren et al., 2002; Merians et al., 2002; Svestrup et al., 2003; Otfinowski et al., 2006) proved that the implementation of computer systems specially designed for rehabilitation purposes speeds up stroke

patients' recovery. Using multimedia in post-stroke rehabilitation makes the therapy process more interesting. It also motivates patients and makes them deeply involved in the rehabilitative therapy as it provides an additional stimuli for their hard and long work. The reported results reflect enhancement of our previous development in this field (Kitowski et al., 2009; Wcislo et al., 2009; Probosz et al., 2009; Szombierski, 2009; Wcislo et al., 2010).

The aim of the project presented in this article is to adjust the computer rehabilitation program in such a way as to make it possible for patients to use at home. Some patients are able to continue their rehabilitation under the supervision after leaving the clinic. The doctors are provided with full insight into patients' performance of exercises having the possibility to remotely control and modify the parameters of the rehabilitative program.

2 COMPUTER-AIDED REHABILITATION

2.1 Rehabilitation Stages

Post-stroke rehabilitation consists of four stages:

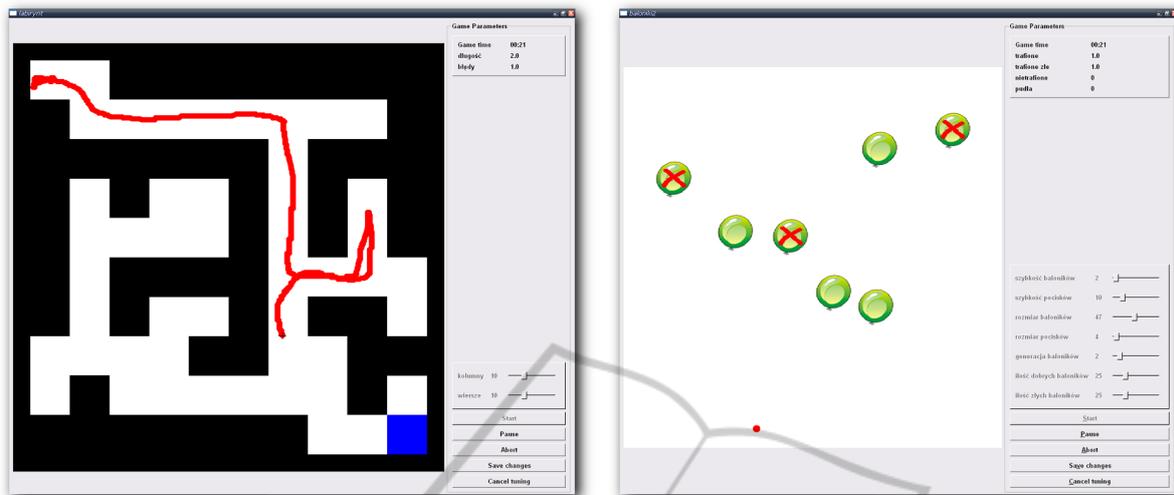


Figure 1: Sample exercises.

- **Stage 1: Diagnostics.** Types and levels of disability are estimated on the ground of neurologic examination and psychological tests.
- **Stage 2: The Main Rehabilitation Stage.** The patients perform adequately chosen exercises within approximately three months' time.
- **Stage 3: Goal Attainment Scaling.** A patient undergoes diagnostic evaluation that assesses their progress.
- **Stage 4: Remote Rehabilitation.** Chosen patients might continue rehabilitation at home – an individualized computer application is prepared for them that lets the doctors monitor the patients' exercises via the Internet. The doctors might also make some changes in the performed tasks.

2.2 Exercises and Trainings

More than 25 rehabilitation exercises have been prepared and verified by psychologists and therapists to target at different disabilities:

- logopedic exercises for patients affected by various forms of aphasia,
- exercises that help retrain stroke-impaired limbs,
- exercises improving cognitive functions (comprehension, association, concentration, memory, etc.).

Some of the exercises take into account more than one disability at a time. Figure 1 shows screenshots of sample exercises. Patients perform the exercises with the use of a joystick, Virtual Reality, a parapodium gloves or a keyboard.

The therapy consists of clearly designed exercises – the exercise quantity and the order of exercises are strictly designated by the training programme. The difficulty level is controlled by exercise parameters. The parameters are selected in such a way that the exercises are neither too difficult (in order not to discourage the patients), nor too easy. During the therapy the computer system stores all the parameters and the patient's results (e.g. the duration of exercise, the number of mistakes). It lets a doctor supervise a patient's progress and, if necessary, modify the exercises and training.

3 REMOTE REHABILITATION

Not all of the patients are able to take part in the remote rehabilitation process. Choosing the proper patients depends on various factors such as medical reasons (e.g. not all of the rehabilitative exercises may be performed without a professional supervision) or the necessity of being the owner of a personal computer and having assistance of somebody who is able to operate the rehabilitation application.

The access to the Internet is not necessary in order to perform the exercises. However, the lack of the Internet access significantly limits the possibilities of the system. A graphical user interface of the software installed on a patient's computer is to be identical with the one that the patient worked on while staying in the clinic. It will facilitate the start of a rehabilitation at home. The system is characterized by the following activities or features:

- The program installed at patient's home sends the achievement scores to the clinic immediately after

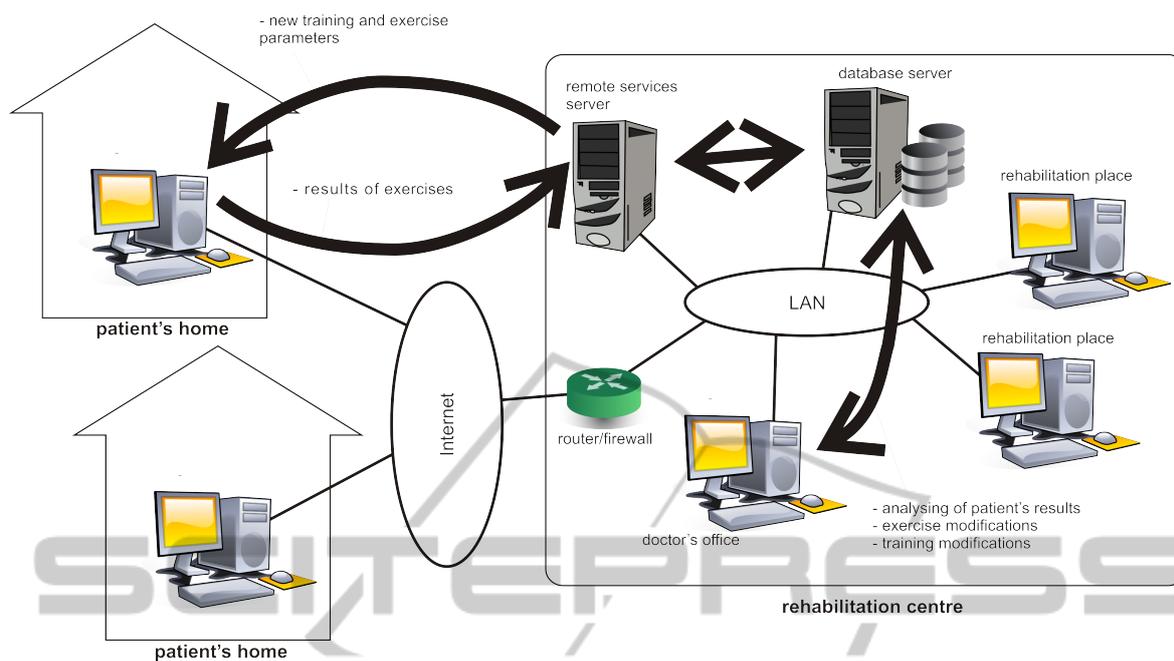


Figure 2: System architecture.

the completion of each exercise, or – if there is no access to the Internet– as soon as the Internet connection is established.

- On the grounds of patient’s scores a doctor is able to change the parameters of the exercises and the trainings so that they can meet the requirements of the rehabilitation better. These modifications are automatically sent to the patient’s application via the Internet.
- Considering the necessity to keep the personal data confidential and secure the transmission between the rehabilitation program and the clinic is encrypted and authenticated bilaterally on the basis of the previously generated (in the clinic) certificates. The login and the password are remembered due to automatic authentication of the patient.
- Due to the same reasons the client’s application are devoid of personal details or the information about the disease since such data is stored only in the rehabilitation centre.

Additionally, a simultaneous audio-video connection between a doctor and a patient during the exercise performance is anticipated. The doctor will watch the patient doing the exercise on one’s computer screen and will be able to provide additional explanation or give another piece of advice.

As the number of patients shall grow due to the necessity of dealing with the remote patients, the advisory system that aids rehabilitation doctors shall be

developed as well. The doctors will be able to get immediate information on each patient including the data about their exercise progress. The system shall automatically highlight the fact that a patient omits certain exercise or does it too rarely; it will also indicate if any exercise is performed too easily or is of great difficulty to a patient.

What seems to be a more difficult challenge is the implementation of the procedures that could propose the modification of exercises on their own (e.g. by making the exercises more difficult) if there is a long break in the Internet connection between a clinic and a patient. It would surely stimulate the patient more and make it possible to avoid the monotony.

4 SYSTEM ARCHITECTURE

Figure 2 presents the architecture of a computer system used in post-stroke rehabilitation. Its most important components are as follows:

- A database server that stores patients’ details, patients’ trainings, parameters of exercises and all of their achieved scores (performance duration, number of mistakes, screenshots, a set of parameters for which the exercise is performed).
- A remote services server for communication with patients’ programs activated outside the clinic.
- Client applications intended for the doctors to follow the patients’ progress and modify the exer-

cises and trainings. Already existing trainings might also be used as templates for creating trainings for new patients – what really facilitates the preparation of a rehabilitation program.

- Rehabilitation applications that are located in the clinic and in the patients' house. They are used for performing the rehabilitation.

All applications are written in C++ using Nokia Qt environment and libraries. As the database server MySQL RDBM system is used.

5 EXPLOITATION NOTICE

The rehabilitation system is in the routine local operation in the Rehabilitation Clinic, CM UJ. According to the tests (Wcislo et al., 2010) for both aphasia disease and concentration and memory dysfunction important improvement of patients' ability was observed. The pilot version of the system for the remote rehabilitation (section 3) has already been validated functionally, proving its reliable operation.

6 CONCLUSIONS

The research has proved the usability of a computer-aided rehabilitation. However, the duration of the rehabilitation plays a crucial role and it is not advisable to finish it after three months. We hope that the remote rehabilitation shall make it possible for many patients to continue their treatment at home and it shall influence their full recovery.

Our future work will be focused on paradigms of exploration of the existing data kept in the relational database system in order to extract knowledge concerning a rehabilitation process of each patient separately. The knowledge will be further used for defining patients' profiles to be used by a kind of advice system for both medical doctors and patients. Its role will be to generate hints autonomously on the basis of extracted knowledge for the doctors and patients concerning continuation of the rehabilitation process.

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