

# A Knowledge-Based System for Rehabilitation of Post-Stroke Patients

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## Abstract

Knowledge-based systems are widely used in health care and more recently in rehabilitation. The most complex and demanding task performed by physical therapists is the rehabilitation of cerebrovascular accident (CVA) or stroke patients. The repercussions of stroke are very subjective, and it can be very complex and demanding to assess and treat post-stroke patients. This research developed a prototype Rehabilitation Expert System for Post-Stroke Patients (REPS). The system assesses a patient based on internationally validated criteria then recommends treatment from a set of commonly used rehabilitation methods. Both the assessment and recommendation are based on the experience of physical therapists at the Fjórðungssjúkrahúsið á Akureyri (FSA) University Hospital in Akureyri, Iceland. REPS demonstrates the viability of knowledge-based systems in the field of physical therapy and post-stroke rehabilitation, in particular.

## Introduction

While knowledge-based systems have been developed in many domains with clinical decision support systems and other knowledge-based systems now commonplace in health care (Coiera, 2003) (Shortliffe et al., 2003), most systems are in the fields of medicine and nursing. Few systems have been developed in the area of physical therapy. This short paper examines REPS, the Rehabilitation Expert System for Post-Stroke Patients.

## Motivation

Fjórðungssjúkrahúsið á Akureyri (FSA) is a university and regional hospital serving the town of Akureyri and the surrounding areas in North-Iceland. The hospital is an institution of knowledge that collaborates with Icelandic

universities on the instruction of health classes and resources in health science.

The rehabilitation of patients that have had a cerebrovascular accident (CVA) or stroke is one of the most complex and demanding tasks performed by physical therapists. CVA results from a sudden and permanent disturbance of blood flow to regions of the brain caused by a blockage in a cerebral artery from a blood clot, from an embolism, or because of a hemorrhage into the brain tissue. As a result, brain cells suffer from a lack of oxygen and other nutrients. Short and temporary disturbances may result in stroke symptoms appearing for only a short time, but longer term disturbances cause a part of the brain to die and upset the activity of other regions resulting in permanent damage and long-term care. Various diseases may cause CVA and the symptoms that appear are dependant on the location and size of the lesion (Sigfússon, Sveinbjörnsdóttir, and Agarsson, 2002).

The majority of symptoms are categorized based on which side of the brain is damaged. Lesions located in the left hemisphere of the brain result in paralysis on the right hand side, aphasia, and an underestimation of ability. Right hemisphere lesions typically result in paralysis on the left hand side, an impaired sense of spatial relations, impaired judgment, and neglect. Other general symptoms include motor apraxia, ideational apraxia, and visual field defects (Baldursdóttir and Middelink, 2003).

CVA patients referred to a physical therapist are evaluated using the CVA Status sheet and the Modified Motor Assessment Scale (MMAS). The CVA Status sheet records the assessment of the patient's mobility. This sheet is used in conjunction with the Modified Motor Assessment Scale (MMAS), which rates an alternative set of patient's abilities. Each is rated on a 0-5 scale every time the patient is visited to adequately track the patient's progress (Carr, 1985). Based on the results of an assessment, an individualized set of rehabilitation exercises is prescribed (Davies, 1993).

## Implementation

Analyzing the MMAS and CVA Status sheets revealed that the CVA Status sheet is used to address some of the

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shortcomings of the MMAS. As a result, the two assessment tools were combined into one when implementing REPS.

REPS was developed using the C Language Integrated Production System (CLIPS) version 6.2.1 as a rule-based expert system. It contains two sets of facts: *initialization facts*, asserted when the program first starts that drive the assessment process, and *patient status facts*, asserted in the assessment process that represent the current status of the patient. The rules are also divided into two categories: the assessment rules and the rehabilitation rules. The assessment rules primarily match initialization facts, while rehabilitation rules only match patient status facts.

### Execution

The expected users of REPS are trained physical therapists accustomed to working with CVA patients. However, some of the users may have little or no experience in the field and may not have any specific training in computer usage.

The system first assesses the patient. This involves seven phases, which correspond with the seven categories of knowledge derived from the MMAS scales and the CVA status sheet. Each phase asks a series of questions. The questions either ask how the patient is rated on a MMAS scale or some specific characteristic of the patient's status.

A scoring scale, which rates the patient's ability to perform tasks, accompanies each MMAS question. The therapist performs the relevant assessment on the patient then enters the points the patient receives on this scale. A score of 2 identifying that the patient could perform the activity described in one item of the scale but was unable to perform the activity in the next item (scored 3).

After going through all the different phases of assessment, the system gives advice on rehabilitation. The rehabilitation phase is based entirely on the information gathered about the patient in the assessment phase and requires no user input. In addition to giving recommendations on rehabilitation, the system can output a status report to a text file, which can be added to the patient's chart.

### Evaluation

REPS was tested for completeness and consistency by searching for eight different types of syntactic errors: redundant rules, conflicting rules, subsumed rules, circular rules, unnecessary IF conditions, dead-end rules, missing rules, and unreachable rules (Gonzalez and Dankel, 1993). None of these errors were found. Informal testing using actual CVA cases was performed to ensure that REPS produces the same output as an expert. No major errors were found and any minor problems were fixed.

### Conclusion

In summary, assessing and rehabilitating a post-stroke patient is a complex task. The goal of this research was to create a knowledge-based system capturing the knowledge used to determine the appropriate therapy. This system aids an experienced physical therapist and will make training new physical therapists easier by guiding them through the process of assessing and rehabilitating a CVA patient.

The current version of REPS is a prototype for demonstrating the feasibility of developing a knowledge-based system for assessment and rehabilitation of post-stroke patients. Emphasis was placed on creating a complete and comprehensive assessment tool that could be expanded and improved through further research. It is obvious that if the system is to be placed in use in a clinical environment it will need further development. Hopefully, REPS will be used as a basis for more extensive knowledge-based systems in the domain of rehabilitation of post-stroke patients.

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