

A Computer-Based Assessment and Rehabilitation of Visual Function in Low Vision Children

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ABSTRACT

In this paper we describe an application that helps in the evaluation and rehabilitation of children with low vision. We have three minor complementary systems: assessment, advisement, and rehabilitation. With the first two we model the children's impairments and needs, while with the last one we train the visual perception.

We have developed some tools to support the information gathering and its evaluation, in detail some questionnaires, perception tests and exercises to train the eye movements.

The next step to follow will be the integration and processing of data, in order to design the child's profile and specific needs. On the other hand, we will construct a first prototype of the advisement system, using the development expert systems techniques. At last, the rehabilitation exercises will be customised in accordance with the visual impairments previously detected.

INTRODUCTION

Recent technical advances in computer science and engineering made possible a higher level of support in the assessment and rehabilitation of low vision patients.

Low vision corresponds to a new therapeutic domain where there is a real need to assess and compare visual rehabilitation methods. The evaluation of results is only of significance if it can be quantified and based on objective criteria, besides the criteria related to quality of life that are already used.

In this way, the development of computer-based applications to perform the recording, comparison, and extrapolation of data gathered in the assessment of low vision patients presents a high relevance.

In 1996, a joint collaborative work has started between the Low Vision Service of Hospital de Santa Maria, of the Lisbon School of Medicine and the Artificial Intelligence Group of the School of Engineering of the Technical University of Lisbon. The initial goal of this collaboration was the development of a database to record and to manage the data obtained in the low vision consultations.

Since the Low Vision Consultation of Hospital de Santa Maria is based on a University Hospital where the co-operation inter-specialities is a constant reality, the child population of our consultation has always had a significant expression. On the other hand, a collaboration protocol with the Ministry of Education allowed the access to the low vision consultation to an increasing number of children, with

visual deficiency, in pre-school and school age.

The need to develop a computer-based application to produce a set of tests that would attract the interest of children has become evident. The goals were the following: to reach a population in the age bracket between 4 and 14, without important cognitive impairment; to allow the evaluation of the alterations or limitations of the visual perception; to promote the training and the rehabilitation of the functional vision; to make possible the analysis of data and the gradual adaptation of the system to the specific needs of each child.

In this perspective, the application reported in this paper, intends to support the evaluation and rehabilitation in children with low vision. Our goal is not to replace the role of the doctor, but rather to help him with this tool.

These features bring a very particular dynamics to the system: the continuous need of being improved and changes. Regarding these aspects, our work does not go beyond a first approach to the problem.

ARCHITECTURE OF THE APPLICATION

According to the introduction, our application intends to provide computer-aided support to doctors and other professionals of the low vision team in their work with children, enabling to follow the child's adaptation to the complexity of visual tasks in an educational setting. In this context, we can distinguish between two phases in the consultation: the phase of *Assessment*, to determine the gravity of the situation of the patient, evaluating the child's performance in daily activities and in tests of visual perception, and the phase of *Rehabilitation*, where it aims at training

the functional vision of the child, helping him or her to surpass his difficulties.

It becomes evident that there is need for the coexistence of specific systems to support each phase: the *assessment subsystem* and the *rehabilitation subsystem*. On the other hand, the requirement of an intermediate system is not less evident: it should be able to establish the rehabilitation plan according to the evaluation already done – we call it *advisement subsystem* (Figure 1).

Following this line of reasoning, we developed tools, in order to make possible not only the information gathering, but also the rehabilitation of the patient. They constitute, in an initial approach to the problem, a first prototype of each one of the above mentioned subsystems.

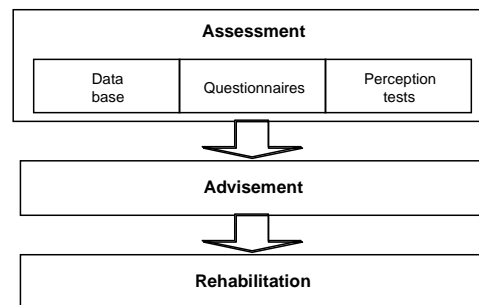


Figure 1: Architecture of the application.

Assessment subsystem

The purpose of this subsystem is to automate the Functional Evaluation of the patient, which is performed during the low vision consultation. The assessment subsystem has three components, the Database, the Questionnaires, and the Perception tests.

Data base

The data base was developed in 1996-97 [Pina & Norte 97], and is organised in the following levels: (1) Personal data; (2) Past history of the patient; (3) Data from the ophthalmologic examination; (4) Data from Multi-sensorial examination; (5) Functional evaluation; and (6) Summary and decisions. These data items are essential for the further categorisation and definition of the patient.

Questionnaires

The functional evaluation corresponds to a three-part questionnaire that aims at the assessment of the degree of difficulty that the child experiences in executing tasks. The first questionnaire, corresponds to tasks related with orientation and mobility; the second questionnaire, corresponds to tasks related with daily living activities; and the third questionnaire, corresponds to tasks related with near vision.

From the selection of the patient, registered in the Database, the subsystem creates the model of the patient and his visual system disease, categorising them after that as a way to produce the most adequate questionnaire.

Perception tests

Alongside the questionnaires, to record information of subjective nature, there are fields to register the results of objective perception tests made by the professionals of the low vision team that evaluate the ability of the child to perform visual tasks of daily life.

These tests are based on the work of Marianne Frostig [Frostig 75], [Frostig, Horne & Miller 87], [Frostig, Lefever & Whittlesey 64], [Frostig & Russel 72], which can be divided in five groups: eye-hand co-ordination, position in

space, figure-ground perception, spatial relations and form constancy. However, in the point of view of the information that they contain, we can additionally characterise them as *selection tests*, *dragging tests* or *drawing tests*.

A coherent system, the Assessment subsystem, was created, integrating these three elements, allowing a first evaluation of the situation of the child. Having into account the information stored in the database on the visual system disorder, the alterations that it induces in the visual function, the limitations and potentials of the individual, it is possible to construct a psycho-physicist model of visual perception, authentic "visual profile" of the child.

Rehabilitation subsystem

This subsystem consists, at first, only in an interactive graphical interface. As in any interface, the decisive factor in its design was the modelling of the user.

There are two users in the system: the examiner and the child.

The task of the child is to interact with the system, being presented with visual stimuli, and, in a simple form, to provide a reply to the visual stimuli. The task of the examiner is, in turn, to lead the evaluation phase, choosing for such the ideal timing to present the child with the questionnaires as well as with the tests of visual perception. In face of this scenario, it became clear that there was need to create a language able to translate easy and intuitively the tasks to be executed, decreasing the learning time of how to use the system, as well as the occurrence of errors.

On the side of the child, the language should conciliate two main aspects. The first one, related with the objects being shown, that must be both appealing and interactive, in order to maximise the interest of the child face to the tasks proposed. The second one,

a little more ambitious, is concerned with the desire to make the objects a challenge to the eyes. It is evident the importance of stimulating the child's visual perception as much as possible, taking into consideration the findings of brain research concerning the speed of the images sequence, levels of colour saturation, brightness and contrast.

Taking all these aspects into account, and due to ages of the patients, we choose a 'metaphor' related with children stories so well known and appreciated by the children.

It was in this context that we had the idea of creating a castle, inside of which are fantasy rooms, accessible through the doors of an interior corridor of the castle.

Inside the fantasy rooms, there are some exercises of visual training, with different tasks to execute. This is a form to present all the tests integrating them in harmony, and to make possible its separate presentation from the evaluation subsystem.

Advisement subsystem

Once the basic tools created for the low vision consultation, we had the ambition of doing more: to support the decisions related to the rehabilitation plan. Of course we are talking about an expert system – a system that contains the rules of thumb used by doctors during the advisement phase, based on the developed tools [Giarratano & Riley 94], but requiring other tools to be developed.

It will be able to make the mapping between the two described subsystems. This means that from the information stored in the Database and once having completed the Functional Evaluation, it would be possible to construct rehabilitation plans, to be presented by the second subsystem.

Of course, such a system must have a similar architecture to a normal expert system, to use the advantages of the

typical functionalities of these structures, as the component of automatic acquisition of knowledge, that will make possible the discovery of rules from the data stored in the system.

CONCLUSIONS

Once all these elements are only a first prototype of a bigger ambition, the need of adjusting them and refining to the new conditions and users (or even to the already existing ones) becomes inevitable.

Beyond these improvements, it still exists the drive to extend the integration of the many subsystems in order to allow the evaluation of the performance of the patient during the rehabilitation phase, thus making possible the gradual adaptation of this system to the specific needs of each child.

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