Knowledge Acquisition System to Support Low Vision Consultation

Cláudia Antunes [1], and J. P. Martins [2]

[1] Instituto Superior Técnico, Portugal
Claudia.Antunes@rnl.ist.utl.pt
[2] Instituto Superior Técnico, Portugal
jpm@gia.ist.utl.pt

Abstract. This paper describes an integrated system to support medical consultations, in particular low vision consultation. In emerging domains where the population is reduced (such as low vision), traditional studies are difficult to conduct and not statistically representative. This work contributes with the creation of an information system, which supports the entire consultation, and is based on three components: a transactional system, a rehabilitation system and a knowledge acquisition system. In particular, the knowledge acquisition system helps the discovery of relations between changes at the organ level and changes at the individual abilities level, and is based on knowledge discovery from databases techniques.

1 Introduction

This work defines and describes an information system, able to support medical domains, where patient's situation is determined based on the combination of their impairment measure and the assessment of their disabilities. Low vision is a particular example of such a medical domain.

The approach presented allows the system, besides recording and managing patients data, to analyze data, in order to discover relations between impairments and disabilities. The system can be used in other medical domains, since transactional system and knowledge acquisition system are independent of the database design. To extend this system to other domains, it needs a new database, since system uses its meta-information to work. The system is composed of three modules: the transactional, the rehabilitation and the knowledge acquisition system. The first one records and manages the patient data, the second one presents a set of rehabilitation exercises and the last one provides the means to discover relations in the recorded data.

In the following section, it is presented a brief description of low vision. Section 3 describes the information system and explains its functionalities and architecture. Section 4 presents the knowledge acquisition system. The results are in Section 5 followed by the conclusions and future work.

2 Low vision

Low vision is a recent therapeutic domain, and is expressed as a partial vision loss that can't be resolved by traditional treatments. Like other medical domains, low vision requires patient monitoring when the patient has lost some abilities due some functional changes at the organ level, caused by a lesion in that organ. In low vision the affected organ is the eye, and lost abilities and functional changes are at the visual level. There are two important aspects in visual assessment: visual functions and functional vision. The issue here is to combine both aspects to establish the patient diagnosis, and therefore determine his rehabilitation plan. How to combine these different aspects is the great problem. Beside the evolution in this domain, there aren't standard measures for most of the visual functions (contrast and glare sensitivity, color vision, binocularity and others) and functional vision stills be appreciated but not recorded. Due to the few number of patients with low vision, studying the impact of visual functions on functional vision is very difficult, and most of the time, these studies aren't statistically representative.

3 Information System

The main goal of this project is to support the entire low vision consultation, including assessment and rehabilitation steps. Beside that, it aims to support low vision investigation. To achieve these goals, the first step is creating an information system to record patient data, including quantitative and qualitative data.

The system is divided in three main modules: a transactional system, a rehabilitation system and a knowledge acquisition system. Both transactional and knowledge acquisition modules have a client/server architecture and manipulate the data recorded in the database. Since both modules use database's meta-information to work, the only thing needed to extend this system to other domains is a new database.

The transactional system is the basic module of the entire system and functions at the operational level, managing the patient data recorded in the database. This system is designed for allow to electronically record patient data, and allow a simultaneous access to data. It has a web interface to the entire system with encryptation mechanisms to secure patients confidential data.

The rehabilitation system consists mainly on a set of exercises for stimulate and train the residual patient vision and its creation was oriented by the need to train the eye-movements (saccadic and persecution) and the eye-hand co-ordination. A detailed description of this module can be found in [1].

4 Knowledge Acquisition System

The knowledge acquisition system is the module responsible for allow data rigorous and systematic analysis, helping in the studies concretization, through a knowledge

discovery from databases process. The term knowledge discovery from databases is used to describe "the non-trivial extraction of implicit, previously unknown and potentially useful knowledge from data" [2]. The main goal of this system is to obtain compact descriptions of the information that is behind the data recorded in the database. The data repository to submit to the knowledge extraction process is the database used by the transactional system. However, the database is in the third normal form, and without any pre-processment it isn't possible to discover relations between different entities. In order to make it possible, the system provides a denormalization pre-processment tool to final users.

The first step in the process is to read data from the database and maintains it in memory. The data reading is done based on the database meta-information (its schemes, entities, attributes and primary keys) and using the WEKA package, programmed in Java [3]. This package provides a set of data mining mechanisms and tools to support the knowledge acquisition process. Having the required data in memory, the next step is applying automatically enrichment techniques, in particular the addition of new attributes derived from old ones (for example patient age from his birthday). At this level, data is ready to be submitted to data mining mechanisms (in particular the Apriori algorithm [4]), and it is up to the user to decide if he invokes this mechanism or applies any pre-processment mechanisms (such discretization, missing values treatment or denormalization) to data.

Denormalization. Denormalization provides a way to re-structure the read data to make possible the discovery of relations between different entities (for example between personal data and pathologies) or between different instances of the same entity for the same patient (for example the relations between different treatments). Denormalization implementation depends on its nature: to relate two (or more) different entities, the system looks for the instances of each entity that refers to a same patient and join them in a new line of a new table; to relate different instances of a same entity (different lines in a table), the system looks for any instance of the entity that refers to a same patient and creates a new table with this data.

After applying data mining mechanisms, discovered rules are reported to the final user with its confidence and support level.

Results

The data used by the knowledge acquisition system, is the data recorded in the low vision consultation of the Hospital de Santa Maria. There are around 150 patients, and only 20% have historical and diagnosis data. On the other side, only 15% have visual functions and functional vision records. So, it was only considered the personal and diagnosis data as the source data to the knowledge acquisition system. Another important aspect is the high amount of missing values between data, and the inexistence of class information.

Nevertheless, the system had discovered some rules, for example, without any pre-processment it were discovered the following rules:

– ·Impairment: installation = sudden => evolution = stable (c=0.8, s=0.2)

– ·Pathology: disease = Macular Degenerescence => type = Acquired (c=1.0, s=0.1)

With table denormalization, it were rediscovered some rules, but also new ones. For example:

– ·Pathology: type#1 = Congenital => type#2 = Congenital (c=0.9, s=0.2)
– ·Treatment: type#1 = Medical => type#2 = Cirurgical (c=0.8, s=0.1)

These rules express some relations between different records of a same entity. With discretization, the system discovered another set of rules. For example:

– ·Impairment Age < 9 => Illness Age < 9 (c=1.0, s=0.1)
– ·Illness Age < 9 => Pathology Type = Congenital (c=0.6, s=0.2)

Although support levels of these rules are very low (10%), they have significant confidence level (greater then 50%) and were already approved by low vision professionals.

Conclusion

This project began four years ago, with the creation of the first database. In the following years, the focus had been centered in the improvement of the processes that compose the assessment of patients' situation, as well as in the creation of the first set of rehabilitation exercises. At the beginning of 2000, the system was fully integrated, to allow a distributed access to eye care professionals, allowing the support of all consultation steps. Now with the conclusion of the knowledge acquisition system, and beside the quantity and quality data problems that characterized data, the system had discovered some interesting relations. These relations have high level of confidence but low support, since patients of the considered population are significantly different.

For the future, at the knowledge acquisition level it would be interesting discover patient profiles, using artificial intelligence techniques, like clustering. With this classification it would be possible to adjust rehabilitation exercises to patient needs, which would be a first step in rehabilitation optimization.

References

1. Neves, C., C.Antunes, I. Lynce, J.P. Martins, A.C. Dinis."A Computer-Based Assessment and Rehabilitation of Visual Function in Low vision Children", in Stuen, C., A. Arditi, A. Horowitz, M.A. Lang, B. Rosenthal and K. Seidman, Vision Rehabilitation, Assessment, Intervention, and Outcomes (pg. 376-379).Swets & Zeitlinger Publishers. 2000.
2. Frawley, W.J., G. Piatetsky-Shapiro, C.J. Matheus. "Knowledge discovery in databases: An overview". AI Magazine, vol. 13 nº. 3 (pg. 57-70). 1992.
3. Witten, I.H., Frank, E.: Data Mining Practical Machine Learning Tools and Techniques with Java Implementations. Morgan Kaufmann (2000)
4. Agrawal, R., Srikant, R.: Fast algorithms for mining association rules in large databases. Proceedings of International Conference on Very Large Databases. Morgan Kaufmann. Los Altos, CA (1994) 478-499