Diabetes Advisor – A Medical Expert System for Diabetes Management

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Abstract. Access to medical services in rural communities, especially in the developing world, is extremely limited. Medical expert systems can play a significant role in alleviating this problem by providing decision support in the giving of advice on diagnosis, treatment and disease management. This study built a prototype for diabetes, a chronic illness affecting millions across the globe. Preliminary evaluation suggests that such a system could be useful for expanding medical services in rural communities and as an educational tool for unskilled medical staff.

Keywords: expert systems, diabetes, decision support

1 Introduction

Diabetes is a serious, life-threatening, chronic disease affecting over 300 million people [1]. It is estimated that this figure will reach 366 million by 2030 [2] with 81% of these diabetics being in developing countries,where medical care remains severely limited.

Fortunately, diabetes can be managed very effectively through healthy lifestyle choices, primarily diet and exercise. Furthermore, people who are at high risk can avoid developing the disease also through diet and exercise. This paper reports on a prototype expert system for the provision of medical advice on diabetes which can be used at home or at a rural clinic.

2 Expert Systems

An expert system is a computer program that emulates the decision making ability of a human expert [3]. The expert system developed in this project, Diabetes Advisor (DA), is designed to give advice to patients with diabetes. DA can also be used to educate people without diabetes in order to raise awareness about the disease and to enable people to assess their own risk and take appropriate action. In addition, DA can be used as an educational tool by unqualified medical staff to learn more about diabetes and become better prepared to attend to patients safely and effectively.

Expert systems can provide *decision support* or can be used as *decision makers* [4]. In the decision support role, expert systems assist the clinician. This can reduce the cost of healthcare for the patient because the clinician can consult with the expert system in the same visit instead of referring the patient to a specialist. In rural communities, an expert system can provide decision support or can be the decision maker if medical staff are unqualified or completely absent. In the decision making role, expert systems would be used in place of the clinician. While this might be seen as risky, the risk from getting no medical attention at all is greater than that posed by getting it from a computer.

2.1 Expert Systems for Diabetes

In [5], Hernando *et al.* described DIABNET, an expert system whose purpose was to assist clinicians in treating patients with gestational diabetes. As this form of diabetes tends to be temporary, patients do not have enough time with the disease to learn how to manage it, and frequent visits with clinicians are necessary. DIABNET aimed to reduce the frequency of such visits by giving recommendations on insulin dose adjustment and meal planning. In addition, DIABNET could monitor patient data continuously and alert clinicians when unusual readings appeared, allowing clinicians to attend to patients remotely. Rudi *et al.* proposed a similar expert system [6] for giving diabetes management advice as well as storing clinical data and enabling doctors to remotely monitor patients. In [7], Garcia *et al.* described ESDIABETES, an expert system for helping patients monitor and control their blood glucose level. These systems suggest that diabetes management is particularly amenable to expert system intervention.

3 Development of DA

DA is a medical expert system prototype for medical advice provision on diabetes built using the JESS expert system shell [8]. DA is designed as a menu based interactive system and the language is simplified so that novice users can easily understand it. It gives advice at various points in the course of the consultation to avoid giving a large amount of advice at the end of the consultation as this could overwhelm and confuse the user. People might not have the patience to read so much information at once. The system gives some information for each symptom to the user during the consultation process and thus helps the user to gain more understanding of diabetes. This is an advantage over consulting a human because doctors do not normally have time to explain their reasoning to each patient. The final output of a DA session is a summary of the main recommendations that a patient will need to take note of and may tell the patient to visit a clinic or to see a doctor.

3.1 Knowledge Engineering

Acquiring high quality knowledge and validating it can be extremely time-consuming. Converting it into a form suitable for a computer program (knowledge representation) adds another layer of complexity. In this project, knowledge acquisition occurred through meetings with the diabetes expert in which notes were written by hand and conversations were audio-recorded. This knowledge was converted to IF-THEN rules as required by JESS.

3.2 System Development Methodology

An iterative system development approach was used. After the first meeting with the diabetes expert, the first prototype was designed. This prototype gave advice on exercise plans, eating plans and monitoring sugar level. The system first asked the patient about the symptoms or warning signs they were experiencing. A second meeting with the expert revealed certain flaws and what improvements were needed, as follows: the system was not able to consider all aspects relevant for decision making; advice was only provided at the end of the consultation; the system was not giving enough advice to patients; the language used was not simple enough for people with poor literacy; the system asked for unnecessary information that was never used in formulating advice; the system assumed only people with diabetes would use the system (this assumption was removed in the final system). The expert also provided magazines, leaflets and other documents to aid in the implementation of the improvements identified in the first prototype. A second prototype was designed incorporating the suggestions made. Below are some of the questions the system asks the user.

Do you experience increased thirst? (y/n)
Have you experienced unexplained weight loss? (y/n)
How often do you eat fruits and vegetables? (0-9)
How many meals do you eat per day? (0-9)
Do you smoke? (y/n)
Do you consume alcohol? (y/n)
Do you monitor your blood sugar level? (y/n)
Do you experience unexplained weakness and exhaustion? (y/n)

The final system had a simple text-based user interface which provided entry into the following use cases.

1. Receive diabetes advice
2. Learn more about diabetes

The next section gives two scenarios of the sytem in use.

3.3 Use Case for Diabetes Advice

Patient A, who has diabetes, provides information to DA. This information is represented as facts within DA. These facts, then, cause the appropriate rules to fire, and these rules in turn generate output for the user which is tailored to her needs. Different ouput would be generated for someone without diabetes.

Patient A is a 20 year old woman, who has been living with diabetes for 2 years. She does not know enough about diabetes management and has been taking insulin to treat her diabetes. DA responds with various recommendations as the interaction proceeds. Some of the recommendations given to patient A are shown in the listing below. (Intervening prompts by the system are not shown.)

Advice for Patient A: Now that you have diabetes, you must make sure that you manage your diabetes properly. Please remember to take your medication as your doctor tells you. Remember that you must not use the same place for injection every time because your medication can stop working. It is good that you have a healthy eating plan. Remember to eat your meals in small portions. 3 meals a day with snacks in between your meals is advisable. High fibre food: Eat 2 to 3 portions of this type per meal.

3.4 Use Case for Diabetes Information

If the user selected to learn more about diabetes, the system displays a menu of eight topics covering what diabetes is, its differnt forms, its causes, symptoms, treatment, prevention, medication and complications. We consider this to be an equally, if not more, important feature of the system because getting people educated about the disease can help them keep it at bay.

4 Evaluation

The diabetes expert used in developing the system checked the knowledge and behaviour of the first prototype and gave feedback, including suggestions for improvement. It was also important, as recommended in [5], to use other evaluators who had not taken part in the development of DA. Therefore four medical students nearing completion of their degree were used as additional domain experts. They were asked to interact with the final prototype and to give feedback via a questionnaire. The questionnaire contained desirable properties in such a system, and the respondents were required to use a Likert scale to rank how strongly these were present in DA. The feedback was largely positive; respondents' median response was Agree to 7 of the 9 statements below and Strongly Agree to Statements 7 and 8; these were the two highest ranks, the others being Neutral, Disagree, Strongly Disagree and Not Applicable. This indicated that the system was useful and met its intended goals.

1. A person with no computer skills can be able to use this system.
2. The clinics or hospitals can use this system to learn more about the required expertise.
3. This system can free physicians from boring routine tasks.
4. This system can be very useful to physicians or nurses in rural areas.
5. This system does look at all branches needed to be considered by a physician while giving advice.

6. Even though I am a medical student I can rely on this system for advice instead of going to a specialised doctor.
7. I would recommend this system to my diabetic patient if necessary.
8. The advice provided by the system is correct and useful.
9. The advice provided by the system can be understood by people with poor literacy.

5 Conclusion and Future Work

In this study, a prototype expert system for the provision of advice on diabetes was constructed. It was evaluated and found to be useful. As this was only a preliminary phase of a planned larger study, the evaluation was not very extensive. A larger number of domain experts are needed to more fully evaluate the system and to confirm the positive results seen here. Secondly, field testing is critical before actual deployment. That is, the system needs to be tested with a random sample of actual rural patients so that its efficacy in its intended environment can be confirmed.

Another important improvement that is needed is in the user interface. The DA prototype has a basic textual interface, which falls short in terms of usability. A graphical user interface or a speech-based interface would be more desirable, and this is included in the plan for future work. In addition, a system like this one could be made accessible to more people if deployed as a Web application. This is also a planned extension to the work in the near future.

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