VHCS: A WEB-BASED E-HEALTH SYSTEM FOR ALOPECIA DIAGNOSIS

SITI SORAYA ABDUL RAHMAN, FAZIDAH OTHMAN, TEO WAI SIE
Faculty of Computer Science & Information Technology
University of Malaya
50603 Kuala Lumpur
MALAYSIA
siti_soraya@um.edu.my, fazidah@um.edu.my, twsie@yahoo.com

Abstract: - This work presents the design and development of a web-based e-health system that aims to diagnose different types of common alopecia or "hair loss" disease. The paper describes the process of acquiring and codifying the knowledge of hair loss disease using expert system approach. The acquired domain knowledge is modeled using decision tree graph followed by representation in the form of production rules before it is transformed into knowledge base. The system architecture and its components such as knowledge base, inference engine, user interface, and explanation functions are also described. The system has 152 rules and 49 images for different types of symptoms and diseases. It can diagnose up to 17 types of diseases of most common non-scarring alopecia.

Key-Words: - E-Health System, Expert System, Web-based Expert System, Knowledge Base, Alopecia Diagnosis

1 Introduction

E-Health is defined as the application of Internet and other related technologies in the healthcare industry to improve the access, efficiency, effectiveness and quality of clinical and business processes utilized by healthcare organizations, practitioners, patients, and consumers in an effort to improve health status of patients [4].

Nowadays, e-health system not only used to store, manipulate and retrieve data; they are increasingly taking on the role of assisting human decision making. Technologies used for e-health system have been widely explored. Integrating Artificial Intelligence (AI) techniques is one example in supporting the system. One of the major contributions that AI has made is in the area of problem solving. AI programs that exhibit expert-level competence in solving problem in a domain of narrow specialization are called expert systems. An expert system contains domain-specific knowledge derived from the human expert. Domain refers to the problem area for which knowledge is captured in an expert system. The main goal of the development of expert system is to provide expertise of domain expert widely available and transferred to a computer program. As for this system, named VHCS[1], the expert system approach helps in providing solutions and suggestions for the treatment to the related hair loss diseases being diagnosed.

Hair loss problem occurs world-wide in both genders of all ages. Generally, people will experience of hair shedding of about 50 to 100 a day. This amount of hair loss is normal. However, excessive of hair loss beyond this amount indicates hair problem. Hair loss or alopecia is a disorder which involves the loss of hair from skin areas such as from the head scalp, face, i.e. eyelashes, eyebrows, beards, and loss of hair on body. Hair is important to the appearance of male and female. Therefore, people with alopecia suffer tremendously. Careful diagnosis of the type of alopecia disease will aid in selecting the right treatment solution.

[1] VHCS stands for Virtual Hair Care Specialist.

2 Domain Background

The domain knowledge is essential for the development of an expert system. There are several different types of hair loss, each with a different cause. Hair loss can be categorized into two types: (1) Non-cicatricial or non-scarring alopecia, (2) Cicatricial or scarring alopecia [8]. Non-scarring alopecia cause temporary hair loss, hair follicles remain undamaged thus potentially reversible. Causes of non-scarring alopecia include iron deficiency, severe stress, pregnancy, or pulling hair. Scarring alopecia is associated with destruction of hair follicles thus irreversible hair loss. Causes of scarring alopecia include scalp diseases, bacterial infections of hair follicles, and trauma such as burns, radiation, and chemical injuries.

The diagnosis scope of the system is limited up to 17 types of diseases of common non-scarring alopecia:

i	Alopecia Universalis
ii	Alopecia Totalis
iii	Alopecia Areata
iv	Alopecia Barbae
v	Monilethrix
vi	Trichophagia
vii	Trichotillomania
viii	Ophiasis
ix	Sisaipho
x	Traction Alopecia
xi	Loose Anagen Syndrome
xii	Telogen Effluvium
xiii	Anagen Effluvium
xiv	Female Pattern Baldness
xv	Male Pattern Baldness (Stage 1)
xvi	Male Pattern Baldness (Stage 2)
xvii	Male Pattern Baldness (Stage 3)

3 Knowledge Acquisition

Knowledge acquisition (KA) refers to the process of acquiring, studying, and organizing the domain knowledge [2]. The KA objective is to compile a body of knowledge on the problem of interest to be encoded in an expert system. Acquiring knowledge from the domain expert has always been regarded as the "bottleneck" in the development of an expert system because it remains the most difficult task [2] as adapted from Hayeth-Roth et al., 1983. This is mainly due to communication problems between the knowledge engineer (KE) and the expert, the inability of the expert to verbalize the knowledge and the difficulty of the KE to extract knowledge from the expert [2].

In this project, the KA process consists of expert interview. The author who acted as KE interviews a consultant trichologist. The expert provides valuable information to assist the author in developing the system. Furthermore, references from specialized books [1] [5] [6] and from different websites [7] [8] [9] appropriate to the domain were also considered. Continuous process of knowledge acquisition through rapid prototyping was used so as to ensure sufficient and concrete knowledge is acquired. This strategy not only aids KE to represent the domain knowledge correctly, but also assists the experts to validate the system's reasoning process and its results.

The acquired domain knowledge is then analysed, modeled using a decision tree graph, before finally being represented in the form of production rules in the knowledge base. Decision tree graph is a diagram consisting of nodes and branches that depicts the solution to a given problem. Figure 1 and Figure 3 depict the decision tree graph for backward and forward chaining reasoning respectively. Backward-chaining is described as top-down reasoning because it reasons from hypotheses down to the low level facts (evidence) which support the hypotheses. In contrast, forward-chaining is referred to as bottom-up reasoning since it reasons from low level problem facts to the top level conclusions that are based on the facts [3].

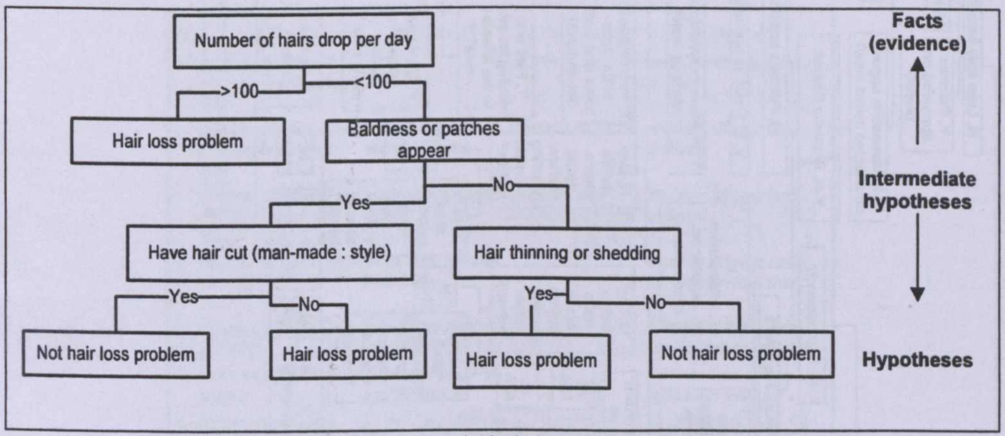

Fig. 1 Backward chaining decision tree

4 System Design and Development

4.1 System Architecture

The system is a web-based application. Public can access to the system at anytime and any place, wherever an Internet connection is available. The system is based upon client/server three-tier architecture. The three layers are client tier, application tier and data tier. The client web browser supports the user interface. The server software in an application tier supports the inference mechanism of the system. This server side inference capability is programmed using PHP scripting language and developed over Microsoft Windows XP Professional platform.

The server-side knowledge base in data tier plays a vital role in the system development. It is used for storing rules and facts needed for disease diagnosis. The knowledge base is designed with MySQL Server Database. Figure 2 shows the three-tier web application architecture.

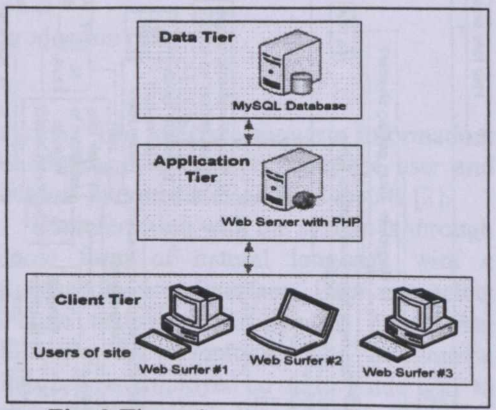

Fig. 2 Three-tier system architecture

4.2 System component

The following sub-sections explain the different component of VHCS in brief.

4.2.1 Knowledge Base

The knowledge base contains set of symptom-consequent pairs in the form of IF-THEN rules, also known as production rules. The decision tree graphs depicted in Figure 1 and Figure 3 above is first converted into production rules before it is stored in a knowledge base. The system has over 152 rules for different types of diseases and symptoms.

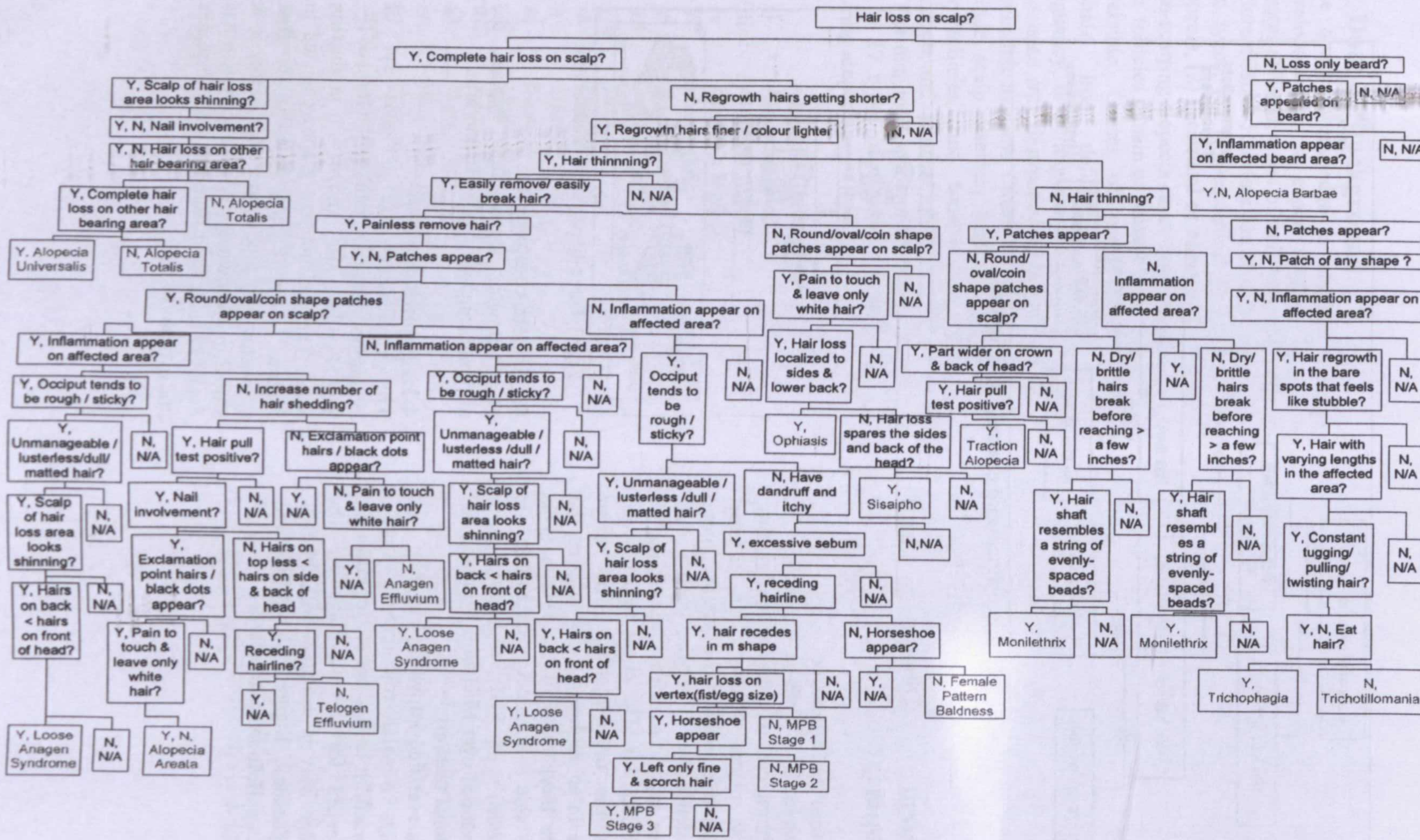

Fig. 3 Forward chaining decision tree

id	IF_Part	AND_Part1	AND_Part2	THEN_Part
a	number of hairs drop per day greater than 100			problem IS hair loss problem
b	number of hairs drop per day less than 100	baldness-patches appear IS yes	man-made IS no	problem IS hair loss problem
c	number of hairs drop per day less than 100	baldness-patches appear IS no	hair thinning-shedding IS yes	problem IS hair loss problem
d	number of hairs drop per day	hairs drop greater than 100		number of hairs drop per day greater than 100
e	number of hairs drop per day	hairs drop less than 100		number of hairs drop per day less than 100
f	baldness-patches appear	baldness-patches appear =yes		baldness-patches appear IS yes
g	baldness-patches appear	baldness-patches appear =no		baldness-patches appear IS no
h	hair thinning-shedding	hair thinning-shedding =yes		hair thinning-shedding IS yes

Fig. 4 Sample of system production rules

4.2.2 Inference Engine

The inference engine of the system emulates human expert reasoning process. It derives some conclusions from the problem facts contained in the working memory and the domain knowledge contained in the knowledge base. Working memory is the component that contains the problem facts of a given session, both entered by the user and inferred by the system along with conclusions drawn by the system.

The system employs both backward chaining and forward chaining inference technique to perform diagnosis. The system will first try to prove or disapprove a hypothesis – is the user facing hair loss? The system would then test the hypothesis by obtaining problem data and attempts to conclude a hypothesis from this data – type of hair loss disease. The system use backward chaining for the first task and forward chaining for the second task. Figure 1 and 3 illustrates chaining graph structures for backward and forward chaining, respectively.

4.2.3 User Interface

The interface serves as medium through which the user communicates with the system. The interface requests information, obtain required answers from the user and outputs intermediate and final results [2].

The interaction with the system is through some form of natural language with a multimedia user interface. User can select simple textual display and/or image that illustrate the symptoms. The multimedia interface is employed so as to guide user to come to a decision by choosing matching symptom images with symptom descriptions. This, in turn increases the accuracy of disease diagnosis.

4.2.4 Explanation Subsystem

The system incorporates explanation facility, the ability of a system to explain its reasoning. The function of this facility is to reveal *WHY* a question is asked during a consultation and *HOW* the system reached a conclusion. *WHY* query is made by showing the rule which it is trying to prove. The system needs to know the premises of a certain rule are true so that the conclusion can be inferred. *HOW* query accessible at the end of every consultation is justified by tracking back through the rules that established the conclusion.

5 System Testing and Implementation

System tests, such as system validation and user acceptance were carried out as a continual process throughout the project. System validation was carried with the help of domain expert in an attempt to validate the system's knowledge and its reasoning. For the user acceptance test, the system was made available to the user and their comment was gathered by conducting user feedback survey. The primary objectives of user acceptance test were to test the interface and to determine the impact of how well the system addresses the needs of the user [2]. An analysis of system implementation results reveals that:

- In general, the system has been an effective aid to user to diagnose hair loss disease. The system reasons in a way similar to that of expert and draws the same diagnosis results as the human expert.
- Identified diseases, final results and suggested prescription on treatment are very informative and useful.
- The multimedia user interface is very effective. The user finds it easier and more accurate to tell symptoms by matching symptom images with symptoms description.
- Explanation subsystem is welcomed and regarded as very convenient tool for user.

6 Conclusion

This paper presents the design and development of a web-based e-health system for alopecia diagnosis. The presented example shows that the diagnosing procedure generated by the system is practical and the system does work. However, the system in its present version has a number of weaknesses which will be addressed in future work:

- The system is limited to diagnose up to 17 types of common non-scarring alopecia. As a result, the intent to extend and augment the knowledge base for more types of diseases covering scarring alopecia is anticipated.
- Diagnosing merely on signs and symptoms. For more accurate result, hair analysis is necessary. The hair analysis results are needed to confirm and support the hair loss disease diagnostic process.

The current version of the system was a proof-of-concept prototype. Through several prototype trials, VHCS proves that an expert system could be designed successfully for hair loss domain.

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