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An expert system design to diagnose cancer by using a new method reduced rule base

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ABSTRACT

Background and objectives: A Medical Expert System (MES) was developed which uses Reduced Rule Base to diagnose cancer risk according to the symptoms in an individual. A total of 13 symptoms were used. With the new MES, the reduced rules are controlled instead of all possibilities (2^{13}= 8192 different possibilities occur). By controlling reduced rules, results are found more quickly. The method of two-level simplification of Boolean functions was used to obtain Reduced Rule Base. Thanks to the developed application with the number of dynamic inputs and outputs on different platforms, anyone can easily test their own cancer easily.

Methods: More accurate results were obtained considering all the possibilities related to cancer. Thirteen different risk factors were determined to determine the type of cancer. The truth table produced in our study has 13 inputs and 4 outputs. The Boolean Function Minimization method is used to obtain less situations by simplifying logical functions. Diagnosis of cancer quickly thanks to control of the simplified 4 output functions.

Results: Diagnosis made with the 4 output values obtained using Reduced Rule Base was found to be quicker than diagnosis made by screening all 2^{13}= 8192 possibilities. With the improved MES, more probabilities were added to the process and more accurate diagnostic results were obtained. As a result of the simplification process in breast and renal cancer diagnosis 100% diagnosis speed gain, in cervical cancer and lung cancer diagnosis rate gain of 99% was obtained.

Conclusions: With Boolean function minimization, less number of rules is evaluated instead of evaluating a large number of rules. Reducing the number of rules allows the designed system to work more efficiently and to save time, and facilitates to transfer the rules to the designed Expert systems. Interfaces were developed in different software platforms to enable users to test the accuracy of the application. Any one is able to diagnose the cancer itself using determinative risk factors. Thereby likely to beat the cancer with early diagnosis.

1. Introduction

Cancer is a group of diseases that occur due to uncontrolled proliferation of the cells of different organs, for which there are different clinical appearances and treatments. In 2012, the incidence of cancer was 14.1 million and 8.2 million deaths occurred due to cancer [1]; a rate observed to be increasing rapidly today. Despite new developments in modern medicine, cancer is still an important health problem being among the top causes of death worldwide. There are more than a hundred cancer types, which vary according to the tissue of origin. Lung cancer is a type of cancer that occurs due to uncontrolled proliferation of lung tissue cells, which can result in the spread of abnormal cells and invasion of other organs. The World Health Organization (WHO) reports that, of the cancer types, lung cancer is the leading cause of death in men and the second highest cause of death in women in the world. Lung cancer is responsible for approximately 1.3 million deaths around the world each year [1]. Breast cancer is the leading cancer type diagnosed in women; one in eight women is at risk of developing breast cancer throughout their lives [2].

Studies have been carried out on minimization method for Boolean functions [3–13] and on expert systems with Reduced Rule Base [14–21]. Similar studies have been reported on developing medical expert systems [22–33], and their use in medicine [34–38]. In literature there are studies on different methods of diagnosing cancer in medicine [39–47]. Their use using Reduced Rule Base

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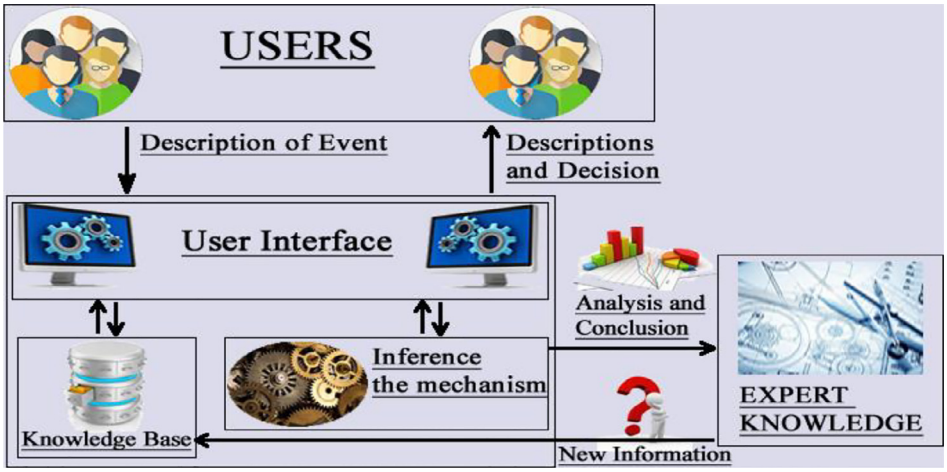

Fig. 1. The general structure of an ES.

with Expert System for the diagnosis of disease in hypertension and the average rate of success was 97.6% [48]. They have done different studies in different fields related to fuzzy values [49–54]. ES were used at coronary heart disease with 86.1% accuracy rate and diabetes with 97.13% in diabetes patients, 97% in non-diabetes patients, 96.5% in Type 1 patients, 98.26% in Type 2 patients, and 97.44% in pregnant patients, average rate of success was 97.6% in hypertension [55].

In our study, a web-based Medical Expert System (MES) was developed which uses Reduced Rule Base and an Expert System (ES) to diagnose cancer risk according to the symptoms in an individual. The method of simplification of Boolean functions was used to establish the Reduced Rule Base for the MES. This new method was used for breast cancer, lung cancer, kidney cancer, and cervical cancer. This method enabled achievement of the same result more quickly by controlling the functions obtained through simplification instead of controlling each possibility. Applications were developed for different software platforms to test the diagnosis and the time taken for diagnosis of cancer types according to the input determinant risk factors. Thirteen determinant risk factors were used to diagnose these cancer types. The aim of this study is to diagnose 4 different cancer types quickly and accurately.

2. Materials and methods

2.1. Cancer symptoms

The 13 risk factors used as cancer determinants in our study, where each symptom is indicated with a letter, are as follows:

Risk factors of cancer symptoms:

A. Have a certain hardness or bloody discharge in the breast end (in women)?
B. Do you get an uncomfortable cough or blood at the time of a cough?
C. Are you overweight?
D. Did you take long-term dialysis treatment (4 h daily)?
E. Do you smoke (especially if you are exposed to environmental pollutants?)
F. Your age.
G. Do you have hypertension?
H. Have you ever had a child?
I. Is there someone in your vicinity who has been diagnosed with cancer?
J. Did you do your first birth after 30 years old?
K. The existence of vaginal bleeding.
L. Unexpected abnormal and poor-smelling vaginal discharge.
M. Pelvic pain and have spotting.

The types of cancer that can be found specified by this situation is given below.

Cancer types detected:

(1) Breast cancer
(2) Lung cancer
(3) Renal cancer
(4) Cervical opening cancer

2.2. General structure of expert system

ES are a type of artificial intelligence, which does not have a general algorithm. The important factor is the large quantity of information. An ES is a computer program that emulates the decision-making ability of a human expert [56]. The general structure of an ES is shown in Fig. 1.

Use Areas of ES: An ES is a means to obtain successful results without the need for applications with very complex contexts, and is mostly used in interpreting, troubleshooting, repair suggestions, design, planning and control.

The most important factors in the structure of an ES are decision-making, the ability for improvement, and to collect and process information. The system should contain more expert information than is merely sufficient for the determined issue.

A conventional program operates using data rather than information. This data is prepared in advance and stereotyped. The processes to be carried out to obtain results are considered and planned. The data is processed first by an algorithm, so that a more definite result may be obtained; the result is traditionally considered to be 1 or 0, true or false, on or off. The possibilities are planned at the beginning or may arise depending on the situations emerging from a series of processes.

Expert systems do not have designed flow diagrams or algorithms; results are always obtained through information-based processes. The existing information is called from the rule base, searching is done after the process, and then the results are obtained and the explanation for these results presented within the scope of information. If it is designed properly, the system can improve itself. Also, learning ability can be added [56].

2.3. Boolean function reduction method

The Boolean Function Minimization (BFM) method is used to obtain less situations by simplifying logical functions. With BFM,