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AN APPLICATION OF EXPERT SYSTEM FOR DIAGNOSIS TUBERCULOSIS DISEASES

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Abstract- *Expert system, a computer based system, is a complex program duplicating an expert in his/her area. Many expert systems have been implemented to assist or remove the expert rules in addressing many problems they facing. An application of expert system in medical science is to diagnose many diseases, including tuberculosis (TBC) which is the most killer. This research emphases for developing an expert system to diagnose tuberculosis diseases for adults. The knowledge base of the system based on facts and rules acquired from experts (internists and pulmonologists). Meanwhile, an inference mechanism implements the Depth First Search Method and the Forward Reasoning. The result of the research is an expert system which is able to assist or remove the rules of experts in tuberculosis disease diagnoses for adults.*

Key words: *Expert system, Tuberculosis Disease, Depth First Search*

I. INTRODUCTION

TB disease is an important public health problem on the world. World Health Organization (WHO), in 2004, reported that one third of the world population have been infected with TB germs, of which 8.8 million are new TB cases. The largest number of TB cases occur in Southeast Asia, in which 33% of all TB cases in the world; when it is viewed from the population, there were 182 cases per 100,000 population.

Household Health Survey (1995) by the Ministry of Health of the Republic of Indonesia shows that TB is the third largest cause of death after cardiovascular and acute respiratory diseases, and the biggest killer in the group of infectious diseases. According to the WHO report in 2004, Indonesia is the third largest number of TB cases on the world after India and China. Each year there are 250,000 new cases of tuberculosis and about 140,000 deaths because of tuberculosis.

TB disease attacks the most productive working age, a weak economy, and less educated population. The management of patients with TB disease and recording and reporting systems at all Health Services Units both government and private that do not have the same systems are suspected as one of the factors emerging the obstacles in tuberculosis control programs.

Meanwhile, the growth of science and computer technology is very fast todays, computers can help people to solve problems in various fields, including health. Expert system, a computer-based system, is a high-level program specializations which is trying to duplicate the functionality of an expert in a field of expertise so that common people can consult with an expert system as if it is a consultation with an expert.

The purpose of this research is to develop a program of expert system for diagnosing pulmonary tuberculosis in adults based on National Guidelines for Tuberculosis Control, a book of reference for the diagnosis of tuberculosis in Indonesia, and experts. The results of this study can assist or replace the role of the doctors in diagnosing pulmonary tuberculosis in adults.

Various studies on the application of expert systems in the health sector have been carried out. Kusrini (2006) used a method of case-based reasoning to build the basic knowledge in diagnosis system of tuberculosis in children. The knowledge created is not obtained directly from an expert, but derived from previous diagnosis cases that are usually stored in the medical record.

Iswanti (2005) developed an expert system for diagnosing respiratory disease that began from the main symptoms of respiratory disease. This study used searching method in developing the inference engine. Sunarko (2008) developed an expert system application to select a category of anti-tuberculosis drugs in TB pulmonary the treatment for adults using DFS (Depth First Search) system. Both Iswanti and Sunarko gained the knowledge directly from the experts through interviews and some literatures.

A thing that has not been addressed in previous studies is to develop an expert system for diagnosing pulmonary tuberculosis in adults by using DFS search method.

This research tries to develop an expert system for diagnosing pulmonary tuberculosis in adults by using DFS search method and knowledge base created is obtained directly from the experts (pulmonary and internist specialists).

An expert system is an artificial intelligence program that combines knowledge base with inference system (Kris, 2004). Inference is a process of acquiring knowledge based on the experiences that happened before.

The structure of expert system consists of consultation environment and development environment. The consultation environment is used by someone who is not an expert to consult. The development environment is used to develop expert systems in terms of both the components and the knowledge base.

The expert system consists of several main components namely; user interface, knowledge acquisition facility, system knowledge database, inference mechanism and explanation facility (Giarratano and Riley, 2005).

1) User interface: a subsystem that is used for the communication medium between the user and the expert system.
2) Knowledge acquisition: a subsystem that is used to incorporate knowledge, construct or expand knowledge in the knowledge database.
3) Knowledge database: it provides the knowledge needed to understand, formulate, and solve problems. Knowledge base is obtained from experts, books, databases, research or images.
4) Inference engine: it contains the methods used to conduct a search or reasoning. The inference engine consists of three main elements, namely (1) Interpreter: it executes multiple items that are selected using the rules in the appropriate database knowledge, (2) Scheduler: it controls the agenda, and (3) Consistency enforcer: it maintains the consistency in representing emergency solution.
5) Explanation facility: a subsystem which function is to provide information to users about the results of the expert system based on feedback information from user and database knowledge acquired from experts.

Decision table is a good enough method of classification and search. A set of facts or knowledge that are very big can be compiled into a decision table representing a rule. Rules can be easily understood with any language and can also be expressed in terms of database languages such as SQL to find records in a particular category.

The decision table is also useful to explore data, discover hidden relationships between a numbers of input variable candidates to a target variable. Because the decision tables can combine data exploration and modeling; decision table is very good as the first step in the modeling process even when used as the final model of the other techniques.

A decision table consists of a set of rules to break down a heterogeneous population into smaller and more homogeneous with respect to the target variable. A decision table may be constructed carefully and manually or can grow automatically by applying one or more algorithms decision tables to model data sets that have not been classified.

Target variable is usually grouped definitely and decision table model tends to the calculation of the probability of each record from these categories, or to classify records to group them in one class.

There are a lot of methods that can be used to create a decision table, one of them is DFS method. DFS is a searching method that requires relatively little memory, and enable to find a solution quickly without having to examine all the nodes at all levels (Suyanto, 2007).

DFS searching method is performed in a node of each the leftmost level. If the solution has not been found at the deepest level, the search continues to the right node and left node can be removed from memory. If the solution has not been found at the deepest level, thus the search backwards to the previous level. And so on until you find a solution.

Tuberculosis is an infectious disease caused by infection of Mycobacterium tuberculosis complex (PDPI, 2006). Most of the TB germs attack the lungs, but it can affect other organs (extra-pulmonary). Diagnosis of pulmonary tuberculosis in adults can be established based on clinical symptoms and laboratory tests including microscopic examination of the bacteriological and radiological examinations.

II. RESEARCH METHOD

The expert system program, generally, for diagnosing pulmonary tuberculosis in adults can be shown in Figure 2. The knowledge obtained from the experts will be processed and stored in the knowledge database. Based on the knowledge database, the inference engine will analyze/diagnose facts (symptoms) were obtained from the user (patient) with DFS method. The results of the analysis in the form of a decision (positive/negative) and suggestions will be provided to the user through an explanation facility.

The steps that are taken in this study are as follows: (1) interviews and literature review. At this stage, the researchers conducted interviews with experts (pulmonary and internist specialists), and studying the literature related to expert system and pulmonary tuberculosis diagnosis in adults to obtain the facts and rules. (2) System design. At this system design stage, researchers design the system architecture, knowledge database, user interface, and explanation facilities. (3) System implementation. It is a phase of the program (coding) based on the results of the system design. The implementation is using the PHP programming language and MySQL DBMS (Database Management System). (4) Trial. This phase is to ensure that the program developed is running well. In the pilot phase, the researcher involves expert as a reference.

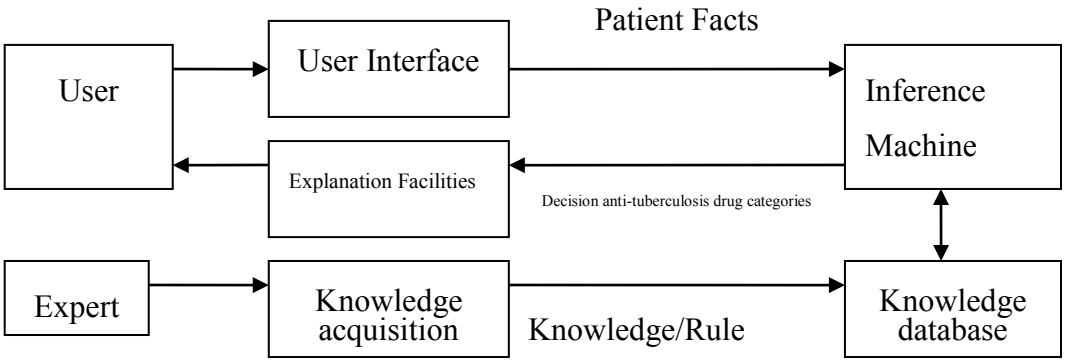

Figure 1. Expert system to diagnose Pulmonary TB disease

III. FINDINGS AND DISCUSSION

The knowledge that is obtained from experts includes facts/symptoms and rules. Symptoms consist of the main symptoms: (1) productive cough for at least 2 weeks, (2) fever without obvious causes for more than 1 month, and accompanying symptoms: (1) sputum mixed with blood, (2) bleeding cough, (3) shortness of breath/chest pain, (4) weak body, (5) decreased appetite, (6) weight loss, (7) night sweats without physical activity, (8) history of contact with people with TB/cough over 2 weeks. While the diagnosis of suspected for positive pulmonary tuberculosis if it fulfills any of the criteria of rules: (1) 2 major symptom (+), (2) 1 major symptom (+) with 3 accompanying symptoms (+), or (3) 4 accompanying symptoms (+).

By those facts and rules, the representations of knowledge base of TB suspect diagnosis can be drawn up in the form of decision tables as shown in Table 1 to facilitate the searching of clinical symptoms in the diagnosis.

Table 1. Decision tables of tuberculosis suspect

No	Facts/Symptoms of TB Suspect	TB Suspect Diagnosis (+)					
		A1	A2		A3		
1	Productive cough > 2 weeks	Y	Y	Y	N	N	N
2	fever without obvious causes > 1 month	Y	N	N	N	N	N
3	sputum mixed with blood	Y/N	Y	Y	Y	Y	Y
4	bleeding cough	Y/N	Y	Y	Y	Y	Y
5	shortness of breath/chest pain	Y/N	Y	Y/N	Y	Y	Y
6	weak body	Y/N	Y/N	Y	Y	Y/N	Y/N
7	decreased appetite	Y/N	Y/N	Y/N	Y/N	Y	Y/N
8	weight loss	Y/N	Y/N	Y/N	Y/N	Y/N	Y
9	night sweats without physical activity	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
10	history of contact with people with TB/cough > 2 weeks	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N

Note: Y = Yes, N = No, A1 = Rule 1, A2 = Rule 2, A3 = Rule 3

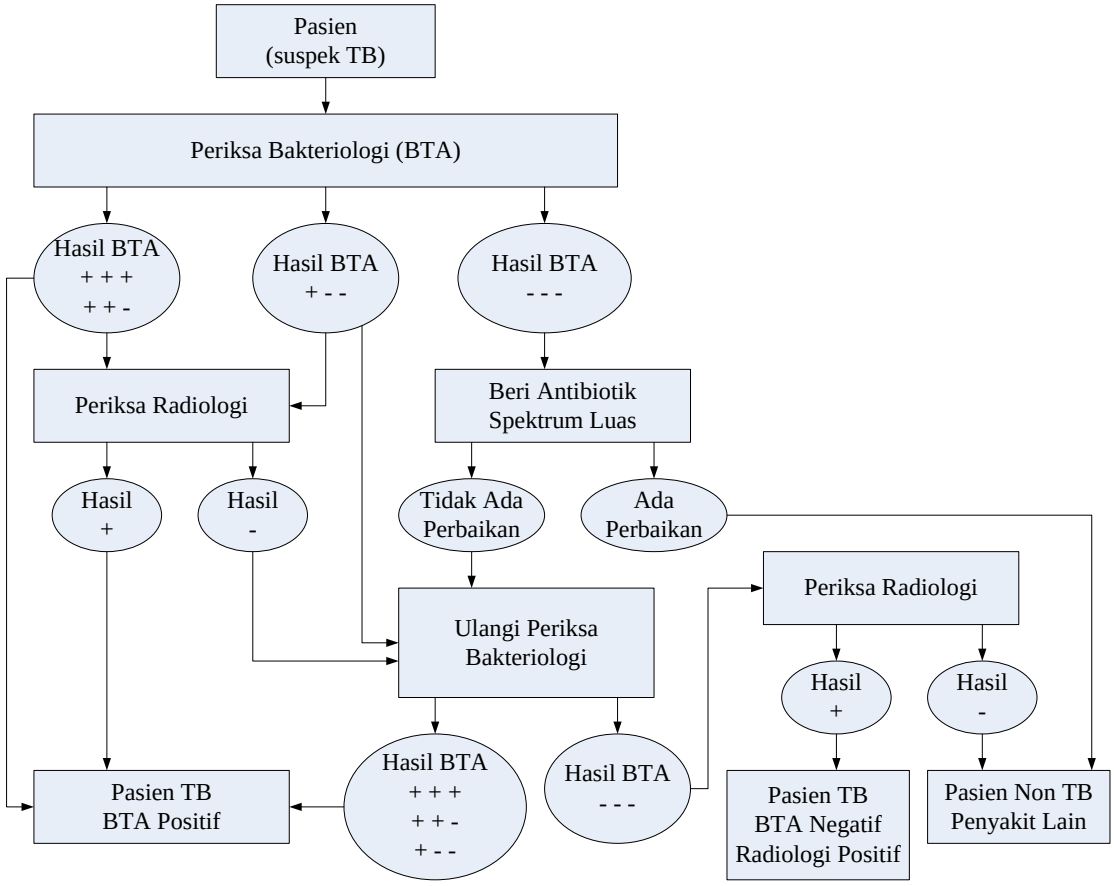

Figure 2. Algorithm of Pulmonary TB Diagnosis

The searching of clinical symptoms produce two possible decisions namely TB Suspect or Not TB Suspect. If the result of the decision is TB Suspect, thus the process if continued to search the facts of bacteriological and radiological examinations to diagnose pulmonary tuberculosis. Algorithm of pulmonary tuberculosis in adults can be shown in Figure 2.

Those facts and rules are stored in the Knowledge Base Table with structure:

nama_field (id_basis_pengetahuan, nama_basis_pengetahuan, parent, solusi_ditemukan) with type {int (10), varchar (250), int (10), int (10)}.

Referring to the decision table and flow chart diagnosis of pulmonary tuberculosis, then they can be encoded into a program. Broadly speaking, the inference engine of this expert system consists of three main sub-programs namely interconnection to the database, knowledge base entry, and tracking symptoms to determine the diagnosis.

This interconnection sub-program serves to connect the expert system program with MySql Server DBMS (Data Base Management System). The coding program for interconnection sub-program is as follows:

```
function Database($host, $dbname, $user, $pass)
{       $this->host   = $host;
        $this->dbname = $dbname;
        $this->user   = $user;
        $this->pass   = $pass;
        $this->debugmode = false;}
function use_database()
{       $this->connect();
        $this->select_db();}
function connect()
{ switch($this->debugmode)
  { case true:
   $this->link = @mysql_connect($this->host, $this->user, $this->pass); break;
```

```
  case false: $this->link = @@mysql_connect($this->host, $this->user, $this->pass);
  break; }
 }
```

The function of knowledge base entry sub-program is to receive data input from the user and to save the data to the database. The coding program for the knowledge base entries sub-program is as follows:

```
function Newbasis_pengetahuan()
        {global $db;
        $date = date('Y-m-d'); //id_basis_pengetahuan          nama_basis_pengetahuan parent
        solusi_ditemukan
$QueryInsertDatabasis_pengetahuan = $db->insert("basis_pengetahuan","",
"'$_POST['nama_basis_pengetahuan']."', "'$_POST['parent']."', "'$_POST['solusi_ditemukan']."');
        $Newbasis_pengetahuan =' Data Ditambahkan ';
        return $Newbasis_pengetahuan;}
```

Diagnosis search result sub-program serves to track the results of the diagnosis based on knowledge base of the expert system program and the facts given by the expert system so that users can obtain the diagnosis.

```
function get_list_basis_pengetahuan()
{       global $db;
$list = $db->select("*","basis_pengetahuan","parent='".$_GET['id_basis_pengetahuan']."'");
        $get_list_basis_pengetahuan .='<table align="center"><tr>';
        for ($i=0; $i<count($list); $i++)
         { if($list[$i]['solusi_ditemukan']==0)
            {    $get_list_basis_pengetahuan .='
<td><a
href="index.php?mode=basis_pengetahuan&id_basis_pengetahuan='.$list[$i]['id_basis_pengetahuan']."">
'.$list[$i]['nama_basis_pengetahuan'].' </a> </td>';
} else { $get_list_basis_pengetahuan .='
<td>Vonis : <br /> '.$list[$i]['nama_basis_pengetahuan'].' </td>';}
        }
         $get_list_basis_pengetahuan .='</tr></table>';
         return $get_list_basis_pengetahuan;}
```

The expert system that has been developed consists of a database and two main programs namely: Admin program for system administrator and users program for users. The database is managed by the MySQL Server and the program compiled with the PHP programming language.

Admin program has functions for entries and knowledge base editing. When you sign in to the administrator, the administrator must enter the identity of the data of username and password in the Login window, see figure 3. It is intended to filter the users. Not all users are allowed to access this administrator program because there is the Knowledge Base program that has facilities for entry and update of knowledge which is a very important element in the program of expert systems.

Figure 3. Login window

Once logged in, the administrator will log in to the Administrator System that consists of the Knowledge Base and Log Out menus. Administrator System Program has a pull down menu structure as seen in Figure 4.

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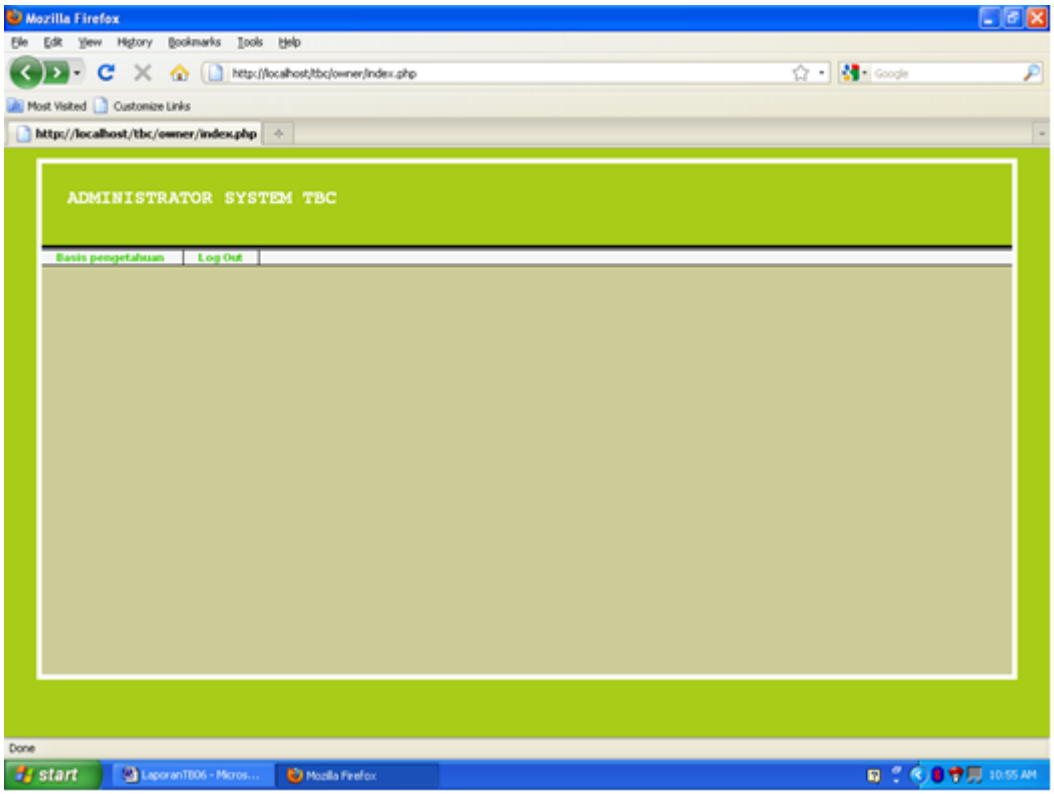

Figure 4. Pull-down Menu Structure of the expert system program

Knowledge Base menu and Log Out menu. Log Out menu has a function to exit from the expert system program. Knowledge Base menu has several forms that serves to incorporate the knowledge needed by an expert system. Figure 5 displays the structure of the knowledge base as well as knowledge entry form that serves to update the knowledge.

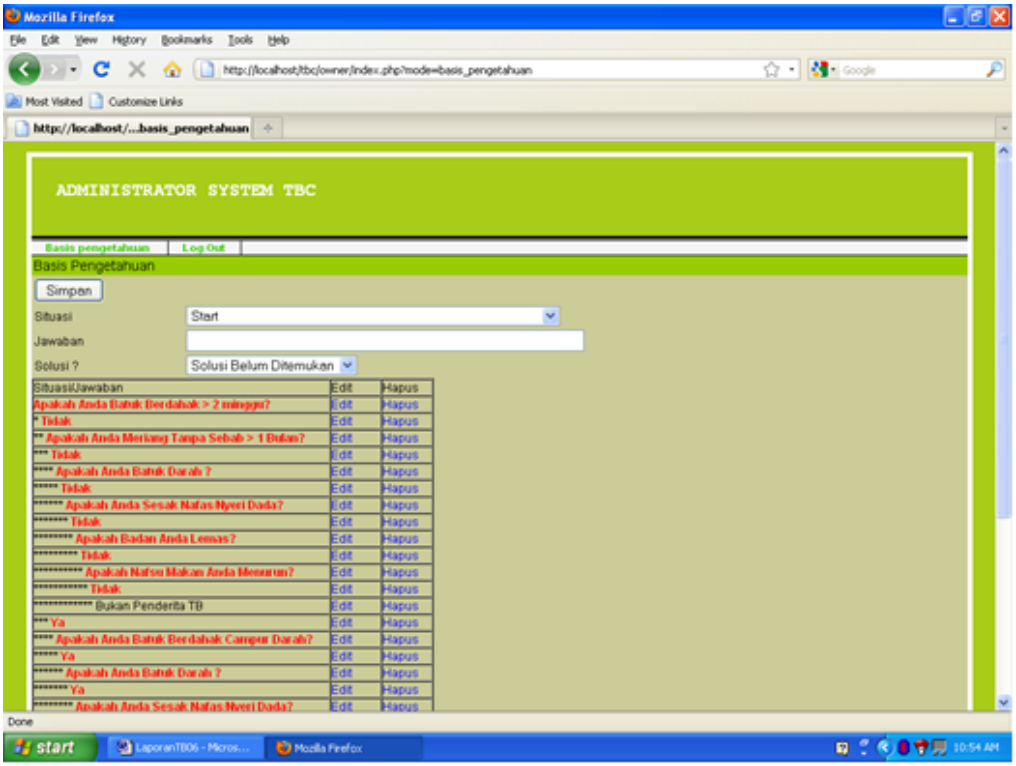

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Figure 5. Knowledge base

The Knowledge Base window is used to enter the knowledge about the diagnosis of pulmonary tuberculosis and displays the rule structure created as a whole. In addition, this window is also used to update the knowledge.

Another part of the Expert System program is User System which is created especially for patients (public). Unlike the Administrator System, in order to log in to User System, the patients do not need to be filtered because the system does not provide the facility to edit the data so that users will not be able to change the knowledge of the expert system. The User System consists of anamnesis (the search results of diagnosis) which is a window that displays a series of questions to be answered by the user (patient) to get the diagnosis. Figure 6 is an example of a window that displays the first question of the clinical symptoms of pulmonary tuberculosis, while Figure 7 is an example of a window that displays the answer choices.

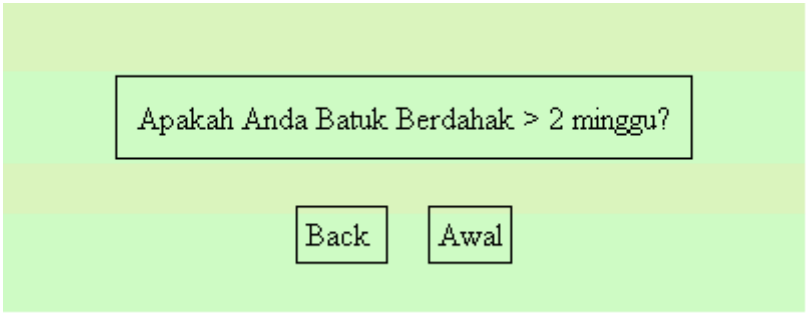

Figure 6. User Window

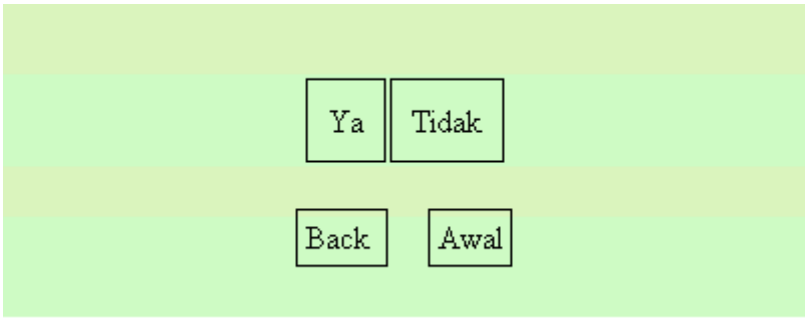

Figure 7. Answer Window

After answering a series of questions presented by the expert system, the expert system will give the diagnosis results. Figure 8 shows an example of diagnosis results.

Figure 8. Diagnosis Results

The results of the needs analysis showed that the facts and rules in the diagnosis of pulmonary tuberculosis suspect in adults obtained from the experts are little bit different from the facts and rules in the diagnosis of pulmonary tuberculosis suspect in adults compiled by PDPI (2006). PDPI (2006) stated that the

main fact with pulmonary tuberculosis suspect in adults is coughing with phlegm for three weeks or more, while this time the experts state that the main fact of pulmonary tuberculosis suspect in adults is coughing with phlegm for at least two weeks or more and fever without obvious cause for more than a month. This is because the knowledge of the experts of pulmonary tuberculosis has evolved so that the treatment of diagnosis of pulmonary tuberculosis suspect in adults has clinically changed. While compiling the knowledge base in the expert system program, the researchers used the facts and the latest rules, which is in accordance with the experts' opinions todays.

This expert system program provides some facilities for entry and knowledge base editing so that when experts' knowledge of pulmonary tuberculosis has more developed (emerging new facts or rules), then the new facts or rules can be added to the knowledge base existing in this expert system program, through the Entry facility. And conversely, if there are facts or rules diagnosis of pulmonary tuberculosis which are not relevant can be deleted from the knowledge base of this expert system program through the Delete facility. In addition, if there are changes in facts and rules of the facts and the rules that already exist in the expert system program can be modified through Edit facility.

This expert system program has been able to provide facilities for the acquisition of knowledge through the Administrator System and search facilities of the pulmonary tuberculosis diagnosis through the User System. These capabilities are shown in Figure 5 to Figure 8, where the pictures show that the user can browse the results of pulmonary tuberculosis diagnosis based on the symptoms being experienced. Users will be asked a few questions, about symptoms of pulmonary tuberculosis, which appear in a sequence. From the answers given by the user to the expert system program, then the program will deliver an expert system diagnosis.

IV. CONCLUSION AND SUGGESTION

Expert System Program for Diagnosing Tuberculosis Disease has been prepared to provide facilities for the acquisition of knowledge for administrator system and facility of consultation to search the result of pulmonary tuberculosis diagnosis for users. Therefore, expert system program has been able to assist or replace the role of experts (doctors) to provide consultations for adult patients to independently diagnose the pulmonary tuberculosis.

This expert system program remains some shortcomings such as the simple interface and the length of consultation process (search results of diagnosis), therefore it still needs further research to shorten the search results of pulmonary tuberculosis diagnosis.

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