A Logic Simplification Based on Expert System Application for TBC Diagnosis

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Abstract. Tuberculosis (TBC), caused by the bacterium My tuberculosis (Mtb), is a growing international health crisis [1]. TBC is one of the main causes of death produced by infectious illness and is responsible for almost 3 millions deaths every year [2]. In this study, a controlled Expert System (ES) have designed to diagnosis of TBC and truth table have created by considering the probabilities of TBC (12 symptom, 2^{12}=4096 different cases). According to the probabilities of TBC, 6 different cases have accepted as output values and reduced rule bases have obtained. These output values have been processed by an ES and have tried to diagnosis of TBC with help to ES. We obtained very good results and the results of analyses carried out indicated that controls performed with ES provide less time, less probability, reliable and consistent diagnosis and that are feasible in real life.

Keywords: Logic Simplification, Logic Synthesis, Reduced Rule Bases, Expert System, TBC.

1 Introduction

TBC remains a global emergency with estimates of 1.8 millions deaths worldwide in 2008 and over 9 million cases. According to the World Health Organization (WHO) worldwide, disease mortality was approximately 1.5 million people, with 5 million new and relapse cases in 2005 [3]. In 2008, estimated global incidence rate fell to 139 cases per 100,00 population after reaching its peak in 2004 at 143 per 100,00. However, this decline was not homogeneous throughout WHO regions, with Europe failing to record a substantial decline, but rather appearing to have reached a stabilization of rates [4]. Despite effective antimicrobial chemotherapy, TBC remains a leading cause of death from an infectious disease [5]. Newly, infected persons may be identified by investigation of close contacts of an infectious case. The Centers for Disease Control and Prevention recommend identifying and offering therapy to all close contacts of persons with active TBC [6]. Twenty-two countries in the European Union (EU) and European Economic Area (EEA) reported treatment outcome monitoring

J. Lin and K.S. Nikita (Eds.): MobiHealth 2010, LNICST 55, pp. 27–34, 2011.

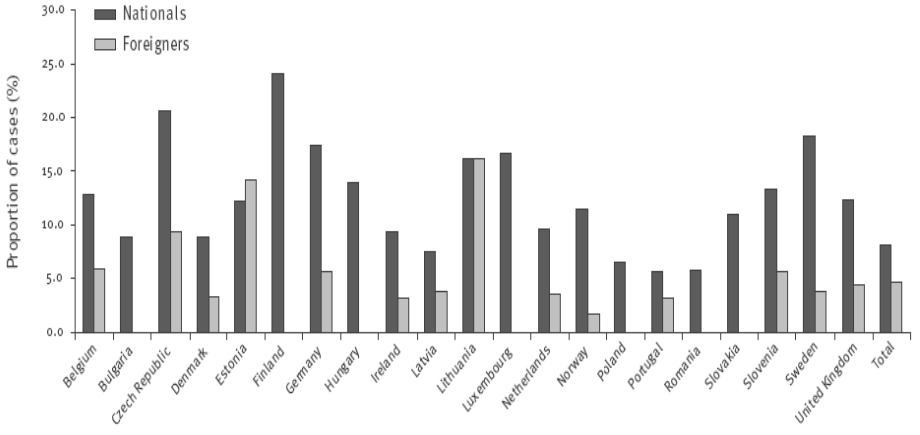

Fig. 1. Proportion of TBC death by geographic origin, EU/EEA countries, 2007 (EAA: European Economic Area; EU: European Union) [7]

data for culture-confirmed pulmonary TBC cases reported in 2007 [7]. We can see proportion of TBC deaths by geographic origin at Fig. 1.

As can be seen at Fig.1, TBC is a serious threat. Excluding countries at Fig.1 that did not or not in all years report cases. Worldwide there are roughly 12 million new active cases annually, and of those about 2 million will die every year [8].

2 Materials

TBC is one of the most common infectious diseases worldwide. In developing countries, TBC is associated with high morbidity and mortality rates. The disease is increasing in Western countries especially among immune compromised individuals such as patients who are HIV (Human Immunodeficiency Virus) infected [9].

Attention to TBC control in the EU, EEA and in the world has been raised in recent years through a number of initiatives, including the launching of a Framework Action Plan to Fight TBC in the EU. Among the key issues underlined in the Action Plan is the need to achieve and sustain acceptable levels of treatment success among all TBC patients [10].

2.1 TBC's Symptoms

- A cough that lasts (for more than 3 weeks)
- High fever (systematic symptom)
- Sweat (specially during night)
- Come out sputum and blood as coughing
- Loss of appetite
- Weight loss
- Weakness

- Weariness
- Hemoptysis
- Thorax, back and flank aches
- Shortness of breath (respiratory symptom)
- Hoarseness (in the future)

Special symptoms;

- Cough, Sputum, hemoptysis,
- Thorax, back and flank aches
- Heartbeat

2.2 Similar Diseases

There are some diseases like TBC because of symptoms and specialties. These diseases are; Primary TBC, Post Primary TBC, Sarcoidosis, Pleuritis and Mumps. These diseases have been explained detailly in resources [11–13, 14].

2.3 Expert System and Architecture

Expert Systems (ES) is a branch of Artificial Intelligence (AI). AI is the capability of a device such as a computer to perform task that would be considered intelligent if they were performed by a human [15]. An ES is a computer program that attempts to replicate the reasoning processes of expert and can make decisions and recommendations, or perform tasks, based on user input [16].

Rule-based ESs should contain, at the very least, the three components of an AI production system: the knowledge base; the database; the rule interpreter. You can see that structure at Fig. 2.

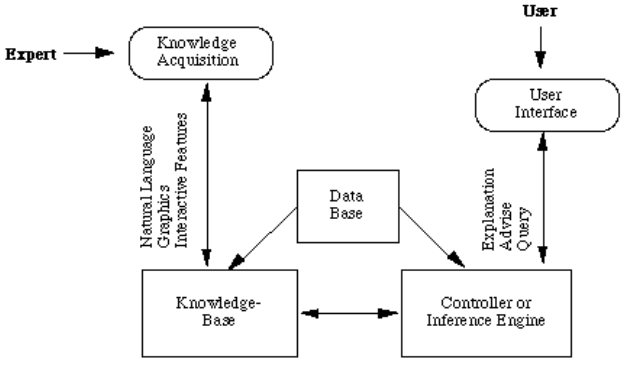

Fig. 2. An Expert System Structure

The knowledge base holds the set of rules of inference that are used in reasoning. Most of these systems use IF-THEN rules to represent knowledge. Typically systems can have from a few hundred to a few thousand rules. The database gives the context

of the problem domain and is generally considered to be a set of useful facts. These are the facts that satisfy the condition part of the condition action rules as the IF THEN rules can be thought of. The rule interpreter is often known as an inference engine and controls the knowledge base using the set of facts to produce even more facts. Communication with the system is ideally provided by a natural language interface. This enables a user to interact independently of the expert with the intelligent system [17].

3 Method

To prevention of TBC, there are a lot of method, for instance a circuit-based simulation, using an antibody-based piezoelectric biosensor, fuzzy logic, image processing and neural computing, lazer therapy and so forth.. However, our used method that Logic Simplification Method is considerably a new method to diagnosis of TBC, including truth table, input and output values, reduced rule bases. In function, 4096 different cases evaluated for each one output function. Table 1 show below input and output values for function.

Table 1. Input, output cases and symbols

Input Symbols	Input Cases	Output Symbols	Output Cases
x1	A long lasting cough	y1	TBC
x2	High fever (systematic symptom)	y2	Primary TBC
x3	Sweat (specially during night)	y3	Post Primary TBC
x4	Come out sputum and blood as coughing	y4	Sarcoidosis
x5	Loss of appetite	y5	Pleuritis
x6	Weight loss	y6	Mumps
x7	Weakness		
x8	Weariness		
x9	Hemoptysis		
x10	Thorax, back and flank aches		
x11	Shortness of breath (respiratory symptom)		
x12	Hoarseness (in the future)		

3.1 Logic Synthesis and Minimization Method

Two-level logic minimization is a basic problem in logic synthesis [18, 19]. The minimization of Boolean Functions (BFs) can lead to more effective computer programs and circuits. A wide variety of Boolean minimization techniques have been explained in [18, 19, 20 and 21].

In order to simplify the formed function, Exact Direct Cover Minimization Algorithm has been developed. This algorithm is explained in [21]. Exact Direct Cover Minimization Method algorithm is given in below;

```
Minimization Algorithm (S_ON, S_OFF)
Begin
  start:
    if (S_ON =∅) then goto end
    TM ← select any On minterm from the S_ON set
    Call S_PI(TM) procedure
    if |S_PI(TM)|=1 then goto result
    Select PI which is cover the most minterm from
       the S_ON set
  result:
    S_EPI(TM) ← selected S_PI(TM)
    set of result ← S_EPI(TM)
    Call cover procedure
    goto start
  end:
End


Determination of S_PI(TM) Procedure
Begin
  1)Expand the elements of SOFF set by the TM X
  2)Remove from a result the non maximal cubes
  3)Subtract the result from the n-cube
    S_PI(TM)←(x)^n#(step 2)
  4)Return (S_PI(TM))
End


Cover Procedure
Begin
  S_ONi ← S_ON(i-1) # S_EPI (TM)
  S_EPI ← S_EPI ∪ S_EPI (TM)
  Return (S_ONi and S_EPI)
End
```

4 Results

TBC will continue to be the public health problem with more than one crore of patients at one time. The main hurdle in the control of TBC is poor cure rate (35%) due to high drop out because of long duration of treatment. With present strategy of treatment, the control of TBC is a far cry for several decades. In near future the situation will further deteriorate due to AIDS (Acquired Immune Deficiency Syndrome) and during resistance, unless and until some new methods of treatment are not used [22].

In this study; all the probabilities of the 12 symptoms which are the general symptoms of TBC and simplified output values have been evaluated (12 symptom, 2^{12}=4096 different cases and 6 different cases). In function, 4096 different cases evaluated for each one output function. In the reduction of symptoms, Logic Simplification Method has been used. By this method, reduced functions for each output have been obtained in Table 2.

The mean of 0, 1 and x which shows like simplification function at Table 2 is: For 0; there is not symptom For 1; there is a symptom. For x; it is not importing for symptom of represent disease who is ill person. For example; Disease probabilities and results for y3 have been given in table 3.

Table 2. Simplification output values

Output Symbols	Output Cases	Simplification funcion			
y1	TBC	010100000010 1111xxxxx1x0 11111xxxxxxx	111x11011010 1111xxx0xxxx 1111xxxx1xxx	1111xx0xxxx1 1111x0xxxxxx	1111xxxxx00x 1111xx1xxx1x
y2	Primary TBC	1010x1101000 xx1x1101xxxx x11x11xxxxxx	10101x101101 xx1x11x0x1xx xx1x11xxxx1xxx	xx1x11xxx0x0 xx1x11xxxx0x 1x1x11xxxx1x	xx1x111xxxx1 xx1011xxxxxx
y3	Post Primary TBC	101010101100	111xx11x1111		
y4	Sarcoidosis	1011101001x1 101x011x011x 1x1x0xx0xx1x 1x1x11xxxx1x 11x0xxxxxx1x	1011x01x0010 101xxxx1x01x 1x1xx00xxx1x 1x11xxxx1x1x	101000110x1x 1111xx1xxx1x 1x1xxxx0x11x 1x1xxxxx111x	1x101x10001x 1x1xxxx1xx11 1x11xxxxx11x 110xxxxxxx1x
y5	Pleuritis	xxxxxxx111xx			
y6	Mumps	101010101010 0xx1xx1x11xx xx0xxx1x11xx	111110111x11 x0xxxx1x11x0 xxxxx01x11xx	xxxx1x1x11xx xxxxx11111xx xxxxxx1x111x	xxx0xx1x11x1 11xxxx1x11xx

Table 3. Symptoms, Output Cases and results for y3

Output Symbols	Cases	Symptom and Output Cases											
		x1	**x2**	**x3**	**x4**	**x5**	**x6**	**x7**	**x8**	**x9**	**x10**	**x11**	**x12**
y3	Post Primer TBC 101010101100	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**0**	**0**
y3	Post Primer TBC 111xx11x1111	**1**	**1**	**1**	**x**	**x**	**1**	**1**	**x**	**1**	**1**	**1**	**1**

According to Table 3, the mean of 101010101100 output values; we can say Post Primer TBC a person which has x1, x3, x5, x7, x9, x10 probabilities and has not x2, x4, x6, x8, x11, x12 probabilities. Furthermore, if we want to see the result (for 101010101100) in a ES;

Rule: ***IF*** x1 is 1 and x3 is 1 and x5 is 1 and x7 is 1 and x9 is 1and x10 is 1 and x2 is 0 and x4 is 0 and x6 is 0 and x8 is 0 and x11 is 0 and x12 is 0 ***THEN*** patient is Post Primary TBC.

Table 4. Rule table for y3 output

IF	**input**												**THEN**	**output**
	x 1	x 2	x 3	x 4	x 5	x 6	x 7	x 8	x 9	x 10	x 11	x 12		**Y3**
	1	0	1	0	1	0	1	0	1	1	0	0		Primary TBC

In conclusion, we thing that use logic simplify method might be used as a reliable in ascertain for TBC.

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