

# The Study of Symptoms of Tuberculosis Using Induced Fuzzy Cognitive Maps (IFCMS)

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**Abstract-** Tuberculosis or TB is a common, infectious disease caused by various strains of mycobacterium usually called as mycobacterium Tuberculosis. Tb attacks the lungs but can also affect other parts of the body. Most infections are asymptomatic and latent, but about one in ten latent infections eventually progresses to active disease which, if left untreated, kills more than 50% of those so infected. Hence, this paper analyses the symptoms of Tuberculosis using Induced Fuzzy Cognitive Maps (IFCMS). IFCMs are a fuzzy-graph modeling approach based on expert's opinion. This is the non-statistical approach to study the problems with imprecise information.

**Keywords** - Induced fuzzy Cognitive Maps (IFCMS), Tuberculosis, symptoms.

## I. INTRODUCTION

Tuberculosis is a common and an infectious disease which is caused by bacteria called "Mycobacterium tuberculosis". It was first isolated in 1882 by a German physician named "Robert Koch" who received the Nobel Prize for this discovery. Tuberculosis most commonly attacks the lungs but can also affect the central nervous system, the lymphatic system, the circulatory system, the genitourinary system, bones, joints and even the skin. It spreads through the air when people who have an active TB infection cough, sneeze, or otherwise transmit their saliva through the air. TB infection usually occurs initially in the upper part (lobe) of the lungs. The body's immune system, however, can stop the bacteria from continuing to reproduce. Thus, the immune system can make the lung infection inactive (dormant). On the other hand, if the body's immune system cannot contain the TB bacteria, the bacteria will reproduce (become active or reactivate) in the lungs and spread elsewhere in the body.

### A. Types of Tuberculosis

#### a) Active Tuberculosis

Active TB means the bacteria are active in the body. The immune system is unable to stop these bacteria from causing illness. People with active TB in their lungs can pass the bacteria on to anyone they come into close contact with. When a person with active TB coughs, sneezes or spits, people nearby may breathe in the tuberculosis bacteria and become infected.

#### b) Inactive Tuberculosis

Inactive TB infection is also called latent TB. If a person has latent TB, it means their body has been able to successfully fight the bacteria and stop them from causing illness. People

who have latent TB do not feel sick, do not have symptoms and cannot spread tuberculosis [9].

#### c) Tuberculosis meningitis

This is caused by the spread of Mycobacterium tuberculosis to the brain, from another site in the body. The symptoms usually begin gradually.

#### d) Genitourinary TB

In men, genital TB may present as epididymitis or scrotal mass. In women, genital TB may mimic pelvic inflammatory disease. This type of TB causes approximately 10% of sterility in women worldwide and approximately 1% in industrialized countries.

#### e) Gastrointestinal TB

Any site along the gastrointestinal tract may become infected. Tuberculosis lymphadenitis (scrofula):

The most common site is in the neck along the sternocleidomastoid muscle. It usually is unilateral. It usually is unilateral, with little or no pain. Advanced disease may suppurate and form a draining sinus.

#### f) Cutaneous TB

Several different types of cutaneous TB exist. Direct infection of the skin or mucous membranes from an outside source of mycobacteria results in an initial lesion called the tuberculous chancre.

#### g) Uterus Ovarian TB

Female genital organs are one of the common sites to be involved in women. It is a chronic disease and bacteria may remain for long time slowly destroying the organs. The disease may remain totally symptomless or may lead to pelvic pain, Infertility may be caused even by early or minimal disease.

#### h) Osteo-articular Skeletal - Bone - Joint TB

The most common site of involvement is the spine "Potts diseases. Symptoms include back pain or stiffness. Lower extremity paralysis occurs in as many as half the patients with undiagnosed Potts disease. Tuberculosis arthritis usually involves only 1 joint. Although any joint may be involved, the hip of the knee is affected most commonly, followed by the ankle, elbow, wrist, hip or the knee is affected most commonly, followed by the ankle, elbow wrist and shoulder [10]. Other types of tuberculosis include: Mycobacterium Avium-Intracellulare, Mycobacterium Chelonae, Mycobacterium Fortuitum, Mycobacterium Gordona, Mycobacterium Haemophilum, Mycobacterium Kansaii, Mycobacterium Marinum, Mycobacterium Xenopi. It may take many months from the time the infection initially gets into the lungs until symptoms develop. By our interview with TB patients, we

gathered their illness and symptoms before and after infection. This paper deals with the symptoms and remedy for Tuberculosis using Induced Fuzzy Cognitive Maps (IFCMs). Section two presents the basic definitions and section three Presents the analysis using the IFCMS model. In fourth section we draw the conclusions from our study and proposed remedial measures.

**II. BASIC NOTION AND DEFINITIONS**

We proceed to state the definitions of IFCMS model.

**A. Definition**

Fuzzy Cognitive Maps (FCMs) are digraphs that capture the cause/effect relationship in a system. Nodes of the graph stand for the concepts representing the key factors and attributes of the modeling system, such as inputs, variable states, components factors, events, actions of any system. Signed weighted arcs describe the casual relationships, which exists among concepts and interconnect them, with a degree of causality. The constructed graph clearly shows how concepts influence each other and how much the degree of influence is. Cognitive Maps (CMs) were proposed for decision making by Axelrod [10] for the first time. Using two basic types of elements; concepts and casual relationship, the cognitive map can be viewed as a simplified mathematical model of a belief system. FCMs were proposed with the extension of the fuzzified casual relationships. Kosko [3], introduced FCMs as fuzzy graph structures for representing casual reasoning. When the nodes of the FCM are fuzzy sets then they are called fuzzy nodes. FCMs with edge weights or causalities from the set  $\{-1, 0, 1\}$  are called simple FCMs. Consider the nodes/concepts  $P_1, P_2, P_3, \dots, P_n$  of the FCM. Suppose the directed graph is drawn using edge weight  $e_{ij}$  from  $\{-1, 0, 1\}$ .

**B. Definition**

The matrix  $M$  be defined by  $M = (e_{ij})$  where  $e_{ij}$  is the weight of the directed edge  $P_i P_j$ .  $M$  is called the adjacency matrix of the FCM, also known as connection matrix. The directed edge  $e_{ij}$  from the casual concept  $P_i$  to concept  $P_j$  measures how much  $P_i$  causes  $P_j$ . The edge  $e_{ij}$  takes values in the real interval  $[-1, 1]$ .

- $e_{ij} = 0$  indicates no causality.
- $e_{ij} > 0$  indicates casual increase/positive causality.
- $e_{ij} < 0$  indicates casual decrease/negative causality.

Simple FCMs provide quick first-hand information to an expert's stated casual knowledge. Let  $P_1, P_2, P_3, \dots, P_n$  be the nodes of FCM. Let  $A = (a_1, a_2, \dots, a_n)$  is called a state vector where either  $a_i = 0$  or  $1$ . If  $a_i = 0$ , the concept  $a_i$  in the OFF state and if  $a_i = 1$ , the concept  $a_i$  in the ON state, for  $i = 1, 2, \dots, n$ . Let  $P_1 P_2, P_2 P_3, \dots, P_i P_j$  be the edges of the FCM ( $i \neq j$ ). Then the edges form a directed cycle.

**C. Definition**

An FCM is said to be cyclic if it possesses a directed cycle. An FCM with cycle is said to have a feedback, when there is a feedback in an FCM, i.e., when the casual relations flow through

acyclic in a revolutionary way, the FCM is called a dynamical system. The equilibrium state for the dynamical system is called the hidden pattern. If the equilibrium state of a dynamical state is a unique state vector, it is called a fixed point or limit cycle. Inference from the hidden patterns summarizes the joint effects of all interacting fuzzy knowledge.

**D. Algorithmic Approach in IFCM**

Even though IFCM is an advancement of FCM it follows the foundation of FCM, it has a slight modification only in Algorithmic approaches. To derive an optimistic solution to the problem with an unsupervised data, the following steps to be followed:

- Step 1: For the given model (problem), collect the unsupervised data that is indeterminate factors called nodes.
- Step 2: According to the expert opinion, draw the directed graph.
- Step 3: Obtain the connection matrix,  $M$ , from the directed graph (FCM). Here the number of rows in the given matrix = number of steps to be performed.
- Step 4: Consider the state vector  $S(X_1)$ , by setting  $c_1$  in ON position that is assigning the first component of the vector to be 1 and the rest of the components as 0. Find  $S(X_1) \times M$ . The state vector is updated and threshold at each stage.
- Step 5: Threshold value is calculated by assigning 1 for the values  $> 0$  and 0 for the values  $< 1$ . The symbol ' $\leftrightarrow$ ' represents the threshold value for the product of the result.
- Step 6: Now each component in the  $C_1$  vector is taken separately and product of the given matrix is calculated. The vector which has maximum number of one's is found. The vector with maximum number of one's which occurs first is considered as  $C_2$ .
- Step 7: When the same threshold value occurs twice. The value is considered as the fixed point. The iteration gets terminated.
- Step 8: Consider the state vector  $C_1$  by setting  $C_2$  in ON state that is assigning the second component of the vector to be 1 and the rest of the components as 0. Precede the calculations discussed in Steps 4 to 6.
- Step 9: Continue Step 9 for all the state vectors and find hidden pattern.

**III. ANALYSIS USING IFCMS MODEL WE TAKE THE FOLLOWING ATTRIBUTES IN THE CASE OF SYMPTOMS**

- $C_1$ - Pain in breathing, chest pain and shortness of breath, all these together make the breathing difficult.
- $C_2$ - cough with thick, cloudy and sometimes bloody mucus from the lungs for more than two weeks.
- $C_3$ - Increased speed in heartbeat, chillness of the body and night sweats..
- $C_4$ - Fever and continuous cough gives irritating mood to the patient, also gives headache and mental stress.

Table 1

Number	Attribute ON state	Triggering pattern
Step1	C <sub>1</sub> :(10 00 00 00)	C <sub>1</sub> → C <sub>7</sub> → C <sub>5</sub> →C <sub>5</sub>
Step2	C <sub>2</sub> ;(0 100 00 00)	C <sub>2</sub> → C <sub>5</sub> →C <sub>5</sub>
Step3	C <sub>3</sub> ;(0 0 100 00)	C <sub>3</sub> → C <sub>1</sub> → C <sub>5</sub> →C <sub>5</sub>
Step4	C <sub>4</sub> ;(0 00 100 00)	C <sub>4</sub> → C <sub>5</sub> →C <sub>5</sub>
Step5	C <sub>5</sub> ;(0 000 100 0)	C <sub>5</sub> → C <sub>2</sub> → C <sub>5</sub>
Step6	C <sub>6</sub> ;(0 000 0 100)	C <sub>6</sub> → C <sub>5</sub> →C <sub>5</sub>
Step7	C <sub>7</sub> ;(0 000 00 0 10)	C <sub>7</sub> → C <sub>5</sub> →C <sub>5</sub>
Step8	C <sub>8</sub> ;(0 000 000 0 1)	C <sub>8</sub> → C <sub>5</sub> →C <sub>5</sub>

C<sub>5</sub>-continuous cough gives throat pain, dryness in the tongue and also creates abdominal pain.

C<sub>6</sub>-Immunity of the body decreases, body become weak and it results in weight loss..

C<sub>7</sub>- Back pain, overall sensation of feeling unwell, pain in joints, kidney pain etc.,

C<sub>8</sub>- Patient becomes tired, feels sleepy and fatigue.

An expert, a lady doctor, according to her opinion on the same set of 8 attributes has been converted into a connection matrix M.

$$M = \begin{pmatrix} 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 \end{pmatrix}$$

Analysis using IFCMS:

Step 1:

Let C<sub>1</sub>(1 000 000 0)

C<sub>1</sub>' M=(0 0 1 1 0 0 1 1) = C<sub>1</sub>

C<sub>1</sub>' M≈

(0 0 1 0 0 0 0 0)M=(1 0 0 0 0 0 0 1)

(0 0 0 1 0 0 0 0)M=(0 0 0 0 1 0 0 1)

(0 0 0 0 0 1 0 0)M=(1 1 1 0 1 0 0 1) = C<sub>2</sub>

(0 0 0 0 0 0 1 0)M=(0 0 1 0 1 1 0 0)

C<sub>2</sub> M=(1 1 1 0 1 0 0 1) M=(3 1 3 2 2 1 3 4)

↪ (1 1 1 1 1 1 1 1) = C<sub>2</sub>

C<sub>2</sub>' M≈

(1 0 0 0 0 0 0 0)M=(0 0 1 1 0 0 1 1)

(0 1 0 0 0 0 0 0)M=(1 0 0 1 1 0 1 1)

(0 0 1 0 0 0 0 0)M=(1 0 0 0 0 0 0 1)

(0 0 0 1 0 0 0 0)M=(0 0 0 0 1 0 0 1)

(0 0 0 0 1 0 0 0)M=(1 1 1 0 0 1 1 1) = C<sub>3</sub>

(0 0 0 0 0 1 0 0)M=(0 0 1 0 1 0 0 1)

(0 0 0 0 0 0 1 0)M=(1 1 1 0 1 0 0 1)

(0 0 0 0 0 0 0 1)M=(0 0 1 0 1 1 0 0)

C<sub>3</sub> M=(1 1 1 0 0 1 1 1)M=(3 1 4 2 4 1 2 5)

↪ (1 1 1 1 1 1 1 1) = C<sub>3</sub> C<sub>3</sub>' M≈

(1 0 0 0 0 0 0 0)M=(0 0 1 1 0 0 1 1)

(0 1 0 0 0 0 0 0)M=(1 0 0 1 1 0 1 1)

(0 0 1 0 0 0 0 0)M=(1 0 0 0 0 0 0 1)

(0 0 0 1 0 0 0 0)M=(0 0 0 0 1 0 0 1)

(0 0 0 0 1 0 0 0)M=(1 1 1 0 0 1 1 1) = C<sub>3</sub>

(0 0 0 0 0 1 0 0)M=(0 0 1 0 1 0 0 1)

(0 0 0 0 0 0 1 0)M=(1 1 1 0 1 0 0 1)

(0 0 0 0 0 0 0 1)M=(0 0 1 0 1 1 0 0)

(1 1 1 0 0 1 1 1) is the fixed point and the triggering pattern is C<sub>1</sub>→ C<sub>7</sub>→ C<sub>5</sub>→C<sub>5</sub>whenThe first attribute is kept in on state. The following table gives the triggering patterns when other attributes are kept in ON state consecutively.

Table 3.1 Induced Patterns for M by IFCM

Merging all these induced graphs on a single graph, we obtain the following graph.

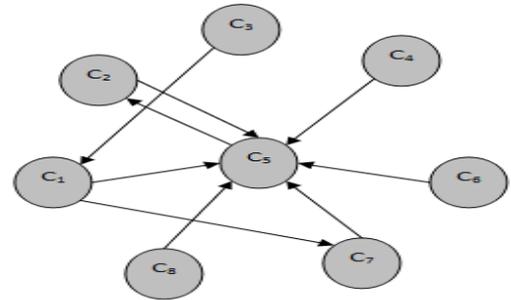


Fig 1: Induced graphs on a merged graph

The interrelationship between the attributes revealsthatC<sub>5</sub>[continuous cough gives throat pain, dryness in the tongue and also creates abdominal pain] is the terminalnodeand C<sub>2</sub>[A cough with thick, cloudy and sometimes bloody mucus from the lungs for more than two weeks]plays

theroleofintermediarynode.The limitpointcorresponding

toC<sub>5</sub>(11100111)highlightstheattributesandC<sub>1</sub>, C<sub>2</sub>,C<sub>3</sub>,C<sub>6</sub>,C<sub>7</sub>,C<sub>8</sub>whichseems to be major symptoms of Tuberculosis.

#### IV. CONCLUSION

In all the diseases, prevention is must than curing it. So to reduce the illness after the infection of tuberculosis, the patient has to follow certain remedial measures in order to have a happy surrounding for him and also to others by not spreading it.The corporation has to maintain some safety measures and follow some steps to overcome this problem.We suggest the following remedial measures.Covering of mouth by a mask will prevent from spreading of the diseases.Increase the immunity by performing regular exercise everyday and good, undisturbed sleep will also strengthens the immune system.Taking healthy foods and get tested regularly with doctor will give you a better improvement.A drug called Isoniazid(INH) can be used as a preventive therapy for those who are at high risk of becoming infected with tuberculosis.

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