

Mathematical Modelling for Interpretation of HIV /AIDS Infection in Human Body by Using IFCMs

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Abstract- In this paper HIV/AIDS (Human Immunodeficiency Virus / Acquired Immune Deficiency Syndrome) and symptoms of HIV infection; relation between symptoms and interpretation for most probable symptoms of HIV infection are explained. For explanation Induced Fuzzy Cognitive Maps is used.

Key words: - Fuzzy Cognitive Maps, Induced Fuzzy Cognitive Maps, Symptoms of HIV infection, Interpretation of Infection.

I. INTRODUCTION ABOUT HIV/AIDS

HIV/AIDS is a disease of the human immune system caused by infection with Human Immunodeficiency Virus (HIV). During the initial infection, a person can experience a brief period of influenza-like illness. This is usually followed by a longer period of time without symptoms. As the disease progresses, it mixes up more and more with the immune system, what the person is much more likely to infections, including opportunistic infections and tumours. HIV is primarily transmitted through unprotected sex (including anal and also Oral sex), contaminated blood transfusions, needles, and from mother to child during pregnancy, birth, or breast-feeding. Some of the body fluids such as saliva, tears, do not transmit HIV. The prevention of HIV infections is primarily through safe sex and needle-exchange programs, is a key strategy for the dissemination of disease control. There is no cure or vaccine; however, the antiretroviral treatment can check the history of the disease and can lead to an almost normal life expectancy. The antiretroviral treatment reduces the risk of death and complications of the disease, these drugs are expensive and can be fitted with side effects. The genetic research indicates that HIV arose in the West - Central Africa during the early twentieth century. AIDS was first of the Centre for Disease Control and Prevention (CDC) in 1981 and its cause HIV infection - was in the first half of the decade. Since its discovery, AIDS has caused almost 30 million dead (as of 2009). From 2010 approximately 34 million people are living with HIV worldwide. AIDS is a pandemic - a disease which spread over a large area and is active. HIV/AIDS has a great influence on the society, both as a disease and as a source of discrimination. The disease also has a significant economic impact. There are many misconceptions about HIV/AIDS, such as the belief that it can be transmitted by and non-sexual contact. The disease is also the subject to much controversy with religion. The most common transmission of HIV is through sex with an infected person. The majority of all transfers worldwide occur through heterosexual contacts i.e. sexual contacts between people of the opposite sex; however the pattern of transmission varies considerably between countries. In the United States, as of 2009, the sexual transmission occurred in men who have sex with men with this population accounts for 64% of all new cases.

With reference to unprotected heterosexual contacts, estimates the risk of HIV transmission per sexual act seems to be four to ten times higher in countries with a low income than in countries with a high income. In countries with low incomes, the risk of female to male transmission is estimated as 0.38% per action and the male-to-female transmission as 0.30% per action; the corresponding estimates for countries with high incomes are 0.04% per document for female-to-male transmission, and 0.08% per act for the Male-to-female transmission. The risk of transmission of anal sex is particularly high, the estimated 1.4-1.7% per act both in the hetero and homosexual contacts. While the risk of transmission of oral sex is relatively low, it is still there.

II. SYMPTOMS OF HIV/AIDS

The symptoms of HIV vary from person to person and sometimes the symptoms may not even palpable for years too. There are three stages of HIV: The acute primary infection stage, the asymptomatic stage and the Symptomatic Stage. In acute primary infection stage some people experience a flu-like illness within 2-4 weeks after an HIV infection. But some people may not feel sick during this phase. Flu-like symptoms may include: fever, chills, rash, night sweats, muscle pain, neck pain, fatigue, swollen lymph nodes and ulcer in the mouth. These symptoms can be anywhere from a few days up to several weeks. During this time, a HIV infection it is not on a HIV test, but people who are highly contagious and can infect others also. One should not assume that one has HIV, just because a person has any of these symptoms. Each of these symptoms can be caused by other diseases. And some people who have HIV do not have all the symptoms at all for ten years or more. The majority of HIV test to identify antibodies (proteins that your body is in response to the presence of HIV), not HIV itself. But it takes a few weeks for a body to produce these antibodies, so if a person is too early, he/she could not provide an accurate measurement result. A new HIV test is available that can detect HIV directly in this early phase of the infection. If a person is HIV positive then find out the ways to prevent HIV. There is a high risk of transmission of HIV to others during the early phase of HIV infection, even if a person has no symptoms. For this reason it is very important to take measures to reduce the risk of transmission. After the early stage of HIV infection, the disease moves into a phase of clinical latency stage as a "chronic HIV infection". This is called asymptomatic stage. During this stage, HIV is still active, but increasingly at a very low level. People with chronic HIV infection may not have HIV-related symptoms, or only mild. For people who do not take medicines to treat HIV called antiretroviral therapy or art, this period may be a decade or longer, but some can progress through this phase faster. People who are taking medication for the treatment of HIV in the right way, every day can at this stage for several decades, because the treatment helps to ensure that the virus in the review. It is important to remember that people can still transmit HIV to others during this phase, even if they have no symptoms, even though people on art and stay virally suppressed (with a very low level of virus in your blood) are much less likely that HIV than those who do not virally suppressed. If a person has HIV and he/she is on the arts, finally the virus weakens the immune system of his/her body and he/she will progress to AIDS), the late stage of the HIV infection is symptomatic stage. Symptoms of this stage may include: rapid weight loss; recurrent fever or extensive night sweats, extreme and unexplained tiredness, lasting swelling of the lymph nodes in the armpits, bars, or on the back of the neck; diarrhea, longer than a week; wounds in the mouth, anus and genitals; pneumonia; red, brown, pink, violet or stains on or under the skin or in the mouth, nose or eyelids; memory loss, depression and other neurological disorders. Each of these symptoms can be also used in conjunction with other diseases. So the only way to ensure to know if you are infected with HIV is audited. Many of the serious symptoms and diseases of HIV disease come from the opportunistic infections that occur because your body the immune system has been damaged. Symptoms are mentioned in fig (5.1).

III. INTRODUCTION ABOUT FUZZY COGNITIVE MAP

Fuzzy Cognitive Maps of researchers are signed procedure & may include different kinds of knowledge to draw and analyse complex operating system. During the process of learning and understanding mapping system between particular favours, in which the process of representation and public buildings researchers FCM certain perception of the obstacles created reason. A SEI consists of many elements / concepts / nodes / factors and their influences on one another, the chances of the weighted are depicted with arrows between the elements. The analysis of the relationship between the attributes has been found in a SEI by detecting and interpreting the map and understanding its structural properties and the dynamism. The structured ways of collecting and data coding enables comparison studies have been reused.

Definition: 1

An FCM is a directed graph with concepts like policies, events etc. as nodes and causalities as edges. It represents causal relationship between concepts. If increase (or decrease) in one concept, a lead to increase (or decrease) in another, then it gives the value 1. If no relation exists between two concepts, then the value 0 is given. If increase (or decrease) in one causalities decreases (or increases) another, then give the value -1. Thus FCMs are described in this way.

Definition: 2

When the nodes of the FCM are fuzzy sets then they are called as fuzzy nodes.

Definition: 3

FCMs with edge weights or causalities from the set $\{-1, 0, 1\}$, are called simple FCMs.

Definition: 4

Consider the nodes or concepts $C_1, C_2, C_3, \dots, C_n$ of the FCM. Suppose the directed graph is drawn using edge weight $e_{ij} \in \{0, 1, -1\}$. The matrix E be defined by $E = e_{ij}$, where e_{ij} is the weight of the directed edge $C_i C_j$. E is called the adjacency matrix of the FCM, also known as the connection matrix of the FCM. It is important to note that all matrices associated with an FCM are always square matrices with diagonal entries as zero.

Definition: 5

Let $C_1, C_2, C_3, \dots, C_n$ be the nodes of an FCM. $A = (a_1, a_2, a_3, \dots, a_n)$, where $a_i \in \{0, 1\}$. A is called the instantaneous state vector and it denotes the on-off position of the node at an instant.

$$\begin{aligned} a_i &= 0 && \text{if } a_i \text{ is off and} \\ a_i &= 1 && \text{if } a_i \text{ is on} \\ &&& \text{for } i = 1, 2, 3, \dots, n \end{aligned}$$

Definition: 6

Let $C_1, C_2, C_3, \dots, C_n$ be the nodes of a Fuzzy Cognitive Map. Let $\overrightarrow{C_1 C_2}, \overrightarrow{C_2 C_3}, \overrightarrow{C_3 C_4}, \dots, \overrightarrow{C_i C_j}$ be the edges of the FCM ($i \neq j$). Then, the edges form a directed cycle. An FCM is said to be cyclic if it possesses a directed cycle. An FCM is said to be acyclic if it does not possess any directed cycle.

Definition: 7

An FCM with cycles is said to have a feedback.

Definition: 8

When there is a feedback in an FCM, i.e., when the causal relations flow through a cycle in a revolutionary way, the FCM is called a dynamical system.

Definition: 9

$\overrightarrow{C_1 C_2}, \overrightarrow{C_2 C_3}, \overrightarrow{C_3 C_4}, \dots, \overrightarrow{C_{n-1} C_n}$ be a cycle. When C_i is switched ON and if the causality flows through the edges of a cycle and if it again causes C_i we say that the dynamical system goes round and round. This is true for any node C_i for $i = 1, 2, 3, \dots, n$. The equilibrium state for this dynamical system is called the hidden pattern.

Definition: 10

If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point.

IV. ALGORITHM FOR INDUCED FUZZY COGNITIVE MAPS (IFCM)

Induced Fuzzy Cognitive Maps is upgradation of Fuzzy Cognitive Maps. IFCMs has some modifications in algorithms. To interpret solution of the problem go through the following steps:

Step 1:

For the given model collect the unsupervised data that is in determined factors called nodes.

Step 2:

According to the expert opinion, draw the directed graph.

Step 3:

Obtain the connection matrix, 'A' from the directed graph (FCMs). Here the number of rows in the given matrix is equal to number of steps to be performed.

Step 4:

Consider the state vector C_1 which is in ON position. Find $C_1 \times A$. The state vector is updated and threshold at each stage.

Step 5:

Threshold value is calculated by assigning 1 for the value greater than 1 and 0 for the values less than one. The symbol \rightarrow represents 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 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.

V. ANALYSIS OF THE MATHEMATICAL MODEL

Now, a model for HIV infected people is explained to find out most probable symptoms. At the first stage, following seven arbitrary attributes ($S_1, S_2, S_3, S_4, S_5, S_6, S_7$) have been taken. The following attributes are taken as the main nodes for study.

S_1 = Diarrhea

S_2 = Fever

S_3 = Weight Loss

S_4 = Fatigue

S_5 = Skin Rashes

S_6 = Chills

S_7 = Shortness of Breath

Here a Directed Graph is mentioned by using Symptoms of HIV Infection,

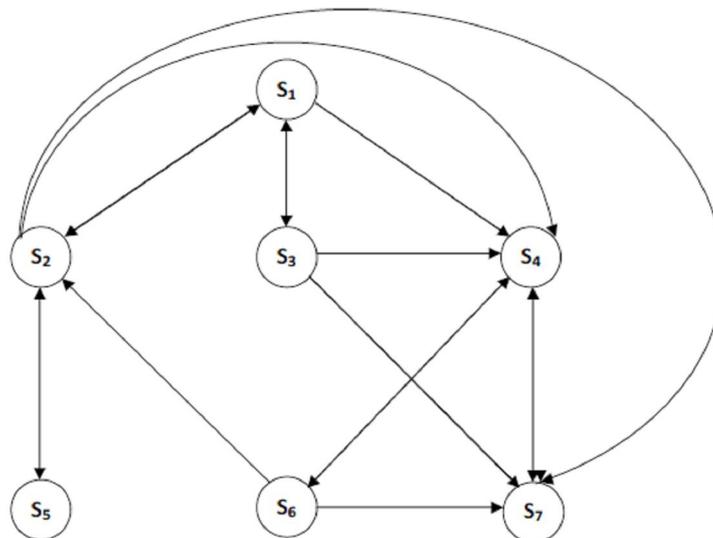


Fig (5.1) : Directed graph by using symptoms of HIV infection.

VI. IMPLEMENTATION OF MATHEMATICAL MODEL

According to the study symptoms for being infected by HIV have been found. Now, here is implementation of the model. for this, matrix 'A' is formed as below:

$$A = [a_{ij}] = \begin{matrix} & S_1 & S_2 & S_3 & S_4 & S_5 & S_6 & S_7 \\ \begin{matrix} S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \\ S_7 \end{matrix} & \begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ 1 & 0 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 \end{bmatrix} \end{matrix} \dots\dots\dots(6.1)$$

Initially it started form S₁ (Diarrhea) to interpret the problem here and it is supposed that only S₁ state is ON and others are OFF.

Then,

$$C_1 = (1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) \dots\dots\dots(6.2)$$

Multiply C₁ with matrix 'A',

$$C_1 A = (0 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0) \sim (1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0)$$

i.e.

$$C_1^1 A = (1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0) \dots\dots\dots(6.3)$$

In the calculated value first zero (0) in first place is replaced by one because of the hypothesis that only S₁ state is ON and others are OFF.

As it is known that threshold value is calculated by assuming one (1) for the values greater than one and zero (0) for the values less than zero.

Now, calculation of threshold values by iteration method, in this process, all S_i's supposed to be ON one by one.

As it has been supposed for S₁, then,

$$C_1^1 A \sim (1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) A \rightarrow (0 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0) \dots\dots\dots(6.4)$$

$$C_1^1 A \sim (0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0) A \rightarrow (1 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1) \dots\dots\dots(6.5)$$

$$C_1^1 A \sim (0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0) A \rightarrow (1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 1) \dots\dots\dots(6.6)$$

$$C_1^1 A \sim (0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0) A \rightarrow (0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 1) \dots\dots\dots(6.7)$$

$$C_1^1 A \sim (0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0) A \rightarrow (0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0) \dots\dots\dots(6.8)$$

$$C_1^1 A \sim (0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0) A \rightarrow (0 \ 1 \ 0 \ 1 \ 0 \ 0 \ 1) \dots\dots\dots(6.9)$$

$$C_1^1 A \sim (0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1) A \rightarrow (0 \ 1 \ 0 \ 1 \ 0 \ 0 \ 0) \dots\dots\dots(6.10)$$

Let

$$C_2 = (1 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1) \dots\dots\dots(6.11)$$

Because the threshold having maximum 1's will assumed as C_2 , then repeat the above process again,

So,

$$C_2 A = (0 \ 1 \ 1 \ 1 \ 0 \ 1 \ 1) \sim (1 \ 1 \ 1 \ 1 \ 0 \ 1 \ 1)$$

i.e.,

$$C_2^1 = (1 \ 1 \ 1 \ 1 \ 0 \ 1 \ 1) \dots\dots\dots(6.12)$$

Now,

$$C_2^1 A \sim (1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) A \rightarrow (0 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0) \dots\dots\dots(6.13)$$

$$C_2^1 A \sim (0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0) A \rightarrow (1 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1) \dots\dots\dots(6.14)$$

$$C_2^1 A \sim (0 \ 0 \ 1 \ 0 \ 0 \ 0 \ 0) A \rightarrow (1 \ 0 \ 0 \ 1 \ 0 \ 0 \ 1) \dots\dots\dots(6.15)$$

$$C_2^1 A \sim (0 \ 0 \ 0 \ 1 \ 0 \ 0 \ 0) A \rightarrow (0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 1) \dots\dots\dots(6.16)$$

$$C_2^1 A \sim (0 \ 0 \ 0 \ 0 \ 1 \ 0 \ 0) A \rightarrow (0 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0) \dots\dots\dots(6.17)$$

$$C_2^1 A \sim (0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 0) A \rightarrow (0 \ 1 \ 0 \ 1 \ 0 \ 0 \ 1) \dots\dots\dots(6.18)$$

$$C_2^1 A \sim (0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1) A \rightarrow (0 \ 1 \ 0 \ 1 \ 0 \ 0 \ 0) \dots\dots\dots(6.19)$$

Let

$$C_3 = (1 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1) \dots\dots\dots(6.20)$$

By using (6.11) & (6.20), it can be seen that,

$$C_2 = C_3 = (1 \ 0 \ 0 \ 1 \ 1 \ 0 \ 1)$$

When the same threshold value occurs twice, the value is considered as the fixed point. Then terminate the iteration.

VII. CONCLUSION

After all the process the results can be analysed as follows:-

- By putting S_1 (Diarrhea) in ON position it is found that the result is (1 0 0 1 1 0 1).
- S_1 (Diarrhea) could be a major symptom of HIV infection if patient suffering from long time.
- It is found that S_1, S_4, S_5, S_7 are major symptoms in case of HIV infection.
- By observing the iterations it can be seen that S_4 (Fatigue) is the very strong symptom which will lead to further investigations.

- Shortness of Breath (S_7) is also a symptom which is duly related with S_4 .
- Skin Rashes (S_5) is also a major symptom of HIV according to study.
- As resistance power varies from person to person there will be variation but S_2 (Fever) is also a symptom if it is repeated several times with some other symptoms.
- In this period S_3 (Weight loss) is also a symptom which is directly related with immune system.

VIII. FUTURE SCOPE OF THE RESEARCH

Present paper analyses most probable symptoms of HIV infection. In next step we can go for analysis of causes of the disease and then after for prevention, treatment and also we can use this analysis in the making of medicines.

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