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Application of Fuzzy Hypergraph in Medical Diagnosis

Saridha S[1], Vidhya R[2]
[1, 2]Associate Professor, PG Student, PG and Research Department of Mathematics, Cauvery College for Women (Autonomous), Trichy-18

Abstract:In this paper fuzzy hypergraph is applied in medical diagnosis to find the affected patient of a particular disease using the symptoms. Patients are treated as lines and symptoms as points.
Keywords: Hyper graph, fuzzy hypergraph, fuzzy α - cut hypergraph and medical diagnosis.

I. INTRODUCTION

Since its introduction by Berge [1], the hypergraph has been seen as a helpful tool for representing a partition, covering, and clustering as well as for analyzing a system's structure. Kaufmann [5] introduced the idea of fuzzy hypergraph, which is an extension of the hypergraph concept in fuzzy theory. It has been noted, nevertheless, that fuzzy partitions and other systems are not well represented by Kaufmann's definition of a fuzzy hypergraph [5].

In order to be helpful for system analysis and fuzzy partitioning, the fuzzy hyper graph concept has been redefined. A-cut hypergraph, dual fuzzy hypergraph, strong class, and strength of edge (class) are a few of the helpful ideas that will be developed. As we shall see, the suggested fuzzyhyper graph is helpful in providing a visual description of a fuzzy covering or partition. In addition, the strength of edge (class) enables us to choose strong classes for a partition, and separating the strong classes from the other portions can help manage less data overall. The suggested ideas have applications in pattern recognition, circuit clustering, and system analysis.

In section II, some basic definition are discussed, medical diagnosis fortyphoid, malaria and dengue are imported in section III. In section IV,the concept of fuzzy hypergraph is applied in medical diagnosis and using α - cut fuzzy hyper graph the patients with particular disease is identified.This can be further extended in the field of automata theory [7,8,9,10,11] and it can also be applied in labeled graph [6,12,13,14].

II. PRELIMINARIES

In this section some basic notions which are needed for the succeeding sections are discussed.

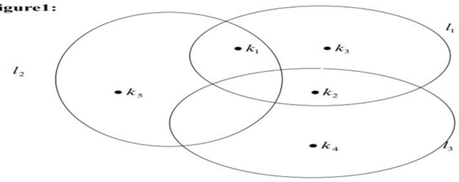
A. Definition 2.1

A hypergraph H can be defined as a pair (K, L), where K is as set of points, and L is a set of hyper lines between the points. Each hyper line is a set of point $L \subseteq P(K)$ .The hypergraph, which is defined as follows: $H = (K, L)$ Where, K is the set of points, L is the set of hyper lines.

Example: Consider a hyper graph $H = (K, L)$ such that $K = \{k_1, k_2, k_3, k_4, k_5\}$, $L = \{l_1, l_2, l_3\}$, where, $l_1 = \{k_1, k_2, k_3\}$, $l_2 = \{k_1, k_5\}$, $l_3 = \{k_2, k_4\}$.

The hyper graph, which represents the incident matrices, is displayed as follows:

Figure1:



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Incidence matrix:

$$\begin{array}{c|ccc} H & l_1 & l_2 & l_3 \\ k_1 & 1 & 1 & 0 \\ k_2 & 1 & 0 & 1 \\ k_3 & 1 & 0 & 0 \\ k_4 & 0 & 0 & 1 \\ k_5 & 0 & 1 & 0 \end{array}$$

B. Definition 2.2

In ordered pair $\hat{H} = (\hat{K}, \hat{L})$ such that is a fuzzy hypergraph

(1) $\hat{K} = \{k_1, k_2, k_3, \ldots\ldots\ldots, k_n\}$ a finite set of points,(2) $\hat{L} = \{l_1, l_2, l_3, \ldots\ldots\ldots\ldots, l_m\}$ a family of fuzzy subset of $\hat{K}$

(3) $\hat{K}_j = \{(x_i, \mu_j(x_i) \setminus \mu_j(x_i) > 0\}, j = 1,2,3,\ldots\ldots.,m$, (4)$\hat{K}_j \neq \phi$, j = 1,2,…….,m (5)$\bigcup_j \sup(\hat{K}_j) = S$, j = 1,2,…….,m

III. MEDICAL DIAGNOSIS FOR TYPHOID, MALARIA AND DENGUE

In this section, some symptoms for typhoid, malaria, dengue and the nature of symptoms are presented.

Typhoid: A bacterial disease called typhoid is contracted by drinking tainted water or food. Children are more vulnerable to typhoid disease, which is more common in communities without access to clean water and proper sanitation. In places where typhoid is prevalent, vaccinations are advised. Symptoms are high fever, headache, nausea, weakness, vomiting and loose stools.

Malaria: An infection contracted from a plasmodium parasite by mosquito bites. The majority of human cases of malaria are transmitted by female Anopheles mosquito bites. Malaria can also be spread through blood transfusions and infected needles. If P. falciparum malaria is not treated, it can cause severe sickness and death in as little as 24 hours.Symptoms are chills, fever and sweating.

Dengue: A viral illness spread by mosquitoes that is seen in tropical and subtropical regions. Dengue can cause mild to severe sickness, or it might be an asymptomatic infection. One in four dengue virus infections are thought to present symptoms. The most typical presentation of a symptomatic dengue virus infection is a mild to moderate acute fever. One of the four dengue viruses can cause infection, and that virus-specific immunity will last a long time. People can contract dengue more than once in their lifetime due to the four different strains of the virus. Early clinical manifestations are nonspecific but warrant a high index of suspicion since patients can be spared mortality if early signs of shock are identified and intense supportive care is started quickly.Symptoms are muscles and joints pain, rash, headache and high fever.

IV. FUZZY HYPERGRAPH IN MEDICAL DIAGNOSIS

This section deals with the generalization of fuzzy hypergraph in which patients affected by some symptoms are taken. P is treated as patients and is called the set of lines (or hyper lines), whereas the set S is treated as symptoms and is called the set of points.

The set S, also known as the set of points, is represented by $s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9$ and is defined as follows. And the set P, also known as the set of lines, is represented by p_1, p_2, p_3 and is defined as follows. The fuzzy hypergraph is defined as follows:

$\hat{H}_P = (\hat{S}, \hat{P})$, $\hat{S} = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9\}$: a finite set of symptoms and is called the point,

$\hat{P} = \{p_1, p_2, p_3\}$: a family of fuzzy subset of S, Where, $p_1 = \{s_1, s_2, s_3, s_4, s_5\}$, $p_2 = \{s_1, s_6, s_7\}$, $p_3 = \{s_1, s_2, s_8, s_9\}$,

$\hat{P}_j = \{(x_i, \mu_j(x_i) \setminus \mu_j(x_i) > 0\}, j = 1,2,3,\ldots\ldots.,m$ $\hat{P}_j \neq \phi$, j = 1,2,…….,m

$\bigcup_j \sup(\hat{P}_j) = S$, j = 1,2,…….,m---(1)

The lines, also known as hyper lines, $\hat{P}_j$ are fuzzy sets of points. $\mu_j(x_i)$ defines the extent of involvement (membership) of point. Crisp sets $\hat{S}, \hat{P}$ make up other sets.

From (1), we have, $\bigcup_j \hat{P}_j = S$, j = 1,2,……., m ------------------------------(2)

By substituting (1) with (2), we can expand the concept of fuzzy hyper graph. The related fuzzy incidence matrix $M_{\hat{H}}$ of fuzzy hyper graph is natural way to express it. The fuzzy matrix element a_{ij} denotes the degree of participation or membership of x_i to $\hat{P}_j$ $(ie.)\mu_j(x_i))$.

You can utilize the diagram with its incidence matrix or the description of hyper lines in the fuzzy hyper graph, as the hyper graph graphic does not suggest the membership degree of point.

Example: Let us consider a hyper graph $\hat{H}_P = (\hat{S}, \hat{P})$ such that $\hat{S} = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9\}$, $\hat{P} = \{p_1, p_2, p_3\}$ Where,

$p_1 = \{(s_1,0.2),(s_2,0.3),(s_3,0.5),(s_4,0.1),(s_5,0.4)\}$, $p_2 = \{(s_1,0.2),(s_6,0.7),(s_7,0.8)\}$,

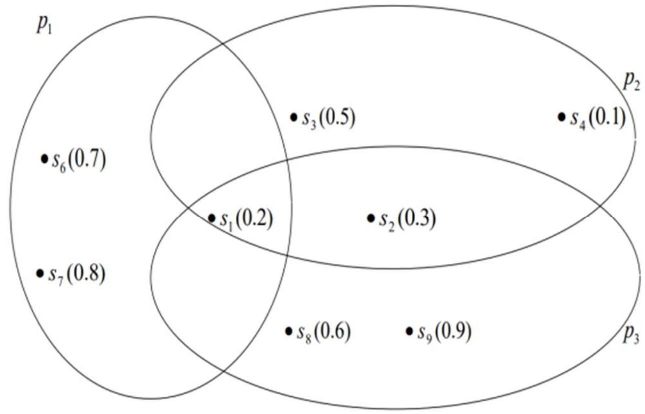
$p_3 = \{(s_1,0.2),(s_2,0.3),(s_8,0.6),(s_9,0.9)\}$

We are going to diagnosis the patients having fever, headache, stomach pain, weakness vomiting, chills, sweating, rashes and muscle pain by using fuzzy hypergraph.

A. *Fuzzy Incidence Matrix*

Figure2:

$$
\begin{array}{c|ccc}
\hat{H}_P & p_1 & p_2 & p_3 \\
\hline
s_1 & 0.2 & 0.2 & 0.2 \\
s_2 & 0.3 & 0 & 0.3 \\
s_3 & 0.5 & 0 & 0 \\
s_4 & 0.1 & 0 & 0 \\
s_5 & 0.5 & 0 & 0 \\
s_6 & 0 & 0.7 & 0 \\
s_7 & 0 & 0.8 & 0 \\
s_8 & 0 & 0 & 0.6 \\
s_9 & 0 & 0 & 0.9
\end{array}
$$



B. *Fuzzy α –cut hyper Graph*

The fuzzy α - cut hypergraph $\hat{H}_{P_\alpha}$ is obtained by cutting a fuzzyhypergraph $\hat{H}_p$ at the α level.

$$\hat{H}_{P_\alpha} = (\hat{s}_\alpha, \hat{p}_\alpha), \hat{s}_\alpha = \{\hat{s}_1, \hat{s}_2, \hat{s}_3, \hat{s}_4, \hat{s}_5, \hat{s}_6, \hat{s}_7, \hat{s}_8, \hat{s}_9\}, \hat{p}_\alpha = \{\hat{p}_1, \hat{p}_2, \hat{p}_3\}$$

$$\hat{p}_\alpha = \{\hat{p}_{j,\alpha} \mid \hat{p}_{j,\alpha} \neq \phi, j = 1,2,3,.......,m+1\}, \hat{p}_{j,\alpha} = \{x_i \mid \mu_j(x_i) \geq \alpha, j = 1,2,3,.....,m\}$$

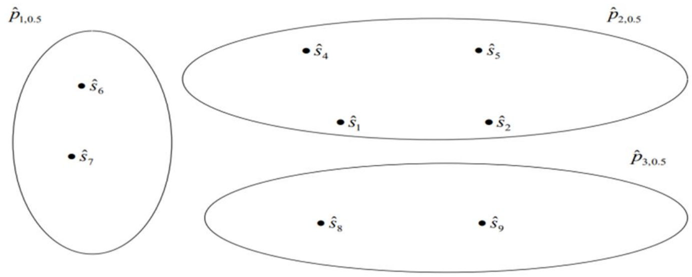
Now, the lines within the fuzzy α - cut hypergraph are distinct sets.

Example: In the above fuzzy α -hypergraph, take symptoms $\hat{s}_1$ as fever, $\hat{s}_2$ as headache, $\hat{s}_3$ as stomach pain, $\hat{s}_4$ as weakness, $\hat{s}_5$ as vomiting, $\hat{s}_6$ as chills, $\hat{s}_7$ as sweating, $\hat{s}_8$ as rashes, $\hat{s}_9$ as muscle pain and $\hat{p}_1, \hat{p}_2, \hat{p}_3$ are patients.The fuzzy hypergraph of the hypergraph at $\alpha = 0.5$ and incidence matrix $M_{\hat{H}_{0.5}}$ as follows:

C. *Incidence Matrix*

$$
\begin{array}{c|ccc}
\hat{H}_p & \hat{P}_{1,0.5} & \hat{P}_{2,0.5} & \hat{P}_{3,0.5} \\
\hline
\hat{s}_1 & 1 & 0 & 0 \\
\hat{s}_2 & 1 & 0 & 0 \\
\hat{s}_3 & 1 & 0 & 0 \\
\hat{s}_4 & 1 & 0 & 0 \\
\hat{s}_5 & 1 & 0 & 0 \\
\hat{s}_6 & 0 & 1 & 0 \\
\hat{s}_7 & 0 & 1 & 0 \\
\hat{s}_8 & 0 & 0 & 1 \\
\hat{s}_9 & 0 & 0 & 1
\end{array}
$$

Figure3:



The element with larger than 0.5 membership to all lines is contained in the 0.5-cut hypergraph.

By using the cut- hypergraph at $\alpha = 0.5$, patient1 $\hat{p}_{1,0.5}$ suffers from typhoid, patient2 $\hat{p}_{2,0.5}$ suffers from malaria and patient3 $\hat{p}_{3,0.5}$ suffers from dengue.

V. CONCLUSION

This paper gives a spark in the line of medical diagnosis how to find a patient affected by a particular disease. In similar manar this can be extended in human trafficking by treating vertices as causes for human trafficking and edges as types of human trafficking.

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