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A Fuzzy Multi-Criteria Decision Technique (FMCDT) To Model Wellness

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Abstract – There is no such a concept called total wellness or non- wellness. Human society always experiences a gradual transition between wellness to non-wellness. Wellness cannot be modelled or assessed in classical logic or traditional logic. Wellness contains a notion of fuzziness or a blurred boundary, because there is no such a state in human life where we can assess and say that wellness exists or it doesn't exist. But it is often observed that someone is more realistically described as being 'more or less' well rather than as being only either well or non-well. This interpretation is mathematically determined by a Fuzzy Set concept. In a Fuzzy concept 'Wellness is a matter of Degree'.

This paper uses Fuzzy Multi-Criteria Decision Technique to capture the extent of wellness of a person incorporating both the quantitative and qualitative factor of health status. The multi-Criteria are: Physical, Mental, Emotional, Spiritual, Economic, Social and Environmental. These Multi- Criteria are called the Wellness determinant factors.

Fuzzy multi-criteria Technique uses fuzzy numbers system to capture the experts' opinion. Experts' opinions are generally in linguistic variables such as very well, almost very well, almost well; well, rather well, not-so-well and not-at-well. These variables need Fuzzy Numbers to quantify the data. So far, triangular, trapezoidal, and pentagonal fuzzy numbers have been used. This paper introduces Septa-gonal Fuzzy Membership Function to assess the wellness of an individual or a community accommodating multi-directed hyper graph. This paper has three sections namely introduction, review of literature, wellness assessment model with an example and conclusion.

Keywords: Wellness, Multi-Criteria, Fuzzy Numbers, Septagonal Fuzzy Membership Function, Fuzzy Bi - directed hyper graph. AMS Mathematics Subject Classification (2010) 03E72.

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1. INTRODUCTION

These days, it is observed that human environment is being overloaded by unhealthy environments such as polluted environment, high level of violence, emotional disorder, and influence of increased stress factors and reduced social support etc. Hence, wellness is a matter of concern and subject which needs to be studied or analysed based on scientific method.

Though scientifically wellness comes under the medical domain, yet it can be discussed mathematically too. Human society does often experience a gradual transition between wellness and non-wellness. Now the question before the human is that how to decide who is well and who is not well. Wellness cannot be modelled or assessed in classical logic. It is so because the concept of wellness has a notion of imprecise boundary. There is no such a state in human life where one can deterministically decide exactly the condition of wellness is more realistically described as being 'more or less' well rather than as being only either well or non-well.

Imprecise concept like 'wellness' is mathematically interpreted by a Fuzzy Set concept using multi-criteria decision factors. The multi-Criteria are: Physical, Mental, Emotional, Spiritual, Economic, Social and Environmental. These Multi-Criteria are called the Wellness determinant factors.

This paper uses fuzzy decision making model to study wellness. The subject of decision making is the study of how the decision is made and how decision can be made better or more effective. There are a variety of decision-making techniques, for example: MCDM (MultiCriteria Decision Making), MADM (Multi-Attribute Decision Making) and MODM Multi-Objective Decision Making), TOPSIS (Multi-Objective Target Programming Technique), MOGeP (Multi-Objective Geometric Program), AHP (Analytic

Hierarchy Process). All these methods deal with precise or exact or deterministic value models representing a crisp value.

But then to analyse qualitative, imprecise information or data or even ill –structured decision problems fuzzy decision model employing the fuzzy set theory has been suggested as modelling tool for complex system that can be controlled by humans but are hard to define exactly.

Fuzzy Decision model is a branch of mathematics that allows the scholars or researchers to model real world problem the way people do. Sets of blurred judgments and information that offer an simple way to think in unclear, uncertain and inconsistent environments. It also provides more flexible membership function that allows for partial membership in a set. Exact reasoning is viewed as a limiting case of approximate reasoning. When individuals take part in making decisions, human subjectivity is not the standard or perfect indicator of the scientific method. This makes fuzzy decision making necessary tool to model wellness.

2. REVIEW OF LITERATURE

The various alternatives and choices show that decisions take place in fuzzy logic environment. Bellman and Zadeh developed the first decision-making method in a dynamic system in 1970. They used fuzzy set into the MCDM field giving a better result than crisp MCDM. Latter Baas and Kwakernaak's in 1977 worked on fuzzy MADM method at which they found that fuzzy decision attained its maximum value. Some titles among recently published papers show that latest interest areas of MADM and MODM. In 1999 Ravi and Reddy showed that in coking and noncooking Indian energy, India uses MADM (Multiattribute Decision-making). We use the 1978 fugitive MADM method of Saaty AHP and Yager to produce fuel for industrial usage with the finest quality material. The review on AHP and fuzzy AHP provide a rich description of the social and economic phenomenon, enabling a more acceptable distinction between crisp decision making tools and fuzzy decision methods. Fuzzy AHP is also used to analyse poverty level resulting in a better and satisfactory result.

2.1 Mathematical principle in crisp decision: Classical Set Theory Approach

A classical (crisp) set usually describes a number, which may be finite, countable or overrecounting, of elements or itemsx to diameter X. For the previous case, the answer belongs to A, although the other is incorrect. In the former situation, the reason belongs to A.

The classical group may be represented in many forms. Either the elements which belong to a group may be listed; for example, the sets may be analytically identified by listing membership criteria (A={x Alwaysx Always 5} or the member is specified by using a characteristic function where 1 implies membership and 0 does not belong. In this view, poverty status is characterized as a binary variable which attributes one of the two possible descriptions of a household or an individual that is he or she is poor or is non-poor.

3. FUZZY MULTI-CRITERIA DECISION TECHNIQUE (FMCDT) TO MODEL WELLNESS

3.1 Problem Definition

In solving fuzzy multi-criteria decision making problems the weights of criteria or alternatives can be calculated by many different ways. Two of the key approaches to test the environment core. In the context of addressing wellness with seven identifiers dimensions, enumerated as wellness determinant factors using stepta-gonal fuzzy numbers derived from the concept of fuzzy Numbers

3.2 Underlying concept of fuzzy numbers

Fuzzy numbers refer to a quantity whose value is imprecise in contrast to an ordinary or absolute or crisp number. A Fuzzy number is an series of numbers with a significance that has several specific effects. The term fuzzy number is used to handle imprecise numerical quantities, such as "close to 10", "about 7", "several", "nearly 5", "more or less 45", Explanation: close to 10 means close to ten instead of 10 (crisp number). Similarly, about 7 means close or near to seven instead of 7 (crisp number).

Fuzzy numbers are viewed as fuzzy intervals. We obtain an abstract impression of relative quantities or ranges such as "quantities past a certain numerical number" or' numbers around a certain ranges in real numbers' in order to interpret them in this manner. These conceptual principles are important for the characterisation of fluid variables and hence play a major role in the implementation of adaptive decision-making and in many other applications such as fluid controls, approximate reasoning, optimization and statistics with imprecise probabilities.

3.3 Definition Fuzzy Numbers

Consider a Fuzzy number $\underset{\sim}{A}$ a fuzzy subset on the real line R such that $\mu_{\underset{\sim}{A}} : X \rightarrow [0,1]$ and $\mu_{\underset{\sim}{A}}(x) \in [0,1]$ where x takes its number on the real line R, then $\underset{\sim}{A}$ is a fuzzy number if it satisfies the following properties

(i) $\underset{\sim}{A}$ must be normal that is $hieght(\underset{\sim}{A}) = 1$

(ii) $\underset{\sim}{A}$ is fuzzy convex that is $\underset{\sim}{A}(\lambda x_1 + (1-\lambda)x_2) \geq \min[\underset{\sim}{A}(x_1), \underset{\sim}{A}(x_2)], \forall x_1, x_2 \in R \text{ and } \lambda \in [0,1]$

(iii) There exists at least exactly one $x_0 \in R$ with $\mu_{\underset{\sim}{A}}(x_0)=1$ that is core $(\underset{\sim}{A})=x_0$

(iv) The membership function $\mu_{\underset{\sim}{A}}(x)$, $x \in R$ is at least piecewise continuous.

Let us denote the space of fuzzy numbers by R_F in [0, 1].

3.3.1 Fuzzy Real Numbers

Let R be the set of real numbers and $n \in R$ a given real number. From the real number n one can construct a fuzzy number N as a fuzzy set that covers number n.

3.3.2 Definition of Real Numbers

Let $\underset{\sim}{N}$ be a fuzzy number if and only if : (i) it is a fuzzy subset of the set R of real numbers. (ii) it membership function $\mu_{\underset{\sim}{N}}(x)$ has the following properties:

a. $\mu_{\underset{\sim}{N}}(x)$ is a continuous function

b. $\forall x \in (-\infty, c], \mu_{\underset{\sim}{N}}(x)=0$

c. $\mu_{\underset{\sim}{N}}(x)$ is strictly increasing in [*c*, *a*]

d. $\forall x \in [a, b], \mu_{\underset{\sim}{N}}(x)=1$

e. $\mu_{\underset{\sim}{N}}(x)$ is strictly decreasing in [*b* , *d*]

f. $\forall x \in [d, +\infty), \mu_{\underset{\sim}{N}}(x)=0$

From this definition it follows that N is a fuzzy real number if and only if N is a convex and n normal fuzzy subset of R.

3.3.3 Wellness: A Vague Predicate

Wellness is a vague predicate because, (i) It involves borderline cases (a person is not clearly well and not clearly non-well), (ii) There are no clear limits (along a theoretical continuum of well-being, an exact point when a well-being is not very good).

3.3.4. Wellness Set: A matter of degree

Wellness Set can be defined as a matter of degree based on the fuzzy logic concept. The fuzzy decision making tool approach considers wellness as a matter of degree rather than an attribute that is simply present or absent for a person in a given health condition. A argument may be valid to a certain degree in dynamic reasoning. Therefore, an individual or a community are assigned a degree in relation to the membership functions. A good individual of a given group of a separate degree is allocated the membership values 1 (the individual of the healthy) and 0 (the person of the not-well). In mathematical terms it can be represented as follows: False: Truth value = 0, True: truth value =1, Uncertain: 0 < Truth value < 1.

3.3.5 Fuzzy Subset approach to Wellness Model

Let us consider a set E of n individuals or community and let $\underset{\sim}{A}$ be a subset of E consisting of the well person, such that a fuzzy membership is given by $\mu_{\underset{\sim}{A}}(x_i)$ where $(i=1,2,3,\ldots,n)$ denote for each individual or community in $\underset{\sim}{A}$ and $\mu:\underset{\sim}{A}\rightarrow[0,1]$. The membership role is then specified for the good person

1) $\mu_{\underset{\sim}{A}}(x_i)=0$, if i^{th} individual is certainly not *well*;

2) $\mu_{\underset{\sim}{A}}(x_i)=1$, if i^{th} individual is *well*;

3) $0<\mu_{\underset{\sim}{A}}(x_i)<1$, if i^{th} individual exhibits a partial membership in the subset of $\underset{\sim}{A}$;

Fuzzy Multi-Criteria Strategy is attempting to reply: I How can memberships be assigned to elements in a flush set? (ii) How to adapt the definition of fuzzy sets to specific issues? The first problem applies to the creation of a metric scale in order to satisfy the requirements in logical measurement schemes for membership values. The membership role is delegated to the parameters and alternatives.

4. DETERMINANT FACTORS TO MODEL WELLNESS

The following multi-criteria are factors that attribute to model wellness :

(DFW)$_1$ Physical :

(i) Nutrition Level: Pattern of Food Habit:

(Ordinary Food, Adequate Food, Calories Level)

(ii) Sources safe drinking Water

(iii) Physical Activities

(iv) Accessibility to Health Centres (Use of Medical Advice)

(v) History of illness(personal or family)

(DFW)$_2$ Mental :

(i) Intellectual (Pattern of Thinking or Reasoning) Attitude to Life

(ii) Level of Education (Illiterate, Primary, Secondary, High Secondary, College, Technical, Diploma etc.)

(DFW)$_3$ Economical : Employment Status

(i) Formal Sector (organized sector)

(ii) Informal Sector(unorganized sector)

(iii) Level of Income and Expenditure

(iv) Source of Income (Land, Job, etc)

(DFW)$_4$ Social Status : Social Cohesion (Inclusion, Exclusion)

(i) Class Status

(ii) Caste Status

(iii) Gender Justice

(iv) Pattern of Justice

(DFW)$_5$ Environment :

(i) Location of the Premise(House)

Where is your house located? What is the environment of the area. Near the road, slum location or staying with general community. What is distance from the town. Surrender, Is there national resource around the house.

(ii) **Weather Condition** due to impact of climatic change.

(DFW)$_6$ Emotional Status : Managing Stress

(i) Self-Steam

(ii) Pattern of life style

(iii) Pattern of Sleep

(iv) Pattern of Leisure

(v) Pattern of Sleep

(DFW)$_7$ Spiritual Status : Awareness State of one self. Also **awareness** of the state of environment and neighbours**.**

4.1 The numerical assignment of the fuzzy numbers to the wellness Attributes defined as follow:

Let $\underset{\sim}{N}$ be the set of all fuzzy numbers such that

Membership funtion of wellness of $\mu(\underset{\sim}{A})=\left\{x:x=\frac{w}{w+1},w\in\underset{\sim}{N}\right\}$, where $\{\underset{\sim}{N}=1,2,3,4,5,6,7,8,9...\}$.

Let $\underset{\sim}{N}$ be the set of all fuzzy numbers such that

Membership function of non - wellness of $\mu(\underset{\sim}{A})=\left\{x:x=\frac{w}{w^2+1},w\in\underset{\sim}{N}\right\}$, where $\{\underset{\sim}{N}=1,2,3,4,5,6,7,8,9...\}$.

4.2 Hyper Graph

A diagram is a common diagram on which an edge may connect a variety of vertices. Hypergraph is a pair of which a collection is labeled hyper edges or nodes and a collection is a non-empty subset.

4.2.1 Fuzzy Hyper Graphs

Let X be a finite set and E be a finite fuzzy subset of Xs uch that

$$X=\bigcup_{\mu\in E}\text{supp}(\mu(\underset{\sim}{A}))$$

the pair H(X, E) is called a fuzzy hypergraph on X and E is called the edge of H. which is denoted by E(H). Members of E are called fuzzy edges of H.

The height of H is defined by $h(H)=\vee\{h(\mu(\underset{\sim}{A}))|(\mu(\underset{\sim}{A}))\}$, *where we recall that* $h(\underset{\sim}{A})$ the height of $h(\underset{\sim}{A})$.

4.2.2. Definition-1

Let $H=(X,E)$ be *fuzzy hypergraph. Suppose that* $t\in[0,1]$.

$Let E^t=\{\mu^t\neq 0|\mu\in E\}$ and $X^t=\bigcup_{\mu\in E}(\mu^t)$.

If $E^t\neq 0$, *then Crisp hypergraph* $H^t=(X^t,E^t)$ *is the t – level hypergraph of H*

4.2.3 Definition-2

Let $H^t=(X^t,E^t)$ be the t-level hypergraph of H.

These sequence of real number $\{r_1, r_2, r_3, ... r_n\}$, $0<r_n<...=h(H)$,

which satisfies the following properties

(i) *If* $r_{i+1}<s\leq r_i$, *the* $E^s=E^{r_i}$,

(ii) $E^{r_i}\subset E^{r_{i+1}}$

is called the fundamental sequesence of H, and is denoted by F(H)

and the set of r_i *– level hypergraphs* $\{H^{r_1},H^{r_2},...,H^{r_n}\}$

is called the set of core of H and is denoted by C(H).

If $r_1<s\leq 1$, in definition (3), then the $E^s=\{\phi\}$ *and* H^s *does not exists.*
For simplicity, whenever there is no confusion, We shall use H_i to denote the r_i *– level hypergraphs* H^{r_i}. *Further* X_i and E_i shall useally denote the vertex and edge set of the core hypergraph H^{r_i}. *Thus* $H^{r_i}=(X^{r_i},E^{r_i})=H(X_i,E_i)$, $i=1,2,...n$.

4.2.4 Algorithm to Model Mellness

Step-1. Let (DFW)$_n$, for n=1,2,...m, be Determinant Factors of Wellness.

Step -2. Assign observations numerical value to the (DFW)$_n$ to get the fuzzy numbers in the following functions:

Let $\underset{\sim}{N}$ be the set of all fuzzy numbers such that

Membership funtion of wellness of $\mu(\underset{\sim}{A})=\left\{x:x=\frac{w}{w+1},w\in\underset{\sim}{N}\right\}$,

where $\{\underset{\sim}{N}=1,2,3,4,5,6,7,8,9...\}$.

Let $\underset{\sim}{N}$ be the set of all fuzzy numbers such that

Membership function of non - wellness of $\mu(\underset{\sim}{A})=\left\{x:x=\frac{w}{w^2+1},w\in\underset{\sim}{N}\right\}$,

where $\{\underset{\sim}{N}=1,2,3,4,5,6,7,8,9...\}$.

Step -3. Representation of fuzzy values to get the fuzzy hyper graph

Step – 4. Write down the Incidence Matrix of the fuzzy hyper graph values

Step – 5. Use Heptagonal Fuzzy Membership Function to get Fuzzy Aggregate values

Step – 6. Modelling Multi-Criteria Decision Technique

Let $X=\{x_1,x_2,x_3,\ldots\ldots,x_n,\}$, and Let $\tilde{C}=\tilde{C}=\{\tilde{c}_1,\tilde{c}_2,\tilde{c}_3,\ldots\ldots,\tilde{c}_m,\}$ be set of alternatives and a set of criteria characterizing a decision situations respectively. Then the information in multi-criteria decision making can be expressed as follows: Incidence Matrix X_1 X_2……X_n

$$W=\begin{matrix}\tilde{C}_1\\ \tilde{C}_2\\ \cdots\\ \tilde{C}_m\end{matrix}\begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n}\\ r_{21} & r_{22} & \cdots & r_{2n}\\ \cdots & \cdots & \cdots & \cdots\\ r_{m1} & r_{m2} & \cdots & r_{mn}\end{pmatrix}$$

Let us assume that all entries of the matrix are needed in [0,1] and each entry c_{ij} expresses the degree to which criteria x_i is satisfied by alternatives x_j (i ε N, j ε N). Sometimes, instead of Matrix W with entries in [0,1] another matrix R is initially given. Then we convert R into W by using the formula: as given in Step-7.

Step-7 Calculate the Wellness Degree Using following Fuzzy Decision Formula:

$$W_{ij}=\frac{r_{ij}\min r_{ij}}{\max r_{ij}-\min r_{ij}}\qquad for\ all\ \ i\in N, j\in N$$

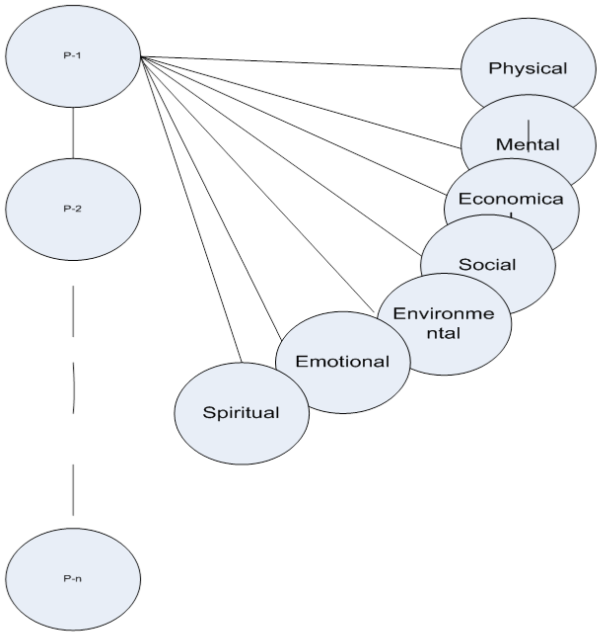
The Multi-Criteria decision problems is converted into a single criteria decision problem by finding a global: $r_j=h(r_{1j},r_{2j},\ldots,r_{mj})$ Criterion. That for all x_jεX is an aggregate of values $r_{1j},r_{2j},\ldots,r_{mj}$ to which the individual criteria $C_1,C_2,\ldots.,C_n$ are satisfied.

Aggregate Operator : An aggregate operator is the fuzzy weighted Average given by the Formula :

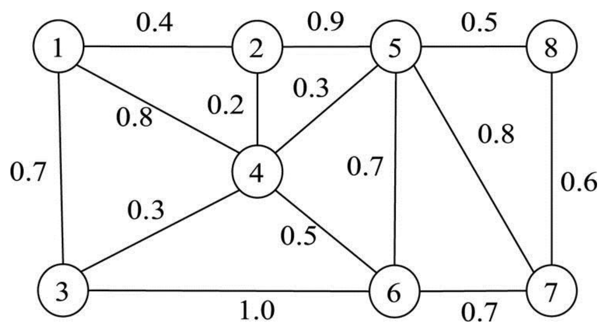
$$r_j=\frac{\sum_{i=1}^{m}w_i r_{ij}}{\sum_{i=1}^{m}w_i},(j\in N)$$

Where are the weights that indicate the relative importance of the fuzz criteria: $\tilde{C}_1,\tilde{C}_2,\tilde{C}_3,\ldots,\tilde{C}_m$.

Graphical Representation of Fuzzy Hyper Graph Algorithms



Fuzzy Hyper Graph Values



Membership values indicate the strength of the relation between vertices and edges.

Step-8 Wellness Linguistic Fuzzy Variable (Hedges)

Wellness Linguistic Fuzzy Variables and Fuzzy Membership values

Fuzzy Membership Variables (Hedges)	Fuzzy Membership Values
Very Well	1.00 – 0.9
Almost Very Well	0.7 - 0.8
Almost well	0.5 – 0.6
Well	0.5
Rather Well	0.3- 0.4
Not- so- Well	0.1- 0.2
Not well at all	0.0

CONCLUSION

Result Interpretation: Using Fuzzy multi-criteria Decision Technique, it is found status of wellness of any individual or a community can be levelled in a linguistic manner such as very well , almost very well, well, rather well, not so well and not well at all assigning fuzzy membership values. This gives a better picture of someone's wellness condition in more exact and deterministic approach. Hence, with help of FMCDT it can be concluded that this approach is able to handle vagueness, impreciseness and complexity, strengthening the connection between fuzzy subset theory and empirical wellness status of an individual or a community.

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