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EPIDEMIC CONTROL PROBLEM FOR THE STATE LEVEL MODEL IN FUZZY MATHEMATICS

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Abstract:

Human welfare Development systems are very essential, virtually for all countries and hence have been for a long time a subject of intensive research effort. In most real-world settings, Decisions are made in an Environment, in which the Goals, Constraints and dependencies are not sharply defined and served as a point of departure for an enormous variety of fuzzy models and approaches. The basic scheme of fuzzy Decision-Making (control) is a natural consequence and it is a perfect point of departure for an analysis, and has proven to be very effective and efficient in many real -world applications ranging from every day products to specialized equipments. "Fuzzy Environment consists of Fuzzy Goals, Fuzzy Constraints and a Fuzzy Decision. The formulation of Decision-Making problem in a fuzzy environment is "Attain G and Satisfy C." Epidemic is a disease affecting at the same time a large number of persons that is it is capable of being transmitted as from one person to another. Malaria is one of the Epidemic disease and in man it is caused by four distinct species of Malaria Parasite- P.vivax.P.falciparum P.malariae and P.ovale. Plasmodium vivax has the widest geographic distribution throughout the world. There are many processes employing medicines to regulate epidemic disease towards Human welfare. Imprecision (Fuzziness) may be caused by various reasons such as, we are unable to exactly assess damage in quantitative terms in particular in the case of loss of living beings. So, the multistage fuzzy control model for epidemic control be employed. The main concepts of this paper are to briefly summaries the Decision Making in a fuzzy control and to explain how the real-world problems in decision analysis can be formulated and solved through the use of fuzzy Branch-and-Bound algorithm.

Key Words: Fuzzyset, Membership Function, Universe of Discourse, Fuzzy Goal, Fuzzy constraints & Fuzzy Decision.

1.Introduction:

Decision-making in a Fuzzy Environment is Omni present in any human activity and handling of imprecise concepts, relations etc. Decision-making a fuzzy environment was introduced by "Bellman" and "Zadehs" in 1970, is a simple yet extremely powerful framework within which virtually all fuzzy models related to decision making. Fuzzy sets theory introduced by Lotfi A Zadeh in 1965, is an efficient means of handling imprecise information. The membership function taking values in the whole unit interval from '0' for element does not belong to the set to '1" for element belongs to the set, through all intermediate values between 0 and 1 standing for the belongingness to some degree. A fuzzyset A ina universe of discourse X = {x} is defined as a set of pairs A={(μ_A(X), X)}...........(1)Where μ_A: X→ [0, 1] is the grade of membership of an element x € X in a fuzzy set A. The fuzzy approach to "Epidemic Control" was proposed by Esogbue, Thelogidu & Guo. In this, how the problem is formulated and how its fuzzy (imprecise) aspects are represented.The main objectives of this paper are to briefly summarize the fuzzy environment, and to explain the medical measures employed to control Malaria and to explain the principles of decision-making and environmental benefits.

2. Fuzzy Environment:

Fuzzy Environment consists of Fuzzy Goals, Fuzzy Constraints and a "Fuzzy Decision". The fuzzy environment starts with the assumption of some set of decisions denoted by X={x} where x means the genetic element of X.

3. Fuzzy Goal:

The fuzzy goal is defined as a fuzzy set G in the set of options X, characterized by its membership function μ_G: X→[0, 1]... (2). Such that μ_G (X) € [0, 1] specifies the grade of membership of a particular option x € X, in the fuzzy goal G.

4. Fuzzy Constraint:

The fuzzy constraint is defined as a fuzzy set C in the set of options X, characterized by its membership function $\mu_C: X \rightarrow [0, 1]$... (3) Such that μ_C (X) € [0, 1] specifies the grade of membership of a particular option x€X in the fuzzy constraint C.

5. Fuzzy Decision:

If G is a Fuzzy Goal, C is a Fuzzy constraint, both defined as fuzzy sets in the set of options X = {x}, the "Fuzzy-Decision D" is a fuzzy set D, defined also in set of options X resulting from an aggregation characterized by its membership function $\mu_D(x)= \mu_C(x)*(x)$ .....(4) for each x € X.Suppose that X=R, the set of real numbers. Then the fuzzy goal "should be much larger than 5" may be represented by a fuzzy set whose membership function $\mu_G(x)$ and the fuzzy constraint "x should be more or less 6" may be represented by a fuzzy set whose membership function $\mu_C(x)$ is shown in figure (1)

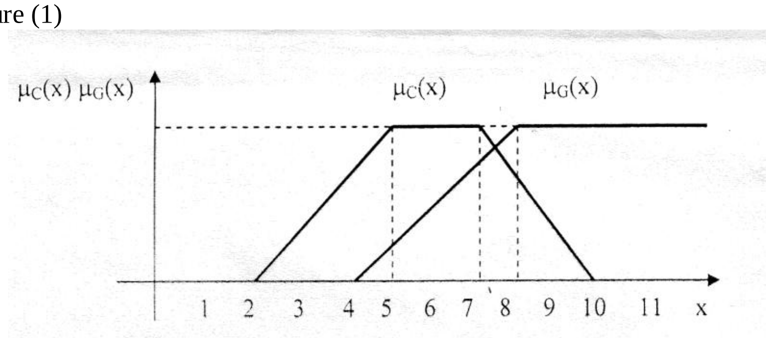

Figure 1

Fuzzy Goal, G, "x should be much larger than 5" and fuzzy constraint, C, "x should be more or less 6".

- ✓ If the Value of x attained is atleast $\overline{x_G}$ (equal 8) which is the "satisfaction level" of X (i.e.) for $X \geq X_G$? , then $\mu_G(X) = 1$ which means that fully "satisfied" with the x attained.
- ✓ If x attained does not exceed xG (equal 5), which is the lowest possible value of x, then $\mu_G(x) = 0$, which means that fully dissatisfied" with the X attained.
- ✓ For the intermediate values $\underset{-G}{\chi}$ $<x<\overline{x_G}$, (i.e)$0<\mu_G(x)<1$ which means that our satisfaction as to a particular value of x is intermediate (i.e) "between the full satisfaction" and "full dissatisfaction".

6. A Fuzzy Formulation of the Optimal Epidemic Control Problem for the State Level Model:

The system under control is assumed to be a geographical unit which is affected by Epidemic (Malaria) disease. This causes huge loses and these loses are prevents using some measures namely medical and non-medical measures.

7. Medical Measures:

Mefloquine or sulfadoxine or sulfane / pyrimethamine, chloroquine, chemoprophylaxis, Anti-Malarial Vaccine.

8.Non-Medical Measures:

Primary health centers, hospitals, individual insurance, dispensaries, local medical practitioners, blocking the channels of transmission, water purification, destruction of insects and indoor residual spraying with DDT.The impression (fuzziness) may be caused by various reasons such as, (1) we are unable to exactly assess damage in quantitative terms and (2) it is practically impossible to exactly predict the effects of the medical and non-medical measures employed, and hence the problem can be solved by using fuzzy branch and bound algorithms.The regional system is represented by a fuzzy system under control whose dynamics is governed by the state transition equation $X_{t+1} = F(Xt, Ut) =$ 0,1, ... denote the level of damage due to epidemic before the control U_t and offer U_{t+1} is applied.The main elements of this model are defined as follows:

- ✓ Stage-the region for epidemic control.
- ✓ Decision (control) - the level of total investment for region.
- ✓ State- the effect of epidemic control for region.

9. Solution Using a Branch - and - Bound Algorithm for the State-Level Model:

The optimal investment level for the particular regions, $j_1^*, j_2^* j_3^*, \ldots, j_{10}^*$ State,

$$\Phi = \max [R_1(j_1)+R_2(j_2)+R_3(j_3)+ \ldots + R_{10}(j_{10})] \ldots\ldots (5)$$

Subject to

$$R_n(j_n) = W_n [G_n(j_n) \wedge C_n(j_n)] \text{ and } \ldots\ldots (6)$$

$$W_1 + W_2 + W_3 \ldots + W_{10} = 1 \ldots\ldots (7)$$

Φ- the optimal weighted sum of effects of epidemic control for the state.

The total investment available for the country j, that is by adding (5) →(7), $j_1 + j_2 + j_3 + \ldots + j_{10} \leq j$.................. (8)

The membership function of Goal at the State level' is

$$G(j) = \begin{cases} 1 \; for \; j < 0 \\ \Phi \; for \; 0 \leq j < \bar{j} \\ 0 \; for \; \bar{j} < j \end{cases} \quad \ldots\ldots\ldots\ldots(9)$$

The solution of the fuzzy mathematical programming problem is obtained, as Jn* - the optimal investment level for region n ,n = 1,2....10

The necessary data used in the model are:

- ✓ C(j) - the membership function of a constraint for the state,
- ✓ G(j) - the membership function of a goal for the state,
- ✓ $C_n(j)$ - the membership function of a constraint for region n, n = 1,2,....,10
- ✓ Cn(j) - the membership function of a goal for region n,
- ✓ J - the upper bound of total investment for the state critically the region n, n=1,2, ...,10
- ✓ Wn-a relative importance of region n.

At this level C(j) are defined on the set of all feasible investment levels for the state, While, $C_n(j)$ and $G_n(j)$ are defined on the set of all feasible investment levels for region n.The optimal investment levels for the regions j_1^*, j_2^*, j_3^*,.....,j_{10}^* state,

$$\Phi = \max[R_1(j_1)+\ldots+R_n(j_n)+\ldots+R_{10}(j_{10})] \; j_1 \; j_2 \; j_3 \ldots\ldots j_{10} \quad \ldots\ldots\ldots (10)$$

Subject to

$$R_n(j_n) = W_n[G_n(j_n) \wedge C_n(j_n)] \ldots\ldots\ldots (11)$$

$$W_1+W_2+W_3+\ldots+Wn+\ldots+W_{10} = 1 \text{ and } j_1+j_2+j_3+\ldots+j_n\ldots+j_{10} \leq j \ldots\ldots\ldots (12)$$

$$j_1+j_2+j_3+\ldots+j_n+\ldots+j_{10} \leq j \ldots\ldots\ldots (13)$$

This first part of the objective function (10) is

$$R_1(j_1)+\ldots+R_n(j_n) \ldots\ldots\ldots (14)$$

The second part of the objective function (10) is

$$R_{n+1}(j_{n+1})+\ldots+R_{10}(j_{10}) \ldots\ldots\ldots (15)$$

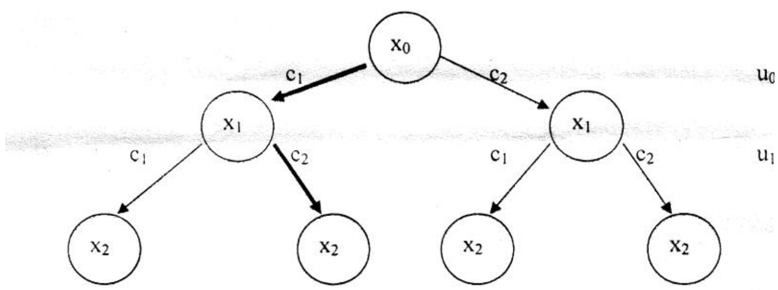

Fig.2. Decision tree

The upper bound of the branch in the corresponding decision tree, when in stagen, is the sum of the elements in the first part of objective function (14) and the upper bound of the second part of the objective function(15) is defined as

$\text{Max}_j R_{n1}(j)$, for n = 1,2, ..., 9 16

0,for n = 10

From the decision-tree, the sum of the first part and Hn is not greater than the best solution at present, this branch is not transversed and (13) does not hold is not transvered either. Finally at state n = 10, the new solution is obtained and the present best solution is updated.

10.Measured to Control Epidemic Disease:

The various measures to control the malaria have been classified as, protection against mosquito bites, vaccination, sanitary improvement, educating the public, intermittent drying of water containers, small scale drainage and water management and measures against Malaria Parasites – Presumptive treatment, radical treatment. In planning malaria control, the approach should be flexible choosing the most suitable combination of methods to the best advantage, depending upon local conditions and circumstances and financial resources.

11. Conclusion:

The use of fuzzy rules provides a way of Exploiting the Tolerance for Imprecision to achieve. Tractability, Robustness and Low solution cost etc. Decision making is a natural consequence and it is a perfect point of departure for an analysis, and has proved to be very effective and efficient in many real-world applications ranging from every day products to specialized equipments.

Nomenclature

A Fuzzy set

X Universe of Discourse

$\mu_A(x)$ Membership function of Fuzzy set A

$\mu_G(x)$ Membership function of Fuzzy goal G

$\mu_C(x)$ Membership function of Fuzzy constraint C.

$\mu_D(x)$ Membership function of Fuzzy Decision D.

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