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Notes :

APPLICATION OF FUZZY SETS AND SYSTEMS APPROACH IN PLANNING AND DEVELOPMENT

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ABSTRACT

This paper presents a methodology combining statististical and fuzzy set thoretic approaches for determining the multi dimensional goals for development in third world countrics concerning the overall satisfaction of the quality of the life. by integrating economic, social, cultural, environmental, infrastructural, management and other aspects.

Through our ability to model large scale systems has in creased considerably with the advent of large-scale cpmputers which can solve hundreds or even thousands of non-lines or difference equations at low cost and h gh reliability, the problem which has not been solved satisfactorily by classical probability based mathematics, is that of characterizing the behaviour of systems in which the sources of uncertaini y and imprecision are, for the significant part, non-statistical in nature. Large number of societal systems and . subsystems fall into this category The theory of fuzzy sets and systems and also the theory of possibility which is based on it as enunciated by Zedeh and developed and applied by a host of other scientist in diverse fields of study (Refs 1-6) have a high degree of relevance for analysis and information systems for biosocial systems and for developing methodologies of planning for development and its associated decision making processes. The probabilistic and fuzzy set theory including possibilistic methods are complimentary rather than competitive, as these two theories are disjoint rather than coextensive. So long a broader theory applicable to entire spectrum of uncertainities is discovered, a judicious combination of probability based methods will have to be used in problem involving forecasting, analysis of evidence and decision making under uncertainity. We take a simple example of project selection. A fundamental basis for project selection is the construction of a criterion function which serves as a composite measure of the compatibility of alternative projects with respect to three major policy specifications : Worth, Cost and Risk. Among these, cost can be measured with certain degree of precision; worth and risk are essentially qualitative and so fuzzy in nature. To facilitate the articulation of such a combination of qualitative and quantitative data fuzzy algorithms can be developed and computed.

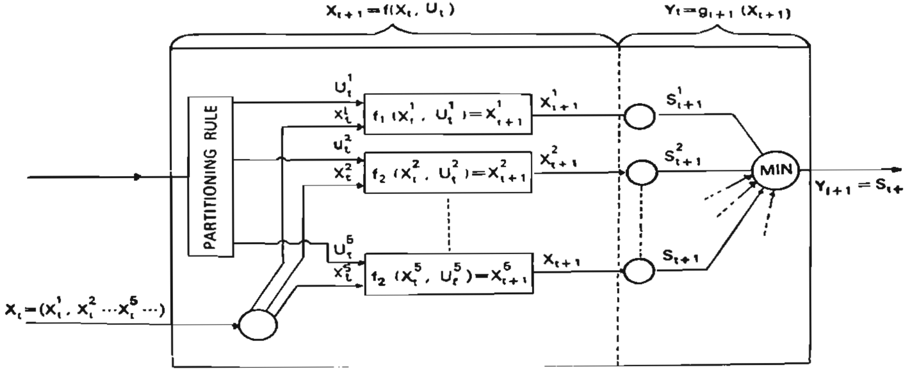
$$\text{Project} = \text{Worth} \cap \text{Cost} \cap \text{Risk} \tag{1}$$

To allow the trade-offs between the components the algebraic product is employed to combine the compatibilities of project worth, cost and risk. When the compatibility value equals to 1, it is the most ideal, if it is 0, it is to be rejected. In general higher the value, the more preferable the project becomes. The Integrated Regional Development, aims at intergrating economic, social, enviromental, infrastructural, management, and other aspects. Fuzzy constraints are imposed on investments (controls). Fuzzy goals concern satisfaction due to the the quality of life (QL) attained. Fuzzy decision is the intersection of fuzzy constraints and fuzzy goals. Methodology has to be such that a decision maker can modulate a decision function by some measure of his satisfaction with this fuuction.

We take the liberty of representing the region as a time-invoriant finite-state deterministic system (Fig. 1) whose behaviour is governed by the following state and output equations :

$$X_{t+1} = f_t(X_t, U_t) \tag{2}$$

$$Y_{t+1} = g_{t+1}(X_{t+1}) \tag{3}$$



$X_{t+1} = f(X_t, U_t)$
$Y_t = g_{t+1}(X_{t+1})$
PARTITIONING RULE
U_t^1
X_t^1
u_t^2
X_t^2
U_t^5
X_t^5
$f_1(X_t^1, U_t^1) = X_{t+1}^1$
$f_2(X_t^2, U_t^2) = X_{t+1}^2$
$f_2(X_t^5, U_t^5) = X_{t+1}^6$
X_{t+1}^1
X_{t+1}^2
X_{t+1}
S_{t+1}^1
S_{t+1}^2
S_{t+1}
MIN
$Y_{t+1} = S_{t+}$
$X_t = (X_t^1, X_t^2 \cdots X_t^5 \cdots)$

Fig. 1

Where : $X_{t+1} \in X$ is the state at time $t+1$, $U_t \in U$ is the control (investment) at time t and $Y_{t+1} \in Y$ is the output at time $t+1$.

The indicators of the quality of life (QL) are elements $(X_1, X_2, \ldots X_5 \ldots)$ of the state vector representing economic, environmental, health service, employment opportunity, cultural amenities, housing quality etc. The control U may be opptimally partitioned into parts $U_1, U_2, \ldots, U_5 \ldots$ devoted to $x_1, x_2, \ldots, x_5 \ldots$ respectively. For each x_i we have to derive the S^i_t, the overall satisfaction being

$$S_t = Y_t = \text{Min}\,(S_t^1, S_t^2, \ldots S_t^5 \ldots) \qquad \ldots(4)$$

The next step is to define the fuzzy goals $f_g t(Y_t)$ for the intermediate control states and $f_g{}^N\,(Y_N)$ for the end of the process.

If X_0 is the initial state, then fuzzy decision $f_D(U_0, U_1, \ldots U_{N-1}/X_0)$ may be taken to be the intersection of fuzzy goals and fuzzy constraints :

$$f_D(U_0, U_1, \ldots, U_{N-1}/X_0) = \max_{U_0 \ldots U_{N-1}} \min\,[f_{G0}(U_0), f_{G1}(Y_1); \; f_G^{N-1}(U_{N-1}), f_G^N(Y_N)] \qquad \ldots(5)$$

This is the algorithm for the intermediate control stages, final Goal may be obtained by setting $f_G{}^t(Y_t) = 1$, for $t = 1, 2, \ldots N-1$. Bellman and Zadeh (1970) suggested to solve such problems by using dynamic programming methods. But Kacpr ZYK (1978) developed a branch and bound algorithm which could be employed both for finite and finite planning horizons with better results, in determining optimal policies concerning investments as seen from a high policy making level. These methodologies along with statistical ones can be of great use in implementing policies in different sectors and at different levels of hierarchy to identify the plausible policy choies and to asses the resulting first-order and higher-order impacts in both short and long-term policies.

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