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TOWARDS COMPUTER SIMULATION OF POLITICAL MODELS OF URBAN LAND USE CHANGE

CARL GREGORY

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TOWARDS COMPUTER SIMULATION OF POLITICAL MODELS OF URBAN LAND USE CHANGE

Carl Gregory

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16. Abstract

The design concepts used to implement a computer simulation of a land use decision model are described. Sources delineated by a literature search are examined for the statements made ("source postulates") concerning the interactions of leaders of dominant and subdominant social groups when making land use decisions. Specific attention is paid to the role of leader personalities and the power of the social groups represented in the final decision outcome. Source postulates are rewritten in a symbolic logic notation, and a set of "rules of behavior" is derived. Consistency among source postulates and correct implication procedures in deriving rules can be checked via theorem-proving methodology. The second phase of design entails replacing symbolic logic statements with "fuzzy logic" statements and algorithms. The set of rules in either notation constitutes a model, and both notations are programmable.

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computer simulation, source postulates, consistent rule framework, rules of inference, theorem-proving, symbolic notation, fuzzy sets, fuzzy logic

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EXECUTIVE SUMMARY

INTRODUCTION

The model of land use decision-making to be simulated assumes that leaders of dominant and subdominant social groups interact in a "decision-making group" according to each leader's role perception, risk-taking propensity, and personality characteristics. The interactions of the decision-making group are further determined by the relative power of the groups each leader represents, and the type of issue under consideration (in this case, the use of land). Various sources describe the impact of a given leader's personality, the power of the group he represents on the position he will take, and the influence he will have among leaders of other groups. A computer simulation model of leader interactions and decision outcomes requires that a consistent set of "rules of behavior" be derived from the statements postulated by the various sources. This paper describes the development of a methodology to design such a model.

PROBLEM EXAMINED

The design of a computer simulation of land use choice must accomodate two constraints: (1) a consistent rule framework must be derived from a variety of sources, while (2) some allowance for the non-rational nature of human behavior must be made if the model is to be accurate without minimizing its utility.

RESULTANT DESIGN METHODOLOGY

Two phases of design are established. Phase I: source postulates and leader personality descriptions are rewritten in a symbolic logic notation and a set of "rules of behavior" is derived. The soundness of the logic by which the behavior rules are inferred from the source statements can be tested via theorem-proving procedures. This set of behavior rules constitutes a deterministic model of land use decision-making which is programmable. Phase II: The symbolic logic statements describing rules of behavior are replaced by "fuzzy logic" statements and algorithms. The resultant set of behavior rules is still consistent and programmable but constitutes a more stochastic model of land use choice behavior.

UTILIZATION OF RESULTS

The extablished design procedure is currently utilized to produce a deterministic and a stochastic model of land use choice. The models are to be programmed for testing purposes; each will describe the choices made by a given set of personalities for a given set of options. The choices indicated by the simulations can be compared to choices among the same options by the actual decision-makers whose personalities were used, and the accuracies of deterministic and stochastic models can be contrasted. While a highly accurate model may be used to predict future land use decisions, even a less accurate simulation illuminates the critical factors involved in land use decision-making; this separation of critical and superfluous factors is an important legacy for future studies.

CONCLUSION

Statements in logical notation can be interpreted linguistically, mathematically, or in the form of computer program algorithms. A model consisting of such symbolic statements should therefore find broader utility than either linguistic or mathematical models alone. The use of fuzzy logic allows a potentially more accurate model of human behavior while preserving the consistency of structure necessary for the requirements of computer simulation.

ABSTRACT

The design concepts used to implement a computer simulation of a land use decision model are described. Sources delineated by a literature search are examined for the statements made ("source postulates") concerning the interactions of leaders of dominant and subdominant social groups when making land use decisions. Specific attention is paid to the role of leader personalities and the power of the social groups represented in the final decision outcome. Source postulates are rewritten in a symbolic logic notation, and a set of "rules of behavior" is derived. Consistency among source postulates and correct implication procedures in deriving rules can be checked via theorem-proving methodology. The second phase of design entails replacing symbolic logic statements with "fuzzy logic" statements and algorithms. The set of rules in either notation constitutes a model, and both notations are programmable.

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TOWARDS COMPUTER SIMULATION OF POLITICAL MODELS OF URBAN LAND USE CHANGE

Introduction

This paper describes the design concepts that will be used to implement a computer simulation of the land use decision model postulated in Koegal et al., "Towards Political Decision Models of Urban Land Use Change."[1] To briefly summarize the relevant features of that model, decision-making is investigated from both conflict and power perspectives. Conflict occurs as a result of competition (incompatible goals) among behavioral units (groups).[2] Power is the potential of one or more actors to change and attain goals within a social system, while decisions are choices among alternatives that result from the exercise of power (influence).[3] Decision-making, then, occurs within structures describing patterns of influence, based on power structures describing patterns of potential influence, operating within a context of conflicting groups. Aiken's decision-making "structure of factions" integrates the above perspectives.[4] While this suggests a group-dominant context,[5] group aims are seen to be expressed by individual leaders (thus allowing utilization of Dahl's concepts of individual-dominant decision-making)[6] who gain ascendency on the basis of three variables: their role perception,[7] their risk-taking

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[1] Koegal, Joanne et al., "Towards Political Decision Models of Urban Land Use Change," manuscript for U.S. Department of Transportation by the Council for Advanced Transportation Studies, The University of Texas at Austin, 1975.

[2] Boulding, K.E., Conflict and Defense: A General Theory, New York: Harper and Brothers, 1962.

[3] Clark, T.N., "The Concept of Power," in T.N. Clark (ed.), Community Structure and Decision-Making: Comparitive Analyses, San Francisco, California: Chandler Publishing Company, 1968.

[4] Aiken, M., "The Distribution of Community Power: Structural Bases and Social Consequences," in M. Aiken et al., ed., The Structure of Community Power, New York: Random House, 1970.

[5] Presthus, Robert A., Men at the Top: A Study in Community Power, New York: Oxford University Press, 1964.

[6] Dahl, Robert A., Who Governs?, New Haven: Yale University Press, 1961.

[7] Kaplan, Harold, Urban Political Systems: A Functional Analysis of Metropolitan Toronto, New York: Columbia University Press, 1967.

propensities,[8] and their unique personalities.[9] These same variables influence the decision-making processes among groups of leaders, with an additional factor being the relative power of the groups each leader represents. The final picture of the model, then, is one of dominant groups and their leaders interacting with subdominant groups and their leaders, while both types of groups also interact among themselves.

It is obvious that this model incorporates many postulates about the actions of individuals within groups, the nature of social structures, and the actions of individuals and groups within social structures. What bearing this has upon the development of a computer simulation can best be seen by first distinguishing between "computer" and "gaming" methods of simulation. Given that simulation is "an attempt to present...some facets of reality in a convincing manner for purposes of explanation, manipulation, and analysis,"[10] and that a simulation <u>model</u> is a simulation "governed by some predetermined and consistent rules for handling and manipulating events and information as they are introduced into the simulation,"[11] then a <u>computer simulation</u> is a simulation model in which society is treated "as a system of interacting variables which blindly respond to data introduced into the system externally,"[12] while a <u>gaming simulation</u> is a simulation model "in which the model of some institution or organization is imbedded into the rules of a game"[13] that is then played by human actors.[14] The task of the computer simulation

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[8] Horowitz, Ira, <u>Decision-making and the Theory of the Firm</u>, New York: Holt, Rinehart, and Winston, Inc., 1970.

[9] Megarges, Edwin Inglee, <u>The California Psychological Inventory Handbook</u>, San Francisco: Jossey Bass, 1972.

[10] Kibel, Barry M., <u>Simulation of the Urban Environment</u>, Washington, D.C.: Association of American Geographers, 1972, p. 13.

[11] <u>Ibid</u>., p. 13.

[12] <u>Ibid</u>., p. 13.

[13] <u>Ibid</u>., p. 14.

[14] While this study intends to construct a computer simulation of political decision-making, gaming simulations may be used for testing the validity of the computer model, as described later in this paper.

of land use decision-making, then, is to convert those postulates incorporated within the above model into consistent rules that will govern the manipulation of information independently of human intervention.

Since the postulates of the decision-making model come from a variety of sources, the emphasis on the consistency of rules is crucial in designing the simulation.[15] However, an additional design constraint is imposed by the subject matter of the model itself, namely, the nature of human behavior. This study does not wish to require the existence of "rational economic man"[16] as a prior assumption to the rules of individual or group behavior, but hopes to be able to allow the suggestion that "much of the logic behind human reasoning is not the traditional two-valued or even multivalued logic, but a logic with fuzzy truths, fuzzy connectives, and fuzzy rules of inference."[17] To accomodate these two constraints, the development of the computer simulation will occur in two phases: first, the construction of a rigorous rule framework in three stages,[18] followed by a second phase of converting definitive rules into more probabilistic statements at each stage. Each phase of development is described separately below, followed by a discussion of procedures for testing the validity of the simulation and the predictions of land use decisions based on the results of the simulation. The data used to construct the simulation are the responses of selected leaders, as described in Koegal et al.[19] A diagram of the full simulation procedure is shown in Figure 1.

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[15] The Koegal et al. paper particularly notes the difficulty of interfacing axioms regarding the nature of variables that are not always instrumentalized to the same degree, citing the variety of approaches by their sources as the cause of disparity in instrumentalization.

[16] Koegal, op. cit.

[17] Zadeh, Lofti A., "Outline of a New Approach to the Analysis of Complex Systems and Decision Processes," in IEEE Transactions on Systems, Man, and Cybernetics, New York: The Institute of Electrical and Electronics Engineers, Inc., Volume SMC-3, Number 1, January 1973, p. 28.

[18] 1. The definition of profile variables for individual leaders: role-perception, risk-taking tendency, personalities measures
2. The effect on "leader" interactions of their personality variables
3. The effect on "leader" interactions of the positions of their groups within the social power structures.

[19] Koegal, op. cit.

Phase I: Design of Logical Rule Framework

A. Use of Symbolic Logic Notation

The governing rules of the land use decision-making simulation will be defined in symbolic logic notation. Briefly, such a notation consists of symbols representing statements, a means of describing relations between statements, and rules by which conclusions postulated from a given set of statements and relations can be either proved or disproved. For example, two statements can be represented as follows:

p_1 = The man is tall
p_2 = The man is walking

One example of a relation between these two statements is a relation of implication, i.e.,

If the man is tall, then the man is walking.
(If p_1 then p_2)

Given that the above relation is true, and given that statement p_1 is true (the man is tall), then is it valid to assume that p_2 is true (the man is walking)? The methodology for proceeding from the given truths to the postulated conclusion is a stepwise theorem-proving algorithm consisting of a set of rules that must justify each step taken. If the postulated conclusion can be reached via this method, then the conclusion is valid for the given assumptions; conversely, if no steps can be taken that will reach the postulated conclusion, or if steps can be taken to reach the negation of the postulated conclusion, then the conclusion is invalid for the given assumptions.

The value of symbolic logic notation in designing the computer simulation is threefold:

a. Mathematical Rigor - the use of symbols is concise, while mathematical logic is both consistent and powerful.

b. Applicability to Linguistic Definitions - the variety of sources for the model postulates have stated those postulates in various forms, (for example, Horowitz is generally equational in his description, while other sources are linguistic). The symbolic logic provides a common denominator for expressing both "natural language" and equational statements, an additional contribution of consistency to the simulation design.

c. Validation of Assumptions and Inferences - as demonstrated, a theorem-proving algorithm provides a check on the validity of conclusions drawn from given assumptions. As will be described in more detail below, this checking procedure may be used to ensure valid predictions of decision-making behavior; also, since many of the postulates of the model are themselves inferences (e.g., the influence of a leader in a group, given his risk-taking propensity), some further consistency among the postulate sources will be gained by assembling their statements in symbolic notation and ensuring that the assumed postulates are not contradictory among themselves. As shown later, the "proof" procedures associated with symbolic notation aid in this testing procedure.

B. Choice of Symbolic Logic Notation

While mathematical logic is generally standardized, notational symbols are quite varied. This study will use a notation devised by Lukasiewiecz[20] with particular advantages for this simulation: 1) the relative obscurity of the notation requires that staff members familiar with various other notations that may be only slightly dissimilar must now learn a relatively new, common format, hopefully producing a "common denominator" effect that will reduce confusion due to biases toward more familiar notations; and 2) the particular construction of the Lukasiewiecz notation is functional rather than equational. That is, rather than placing relational symbols between statements, as in

$$p_1 \underline{\text{and}}\ p_2,$$

relational symbols are treated as functions of the given statements, so that the above expression becomes

$$K\text{-}p_1p_2.$$

The concept of relational functions rather than relational conjunctions is closer to the nature of computer processes, and so more easily

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[20] Described in the WFF'N proof games series developed at the Yale Law School. Although these games were intended for use at the sixth grade level, the notation is far from simplistic. Also, the games constitute a programmed learning methodology by which new staff members may become familiar with the notation. (See Allen, Laymen E., WFF'N Proof, New Haven, Connecticut: Yale Law School, 1962.)

implemented. The second relation is also more easily perceived as being used as a "statement" in a larger relational phrase, e.g.,

$$(p_1 \ \underline{\text{and}}\ p_2)\ \underline{\text{or}}\ (p_3 \ \underline{\text{and}}\ p_4)$$

versus

$$A\text{-}Kp_1p_2 - Kp_3p_4.$$

As will be shown later, the aggregation of relations into larger relations is central to the simulation design.

The theorem-proving algorithm (rules of inference) for the Lukasiewiecz notation need not be reproduced for this discussion, but a brief list of the relational symbols used will be helpful before proceeding:

K - p_1p_2	p_1 $\underline{\text{and}}$ p_2 (conjunction)
A - p_1p_2	p_1 $\underline{\text{or}}$ p_2 (disjunction)
C - p_1p_2	$\underline{\text{if}}$ p_1 $\underline{\text{then}}$ p_2 (implication)
E - p_1p_2	p_1 $\underline{\text{if and only if}}$ p_2 (equivalence)
N - p_1	$\underline{\text{not}}$ p_1 (negation)

C. Stages of Rule Framework Definition

Stage 1: Individual Profile Variables

a. Role Perception

A leader's role perception is described by a single statement, e.g.,

p_1 = the leader sees himself as a mediator.

b. Risk Taking

A leader's attitude towards risk is described by a single statement, e.g.,

p_2 = the leader is a risk-evader.

c. Personality Characteristics

Each characteristic measured by the study's revised California Psychological Inventory scale is described by a single statement, e.g.,

p_3 = the leader is dominant[21]

Np_4 = the leader is not flexible

d. Profile Construction

A given leader's profile is described by the conjunction of all the above characteristics, e.g., "The leader is a mediator and he evades risk and he is dominant and he is not flexible, etc." Or,

$L_1 = K - KKp_1p_2p_3 - Np_4$.

Stage 2: Inferring Interactions from Profiles

Once a profile has been constructed, there are inferences that can be made concerning the interactions of individuals possessing those profiles.

a. Source Postulate Construction

Postulates incorporated in the model are described by rules of inference concerning the effects of profile variables upon behavior tendencies. For example, the von Neumann-Morgenstern definition of "risk-evader"[22] might be stated: "If the leader is a risk-evader, then he requires that the expected payoff of a risky alternative be greater than the guaranteed payoff of a certain alternative."

Or, for

t_1 = the leader requires that $E\ (p) > g$

then

$C\text{-}p_2\ t_1$.

---

[21] It should be emphasized that, even at this preliminary stage, the statements defined are actually relations. For example, "if the score is 15 or more, then the leader is dominant" may be written

$$C - s_1s_2$$

and "the leader's score is 19" may be written

$$s_3$$

so that the statement p_3 above really represents

$$p_3 = K - Cs_1s_2 - s_3$$

It can be further noted that p_3 is actually not a relation, but a conclusion drawn from the given rules of the surveying process along with a threshold value at which a score qualifies for the label "dominant." As noted previously, this notation can now be subjected to the "proof" procedures described in stage 2 and so tested for consistency.

[22] In Horowitz, op. cit.

Rules of inference for interactions might take the form:
"Dominant individuals vote against inflexible individuals"
Or, for

$L_1 = p_3$
$L_2 = Np_4$
t_2 = leader 1 votes against leader 2

Then "given L_1 and L_2, it is valid to infer t_2" is a statement of this rule of inference.

b. Individual Inferences from Profiles

A typical individual inference might be:

Nt_3 = the leader opposes the use of eminent domain.

Thus, an inference test might be:
Given the source postulates, and given $L_1 = K\text{-}KKp_1p_2p_3 - Np_4$, is it valid to assume that

Nt_3 ?

If the conclusion can be reached from the given profile and source postulates, then the inference "If L_1 then Nt_3" is valid and may become part of the simulation rule framework.

c. Leader Interaction from Profiles

As above, if conclusions such as t_2 can be reached from the profile and source postulates, then the inference "If L_1 and L_2, then t_2," describing the interaction of two leaders, becomes a part of the simulation rule framework.

Stage 3: Inferring from the Power of Represented Groups

As in stage 2, source postulates may become rules of inference concerning the effects of the relative power of two or more groups upon the interactions of their leaders. For example, if

S_1 = group 1 is powerful
NS_2 = group 2 is not powerful
s_1 = a group is powerful
s_2 = a group is influential

and $C - s_1s_2$ is a valid rule of inference,
then it may be valid to infer that if the leader of group 1 opposes the

leader of group 2, then the group 1 leader's decision will be followed.

Summary of Phase I

The preceding examples, while necessarily general at this point in the design of the simulation, serve to illustrate the nature of the rule framework that will govern the simulation. This framework will translate various postulates into precise statements about which group leaders will act in which ways, and about whose decisions will emerge from leader interactions. No probabilistic inferences will be a part of the model at this point. The movement from definitive statements to a more realistic description of tendencies occurs in Phase II.

Phase II: Introduction of Fuzzy Concepts

As mentioned in the introduction, it is not the wish of this study to model decision-making behavior as though human actors blindly obey textbook postulates describing expected behavior. Yet, in order to provide a consistent rule framework for the simulation from a variety of source data, the design thus far described is necessarily mechanistic. The next task of the design process is to replace deterministic rules of inference with more probabilistic statements of behavior while preserving mathematical precision and logical consistency in the simulation rule framework.

One approach to this task can be to inject a quasi-randomness to the rules of inference by assigning probabilities to their expected occurrence, rather than assuming their certainty. For example, rather than stating that "given two leaders with profiles L_1 and L_2 it is valid to assume that the decisions of L_1 will be carried out," the model would assign "weights" to the impacts of the profile variables for L_1 and L_2 so that some value of expected result might be stated: "It is valid to assume that the decisions of L_1 will be carried out 73 percent of the time." These statements would then be testable postulates of the simulation model.

Such an approach, however, is very dependent on a subjective weighting system, which very likely could not be justified by only a single piece of source material. The danger is of applying patchwork adjustments for the sake of "realism" to a logical rule framework designed to overcome the discrepancies between diverse source materials, which is clearly at cross purposes with the first phase of design. So while the "weighting" approach might serve as an intermediate step for checking purposes, a preferable approach to the task of the second design phase is to employ "a methodological framework which is tolerant of imprecision and partial truths..."[23] but "is actually quite precise and rather mathematical in spirit,"[24] i.e., the use of fuzzy sets and fuzzy algorithms.

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[23] Zadeh, *op. cit.*, p. 29.

[24] *Ibid.*, p. 30.

As Zadeh describes it, the "fuzzy" approach to the analysis of decision processes and complex systems concerns so-called "linguistic" variables, simple relations between these variables, and complex relations described by fuzzy algorithms.[25] As described in the stages of Phase I, the design of this simulation concerns profile variables, simple relations between the variables, and a complex system of inferences describing the impact of leader personalities, social structure, and potential influence of groups upon the outcome of land use decision processes among leaders of groups. The methodologies, then, are parallel in structure, and the fuzzy methodology has specific applications at each stage of design.

Stage 1

It was noted in Phase I that profile variable statements were actually inferences from test scores and the threshold points at which the scores qualified the individual leaders for descriptive labels. This "inference" may now be seen as membership or nonmembership in a set of scores qualifying for each descriptive label. For example, if the median score for 20 questions measuring "dominance" is 15, then membership in the set of scores (15, 16, 17, 18, 19, 20) allows the profile variable statement, "the leader is dominant." Put another way, scores between 15 and 20 have a grade of membership of 1 in a set labeled "dominant," while scores below 15 have a grade of membership of 0. Conversely, scores below 15 have membership grade 1 in the set labeled "not dominant" while scores 15 and above have membership grade 0.

The fuzzy methodology allows membership in a set to fall between 1 and 0, so that more descriptive labeling may be used without abandoning their quantitative meaning. Thus, while "dominant" describes the upper portion of the set of scores 0-20, "very dominant" might describe only scores of 18-20, "not dominant" might be scores of 0-10, "somewhat dominant" scores of 8-15, and "fairly dominant" scores of 13-17. It is important to note that the sets of scores can overlap, so that a profile score for an individual leader may qualify for more than one descriptive label, but that score will qualify with different grades of membership for each set. So a score of 9 might have

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[25] *Ibid.*

membership grade (.9) in "not dominant," membership grade (.4) in "somewhat dominant," and membership grade 0 in all other sets.[26]

The result of the fuzzy profile construction will be to diversify the relations for which a particular profile has an impact. For example, given some relation for interactions between a "very dominant" leader and a "somewhat dominant" leader, a profile L_1 with a score 9 would be involved in such a relation, but less so than in some other relation for interactions between a "very dominant" leader and a "not dominant" leader. The logic of the profile structure remains intact; what is added is that the statement "the leader is dominant" no longer is binarily "true" or "false," but may now take on a range of meanings in each context for which it must be considered.

Stages 2 and 3

The fuzzy methodology includes precise rules for computing the meaning of relationships of conjunction, disjunction, negation, implication, and equivalence between fuzzy variables. A description of those algebraic techniques is not necessary here;[27] it is sufficient to say that the logic of the relations is identical, as is the logic of constructing rules of inference, so that fuzzy variables may be substituted for the basic statements in the rule framework described in Phase I. The impact of the change in the computed meaning of the relations, however, is significant.

As basic statements have been replaced by fuzzy variable sets, so valid conclusions of rules of inference become fuzzy sets of possible outcomes, with grades of membership for each conclusion. For example, the conclusion that "it is valid to assume that L_1 and L_2 will disagree and that the decision of L_2 will result" would become a set of decisions with grades of membership for L_2, so that one decision is not necessarily described. The introduction of

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[26] The composition of each set can, in fact, be formulated rather than stated as a set of scores with membership grades assigned to each score, so that profile statements for each individual leader may become simply "the leader's scores are 12, 4, 13, etc." and the labels implied by those scores computed for the relational inferences constructed in the next stage.

[27] For a description, see Zadeh, op. cit., pp. 34-38.

fuzzy algorithms,[28] to replace the second part of the conjunction above with a process for determining the decision made, adds more variability to the nature of the conclusion, i.e., the statement might be "...that the decisions of L_2 will usually result" where usually describes the outcome of an algorithm whose data are the computed relations and inferences for the fuzzy profile variables and conclusion sets.

Summary of Phase II

A description of the introduction of fuzzy concepts is, like the description of the basic rule framework design, necessarily vague pending the specific construction of profiles and formulation of rules of inference from the source postulates in symbolic notation. The cohesiveness of the two phases, however, is still apparent, and the combination of the two approaches promises to result in a cohesive simulation model framework which is logically consistent, precise, and programmable.

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[28] *Ibid.*, p. 38.

Testing and Predictability: Summary

The accuracy of any simulation model is a measure of both its replicative and predictive capabilities. A proposed method for testing both features of the land use decision-making model is the use of gaming simulations (described in the introduction). As noted earlier, source postulates concerning the implications of social power and influence structures are imbedded in the game rules of play, with decisions being made by human players in turn. A gaming simulation, then, provides a set of move options which might be used as the set of possible outcomes described in Phase II: the model is prepared to "play" a game.

Of significance for testing purposes is the possibility of having the surveyed leaders, or groups of them, play a simulated land use game so that the transcript of their play can be compared to the moves chosen through operating the simulation model with the profiles and group power structures of the "leader-players" involved. Some games assign roles to the players by giving them different goals for game "success" (see, for example, URBAN POLITICS).[29] The simulation may be tested with such games for its accuracy in representing the play of leaders in roles both similar and dissimilar to the roles suggested by their profile and power structures. Alternatively, games such as the Cornell Land Use Game (CLUG)[30] make no player role assignments, providing a test of the simulation in a more constraint-free environment. A search is currently under way to assemble the most appropriate gaming models for the use of this study.

"Predicting" behavior in a gaming situation is, of course, only one step toward making predictions about decisions in a "real" social environment over time. Some rules of inference imbedded in the simulation model framework assume certain social power and influence structures (see Introduction) that may differ from the constrained environments postulated for various gaming activities. Any broad predictive capabilities of a decision-making simulation model will depend on the ability of the model design to incorporate the structures and rules of "the ultimate game:" the actual land use options, social, political

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[29] Kibel, op. cit., p. 115

[30] Ibid., p. 54

and economic structures, and leadership personalities occurring dynamically in an urban environment. The task of assembling comprehensive data for these variables is by itself beyond possibility, as any modeling effort soon discovers.

The result is that either some variables must be omitted in order to gather a manageable amount of data from which intricate predictions are possible, or else intricate predictive capability is sacrificed in favor of a more general modeling of the interactions of as many factors as possible. A compromise is attempted here, with the inclusion of social structure, power structure, and personality variables for a group of decision-makers concerned with land use decisions only. By not considering other types of decisions, this study hopes to reduce the need to gather data on the effects of social and power structures on other types of decisions, expecially avoiding the inclusion of national influences (political, social, and economic) on the use of land. In this way, examination of the intracacies of local decision-making dynamics is made feasable, yet including as wide a range as possible of micro-scale variables. "Local" effects on land use are thus studied in detail, while predictions of land use with regard to national economic or political forces are less precise.

Even within the framework of this compromise, the ability to predict precise land use patterns is improbable at this time. A greater degree of precision than other techniques provide is expected; however, the ultimate benefit of this study is rather the isolation of critical factors affecting land use decisions within social and decision-making groups, the behavior tendencies formed as a result of those factors, and the narrowed range of land use options defined by the tendencies of decision-making behavior.

This model, then, will more often be enlightening than predictive, describing behavior tendencies within constraints rather than predictable decision outcomes in an absolute sense. It is the purpose of the simulation design, however, that a high level of precision will be achieved in the meaning of the described dicision-making tendencies. No other modeling approach thus far reviewed for this study has attempted both to consistently structure various sources symbolically and achieve mathematical precision while preserving the linguistic features of source postulates. It is hoped that this study will aid both the development of future simulation modeling conceptions and the exploration of the applicability of fuzzy mathematics to the study of complex humanistic systems.

DIAGRAM OF MODEL DESIGN PROCESS

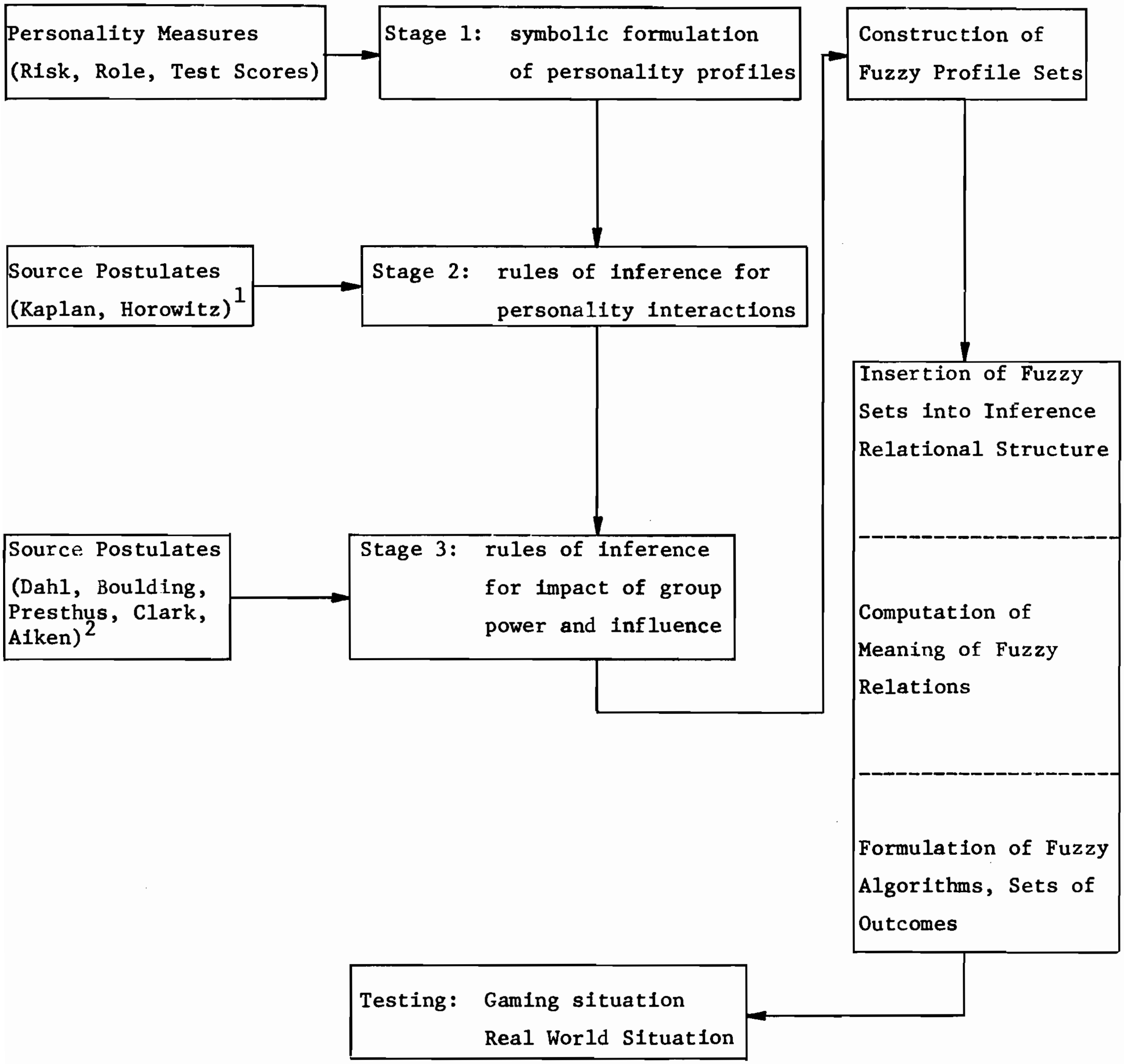

Figure 1.

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   I. Horowitz. Decisionmaking and the Theory of the Firm, New York, 1970.

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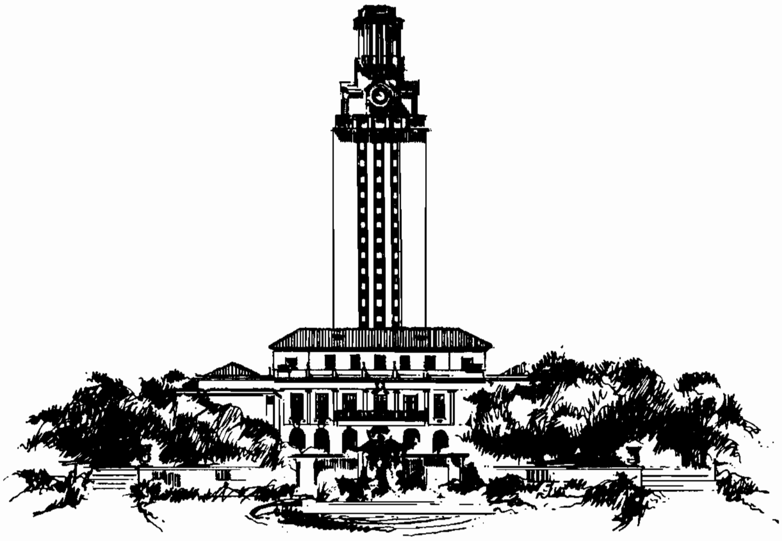
Figure 1. Continued

BIOGRAPHICAL STATEMENT

Carl Gregory received his B.A. degree from the University of Texas at Austin in 1972. He is currently preparing his thesis for completion of an M.S. degree in Community and Regional Planning at U.T. Austin. His background includes both Liberal Arts study and wide experience in writing computer programs whose subject matter involve both "hard science" and social science material. His thesis research will center on social and institutional responses to environmental and energy resource constraints.



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