International Journal of Game Theory and Technology (IJGTT), Vol.9, No.1/2, June 2023

PREDICTING THE EVOLUTION OF CONFLICTS USING FUZZY RECURRENT GAMES

Myron S. Karasik

McCracken Institute, Atlanta, GA, USA

ABSTRACT

Game Theory is premised on a modeling a conflictual interaction between two known parties where tactics are well-defined and payoffs can be easily measured, like a game of chess. This paper offers an extension of the Game Theory model incorporating 'fuzzy variables' representing possible situations and results, and also the discrete logistic curve to effectively capture the chaotic aspects of population dynamics impacting the decision-making in the composite societies (players). These are the typical actors in multiplayer political-economic games. This would reflect more closely the real-world behaviors and provide greater predictive accuracy. A trained AI-enhanced model, using regression data collected from previous, resolved games as well as previous 'moves' in the current game could prove helpful in predicting likely next 'moves' in the continuing game. This will allow us to model the evolution of strategies over the course of time in real conflicts and help mitigate exacerbation of extreme violence by simulating ways to reduce the driving force – the degree of deviation between what is acceptable and unacceptable to the players involved.

KEYWORDS

Recurrent games, fuzzy variables, chaos, dissonance, political-economic conflicts

1. INTRODUCTION

Game theory was originally formulated to predict likely actions taken by either party subject to crisply valued expected gains or losses. Extensions of the theory to continuous, probabilistic, state dependent strategies useful in understanding cooperation as well as evolutionally stable strategies were made (Mesterston-Gibbons, 1982). In 1965, Lofti Zadeh of UC Berkeley proposed the concept of fuzzy sets and fuzzy logic to model decision making in control systems where response needed to be graded according to a stepwise linear function. In 1970, the author built the first all-digital control system and confirmed that optimal control followed such a stepwise function. Fuzzy variables have been applied to game theory models in a limited fashion, (Butnariu, 1978), (Billot, 1998), (Al Obaidi, 2013), (Chakeri, et al, 2013) and (Sangeetha, Parimala 2021). They focus on either coalition building, tactical options or uncertainty of payoffs. I propose instead to focus on player mix, resources to support actions and deviation between acceptable and unacceptable environmental states as the variables that are fuzzily defined.

Game theory can be viewed as a multi-controller (player) system in the engineering sense, where each player seeks to 'control' a shared environment in order to minimize loss (the converse of maximizing utility). If the players have different assessments of a shared political-economic environment and different desired states, conflict will ensue (Karasik, 1984). The greater the dissonance, or deviation from an acceptable environmental state, the stronger (and more violent) the reaction. The reaction is usually chosen from a set of available resources to the player. Depending on the scope of the shared environment, there may be many potential players entering the 'game' as the environment changes under the actions of the initiating player(s). Resource levels will change over time and constrain or enhance actions available. The game will only be 'over' when all

DOI : 10.5121/ijgtt.2023.9201

players are either satisfied with the situation or their resources are spent. Thus, the game is 'recurrent' in that each discrete 'play' changes the state of the shared environment and causes each party impacted to recalibrate their dissatisfaction or dissonance and respond accordingly. As long as resources are available and the situation is unacceptable to one or more parties, the game continues. While to each player, the tactics and intended expected payoffs are usually 'crisp', the fuzziness starts with who might be playing, with what resources and what will be their level of acceptability of a given situation. In real political-economic interactions among multiple parties we find we are dealing with composite entities, whose cohesive subgroups may have different assessments of the situation and thereby impact the scope of actions the leadership may take. It is also often unclear who are all the impacted parties, the stake holders in the current environment.

2. FUZZY RECURRENT GAME THEORY

The quest of science is to develop computational models sufficient to predict the behaviors of a system under various conditions. The accuracy of the prediction serves as a measure of the "correctness" of the model in capturing the essential elements that define the behaviors under study. Whereas physics has been considered the "gold standard" for the success of the scientific enterprise, in other areas, such as economics and social behavior, the models are seen as far less reliable. Game Theory's genesis was in the area of economic decision-making (von Neumann and Morgenstern, 1944), such as whether to raise prices or not given possible responses of competitors. When it comes to political dynamics, we are dealing with populations living under various forms of governance. In posing the question of what actions a particular 'actor', usually a sovereign state, will do we tend to ignore the underlying dynamics of that entity and also have little sense of the driving forces at work. The overt goals might be paraded openly but the real goals and valuations of potential gains and losses of a given strategy are rarely publicized or even measurable in crisp numeric terms. Therefore, a better way the gains / losses can be represented is by using fuzzy (linguistic) variables to represent the degree of unacceptability of the current state of affairs and have the recurrent aspect of a conflict be represented by underlying changing conditions as captured in a logistic curve model as described later in this paper. The 'conditions' are the internal dynamics of the players and the resources at their command to take actions to change the environment. The 'actors' being composite entities of their populations also are dynamic with the propensity toward a given action being a result of the nominal decider's power relative to other power centers in the entity. Recurrence is the very nature of our political-economic game, it has many 'moves', again like chess, each player responds to the other's moves and continues until a final resolution. Unlike chess which is limited to two sides, the real world may have several 'sides', with multiple parties in 'coalitions' to some degree.

2.1. A Perspective on Modeling Reality

To say we have an accurate model that represents the dynamics of a system so as to predict the future states given present knowledge; experiential confirmation is key, for which we need data and a yardstick for measuring those data consistently over time.

There is an important refinement, however: We also need our "models", to properly incorporate the interrelationships among the observable dimensions, the structures involved in the data. What we measure, empirically, are objective values of variables (i.e., values are independent of specific observer), changing over time.

To successfully anticipate change, there must be a 'landscape', a pattern of things that do not change, i.e., "invariance"- from which to infer the changes that do happen. For example, in physics, invariance takes the form of conserved quantities such as mass-energy-momentum, electronic charge, etc. In addition, there are key principles, such as the Principle of Least Action in physics, which defines the transformative "norms" of a physical system. For modeling conflicts in game theory, I posit a **Principle of Least Dissonance** that drives an entity's behavioral repertoire. Dissonance represents the deviation from the 'expected' or 'preferred' state to the actual one. The tolerance for any given deviation will vary among individuals but when looked at from a group dynamics point of view, there will be a 'tipping point' when the group's total dissonance is too great and action to minimize it sufficiently must be taken. Then as Sherlock Holmes would say, 'the game is afoot.'

Second, tests against "reality", of necessity, are always made against the evidence of the past, for the "future" has not yet occurred and the "present" is (at least conventionally) but a moment standing between past and future. In sum, there must be reality checks to our models; and these checks must be against our record of the past. The model must therefore be adaptive and self-correcting, using new data points to refine the modeled relationships and linkage weights.

2.2. Horizon of Predictability - Limits

Issues relating to predictability can be sharpened by reference to the idea of the *state space* of a system. Such a space may be defined as one having "orthogonal coordinate directions representing each of the variables needed to specify the instantaneous state of the system" (Baker and Gollub, 1991, p.7). Such variables are then known as *state variables*. In combination, these state variable coordinates define the location, in the space, of a point—corresponding to a particular definite state of the system (Arrowsmith and Place, 1990, p. 1; Baker and Gollub, 1991, p.7; Penrose, 2005, p.220).

We are each, members of at least one such system, the social system with which we most closely identify. In turn each such social system exists in the domain of our global (planetary) system. The state of this system is time-dependent, i.e., it changes (continuously, at lease in some dimensions) over time. The corresponding series of points forms a "trajectory", a state space curve if you will, in a vast number of different dimensions comprising the global system. An accurate future prediction is equivalent to knowing the future path of the trajectory given you know the historically measured points. The issue however is that we can't do it precisely, for the following reasons:

- Random perturbations occur (e.g., climatic and other geologic catastrophes, also biologic events like disease and blight)
- Population growth and demographic changes (including population movements) – in larger social systems, individuals might be members of multiple groups, each with their own "value" set, the combinations of which might not be simply additive
- Technological discoveries and changes impact scope of human action
- Behaviors are not deterministic, but depend on degree of dissonance that can be tolerated based on socially held core "values" and the technologic and economic resources available
- Core values can mutate over time and not always be overt.

The result of these characteristics is that the dynamics of such a system must inherently be nonlinear and "chaotic" in a very specific sense. Such systems are characterized by trajectories that never quite repeat, that never come to a “stop” as would a single pendulum (when subject to friction). Instead, we get imprecise and partially repetitive patterns that can on occasion “flip” between multiple temporary “rest” states or equilibria. The equilibria form around points known as ‘attractors’

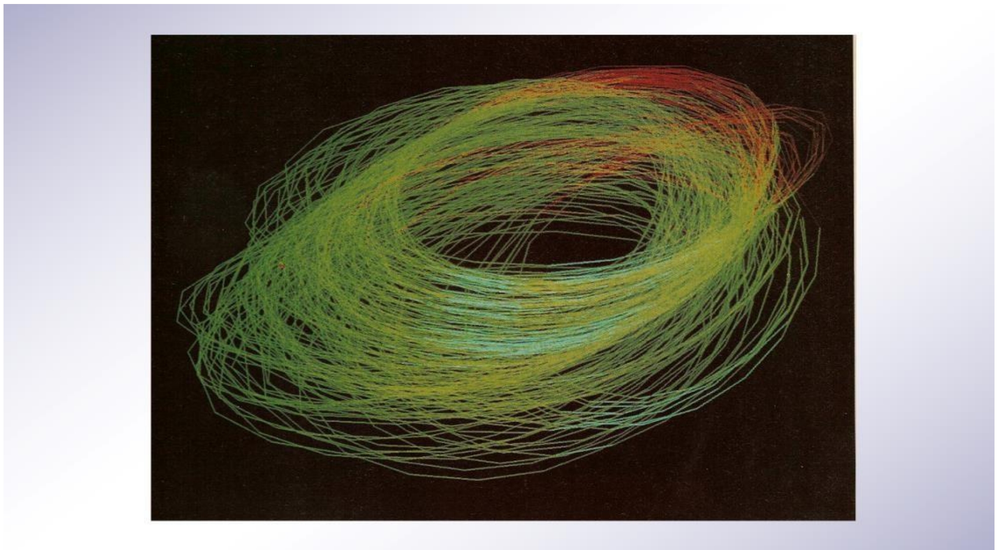
EEG ‘phase portrait’ of smelling a familiar scent

Figure 1. An EEG ‘phase portraits’ of smelling a familiar scent (Sci. Am)

An example of this in real life is an electroencephalograph-generated phase portrait (Figure 1) of a small set of cells (neurons) while recognizing a particular scent. (In remembering something that you smelled a long time ago, you are recruiting small populations of cells to ‘retrace’ that pattern.) The spatial dimensions correspond to various electrochemical state variables describing the system of neurons. The aroma need not be exactly the same as laid down the original memory. The activation of the memory will require only a degree of similarity in the ‘new’ pattern and thus can invoke associated memories of dimensions other than smell, including happy or sad feelings associated with the original memory. [One can analogize that the corresponding interactions among the brain cells -- the synapses-- are not unlike interactions among human agents in a society whose members interact inaccordance with degree of proximity and relevance.]

In general, the possible trajectories of future states, pictured as a line sequentially connecting a set of points corresponding to time, can be modeled by complex dynamics (having multiple possible time series of future state values) that typically inhabit a constrained set of values. These sets may or may not incorporate "attractors" (that is, a compact sub-set of semi-stable equilibrium values, toward which nearby state space points are drawn should the trajectory be “closer”). Think of a single attractor as like a drain in a sink, as parts of the liquid come closer, they spiral into the drain and never ‘escape’. The more complex the model in terms of numbers of interacting populations of atomic entities such as neurons or people, the more alternative attractors there are. Further, the existence of multiple attractors leads to bifurcations of possibilities (“crises” in political discourse) when a particular trajectory comes near enough to the boundary between two such sets of values. Theset of possible trajectories includes the potential "responses" to singularities in complex space; these points of discontinuity, called poles or singularities, may still exhibit well-defined behavior. (See

Arrow smith and Place, 1990, pp. 64-89; Ott, 1993; and Zaslavsky, *et al.***,** 1991.)

In a state space view of things, the collection of possible future states can be constrained by the "shape" at the "present"; that is, the transition to a "next state" is completely determined by the current state. Another way of expressing it is that the system process is recursive or *iterative*; that is, the current state was determined by the immediately preceding state, which was determined by the state before that one, etc. Moreover, this process can be probabilistic: each transition from one state to another can be mapped by a transition function which computes the likelihood of the transition of state $x(t - 1) \rightarrow x^i(t)$ as $P^i\{ x |T\}$; where the sum of P^i 's = 1, $T \equiv x(t - 1)$ is a shorthand way of referring to the prior state x(t - 1) that held at time t - 1 , and the form $P^i\{\ldots|T\}$ denotes a conditional probability. The series of transitions therefore obeys the rules of what are known as 'Markov transformations.'

The most general expression of the state space approach is to view the 'state' as being described by a 'vector' of attributes of those features that completely describe the 'state'. Things like wealth, education, health, gender, religious affiliation, political affiliation. etc., would describe an individual human. Today, at time t, we all stand in a world that is in a certain state because of a series of phase points corresponding to the states which the world has previously occupied at all prior values $t_0 < t$. The present state has the compressed "memory" of the system, if you will, of everything that has happened in the past even if you couldn't recapitulate it just from knowing the present state.

For example, as individuals we have embedded within us the history of our family, species and planet. The history of humankind is a portfolio of histories of various subgroups and their interactions. In our 'games' we have as our 'actors', composite entities with target states of acceptable dissonance from the 'ideal' (complete control over the environment) and with capabilities and capacities of actions that (in theory) would reduce unacceptable dissonance.

3. NON LINEARITY AND CHAOTIC BEHAVIOR.

Any model's predictive accuracy is limited by non-linearities and its possible expression in the phenomenon of "chaos." Non-linearity means that the responses of the system to any particular stimuli, exogenous shocks, or perturbations, are not necessarily proportional to the "strength" or "significance" of the stimuli. For our 'actors' such perturbations may come from sources such as rapid climate change, microbial pandemic, or direct contact with 'alien' migrating human groups.

Chaos refers the situation where the phase points comprising any region, no matter how small, diverge to nearly all locations in the space after a finite period of time. In that case, any uncertainty whatsoever in the present system state implies complete loss of system predictability within some finite time period.

Simple idealized models of species populations and inter-species competition such as the predator- prey and logistic functions, illustrate that even very simple nonlinear, iterative systems may display chaotic behaviors over time [Arrowsmith and Place, 1990, pp. 119-179 (Ch. 3) and pp. 302-378 (Ch. 6); and Baker and Gollub, 1991]. The logistic function, usually defined on integers such as discrete moments in time corresponding to the beginning of a period, n + 1 and the beginning of its predecessor period, n. Using the logistic functions to model the value of some attribute(s) of interest, say a group's population, also behaves in accordance with an evolutionally stable strategy (Mesterton-Gibbons, 1992, page 61), and Maynard Smith, 1982, page 54). We describe a human population group at period n to be designated by p_n. Then the corresponding logistic map is given (Baker and Gollub, 1991, p.77) by

$$p_{n+1} = \mathbf{a} \cdot p_n \cdot (1 - p_n) \text{ , where } 0 \le p_n \le 1 \text{ and } \mathbf{a} > 0 \text{ .} \qquad (1)$$

Equation (1) expresses the idea that system state, in the form of the state variable p_{n+1} in period n + 1, is dependent on its prior state p_n in period n). Note that p_{n+1} depends, on the amount by which p_n falls short of its maximum value of 1; i.e., p_n appears twice. This leads to a second order polynomial (nonlinear) relationship; and to the fact that as you iterate this particular function you get a very complicated trajectory over time. In consequence, for certain values of the parameter **a,** the variable p_n will exhibit chaotic trajectories, meaning that it will bounce from each iteration to the next across the entire available range of values. In this latter case two points with initial values, say p_n and p'_n, no matter how close together they are, can be arbitrarily far apart after a finite number of iterations; so, any degree of uncertainty, no matter how small, in the current value of a given p_n will lead, after a finite period of time, to complete uncertainty in its future values. Thus, the ability to predict future states drops exponentially over time (because the number of accessible states—in the example, the range of possible values of p reached in finitely many steps starting at p_n grows exponentially; Baker and Gollub, 1991, pp. 76-87, 120-128). The logistic function also exhibits the possibility of chaotic behavior due to 'growth', a situation in which a quantity called the Lyapunov exponent, λ, is constrained by $\lambda > 0$ (Baker and Gollub, 1991, pp. 85ff; Çambel, 1993, pp. 82 - 112).

Empirically, chaos is found even in "simple" systems such as mixtures of 2 or 3 species in chemical kinetics. Chaos also is found in realistic models of populations of predator-prey ecologies where 3 or more species compete for common resources (Huisman, Weissing, 2002).

A game's actors are subject to nonlinear elements such as changing demographics. In the human domains, different social groups such as professions, business firms or industries, are competing in some way for common resources, while sharing some common domain or a certain 'space.' In this way we have the same fundamental possibility for chaotic behavior. Moreover, the complicating features of the contemporary world include increased "proximity" between human groups, in the form of greater interaction facilitated by advanced communication technologies that can amplify both information and misinformation, along with people having multiple group memberships, all of which may increase the potential for nonlinearities and chaos.

It can be argued that population and technology changes are the main contributors to the instability of human social systems. For example, technological change allowed humans greater range of actions to impact their environment and each other. However, there is also a consideration more specific to nonlinear dynamical systems. [Casti, 1992, pp. 288-292 (Part I, Section 4.8, Economic Chaos); Chen, 1988; Karasik, 1987.] In particular, the logistic map given as equation (1), above, exhibits approximately exponential growth in some circumstances (e.g., sufficiently small values of p, relative to the carrying capacity of the environment). the positive coefficient **a** corresponds to a positive rate of growth and, simultaneously, to a positive Lyapunov exponent which, as mentioned earlier, signals the possibility of chaotic behavior in the system under consideration. In situations where the growth process can be regarded as the result of investment, the above positive values also correspond to a return in excess of resource value invested (Karasik, 1987). In that regard, the classic criticisms of Malthus and Marx correctly identified the culprit variables defining the "crisis" of the industrial age (Karasik, 1984).]

In each human group, the arbiters of a society are the primary actors in the political 'games' we may seek to model (i.e., the leadership elites) who are able to mobilize the group population one way or another. Within any society, its human members cluster into various subgroups, each having a profile of behaviors, perceptions and beliefs that are tightly correlated with the other members. While individuals will show differing levels of dissonance with respect to the 'current state of affairs', and propensity for certain actions and emotional rapport, the group members will cluster around certain averages. Each group constitutes a collection of individuals who on the whole see the world in the same way, a common set of behaviors, a common set of core values that they are measure perceptions against, and common body of knowledge, rituals, taboos, hierarchies and judicial methods; and characteristic means for achieving goals, technologies they can deploy, resources they can bring to bear to alleviate dissonance

Furthermore, the actions of the group are mediated by the messages of the leaders / arbiters in response to environmental stresses and cultural/personal dissonance since arbiters constitute those persons of highest "credibility" within a group. Another mechanism: human societies under duress will respond as a single unit and bear the stamp of the stressful experience, be it the Exodus from Egypt, the Great Patriotic War, the Long March, or September 11^{th}, 2001. Understanding the nuances of such messaging and the core experiential crises offers insight as to the perceptions and possible responses a given actor will have when confronted with a specific situation.

In sum, the group has, therefore, as part of its cultural repertoire, the series of behavioral pre-dispositions that say when a certain kind of event happens, then there are allowable recommended behaviors. This fact of relative uniformity, including group-specificity of behavior, simplifies the global state space and, thus, the task of short-term behavioral prediction. We can regard and evaluate norms and other attributes as characteristics of the group around which the clustering occurs, without needing to evaluate each individual member.

4. THE ACTORS IN THE GAME – COMPOSITION, BOUNDARIES, AND INTERACTIONS

Abstractly, a boundary can be regarded as any way of characterizing circumstances under which elements from two distinct sets (domains) come into mutual contact. Boundaries largely remain implicit in the major human group memberships. Such memberships should be measured, I propose, by a couple of factors, called *proximity* and *credibility*, describing the relationship between pairs of human individuals. By credibility, I mean the extent of trust between individuals and the degree to which messages received are acted upon in a normative fashion (Yates, 1984). By proximity I mean the relative ease or difficulty for the pair to interact with each other. Expressed as a quantity, mutual proximity means the same as the reciprocal of mutual distance between the pair. In primitive times this would mean geographical proximity; as we move forward to the present, geography gradually becomes less important relative to other factors--political, economic, sociological--as determinants of proximity. Ideological and sectarian belief systems, coupled with linguistic divisions are core determining elements; you cannot communicate if you cannot understand each other or if a communication's meaning doesn't "gel". In addition, increasing fractionalization of knowledge through use of specialty jargon and new variations of beliefs create new elements which may contribute to decreasing proximity, even as older distancing elements are submerged.

More abstractly, proximity may be represented by interaction coupling strengths between the parties, meaning the strength with which each reacts to characteristics or events in the other. Consider the game of 'Go' where one places white or black markers at the intersections of the horizontal and vertical lines that define the game board. Control over a section of the board is accomplished through placing a series of markers (in a series of moves) in such a way as to surround an area and 'convert' it to 'white' or 'black'. This leads to a series of 'territories' defined by their boundary color.

In the proposed approach, individual human system members would be regarded as cross linked with each other, via a series of "coupling strengths", which constitute the means by which aggregation occurs. The corresponding and mediating aggregation parameters—such as language, belief system, economic class, nationality, education level, locality, kinship, internet access, cell phone access, wealth—basically define the degree of mutual proximity and credibility/receptiveness between groups and their individual members. Boundaries between groups then correspond to encounters between individuals lacking mutual proximity and/or credibility. This defines the potential set of actors in a game generated by the occurrence of a significant event of 'interest' or saliency to the values of a group. Russia's attack on the Ukraine, driven by casting independent Ukraine as a recurrence of Nazi invasion (Great Patriotic War) didn't only involve those two actors but spread to Poland, Moldova, Finland, Sweden, Hungary, NATO, and now China (which has its own issues with recognizing sovereignty of Tibet, Uighers and Taiwan).

5. PAYOFFS – DISSONANCE REDUCTION VERSUS CORE VALUES/NEEDS

Of key normative and scientific concern is with the socio- political- economic "storms" that impact all of us on this Earth, directly or indirectly; that is to say, the concern is with conflict and its potential. Moreover, the above analysis suggests that predictable regularities are likely to be found in relationships between groups. Thus, in the present discussion I focus on conflict between groups.

There are two aspects. The first is a proposed role for "fundamental" human needs. Structurally, we try to assert that certain variables are "independent" and therefore "cause" changes in the values of other variables that are deemed to be "dependent". My second thesis is that, in the case of human social systems, the fundamental independent variables take the form of four "drivers" – propensities, by different social groups, to exhibit, in a given set of conditions, certain characteristic behaviors in response to four fundamental needs (attributes that are of concern to them). These needs are for:

- Sustenance
- Safety
- Acceptance
- Fulfillment.

Clearly the need for sustenance is basic, without which there is no individual survival. Safety follows closely, otherwise we are some other's 'meal'. Acceptance in terms of emotional sustenance via group membership is again basic to the primates and many other species. Our long, dependent childhood reinforces all the primal needs, the first three on the list.

The last need is an emergent one among humans, though studies now show that other species have altruistic behaviors that are not always motivated by primal needs (consider cross species ‘adoptions’). In human terms, it is the need to understand one’s place in the universe and how the universe functions. I would venture to say it is the need for "self-acceptance". It can take the form of an individual’s method of expression in the form of artistic, intellectual or other personal behaviors.

Because they affect the level of comfort of the individual with the state of the world, with the state ofthe group, and with his or her own personal state, these core (independent) variables define the "potentials" to drive "action" in human populations. Moreover, the presence and functioning of these four basic drivers is stable over the time scales of interest (~ thousands of years) in studying the current global system.

Group uniformity and individual basic needs are connected: the commonalities, to which above reference was made, comprise the action set that allows the group to impact the environment to achieve its ideal state, including survival and other basic needs of the human members. The upshot is, each tightly correlated group generates behaviors impacting the environment in a manner deemed "advantageous" to the group. Each group has desired “end states” for the environment, the comfort zone of the group. These "end state" considerations correspond to the drivers just mentioned.

The aspect connecting group characteristics to conflict potential, and of great behavioral interest, is the state of *dissonance*, meaning the condition in which the environment is too different from the group ideal (from where the group feels it ought to be) for comfort. Such ideals are defined with respect to the drivers. Depending on the capacity of the group and regardless of its cause, every effort will be expended to bring a dissonant environment back into the comfort zone. One result of dissonance is the societal disruption entailed by this effort.

This results in the increased potential for overt conflict. In particular, when groups encounter each other, if the ‘alien’ group is impacting the dissonant environmental state of the referent group, and if the degree of dissonance is great enough, there will be potential for conflict at some level until the dissonance is reduced. The extreme form of this is the idea of war arising from the circumstance in which the referent group feels its survival is threatened by the outside group. One merely has to go to the Middle East to see this at play.

As mentioned, most societies are composite groups and whenever dissonance differences occur between sub-groups, it acts as an "internal stress" on the integrity of the composite group. One form this might take is the demand, mentioned earlier, for internal change in response to external stress or lead to ambiguity in the identity of the "proper" group arbiters; e.g., as in Sunni versus Shiite in Iraq after the 2003 invasion or Trumpian Republicans vs. Democrats in the U.S.

Stated in a general form, the predictive issue is to capture the "critical points" where group behavior changes including, in particular, when violence against members of another group occurs. While we have yet to achieve such prediction, I suggest one promising indicator of it is a combination of dissonance between the differing group value systems, and proximity between members of the groups (or their individual members) along a common boundary or in a shared environment. This suggests that the potential for between-group conflict may vary with a dissonance-distance gradient (Karasik, 2014), a ratio [between-group differences] / [between-group distance], given in squared form as

$$(\left| x - x^* \right| / \mathbf{r})^2 = (D/\mathbf{r})^2 \quad (2)$$

Where:

x = actual position of alien group
x*= ideal alien group position *as judged by* referent group from its own norms
r = mutual distance (reciprocal of mutual proximity) between the 2 groupsD = $|x - x^*|$ = dissonance of referent group with respect to alien group.

Mathematically a "gradient" is the vector of partial derivatives of a potential function with respect to spatial dimensions. In this case the "potential function" is the "ideal state" characteristics from the point of view of a particular group. The dissonance gradient exists because reality deviates from that ideal through the actions of one or more other groups having different ideals.

By this analysis, therefore, from a mathematical/scientific perspective we are interested in measuring and studying such gradients experienced by different groups of human populations. Empirically, the ideal states-- the values of the x* --and the condition or degree of dissonance could be determined by highly structured or standardized opinion surveys—in those instances where it is feasible to conduct them—in which the focus would be on the likely drivers. Informal 'e-chatter' and 'i-reporting' would also allow us to 'tune' in the 'social' state of mind of the group in question. With some track record we could likely extrapolate behavioral predilections.

Dissonance and its effects hold the prospect of becoming empirical. First, we can measure it; it is physiological, every human being is constantly measuring her/his own. Second, the basic needs giving rise to it are, themselves, fairly concrete and empirical. We can measure macroscopic levels ofeconomic health, safety, physical health and social cohesiveness. Further, a point to which we return, below, one can readily track behavioral changes due to dissonance because they are sudden and discontinuous.

5. THE ACTORS, THEIR ACTIONS AND ASSOCIATED COSTS.

We've described the interior state and dynamics of a social group. Now we look at their exterior interactions with other groups. When different social groups interact, the dynamics of the interactions between them begin to predominate over the dynamics internal to any one of them. In part, this is because between-group dissonance is much greater vis-à-vis the current shared domain(s)., Thus behaviors that are dissonance driven occur more rapidly and generate a greater discontinuity of change.

I maintain that the effects we recognize as comprising human societal evolution--"history", as we understand the term--came about because of the contact between groups. These effects were the source of discontinuous changes forged when a group was confronted with exogenous shocks, such as the shock of contact with an alien group, or the shock of radical and/or rapid technological or population change. With mutual contact, the interactions among the various groups are multi- faceted. One aspect is the between-group dissonance phenomenon already discussed; this may take the form of variations between the group behavioral sets impacting on the respective members, who otherwise would view their "way" as the "only way". Another aspect is the potential for cooperation; in some cases, the alien group has assets of value: technological, geological, or biological. This actually can be regarded as similar to dissonance, but functional rather than dysfunctional. The similarity is that an interest in alien assets may correspond to perception of differences in the form of economic comparative advantage.

Then three responses are possible:

[1] Peaceful interaction among peoples for "excess" food production or other vital resources is a common behavior. When this happened and if relationships became routine, then sharing of technologies, knowledge and cultural traditions also occurred. A further and reinforcing consideration is that groups have variable limits; some are more tolerant than others in terms of how much dissonance they will put up with. These limits may be issue-specific; that probably is the basis for potentially integrating multiple groups because some groups can say, "Oh, I can let that go; it's important to you, it's not that important to me". Thus, blocs of groups may coalesce around the commonality of major stressors, where the dissonance among the groups within a bloc is far lower than the dissonance experienced with groups outside the bloc.

[2] Unfortunately, another common response is the use or threat of physical violence to take resources desired or needed. As I suggested above, the great stress-or, the group-on-group behavior of “war”, is a response to severe dissonance driving a group to feel its survival or set of fundamental values is threatened. This response is basically a behavior derived from hunting (a predisposition of human predatory history, reinforced even in modern times by societies that enshrine the warrior/hunter as a role model and ultimate experience). However, the proximate cause is thedissonance experienced by the interacting groups; if this is too great, the “need for fulfillment” or “safety” will be violated and either there will be a clash between the groups or within one of them.

The latter alternative has another variant: the creation or increase of instability in the referent groupas an internal response to dissonance (perhaps more likely within the “weaker” group), leading to overthrow/modification of the cultural traditions as the means of removing the source of dissonance.

[3] The last response, now almost entirely ineffective, is to maintain (or restore) isolation through theuse of technology or force or both, in short to withdraw from the shared domain. China and Japan for instance, at various points in the past, chose to cut themselves off from the rest of humanity, seeingno value in having commerce or cultural interchange, and developed harsh policies as a means of enforcement until it became no longer viable. Though we are seeing potential partitioning of the universal world-wide web and closure of access to certain applications among those parties who see themselves besieged.

In the terms employed, these three response patterns are the only ones available (Karasik, 1984) to any social group responding to perturbations in the environment. A somewhat different way of viewing the possibilities of mutual encounter is shown in Figure 2 (see also Karasik, 1987, pp. 234- 239): 1) A group can make a change in the state of the world through physical manipulation of it. Such manipulation can be used, further, by one group to try to control the other one. 2) The other thing the group can do is communicate with the other populations or individuals to try to change theirbehavior, to achieve the end result. And so the politics of persuasion come in that particular factor. (Of course, any communication requires a physical mode of transmission. In that respect, all forms of action involve physical manipulation; but one can further distinguish “communication” as manipulation having a relatively high information content.)

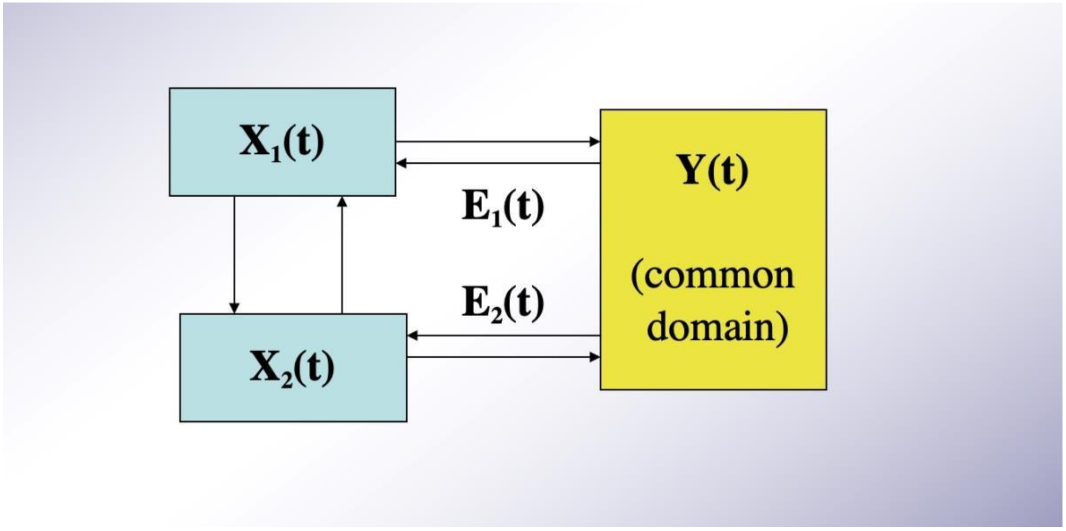

Figure 2. Two Actors Whose Efforts Impact A Shared Domain

In the Figure 2 above, the situation is illustrated for the case of two groups (**X**'s). The state of the environment in which one of the groups, say $\mathbf{X_1}$ finds itself, is based on its internal state, plus what it is doing to act on other groups such as $\mathbf{X}_2$ and on the environment or "common domain" **Y**. The latter comprises elements/conditions not specific to any one agent or group but common to them all, suchas variables describing the non-human ("natural") environment, e.g., climate and, possibly, other groups momentarily considered as passive elements. The efforts in terms of all related actions taken by $\mathbf{X}_1$, in all its various behavioral modalities, are subsumed in the variable vector quantity $\mathbf{E}_1$ in the figure. This latter is the "control" variable, so called because it is whatever will impact to change the state of the system to bring it into closer alignment to where the group wants to be (i.e., to reduce dissonance). These elements we consider further in the computational model,

Today, in our ever shrinking, interconnected world, all human groups are "touched" by many other groups, more than in the past and in greater diversity. More groups are interacting with each other because they are able to communicate across the world. Time and distance do not mean little nowadays; we can communicate instantaneously; we can travel around the globe within a day. We are now all in each other's face. There is nothing that happens anywhere in the world that does not affect all of us. Correspondingly, there are a great many dissonances with which groups (and individuals, also) must deal, for which the conflict potential is great. Multiple interacting groups may never, in fact, achieve a stable equilibrium, due to the fact that a new condition in one group potentiates changes in all the others, so that change perpetually bounces through the system, from group to group.

If one group has little dissonance when the other has a lot, and *visa-versa*, so that what is good for one is bad for the other, then conflict is further potentiated by viewing things narrowly in the behavioral norms as a "zero-sum" game, if you "win", I "lose". Perhaps these differences can be partly or wholly reconciled, however by enlarging the number of behavioral states one can generate a positive contribution to each group, reducing dissonance experienced and get away from "zero-sum" and move to a "win-win" scenario. In essence one is diluting the dissonance by providing countervailing positive attributes. In cases of bloc formation as in trade, the overlap of value systems and degree of consilience regarding appropriate individual and group behaviors may lead to long term symbiosis; that is, a stable cooperative state between groups. Thus far, humans have not been able to engineer such stable composite groupings for more than a few centuries.

5.1. Historical Perspective

There are many "fault lines", even within the "core" cultural traditions. Christians as well as Muslims follow several variant religious and linguistic traditions often at odds with each other, sometimes violently so. There are a number of "undigested" subgroups, particularly true in Central and South America, whose pre-European cultural traditions have been maintained, even after mass European migration. In some cases, such cultural groups are significant or potentially dominant in certain sovereign nation states. Africa remains both the "motherland" of homo sapiens and a battleground between tribal groups artificially confederated (by Europeans) with one another into "nations" havingno history except as artifices of a short-term European exploitative relationship. Continued turmoil, the lack of a political model providing a basis for making the transition to a stable and economically viable state, apparently makes this area a potential hotbed of conflict for many years. There does not seem to be any obvious "attractor" among the other core traditions around which Africans can coalesce.

One anomalous situation, is the relative success, at least through the 20th century, of the United Statesin creating an environment whereby the cultural traditions of many groups are tolerated and a common social-political-economic infrastructure is maintained and shared. This did not happen without some significant conflict and persecution, but peoples who in other parts of the world are actively warring with each other, seem to be able to come together in the United States without the same level of rancor and hostility. But, as happened with Cordovan Spain, such periods of multi- cultural peace can be destroyed by fanaticism (Menocal, 2002, pp. 189 ff.) driven by cognitive dissonance and directed by “arbiters” who sought to purify their “traditions” (early Al-Qaida) and now even in the U.S. there is a hardening schism between ‘left’ and ‘right’ political groups harkeningback to its Civil War and 1960’s cultural divides.

6. INVARIANTS AND DRIVERS OF THE GAME.

The concept of energy is central to the modeling approach described here. In human societies quantities that have energy-like behavior are wealth (Karasik, 1984), price levels, core beliefs. Such energy-like quantities are invariant during the period of a ‘game’. Every time there is a perturbation of a system potentially subject to a ‘game’, it then tends to try to return to its previous state. Or, as I would posit, the system tends toward the lowest state of dissonance among all the actors involved. Thus, stress and dissonance are equated; they correspond to the application of a ‘force’ that is counterbalanced up to a point, then followed by a catastrophic ‘break’. If any of the actors remains outside their comfort zone; the game will continue. Think of the Versailles Treaty ‘ending’ the game of WWI only to generate WWII. In short, as long as the actors share a common domain of interest, and have different preferred outcomes, they will be engaged in new ‘rounds’ of the game. Only if there is ‘merger’ of actors into a consolidated grouping sharing a common set of preferences or the complete annihilation of one of the actors will the game between them be over.

Changes in behaviors of an entire group are tied to satisfying individual dissonances. You will not get people rioting in the street, nor will people will go to war, unless things are bad enough. If the latter condition is not met but war still is chosen by the arbiters, support for war will be so weak as tothreaten its continuance or, even, the continued dominant institutional, career, or even personal survival of the group's arbiters.

The connection between individual and group behavior change is that one gets group behavioral change when the collection of people that first breaks into new behavior turns out to be an "important" subgroup; that is, if they turn out collectively to constitute a new "attractor". Put another way, an important subgroup is one that is capable of infecting the rest of the group with the behavioral change. In that event, suddenly they can "recruit" the rest of the larger composite social group who may not have reached their critical dissonance point yet ("critical" in the sense that behavioral norms will switch to "emergency" – by nature a more aggressive response). The smaller subgroup will take everybody else along with it. (This is a further illustration of the significant role played by multiple group memberships; in this instance membership in both the "new behavior" subgroup" and the larger group, affecting the behavior of the latter--namely its capacity to shift behavior.) Then, suddenly, one has a mass movement that says "we've all had it". That is where you can get a sudden discontinuous change in the political environment or landscape. That is the way we will be able to model discontinuous change (Karasik, 1984). If we are left with either war or peace as only alternatives, we need to make war the less attractive option even if it means the "enemy" remains and we cannot have our "ideal" world. Unfortunately, our skills in making war have more than kept pace, while our skills in engineering symbiotic environments and desensitizing the core belief systems that are inflexible and intolerant has not kept pace.

7. Outline of a Dynamic Fuzzy Recurrent Game Model

We have focused to this point on the crucial importance of measuring the dissonance and how it is the driving force behind the overt behaviors any individual or social group may employ to make their environment 'acceptable'. Now, how is Game Theory applicable? In the first place, who are the players? In this case any group impacted by an exogenous change in the shared environment. This change in the environmental 'state' causes a change in the dissonances experienced by the various groups. If the new value of the dissonance is greater than the group's threshold of acceptability it will lead to corrective 'action' to return the environment's state to within the acceptable threshold. The actions chosen will be from a set of tactics related to a primary strategy that dissonance with respect to particular dimensions will normally map into. These actions will be constrained by availability of resources to support the efforts. Use of these resources generate 'costs.' The actual outlays may vary significantly from expected outlays factored into the initial decision making. Tactics used will be chosen based on the expectations relative effectiveness versus costs entailed.

Chosen strategies, specific tactics, will evolve in response to their 'success' or 'failure'. These are applied to the perturbed environment and it reaches its new state in conjunction with changing resource capabilities to enhance or sustain the new state. (The US – Iraq war of 2003 is a now classicexample of underestimating the costs of indefinitely maintaining the new state relative to the costs of achieving the targets of the original mission). The resultant (payoff) state as initially attained however, may engender new players entering because now the 'acceptable' state for the first actor is no longer acceptable to another (or others not originally in the game).

[Side Bar: Russia has learned that the hard way, vis-à-vis the Ukraine, not only underestimating their capacity to resist and fight back, but also in the degree of involvement of NATO members to support the Ukraine primarily through enhancing resource capacities and attempting to increase the costs that Russia has to pay. On the other hand, China was drawn in as support for Russia because they have their own issues of sovereignty with respect to Tibet, Taiwan and the Uighers and view ex-Soviet sovereign states and Ukrainian independence negatively, as dissonant with respect to a vital ideal of their own.]

In short, every potential player has their own 'lens' through which they view the shared environment and how the environment impacts their own social system with respect to vital core values and interests. Every game has its 'stakeholders', those who will respond to changing shared domain as their dissonance tolerance is exceeded.

So, starting from the state space mapping of dimensions of interest of a shared environment and the dissonance valuation vectors for each group therein with respect to their 'ideal states'. We also have state spaces for each potential actor, with their resource capacities / capabilities and the mappings from these resources to specific tactical actions that might be employed to support a given strategic dissonant state-dependent response. The 'game' is thus a discrete time mapping of related episodes impacting a shared environment whereby players enter or exit as their dissonance deviates from 'acceptable' to 'unacceptable'. The 'payoffs' are dissonance reductions sufficient to return to 'acceptable ranges, subject to costs of actions needed to enable such reductions as constrained by resource capacities. These 'valuations' are hardly 'crisp' and can be categorized linguistically by fuzzy variables (Karasik and Williamson, 1994) such as 'extremely dissonant', 'moderately dissonant', 'slightly dissonant', 'marginally acceptable', 'acceptable' and 'very acceptable'.

Our modelling thus requires us to have a solid understanding of the 'ideal' environment and range of acceptability with respect to each dimension for every potential composite social actor with a shared interest in the 'environment' (suitably bounded). Most importantly we need to know the not only the 'ideal' states with respect to given dimensions; but the perceived states from perspective of each potential actor and finally the actual observed states of the environment. We need also to understand the internal dynamics of composite actors as well since the unacceptable dissonances as related to sub-groups may drive decision-making toward violence. We need to understand and track resource capacities and acceptable ranges of costs that an actor might be willing to bear to achieve desired changes.

The 'game' can only 'end' when each impacted actor has acceptable dissonance or if capacities to act otherwise are exhausted. One method whereby total dissonance can be modified is to provide compensating payoffs in other or even added dimensions of the environment. Such as 'offset' could override the original payoff that has proven unacceptable to others. This essentially extends the range of acceptability of the total set of environmental states with respect to one or more actors without increasing dissonance of any other. Sort of a Pareto-optimality condition in the sense that total dissonance across all M actors in the shared environment falls within the M x N dimensional manifold, where N is the dimension of environmental variables of interest.

.

8. CONCLUSION – WHO ARE THE ACTORS IN THE GREAT GAME?

While this paper is focused on the scientific aspect of building better predictive models; underlying the effort is a normative one: If all human populations shared at least one language and a set of core values then perhaps the human species could evolve without major internecine strife. But war represents the most "energy efficient" way of permanent dissonance reduction, as it requires no change in a victor's culture. Peaceful dissonance reduction requires a change among all groups concerned. Ultimately, if we are to create an environment that gets past conflict, we need to develop some common core values and methods to measure and reduce overall dissonance that is felt by all the different populations that are sharing our common planet, our spaceship earth.

Until we reach that state of affairs, we need to more effectively evaluate the inter-group dissonance gradients and channel our efforts to mitigating them. It should be done as to maximize the ability of our species to fulfill all the needs of its members as much as possible without destroying the planetary resources needed to sustain us indefinitely. To this end, a program of global computational modeling and forecasting can be indispensable. Such a program entails a proper definition of the shared environment and the critical dimensions that societies use to assess acceptability. We also need to catalog social population groupings, with sufficient fineness of granularity to capture major "value system" variations, even within a nominal cohesive political-economic entity. The value systems define the group response patterns under stress (severe dissonance). These responses, sources of potential actions for changing the shared environment need to be catalogued and assigned likelihood valuations and associated costs. Propensities for violence given particular dimensions of dissonance are the most important in modeling possible onset of a new game. Much of the data can be developed from information that now exists in various forms. An additional key element would be based on observers within the various groups reporting on changing memberships, arbiters, available sanctioned actions and experienced dissonance. Reliance would be placed on standardized continuous surveys to understand when the next occurrences of the continuous game environment arehappening, which actors are involved directly and which impacted ultimately.

REFERENCES

[1] Abraham, R. and C. Shaw. (1984) Dynamics: The Geometry of Behavior, The Visual Mathematics Library, Vol. 2. Santa Cruz, CA: University of California, Santa Cruz.

[2] Al-Obaidi, Maysaa (2013) Fuzzy Game Theory for Decision Analysis, Thesis, Eastern Mediterranean University.

[3] Arrowsmith, D. K., and Place, C. M. (1990) An Introduction to Dynamical Systems. CambridgeUniversity Press.

[4] W. Brian. (1990) “Positive Feedbacks in the Economy,” Scientific American, Feb, 1990.

[5] Bak, Per and Kan Chen. (1991) “Self-Organized Criticality,” Scientific American, Jan. 1991.

[6] Baker, G. L. and J. P. Gollub. (1991) Chaotic Dynamics. An Introduction. Cambridge University Press.

[7] Billot, Antoine (1998), “Example of Fuzzy Game Theory”, Fuzzy Sets and Decision Analysis, Operations Research and Statistics, Ed. Roman Slowinski,Springer p. 137-176

[8] Butnariu, Dan (1978), “Fuzzy Games: A Description of the Concept”, Fuzzy Sets and Systems 1, North-Holland Publishing Company, p. 181-192

[9] Casti, John L. (1992) Reality Rules. John Wiley and Sons.______. (2000) Five More Golden Rules,John Wiley and Sons.

[10] Chakeri, Alireza; Sadati, Nasser; Dumont, Guy (2013) “Nash Equilibrium Strategies in Fuzzy Ganes”, Intech Chapter 15, http://dx.doi.org/10.5772/54677

[11] Chen, P. (1988) “Empirical and Theoretical Evidence of Economic Chaos”, System Dynamics Review, No. 4, Nos. 1-2, pp. 81-108.

[12] Çambel, Ali Bulent. (1993) Applied Chaos Theory: A Paradigm for Complexity. Boston: Academic Press.

[13] Freeman, Walter. (1991) "The Physiology of Perception,” Scientific American, Feb. 1991.

[14] Haykin, Simon. (1994) Neural Networks, a Comprehensive Foundation. IEEE Press.

[15] Huisman Jef, Weissing, Franz (2002) ‘Oscillations and chaos generated by competition for interactively essential resources’, Ecological Research (2002) 17, 175–181

[16] Karasik, Myron. (1984) "Conservation Laws and the Dynamics of Economic Systems" in Proceedings, IEEE, Conference on System, Man and Cybernetics, Dec. 1983 - Jan 1984. New Delhi, India: IEEE Press,

pp. 756-762._______. (1987) "The Dynamical Behavior of Ensembles of Autonomous Systems" in Proceedings, Fifth International Conference on Mathematical Modeling (Berkeley, CA, 1985). Oxford, England: Pergamon Press, Lofti Zadeh ed.
[17] Karasik, Myron and Williamson. Paul, (1994) "Modeling Complex Human Social Dynamics using Neural Networks of Fuzzy Controllers" in Proceedings, World Congress on Neural Networks (San Diego, CA), pp. 765 - 770., Lofti Zaheh, ed.
[18] Karasik, Myron, (2014) “Forecasting the Evolution of Cultural Collisions Using Annealing-Nucleation Methods”, Predicting the Future in Science, Economics and Politics, Eds. Wayman, Williamson and Bueno De Mesquita, Edward Elgar Press, 2014; Page 261ff.
[19] Maynard Smith, John, (1982) “Evolution and the Theory of Games”, Princeton University Press.
[20] Maria Rosa. (2002) The Ornament of the World. Little, Brown and Company.
[21] Mesterton-Gibbons, Michael, (1992), “An Introduction to Game-Theoretic Modelling’, Addison Wesley Publishing.
[22] Ott, Edward, (1993) Chaos in Dynamical Systems. Cambridge, UK: Cambridge Univ. Press, pp. 158-166.
[23] Penrose, Roger. (2005) The Road to Reality. A Complete Guide to the Laws of the Universe. New York: Alfred A. Knopf.
[24] Rashevsky, Nicolas. (1968) Looking at History Through Mathematics. Cambridge, MA: The MIT Press.
[25] Sangeetha K, Parimala M, (2021) On Solving a Fuzzy Game Problem Using Hexagonal Fuzzy Numbers, Material Today Proceedings, Volume 47, Part 9, pp. 2102-2106, https://doi.org.10.1016/j.matpr.2021.04.591
[26] Soodak, H. and A. Iberall. (1978) "Homeokinetics: A Physical Science for Complex Systems," Science 18 August 1978: Vol. 201. no. 4356 pp. 579 - 582.
[27] Stauffer, D. and A. Aharonov. (1992) Introduction to Percolation Theory, 2nd Ed. Taylor and Francis.
[28] von Neumann, John and Morgenstern, Oskar (1944) “Theory of Games and Economic Behavior”, Princeton University Press.
[29] Yates, F. Eugene. (1984) “Dynamics of Adaptation in Living Systems”, in O. G. Selfreidge, E. Ridel, and M. A. Arbib (Eds.), Adaptive Control of Ill-Defined Systems, pp. 89-113. Plenum.
[30] Zaslavsky, G. M., and R. Z. Sagdeev, D. A. Usikov and A. A. Chernikov. (1991) “Weak Chaos and Quasi Regular Patterns” Cambridge, UK: Cambridge Nonlinear Series, pp 21-35.

AUTHOR

Myron Karasik has an MSEE from Purdue University in computer and control systems, having completed all PhD coursework. He did research in using AI techniques for speech recognition and predicting economic behavior. He also developed a prototype robotic manufacturing control system. As a Member of the Technical Staff at Bell Labs, he developed software quality assurance and management techniques adopted as Lab standards and oversaw the first successful implementation of a mission critical commercial system to manage the circuits of a Bell Company. Mr. Karasik also has an MBA with Distinction from Northwestern University where he was also on adjunct faculty supporting financial and accounting research. There he developed a model for ongoing evaluation of investment decisions eventually commercialized, becoming the preferred basis of shareholder valuations. Subsequently a partner in a two CPA firms, he provided strategic management services to clients and developed several categories of applications. He later became CTO, COO, CFO, over a 30-year period, at various companies in professional services, healthcare and insurance industries while in parallel contributing research publications in the areas of software engineering and complex systems modelling. In particular, Lofti Zadeh presided over two of his presentations, on agent-based modeling (abm) and fuzzy neural networks (fnn) and helped to popularize the use of these methods. He currently is associated with the McCracken Institute for advanced financial management and also provides strategic and financial consulting for several private clients.