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Computational Models of Intercultural Relations in Banat and Transylvania: Theoretical and Practical Issues

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Abstract. This paper outlines the basic issues and challenges in building and testing computational models of intercultural conflict and harmony in Banat and Transylvania, using selected archival and online records of intercultural relations between heterogeneous populations in these regions at important moments in their history. This kind of project, the paper argues, can be successful only if it combines the qualitative methods of the humanities and the social sciences with the latest analytical and statistical methods from the Artificial Intelligence (AI) field of data mining, using entity relation modeling based on entity identification. The paper then describes a new method of parallel computation, based on the Quantum Relations Principle (QRP) – an offshoot of general systems theory, specifically complexity and self-organization theory, which is ideally suited for the modeling of intercultural relations.

Our project adopts and modifies the notion of "culture contact," which was first introduced in cultural anthropology and geography and was later taken up by other academic fields, such as literary and cultural studies, sociology, and cultural history. In the past few decades, the term has generated a cluster of other terms and concepts around it, such as *acculturation* (the transformations in systems of values and beliefs, artifacts, and customs that result from intercultural contact); *incorporation* or *amalgamation* (the adoption of ideas, characteristics, and customs from another culture); *assimilation* or *naturalization* (the integration of culturally heterogeneous individuals or groups into the dominant culture of a certain society) *cultural or transcultural diffusion* (the spread of ideas, fashions, customs, religions, technologies, languages from one culture to another). Our project attempts to place such concepts into a well-defined, regional reference frame, transforming them (to the extent possible) into generators of potentially testable assertions.

Violent Intercultural Contact. We are focusing particularly on the conditions and factors that lead to unsuccessful, violent intercultural contact, because (1) such contacts are well-recorded; (2) they are often well-analyzed by historians and others; and (3) they are critically important in people's lives. By studying violent conflicts, we hope to offer strategies and methods to avoid them. There have been a number of recent analyses and computer-assisted simulations of various violent conflicts, including the 1990s war that led to the dissolution of former Yugoslavia [21] [32] [12]. Despite this increased scholarly attention, there is no agreement among researchers as to the causes of these violent episodes in the life of the world communities. The most common explanations include "dire economic conditions", "ancient hatreds", "religious intolerance", and "political manipulation". More recently, a widely supported thesis (having a direct relation to our project) holds that since World War II national and ethnic questions have become a major source of violent conflicts [19]. Scholars point out that between the time of the Vienna Congress (1816) and the "New Order" in the wake of World War I, most of the major armed conflicts did not have national liberation as principal cause [38], [6]. By contrast, 77% of the wars after World War II were inner state, instead of inter state wars [35]. In the aftermath of the cold war, 75% of the wars were fought in the name of the nation [38]. The collapse of the Soviet Union and the outbreak of nationalist conflict in Yugoslavia at the end of the cold war appear to indicate the rise of an age of ethnic conflicts [19]. Identities instead of interests, the argument goes, has become the dominant motive for violent actions in our time. We propose to test this hypothesis and explore the counter-thesis that interethnic relationships and ethnic identities are too numerous and multi-faceted to explain the relatively rare event of generalized violence [10], [15].

Our own working hypothesis is that political and other elites can stimulate the emergence of intercultural mistrust and violent clashes, but their ability to do so is shaped by the network structure of their communities. In other words, we propose that elites and their communities engage in positive or negative feedback loops that may occasionally erupt in violence. The question is to find out why some of these loops never turn violent, despite expectations to the contrary (e.g., the Romanian and Hungarian interethnic disputes in Transylvania in the 1990s) and how we can defuse those that have a strong violent potential before they escalate to the point of no return. Complexity and emergence theory with its computer-assisted methods will be useful in exploring these issues as well.

Theoretical Assumptions to be Tested and/or Refined through our Computational Model. Today "culture contact" features prominently in North American and West European cultural studies and often implies conflict and force, being invoked in the so-called "culture wars". It is evident, for example, in Samuel Huntington's well-publicized theory of the "clash of civilizations" [20] and in Mary Louise Pratt's less-known notion of "criticism in the contact zone." Pratt defines such zones as "social spaces where disparate cultures meet, clash, and grapple with each other, often in highly asymmetrical relations of domination and subordination" [30] (p. 4). These theories and their hypothesized methods (such as the concept of "domination") are supported by anecdotal data only. Through our empirical model, we intend to

test theories that are power-based, as well as theories that depend on historical personalities, or on geographical boundaries.

As the two regions under study were for long periods in their history under Habsburg rule, we would also like to test the thesis that the Habsburg Empire was a "prison of nations", as well as the counter thesis, advanced by a number of late 19^{th} and early 20^{th} century prominent political and cultural figures, including Lajos Kossuth, Bishop Josip Strossmayer, Jászi Oskár, Karl Renner, Joseph Roth and Robert Musil, that this Empire was – or could have been – "a multicultural haven", with enlightened ethnic and religious policies. (The latter view inspired Kossuth's project of a "Danubian Federation" and, later on, Popovici's less enlightened project of the "United States of Greater Austria," which lost relevance with the assassination of Archduke Franz Ferdinand and the outbreak of World War I). Lastly, we hope to determine what lessons could be learned today from earlier attempts at creating multinational and multicultural European unions.

Intercultural Contact and Liminality. Our computer-based social modeling, even when it does not precisely emulate actual histories, may help reveal unexpected, nonlinear causes of conflict, as well as plausible models of peaceful coexistence. If certain universals are compelled by the data, but the models nonetheless give rise to conflicting possible outcomes, it might well turn out to be the case that there exists a no man's land between cultures, "gray areas" between borders in which nothing is quite settled and in which new social arrangements become possible. They may constitute privileged sites for intercultural dialogue, negotiation and cooperation, not just privileged sites of conflict. Thus, borders or boundaries may not only separate people but also bring them together.

In this regard, we wish to complement the conclusions of a recent computer simulation in the social sciences, carried out by Yaneer Bar-Yam and his team at the New England Complex Systems Institute in the USA, which has a number of methodological features in common with our project, although it starts from different theoretical assumptions. It studies the interactions between multiethnic communities in Switzerland, former Yugoslavia and India, concluding that setting boundaries (mainly geographical, such as mountains and rivers) between these communities has largely prevented violent conflict [24]. We shall factor in and further test their conclusions, exploring the possibility that boundaries between heterogeneous cultures can also be fertile, liminal spaces, facilitating peaceful intercultural cooperation.

We are therefore linking our theory of intercultural contact with the notion of liminality – a term that derives from the Greek and Hebrew *limen*, meaning "harbor" or the meeting place between land and sea, but also "threshold." Furthermore, in Latin, *limes* meant the confines or the borders of the Roman Empire. Thus, liminality in its broadest sense refers to the "transit" or "gray" spaces in-between organized systems and reference-frames, whether they are physical, geographical, or cognitive (such as the gray areas at the interface of disciplines, where the present project equally situates itself). We hypothesize that this notion can become an important conceptual tool in understanding not only how cultural (and cognitive) transformations may occur, but also how they may be shaped into a peaceful mode.

For example, through our concept of liminality, we hope to throw new light on the relationship between center and margin/ periphery that has preoccupied cultural theorists and sociologists in the past two decades and that has gained renewed relevance in the context of the enlargement of the European Union. As a rule, this relationship is seen as asymmetrical and conflictive, with the center dominating the margin, and with the margin challenging the center, often seeking to replace it. One can circumvent this power-based dialectics by drawing a distinction between the marginal/peripheral and the liminal. The margin or periphery can be liminal, but the limen can never be marginal or peripheral: whereas the periphery always defines itself in terms of the center, the liminal moves away from it, often in irreversible fashion. In this regard, we plan to focus our attention on a number of "liminal" cities such as Timişoara and Cluj-Napoca, and their complex relationships with the "center" (Vienna or Budapest or Bucharest), as well as on a number of "liminal" historical figures who came from the two border regions, who played a major role in proposing creative models of intercultural relations precisely because they were aware of the liminal opportunities offered by the "periphery" of the Habsburg empire.

We also propose to show that if we are to acquire a genuine transnational, transcultural, and transdisciplinary perspective inside and outside the European Union, we can effectively achieve it not from the center of a multistate economic or political entity, nation, culture or discipline, as many thinkers and politicians believe, but from its limes or borders. A liminal position, outside the established structures (be they social, political or cognitive), allows the observer to see the limits/limitations of any such structure so that s/he can begin to work toward remapping them or transcending them altogether. In other words, liminal spaces can also be transit points to new reference frames and systems, whether sociopolitical or cognitive.

The Role of Social Elites. We also wish to test the hypothesis that the social elites of the heterogeneous communities involved actually play a decisive role in the outcomes of intercultural interactions. We are exploring what seem to be rather complex feedback loops not only between the various populations engaged in close intercultural contact, but also between an individual population and its own elite, as well as those between the heterogeneous elites themselves; in many cases, the larger and the smaller groups of the same population may be at variance, which often results in unsuccessful, violent contact at the intercultural level. There is no requirement that each agent or group of agents in the model be identical, or have identical interactions, and if we succeed in modeling history through using elite and non-elite groups (and fail without them), then this would be evidence that elites are, in fact, determinative. What individual factors would define a specific elite group remains a significant subject for our research at this point.

Virtual Intercultural Contact and the Mass Media. We believe that a scientific theory of intercultural contact in today's world must explore the complex interactions between the zones of physical intercultural contact and long-distance or virtual contact, e.g., through contemporary mass media. How to model such "inputs" to the cultures is a major challenge. For most of our proposed research period, today's mass

media did not exist, yet there were analogous methods of wide-scale dissemination of information. As the electronic mass media have developed over the past six decades, one might expect different "coupling constants" that would change group dynamics. There is an enormous amount of data available in this area – indeed, the situation here is precisely one of too much data. But we hypothesize that statistical methods will allow us to reduce it to a manageable amount, and high-speed computer technology will enable us to run a very fine-grained model. We shall partly investigate this new group dynamics, especially through large-scale electronic news analysis. We expect that other researchers will adopt our methods and models in the future in order to continue to develop this vast area of research.

Political, Economic and Moral Implications. We are aware that our proposed research has wide-ranging social ramifications. From political, economic, and moral viewpoints, it appears that when heterogeneous populations engage in violent conflict, everyone loses, including the winning party. One population may succeed in subjugating or even wiping out another, but the victorious group may lose out as well: in the first case, because the defeated population will accept subjugation only temporarily and will continue rising against their oppressors, thus destabilizing the victor's society; in the second case, because genocide may generate instability, perhaps by doing damage to the collective psyche of its perpetrators, arousing and then suppressing feelings of guilt and remorse, thus dividing the individual members of their community. These are, we believe, testable hypotheses. They are worth testing before we adopt the simplistic logic of the "culture wars" that is currently in vogue in the global mass media and on the Internet. If the result of winning such wars is only more war, then there is an argument for peace.

Normative Value of our Research. We believe that a theory of intercultural contact should have not only a descriptive, but also a normative value. In this regard, we propose to adopt a simple value system: peace, nonviolence, spiritual and material well-being, without deep pockets of human suffering or deprivation, are good; and violent conflict, disease and starvation are bad. Except for these guiding principles, we intend to set aside dogmatic beliefs and ideologies. We assume that a scientific study of intercultural conflict and harmony will generate further principles, and perhaps they will be in accord with one ideology or another. Nevertheless it should, to the greatest extent possible, be built from data, not from ideologies.

Because our model of intercultural conflict and harmony will undoubtedly prove controversial, we shall debate it (and the overall approach) at various stages of the project from philosophical and ethical standpoints. We are not proposing to rationalize every aspect of intercultural conflict, or to construct a reductionist theory, but rather to discern which combinations of measurable factors can be, in fact, empirically tested using available tools.

Novelty and Risks of our Project. The threshold question of our research is if computer simulations can yield useful sociological results. Computer-based modeling

is customary in physics (e.g., statistical quantum thermodynamics), biology (genetic research) and computational linguistics, but it is still rather limited in studying human behaviour. Consequently, our project situates itself at the frontiers of the social sciences, humanities and AI-based information technology. Should it prove successful, it would constitute a significant step forward in these fields. The recent history of the beginnings of other similar trans-disciplinary cognitive fields (such as biology and IT, for example) shows that such fields usually had to overcome objections from experts in both domains. In our case, the objections will probably come primarily from the traditional social sciences. Yet, from the standpoint of social science, there is no compelling reason to assume that certain processes that are observable or inferable and can be measured in the physical world may not at least partially apply to human beings, who equally belong to this world and are inseparable from it. The usual objection that human individuals and societies are too complex for accurate calculations often overlooks the recently developed field of complexity and emergence theory, as well as the rapid and huge advances in AI-based computation (see, for example, our advanced technological platform, based on the Quantum Relations Principle, which we describe below).

Additionally, social scientists often doubt the possibility of accurate predictions of human behaviour, but again this objection arises from an insufficient understanding of the function of computer simulations, which are used not only as predictive tools, but also as virtual experiments [16], [17]. Therefore, even assuming that our computational models may not be entirely successful in accurately predicting individual or group behaviour, they will still help us better understand this behaviour and offer new ways of addressing it.

Methodology. We propose to combine the qualitative methods of the humanities and the social sciences with the latest analytical and statistical methods from the fields of physics (from which we borrow lattice theory, Fisher analysis, stochastics and the Lagrange-Hamiltonian), discrete mathematics, economics and finance. Our methods are largely empirical; although we recognize that it is impossible to avoid theoretical bias, we shall at least try to identify where it enters into our models. We shall, as much as possible, use data-based models and let the data drive the theory. We shall develop our theory of intercultural contact based on empirical, historical research and then test it against several computer simulations of historical circumstances in Central Europe concerning the two regions, especially during the periods when they experienced significant political and social upheavals, which resulted in either violence or peaceful cooperation. At one level, we intend to focus on the cultural interactions between influential individuals of different ethnic groups located both in the "liminal" and in the "central" zones (Vienna, Budapest, Belgrade, Bucharest, etc.). At another level, we shall investigate the spread of ideas and official political positioning, tracing concepts and the production of meaning in cultural and political newspapers and other periodicals printed during the periods and regions under study. At a third level, we shall explore how intercultural relations are being presented in influential works of fiction, drama, poetry, songs and other artistic media, including traditional and new folklore, architecture, painting, museums, monuments, films, and musical productions.

Also, during archive research we expect to identify police and secret service records concerning censorship of publications and rumours of a political nature, which will also report on interethnic relations. Finally, we shall look at the relationships between the elites and their own populations in the liminal zones, as well as at the daily interactions of heterogeneous groups in several border towns during selected periods of war and peace (e.g., the remarkable cooperation across national borders between the Serbian and Romanian populations in Banat/Vojvodina during the Yugoslavian civil war in the 1990s).

Multi-Group Models of Harmony and Discord. We are building computer simulations of two real-life locations in Central Europe, Banat and Transylvania, from 1800 to the present, using as initial conditions the circumstances at certain historical junctures when there was real or potential violent conflict in those locations. We are developing models of interactions among individuals and small groups, with multiple factors in each individual, and extend these to multi-group models of harmony and discord through computational means. Individuals within the two simulated Central European borderlands are modeled as vectors, that is, collections of parameter values for such things as gender, social status, language, ethnicity, religion, health, nutritional state, level of education, literacy/illiteracy, aggressive or non-aggressive behavior; politically active or passive tendency; the environment also has parameter values, such as geographical characteristics, climate, crop success, population movement, aggression from neighbors, foreign occupation. The computer will calculate interactions among individuals and between individuals and the environment, using sets of stochastic, probabilistic differential equations similar to those employed in modern quantitative finance.

It is our hypothesis that the various interactions between such clusters will emulate both the statistical results and the interactions of the actual human cultures in those historical settings. We anticipate that there will be many hidden variables or processes that we cannot measure directly, but assert that the application of advanced computing methods will help highlight what these are [13]. The stable solutions of the differential equations will be used to derive new parameter values, and the system will be allowed to evolve.

Basic Theoretical Assumptions of our Computational Model. In building our computer-based models, our methodological assumptions are these:

1. That there is a finite set of objective, measurable factors that allow grouping of a set of individuals into culturally distinct subsets;

2. That interaction between such subsets is different in kind than interactions between individuals (this is equivalent to the assertion that such grouping is meaningful or predictive with respect to the interactions);

3. That local interactions such as individual-to-individual, and family-to-family will prevail and that non-local interactions will be few, thus reducing the com-

putational complexity from exponential to polynomial. This is an assumption similar to those commonly made in field theories and is testable.

4. That the missing and hidden variables important to making a realistic model can be discovered and that parameters can be established for them.

5. That the factors can be used in a parametric model that can be time-evolved to make predictions about the group interactions.

A contrived, but simple example will clarify these points. Assume that in a given area, called Region-1, one can measure, through baptismal records or another means, the religious affiliation of each member of a community. Assume that the data show that thirty percent of the members are religion A, and sixty percent are religion B, and the other ten percent are varied. In Region-2, the corresponding percentages are fifty, forty, and ten. We can speak of members of religion A in Region-1 as a "culture", called perhaps Culture-1A, and those of religion B in Region-1 as Culture-1B, and so forth, giving us a matrix of possible cultures:

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Culture-1A     Culture-1B     Culture-1     (other)
Culture-2A     Culture-2B     Culture-2     (other)
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Let this matrix have the values:

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30     60     10
50     40     10
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We might find, empirically, that Culture-1 has a higher (or lower) level of political unrest than Culture-2. If this finding were repeated consistently throughout regions and throughout historical periods, then we could make a testable hypothesis about the relation between religious uniformity and political unrest.

Definition and Processing of Data for our Computational Models. We start by analyzing the sources of data. For our purposes, data are observable facts about a population and potentially include everything from the environment to standard of living to medical records. For each data source we document the parameters of the data, noting such things as maximums, minimums, standard deviations (in the case of numerical data), or sources of uncertainty or unreliability. We do not limit ourselves to numerical data, but include human characteristics such as languages spoken, customs, religious beliefs, nutritional habits and types of food, tools, artifacts and artistic creations. The next step is to build, using principally statistical reduction techniques and genetic algorithms, models that can evolve over time to produce later values in a reliable and reproducible way. The starting point is a classical factors analysis, using linear models, to harvest any "low-hanging fruit" from the data. This can be used to create a core of factors that might interact. We will then begin a massive genetic algorithmic search for complex interacting factors and combinations that are predictive.

We have already begun the process of data collection from Banat and Transylvania in order to create a simplified data-driven model, using principally statistical techniques. Historical data that are easily available on databases (populations, life-spans, food supply levels, and religious, ethnic and cultural affiliations) are being supplemented by selected data available from archives, and entered into computer databases. Archival records are being photographed and electronically scanned to extract information, and, where necessary, human analysts will edit them. The databases that result will be used within the project, but will also be accessible to other researchers.

Observable **data** that we are collecting and processing include: ethnic and/or racial groups as percentages of total population and as discrete numbers; income model (including distribution and shifts); social status; religious denomination; number of town neighborhoods or villages segregated according to religious and ethnic factors; number of mixed, "integrated" town neighborhoods or villages; number of churches, temples, mosques; certificates of baptism, marriage, death; interdenominational marriages and number of conversions; records of Christian and other names; number of changes of family names (for political, economic, social status reasons); inter-ethnic marriages; segregated or integrated cemeteries; multilingual and monolingual groups; number of primary, secondary and tertiary schools and school graduates; number of teachers; number of libraries, literacy, population changes and movement, occupations and professions; number of managerial positions in factories and institutions; number of factory workers and other lower-paid employees; number of property owners; number of officials in public administration and the legal system, number of officers in the military service, official languages, minority languages, number of newspapers, literary magazines, presses, publishing houses, cultural institutions such as theaters and operas, radios, and so on.

Physical Sources of Our Database. Our data are derived from selected publications concerning intercultural contact about the two regions under study, to be found in libraries and archives as well as on the Internet. For the contemporary period (1989 to the present), we intend to investigate, through large-scale news analysis, the new intercultural group dynamics created by the electronic media. Here the database are primarily limited to textual public communications, including newspaper reports, internet websites, and internet weblogs concerning Banat and Transylvania. We believe this is a viable strategy, because the content of both news and weblogs is heavily influenced by national government policies and the local population's reactions to them. These, in turn, reflect deep-seated cultural beliefs, including perceptions of intercultural issues, and thus fall within the scope of our research. In the cases where the news data are not electronically available, the pioneering research of Sherrill Stroschein in Romania and Slovakia shows that conventional data collection with respect to newspaper articles is also possible, at relatively low cost [34] [18].

In addition to data gathered within the study, we shall take advantage of many large, existing databases, such as the Militarized Interstate Dispute (MID) data set of the COW [18]. At the same time, our research will supplement part of the information missing from such databases; this will be particularly useful to the scholarly community and other interested public agencies, because, according to some critical

assessments, more than 70 per cent of the missing data is from Central and Eastern Europe, where our regions lie.

We shall continuously compare and test our computer analyses against the various theories of intercultural contact in the contemporary social sciences, thereby refining both the theoretical and the practical components of our research.

AI-Based Technological Platform for Our Research. We propose to combine the qualitative methods of the humanities and the social sciences with the latest analytical and statistical methods from the Artificial Intelligence (AI) field of *data mining*, using *entity relation modeling* based on *entity identification*. We shall investigate the interactions among individuals and small groups, with multiple factors in each individual, and extend these to multi-group models of intercultural relations through computational means. The "success" of the individual model will be determined by its agreement with the overall statistical model and by its prediction of reasonable probabilities for discrete events of historical conflict and non-conflict in the four borderlands under study.

There are several recent approaches in the area of AI-based computing which we can choose from or use in combination, as we build our models of intercultural harmony and discord:

Linguistic Analysis. Our basic approach to linguistic textual analysis is one that has been successful in many fields. We digitize printed textual images, then use OCR technology to transform it into machine-readable text. Once we have acquired a sufficient sample, we shall use simple grammatical filters to extract name, location, and concept tags, and then use classifier algorithms, trained by human readers, to extract further information. Each text will thus be reduced to a set of XML data that can be stored and used to build models. This approach is not perfect, but it is fast and efficient, and has been successful in many previous applications, particularly when the dataset is large. Because all of the data will remain available in digitized form, as the linguistic processing gets better, the data will increasingly become more valuable for this and for other research.

Extraction of Concepts. Computer-based linguistic analysis has been remarkably successful in extracting identities such as names, places, political parties, companies, and so on from textual news stories and other printed material. The techniques for doing so are well known. In addition, the same techniques can be used to extract other information that is either (a) named, or (b) relational. Examples of the first kind are "democracy" and "Hungarian," both of which are named concepts. Examples of the second type are verbs, such as "A attacked B" or "A discussed B." Both identities and concepts can be extracted, stored as XML and analyzed. Another example of relational data is time, which includes the date when something was published and the relational dates within a narrative, for example, "After visiting the Vatican, A returned to Cluj."

Once we have extracted identity, time, and concept information through linguistic analysis and classifier techniques, we perform factor analysis on it, including hidden-variable and Fisher analysis to discover relations and correlations. To the largest extent possible, the statistics as well as the models are based on actual, measured factors from the textual data. In other cases, such factors must be inferred, and we will be explicit about the inferences used.

Formal Concept Analysis (FCA) and Concept Mapping. To investigate the spread of ideas, official political and ideological positioning, trace concepts and identify the creation of meaning in cultural and political journals, periodical and newspapers printed in the heterogeneous languages of both the central and the liminal areas, we intend to apply **formal concept analysis** (FCA) and build **concept maps** that are best suited to organize and represent knowledge [23], [27], [3]. FCA allows for conceptual knowledge representation and data analysis [14], [2]. Through this research method, we can discover how concepts were used, interpreted and how they circulated in periodicals and other printed material. A simple example from our ongoing research in Transylvania will illustrate this point. In our study of the Hungarian, Romanian and German press attitudes towards other ethnic groups in interbellum Cluj-Napoca, a multi-ethnic and multi-denominational city in Transylvania, we selected a set of objects–the periodicals, and a set of attributes-the terms that relate to concepts. These terms were extracted from the cultural and political periodicals published in Cluj-Napoca between 1919 and 1937. The initial results identified publications that were regularly promoting conflict between ethnic groups; they also pointed to the development, usage and distribution of related divisive concepts in the journalistic landscape of the interwar Cluj-Napoca and Transylvania in general.

In turn, we are using **concept mapping** [36], based on written documents from selected historical periods within the geographical areas under study. It is our hypothesis that the various interactions between conceptual clusters in those documents will emulate the interactions of the actual human communities in the corresponding historical settings. We intend, moreover, to represent the texts as networks. This allows us to discover the most important concepts, identify communities of interrelated ideas, the generation of meaning, and the clusters of meaning circulation. Also, we organize our texts in groups following the initial results based on similarities between the authors and their work and identify the connection points and related concepts among the groups. We can even identify a "mind set," if we assume that individuals are influenced by the texts they read, through which they form a "mental model." This model could be represented as a graph and could reveal the "emotional state and action" associated with it [29].

Author Co-Citation Analysis. Another bibliometric technique we are using is **author co-citation analysis** (ACA). This technique is employed today to map the intellectual structure, major trends, and general development of a research field. It also suggests which authors are central or peripheral to a field of study and how their relative positions may change over time [36] [43] [42]. For our purpose, ACA has considerable potential. For example, we have applied this research method to analyse

the co-citation relationship of scholarly books published between 1800 and 1918 in two cities from Banat and Transylvania. The books were in Romanian, German and Hungarian, the three main languages present in the two cities during that period. In order to visualize the citation relationships, we used NodeXL, a Microsoft Excel template developed by Microsoft Research to study social networks, and VOSviewer, a software for building maps based on network data. The visualized data revealed 256 nodes or connection points between the authors who published in the two cities during that period. The results showed that there was a significant interaction between scholars of the three ethnic groups in the two regions, and it also revealed who were the most influential authors, in terms of citations received. Their works can be seen as bridges linking the three communities, because all of them were familiar with each other's languages and intellectual positions. One could further refine the research by analysing the content of the citations (favourable or unfavourable) and the frequency of the citations in relation to the author's ethnicity. Thus, the German scholars were most frequently (and most favourably) cited by both Romanian and Hungarian authors, while Romanian authors were the least cited by the other two ethnic groups.

Information epidemics and contagion. We also employ methods of analysing "information epidemics and contagion" among the various ethnic groups. These methods study the generation, spread, and containment of information on the pathogenic pattern of contagious diseases. Several models are available, including SIRS and SIR [26] [28]. SIRS assumes that a group or community is "susceptible" (S) to a certain idea, belief, or ideology, becomes "infected" (I) with it and, then, after a refractory process (R), becomes susceptible again. In turn, SIR assumes that once a certain susceptible group was (I) infected, the same group cannot be infected again with the same ideology. Thus (R) stands for "removed".

In discussing the SIR model, Newman [26] notes that "refractory" and "recovered" have the same meaning: in medical terms when an individual becomes recovered, thus immune to further contamination, he is also refractory. In SIRS, however, "refractory" (R) is an intermediate stage before the group returns to being "susceptible," while in SIR "removed" (R) presumes that the same group cannot be infected again with the same "disease." The mass phenomenon of German National Socialism is a case in point. For complex historical reasons, Germany was susceptible to this ideology and became "infected" with it; the infection was later "removed," and it is now inconceivable that a National Socialist Party would rule Germany again in the 21^{st} century. In the case of our project, these models can be used to investigate the role and influence of political elites within a certain group or community, or to study the official ideology concerning intercultural relations (as manifested in political speeches, official newspapers, popular literature, autobiographies and memoirs of state officials) in the central zone and its level of propagation and success in the liminal zones, as well as the intensity of the feedback loops between margin and center. They can also be useful in large-scale news analysis.

Large-Scale Textual Analysis and the Quantum Relations Principle (QRP). For computer-based, large-scale textual analysis of intercultural discourse, including

textual news analysis in real time on the Internet, we are using a new technological platform that is an advanced AI application, able to process extremely large amounts of data in order to model human thought in all its diversity, including its almost infinite number of socio-cultural and intercultural contexts. This platform is based on what Hardy F. Schloer – one of its creators and a member of our team – calls the Quantum Relations Principle or Quantum Relations (QR) for short.

As its name indicates, Quantum Relations starts from the basic insights of quantum physics. At the same time, however, it argues that these insights should apply not only to the physical world, but to the human world as well. In this sense, QR is both a critique and an extension of the principles of quantum mechanics and of the theory of relativity. Although these theories recognize that the presence of the observer modifies the nature of the phenomena observed, they do not act upon this recognition in a radical and consistent manner. Moreover, QR incorporates the insights of general systems theory, as well as those of Whitehead's philosophy of process. Just like systems theory and Whitehead's process ontology, QR moves away from the Western classical ontological premise of the independent existence of a knowing subject and a knowable object. It postulates that nothing exists independently in our universe and that reality arises primarily not as objects and entities, but as dynamic networks of relations among such objects and entities, which are in a state of continuous flux. Everything arises contingent on conditions or events (understood in both a physical and a mental sense). Things do not possess an unchanging, abiding essence. They arise co-dependently, so that reality can be described only in terms of relations among objects, entities, and self-organizing systems, nestled within each other and within our universe. In turn, our universe is nestled within larger universes or relational frameworks.

QR subscribes to the assumption of general systems theory that our universe is a web of interrelated systems that mutually affect each other when they interact. QR is a theoretical account of the ways in which such systems interact (and not of the way systems "are"). If different systems present different accounts of the same sequence of events, then each description of reality can be understood only as relative to a particular system. A system can have a reciprocal relationship with another system, but any description of reality by one system is "interaction-dependent" and can only be viewed through the relationships that arise between the "observer" system and the "observed" system at any given moment. If this relational process applies equally to all systems in our universe, then it should also apply to any possible description of the human mind. We can thus describe mind or "consciousness" by the same relational processes that we use to describe physical and other systems.

QR acknowledges the inherent unity of the body/mind through the complex networks of relations that emerge among its components. This holistic viewpoint is essential in describing consciousness in its full subtlety and in exploring its complementary relationship with the physical world. At the same time, QR acknowledges that the conventional notion of causality, defined as a linear, local and physical relation, is inadequate for describing the complementarity of mind and body. QR replaces this conventional notion with the nonlinear and nonlocal concept of mutual causality, thus providing a much more complex, qualitative account of the reciprocal relations

among the systemic networks that our minds and bodies constitute.

According to QR, a human mind forms quantum relations with other systems and builds an internalized universe (state-space) composed by these relationships. QR defines a "quantum relation" as the relationship or interaction that arises between an observing system (*System S*) and the observed system (*System O*), involving a mutual exchange, transfer, or conversion of small, discrete units of energy or any other quantum between the two. QR further assumes that a human mind is a network of associations between "quantum instances." A quantum instance is a discrete unit of reality as perceived or imagined by a human mind. It also refers to a family of properties that describe one or more mental states. Quantum instances may include individual thoughts, ideas, emotions, sensations, perceptions, dreams, images or any other category that pertains to a mind's conception or description of physical/mental phenomena. One should, however, not attribute absolute reality to any single mental quantum instance, because, according to QR, the only reality constitutive of a human mind resides in the relations that arise between quantum instances, and not in the quantum instances themselves.

In QR, as in quantum mechanics, all information about the internal relations among quanta is embodied in the mathematical relations between the vectors and operators that represent them, just as the information about the relations between locations in a city is contained in the spatial relations between the points that represent them on a map. The only difference between QR and quantum mechanics in this respect is that states and quanta in quantum relations represent mental/physical systems or subsystems, instead of merely physical systems or subsystems, and that the network of relations among their members reveals an individual mind's perception of reality.

QR revolves around two fundamental concepts that can equally be translated into the mathematical language of quantum mechanics and constitute the cornerstones of any technology platform based on QR principles. These concepts are "frames of reference" (FORs) and "data fusion objects" (DFOs). They are described in some detail in Hardy Schloer's essay included in the present collection. Here I would like to emphasize that FORs, in Quantum Relations, are special vectors in a normalized state-space, representing mental states at a given moment. FORs also form coordinate spaces, where each possible state of the mental system corresponds to a point in the space, and each point in the space corresponds to a possible state of the system. The associations between the mathematical objects that represent FOR spaces reveal the quantum relations that arise between them. For example, a given FOR with x quantum relations between quantum instances can show the way in which an individual perceives a certain object or observes its properties. Vectors can graph such quantum relations, while the distances between points in a coordinate space can reveal information like degrees of attraction and repulsion, of truth and falsehood, of real and imaginary, or any other metric that defines relational behaviour.

In turn, data fusion objects or DFOs can be defined, metaphorically, as mental elementary particles. These particles interact according to well-defined rules, and the result of their interaction can equally become a computed function. DFO particles arise within multiple FORs. Each FOR can be represented as a metric space, i.e., as

a set of DFO elements, with one or more functions. Furthermore, a FOR can also be a DFO and vice versa, depending on their respective positions in the hierarchic space structure. Thus, a DFO can be an elementary particle in a higher-level FOR. In turn, this FOR can be a DFO of another, higher-level FOR structure, and so forth.

What are the technical advantages of implementing the DFO/FOR model? To begin with, this model is self-adaptable and will automatically search for the best method and the shortest path to accomplish its goal. Since the metric distance between a DFO and FOR is stored as a property of the FOR, one can easily change metrics. A metric change is the equivalent of asking for a different interpretation of the underlying data. Because metric distances between DFOs/ FORs are implemented in a hierarchic fashion, one can easily change perspective on an entire data set. Because DFOs implement class inheritance, such changes might ripple down through various levels of sub-DFOs, triggering recomputation of intermediate results in a controlled and natural fashion.

Even more importantly, the DFO/FOR model is capable of self-organization, because data and functions are implemented as sets of hierarchic objects. For example, if the metric of a FOR is differentiable over the set, data in that set can be concentrated by finding the minimum of the differential, just as in the case of physical models. A FOR containing many DFO structures can also contain rules for, among other things, the creation of new DFOs; the interaction between its DFOs; and the calculation of functions between smaller DFOs, including the creation of new objects that embody certain relationships between these smaller DFOs.

DFOs and FORs are based on a complex network of parallel relationships. These relationships can be expressed as positive (attraction) or negative (repulsion). The interaction between two DFOs can include changing properties of the mental particles themselves, much as, in a physical system, an attraction is a function of space that operates to change the position of objects. A reasonable FOR can implement certain rules of symmetry and conservation among its DFO objects. In this way, the model uses mathematical and physical methods to create a framework within which large-scale computations can be performed.

Thus, DFOs and FORs provide a natural model for general parallel computation. Since DFOs and FORs are discrete objects, they can be implemented on multiple processor systems, and calculations can be performed in parallel. The DFO/FOR model is not bound to the theoretical requirement that either the metric or other functions provided by a frame of reference be Turing computable functions. Any function that can take one or more data structures as arguments can be implemented within the DFO/FOR model. Therefore, this model can also provide conceptual methods for implementing quantum computing, as soon as hardware becomes available for such applications. On the other hand, it can equally simulate non-local functions, such as are found in quantum mechanics, and implement them on a Turing-Church type of processor (digital computer).

Furthermore, the DFO/FOR model is both modular and extensible. This means that a set of computations on one data set can be transformed into another data set and used by the second data set to define a set of new functions, translating the preceding FOR into the new one. In addition, a FOR can contain rules for logical

inference and deduction that operate on its component DFO objects. The fact that FORs are also considered DFOs for higher-level frames allows lower-level frames to define data properties. DFOs could equally be used to pose queries on other DFO frames. This means that both the query DFO and the answer DFO would exist within the same FOR structure until a computation would achieve the goal of relating them. In this manner, the DFO/FOR model can implement AI functional and rule-based languages such as Prolog in order to solve real-world and hypothetical problems. It can also translate and incorporate any software program or computer language into its database, thus solving the currently intractable problem of systemic compatibility and interchangeability in computer programming.

Finally, the DFO/FOR model is compact and adaptable, expressly designed to handle extremely large quantities of data, on the scale of gigabit and terabit sets, and to provide methods for manipulating them through parallel processing systems. DFO/FOR structures can be compiled, i.e., translated from a symbolic form into a compact set of machine instructions and can also run continuous restrictions on data in order to prevent database errors. The DFO/FOR model can handle data storage, recuperation, and processing with great flexibility and practically no data loss. It assumes that no piece of information or knowledge from its database can ever become obsolete, because it may always turn out to be relevant in a different DFO/FOR configuration, or coherence, or correlation between data sets.

QRP provides an excellent theoretical basis for developing advanced technological platforms for the kind of intercultural project that we are currently engaged in. In my book on *Global Intelligence and Human Development*, I discuss at length the theoretical advantages of general systems theory and its offshoots, the theories of complexity and self-organization, over their scientific, reductionist counterparts, especially within a global reference frame. I have also pointed out the close similarity between the nonlinear view of reciprocal or mutual causality in these theories and that of early Buddhism and Taoism[1]. QR obviously shares the same theoretical advantages. The DFO/FOR model is based on the "web of life" in its most diverse and complex aspects, including human relations and interactions [4] [5]. Unlike most reductionist scientific theories, QR implicitly acknowledges diversity and alterity as the very conditions of existence. Whereas the reductionist theoretical models perpetuate the globalist pretensions of mainstream Western science, attempting to impose its dualistic, Cartesian perspective on all cultures in the guise of objective, universal knowledge, QR can take into account and process widely different cognitive perspectives, including linguistic, philosophical, cultural, sexual, ethnic, and other observer-dependent variables. Like other contemporary strands of systems theory, QR acknowledges that hierarchies as modes of organization are best understood not as "centers of command and control," but as reference frames or levels of complexity embedded or nestled within each other and engaged in constant communication and mutual interaction. QR thus supports and enhances a cooperative, symbiotic view of our universe, in which all living and nonliving components of the global system and subsystems depend on each other for their well-being and in which each perspective needs to be acknowledged and respected

[1] See especially Chapter 4 in [33]

as potentially valuable for the common good.

In line with the Quantum Relations Principle, we place our intercultural data in a comparative perspective, but only after we generate it from the local viewpoint of each culture or subculture, whether large or small, and not from the so-called "objective" and "universally valid" perspective of current Western mainstream social science. This methodology, we hope, will go a long way toward creating the kind of credible social science needed in our global, intercultural environment.

The QRP-based technology is perfectly compatible with and can integrate any other parallel computing method such as:

Fisher Analysis: A remarkably fruitful approach in socio-historical theory is Fisher Analysis [11]. This approach is based on the assumption that social groups with coherent cultures function as coherent bodies and that such groups change because of internal forces and interactions. Sorokin (referenced in [11], Chapter 9) points out that the groups' properties have a discernible and logical structure, which he calls phenomenal manifestations'. In turn, Yolles, Frieden and Kemp propose in 2008 [40] an information-based theoretical model that incorporates these ideas, with applications to political power and dominance, as well as to intercultural relations and change. For many aspects of our proposed research, including modeling of multicultural population growth and decline, such models appear well suited.

Fuzzy cognitive maps (FCM): Designed particularly for social models such as ours, the method uses Zadeh's fuzzy logic [41] to provide mathematical models of the network links starting from linguistic expressions (rules) aggregated by teams of experts. Rules such as IF (*intolerance* is large) AND (*hunger* is large) THEN (*violent actions* are many) rely on attributes from a finite set of some observable, numerical states that are associated with state variables in the model (e.g. intolerance, hunger). So far, most of the FCM models are dynamic systems converging towards an equilibrium state [1], but more accurate dynamic FCM models have also been introduced [25].

Cellular nonlinear networks and "small-worlds" models: Based on the early work of von Neumann and Ulam (1947), who demonstrated that self-reproducing in artificial systems is possible, the cellular automata model was later extended into a more general network model called a "cellular nonlinear network" [7]. Particular for this model is the *local connectivity*, which dramatically reduces the number of links when compared to the more general model. Surprisingly, such a network model is widely found in nature (and society) and consequently it is of much benefit in reducing the computational load that is otherwise needed in a fully connected model. A further tuning of the topology of the cellular model is called a "small worlds" model [37] [8]. It is essentially a cellular model where a fraction of all links are moved from the local neighbourhood to a "distant position" in the grid. Many recent studies confirm that small-world models are perfectly suited for modeling various natural systems including social ones [31]. Another distinct feature of the cellular and small-world models is cell "cloning,"

i.e. all cells in the system are often identical, with their genes cloned from one to another. This assumption often holds in practice and it allows to reduce the genome of the entire system (otherwise a huge one, formed by concatenation of all n different genes) to a manageable one, making it more easy to apply various optimization methods. Such a simplified genome allows the application of the newly developed *design for emergence* methods [9]. These are in fact guided search methods into the gene parameter space, ensuring fast location of genes associated with a global desired behaviour (which may resemble the behaviour of the observed real social system). We expect that *design for emergence* methods, which we shall apply for the first time in the context of social modeling, will bring novel insights, with a great potential of ensuring a fast and efficient knowledge transfer into our mathematical model.

Particle Swarm Optimization (PSO): This is an optimization method from the emerging field of *swarm intelligence* [22], which essentially began in 1995 with proposing a network model for a "society" of agents. It explores a certain parameter space (gene space) of an objective function to be optimized. Each agent calculates its personal fitness (objective function) based on its actual "position" (where the position in space is given by the vector of parameters or gene) and *cooperates* with other agents (it may be linked to them in either fully connected or more local topology), trying to adjust its position in order to maximize its fitness. To this end, the "speed of moving" in the parameter space is calculated based on three terms: An inertial term (tendency to keep its own direction), a global term (it orients the agent toward the position of the agent with the best fitness) and a personal term (it orients the agent toward its personal best position in the past). The method was successfully applied to solve a large variety of hard optimization problems, and compared to the genetic algorithm has the advantage of simplicity (the speed update rules are extremely simple) and regularity, which makes it easily run in parallel computing environments. The parameters can be used directly as numbers without the kind of coding scheme that is required in genetic and evolutionary algorithms.

Moreover, in the context of this project, we expect that new results will emerge where our social models can be used as basis for building swarm intelligence algorithms with enhanced properties (to be further applied to various optimization problems). This method has been successful in many areas where there is great uncertainty regarding the proper form of the models to be used, including the domains of finance, medicine, and scheduling. The "success" of the individual model will be determined by its agreement with the overall statistical model and by its prediction of reasonable probabilities for discrete events of historical conflict and non-conflict in the two borderlands under study.

Technological Feasibility. For this project we are partnering with SCG (`www.schloerconsulting.com`), a company based in France (Nice) and Spain (Marbella), which has significant expertise in performing large-scale textual analyses. In addition, SCG has extensive experience in parallel computing, as well as in the storage,

search, and organization of large-scale text databases of the kind that we are using in this project. SCG helps us with our system design, data collection, conversion of textual materials to XML structured documents (including linguistic processing in multiple languages), classification, tagging and indexing of such documents, and the design of a database that can be used by our computer models in a streamlined and time-efficient manner.

Current computing hardware is sufficient to build and run our models of intercultural relations. Five years ago, social interaction modeling of this kind would be, as a practical matter, impossible to any but the best-financed government researchers. Today, both hardware and software tools capable of these levels of performance are readily available, and we intend to make full use of them. For example, a commonly available NVIDIA S2070 server has 4×448 processors (CPUs) running at 1.15 GHz, which has a peak performance of 2 teraflops (thousands of billions of computations per second). Several such processors can be combined on one computer, so that 1 000 factor interactions of a test population of 10 000 agents can be executed at tens of thousands of such interactions per second. As a guideline, there are 1 440 minutes in a day, so that a day of interaction of these 10 000 agents would execute in less than 1/20th of a second, or a year's worth, in 60 minutes.

Anticipated Results of our Research. At a minimum, a very significant and useful product of our research will be an enormous digital database of theories and facts about the regions studied, including their intercultural dynamics. We shall put this database online and make it publicly available to researchers, practitioners, and policy-makers concerned with intercultural issues. The project will, moreover, open the way to and inspire new types of intercultural research projects at the interface of the social sciences, humanities, and information technology.

During the course of this project, we shall "teach" our computer models about human culture and about human conflict and cooperation, and the continuous formation and dissolution of humans into various groups. We anticipate that our models will, in turn, teach us something about the same subjects. Unlike human beings, computers start their lives as "blank slates" We shall have to write upon those slates, to the extent that we are capable, the initial axioms and methods that we believe we understand about intercultural contact. Therefore, our project will involve four areas of scientific activity:

1. producing cross-disciplinary scholarly research on intercultural contact that is archival and historical, concerning Banat and Transylvania from 1800 to the present;

2. collecting data related to intercultural relations from selected archival documents, books, journals, magazines, newspapers and, for the contemporary period, textual communications from the Internet;

3. generating the computer models and methods of representation of intercultural conflict and harmony, on the basis of our historical and archival research and data collection;

4. exploring the complex, present-day factors involved in successful (and unsuccessful) intercultural dialogue, negotiation, mediation and conflict resolution within and outside the regions under study – in addition to rational and cultural factors, we shall focus on the dynamics of individual and group emotions, on which the success of intercultural contact often depends, as well as on the practical key factors that would facilitate peaceful resolution of regional conflicts.

Benefits of our research. We believe that our project will be beneficial to the scientific community and to the public and private sectors in at least three substantial ways:

1. Our data collection and organization (which will also update and integrate similar data collected in the past), together with their publication in a form easily accessible to other researchers, will be of significant value to political scientists, sociologists, intercultural psychologists, cultural and literary historians, cultural anthropologists and transdisciplinary researchers in regional and global studies;

2. Unlike many prior scholarly studies in this field, we shall build computational models of how factors in the data develop and interact. We believe that such computer-based models can substantially further basic research in the social sciences and the humanities. They could also be useful in any field of human activity where in-depth analysis of intercultural relations are essential, such as regional and global politics, international commerce, international law, diplomacy, and interfaith initiatives.

3. Finally, the research will pinpoint areas of public discourse in which one can find identifiable patterns (rather than chaotic randomness) as drivers of intercultural harmony and conflict; consequently, it will help design informed public policies and civic initiatives to either stimulate or inhibit such drivers in Central Europe and the European Union in general.

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