Artificial Intelligence and International Politics Gaming

By Charles L. Mitchell
Grambling State University

Prepared for delivery at the 20th World Congress of the International Political Science Association, Fukuoka, Japan, June 13, 2006, Fukuoka International Congress Center
Attempts to evaluate the international situation have for some time appreciated the potential of international politics games for improving perceptions of political reality. Usually in the past, international politics games resembled ordinary board games with persons representing various international entities contending as adversaries. In a few situations, international politics games were developed that involved substantial amounts of role-playing among the protagonists. Whether the international politics game situation was game board oriented or based on role-playing instructions and simulations, the technique encouraged developing one's imagination about the difficulties of the international entity being played.

In recent years, information technology has entered the field of international politics gaming and made some major contributions. The most successful international politics games at present are concerned with the personalities of political adversaries. An excellent international politics game could define personality in several variables including concepts like aggressiveness, nastiness, and paranoia. Computer programs allow the international politics gamer to vary personalities by ascribing a different numerical value to each of these variables. In this way, an infinite number of different personalities can be created. Repeated trials allow the international politics gamer to observe which personalities most successfully contend. The human personality may compete with six or more artificial intelligence personalities. International politics games allow the human adversary to evaluate his strengths against the numerous artificial intelligence personalities with which he competes.

Discussing international politics games in terms of three variables is only to indicate the direction these type games are developing. The number of variables for each artificial intelligence personality is likely to increase substantially. As the number of variables associated with each artificial intelligence personality increases, the ability of the international politics game to replicate the rationalism of real-world political actors increases. Following the stratagems and responses of international political actors appears to have remarkable potential for better perceiving conflicts among international political personalities.

This paper intends to look at the interplay between developments in artificial intelligence and international politics gaming. A thesis of the paper is that artificial intelligence has profound significance for perceiving international politics problems. Improved comprehension of AI is thought to be a substantial improvement in the international relations theorist’s abilities.
Artificial intelligence is becoming increasingly common with the pervasiveness of IT. As desktop computers are increasingly yielding to the sophistication of mobile communications, IT has properly become ICT as information and communications technologies merge and become overlapped. For artificial intelligence these developments have profound significance as mobile communications devices are increasingly artificial intelligence oriented. One cannot evaluate present ICT without some awareness of the pervasiveness of artificial intelligence techniques.

The ubiquitous technique of artificial intelligence is likely to quickly advance, and new developments in international politics gaming can be anticipated. The sophistication of present attempts to appreciate the international situation with international politics gaming and artificial intelligence is likely to dazzle in the years ahead. This paper considers theoretically what artificial intelligence can contribute to international politics gaming. From this discussion the reader is likely to become more perceptive of how international politics gaming in the future may contribute to international realities.

International relations theories have developed in complexity as if following more sophisticated artificial intelligence capabilities. Literature about formal model building in international relations has recently included analysis of international politics that invites the imagination of artificial intelligence. One cannot read the recent literature in formal model building and international relations without believing that future model building developments are very likely to be shaped substantially by the capabilities of artificial intelligence.

International relations theory that combines formal model building with developments in artificial intelligence can be anticipated to produce some superb theoretical developments. The international politics game, *Conquest*, that allows the creation of different player personalities by manipulating the variables of aggressiveness, nastiness, and paranoia persuades that international relations theory can use artificial intelligence in formal model building. Altering search algorithms to affect the aggressiveness, nastiness, or paranoia of computer opponents may appear elemental in theory building, but the use of these and similar variables can be an astoundingly positive influence in international relations model building.

IT experts who believe developments in ICT are substantially shaping global culture, at present, are probably encouraged by how readily the literature in international relations is analyzable with AI concepts. One could claim that the pervasive influence of IT developments is shaping international relations theory. Not surprisingly, international relations theory is yielding to the same IT forces shaping global culture.

The possibility that the conceptual influence is the other direction from international relations theory to artificial intelligence is implausible. However respected contemporary
international relations theories are, one cannot imagine that they are accomplishing conceptual developments in artificial intelligence. When one considers international relations theory backward to Carl von Clausewitz there is surprise at how in the present day artificial intelligence concepts may be leading developments in internationally relations theory. Imagine that the well established field of international relations models could be explained as now subsidiary to conceptual developments in artificial intelligence.

**Artificial Intelligence's Development**

Artificial intelligence refers to the use of information technology to replicate the intelligence functions of human beings. For several decades, artificial intelligence has been producing increasingly sophisticated computer designs to mimic human intelligent behavior. The ability of computers to imitate human thought processes and rational actions have made significant strides. The potential for IT to accomplish astounding results in equaling and surpassing human mental capabilities has become recognized.

As artificial intelligence studies have become more complex, the theoretical significance of the concepts being developed has increased. Human cognitive processes are better understood because of work done in artificial intelligence. The increasing differentiation of ideas about intellectual activities and capacities is reorienting conceptual reasoning in numerous fields. Artificial intelligence studies define and elaborate how reasoning occurs. Other academic fields benefit from the completeness of artificial intelligence's definitions. AI’s ability to quickly enumerate more properties of reasoning than were previously readily perceived continues to improve. The result is a diffusion of theoretical reasoning about how things happen that substantially improves concepts and theory building in other areas of knowledge.

The history of artificial intelligence is often discussed as following an influential paper on the subject published by British mathematician Alan Turing in 1950. Turing's article titled "Computing Machinery and Intelligence" devised a famous test for deciding if a computer was capable of artificial intelligence. The procedure Alan Turing discussed in his famous article became known as the Turing Test.

To qualify as artificial intelligence using the Turing Test, a computer was required to perform indistinguishably from a human subject. A person Turing called the interrogator was connected to both a computer and a human subject. The interrogator then questioned both the computer and the human subject attempting to determine with certainty which was which. If the computer being tested could successfully conceal being a computer from the interrogator, Turing allowed that artificial intelligence had been developed (Luger, 2005, pp. 13-15).
From this beginning, artificial intelligence has increased in sophistication. The contemporary definition of artificial intelligence provided by George F. Luger is that artificial intelligence "is the study the mechanisms underlying intelligent behavior through the construction and evaluation of artifacts designed to enact those mechanisms." The present day definition of artificial intelligence is less theoretical oriented than the original definition and more committed to devising empirical methodology for constructing and testing artificial intelligence models. The new definition emphasizes a belief that artificial intelligence studies will develop as researchers design, run, and evaluate experiments that intend to refine existing models of artificial intelligence (Luger, 2005, p. 825).

The contemporary definition of artificial intelligence is substantially influenced by cooperation between the cognitive sciences and AI. A five step methodology for devising computer models of human problem solving contributes to the current definition of AI. This methodology emphasizes a process of refinement by which successive research improves upon earlier efforts. The steps in this computer modeling research process are as follows:

1. Based on data from a human solving particular classes of problems, design a representational scheme and related search strategy for solving the problem.
2. Run the computer-based model to produce a trace of its solution behavior.
3. Observe human subjects behavior on these same problems and keep track of measurable parameters of their solution process such as those found in think aloud protocols, eye movements, and written partial results.
4. Analyze and compare the human and computer solutions.
5. Revise the computer model for the next round of tests and comparisons with the human subjects (Luger, 2005, p. 839).

This method for further developing artificial intelligence convinces that AI has a powerful perspective on building concepts and theory. The near definitional commitment AI has made to developing ideas and then refining them with successive experiments is likely to produce some very satisfactory results. The explanation for why artificial intelligence is influencing modeling in international relations can be found in this methodology. AI has benefited from the commitment to refine ideas with successive experiments. This technique has produced concepts that are better elaborated, more delineated, and more thoroughly enumerated in comparison to similar ideas produced in other areas of knowledge.

**Expert Systems**
Another technique for explaining artificial intelligence is to discuss intelligent computing in terms of expert systems. An expert system is a computer system that emulates the decision-making of human experts. In this definition, the term "emulate" means "the expert system is intended to act in all respects like a human expert." An emulation is a stronger process than a simulation which need not do more than act like the real thing in some respects (Giarratano and Riley, 2005, p. 5).

Figure One presents the basic concept of the knowledge based expert system. At the most basic level, the expert system has two elements, the knowledge base and the inference engine. Expert system users query the system and receives expert advice. In almost all instances, expert systems are designed with knowledge about one problem domain. Presented with a problem, the expert system reasons and produces advice in the same manner a human expert would.

Several advantages of expert systems have encouraged their development in many fields. Wherever there is a need for an increased availability of knowledge at reduced costs, reduced danger, improved performance, increased reliability, and faster response an expert systems has been developed. Expert systems are usually designed so as to produce the following results:

1. High-performance. The expert system must respond more effectively than a human expert.
2. Adequate response time. Answers must be attainable from expert systems as quickly or more quickly than from human experts. In some situations, expert systems can be asked to produce extremely reliable answers, quickly. Emergency oriented expert systems are required to analyze a situation and
produce fast responses.

3. Good reliability. Expert systems must provide effective answers and not have problems crashing when needed.

4. Understandable. The results obtained from expert systems need be comprehensible and useful to those who access the expert system (Giarratano and Riley, 2005, p. 12).

Heuristics are used by artificial intelligence to accomplished these objectives. Heuristics are a technique for guiding search, manipulating constraints and evaluating different solutions at the object level. There are many interested techniques including genetic algorithms "which simulate an evolution search for gradually improved methods." Heuristics guess a solution and then use deduction to verify its correctness (Sowa, 2000, p. 245).

In devising artificial intelligence, heuristics are used to find the most promising steps in resolving a question. Heuristics could be called insight and are a useful technique for reducing the amount of brute force computations required (Sowa, 2000, p. 541). The heuristics that emerge from this methodological rule observe human problem solving and emulate human techniques. Because of the computational cost of analyzing all alternatives possible on the basis of probability, humans choose likely alternatives from experience and then deductively calculate their likely success. Heuristics and then deductive calculation technique substantially reduces resources expended at various steps in the problem solving process.

Computer games are famous for their use of heuristics. Because of their size and complexity, games can generate extremely large search spaces requiring substantial computer resources. Games could potentially expend most of the computer's memory space resources. Powerful techniques are required for the successful game to determine which alternatives to explore in the problem solving memory space. These techniques are called heuristics. Luger analogizes this computer use of heuristics to "the heuristics used by human to solve problems." (Luger, 2005, p. 21)."

In simple game situations, people are explained as testing their familiar game playing heuristics again how the computer's heuristics solve game problems. Heuristics algorithms can become complicated because of the existence of hostile and essentially unpredictable opponents. Games "provides an interesting opportunities for developing heuristics, as well as greater difficulties in developing search algorithms (Luger, 2005, p. 150)." Heuristics may or may not provide the needed algorithms in game situations. Luger qualifies that, like all rules of discovery and invention, heuristics are fallible. Based on experience or intuition, heuristics are only an informed guess of the next step to be taken in solving a problem. Based as they are on knowledge of a present situation or descriptions of states currently on the open list, heuristics can seldom predict the problem solving space farther along in the search (Luger, 2005, p. 124).
The heuristics and design of algorithms to implement heuristic search "have long been a core concern of artificial intelligence." Consider heuristics analogous to "the rule of thumb" that human experts use to solve problems. Experts systems research has affirmed the importance of heuristics, and expert systems designers "extract and formalize" heuristics when they design expert systems (Luger, 2005, p. 124).

When IBM designed their famous Big Blue Computer, the computer that could defeat all human chess opponents, they used problem recognition techniques. Instead of calculating the probability of all prospective chess moves, Big Blue was programmed to recognize patterns that appear on the chessboard. The human chess player is estimated to recognize something like 50,000 patterns on the chessboard. Big Blue was similarly programmed and no technique was used to reason ahead 50 to 100 possible moves (Giarratano and Riley, 2005, pp. 17-18). Big Blue achieved the success it attained against human opponents by emulating human heuristics in playing chess.

Figure Two presents a more complex perspective on an expert system and include many of the ideas from the above discussion. The expert system described in Figure Two includes the following components:

- **user interface**--the mechanism by which user and expert system communicated.
- **explanation facility**-- explains the reasoning of the system to user.
- **working memory**-- a global database of facts used by the rules.
- **inference engine**-- makes inferences by deciding which rules are satisfied by facts or objects, prioritize the satisfied rules, and executes the rule with the highest priority.
- **agenda**-- a prioritized list of rules created by the inference engine, whose patterns are satisfied by facts or objects in working memory.
- **knowledge acquisition facility**-- an automatic way for the user to enter knowledge in this system rather than by having the knowledge engineer explicitly code the knowledge (Giarratano and Riley, 2005, p. 28).

The preceding discussion about heuristics and algorithms is primarily about the inference engine. The type of search technique used to move the search space is determined by the inference engine. The sophistication used in designing the inference engine distinguishes different expert systems from each other. Inference engines make decisions about whether the next move in a search process can be decided with a heuristics technique. When heuristics techniques are used, a backward chaining occurs in which the inference engine
checks the proposed move deductively through the working memory. Alternatively, search algorithms may follow forward chaining procedures searching through all the available data to determine the next search move (Giarratano and Riley, 2005, p. 31).

Figure Two, also, presents two other basic paradigm of artificial intelligence, representational knowledge and emergent knowledge. The original AI paradigm was representational knowledge. The belief was that if somehow the universe could be effectively represented within the computer, then techniques for solving any type of problem could be devised. A very substantial amount of efforts directed at representing knowledge effectively to the computer occurred. Emergent knowledge refers to the learning capability that can be programmed into a computer. The emergent knowledge facility of a computer determines how the machine can learn about the world (Ein-Dor, 1999, p. 121). In Figure Two, representational knowledge comprises the knowledge base and working memory. The knowledge acquisition facility found in Figure Two is conceptually the computer's emergent knowledge.

**Knowledge Representation**

The relationship between knowledge representation and the inference engine is well rooted in philosophical traditions. Consider Immanuel Kant's discussion of knowledge. To Kant, knowledge had two collaborating energies emerging from the subject’s reasoning and an a posteriori component originating in active experience. Kant explained that experience is a meaningful only as the subject contributes organizing form to his
cognitive experience. Without the active organizing form, the world as explained by Kant would be nothing more than passing transitory sensations (Luger, 2005, p. 9).

John F. Sowa has explained that knowledge representation is a multidisciplinary subject applying theories and techniques from three other fields. Knowledge representation turns to logic for formal structure and rules of inference. Ontology defines those realities that can exist in the computer's knowledge domain. Computation allows that knowledge be appreciated as representing the real world instead of being philosophical (Sowa, 2000, pp. xi-xii). Semantic and mathematical techniques in computing distinguish the real world from abstracts concepts.

Randall Davis, Howard Schrobe, and Peter Szolovits explained knowledge representation to have five basic principles. These five principles included:

1. A knowledge representation is a surrogate. Reality that cannot be directly stored in a computer is stored there with symbols.

2. A knowledge representation is a set of ontological commitments. Ontology being the study of existence, knowledge, representation creates categories explaining reality.

3. A knowledge representation is a fragmentary theory of intelligent reasoning. Any attempt to represent the reality is a theory about how this can reasonably be accomplished.

4. A knowledge representation is a medium for efficient computation. Encoding into a form that allows efficient computing must occur.

5. A knowledge representation is a medium of human experience. Knowledge experts must verify if the representation is realistic as to the domain being described. (Davis, Schrobe, and Szolovits, 1993)

This typology explains that storing knowledge about the world in the computer requires an excellent sense of combining symbols, logic, and computational techniques. The complexity of creating representative knowledge is nicely presented by these authors.

Another issue that occurs in knowledge representation has led to the development and use of fuzzy logic. Multivalued logic was developed in the 1930's by Polish logician Jan Lukasiewicz. The fuzzy logic that Lukasiewicz developed assumed a continuous range of truth values from 0.0 to 1.0 (Sowa, 2000, pp. 364-65). By establishing truth values over this range, one could distinguish between facts on the basis of how acceptable or true they were. Fuzzy logic allow for introducing observations about the real world of varying degrees of exact factual confirmation.

Lotfi Zadeh contributed fuzzy sets theory to representational techniques for knowledge. Zadeh's theory is valuable in measuring the meaning of information. Fuzzy set theory acknowledges in a quantitative fashion the lack of precision that exists in introducing knowledge to representational techniques. Zadeh explains that there are always differences in how completely facts belong to the sets to which they are assigned.
Figure Three considers "fuzzy membership" for a set of small integers. As expressed in Figures Three: $mF(1) = 1.0$, $mF(2) = 1.0$, $mF(3) = 0.9$, $mF(4) = 0.8$ ........ $mF(50) = 0.001$. This fuzzy logic statement creates set possibilities for integer $X$, a small integer, $mF$ creates a possible distribution across all the positive integers (Luger, 2005, pp. 353-354). Where $mF = 1$, the small integer is completely a member of the set “1.” As the $mF$ value decreases, this indicates membership in the set “1” is to a lesser degree. Each successive small integer shows less membership in set “1.”

Figure Four presents a fuzzy set representation for short, medium, and tall males. Observe how set membership for each of these three groups is determined. As Figure Four presents, a person can be a member of more than one height sets (Luger, 2005, p. 354). By establishing the numerical values between 0.0 and 1.0 that explain set
membership, the extent to which a person belongs to one of these height sets can be specified in knowledge representation. The objective of effectively representing the world is accomplished with more precision because of fuzzy set representations.

Fuzzy logic is not the only possible technique that can be used for representational knowledge. Sowa identifies four techniques in all that are useful in establishing reality in the computer. All of these techniques utilize the principle of continuous range of numbers:

1. **Fuzzy logic** as devised by Zadeh and employed by people like a Ted Shortliffe (1976) with his "certainty factors" from +1.0 to -1.0 for each knowledge elements in his expert system.
2. **Statistics** including traditional statistics and probability theory. Bayesian theory of subjective probability is, also, popular. Human judgment is required for Bayesian statistics, the same as in fuzzy logic.
3. **Neural networks** similarly compute with a continuous range of numbers. The product of learning by experience is stored in computers in neural networks.
4. **Virtual reality** is the fourth possibility using continuous numbers. With advances in computer hardware numerical simulations of the physical environment can be carried out efficiently in great detailed. The results of the simulations or virtual reality are valuable in representational knowledge (Sowa, 2000, p. 365).

**Emergent Knowledge**

The emergent knowledge AI paradigm is found in Figure Two. The knowledge acquisition facility box found on Table Two is where the emergent knowledge paradigm is situated. For many years, the argument was made that the best way to impart intelligence to a computer was to provide the computer with the learning capability, turn the computer loose in the world, and let the machine learn from its experience in the world (Ein-Dor, 1999, p. 121).

Herbert Simon in his book *The Sciences of the Artificial* published in 1981 reasons with the emergent knowledge paradigm in artificial intelligence. Simon observed an ant making a progress circuitously along an even and cluttered stretch of ground. The twists and turns the ant's path took was explained as purposive. Simon concluded that: "An ant, viewed as a behaving system, is quite simple. The apparent complexity of its behavior over time is largely a reflection of the complexity of the environment in which it finds itself."

Were this learning principal applied to human beings, the suggestion would be about the importance of culture in forming intellect. The idea that carries over to AI is that
interaction with individual elements of society produces intelligence. Computers, Simon is telling us, can devise intellect with techniques similar to that used by organisms such as ants and human beings (Luger, 2005, pp. 15-16).

Many different techniques can combine to produce a computer system’s emergent knowledge. A programming paradigm that arose in the 1980's is called artificial neural systems and is based on the way the brain processes information. This paradigm is, also, called "connectionism" because neural models simulate connected neurons. Comprised of a large number of highly interconnected processing elements or neurons, the learning process that takes place in a neural network is called training. The analogies to biological systems extend to imagining learning to involve adjustments of synaptic connections between neurons (Giarratano and Riley, 205, p. 51) The training process in neural networks requires activity in small, interconnected processing elements analogous to synapses.

One final knowledge building technique that coordinates multiple knowledge building or problem-solving agents needs be mentioned. Blackboard architecture improves production systems by organizing production memory into separate modules each of which correspond to different subsets of production rules. Blackboards integrate knowledge produced by vastly different production rules into useful knowledge. Knowledge from diverse sources combine in a single global structure, the blackboard (Luger, 2005, pp. 217). The Blackboard is a technique for synthesizing several different answers to the same problem into the most effective and rational answer possible.

**International Relations Models and International Politics Gaming**

In the development of artificial intelligence, board games have been understood to have inherent intellectual appeal. AI work found that the board games make an ideal situation useful in developing techniques. Most games are played using well-defined sets of rules. Games, thus, generate resources requirements including search and problem solving spaces that alleviates any ambiguity problems researchers might encounter in less structured research problems. Some problems with capturing semantics subtleties of more complex problem domains are avoided. Games can be easily played and tested, and a game playing program presents no financial or ethical burden (Luger, 2005, p. 21).

When contemporary international relations literature is analyzed, the thesis that artificial intelligence is a substantial influence appears proven. Formal model building in international relations organizes global politics realities in systematic ways that reflect the pervasiveness of artificial intelligence concepts and theories in contemporary reasoning. Many formal models of international politics created and analyze variables in situations almost like those devised by board game designers. The international politics reality
created by current international relations models and literature is remarkably amenable to
analysis with artificial intelligence concepts and theories.

The popular international politics game *Conquest* designed by Sean O'Conner exemplifies
combining variables theoretically. *Conquest* allows the human opponent to test his
proficiency against seven computer opponents all having different values for the variables
aggressiveness, nastiness, and paranoia (O'Conner, 2006). Most formal model builders in
international politics would be envious of O'Connor's accomplishments with *Conquest.*
When personality variables about leading international decision makers are of such
interest, how can efforts to model personality differences in international situations not be
appreciated? Not only does this game have theoretical significance in comprehending
personality in politics, the game, also, exemplifies AI's commitment to refining concepts
with successive experimental trials.

Several contemporary discussions of international politics that have recently appeared in
the political science literature can be analyzed in approximately the same manner one
discusses the artificial intelligence board game *Conquest.* The result of such analysis is
convincing that artificial intelligence concepts and theories are gaining prominence well
beyond what is presently adequately appreciated. The analysis that follows intends to
reason about the close similarity that exists between contemporary international relations
model building and artificial intelligence in computer games. Such analysis potentially is
valuable for the international relations theorist as he becomes better connected with the
substantial number of profound conceptual perspectives found in the artificial intelligence
literature.

**Formal Models of International Politics**

Several international politics models can be discussed as possibly augmented with
computer AI techniques. The international politics models this paper analyzes all come
from the recent literature on this subject. Each of the international politics model's
considered here have a design and variables that possibly could be converted to a
computer game that employs artificial intelligence.

The remarkable idea appears to be that artificial intelligence theories and concepts are
adequately sophisticated to accommodate all these models of international politics. Were
some requirement to exist that international relations theorists must transform their theory
into a computer game with artificial intelligence, the results might be a significant
increase in knowledge building. AI research believes in conducting a series of successive
experiments refining AI procedures under development. Were this methodological rule
applied to international relations theory, substantial increases in knowledge building
about concepts and theories probably would occur.
The theoretical perspective of this paper intends to imagine recent international politics models as possible scenarios solvable by AI in international politics gaming. For each international politics model from the literature, imagine the variables AI would use to create an international politics game. In each instance, refer back to the expert systems discussion in the preceding section and ask how sophisticated scenario problems could be represented with artificial intelligence.

The power to hurt model discussed by Branislav L. Slantelev exemplifies a model of international politics that could be made more sophisticated with an artificial intelligence game produced from the same analytic perspective. Slantelev hypothesizes in his model that the determinant variable in international conflict is one state's ability to hurt another. Napoleon's use of economic tactics to hurt British exports and thus adversely affect Britain's ability to pay for wars against him is used as an example of the power to hurt (Slantelev, 2003, p. 131).

Another example that Slantelev uses to exemplify the power to hurt model is the German strategy for securing French surrender in 1940. The German strategy feigned an attack into Belgium attracting French forces. Meanwhile the main German attack occurred through the Ardennes. This strategy destroyed the organizational capacity of the French high command and damaged beyond repair the French ability to inflict substantial losses. The result was that with the power to hurt, the French surrendered in 1940 (Slantelev, 2003, p. 127).

The basic hypothesis is "the capacity to inflict pain on the opponent, determined by the ability to bear costs associated with this effort, influences how much a state can demand in a bargain (Slantelev, 2003, p. 127)." According to Slantelev, when a state no longer has the ability to inflict pain on its opponent, conflict ends. From the perspective of artificial intelligence, an expert system would be needed that could evaluate the capacity of states to hurt one another. When the algorithms could not find a state had any capacity to hurt, a cessation of conflict could be anticipated. When there is no more effective searching for how to hurt the other state, conflict could be said to be resolved.

William Reed ascribed asymmetric information the crucial variable role in his analysis of information, power, and war. Balance of power, to Reed, depends upon the distribution of information. Any condition that upsets accepted information about what would occur in conflict was expected to decreases the stability of the international system. Disagreement exists in this model about whether power parity between states enhances uncertainty about the outcome of a militarized clash. A prevalent belief is that power parity so increases uncertainty that the likelihood of conflict substantially increases (Reed, 2003, p. 634).

The artificial intelligence problem for modeling Reed's theory is substantially a heuristics problem of recognizing situations that likely to lead to conflict. Discussing asymmetric
information and the balance of power is asking for a heuristics approach at guessing when conflict is about to erupt. Were a game developer to accept Reed's suggestion about the role of asymmetric information, heuristics reasoning could lead to more thorough deductive analysis whenever asymmetric information was found to occur in the international system. When the heuristics algorithm detected asymmetric information among opponents, the AI developer could use backward chaining to connect his search strategies to all relevant information needed to evaluate conflict potentials. This deductive reasoning process could validate or not the perception that a conflictual situation is at hand.

A geopolitical model of international system stability is elaborated by Lars-Erik Cederman.

One basis for his geopolitical model is the observation that in early modern Europe there were 500 independent geopolitical units. By 1997, the number of such units had decreased to 20. Territorial expansion, according to Cederman, leads to taxing the captured provinces. The extraction rate that prevails is a function of a strength gradient that falls off quickly the further one moves from the center of a state. Technological change improves the extraction rate allowing more resources to be taken further away the center (Cederman, 2003, 138-139).

These rules create four consequences. First, the number states decreases as the power seeking states absorb their victims. Second, as a consequence of conquest, the surviving actors increase in territorial size. Third, decentralize competition creates emergent boundaries around the composite actors. Fourth, once both sides of a border reach a point at which no one is ready or willing to launch an attack, a local equilibrium materializes. If all borders are characterized by such a balance, a global equilibrium emerges (Cederman, 2003, p. 140).

The Cederman model utilizes a self-organized critically (SOC) model. SOC is "an umbrella term for a slowly driven threshold system that exhibits a series of meta-stable equilibria interrupted by disturbances." A burgeoning literature has recently developed using SOC models for subject as diverse as earthquakes, biological extinction events, epidemics, forest fires, traffic jams, city growth, market fluctuations, firm sizes, and wars (Cederman, 2003, pp. 137).

Appreciating how extraction of resources from expanding territories and technological innovation lead to meta-stable equilibria interrupted by disturbances is the SOC component of the Cederman model. In this geopolitical model states extract resources from their territories and gain in strength. Technology can improve the state’s ability to extract resources from locales distant from the state’s center. Equilibrium prevails until difference along the border with the next geopolitical unit become excessive, then a disturbance or international conflict occurs.
International politics gaming within the Cederman geopolitical model would require artificial intelligence capable of predicting how increasing resource acquisition from extractions from newly acquired territories could build stable equilibria or disturbances. Similarly, extraction successes for adjacent states would need to be exactly calculated. When resource acquisition problems occurred in adjacent states, they would need to be detected. This geopolitics model depends on exact calculations of resource extraction at home and in neighboring states because extraction problems can lead quickly to conflict.

Computer opponents would need be programmed to accommodate changing rates of power build ups in order to anticipate how some resource developments could disrupt the meta-stable equilibria that the evolving international system was building. Whether an artificial intelligence game could programmed to identify the moment system equilibria broke and became disturbance is a difficult question. Could a computer outdistance human appraisal of the likeness of equilibria ending? Whatever combination of techniques the computer opponents used, the IT would have to be adeptly developed so as to succeed in predicting disturbances. Possibly heuristics and probability techniques could be combined to produce artificial intelligence that might surpass human ability to detect this break up in meta-equilibria.

The bargaining model of war is another formal theory that has been purported to have adequate strength to account for conflicts in international politics. Dan Reiter explains, "International politics lends itself well to the bargaining perspective. Usually international politics occurs among a small enough group of actors to make models of pure free-market inappropriate, notably, oligopoly models have been applied to international relations. Conflict in international politics involves using war to improve the bargaining position of the protagonists. Disagreements that lead to conflict are usually over resource allocation or policy choices. As economists adjust price between buyer and seller with bargaining, international conflict resolves terms of settlement among states (Reiter, 2003, p. 27-28).

Another proponent of bargaining theory is James Fearon who emphasized that states disagree over their capabilities and/or resolve in his famous 1995 paper, "Rationalist Explanations for War." Fearon's article typified a wave of post-1995 papers that viewed both the causes and termination of war as part of a bargaining process. This wave of formal bargaining models relaxed the assumption that war is a costly lottery. Bargaining was, also, explained in this group of papers as influencing what takes place during war as well as before and at the conclusion of war (Reiter, 2003, p. 29).

Fearon's bargaining model developed three conditions under which war is possible. First, there must be disagreement between the two sides as to the likely outcome of the war. Complete information would appear to reduce the possibility of states fighting, and yet states still remain reluctant to reveal the capabilities to resolve war to one another. Second, war may occur because of inability to commit not to fight in the future. Surprise
attack may improve conflictual outcomes or anarchy at home may require conflict for better domestic politics. Third, bargaining may not avoid war if the item under dispute is indivisible. When the good at issue is all-or-nothing, mutually acceptable pre-war bargains may be impossible (Reiter, 2003, p. 29-30).

Developing international politics games from bargaining models allows artificial intelligence to compare estimates of opponents and create propensities to use conflict. Bargaining models appeared an excellent opportunity to use fuzzy logic in game design. Numerous situations could be analyzed where bargaining might occur to resolve potential conflicts. Opposing sides likely would not often fit nicely into ordinary set theory. Fuzzy set theory would be a better answer for programmers because international entities in the bargaining game being devised need be represented as having differing commitments to their conflictual ideas.

To improve the sophistication of an international conflict game based on the bargaining model, substantial attention would need be directed towards the emergent knowledge paradigm. Fearon’s three conditions would need be continually analyzed in order to determine if conditions had passed a threshold level and war was imminent. Emergent knowledge techniques using fuzzy logic, statistics, neural networks, and virtual reality could be used to appraise when propensities to war in the bargaining model were near.

Power cycle theory is an international politics model that attempts to improve the explanations for conflict provide by balance of power theorists. Young-Kwan explains that power cycle theory provides a dynamic perspective on core issues of international relations. Power equilibrium fails in balance of power models without explanation of why power equilibrium at one stage loses vitality, dissolves, and then finally gives way to another condition of equilibrium at the next stage. Realist assumptions about the importance of power in explaining international relations are central to power cycle theory. Analysis of the decreasing power of Great Britain and the increasing power of Germany in early 20th century Europe exemplifies power cycle theory’s commitment to realistic assumptions.

Two dimensions must be analyzed in order to understand what is happening in the international system. A horizontal dimension that discusses balance of power need be included. Similarly, a vertical dimension they evaluates the size of state power is required. Only by analyzing both the horizontal and vertical dimension in this model, can one perceive accurately what is occurring in international politics (Young-Kwan, 2003, pp. 6-10).

International politics gaming with power cycle theory could use artificial intelligence's ability to follow trends. Algorithms that search ahead a substantial number of moves are required for games with power cycle theory. To accomplished excellent results, international politics gaming would need effectively look ahead and project powerful
developments in each state's capabilities. The issue of whether heuristics could provide this answer would be difficult to resolve. While heuristics can reduce the number of possible searches required to anticipate many moves ahead, heuristics are not infallible. A basic decision for a computer programmer planning to utilize power cycle theory would be how much resources in terms of space and time the program will have to accomplish trend calculations. If either time or space resources allocation problems exist, the computer programmer is going to need to develop some powerful heuristics to enabled his program to quickly and effectively solved trend projections using heuristics and backward chaining deductive search reasoning.

International Systems Developments

Another possible way of conceptualizing artificial intelligence’s use in international politics gaming is to imagine revising modules in a large complex game to adjust for changing international realities. A very sophisticated international politics game would attempt to be inclusive of all the relevant variables affecting international situations. To make this complex game dynamic, ongoing analysis would be necessary to revise beliefs determining the game outcomes. Changing global conditions would need accommodated into the meta-game.

Both representation of knowledge and emergent knowledge paradigms are involved in revising assumptions so as to be consistent with current conditions. The international relations literature usefully identifies several types of assumptions about international politics that a game theorist would need be attentive to in creating an authentic state-of-the-art meta-international politics game. This paper next considers the complexity of representation and emergent problems in revising such meta-games.

Consider Brooks and Wohlforth's discussion of the case against unilateralism. Were one to have developed a meta-game, some values would be programmed into the game with regard to unilateral action by one state. As world conditions change, unilateral action becomes more thoroughly analyzed with the increasing importance of unipolarity. Representational knowledge in the meta-game's artificial intelligence about unilateralism would need revised either because unipolarity issues are increasing in significance or because knowledge about unilateralism is improving.

Ontology issues in representational knowledge exist. The new concept "soft-balancing" has emerged to explain a frequent response to unilateralism now found in international politics. When the potentially threatened states develop ententes or limited security understandings with one another, soft-balancing can take the form of limited arms buildup, ad hoc cooperative exercises, or collaboration in regional or international institutions. Contemporarily, these actions can balance unilateral policy action (Brooks and Wohlforth, 2005, p. 512).
Introducing the concept soft-balancing to our artificial intelligence would require some modification of our plan for representational knowledge. The soft-balancing concept would need to be integrated with various semantic trees found in our representational system. Similarly, techniques would need to be developed to assess how effective soft balancing response would be in parrying the unilateral action. Probability and Bayesian probability might be useful in devising these representations. Reasonable ideas would need to be present when explaining how soft-balancing would affect each successive step in game problem solving.

Beyond that, the meta-game could accept into representational knowledge evaluations of the costs of unilateralism to the state who decides on this policy. Brooks and Wohlforth identify three possible costs of a unilateral policy. First, deciding among unilateral actions of different types has costs. Whether a unilateral action is precedent setting, already highly institutionalized, or associated with the hegemon's actions can be a costly determination. Second, unilateralism is explained to result in reduction in the efficiency gains that occur from institutionalized cooperation. Cooperative systems may be producing nice results which are disrupted when a state decides on unilateralism. Third, unilateralism can be thought to undermine the legitimacy of the state that pursues this policy. Claims that a state's actions are not consistent with accepted norms can compromise a unilateral policy. (Brooks and Wohlforth, 2005, pp. 517-518).

Evaluating the cost of unilateralism in a meta-game of international politics exemplifies where fuzzy set logic could be useful. The difference in costs between various situations where unilateral policy might be used is likely substantial. The artificial intelligence meta-game relies upon would definitely need to distinguish between situations in terms of their costliness. Although subjective, this differentiation could be accomplished with fuzzy set logic.

Another concept undergoing revision in the international order is accountability. Grant and Keohane have analyzed who is entitled to hold the powerful accountable for their actions. Accountability, to these authors, needs to be accomplished by those affected by actions or by those entrusting an authority with delegated powers. Direct democracy, populism, delegation of powers, or trusteeship can result (Grant and Keohane, 2005 p. 31). The relationship between who is entitled to hold the powerful accountable and types of power wielders is presented in Figure Five.
Analysis of legitimacy that Grant and Keohane produce is useful were one to design fuzzy logic sets to explain different costs of actions with questionable legitimacy. These authors identified three techniques possibly useful in evaluating fuzzy logic set issues pertaining to legitimacy. First, legitimacy can be understood as deriving from conformity to human rights norms. Second, legitimacy principles found inherent in democracy then become recognized as applicable and reasoned at the global level. Third, legitimacy is understood as influenced now by "intense normative pressure" on issues that touch on the extreme economic inequality that permeate the contemporary global political economy (Grant and Keohane, 2005, p. 35).

Cyberpolitics' increasing importance in international relations can be improved in the representational knowledge of a meta-game of international politics. Nazli Chourcri, writing about the globalization of Internet, identifies two phenomena that are occurring. One, globalization of knowledge is occurring via greater diffusion. Two, there is localization of knowledge of the representation of distinct local technical and linguistic features (Chourcri, 2000, p. 259).

The policy significance of global Internet that Chourcri identifies is better flow of knowledge, into domains at the top both within and across societies greatly enhancing inputs into the decision making process. Networking enables stakeholder communities to express their preferences and make explicit inputs into decisions. Internet allows decision- makers access to multiple stakeholder communities. Policy-making is revitalized with a capacity for multi directional interactions transcending underlying social structures (Chourcri, 2000, p. 259).
The emergent knowledge paradigm in a meta-game’s artificial intelligence could provide revised representational knowledge about cyberpolitics. Since emergent knowledge is often explained as the computer being let loose on its own in the world to seek knowledge, an Internet research problem is an inescapable possibility for the emergent knowledge paradigm.

Neural networks, a contemporary popular technique for emergent knowledge, analogizes the emergent knowledge facility as something like the synapses in the human nervous system. This approach to emergent knowledge requires several active centers, the synapses, to acquire and process new knowledge. Neural networks explains that emergent knowledge is acquired with training not programming. Creating a trained neural network requires accepting and processing information the computer locates on its own.

Globalization is another international systems developments that a meta-game of international politics need accommodate. Sven Bislev explains globalization as entailing "The development of supernatural and transitional forces outside the control of national governments and the emergence of phenomena that cross traditional structures of national interest (Bislev, 2004, p. 283-4)."

According to Bislev, globalization is a controversial idea in economics, political science, and cultural studies. The idealistic implications often heard about globalism are contradicted by the reality since few trends and phenomena are authentically global. Contemporary trends tend to be either regional or some form of American hegemony in reality and not an artifact of globalism (Bislev, 2004, p. 284).

As an artificial intelligence phenomenon, globalization is very complex. Assessing the influence of globalization in various representations of knowledge is difficult. While a popular subject, the real evidence of globalism's significance is almost impossible to find. Possibly, proficient emergent knowledge techniques could locate useful knowledge about the significance of globalism. By searching through information networks, a meta-game’s emergent knowledge facility could probably locate enough data to evaluate the current strength of globalism. Techniques such as fuzzy logic sets, statistics, neural networks, and virtual reality could work together and somehow provide an accurate appraisal of globalism’s significance in the international order.

A final international systems development this paper analyzes is political integration. Susan Senior Nello has written discussing problems in economic and political integration. Her thesis is that there is a tension between the economic and political integration. At this time, all parties believe that they benefit from economic integration's trade liberalization. In contrast, political integration remains conflictual. Conflicts among EU member states about political issues is likely to continue. Sharing the European Union's budget widely is not altogether popular and likely will remain controversial. Some
political conflicts likely to occur within the EU could undermine confidence in the euro and EU institutions (Nello, 2000, pp. 292-310).

The most effective example of economic and political integration in the present day is the EU. From the perspective of artificial intelligence, international politics is learning a substantial amount about economic and political integration from EU experiences. The development of probability models of integration from EU experience could allow a meta-game to project the consequences of integration schemes throughout the world. The implications of the EU for the remainder of the world are significant.

Europe's unusual strength in all international politics equations and formal models realize that artificial intelligence need thoroughly and effectively represent integrationist changes that are occurring. The more conflict found in economic and political integration plans, the more explanation required to discuss Europe as a political entity. Questions about whether divisive factors within EU are dominating external policy need be decided. The ability of member states of the EU to produce a unified foreign policy must be determined. An appraisal of the increased economic strength of integrated Europe needs be revised continually. Methods for evaluating the potential impact of new integration issues within the EU must be devised. The complexity of thoroughly evaluating economic and political issues pertaining to EU integration requires some sophisticated use of the representational knowledge paradigm and the emergent knowledge paradigm.

Artificial intelligence's emergent knowledge abilities can allow a meta-game of international politics to closely monitor and evaluate conflict within the EU over integration issues. Working with past and present EU conflicts, emergent knowledge can devise techniques for effectively analyzing any new conflictual issues that may appear. The possibility for the emergent knowledge paradigm to succeed in appraising future situations in the EU is substantial. Expert systems have effectively managed much more complex problems than economic and political issues within the EU. International relations reasoning about EU economic and political issues likely would substantially benefit from introducing the emergent knowledge paradigm to the study of economic and political integration.

Conclusion

An unusual phenomenon appears to be occurring in concepts and theory found in the international politics literature. For decades, international politics has had substantial influence in the development of theoretical understanding. The connection between international relations theory and international political reality has been thought to be excellent. Recent literature in international politics reveals another influence is appearing in this respectable set of ideas. Artificial intelligence is increasingly becoming a substantial influence in the development of models in international relations. The
conceptual and theoretical strength of AI, is ever more present in international relations analysis.

The discussion of artificial intelligence presented in this paper has defined AI and examined the field's history. Expert systems and what has been accomplished is described. The important artificial intelligence paradigms of representational knowledge and emergent knowledge had been explained. How artificial intelligence utilizes concepts like heuristics, algorithms, fuzzy logic, statistics, neural networks, and virtual reality has been included. The belief that AI is remarkable in conceptual and theoretical development has been explained. The reader has been given an opportunity to evaluate for himself the possible contributions AI is making to the field of international politics.

How international politics gaming can combine model building in international relations and artificial intelligence has been presented. Formal models in international politics and emerging trends in international relations both have been reasoned together with AI concepts and theories. The sophistication of international relations models appear less complicated when explained with AI ideas. The feasibility of converting a substantial amount of contemporary models to AI games appears authentic. The strengths of AI would have no difficulty in taking on the major ideas of formal models in international relations.

Emerging international situations are effectively analyzed with artificial intelligence reasoning. This paper uses the idea of a meta-game in international politics and accommodates developments in concepts and situations to the meta-game. Explaining how this could be done in several situations causes one to believe AI is useful in bringing changing ideas and new political developments into a global worldview. The feasibility of allowing AI to incorporate new values and occurrences into a comprehensive perspective on what is happening in the world appear reasonable. Were one to devise a meta-game in international politics, the AI used would probably produce highly satisfactory results. Improved comprehension of international realities and affairs could be anticipated from designing such a meta-game in international politics.
Bibliography


Franz Kohout. "Cyclical, Hegemonic, and Pluralistic Theories of International Relations:


