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Semiotics expert system: An integrative approach towards maintenance of community peace

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Optimum peace maintenance amongst monitored communities is needed for sustainable and social development of the communities and society. The maintenance of peace with the application of correct strategies should be able to deliver maximum degree of trust and strength of relations among the communities. This study presents STES, an expert system that utilizes a biologically inspired novel optimization technique of semiotics that imitates the behavior of predators in marking their territories with their odours and physical marks, known as territorial predator scent marking strategies (TPSMS), to obtain appropriate strategies for maintenance of peace. The current study presents the use of game theory and deterministic finite automata (DFA) theory to model and design a strategic rule set for the Expert System to take decisions for maintenance of optimum peace amongst the communities. A DFA is obtained using various peace states as the set of states, and the alphabet set is constructed by modelling a two-person Prisoner's Dilemma game over TPSMS. A context free grammar is then obtained by employing top-down parsing, which would suggest the proper rules to be included in the rule set of the Expert System for the maintenance of peace and bringing out sustainable development. A key objective in such decision making therefore would be to select the semiotical peace maintenance strategy in a manner that their applicability configuration ensures a high degree of cooperation within often intensely conflicting communities, over a long term resource use scenario.

Key words: Peace, semiotics, prisoner's dilemma game, deterministic finite automata (DFA), context free grammar, top-down parsing, territorial predator scent marking strategy.

INTRODUCTION

Peace may be defined as the degree to which the cooperation impedes or facilitates the interactive movement of resource between two independent communities. Semiotics can be defined as the study of signs and signals existing in the nature which helps to understand the dynamic topics of natural informatics and it is proposed to use the semiotics amongst the territorial species scent marking techniques for the maintenance of peace amongst the communities. Territorial predator scent marking strategies (TPSMS) can be explained as the strategic actions undertaken by the territorial predators for marking and informing the other animals about their settlements and peaceful cooperation in the nature. Further, an Expert System is a rule based

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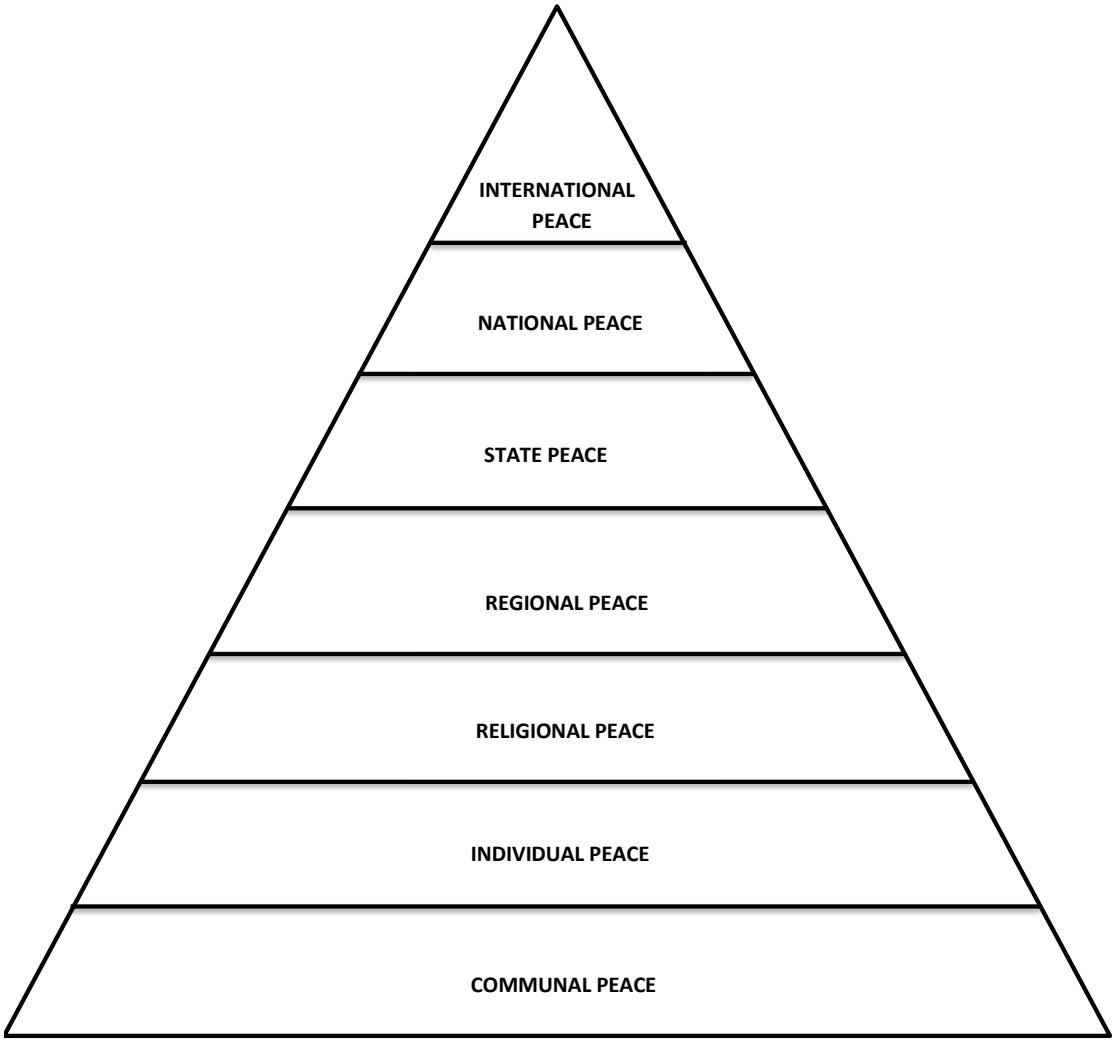

Figure 1. Hierarchy of communal peace maintenance.

computer program that represents and reasons with knowledge of some domain with a view to solving problems or giving advice.

Semiotics, as implied from the definition earlier mentioned, is an integral component of ecological informatics and cooperation amongst the various components of ecology. The objective of semiotics is to facilitate and understand the movement of information between the various components of ecology present in the ecosystem. Semiotics is thus a concept within a given surrounding that generally comprise flow of signals, and connect otherwise fragmented, disconnected, non-contiguous signs in the nature.

Peace maintenance refers to the strategies adopted by international, national or neighboring communities to institutionalize peace, understood as the absence of conflict and a platform of participatory politics that can be sustained for a longer period of time with the optimal relationship flow. Over time, the concept has become considerably important as for the exploitation of resources with the most optimal strategies there needs to be peace among the communities at all the levels of hierarchy.

Scholars, particularly since last two decade of the twentieth century continuing till the present, have generally argued in favour of the application of semiotics for the purpose of optimization and integration in day to day life activities. Researchers have demonstrated that application of semiotics has been instrumental in increasing the information flow and signals of the various components of ecology.

The earlier mentioned discussion implies that any feasible, realistic modelling for the maintenance of world peace must be ecological component – specific exercise, with a proper choice of algorithm for that focal optimization. In this study, a computational procedure has been presented for maintenance of communal peace at all levels of hierarchy as shown in Figure 1. For an issue

as vast and diverse as maintenance of peace, relative application of many concepts and logics with reference to one another becomes an important attribute to consider for making optimal decision for selection of correct strategy and exact resource allocations, for either maintaining existing peace, or even in some instances, creating peace.

The primary purpose of this study is to provide a basic computational framework for perceiving an optimal strategy network design in the optimal maintenance of peace. In this work, all arguments are based on the structural definition of semiotics, where the viability and existence of cooperation is required to be determined entirely by the territorial predator scent marking technique.

The problem of peace maintenance within the communities is described as a deterministic problem. It has been incorporated that the conflict of interest between the communities, the maintenance of peace, optimal use and share of resources are resultant of primarily anthropogenic modifications, through a two-player non-cooperative, general-sum game.

Although the present study makes reference to the semiotics of territorial predator scent marking algorithm, it is essentially schematic and semi-empirical in nature. Accordingly, the discussions that follow do not refer to any real-world data as would have been obtained through a survey routine.

Communal peace

In the quest of trying to understand the true flavour of peace, the present study comes across a variety of dimensions where the dynamics of a 'social individual' matter. Even though the usage of 'social individual' is very oxymoronic in nature, it holds great meaning. Peace is a state or period in which there is no conflict or an existing conflict has ended or the extent of conflict has been minimized. So, it basically deals with freedom from disturbance and tranquillity. When it has been discussed about maintaining inter-community peace, the most optimal but hypothetical condition will be when all communities have equality in all realms of consideration. Since that is a hypothetical concept, and moreover, since humans are intellectual beings, the present study must arrive at a higher understanding by putting the differences behind and motivating in a positive direction by embracing peace.

Semiotics

Semiotics also called semiotic studies is the study of making meanings, the philosophical theory of signs and signs. This includes the study of sign processes (semiosis), indication, likeness, designation, metaphor, analogy, symbolism, communication and signification.

Semiotics is closely related to the field of linguistics, which studies the structure and meaning of languages more specifically. Human beings follow pattern recognition techniques in the provided information and organize them to generate meaning. Collections of these organized patterns create the languages that humans use to communicate. A one line definition is that it is the study of signs itself and the way they work. "Signs" are used among intelligent beings that do not refer to anything in the actual surrounding. They cover things that have been understood in the past (Chandler, 2004).

Territorial predator scent marking algorithm (TPSM)

TPSM algorithm mainly focuses on animal marking area by their odors or scent, urination for communication with their animals for certain factors such as females and food resources. The territory is selected based on resources. Scent marking indicates boundaries of their territories (Begg et al., 2003). Animal odors are used as a communication channel between species according to four different functions such as reproductive signaling, scent matching and resource protection (Descovich et al., 2012).

Game theory

In the present study, it has been described to model a feasible peace maintenance strategy for communities using two specific areas of discrete mathematics. In this section, the work describes the essentials of both these areas, in order to make the work self-contained. The former is Game theory, which studies and models situations of competition and conflict – of cooperation and defection – between several interacting agents, for shared resources (Webb, 2007). The later is Deterministic Finite Automata (DFA) which has been used in this study to model the interactions between possible states of peace within the given area of conflict, and the different community features.

Let $G(\beta, \Sigma, \Pi)$ be a normal form, strategic game where $\forall i \in I, where\ I\ is\ a\ set\ of\ integers,$

1. $\beta = \{\beta_i\}$ is the set of interacting players or competitors;
2. $\Sigma_i \neq \{\}$ Is the set of strategies or moves for the competitors $\beta_i . \Sigma = \Sigma_1 \times ... \times \Sigma_n$ is the space of strategies;
3. $\Pi_i : \Sigma \to \Re$ is the payoff or resultant function, which assigns to each strategy set, σ a real number $\Pi_i(\sigma)$,

the payoff obtained by the player β_i when σ is played in G.

Let the game G be repeated in periods of discrete time $t \in \aleph$. Assume that the players are 'hardwired' to play only pure strategies in G. Thus, each strategy set Σ_i is a member of the standard basis for the strategy space Σ where the i^{th} coordinate is 1 and the rest are zeroes, and thus would correspond to a corner point of the simplex

$$\Lambda = \left\{ \hat{p} = (p_1, p_2, ..., p_n)^T \in \Re : p_i \geq 0, i \in N, \sum_{i=1}^{n} p_i = 1 \right\},$$

which is the simplex corresponding to Σ [1].

Let the Prisoner's Dilemma game be represented by G such that $n = 2$. Let the two pure strategies that the two players can opt for, be called cooperate (C) and defect (D), respectively, giving $\Sigma_i = \{C, D\}, i = 1,2$. The bounded simplex corresponding to G would be given by

$$\Lambda = \left\{ \hat{p} = (p_1, p_2)^T \in \Re : p_i \geq 0, i \in \{1,2\}, \sum_{i=1}^{2} p_i = 1 \right\} \subseteq \Re^2.$$

In the strategic form, G may be described by the following payoff matrix:

	C	D
C	(R,R)	(S,T)
D	(T,S)	(P,P)

With the row player being the first player β_1 and the column player being the second one β_2. In the earlier mentioned game, both the players β_1 and β_2 have two pure strategies each to choose from: either play *C* or play *D*. If both play *C*, each obtains a reward *R* as the payoff for cooperating. If both play *D* instead, each obtains a punishment *P* for defecting, as the payoff. If player one plays *C* while the player two plays *D*, then the one playing *D* obtains a payoff of temptation (to defect) *T* while the one playing *C* gets a payoff of sucker's, *S*. The game G is then defined by the constraint on the payoffs thus: $T > R > P > S$.

It is obvious from the foregoing discussion, that in a single shot, non-iterated game, the dominant strategy is *D*, and hence both the players, being rational, would choose to play *D* in order to maximize their individual payoffs. However, as the above game matrix shows, in an attempt to maximize individual payoffs, the players obtain equilibrium as (P,P), which, being Nash equilibrium, is a suboptimal solution of the game, the optimal solution being (R,R), that could have been obtained through mutual cooperation of the players. Selfish defection gives a higher payoff than cooperation but if both defect, condition is worse than if both cooperate (Hofbauer and Sigmund, 1998).

Prisoner's Dilemma, though being a general-sum game, would adequately capture and model the essential conflicts of interest among the players involved in the present modeling (Axelrod, 1984; Axelrod and Hamilton, 1981). The theme of this study is peace maintenance planning, given the character information about agents (individuals, communities, states, country, etc) of interest. The logics of strategic evaluation suggest that the possible cooperation between the communities in the focal complex could conveniently be represented as a ruleset.

Deterministic finite automata (DFA)

An automaton is defined as a machine where information is transmitted, transformed and used for performing some special task without direct participation of a human (Levett, 2008). A finite automaton consists of a set of states and its "control" moves from one state to a different state in response to external "inputs". The term "deterministic" refers to the fact that on each input there is only one state to which automaton can transition from its current or present state (Papadimitriou and Lewis, 1997). A deterministic finite automaton is five-tuple which consists of (Hopcroft et al., 2006):

1). A finite set of states, often denoted Q.
2). A finite set of input symbols, often denoted ∑.
3). A transition function that takes as argument a state and an input symbol and returns a state, often denoted δ.
4). A start state (q_0), where (q_0) ϵ Q.
5). A set of final or accepting states F, where F ⊆ Q.

A DFA generates a grammar context free as well as context sensitive and thus define a language, that is, the set of all strings that result in a sequence of state transitions from the start state to an accepting state.

Expert system

Expert systems or decision support systems are of great interest of artificial intelligence (AI) scientists which is used by humans to take help in decision making from creating expert knowledge to handle, store and make use of various expert knowledge. An expert system (ES) contains facts and rules that make use of expert's knowledge from its knowledge base to solve problems which belongs to a particular domain for which human

expertise are required. Knowledge is used by an expert system to perform the area specific task. Knowledge used in Expert Systems is generally heuristic in nature rather than the conventional algorithmic structure based knowledge.

Modelling

For the purpose of this study, it has been assumed that the peace maintenance amongst the communities constitute and follow the state transition function and the collection of all these transitions within the communities that share any common resources provide an optimal strategy approach to be opted by the communities with the focal concentration of maintenance of peace. The existence of an edge between any two states of peace represents some logical connection, such as cooperation or defection, amongst the communities.

For the construction of a DFA, the present study classifies peace into 7 major states comparing it with the most important resource, water in ecology. As the present work concentrates on the use of TPSMS so the states of water body in ecology is considered as the states of peace. In the present work before construction of a DFA, a NDFA is created and then used for construction of a DFA. This transition is done because the interaction or movement from one state of peace to another cannot be a linear function or a one to one mapping.

Community peace game model using two-person's prisoner dilemma game

Under the conflict conditions, a community works as an individual agent and employ strategically optimal communication to form highly understandable situations (Ben-Jacob et al., 2000). To do so they have developed sophisticated cooperative behavior and intricate communication capabilities. These interactions include conflict for resources, cooperation for reproduction, etc. Utilizing these capabilities, the communities exhibit typical behaviors in response to adverse resource conditions (Tsimring et al., 1995; Jacob, 2009). The complexity of communities conveys the idea that they constitute a kind of social groups where the coordinated action of individual leads to various kinds of functionalities [14]. These interactions and therefore the emergent strategies are expressed using game theory (2-person's prisoner dilemma game). Following assumptions are made for modeling (Krawezyk et al., 2004):

1. The game trends observed in the communities can be assumed to be a 2-person's prisoner dilemma game
2. Each community is an agent and agents are the player of 2-person's prisoner dilemma game
3. The purpose of the existence of community is to grow and reproduce, thus transmitting resources across the generations.
4. The community fitness defined as a linear function of the payoffs received by the communities in a game, is the combination of community growth and optimal use of resources.
5. Communities have developed sophisticated modes of cooperative behavior to cope with unfavorable conflict conditions.
6. The payoff in the community game is in terms of the effect on the use of resources (optimal use of resources is a measure of the success of strategy).

The use of resources by communities is modeled assuming that the communities play a game of Prisoner's Dilemma (G), iterated over a very large number of aspects for the optimal use of resources over time and use NDFA for modeling the observed community behavior and then obtain a DFA.

The model is based on the following block diagram depicted in Figure 2 of the peace maintenance approach, spread over its constituent states.

NDFA for community peace game model

In the present study, community game and strategies for maintenance of peace and optimal use of resources is modeled, assuming that the communities play 2-person's prisoner dilemma game, iterated over time and use NDFA for modeling the community behavior. A Non Deterministic Finite Automata is a 5-tuple Δ (Q,∑,q,δ, Qo) where:

Q: Set of states
∑: Alphabet Set of inputs (strategy space)
q: initial state
δ: transition function
Qo: set of final states.

and

δ: $Q \times \sum \rightarrow Qo \subset Q$,

Where Qo is a subset of Q.

For the present modeling purpose, the objects of Δ are described below:

Q Comprises of the following states, which discretely represent the different payoffs that a player would receive on his respective strategic moves:

1. Oligotrophic peace *(O)*
2. Fuzzy mesotrophic peace *(FM)*
3. Mesotrophic peace *(M)*

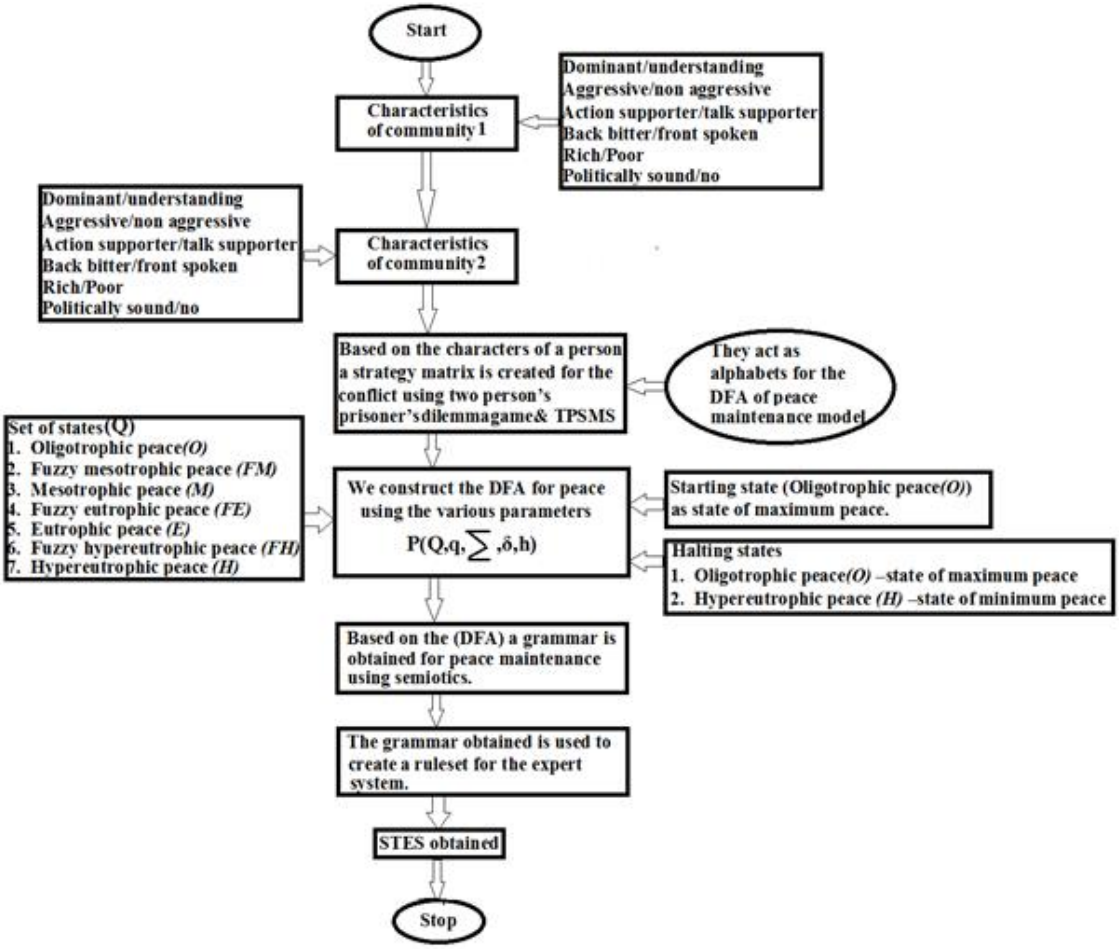

Figure 2. Block diagram of peace maintenance approach and creation of STES.

Table 1. Set of Alphabets for NDFA and DFA.

Strategy	Symbol	Coded as:
Cooperate, cooperate	(C,C)	1
Cooperate, defect	(C,D)	2
Defect, cooperate	(D,C)	3
Defect, defect	(D,D)	4

4. Fuzzy eutrophic peace *(FE)*
5. Eutrophic peace *(E)*
6. Fuzzy hypereutrophic peace *(FH)*
7. Hypereutrophic peace *(H)*

The alphabet Σ comprises of the inputs, which are the strategies used by the players in playing *G*, given Table 1.

Transition table

I is the initial state, representing the initial state of the maximum community peace between two communities.

The transition function δ is described by the following matrix (Table 2):

H and O are the final states of this NDFA because they are the minimum and maximum states of peace respectively. Δ may then be depicted as in Figure 3.

Need for NDFA and DFA

A NDFA is created before DFA because:

Table 2. Transition rule for NDFA.

Inputs	1	2	3	4
States	-	-	-	-
O	O	O	FM, M, FE, E, FH, H	O, H
FM	O	O	M, FE, E, FH, H	O, H
M	O, FM	O	FE, E, FH, H	O, H
FE	O, FM, M	O	E, FH, H	O, H
E	O, FM, M, FE	O	FH, H	O, H
FH	O, FM, M, FE, E	O	H	O, H
H	FH	FH	H	H

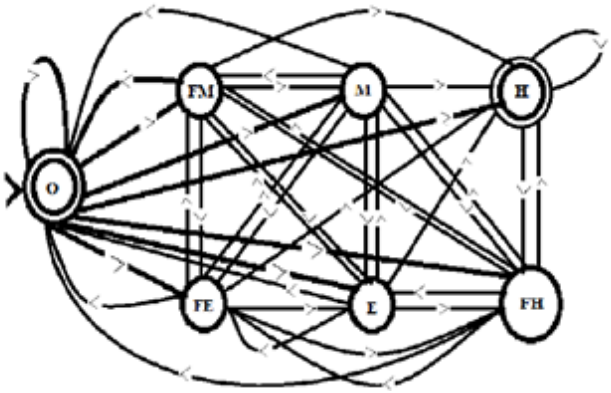

Figure 3. NDFA for peace maintenance.

1. The interactions are discrete and do not determine that what extent of payoff may be lost or gained.
2. So, more than one state can be reached on one move of the game i.e. a set of states can be achieved.

A DFA is constructed after a NDFA because, being a one to one mapping a DFA provides a grammar (context-free as well as context sensitive). The DFA is constructed through a NDFA using two principles of:

1. State multiplicity and
2. State minimization.

DFA for community peace game model

A Deterministic Finite Automata is a 5-tuple (Q,∑,q,δ,h) where:

Q: Set of states
∑: Alphabet Set of inputs (strategy space)
q: initial state
δ:transition function
h: set of final states.

and

δ: $Q \times \sum \rightarrow q \subset Q$, Where q is an element of Q.

Q: Comprises the states formed by state multiplicity rule, which represent the various states of peace and their suitable combinations which have been described in the “procedure notes” (Appendix A).

q is the Oligotrophic peace state, representing the initial state of the states of peace. The set of alphabets remains the same as for the NDFA. The transition function δ is described by the matrix in the “procedure notes” (Appendix A).
h, the set of final states, includes the terminals O, a, b, h & H.

Context free grammar (CFG) for community peace game model

Based on the DFA, the context free grammar is obtained using the codes as mentioned in the “procedure notes” (Appendix A) for the maintenance of peace and an optimal use of resources scenario. Corresponding CFG is mentioned in the “procedure notes” (Appendix A).

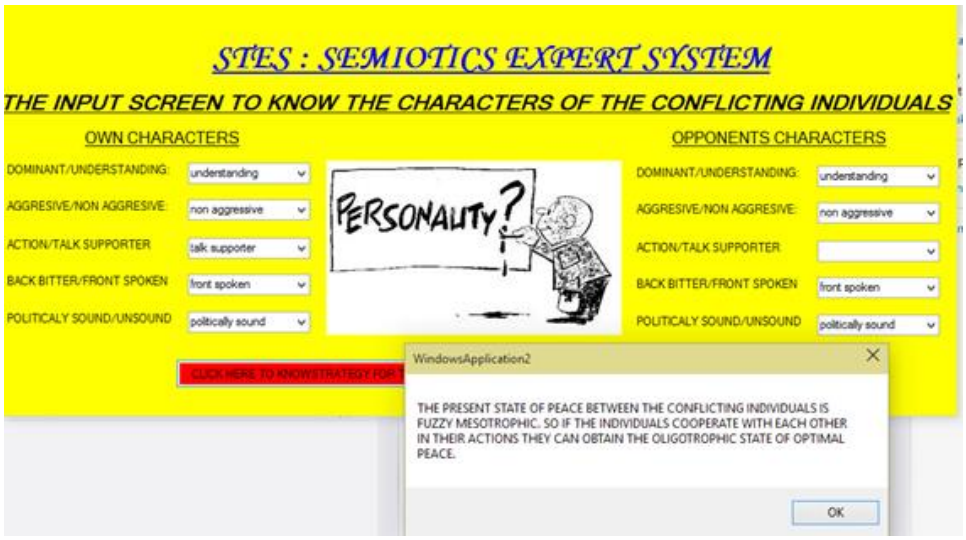

Figure 4. Strategy generation using game theory technique for two conflicting individuals.

Stes – Semiotics expert system construction

An expert system requires various components to be designed in order to facilitate the ease of use and perfect flow of rules. The Semiotic Expert System (STES) has been designed with the following components:

1. Interactive user-interface
2. Expert System shell
3. Intelligence server
4. Analysis based application programs

The current section presents in detail the architecture of the semiotics expert system and its working.

Interactive user interface

The STES presents itself in the form of an interactive user friendly package that facilitates rule based interpretation of Territorial Predator Sent Marking Scheme (TPSMS) for maintenance and optimization of peace. It displays the character section and queries the user to gather the character information. The product assimilates the results obtained from analysis of the data to further design a strategy for peace maintenance. This module has been developed in visual programming software. The user interface has been kept simple as well as with least complexity and maximum trust constraints.

Expert system shell

The expert system shell in STES consists of the knowledge base, working memory and inference engine. The toolkit used for this task is flex which supports rule-based programming integrated within a logical programming environment, and contains its own Knowledge Specification Language (KSL). The sample coding has been included in the “implementation procedure” (Appendix E).

Intelligence server

The intelligence server is a proprietary component of Logic Programming Associates, UK that acts like a bridge connecting the expert system shell with the user interface. The questions written in flex are displayed on the user interface through intelligence server and the user responses are obtained by flex using the same channel. It is a bidirectional flow of inputs and outputs.

Analysis based application programs

This component constitutes analytical programs that use the characters of a community (obtained through the user interface) for generation of strategies for peace maintenance and optimisation.

System evaluation

STES described in the previous section has been tested extensively using the actual user input from two conflicting communities. The results of the strategy generation are described in this section. All communal sections selected for this study have already been interpreted and confirmed for the optimisation details.

Strategy generation using game theory technique for two conflicting individuals

Two individuals were examined and asked to input their characters as shown in Figure 4.

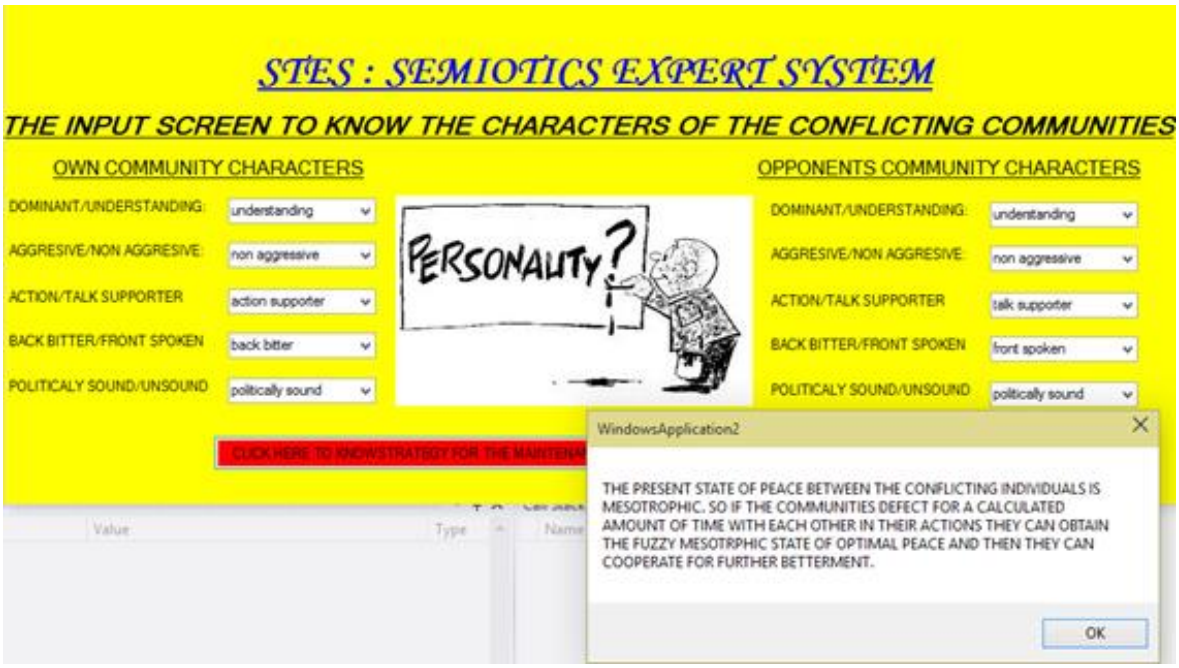

Figure 5. Strategy generation using game theory technique for two conflicting communities.

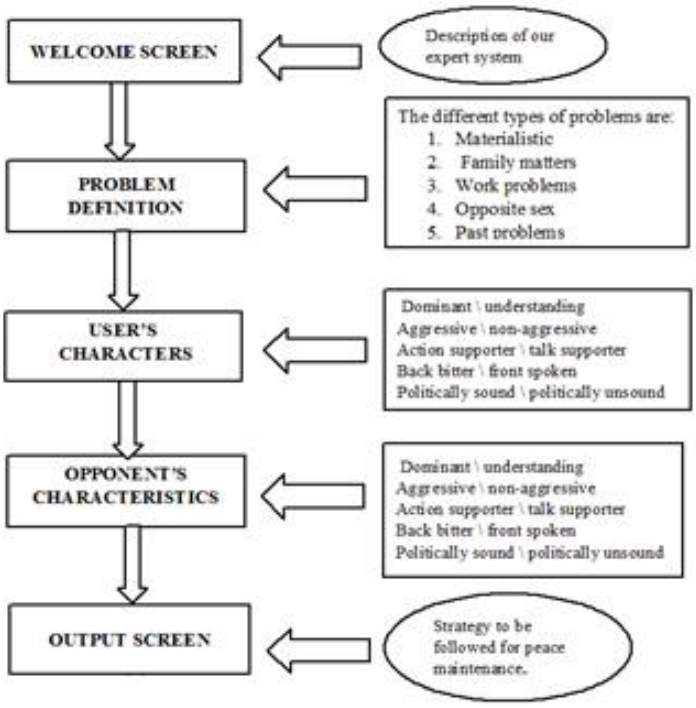

Figure 6. Architecture and flow.

Strategy generation using game theory technique for two conflicting branches

Two branches were examined and asked to input their characters as shown in Figures 5 and 6.

Architecture and flow

Welcome screen

The user will get a brief idea of the software he is going

to interact with, and how the expert system will be of use to him.

Problem definition

The user is made to select the semiotic peace problem he is facing from the list provided in the interface. The problems are segregated as: Materialistic, family matters, work problems, opposite sex and past problems

User's characteristics

User must specify his character from the list specified. This will provide the system with a proper understanding of the nature of the user.

Opponent's characteristics

User must specify his opponent's character also, from the list specified. This will provide the system with a proper understanding of the nature of the user's opponent. The characteristics are specified as (For both the User and the Opponent):

1). Dominant or understanding
2). Aggressive or non-aggressive
3). Action supporter or Talk supporter
4). Back biter or Front spoken
5). Politically sound or politically unsound

The grammar encoded with the different states of peace is used to generate the rule base for the semiotics expert system. The data obtained by the user is internally coded and then the grammar is accordingly applied on the data to obtain the rules.

CONCLUSION

A rule based expert system (STES) has been developed with the capability to provide real time strategies to be carried out in order to optimise and maintain peace between two conflicting communities. An interactive user interface provided through the visual programming software helps in obtaining the user input regarding the characters of the individuals or communities. The analysis used in the back-end carries out various interpretation techniques which include the concepts of applied mathematics like NDFA, DFA, Grammar and Game Theory. However, the interactions considered for the modelling are discrete which may not be the actual scenario in the practical context.

Abbreviations

NDFA, Non deterministic finite automata, **STES,** semiotics expert system.

Conflict of Interests

The authors have not declared any conflict of interests.

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Appendix A.

Procedure notes.

States	Coded AS
FM, M, FE, E, FH, H	a
O, H	b
O, FM,M, FE,E,FH	c
O, FH	d
M, FE, E, FH, H	e
FE, E, FH, H	f
E, F, H	g
FH, H	h
O, FM, M, FE, E	i
O, FM, M, FE	j
O, FM, M	k
O, FM	l
O	O
H	H
FH	FH

States of DFA.

Inputs states	1	2	3	4
O	O	O	a	b
A	c	d	e	b
B	d	d	a	b
C	c	d	a	b
D	i	O	a	b
E	c	d	f	b
F	c	d	g	b
G	c	d	h	b
H	c	d	H	b
H	FH	FH	H	H
FH	i	o	H	b
I	j	o	a	b
J	k	o	a	b
K	i	o	a	b
L	o	o	a	b

Transition function for DFA.

States	Coded as	Coding for grammar
FM, M, FE, E, FH, H	a	J
O, M	b	K
O, FM, M, FE, E, FH	c	L
O, FH	d	M
M, FE, E, FH, H	e	N
FE, E, FH, H	f	O
E, F, H	g	P
FH, H	h	Q
O, FM, M, FE, E	i	R
O, FM, M, FE	j	S
O, FM, M	k	T
O, FM	I	U
O	O	V
H	H	W
FH	FH	X

Context free grammar (CFG) for community peace game model.

→ * V	→	V/J/K/ϵ
*J	→	L/M/N/K/ϵ
*K	→	M/J/K/ϵ
L	→	L/M/J/K
M	→	R/V/J/K
N	→	L/M/O/K
O	→	L/M/P/K
P	→	L/M/Q/K
*Q	→	L/M/W/K/ϵ
R	→	S/V/J/K
S	→	T/V/J/K
U	→	V/J/K
*W	→	X/W/ϵ
X	→	R/V/W/K