Construction of Theoretical Model for Antiterrorism:

From Reflexive Game Theory Viewpoint

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ABSTRACT

This presentation is devoted to the use of Reflexive Game Theory (RGT) for modeling the processes of decision making by terrorists. In the RGT framework, a group of terrorists is represented as a graph with two types of sides: one - expressing confrontation, and the other - expressing collaboration. By decomposition of this graph, an expert can find each terrorist's self-images and construct a choice function which leads to writing equation for each member of the group of terrorists. Every solution of this equation is interpreted as a terrorist's possible choice. The authors then provide examples to demonstrate how an expert can use RGT to model antiterrorist operations.

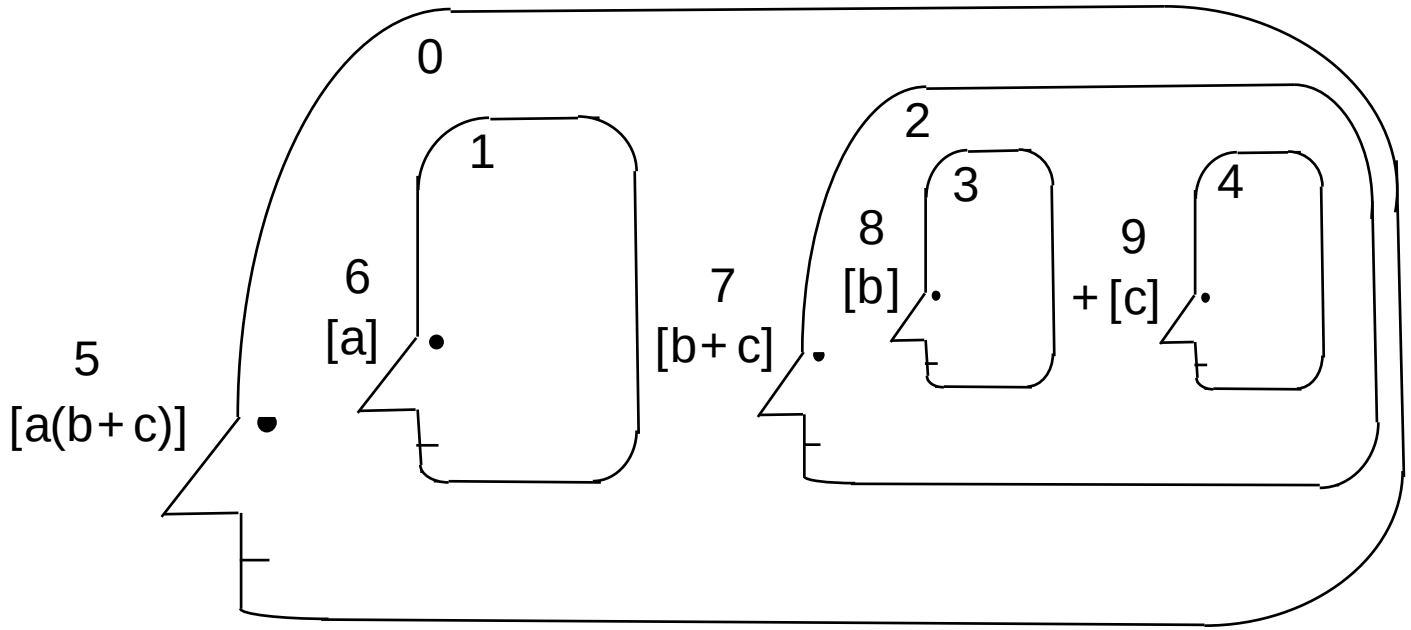
Modeling Terrorists' Activity and Its Specific

A specific feature in the fight against terrorism is the role of the experts' experience in preparing antiterrorist operations. Only highly experienced experts can select significant factors from information received and correctly determine a degree of real threat in a given situation by comparing it with similar instances in the past. Modeling will help an expert to work.
The expert is the one who prepares the information to insert into a model. We will show in this presentation how modeling can be done with the help of RGT, which allows us to include the experts' experience into a model (Lefebvre, 2010; Nyamekye, 2013).

The Main Ideas of the Reflexive Game Theory

At the basis of the reflexive game theory is the assumption that a purposeful agent (Nyamekye, 2013) is reflexive, i.e., the agent has images of the self, which have images of the self, etc. (Lefebvre, 2010).

Reflexive Structure of a Purposeful Agent



The purposeful agent (0) has two mental images of the self (1,2). In the head of image 2, there are two images of the self (3, 4). The agent (0) perceives the group structure: polynomial (5). The image of the self (1) perceives polynomial (6). The image of the self (2) perceives polynomial (7).

Connection between the Structure of an Agent's Images and a Graph of Relation

There is a formal connection between the structure of a purposeful agent's images of the self and a graph representing relations in a group. The graph nodes correspond to purposeful agents, and its sides to relations of agreement or disagreement between them. Graphs may be either decomposable or non-decomposable. The non-decomposable graphs do not allow reconstruction of the structure of self-images. We presume that in this case the purposeful agent's cognitive system simplifies the graph to make it decomposable.

Construction of a Diagonal Form

To construct a diagonal form corresponding to a purposeful agent in a group the following information is needed:

1. A list of purposeful agents in the group.
2. Pair wise relations between the purposeful agents (cooperation or confrontation).
3. A set of actions from which a particular purposeful agent can make a choice.
4. Influences on this purposeful agent by other group members.
5. The order of other purposeful agents' importance for this purposeful agent.

Simple Situation

Consider a situation in which every group member can either do an act α, or refrain from it. In this case the set of choices consists of two elements: 1={α}, 0={ }. The first set, 1, consists of one element - α, and the second set, 0, is the empty set.
Imagine that, using a description of the situation we construct a diagonal form

$$\Phi = \Phi(a, b, c, ...).$$

To find the purposeful agent's choice we have to write the equation for the agent *a*, where the values of other purposeful agents (*b*, *c*, ...) are known, and solve it:

$$a = \Phi(a, b, c, ...). \qquad (1)$$

Choices

For the cases when the set of choices consists of two elements, 1 and 0, Boolean equation (1) is reduced to one of the four forms:

I. $a = a$. This equation has two roots, 1 and 0. The agent may choose either set $\{\alpha\}$ consisting of one action α, or the empty set { }, i.e., refrain from acting.

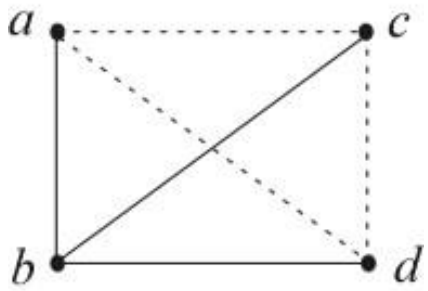
II. $a = 1$. This equation has one root, 1. The purposeful agent in this state chooses only $\{\alpha\}$.

III. $a = 0$. This equation has one root, 0. This means that in this state the purposeful agent makes decision to refrain from action.

IV. $a = \bar{a}$. This equation does not have roots. This means that the group influence on the purposeful agent is such that the agent cannot make any decision at all.

Example 1

A group consists of four terrorists - *a*, *b*, *c* and *d*. Each of them faces a choice: to participate in terrorist action α, or not to participate. Terrorist *b* is in cooperation (union) with *a*, *c* and *d* each, but *a*, *c* and *d* are in confrontational relations (conflict) with each other:



Group relations graph.
Solid lines depict union, dotted lines – conflict.

Example 1 (continue)
A polynomial and its diagonal form

The graph in slide 10 is presented as polynomial

$$b \bullet (a + c + d),$$

where • means union, and + means conflict.

The following diagonal form corresponds to the above polynomial:

$$[a] + [c] + [d]$$

$$[b] \bullet [a + c + d]$$

$$[b \bullet (a + c + d)] \quad .$$

The terrorists' influences on each other

In the table below, the numbers in columns show the influences of other terrorists to the one whose name is on the top of the column and the self-influence, which is the terrorist's intention to choose a set of actions. Terrorist *b* inclines *a* to participate in the act of terrorism (1), while *c* and *d* incline *a* to restrain from it (0). Terrorist's *a* self-influence is the value of variable *a*, unknown to us prior to computations

	a	*b*	*c*	*d*
a	*a*	0	0	1
b	1	*b*	1	0
c	0	0	*c*	0
d	0	0	0	*d*

Modeling the choice made by terrorist *a*

$$[a] + [0] + [0]$$

$$[1] \bullet [a + 0 + 0]$$

$$a = [1 \bullet (a + 0 + 0)] \quad .$$

Operation '• ' is Boolean multiplication and operation '+' is Boolean addition. Operation x^y is given by function

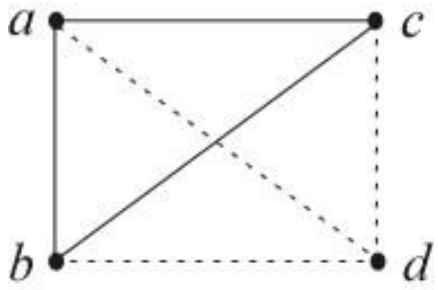
$$x^y = x + \overline{y} \, .$$

After computations we obtain: $a = a$.
This means that terrorist *a* has the freedom of choice and can make either decision: to participate in the act of terrorism or not to participate. Thus, *a*'s choice is unpredictable.
The choices of terrorists *b*, *c*, and *d* can be found similarly.

Example 3

The leader of a terrorist group, *a*, has three aims: to blow a power station - α, to blow a government building - β, to blow a historic monument - γ. The leader cannot commit all three acts at the same time or any two acts if act α is included. But acts β and γ can be committed together.

There are three more members in the group: terrorists *b* and *c* support the leader's opinions (are in union with *a*), and terrorist *d* is in conflict with all others – *a, b,* and *c*:



Alternatives

The set of choices consists of eight subsets of set $\{\alpha, \beta, \gamma\}$. Each subset is an alternative.

1. $\{\alpha\}$ This decision means to blow the power station.
2. $\{\beta\}$ This choice means blowing the government building.
3. $\{\gamma\}$ This decision means to blow the historic monument.
4. $\{\alpha, \beta\}$ This alternative means that one of the actions, α or β, can be realized, but not both of them at the same time.
5. $\{\alpha, \gamma\}$ Only one of these two actions can be realized.
6. $\{\beta, \gamma\}$ In this case, the leader can realize two actions, β and γ, at the same time, or only action β, or only action γ.
7. $\{\alpha, \beta, \gamma\}$ The three actions, α, β, γ, cannot be realized at the same time; two actions, α and β or α and γ, cannot be realized at the same time either. But actions β and γ can be realized at the same time, or any single action - α, β or γ.
8. $\{\ \}$ A set of actions is empty. The leader refused to commit a terrorist act.

The leader's decision

The equation for the leader *a* is

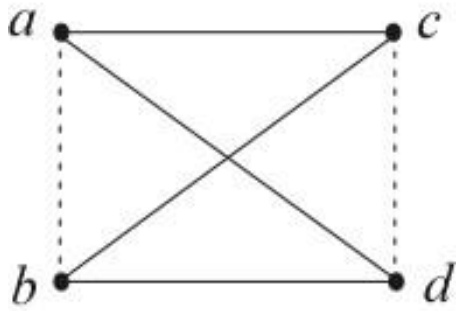
$$a = \frac{[a]\,[b]\,[c]}{[d] + [abc]}.$$

Terrorist *d* inclines the leader to restrain from the act of terrorism: $d = 0$; terrorist *b* advises the leader to blow the government building: $b = \{\beta\}$, and terrorist *c* advises the leader to blow the monument: $c = \{\gamma\}$.

After substitutions and computations, we obtain $a = 0$. Therefore, the model predicts that with the given conditions the group leader will not perform terrorist actions.

Discussion

The terrorist group members are in the following relations:



The leader *a* has to make a decision: either to commit a terrorist act or to refuse to commit a terrorist act. The three remaining members of the group influence the leader. Terrorists *b* and *c* support the idea to strike (*b*=1, *c*=1); terrorist *d* inclines the leader to refuse. Let us find the model of the leader. The graph of relations corresponds to the polynomial

$$(a + b)(c + d).$$

Discussion (continue)

The equation for the leader is

$$[a] + [b] \qquad [c] + [d]$$
$$[a + b] \qquad [c + d]$$
$$a = [(a + b)(c + d)]$$

Since b=1, c=1 and d=0 the value of a=1, that is, the leader of this terrorist group will make the decision to act.

How to make the leader to change the decision?

Reflexive control

In order to make the leader to change the decision, we have to use reflexive control, that is, we have to supply the leader with specially prepared information which will serve as a basis for the decision to refrain from a strike. What kind of information should it be? Since the value of a=1 follows from the given values of the leader's accomplices b, c, and d, the information that we have to send must persuade the leader that c is against the strike (c=0). With this value of c, the root of equation is a=0 (not to strike).

This example demonstrates that RGT makes it possible to elaborate the reflexive control over a group of potential terrorists.

CONCLUSION

We have demonstrated that under indicated assumption, RGT allows us to model decisions made by members of a group of terrorists. How efficient it will be in practice? There could be two types of efficiency. The first type - the plausibility of predictions. The second type - the better understanding of a mechanism of decision making processes in terrorist groups.

The plausibility of predictions can be found as a result of a broad empirical analysis of the descriptions of the real terrorist acts, which will allow us to compare the model predictions with the real terrorists' behavior.

Concerning the second type, our experience in analyzing international relations (Lefebvre, 2010) tells us that using RGT allows us to see many hidden features in the processes of decision making, those that are not readily available in using other methods.