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AGENT TECHNOLOGIES IN LABTSI ™ - USE IN MEDICAL RESCUE

TECHNOLOGIE AGENTOWE W LABTSI ™ - ZASTOSOWANIA W RATOWNICTWIE MEDYCZNYM

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ABSTRACT: *Possible use of modeling and simulation platform for research on agent technologies in the „National Medical Rescue" system is discussed in this article. Appropriate agent model by M.L. Minsky and basic functions performed by it is presented. Distinguished agency having relationship management functions „victim-doctor" with regard to the three-way utility function of its decisions by A. Janicki. Research shows the experiment performed on the computer platform LabTSI ™ that allows modeling of the overall complexity of the problem of prehospital emergency medical services*
KEY WORDS: *emergency medical services, artificial intelligence, quality assessment, modeling and computer simulation*

STRESZCZENIE: *W pracy opisano możliwości wykorzystania platformy modelowania i symulacji do badań nad technologiami agentowymi w systemie „Państwowe Ratownictwo Medyczne". Zaprezentowano odpowiedni model agencji wg M. L. Minsky'ego oraz podstawowe funkcje przez nią realizowane. Wyodrębniono agencję pełniącą funkcje zarządzania relacjami „poszkodowany-*

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lekarz" z uwzględnieniem trójczynnikowej funkcji użyteczności jej decyzji wg A. Janickiego. Przedstawiono eksperyment badawczy wykonany na informatycznej platformie LabTSI™ umożliwiający modelowanie całokształtu złożoności problematyki przedszpitalnego ratownictwa medycznego

SŁOWA KLUCZOWE: *ratownictwo medyczne, sztuczna inteligencja, ocena jakości, modelowanie i symulacje komputerowe*

Introduction

With the development of civilization and the growth of computing capabilities there are more and more new areas of the computer science applications of. Medical rescue services at prehospital level includes a set of activities aimed at rescuing people during events where there is a risk of loss of life or health deterioration. This is achieved by well-built emergency notification system that supports the random events reported. The aim is therefore to provide an effective emergency action to every person in the state of a sudden threat to life or health. Achieving this goal requires formulated tasks related to the processing of information and knowledge relevant to the type of threats involved, for example providing opportunities for immediate call for help using the means of communication, immediate appropriate medical decisions and rescue operations at the scene, etc. The efficiency and effectiveness of these activities depend on the potential of information and decision-making system at the level of emergency medical rescue units.

Medical relations „victim-doctor" in the National Medical Rescue system are becoming complex due to the growing number of victims of disasters, relatively fewer physicians and more advanced methods of diagnosis and treatment. For their understanding, analysis and particularly synthesis, reconnaissance survey was carried out in the National Medical Rescue system and then a model of such relationships was developed. The object of this study was to test the synthesis algorithm rescue agencies including computational intelligence methods (called Computational Intelligence).

In the era of development of information technology adjusted to the needs of modern society we should provide it with advanced tools and technologies of e-space areas (called e-space) for the operation of the decision maker (intelligent agent) with particular emphasis on so-called medical decision support. In order to support the implementation of relationship management between the victims and the ER doctor at the multifunctional trading platform is proposed to introduce the concept of „agency" called „rescue agency", which consists of agents and the relationships between them, such as „the dispatcher agent" acting as so-called Builder in agent technologies; „the team doctor", which plays the role of the medical decision maker; „specialist paramedic" working alternatively with „team doctor" and „agent paramedic" when necessary working alternatively with „specialist paramedic". Their main task is to increase the efficiency and utility of the emergency medical system. The function that rescuer performs in the system is based on legal regulations and subjective assessment of the risks and uncertainties in the above relationship in the system with the use of artificial intelligence methods. As a result the victim and the ER doctor are represented by appropriate „agencies": „victim agency" and „ER agency" (Fig. 2).

Agent-Technologies

Although the computer logic is significantly different from the processes inherent in the human mind, the computational intelligence plays an increasingly important role in creating closer and closer union between man and computer. Computational Intelligence helps man especially in important decision-making process where specific decision problems characterizes significant opacity.

Computational Intelligence is a set of nature-inspired computational methods used to solve complex problems. It includes among others: fuzzy inference systems, neural networks, and evolutionary algorithms.

These methods belong to the class of inductive methods, which are used in problems characterized by a high degree of complexity and covert relations between variables. Inverse relationship occurring between the precision of the problems description in the world around us and their complexity, L. Zadeh aptly describes the principle of inconsistency: „*... with the increasing complexity of the system our ability to formulate significant statements about its behavior diminishes, eventually reaching a threshold beyond which precision and significance become almost mutually features exclusive"*. It is important, therefore, to achieve such results, which provide the option of taking rational decisions.

Examples of problems that may be solved with agent technologies are these associated with making decisions in the National Medical Rescue system. Features of the non-linear behavior concerning chaotic and complex dynamics are usually what makes these problems one of the most complex. Extremely important issue is an appropriate use of information to support decision-making agents. With the agent approach decision makers needs, in an intuitive way, can be modeled and simulated by computer.

Approaches to the problem of relationship management victim-doctor in the transaction National Medical Rescue system can be many. The authors propose in their work to use agent technologies. Agent means an object (an algorithm, a programmed electronic device) functioning in a changing environment, characterized by the ability to adapt to the prevailing conditions, using the mechanisms of communication, reasoning and knowledge to solve problems and tasks resulting from the reality. Agent bears the marks of a being defined by the features corresponding to the concept of so-called intelligent agent.

The process of medical decision support should be seen as part of the overall functioning of the trading system with already built-in mechanisms to support negotiations. It is therefore necessary to support the knowledge and experience of physicians in the identification victims status and their future relations as a consequence of the planned allocation of resources in the National Medical Rescue system. It is also indicated to develop measures of these relationships by conducting computational experiments. Taking into account this complexity of the problem, allows M.L. Minsky's theory [6].

In his work M.L. Minsky formulates the concept of how the mind works and how intelligence arises from the actions that can be called unintelligent. According to the author, intelligent minds are made up of agents, which are treated as simple processes. Combining them in a particular way leads to the origin of true intelligence. Agent called Builder initializes and manages the operation of other agents. Agency seen from the outside is a Builder who does whatever is necessary to achieve its goal, the purpose of the agency. From the point of view of the classification of agents cited, M.L. Minsky undoubtedly extends object-oriented view of the agent and also explains the principles of operation of the agent - Builder, as well as the whole agency. Figure 1 shows the perception of the agent in the agency.

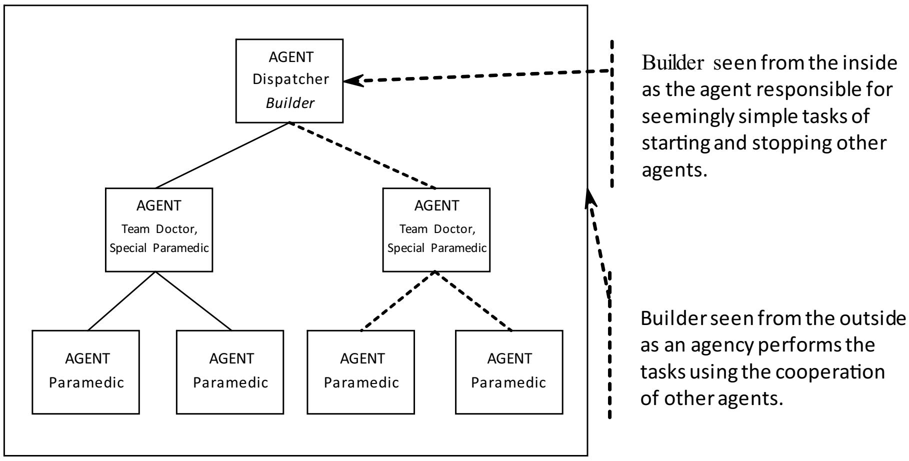

Fig. 1. The perception of the agent in the agency and beyond.
Ryc. 1. Sposób postrzegania agenta w agencji i poza nią.
Source: [6]

Therefore, Builder is able to handle so many random events, as far as resources of the agency permit.

Developing the model of the existing system of medical decision support mechanisms have been used in work to solve the problem of managing relationships between doctors and victims in the emergency medical system. Builder actions in the agency are therefore shaped by the basic resources selected in the process of its construction. By including it in emergency procedures, medical relationships built by this agent become more rational.

Implementation of relationship management victim-doctor in the transaction system presented in the light of the calculation and application of computational intelligence can wear signs of intelligent. Author in the trial attributed the adjective intelligent only to those agents who are understood as a system man-machine. Due to the order of things, the adjective intelligent in connection with agent means here only a man as a decision maker. You can't - in the area of presented solutions - assign the same intelligence to machine and man.

Rescue agency model

In order to determine rescue agency model developed according to M.L. Minsky paradigms is necessary to identify behaviors (behavior) of PRM system components. Was therefore cardiac case, registered in the Pope John Paul II Independent Public

Specialist West Hospital in Grodzisk Mazowiecki, analyzed as a casus.

Sick, a man aged 76 years, with a history of ventricular arrhythmias of recurrent paroxysmal ventricular tachycardia nature, collapsed at home with a painful feeling of tightness in the chest on 3/31/2012. Family called medical assistance. The agent dispatcher immediately sent Basic Medical Rescue Team (PZRM).

The team arrived at the scene in a short time, found the patient unconscious with circulatory and respiratory disorders. The patient was diagnosed as having ventricular tachycardia (VT) hemodynamically inefficient. Basic Medical Rescue Team have made the decision to use electrical cardioversion (EC) in life-threatening arrhythmias. In view of the patient's life-threatening illness, Specialist Medical Rescue Team (with doctor) (SZRM) has been called to assist.

After the first electrical cardioversion there was a short-term improvement in the form of the normal sinus rhythm (RZM). Upon arrival of Specialist ZRM, VT occurred again and again electrical cardioversion was repeated. The patient was intubated on his own breath and with spastic bronchitis and lung edema symptoms, he was transported to the Western Hospital emergency department after obtaining an agreement by radio-telephone was.

At this point, we emphasize that better rational decision of the agent dispatcher would be immediate sending a Specialist ZRM.

In analogy to the perception of the agent and agency shown in Figure 1, Figure 2 describes schematically participants of that case where they are treated as elements of the National Medical Rescue system.

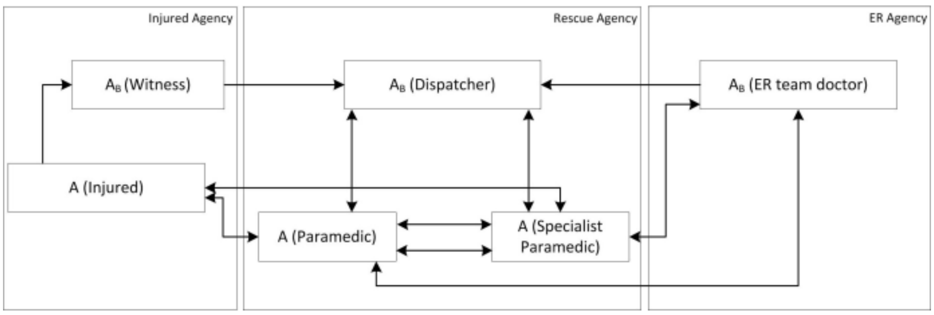

Fig. 2. Diagram of a case in agent technology.
Ryc. 2. Opis przypadku w technologii agentowej.
Source: own.

In order to emphasize relationship of the doctor with his patient, special attention should be paid to create a relationship between them. From the point of view of the entire system, which includes such elements as the victim and the doctor, the key role plays a lifeguard, whose goal is to help both participants in the incident. He plays a specific role as an intermediary managing the relationship between them, where the success of the operation depends on such the level of preparation, environmental conditions and time constraints.

The importance of these conditions describes UML (Unified Modeling Language). Figure 3 showing sequences of actions occurring in different parts of the system.

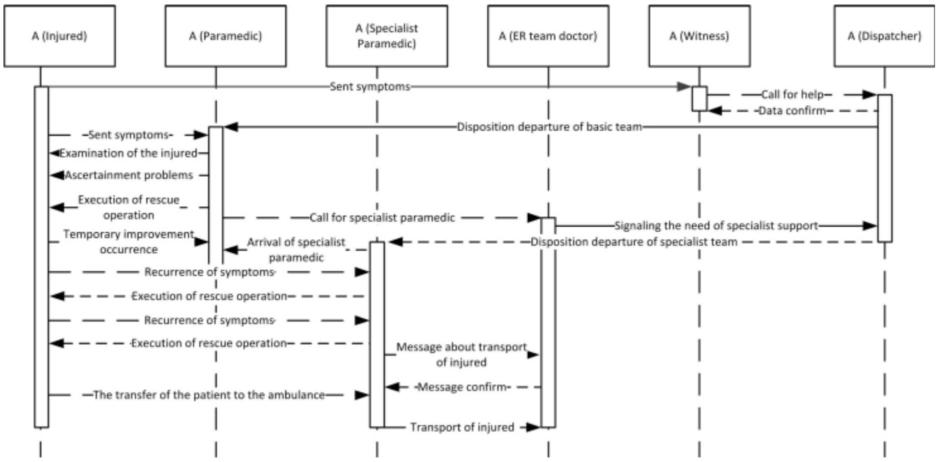

Fig. 3. A case description - UML sequence diagram.
Ryc. 3. Opis przypadku – diagram sekwencji UML.
Source: own.

Thus, by focusing on the activities of the Rescue Agency presented algorithm shows its actions during a case:

1. Answering the call for help.
2. Data confirm.
3. Disposition of Paramedic departure.
4. Examinination of the victim by Paramedic.
5. Ascertainment problems.
6. Execution of rescue operation.
7. Call for Specialist Paramedic.
8. Arrival of Specialist Paramedic.
9. Execution of rescue operation.
10. Re-execution of rescue operation.
11. Message about transport of injured to the ER doctor.
12. Transfer of the injured to the ambulance.
13. Transporting the injured to the ER.

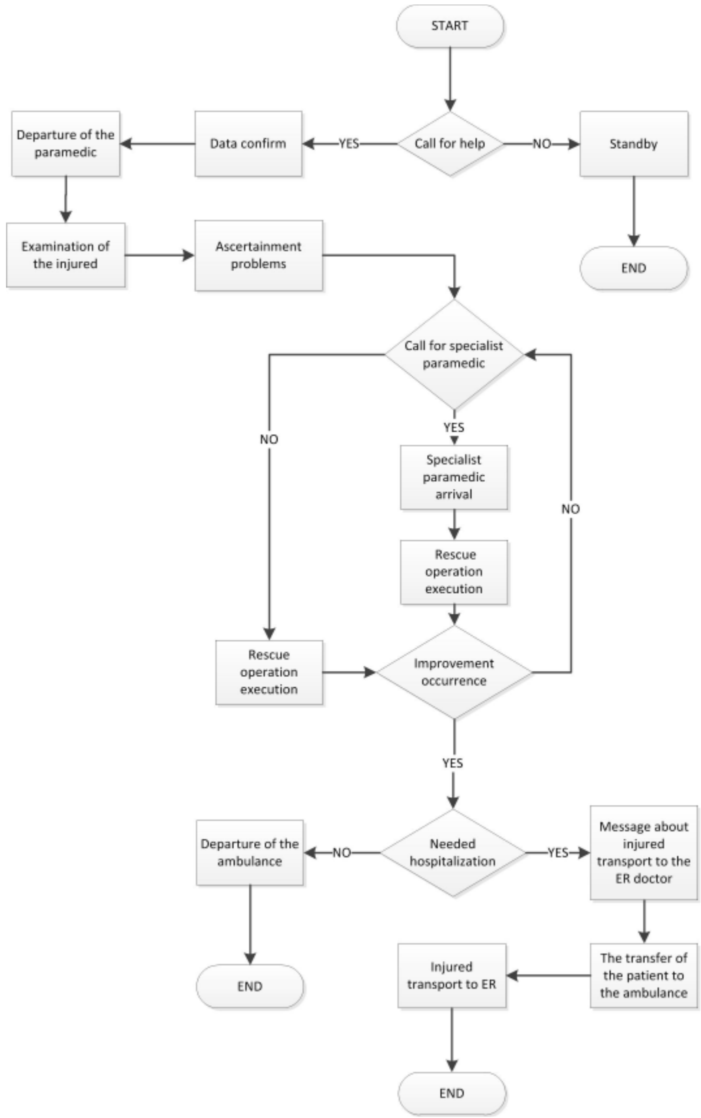

Fig. 4. Graphical adjustment algorithm rescue agencies.
Ryc. 4. Graficzne przestawienie algorytmu agencji ratowniczej.
Source: own.

Summarizing the description of the model shown below, rescue agency and especially her agent and the agent dispatcher and doctor are playing the most import roles. Subject of the transaction, which occurs through the relationships built between its subsidiaries (the victim and the doctor), is the largest value - human life. Rescue agency by managing relationships „victim-doctor" is a key mechanism to ensure the effective functioning of the National Medical Rescue system. Thus, the utility of its actions and decisions that are the solution of the swelling problem to meet existing needs is extremely important.

Simulation studies on models in LabTSI ™

In order to simulate the rescue agency, model of modeling and simulation platform, called LabTSI ™, was used. As a software environment described in the article was chosen specification language *Scilab*. Computational problems in the area of scientific practice can be solved much faster using this environment than the standard programming languages such as Fortran, C, Java. In a very simple way it's possible to generate some results and carry out their visualization. This environment allows you to prepare more complex models for the further development, that can be solved by using more advanced features of LabTSI™.

Scenario showed in the work was simulated with *Scilab* programming language. In the construction of the algorithm of a simulated scenario a model shown in Figures 2, 3 and 4 was used. In addition, memory for the basic activities of each of the agents was provided.

```
//injured
    AP(1,1)=1; // time
    AP(1,2)=0; // symptom
    //witness
    AS(1,1)=1; // time
    AS(1,2)=0; // premedical care
    AS(1,3)=0; // call for help
    //dispatcher
    AD(1,1)=1; // time
    AD(1,2)=0; // answering the call for help
    AD(1,3)=0; // disposition of departure paramedic
    AD(1,4)=0; // disposition of departure specialist paramedic
    AD(1,5)=0; // communication with the ER doctor
    //paramedic
    AR(1,1)=1 // time
    AR(1,2)=0 // disposition of departure specialist paramedic
    AR(1,3)=0 // execution of rescue operation
    AR(1,4)=0 // communication with the ER doctor
    //specialist paramedic
    ARS(1,1)=1 // time
    ARS(1,2)=0 // disposition of departure ER doctor
    ARS(1,3)=0 // execution of rescue operation
    ARS(1,4)=0 // communication with the ER doctor
    //ER doctor
    AL(1,1)=1; // time
    AL(1,2)=0; // communication with dispatcher
    AL(1,3)=0; // communication with paramedic
    AL(1,4)=0; // communication with specialist paramedic
    AL(1,5)=0; // admission of the injured to the ER
```

Each of the agents of the rescue agency was assigned to the variable matrix allowing registration of their behavior. Due to the lack of data about the probability distributions for each of the agents' behavior assumed that actions taken by them at the time will steadily decay probability.

In order to present the results of the simulation they were collected in a summary table of actions performed by agents and obtained sample results of the simulation showed in the chart in time.

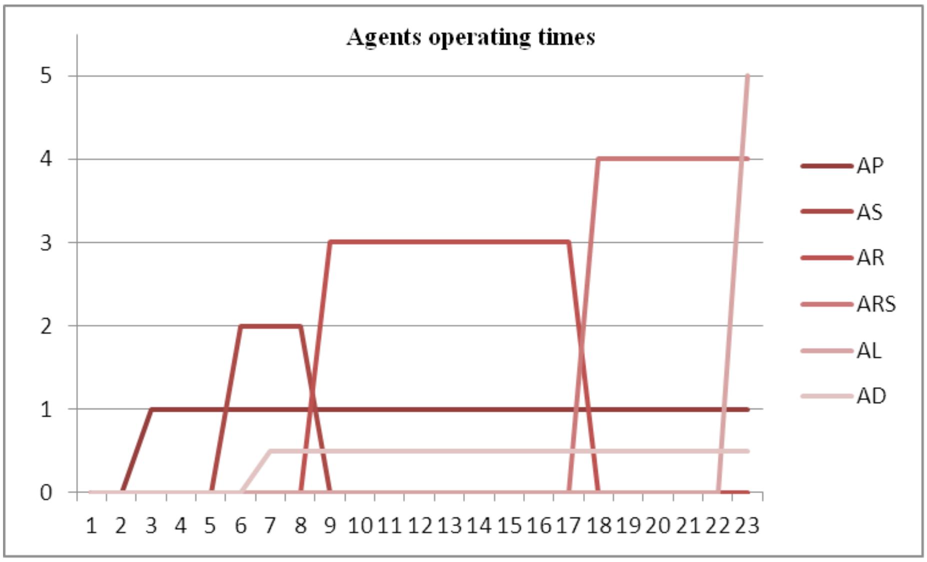

Fig. 5. The sample results of the simulation.
Ryc. 5. Wyniki przykładowej symulacji.

Source: own.

Practically every human action is a kind of game associated with the process of exchange of certain "values" into other values that are specific to the game.

Any decision on human activities is dependent on such factors as entrepreneurial activity and protective and defensive measures (assurance). These two motivations of decision makers were reflected in the proposed by R. Kulikowski two-factor utility function. Due to the systems that are fundamental to public life as financial, military or police systems and wide understood protection and rescue systems, this model has been modified by A. Janicki [5]. The results showed that the quality of solutions to the problem using the function of the R. Kulikowski model and method for the mathematics department called experimental mathematics, the model of A. Janicki three-way function has the form:

$$U(x) = \left[X^{\beta} Y^{1-\beta}\right]^{\alpha} V^{1-\alpha}; \quad \alpha \in [0,1]; \quad \beta \in [0,1],$$

where x is a decision variable, X is a factor related to the expected benefits (within any of the resources) of taking the decision under consideration, Y is a factor associated with the risk of loss of resources involved in the implementation of the project under consideration, factor V represents the so-called survival rate, which recognizes globally decision-making processes in the environment. With the increase in the coefficient α increases the weight that the decision maker attaches to the part of the utility function, which is associated with the action. At the same time decreases the weight of the survival rate. This factor determines the attitude of the decision maker on the activity (α> 0.5) or reflexivity (α <0.5), and β is a factor determining entrepreneurship of the rescue agency (within the meaning of the capacity for creative and sustainable situational solutions).

Decision makers such as the agent dispatcher and the agent doctor (and each of the agents in case of emergency) are continuously subjected to stress. They have to survive in an environment of random events and take actions that increase the chances of success of the rescue operation.

Way of dealing with stress, and thus surviving in a hostile environment, has been the subject of Antonovsky sense of coherence. Successful survival depends on the knowledge about surrounding environment and the ability to adapt to it, and thus ability to act in it in a way that stable gives benefit. It is the result of three specific interactions (vectors), such as:

- Understand the environment Z.
- Assess the feasibility W.
- Reasonableness of actions S.

Survival rate V is expressed by the product of vectors and is a measure of ability to survive under pressure of stressors.

Analyzing usability of the rescue agency, utility function was used with the aim of identifying the need for change in the analyzed scenario in the National Medical Rescue system.

This process of information exchange is concurrently accompanied by an adequate decision-making process. In the decision variable, which is the duration of symptom t, for utility of rescue operations distinguished following factors:

- entrepreneurial activities (reaction time to report of the Witness) X,
- protective (time to communicate with Dispatcher) Y,
- survival (the time of rescue operations and consultation with ER) V.

For example simulation of the scenario and assumed balanced scales of α = 0 , 5 and β = 0 , 5 utility was:

$$U(t) = \left[X^{0,5} Y^{1-0,5}\right]^{0,5} V^{1-0,5} = \left[2^{0,5} 5^{0,5}\right]^{0,5} 15^{0,5} = 8,2$$

Increasing the weight for the internal coherence (α = 0.1) and the weight for the entrepreneurship of actions of the team (β = 0.9) we can increase the utility of the rescue agency.

$$U(t) = \left[X^{0,9} Y^{1-0,9}\right]^{0,1} V^{1-0,1} = \left[2^{0,9} 5^{0,1}\right]^{0,1} 15^{0,9} = 21,7$$

Greater consideration to the factors shown clearly indicates the need for:

- Improving the information flow system between ER doctor and emergency department units: basic R and specialized S,
- Improving the communication between the witness and the paramedics.

In future work the simulations will be optimized with PVM and used to study possible improvements to the National Medical Rescue system for each agent individually and their agencies. These studies will be aimed at optimizing operations for the time limit from injury to the introduction of life-saving interventions so-called "golden hour". The key here will be the role of intelligent paramedic agent as an intermediary in relations victim- doctor and the BLS awareness of the witnesses loss of health emergencies.

Conclusion

In the article possible usage of the agent technologies to describe the case occurring in the National Medical Rescue system was discussed. Thanks to the agent approach it was possible to model and simulate the observed cardiac case registered in the Pope John Paul II Independent Public Specialist West Hospital in Grodzisk Mazowiecki. The developed paramedic model (compatible with assumptions of M.L. Minsky) allowed to identify behavior of elements of the National Medical Rescue system and simulation test of different variants of a given scenario.

Through the system quality evaluation systems such as the National Medical Rescue system might be rationally improved. On the basis of recorded actions of its items assigned utility of actions (consistent with the assumptions of A. Janicki) of the intelligent paramedical agent (Fig. 2) in the presented system and indicated conditions that improve agents operations based on the case study described in this article (see page 5) registered in the National Medical Rescue system. The authors are convinced that the implementation of the proposed improvements to the National Medical Rescue system will not only increase its effectiveness, but also allow for a noticeable reduction in the cost of the system.

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