Agent Based Emergency Response Cognition Model

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**Abstract** - This study considers agent based emergency response cognition model. To operate distributed and dynamic environments are inevitable in real life to realize process in a short time. Decision-making processes among autonomous agents can support to solve dynamic and large system problems. This paper presents an agent based emergency response coordination model that considers the knowledge structure, the space event type and time dimension and the dynamics of the real environment.

**Keywords:** Cognitive Agent Multi agent system, Emergency Response Model Cooperative Distributed Decision-Making,

**I. INTRODUCTION**

The cognitive cycle of the agent model try to quick situational responsiveness develop shared understanding of the operational environment, to check the condition and the execution of the strategies, to deal with multiple, simultaneous crises. The cognitive model attempts to more agile response during the making decision. The probabilistic information and response mechanism is so important part in the suggested model. The cognitive model includes the uncertainty situations for the next decision mechanism. At the same time, learning is very important in cognitive model for thinking and problem solving. Also the learning can realize the process from the experiments; information or with the methods. Moreover, the learning method able to analysis the uncertain situations with interactive markov chains in this study.

Emergency response model covers the nature events and the non-nature events. In particular, unexpected events cause the turmoil among the people most of time. To prevent the turmoil and to save their life in every time, in particular depend on the emergency responses. Appropriate responses are needed in the form of allocating resources to handle the effects of emergency responses. The form and remedy kind may help to people easily kind of the unexpected event. Also the early caution systems can able to stimulate people to this kind of events.

Determination of the unexpected events type is so important for help the people. In the World, people every time faces to nature events such earthquake, forest fires, terrorist attacks, war threads. Also to operate distributed and dynamic unexpected environments are inevitable and so important in real life to realize process in a short time. Using of the cognition model help to understand decision situations and to analyze complex cause-effect representations and to support communication. Multi-agent emergency response system has been extensively used in the different tasks of decentralized emergency response problem solving such as communication among agents, collective decision making, cooperation, collaborative planning in large scale that deals with uncertainty and conflicting information during emergency response management.

This paper organized as follows: the next section presents an overview of works in the literature related to emergency response structure, cognitive model and multi agent systems dynamic modeling and simulation; the next section introduces overall architecture which attains the proposed aims and emphasizes the roles played by the agent based emergency system components; and describes the complete working flow and details theoretical approach on which relies the work; then, the next describes how the process model applied to emergency response real model. Conclusions and future works close the paper.

**II. LITERATURE SURVEY**

Cognitive model compromises four components which are conative, cognitive, skills and instinctive. It covers the conative with feelings, emotions, and cognitive with thinking and problem solving, and skills with actions and driving and instinctive with reflex and reactions (Lawson, 2001). Suggested model takes in the thinking and problem solving instantaneous. In particular, learning process from experiments,
information and designed method is available with multi-agent system (Brunswik, 1957). The probabilistic information and response mechanism is so important part in the suggested model. The cognitive model includes the uncertainty situations for the next decision mechanism. The learning is very important in cognitive model for thinking and problem solving. Also the learning can realize the process from the experiments; information or with the methods. The learning method able to analysis the uncertain situations with interactive markov chains in this study.

Emergency management is so important for the sustainable qualify life conditions. In particular, to take precautions for unexpected emergency situations are so important for the human life. MAS may use in emergency situations resulting from natural and human made emergency responses, such as flood, tsunami, earthquake, terrorist attack, fire in building etc, represent complex and dynamic environments with high level of uncertainty; hence autonomous notification and situation reporting for emergency response management system will be done by multi-agent response system. Suggested agent based emergency response cognition model provides the basic components for the system. In literature, Wang et al. (2013) suggested the emergency management response system structure for a city in China. Also, Basak (2011) et al., suggested the agent based disaster management and Chou et al. 2008, suggested the dynamic parking structure with agent based platform. The suggested agent based model designed with cognitive structure.

Belief Desire Intelligence (BDI) is very important architecture for offer an agent with artificial cognitive capabilities. The other say, cognitive agent aims to perform cognitive activities with considering of the human cognitive behavior. Cognitive activities based on the three components which are perception, reasoning and execution. In addition, traditional agent characteristics which are autonomy, social ability, reactivity and pro-activities have to combine with cognitive abilities. Some of the emergency response response systems have been developed based on multi-agents systems approach (such as: DrillSim developed by Balasubramanian et al. 2006, DEFACTO designed by Marecki et al. 2005, ALADDIN modeled by Adams et al. 2008 and Jennings et al. , RoboCup Rescue suggested by Kleiner et al. 2005, and FireGrid proposed by Berry and Usmani in 2005) and more are being developed. Our study covers the behavioral response structure which is influenced by objective (cognition or abilities) and subjective (feelings or reflexes) processes. It focuses on objective processes which may influence the behavioral response. In particular, to cognition and the relation to the decision-making process in the context of evacuation dynamics are given.

The autonomy is an ability of agent to achieve its goals without any supporting from other agents. On the other hand, the interaction of agents to get the global goal of the system is the social ability of agents. The reactivity, which is based on the relation between perception and action, is an ability of agents to respond to the environmental changes. The pro-activeness of agents is an ability to express the goal-directed behaviors. The reactions of agents to the environmental changes are the reactivity or pro-activeness that depends on what kind of architecture of agent is used to develop agents. The different characteristic of the cognitive agent in comparison with the traditional agent is the intelligence of the cognitive agent, which is shown at the improvement of the pro-activeness characteristic. Intelligence is the ability of the agent using its knowledge and reasoning mechanisms to make a suitable decision with respect to the environmental changes.

III. AGENT BASED EMERGENCY COGNITION MODEL

This section includes overall architecture which achieves the proposed aims and emphasizes the roles played by all system components; and describes the complete working flow and details. Theoretical approach on which relies the work. The cognitive cycle of the agent model presents the detail structure in agent model with algorithm. The next subtitle of the Agent Based Model gives the detail of the emergency responsive model with components.

3.1 The Cognitive Cycle of the Agent Model

The cognitive cycle of the agent model aims to quick situational awareness develop shared understanding of the operational environment, to monitor the situation and the execution of the strategies, to deal with multiple, simultaneous crises. The cognitive model aims to more agile response during the making decision.
The suggested model is able to realize communication and collaboration with coordination, coalition and collaborative information distribution properties. Agents communicate in order to achieve better the tasks of them or of the society/system in which they exist. Communication can enable the agents to coordinate their actions and behavior, resulting in systems that are more balanced. For communication, agents are able to coordinate, coalition and collaborative information each other agents.

The suggested model is able to process the data cognition of knowledge judgment system. Also, it can realize the understanding and sense making. The cognition model notations are given in Table 1.

\[ a(t, x, z, n) = F^{Act}(x, z, n, D_T(t, x, z), A_T(t, x, z), S_T(t, x, z), E_T(t, x, z), L_T(t, x, z), O_T(t, x, z)) \]  

Eq(1)

Dynamic modeling of the abstract model for agent based emergency cognition model shows in Figure 1. Dynamic abstract model covers the action, sensing, dynamic cognition evaluation, learning and decision. In addition the control module activities are listed in Table 2. Also Eq. 1 represents the all of the activities of abstract system.

Our suggested model could be done flowing properties:
- situation assessment
- understanding context surrounding
- communication
- collaboration

Table 1. Summary of the notation

<table>
<thead>
<tr>
<th>Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Agent's dynamic abstract model</td>
</tr>
<tr>
<td>(A^a(x, z, n))</td>
<td>set of all agents</td>
</tr>
<tr>
<td>(a)</td>
<td>time</td>
</tr>
<tr>
<td>(x)</td>
<td>bid, information</td>
</tr>
<tr>
<td>(z)</td>
<td>related system activity: sending bid, receiving bid, negotiate; initiate, request notifications, computing, learning</td>
</tr>
<tr>
<td>(p(x))</td>
<td>Agent's all of the functions</td>
</tr>
<tr>
<td>(D)</td>
<td>process (task)</td>
</tr>
<tr>
<td>(Ac)</td>
<td>action</td>
</tr>
<tr>
<td>(S)</td>
<td>sensing of the situation</td>
</tr>
<tr>
<td>(E)</td>
<td>evaluate (alternatives)</td>
</tr>
<tr>
<td>(L)</td>
<td>learning (situation)</td>
</tr>
<tr>
<td>(O)</td>
<td>Outcome of task T</td>
</tr>
<tr>
<td>(B)</td>
<td>Update ((B_D))</td>
</tr>
<tr>
<td>(C)</td>
<td>Cooperative (CDE)</td>
</tr>
<tr>
<td>(An)</td>
<td>Announce</td>
</tr>
<tr>
<td>(Na)</td>
<td>Negotiate</td>
</tr>
<tr>
<td>(N)</td>
<td>Notify</td>
</tr>
<tr>
<td>(P)</td>
<td>Request notification</td>
</tr>
<tr>
<td>(C)</td>
<td>Computing</td>
</tr>
<tr>
<td>(Co)</td>
<td>Coalition</td>
</tr>
<tr>
<td>(Coe)</td>
<td>Coordination</td>
</tr>
<tr>
<td>(CBS)</td>
<td>Cooperative Information Sharing</td>
</tr>
<tr>
<td>(Col)</td>
<td>Collective Information</td>
</tr>
</tbody>
</table>

III.2 Emergency Response Agent Based Cognition Model

In this paper, the current emergency response management and response systems are analyzed and taking in consideration of domain requirements, agent-based design methodology and systems' comparative view. Dynamic probabilistic unexpected movements and service capabilities illustrated with dynamic stochastic model. Modeled of the system includes the expected and unexpected events. Markov chain model is applied to system and solved for the steady state probability distributions of queue lengths and waiting times. Several performance measures computed with the developed algorithms for the modeled system.

Suggested agent model covers the some parts, which are collective information, coordination, communication, coalition, cooperative distributed information sharing, problem solving and evaluation, decision making. Contract Net (CNET) is preferred to achieving efficient cooperation through task sharing in networks (Weiss, 2012) as well as used in Emergency response System for communicating problem solvers.

Multi-agent emergency response system includes the different tasks of distributed emergency response problem solving such as collective decision making, communication among agents, cooperation, collaborative planning in large scale that deals with uncertainty and conflicting information during emergency response management (Adams et al.). In detail, the suggested type of emergency response systems can be viewed on information and knowledge fusion and take the feedback from the existing agents for sensing, coordinating, decision making and acting. It must be able to achieve these objectives in environments in which: control is distributed; uncertainty, ambiguity, imprecision; multiple agents with different aims
and objectives are present; and resources are limited and vary during the system’s operation.

The suggested model may provide some benefits which are: more robust, interoperable, and priority sensitive communications, better situational awareness, improved decision support and resource tracking, greater organizational agility, better engagement of the public. Emergency response model covers the very wide area respects of the nature events (earthquake, floats, fires, hurricane, and thunder storms), terror events (considering of the coming information), fault of the people or devices (accidents, fires, explosions etc.).

**Knowledge Base Agent:** It includes the terror events and accidents as unnatural events, also natural events include the earthquake, flood, fire, hurricane, statistical data and current data. The knowledge base agent takes data from environment observation. Also system inputs connected with the knowledge base with simultaneously coming data information, historic data and weather data. At the same time, learning process shares the data with system inputs and knowledge base. It covers the database, which is related to the system components. It provides the using of the information whole system.

**Input Agent:** In this part uses the knowledgebase agent’s database and obtained simultaneous data. At the same time statistical data and simultaneous data are evaluated with together in this part.

**Risk Assessment Agent:** It occurs from two parts, these are analysis and evaluation. Analysis part considers the hazard analysis, damage assessment, loss assessment with current situation in grading to the importance degree during the decision making. Evaluation includes the alternatives and criteria’s comparison structure.

**Learning Agent:** Learning agent is the most important part. Three different approach help to realizes the learning procedure which are experiment, information and method also it can assist to capability of the intelligence in agent system.

**Performance Estimation Agent:** It includes the information and coming data information. Processing of the information provides the coming data analysis and evaluation with proper decision making structure.

**Service Provider Agent:** The agent includes the service system which includes the ambulance service, logistic service, police linked service, combined emergency service.

**Decision Making Agent:** It includes the system outputs which are prediction of the event type, prediction of the location, prediction of the correct resource usage and correct resource coordination.

The system goal in this agent-based coordination network between emergency support system and people who are needs to support is divided into three parts: defining the initial negotiation strategy, considering the emergency assessment factors, and finding the cost functions and report results.

The architecture of a cognitive agent shown in Fig. 2 consists of five modules: perception, decision making, knowledge, control, and communication. The perception module is responsible for data acquisition in the environment. The decision making module is in charge of the agent making a decision in an autonomous way.

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**Figure 2 Agent Based Emergency Response Cognition Model**

The control module processes the plan into tasks and executes the tasks to the environment. At the same time, this module sends the tasks to the communication module if the plan is processed by the agent team. The communication module is responsible for interactions between the cognitive agent and the agent community. It receives or sends messages, interprets them and transmits the tasks of the control module to other agents. The knowledge module contains
intentions, and plans of the agent. Control module is so important for the decision making agent. It covers the update, process of the task, evaluate of the alternatives, compare, learning, announce, negotiate, notify, request, notification and computing. Figure 3 represents the common model for markov chain based probabilistic transition and information. The algorithm structure shows the main loops of the control module. Some of the main processes in decision making algorithm are listed in below:

<table>
<thead>
<tr>
<th>Process</th>
<th>D(t,x,z_n)</th>
<th>D:process(task)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing</td>
<td>SD(t,x,z_n)</td>
<td></td>
</tr>
<tr>
<td>Evaluate</td>
<td>E(t,x,z_n)</td>
<td>e:evaluate(alternatives)</td>
</tr>
<tr>
<td>Evaluate</td>
<td>L(t,x,z_n)</td>
<td>l:learning(situation)</td>
</tr>
<tr>
<td>Negotiate</td>
<td>p:learning(situation)</td>
<td>l:learning(situation)</td>
</tr>
<tr>
<td>Notify</td>
<td>Communication</td>
<td>Announce</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process</th>
<th>p:=p Alternative plans</th>
</tr>
</thead>
</table>

Suggestion of the new plan for current situation
Realization of the plan degree
Comparing of the plan and the real situation
Plan’s success degree

Execute (p) adjusting of the conditions and situations for execution of the plan

![Figure 3: A common model for information processing. Example schema of information processing unit.](https://via.placeholder.com/150)

IV. AGENT BASED EMERGENCY RESPONSE COGNITION MODEL: CASE STUDY

The case study covers the some steps which are system analysis and design; building of conversation; system processes.

4.1 System analysis and design

The coordination network covers the system component, experts and people. FIPA –Contract-Net-Manager protocol is applied to analyze and
design the system. Finally, the pattern of this system is built and illustrated. This study emphasizes the coordination of the network emergency assist system and who needs the assist one. The agent mechanism structure can be applied to establish such a negotiation system with the distinction from the emergency information system, and at the same time based on research as shown in the literature review.

4.2 System analysis
The agent can complete complicated negotiation with related agent. Agents work automatically without rest on coordination, enabling the drivers to seek out. As the agent architecture, the FIPA – Contract-Net-Manager protocol is preferred.

4.2.1 Agent classes
In negotiation, the agents engage in dialogue, exchanging proposals with each other, evaluating other agents’ proposals and modifying their own proposals and then modifying their own proposals until all agents are satisfied with the set of proposals. Standard negotiation mechanisms adopted are based on game theory or on human-inspired negotiations. Every task also defines higher level, complex interaction protocols requiring coordination between multiple agents. First, the system checks emergency assist opportunities information for user when he inputs data into the system, and sends a message to emergency support agent. Second the user agent negotiates with the user agent through to emergency assist agent. The bidding continues until the driver agent accepts one bid or rejects them all.

4.2.2 Tasks
A task is a structured set of communications and actions. The ovals denote tasks that the role must execute in order to accomplish its goal. These concurrent tasks are defined as a finite state automation specifying messages sent between roles and tasks. The lines between nodes indicate protocols between tasks, which define a series of messages between the tasks that allow them to work cooperatively.

In this step, an agent class diagram is created, as depicted in Figure 4 from the viewpoint of the roles, documented. The agent class diagram depicts agent classes as boxes, and the conversations among them as lines connecting the agent classes. Four agent classes are defined: user agent; assist agent; information agent; decision making agent.

4.2.3 Roles
- Reporting any situation that requires a police officer at the scene (e.g. assaults, traffic accident, burglary report, damage to property, parking complaint, other ordinance violations, etc.)
- Call an ambulance for medical assistance.
- Reporting fire, smoke or fire alarm.
- Reporting a crime in progress.
- Reporting suspicious or criminal activity. (shouts for help, glass breaking, vehicle or person that does not appear to belong in neighborhood).

4.2.4 Sequence Diagrams
A use case is a narrative description of a sequence of events defining desired system behavior. A sequence diagram depicts a sequence of events between multiple roles and defines the minimum communication between roles. Use cases can be drawn from the system requirements and users. Then the use cases can be restructured into sequence diagrams. The proposed system has five main sequences of events, which are described in the following by use cases and sequence diagrams.

Refining roles: The third step is to ensure that all the necessary roles have been identified, and to develop the tasks that define role behavior and communication patterns. Through applying the use case step, the roles of the proposed system have been defined roughly, so in this step they are refined, and tasks associated with each role are created. Fig.4 illustrates a agent architecture role model.

4.2.5 Conversations
With negotiation, the agents engage in dialogue, exchanging proposals with each other, evaluating other agents’ proposals and then modifying their own proposals until all agents are satisfied with the set of proposals. Standard negotiation mechanisms adopted are based on markov chain approach and human inspired negotiations.

In negotiating phase, the roles which are emergency support agent, decision making agent, user agent includes the main messaging system. A communication diagram is a pair of finite state machines defining a conversation between two participant agent classes. The
syntax of the communication class diagram is very similar to that of the roles include emergency response parameters.

The assist agent realizes the negotiation as follows:
The initiator agent estimates the minimum cost and time resource point
The respondent agent proposes the bid lately
The initiator agent proposes the minimum cost
The initiator agent proposes the minimum distance
The initiator agent bids

Figure 4 Agent based architecture

The suggested model realizes the following steps:
Step 1: Determine the asking help choices and the assist alternatives
Step 2: Revise asking resource slightly
Step 3: Diagnose whether exceeding the end time and distance
Step 4: Consider the types of messages
Step 5: Control of the limitations
Step 6: Evaluate the final situation

The agent architecture defines the configuration of the system to be implemented. The overall system architecture is defined by deployment diagrams. The proposed system is divided into two subsystems. Subsystem 1 includes four agents: agent; assist agent; information agent; decision making agent that provides the negotiable spaces of the dynamic behavior. Also some of the system components uses the some input data such as calling system people’s voice tone like calm, angry, excited, slow, rapid, soft, loud, vulgar, laughing, crying, normal, distinct, slurred, intoxicated, nasal, stutter, lispy, raspy, ragged, clearing throat, deep breathing, cracking voice, disguised, accent, electrically altered, familiar, rational, irrational; background voice frequency like, airport, animal noises, baby, clear, local, school, factory machinery, office machinery, restaurant, television, house noises, motor, music, street noises, kids, traffic, long distance, party

4.2.6 System process

In multi agent decision making, the agents utilize classical artificial intelligence decision making methods to decision making their activities and resolve any foreseen conflicts.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Event Type</th>
<th>Event Distance</th>
<th>Emergency Size</th>
<th>How many per</th>
</tr>
</thead>
</table>

Table 4 Emergency response criteria types

In order to represent the subjective multiple attribute preference of making decision of emergency, a decision hierarchy based on the ordered weighted averaging (OWA) is used. OWA is a useful decision analysis tool which analyzes the decision problem quantitatively by utility. The basic idea of the OWA is for dealing with a problem where its result comes from two or more attributes. Also OWA provides a general class of parameterized aggregation operators that include the min, max, average, and several other operators. OWA was originally introduced by Yager (1988; 1993) has gained much interest among researchers, hence many applications in the areas of decision making, expert systems, data mining, approximate reasoning, fuzzy system and control have been proposed.

Attributes can be specified and then a ordered weight function can be constructed to evaluate utility values of different solutions. The solution with the best utility will be selected. Each agent keeps a driver’s decision hierarchy as multi-attribute preferences. The people who have some problems that related about the

1. System have to determine the problem class
2. After classification, system has to find solution about the problem in a short time and short distance to someone who needs to emergency assist.
3. Emergency assist agent system has to making decision with the all of the components.

The suggested system considers the different parameters for the evaluation of the information for selection of the best choice. The system decision making process uses the different management methods like the OWA and fuzzy logic for the uncertainty situations. Also multi attribute utility theory uses the certain information and uncertain information with fuzzy approach. $U = w_1U_1 + \ldots + w_nU_n$, where $U$ is the overall utility value; $w_i$ is the
weight of the \( i \) th attribute; and \( U_i \) is the utility of set \( i \) th attribute. The sum of the weights \( w_1 + \ldots + w_n \) is equal to one. Weights correspond to the relative importance that manager place on the related attributes.

V. Conclusion

This paper discusses agent based emergency response cognition model with an active multi agent database system which incorporates active rules in a multi computing environment. The partitioning of the rule set into multi agent system events has also been obtained from Markov chain model. Answer based event recognition has been introduced to active multi agent databases, which is an important contribution from the perspective of performance. (matching the situations) This system helps people to reach emergency remedy resources easily. Finally, due to frequent changes in the positions and status of objects in an active mobile database environment, the issue of temporality should be considered by adapting the research results of temporal database systems area into active mobile databases.

This paper gets the agent-based simulation and determines an optimal plan to emergency response model in the shortest time possible. Agent simulation for emergency response cognition model improves upon other simulation models that are concerned with numerical analyses of inputs or amounts of people and structures. The agent-based system for emergency response model is grounded on empirical data taken from real-world experiments. If the agent sees an exit, it will proceed towards it and if it receives any types of direction to leave, that will be carried out without failure. Further study includes the improvement of the text mining techniques with new respect. Also agent based emergency response cognition model provides to evaluate uncertain and vagueness information.

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