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A Review of Various Agent Based Resolution Modelling Methods

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***Abstract*— Resolution modelling has been used for the display of the real time information of a system hierarchy such as defence system, business management system and others. Many resolution models has been proposed such as variable resolution modelling, cross resolution modelling and multi resolution modelling in terms to enhance the quality of the real time information display. These resolution models are constructed along with agents who are meant to pass the information between the various levels of hierarchy. This paper provides an overview of variable resolution modelling, cross resolution modelling and multi resolution modelling by presenting their functionality and characteristics. Also the comparison is provided based upon the calibration, decision-making, aggregation, level of resolution for a finer detail.**

Keywords - Cross-Resolution Modelling, Variable-Resolution Modelling, Multi-Resolution Modelling, Agent Based Simulation

I. Introduction

Resolution modelling is a growing technology that allows the users to access the information at various levels of system hierarchy. It generally deals with two level of resolutions that are disaggregation level and aggregation level. A disaggregation level provides a high resolution detail about the entities of a level of hierarchy while an aggregation level provide low resolution detail regarding the entities. A model is said to be of high resolution if it deals with more fine grained entities and their attributes. A model with the same set of entities and attributes may have high resolution then other if it provides the information regarding the relationship between the attributes in more detail. Figure I show the various aspects of the resolution.

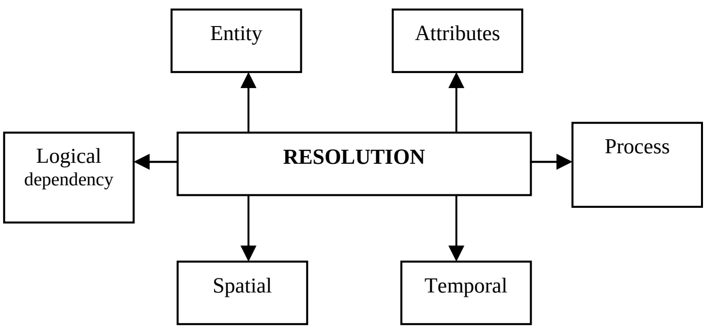

Figure-I Aspects of Resolution

Usually, people doing simulation think of higher resolution as associated with lower-level resolution. By taking the example of military we make the distinctions among different aspects of resolution. Entity resolution refers to the individual units rather than battalions. Attribute resolution explains the net weapon strength of each battalion at low level and number of various weapons held by each battalion at high level. Logical-dependency resolution that standard formation (sum of men in battalion) at low level is same as the circumstantial formation (number of men in the battalion) at high level. It includes the constraints on the attributes and their interrelationships. Process resolution allocates the attrition evenly among battalions on the front line at low level and computes the combat attrition at battalion level based on battle situation at high level resolution. Higher spatial and temporal resolution means using finer scales for space (miles for low level and feet for high level) and time(days for low level and minutes for high level).

An agent based model consists of agents that interact with the environment and programmed to react to the computation environment of the model. These agents can pass the informational messages to each other and act on the basis of what they learn from these messages. The interaction between the agents makes the agent based modeling different from the other computational models. The JACK intelligent agent framework by Agent Oriented Software brings the concept of intelligent agents into the main stream of commercial software engineering. JACK intelligent agent is a third generation agent framework designed as a set of light weight components with high performance and strong data typing. Figure-II represents the functions and attributes of the agents.

Figure-II: Agents Function and Attributes

The rest of the paper is organized as follows. The section II presents the variable-resolution modeling, section III presents the cross-resolution model connection. Section IV presents the Multi-resolution modelling. Section V presents the agent based simulation. Section VI presents the overall comparisons of all the resolutions models in terms of consistency, calibration, decision making, cost and explanatory power. Section VII presents the conclusion of the models. Section VIII presents the future scope. Section IX presents the acknowledgement. Section X presents the references.

II. VARIABLE RESOLUTION MODEL

Variable resolution modelling is defined as connecting, different resolution models to form a "family". It basically was made for the Defence Advanced Research Projects Agency. For every analysis, the model should involve two or more levels of resolutions, where resolution is a relative concept but increasing or decreasing resolution depends upon the given level. It was developed in 1983. Variable resolution modelling building models or model families so that users can change readily the resolution either by turning resolution knobs within a single model or turning from one model to another in a family[3]. Variable resolution is important to us because of low and high level resolution. Need for low level resolution modelling is because of initial cuts (innovation, exploration, etc.) systems analysis and policy analysis, decision support, Low cost and rapid analysis and need for high level resolution modelling is because of understanding phenomena, representing knowledge with full detail, simulating reality, making use of high-resolution knowledge and data. Its main applications were selected combat and political models.

To support the zooming interaction, the simulation model has to be designed at multiple levels of resolution. We cannot create simulations that will support continuous zooming but we can aim to making several discrete changes in the resolution that are easy to follow but within limits. By this we can zoom at a desired level. So it is upon us that which level we want to see in detail or normally. The model should be hierarchical. VRM methods are also often used to enable cooperation between multiple models with different levels of resolution that were originally designed to run separately. We use this model because of the execution speed is very high for complex model [5]. Some earlier studies told us that variable-resolution modeling had the disadvantage of conveying to some readers the misimpression of continuously variable resolution [2].

III. CROSS-RESOLUTION MODEL CONNECTION (CRM)

Cross-resolution work is done by linking existing models that were not designed to be connected. It links the existing models with different resolution that cooperate to fulfil a common objective. This linking may be difficult, particularly in the case where the models were designed independently. The output of one model becomes the input of another model [1]. But sometimes it is also unable to accomplish well. Models are forced to combine which are not initially designed for integrate. But cross-resolution model connection can often be accomplished best than variable-resolution modelling as if we roll back and assume to have a start again. So in this results are more consistent [2].

IV. MULTI-RESOLUTION MODELING (MRM)

Multi-Resolution Modeling (MRM) is one that conducts the simulation using multi-precision and multi-level method. It takes the difference between interaction levels as principles, uses modelling methods of different precisions and different levels to describe each function to Control the System, in order to improve simulation fidelity and efficiency. The multi-resolution modelling methods had two focus problems, model's consistency and cost-effectiveness. One sufficient method to MRM should satisfy the following requirements. (1) Multi-resolution interactions. The simulation entities in different levels of resolution could send and receive interactions to change some attributes concurrently. (2) Multi-representation consistency. Consistency means accuracy. The simulation models in different levels of resolution must maintain consistency. (3) Cost-effectiveness. In a good multi-resolution model, the cost of simulating multiple models and maintaining consistency among them should be comparatively lower [7].

The primary MRM methods are selective viewing, aggregation-disaggregation and multi-resolution entity. In these methods, aggregation-disaggregation was most widely used and was considered to be the most capable of manifesting the essence of MRM. In aggregation-disaggregation method, a simulation entity was built multi-resolution model which could dynamically change its level of resolution in simulation process. In general situation, the simulation entities were executing in low-resolution level. When simulation needed more model details, the model changed itself to high-resolution level. After that, the model could also change back to low-resolution level when those details were not needed any more.

Multi-resolution modelling (MRM) is building a single model, a family of models, or both to describe the same phenomena at different levels of resolution [2]. It is independent of computational power. MRM sometimes called variable-resolution modelling but it is more consistent. It is also called model abstraction so that we get the important detail of any model. It is very useful for complex models. It is used in war-gaming and transformation. It is economical because not every time we are using the high resolution. It has good explanation power. Together, VRM and MRM methods are collectively referred to as MRM. In MRM, multiple models at different detail levels are executed jointly.

V. AGENT-BASED MODELING AND SIMULATION (ABMS)

Distributed Artificial Intelligence is closely related to and a predecessor of the field of Multi-Agent System. Agent-based modeling and simulation is a relatively young approach for the analysis, modeling and simulation of complex systems. The systems that we need to analyze and model are becoming more complex in terms of their interdependencies. We are beginning to be able to take a more realistic view of these systems through Agent Based Modeling and Simulation (ABMS). By this data is becoming more organized into databases at finer levels of granularity. Agent Based Modeling and Simulation (ABMS) is used where large number of simulations are required. An agent specifies a set of properties that must characterize an entity to effectively call it an agent, and in particular autonomy which refers to the possibility to operate without intervention by humans, and a certain degree of control over its own state. Social ability is meant for the possibility to interact employing some kind of agent communication language. Reactivity is the possibility to perceive an environment in which it is situated and respond to perceived changes and the last is *pro-activeness* refers to the possibility to take the initiative, starting some activity according to internal goals rather than as a reaction to an external stimulus. ABMS uses to support decision-making. Computational advances have made possible a growing number of agent based applications in a variety of fields. Applications range from modeling agent behavior in the stock market and supply chains, to predicting the spread of epidemics and in military applications and war gaming. ABMS has strong roots in the fields of multi-agent systems and robotics from the field of artificial intelligence (AI) [6]. The JACK Intelligent Agents framework by Agent Oriented Software brings the concept of intelligent agents into the mainstream of commercial software engineering and Java. JACK Intelligent Agents is a third generation agent framework, designed as a set of lightweight components with high performance and strong data typing [4]. It supports the BDI (belief, desire and intention) model and Simple Team, an extension to support team-based reasoning. BDI (belief, desire and intention) is an intuitive and powerful abstraction that allows developers to manage the complexity of the problem. Figure 3 illustrates the multi agent based system at micro and macro level in which it has a hierarchy system from top to bottom level and user can see the detail according to the need.

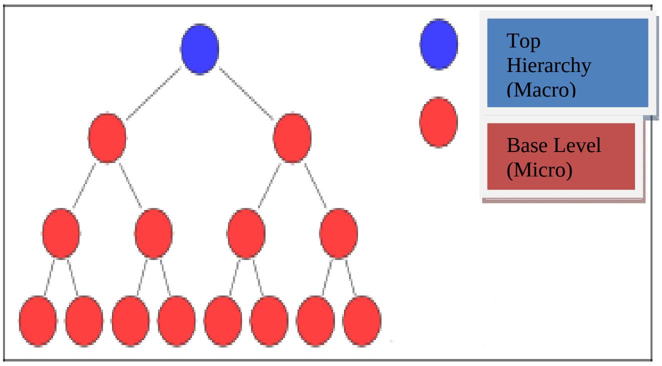

Figure III Multi-Agent Based Simulation (MABS)

VI. Comparisions Of Models

This section provides the comparative analysis of the variable resolution modelling, cross-resolution modelling and multi-resolution modelling on the basis of consistency, calibration, decision making, computational force, cost and explanatory power. (Table I)

VII. Conclusion

In this paper, we have reviewed a broad range of resolution modelling methods with agent based simulation. We classify all models and summarize the properties, describe the operation, advantages, characteristic and list the strengths and weaknesses. We have focused on variable resolution modelling, cross-resolution modelling and multi-resolution modelling on the basis of consistency, calibration, decision making, computational force, cost and explanatory power. Agent based modelling and simulations are also discussed depending upon their autonomous behaviour, pro-activity, social ability, decision-making and interdependences.

VIII. Future Work

So many models have been used for resolution modelling like variable resolution modelling, cross-resolution modelling and multi-resolution modelling. Variable resolution modelling, cross-resolution modelling are good but do not accomplish well for given task as they are not so much consistent. In multi-resolution modelling we can enhance the productivity by lesser the computational power. It is less expensive. Command Agent can do effective and accurate decision making based on the propagated beliefs of its sub teams. We can enhance this work to next level by using the IHVR (Integrated hierarchical variable resolution) model in which we apply different models at every level.

IX. Acknowledgement

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Table-I Comparision Of Models

Models	Consistency	Calibration	Decision-Making	Computational Force	Economical	Explanatory Power
VRM(variable-resolution modelling)	Moderate	No	Not appropriate	More	No	Low
CRM(cross-resolution modelling)	Good	Yes	Yes	More	No	Good
MRM(multi-resolution modelling)	Very good	Yes	Very good	Less	Comparatively low	High

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