Component based Agent Simulation Modeling for Self-Evolving House Market Prediction

Joonyoung Jung, Jang Won Bae, Chunhee Lee, and Euihyun Paik
Smart Data Research Group
Electronics and Telecommunications Research Institute
Deajeon, Korea
e-mail: jyjung21@etri.re.kr

***Abstract*— Because actual population forecasting is expensive and impossible, recent agent-based microsimulation is used to predict social problems. An agent-based model (ABM) models the interaction between an agent and each agent. However, long-term simulations using rule-based ABMs accumulate simulation errors. To avoid this error accumulation, the simulation model must be dynamically reconfigured using the actual data during the simulation. In this paper, we propose a component-based agent simulation modeling for model reconstruction and implemented a housing market ABM simulation system using DEVS (Discrete Event System Specification) C++ engine to evaluate the effect of error accumulation avoidance. As the simulation progresses, the housing market ABM is dynamically modified to reduce errors between the actual data and the simulation results.**

Keywords-Agent Simulation; Component; Self-Evolvement.

I. INTRODUCTION

Actual population expectation is expensive and impossible because the modern society is complex and various. Therefore, microsimulation modeling (MSM) and agent based modeling (ABM) are used for modeling and simulation. Microsimulation models the individuals with real data and defines behaviors based on transition probabilities derived from micro data. ABM models individuals and interaction between the individuals. ABM mostly defines behaviors based on rule. Simulation mimics the operation of an actual process or system and is used to predict the future [1]. We can perform simulations to take appropriate action on potential problems in the future. Through micro-simulation, various characteristics of the members of society can be predicted and used to predict social problems [2] [3]. However, agent-based simulation has the disadvantage of accumulating errors, so long-term simulations can be error-prone. To avoid this error accumulation, it is necessary to reconstruct the simulation model dynamically using real data. In this paper, we propose a component-based agent simulation model for reconstructing a simulation model.

The rest of the paper is organized as follows. Section II describes related work, while Section III describes the house market simulation. In Section IV, we describe component based ABM modeling for housing market simulation, and in Section V, we provide the result of our experiments. Some concluding remarks are finally given in Section VI.

II. RELATED WORK

MSM is one of the most useful modeling tools for simulating at micro level and for predicting the consequences of possible policy changes [2] [3]. A simulation model for predicting the future using MSM was implemented. In other words, the dynamic simulation of the income model was developed to analyze the long-term distributional consequences of retirement and aging problems in the United States [4] and the dynamic microsimulation model was developed in Australia to model economic and demographic change in the Australian population over time [5] [6]. An agent is a micro-unit that can independently determine its behavior based on environment, own state, and interaction with other agents [7]. The ABM was proposed in the segregation model [8], household demography [9] and population dynamics [10]. However, previous ABMs are not able to evolve the structure and parameters of model. Therefore, long-term simulations accumulate simulation errors.

III. HOUSING MARKET SIMULATION

We designed and implemented a housing market ABM simulation system to evaluate the effect of error accumulation avoidance.

A. Self-evolving simulation framework

The Self-evolving simulation is an agent simulation to mitigate long-term simulation error autonomously. To evolve simulation model, there are some modules in framework. The data management module (DMM) collects, digitizes, and saves data in database. The change recognition module (CRM) receives real world data and simulation results from the DMM and a simulation module (SIM). And then, it compares these data. Whenever the CRM recognizes difference over threshold, the CRM informs a model evolvement module (MEM) of the change. The MEM is triggered by the CRM when change is discovered. The MEM finds the evolving strategy to decrease the difference between real world data and simulation results. And then, it suggests that an ABM reconfiguration module (ARM) should change parameter and model with new parameter and model, which are suggested by the MEM. The ARM updates the simulation model according to the strategy from the MEM. To update a simulation model using an evolving strategy, the simulation model should be consisted of components. For simulation performance, the distributed and paralleled simulation may be accomplished by a simulation engine.

B. House market simulation scenario

The self-evolution simulation framework can be applied to social problem simulations that require long-term simulations. We apply the proposed framework to a house market simulation, as shown in Figure 1. First of all, there are some agents, such as a house holder, external supplier, and bank, and some environments, such as a house market and house, in a house market ABM. The house holder is a micro agent to buy, borrow, sell, and lend a house. The external supplier is a micro agent to make, sell, and lend a house. The bank is a micro agent to give loan to the house holder who wants to buy or borrow a house. The house market is an environment to collect the house information, which is listed to buy or sell. The house is an environment to have all houses information. The real world house market data are collected. The essential data are house price and house trade volume. The economic data related to house market are gross domestic product, exchange rate, price index and money supply. Therefore, these data is received in real world and then digitized. The house policies are policy parameters, which have an effect on the house price and house trade volume. These policies are input parameters of the simulation. And then, these policies are analyzed using the simulation results.

Figure 1. Hosing market simulation scenario.

The CRM receives the house price and trade volume of real world from DMM and the house price and trade volume of ABM simulation result from SIM.

CRM receives real world house prices and trade volume from the DMM, and receives the house values and trade volume of the ABM simulation results from SIM. When CRM perceives the difference over threshold between these data, CRM informs MEM of it. The MEM evolves the economic condition recognition of each agent as hidden variable. The MEM decides the hidden variable using machine learning and then sends it to ARM. The ARM updates the simulation model according to information from MEM. After updating the simulation model, the new simulation model conducts a simulation. This process is recursively repeated to reduce a long-term simulation error.

After finishing the simulation, the simulation results are analyzed by policy maker or simulation analyzer.

IV. COMPONENT BASED ABM MODELING FOR HOUSING MARKET SIMULATION

Agent model can be componentized. Each agent consists of the situation awareness (SA), adaptation and projection (AP), and decision making (DM). Each SA, AP, and DM consists of one atomic component. Components have various levels from atomic model (AM) to coupled model (CM). The model structure from the top level, housing market ABM, to the lowest level, AM, is shown in Figure 2.

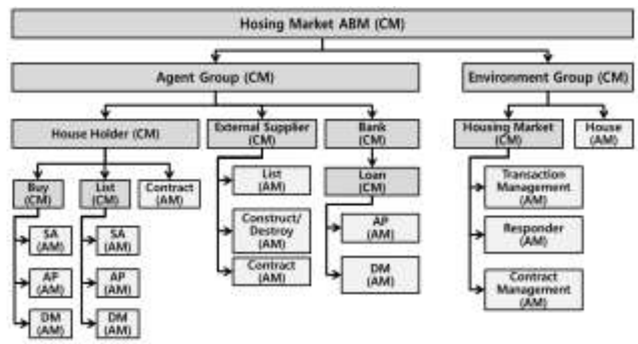

Figure 2. Housing market ABM structure.

Housing market ABM is a top level model and includes the agent group and environment group. Agent group can identify the situation and make judgment on its own as an individual subject. The agent group is divided into the house holder, external supplier, and bank. The environment group is a passive object that does not judge itself and affects agents. A house holder is a key component of this model and includes buy, list, and contract actions. For buy and list, it is designed by SA, AP, and DM concept. An external supplier has the actions of list, construct, destroy, and contract. A bank gives a loan and receives money from house holder. The loan behavior can be designed by SA and DM concept. A housing market is an environment element that connects the house holder and house. It consists of the transaction management, responder, and contract management. In these AM and CM, the essential models are the agent group and buy model.

A. Agent group design

Agent group model consists of the house holder, external supplier, and bank. These agents interact with each other and environment group, as shown in Figure 3.

The house holder provides the following functions. First of all, it lists houses for sale and rental at an environment group. Second, it purchases and rents a house listed in the environment group. Third, it carries out contracts with other agent. Forth, it requests the house information listed in the environment group. Fifth, it receives information about economic indicators from the environment group. Sixth, it receives and processes contract termination information from environment group. Seventh, it receives the housing market information from the environment group. Eighth, it requests loanable amount to the bank and receives the response from the bank. Ninth, it requests a loan to the bank and receives the response from the bank.

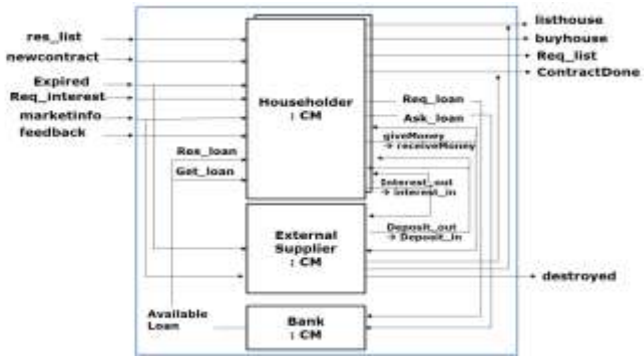

Figure 3. Agent group model for housing market ABM

The house holder provides the following functions. First of all, it lists houses for sale and rental at an environment group. Second, it purchases and rents a house listed in the environment group. Third, it carries out contracts with other agent. Forth, it requests the house information listed in the environment group. Fifth, it receives information about economic indicators from the environment group. Sixth, it receives and processes contract termination information from environment group. Seventh, it receives the housing market information from the environment group. Eighth, it requests loanable amount to the bank and receives the response from the bank. Ninth, it requests a loan to the bank and receives the response from the bank. The external supplier provides the following functions. First, it requests for demolition of the existing house listed in the environment group. Second, it builds new house and lists the new house in the environment group. Third, it receives and processes the contract termination information from the environment group. Forth, it receives the housing market information from the environment group. The bank provides the following functions. First, it carries out the function of giving loan to the agent who wants to purchase and rent the house. Second, it receives the inquiry message about loanable amount from the house holder and responds the loanable amount to the house holder. Third, it receives a message requesting a loan from the house holder and responds the loans to the house holder.

B. *Buy behavior design*

The buy behavior is consisted of SA, AP, and DM. The modeling methodology designed through SA, AP, and DM can easily reconstruct the detailed behavior of each agent. Basically, each behavior of Agent is designed as SA, AP, and DM as shown in Figure 4.

The SA can be reconfigured into any type of component if only the input and output matches the AP and DM. AP and DM can be easily reconfigured if the input and output are matched with other components.

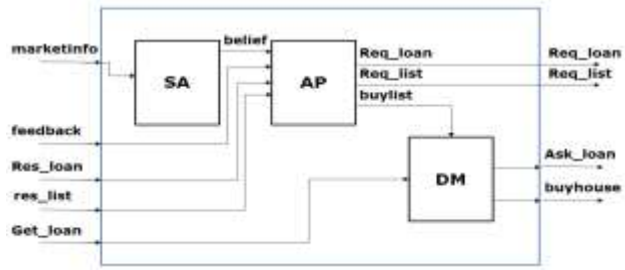

Figure 4. Buy behavior model for housing market ABM

The SA receives the market information (average transaction price, average transaction rate, etc.) of housing from the environment group and judges the real estate market situation as boom, a recession and a normal time, and then transmits the real estate market situation to AP as shown in Figure 5.

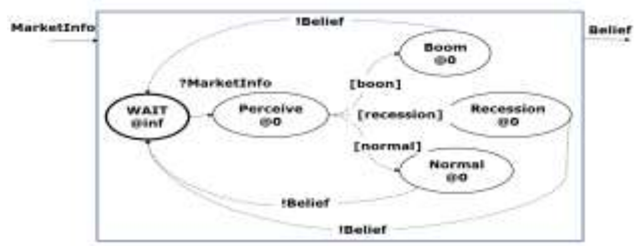

Figure 5. SA model of buy behavior for housing market ABM

The AP requests loan and house information and then receives the information on the market situation (boom, recession, normal), feedback (list of sale information, selling price, average selling price), loans, and a list of available houses. After receiving all information, it judges the house price after considering the current price and the future price, and transmits the result of judgment (buy list) to the DM as shown in Figure 6.

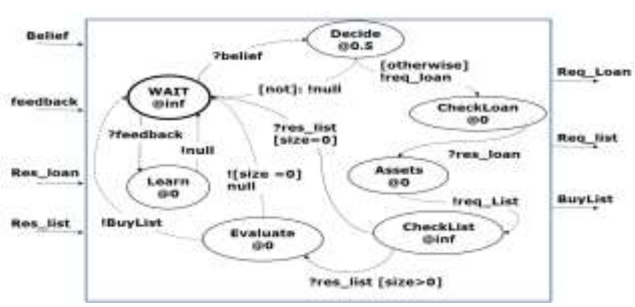

Figure 6. AP model of buy behavior for housing market ABM

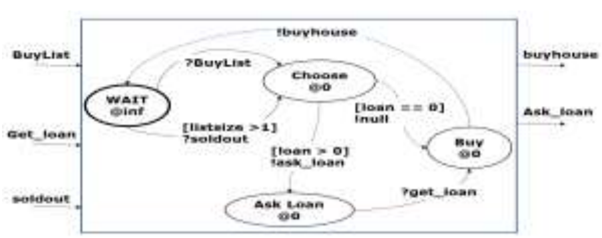

Figure 7. DM model of buy behavior for housing market ABM

The DM receives a list of houses to be purchased from the AP and requests and receives a loan amount. And then, it determines a house to be purchased using the loan amount and the house list information. The result of DM (buy house) is transmitted to the environment group as shown in Figure 7.

V. EXPERIMENTS

In order to verify the developed housing market ABM, we implement it as a formal agent component model, and verify the reconstruction of component.

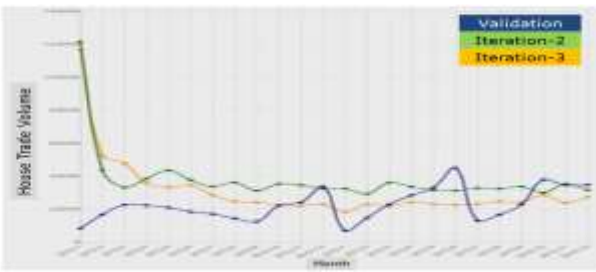

Figure 8. Model reconfiguration phase for mitigating the difference between validation data and simulation result

We implement an ABM simulation system using the discrete event system specification (DEVS) C++ engine. The initial model (iteration 1) is conducted in the simulation system and then the simulation result (house trading volume) is compared with the validation data. The MEM finds better parameter and component of model to reduce the error between validation data and simulation result and then sends result information to ARM. The ARM updates the model according to the information from MEM, and then conduct simulation recursively.

During the evolving simulation, the errors of previous model and changed model are compared as shown in Figure 8. Errors with the verification data in the iteration 2 were reduced in the iteration 3. The validation data are the real house trade volume of Seoul in Republic of Korea. We got the real house trade volume data from the web site managed by Ministry of Land, Infrastructure and Transport in Republic of Korea.

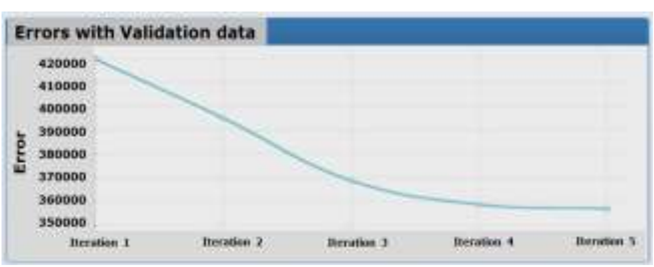

Figure 9. Self-evolving simulation result for house market ABM

After finishing the evolving iteration, the house trade volume of each model (from iteration 1 to iteration 5) is compared to see how much errors have gone down, as shown in Figure 9. As the iteration progresses form iteration 1 to iteration 5, the house trading volume errors with the validation data are reduced. Therefore, the parameter and component of model are properly modified autonomously.

VI. CONCLUSION AND FUTURE WORK

This paper addressed the component based agent simulation modeling for self-evolving house market prediction. This paper proposed component model to reconfigure the model autonomously. To evaluate the effectiveness of the component based agent simulation modeling for self-evolving simulation, we implement house market ABM simulation system using DEVS C++ engine. The self-evolving simulation automatically updates the housing market ABM and reduces errors between the validation data and the simulation results.

We will implement the proposed simulation in the distributed and paralleled simulation environment.

ACKNOWLEDGMENT

This research was supported by the ICT R&D program of MSIP/IITP, [R7117-16-0219, Development of Predictive Analysis Technology on Socio-Economics using Self-Evolving Agent-Based Simulation embedded with Incremental Machine Learning].

REFERENCES

[1] J. Banks, J. Carson, B. Nelson and B. Nicol, “Discrete-event system simulation,” Prentice Hall, 1984.

[2] G. H. Orchtt, "A new type of socio-economic system," The review of economics and statistics, vol. 39, no. 2, pp. 116-123, May 1957.

[3] A. Harding, "Challenges and opportunities of dynamic microsimulation modelling," Plenary paper presented to the 1st General Conference of the International Microsimulation Association, Vienna, Aug. 2007.

[4] M. Favreault, and K. Smith, "A primer on the dynamic simulation of income model (DYNASIM3)," Urban Institute, Feb. 2004.

[5] S. Antcliff, "Introduction to DYNAMOD: a dynamic population microsimulation model," Technical Paper No 1, National Centre for Social and Economic Modelling (NATSEM), University of Canberra, 1993.

[6] A. King, M. Robinson, and H. Baekgaard, “DYNAMOD-2: An overview,” Techincal Paper No. 19, National Centre for Social and Economic Modelling (NATSEM), University of Canberra, Dec. 1999.

[7] A. Getchell, "Agent-based modeling," Physics, pp. 757-767, Jun. 2008.

[8] T. C. Schelling, “Dynamic models of segregation,” Journal of mathematical sociology, vol. 1, pp. 143-186, 1971.

[9] N. Geard, J. M. McCaw, A. Dorin, K. B. Korb, and J. McVernon, “Synthetic population dynamics: A model of household demography,” Journal of Articial Societies and Social Simulation, 16(1) 8, Jan. 2013.

[10] K. Singh, M. Sajjad, and C. W. Ahn, "Towards full scale population dynamics modelling with an agent based and micro-simulation based framework," International Conference on Advanced Communication Technology (ICACT), pp. 495-501, Jul. 2015.