Development of Agent Based Modeling: Case Study on Swiss German University Classroom's Electrical Usage

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Abstract:Lately electrical energy consumption is being the concern in the enterprises facility operation. To measure and replicate the electrical energy usage, the experiment should be conducted. Meanwhile, conducting the experiment on the campus building in the same way as the other experiment which should isolate the environment to the outside world is nearly impossible to do. The agent based modeling and simulation offer the good alternative to doing an experiment to a computer program that could be replicate the real world environment, in this case is the Swiss German University campus building. This study aims to studying the characteristic of agent based model in simulating the electrical usage in SGU, the differences between the agent based simulation and empirical data calculation, and studying the electrical usage of Swiss German University classroom. The simulation is intended to replicates the real usage of the Swiss German University classroom. The result shows the simulation is not replicating the classroom usage, but the simulation is replicating the usage of the electrical energy usage in Swiss German University it not determined by the number of classroom is being use.

Keywords: Agents, agent-based model, model, simulation, state, state chart, watt

1. Introduction

The primary purpose of this research paper is to develop an agent-based model simulation that will replicate the usage of the electricity of the Swiss German University classroom. Throughout the development of agent-based model of electricity usage, the research focused on the usage of classroom's lighting, and air conditioning system. The expected result of this study is the simulation that represents the daily usage of the classroom's lighting and air conditioning system electricity.

2. Related Work

T. Zhang et al. (2010) conducted a research that creating an agent based model simulation to simulate the electricity usage in a school building. The simulation conducted with an AnyLogic simulation software. The simulation is resulting in the electricity usage strategy where it is controlled by automated system, and staff.

F. C. S. Liu (2011) has stated in the publication that there are 3 steps of validating the agent based model:

- The researcher uses empirical data or empirical knowledge to narrow down conditions, to reduce dimensions, or to calibrate initial conditions and the ranges of the model parameters.
- The researcher uses the model specification and generates a Monte Carlo set of micro and macro time series data for that particular combination of empirically plausible parameter values.
- The researcher compares between theoretical realizations and empirical realizations (i.e. real-world data).

In the research paper N. Gilbert(2008), describes about the agent-based model. The brief explanation about the agent based model is:

- Agent based model is a computational method where the simulation are carried by the computer equation using a program, or the simulation itself is the computer program.
- An experiment where the representation of the social phenomenon is replicated and implemented in the isolated environment where it is almost impossible to be conducted without the simulation.
- Model. The replication of real-world phenomenon.
- Agent-based model consist of the interacting agents in the environment. The agent could be the separated computer program, or distinct part of program that represent the entities in the real-world phenomenon.
- The environment is the virtual world where the agent interacting. It could be giving an effect or not to the agent and vice versa.

3. Methodology

There are several steps to conduct this research:

- 1. Data gathering. The interview and survey conducted to gather the data that needed for this research.
- 2. Calculating the electrical usage. The usage of electricity is calculated based on the assumption that gathered from the interview according to the past schedule.
- 3. Creating the agent based model simulation. The agent based model and simulation developed using the AnyLogic software, with a data that gathered in the interview.
- 4. Comparison. To obtain the validity of the agent based model. The output of the simulation is being compared by the calculation result.

4. Model and Simulation

A. Classroom Agents

A classroom agent is the agent that represents the classroom. It has 3 distinctive states that represent empty, empty in the office hour, and operating.



Figure 1. Classroom usage state chart

B. Air Conditioner and Lighting System State charts

There are two state charts that represent the operation of the air conditioner and lighting system.

The air conditioner state charts have states that represent the full and partial operation of the air conditioner. The state chart is triggered by the classroom operation. The air conditioner operation is different while it operates in the full operation than while it is operate in the partial operation.



Figure 2. Air conditioner system usage state chart

The state chart that represents the operation of the lighting system has two states. State that represent when the lighting system is operating or not operating. This state chart also triggered by the operation of the classroom.



Figure 3. Lighting system usage state chart

C. Schedule

There is another agent that represents the weekly schedule of the classroom usage. The schedule will trigger how many classrooms that would be operating in a particular office hour in a day. The rate of the classroom that operates is different from day to day in a week.

The rate of the classroom operation is determined by the calculation of the past weekly schedules.

Sun	Mon	Tue	Wed	Thu	Fri	Sat	Start	End	Value	*
	\checkmark	V	\checkmark	V	V		7:00	8:00	3.733333	E
	\checkmark	\checkmark	\checkmark	V	V	_	8:00	9:00	6.666667	
	\checkmark	\checkmark	\checkmark	V	V		9:00	10:0	5.6	
	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		10:0	11:0	1.666667	
	\checkmark	\checkmark	\checkmark	V	V		11:0	12:0	0.4	-

Figure 4. Classroom operation rate weekly schedule

D. Result

The simulation result and the calculation based on an assumption from the past schedules are being compared. There is a wide gap between the results of the simulation and the calculation based from a schedule for a classroom usage. This gap occurred because of this simulation characteristic that ignored the lunch break and classroom usage gap. On the Friday of the simulation, a huge gap occurred due to the schedule policy in the Swiss German University which ordering all of classroom activities are taking a lunch break together at 12 PM in Friday.



Figure 5. Classroom usage simulation result compared to past schedule usage.

The comparison of the electricity usage between the simulation result which represented as thick line, and the actual of fifth academic week usage which represented as thin line. The result shows where there is a gap between the simulation result and actual usage, but there is no spike between them and there is pattern similarity. Even though the electricity usage simulation results quite similar with the actual fifth academic week usage, there is still a huge gap between them in Friday.

5. Conclusion

From the model and simulation result, several conclusions are made:

• This study develops the Swiss German University classroom usage agent based model. The model is replicating the electrical usage of the Swiss German University's classrooms. But this simulation did not replicate the classroom usage due to the dynamic behavior of real case classroom usage like the classroom cancelation, make-up class, and the special occasion classroom.



- Measuring electrical usage from the past is better to conduct with the schedule data and usage behavior assumption calculation. The better usage of the model simulation is to predicting and forecasting the usage, if there are some changes in usage variable like the changes of the air conditioner policy, air conditioner devices, and other variables that affecting the energy usage.
- Energy usage in Swiss German University is not determined by the number of classroom that being use. Due to the usage behavior that letting the air conditioner turned on when the class is empty, when there are another schedule that filled the classroom in the next time in the same day. For instance: schedule break, lunch break, and schedule gap.

Agent based model simulation is the good alternative to replicates the real environment. Building management team could take an advantages to this method of simulation for taking a managerial decision. Especially when there is a decision that requires forecasting, and prediction.

In the future, the study may be focused on the building a more specific usage behavior, like applying the student agents and its behavior, the janitor agents and its behavior. Applying another agents that affecting the electrical consumption resulting to the more specific and valid usage simulation.

And also, the study in another field like the usage of the office room, parking lot, and another study that involving the real life environment could be conducted with this approach due to the high flexibility of agent based modeling and simulation.

References

- F. C. S. Liu, (2011), Validation And Agent-Based Modeling: A Practice Of Contrasting Simulation Results With Empirical Data, World Scientific Publishing Company.
- N. Gilbert (2008), Agent-Based Models, Guildford, UK: SAGE Publications, Inc
- T. Zhang, P.-O. Siebers dan U. Aickelin, (2010), *Modelling Office Energy Consumption: An Agent Based Approach*, Nottingham: School of Computer Science, University of Nottingham.