論文審査に着目した
学会の質の推移のマルチエージェントシミュレーション

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あらまし　個体による環境の認識と行動とを表現するモデル（エージェント）を基本単位として社会システムのモデルを構築する、現在進行中のプロジェクトについて報告する。本報告の主な観点はモデルが現実世界で経験的に観察される現象に対応可能な振る舞いを示すか否かである。学会をモデル化の対象とし、会員である個体の局所的な行動が学会の社会システムとしての振る舞いに影響を与え、その振る舞いが各個体の行動に影響を与えかえすという関係の表現を行ない、学位取得のための条件や論文審査における情実の有無が、各個体の状態と学会の振る舞いに及ぼす影響を見る数値実験を行なう。計算結果の報告とそこから得られる現実世界に関する洞察を行なう。

キーワード　社会システム，エージェント，学会，シミュレーション，モデル

Multi-Agent Simulation of the Transition of the Quality of Research Association focusing on the Referee Process

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Abstract　This paper reports some current achievements of an on-going project aiming to construct a computational model of an academic association. The authors try to construct the model by organizing agents, each of which represents a researcher belonging to the academic association and the mechanism coupling the perception of environment by the researcher and the actions performed by the researcher. The actions by the agents are expected to produce the behaviors of the academic association, which could be interpreted as the characteristic phenomena in the association. Some results of numerical studies are shown.

Key words　Society System, Agent, Academic Association, Simulation, Model

1. Introduction

This paper reports the current achievements of an on-going project aiming to construct a computational model of an academic association. An academic association, in general, is mainly organized by researchers. One of its major activities is to issue journals composed of research papers. A researcher writes research papers. A researcher also referees research papers written by the colleagues. The authors try to construct the model by organizing agents, each of which represents a belonging to the academic association and the mechanism coupling the perception of environment by the researcher and the actions performed by the researcher. The actions by the agents are expected to produce the behaviors of the academic association that could be interpreted as the characteristic phenomena in the association.

The system of an association is composed of the individuals belonging to the association. The actions performed by the individuals bring about the phenomena observed in the association, i.e., the behaviors of the system. On the other hand, the system of the association influences upon each individual's perception of the association and the actions performed by the individual. In short, the dynamic interactions between the system and the individuals change both the system and the individuals.

We sometimes justify the decision that we made as inevitable in the circumstances brought about by the system of an association. One might want to say that the one cannot help doing something even though the one believes that the other thing should be done. It could be said that the one abandons the responsibility to make a decision to the system. However, the system of an association is not an entity that is independent form its individual members. Behind the circumstances brought about by the system, there may be actions performed by the individuals that renounce their responsibility to make a decision. The individuals' activities are constrained by the circumstances brought about the system of an association that the individuals have made.

The authors have been trying to provide some elucidation of the mechanism behind the phenomena described above. The authors especially concerns the types of microscopic actions performed by the individuals

that significantly influences the macroscopic behavior of the system of an association. The ultimate goal is to find the clues that may help us to make the agenda to change the circumstances brought about by the system to a desirable direction.

There is anxiety about the current and future directions of the associations in which the authors are involved. For example, a committee in Architectural Institute of Japan concerns certain possibilities that may not lead the quality of journals issued by AIJ to the right directions [1]. The anxiety is that the fact that the number of the paper published in the journals is used for acquisition of a doctor's degree and promotion in some universities may bring about the tendency that quantity of papers may weigh more than their qualities. The authors expect the models proposed in a series of researches to contribute, in a social scientific manner, towards providing ways in the right directions.

2. Academic Association Model (AAM)

The academic association model, or AAM, shown in this paper is an experimental version of the University-Academy Coupling Model [2] to explore the directions of extension of the model. The current AAM focuses on the representation of the activities concerning publication of research papers, to see the relations among the research capability of a researcher, the subjective criterion to judge the quality of a research paper, the quality of an academic journal, the number of papers published in the journal, and the requirements to be qualified as a referee of someone's paper. The relation between these foci and the number of published papers required to be a doctor is investigated on the assumption that a referee should be a doctor. The current AAM produces the quasi-causal relations that the lower the requirement for the doctor's degree is, the lower the quality of an academic journal is.

2.1 Research Agents

A research agent, or a researcher in short, is a model of an individual who is a member of an academic association. A researcher is characterized by its properties and actions described below.

2.1.1 Properties of Research Agents

The major properties of a researcher are the degree, the status, the research capability, the paper quality criterion,

the reliance ration, and the age. The values of each of the properties are shown in Table 1.

Table 1 Properties of Research Agent

propertiy name	propertiy value
degree	master or doctor
position	assistant or professor
research capability	positive real number
paper quality criterion	positive real number
reliance ratio	Real number between 0 and 1
group	index
age	positive natural number

We call an agent a doctor or a master if the degree property is doctor or master, respectively. The difference between the doctor and the master in AAM is that the former is qualified to referee a research paper while the latter is not. A new researcher is born as a master. To become a doctor, a master is required that a certain number of papers written by the master are published in journals issued by the academic association. The number of the papers will be used as the parameter of the numerical studies described later.

We call an agent a professor or an assistant if the status property is professor or assistant, respectively. A professor gives direction to the assistants working with the professor. The paper quality criterion property of the professor influences those of the assistants.

The research capacity property is the basis on which how much effort a researcher makes to write a paper. The paper quality criterion property is used to estimate the probability that a journal should accept a research paper with certain quality. The reliance ratio property represents how much a researcher is influenced by the other researchers and the association.

Every researcher in AAM belongs to one of the groups in the academic association. The group property indicates which group a researcher belongs to. This property is used to define the action patterns that are typical in the agents belonging to a same group.

The age property corresponds to the age of a person in our real world. In AAM, a researcher will vanish from the academic association when the researcher reaches the retirement age. When a researcher disappears, a new master joins the world. When the disappeared researcher is a new professor, one of the existing assistants is promoted to professor. The new professor is selected in accordance with a certain rule. In the numerical studies shown below, an assistant is promoted if the number of the papers published by the assistant is not less than that of the other assistants.

2.1.2   Actions Performed by Research Agents

A researcher performs five types of actions, i.e., paper writing, paper contribution, education, self-development, and paper referee, when their preconditions are satisfied. The verification of a precondition is done on the basis of the properties of the researcher, who would perform the action related to the precondition, and a state of the system of the association. The researcher subjectively perceives its internal state and the environmental state.

If a researcher is not working on a paper currently, the researcher starts writing a paper. A researcher makes an effort, which is equal to 0 to 1/6 of the researcher's research capacity attribute value, to finish a paper. If a researcher is writing a paper, the researcher continues writing until the paper is estimated to be worth contributing to a journal. The quality of a paper is determined on the basis of how much effort is made to write a paper.

A researcher estimates the certainty of acceptance of a paper by an academic association and judges if the researcher contributes the paper to the academic association. The estimation is formed on the basis of the quality criterion of the paper and the paper quality level property of the researcher. Comparison between the estimation and a random number between 0 and 1 forms the judgment. If the estimation is greater than the random number, the researcher concludes that the paper should be published.

A doctor estimates the certainty of acceptance of a paper when the doctor is requested to do so by the academic association and judges whether the association should publish the paper. The estimation is formed on the basis of the quality level of the paper and the paper quality criterion property of the researcher. Comparison between the estimation and a random number between 0 and 1 forms the judgment. If the estimation is greater than the random number, the researcher concludes that the paper should be published. If the estimation is less than or

equal to the random number and if the paper has not been revised, the researcher concludes that the paper should be revised and shows the paper quality criterion of the researcher. The author will revise the paper with accordance to the level. If the estimation is less than or equal to the random number and if the paper has been already revised, the researcher concludes that the paper should not be published. Some doctors inflate the estimation for the researchers in the same group. Comparison between the estimation and a random number between 0 and 1 forms the judgment.

A professor gives a direction to assistants. The paper quality criterion property of the assistant is changed when the direction is given. The value of the property changes to a certain value determined by the current paper quality level property of the assistant, that of the professor, and the reliance ratio of the assistant. The paper quality criterion property also changes on the regular basis. The value changes to a certain value determined by the current paper criterion of the researcher, the average quality of the papers published in the last one period, and the reliance ratio of the researcher.

The research capacity property of a researcher changes whenever the researcher finishes a paper. The value becomes close to the current paper quality criterion property of the researcher on the basis of the reliance ratio of the researcher.

2.2 An Academic Association

In AAM, an academic association is also represented as an agent. A major activity is circulation of academic journals. The academic association selects the referees of a paper when it is submitted and requests them to referee the paper. Two referees are randomly selected from the doctors. The academic association decides if a submitted paper is worth being published in a journal on the basis of the judgments by the referees. When both referees conclude that the paper should be accepted, the academic association publishes the paper. When both referees conclude that the paper should not be accepted, the paper will not be published. When the judgments of the referees are different from each other, the academic association selects another doctor as the third referee and requests the doctor to referee the paper. The final decision will be made on the basis of the judgment by the third referee. If any referee requests revision of the paper, the academic association informs the author that the paper is required to be revised to fulfill the paper quality criterion indicated by the referee.

3. Numerical Studies

An academic association composed of one hundred researchers is modeled for the numerical studies shown here. The four cases are investigated. The cases are different only in the number of papers required to acquire a doctor's degree (Qp), i.e., $Qp = 3, 8, 13,$ or 18. There are two groups in the world in AAM. The researchers in Group-0 inflate the paper quality criterion when they judges a paper written by a researcher in the same group, while the researchers in Group-1 don't. The result of one simulation is shown, at this point, for each of the cases. It is without saying that the ensemble of the results of simulations for each case is required to grasp the general patterns of phenomena. This paper focuses just on what kind of phenomena can be observed in AAM.

3.1 Conditions

The parameters in the initial states are set as follows. The ratio of the number of professors to that of assistants is approximately one to two. The ratio of the number of doctors to that of masters is one to one. The research capacity property and the paper quality criterion property of each doctor are 100. Those properties of each assistant are 50, i.e., 50% of the properties of the doctors. A unit time period in the simulation is regarded as one week. A month consists of four weeks and a year consists of 12 months. The unit time period is set for the convenience of simulation and does not correspond to the time in our real world.

3.2 Quality and Quantities of the Papers

Figure 1 describes the differences in the transitions of the average quality of papers published in the journal issued by the academic association with respect to the difference in the number of papers required to acquire a doctor's degree (Qp). Qp's of the first year are close to each other because of the initial conditions. In the case that $Qp = 3$, the average paper quality increases during the first 20 years but it tends to decrease after 25 years. In the case that $Qp = 8$, the average paper quality increases during the first 15 years and tends to maintain the almost

constant level while a wave with a long cycle is observed. In the case that Qp = 13 or Qp = 18, the average paper quality tends to increase. The increase ratio in the case that Qp = 18 is greater than that of the case that Qp = 13. These observations indicate that the average paper quality becomes higher if the number of published papers required in order to become a doctor is higher.

The mechanism that Qp influences the average paper quality, roughly speaking, is as follows. If Qp is higher, a master becomes a doctor with higher paper quality criterion property. Then, the possibility that a doctor with higher paper quality criterion property is selected as a referee increases. The quality of a paper tends to be estimated with accordance to the higher paper quality criterion. Therefore, the average paper quality of the journal tends to increase. Since the average paper quality positively influences the paper quality criterion property of each researcher, the property tends to be higher if Qp is higher is higher. If the paper quality criterion property becomes higher, the quality of submitted paper tends to increase and the average paper quality of the journal becomes higher. If Qp is not high enough, the quasi-causal relations described above works in the direction that the average paper quality decreases.
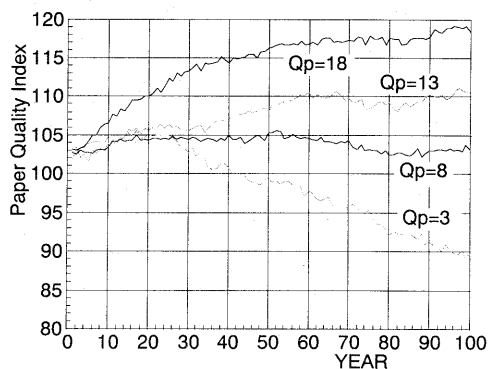

Figure 1 Transitions of the Average Paper Quality Level

Figure 2 shows the differences in the transitions of the number of papers published in the journal issued by the academic association with respect to the difference in the number of papers required to acquire a doctor's degree. In the case that Qp = 3, the quantity of published papers tends to increase. In the case that Qp = 8 or Qp = 13, the number of the papers almost keeps the constant level. In

the case that Qp = 18, the number of papers tends to decrease during the first 30 years and keeps the constant level after the period. These observations, with the observations of Figure 1, indicate that the number of the published papers is not necessarily in inverse proportion to the average paper quality. Focusing on the case that Qp = 18, it is observed that the average paper quality tends to decrease while the number of papers keeps the constant level.
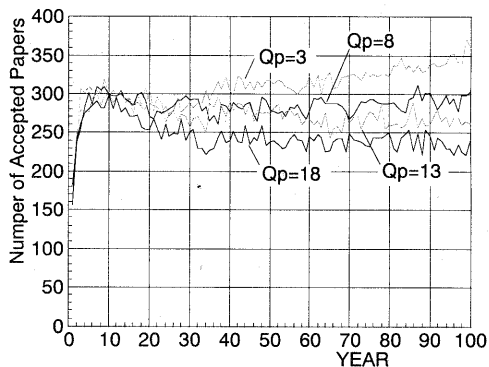

Figure 2 Transition of Paper Quantity

3.3 Research Capability and Paper Quality Criterion

From Figure 3 to Figure 10 show the relation between the research capacity property and the paper quality criterion of the researchers after the period of simulation i.e., 100 years. Each figure describes the relation in each group in each case.

Each figure shows that the paper quality level property level correlates closely to the research capacity property. It is also observed that the maximum values of these properties are close to each other. The tendency that the maximum values become higher if the number of published papers required to be a doctor (Qp) is higher is derived.

The tendency that the ratio of the doctors and professors with relatively lower values of the properties increases if Qp is lower is derived. It is inferred that this relation should support the mechanism explained above. Detailed investigations are required to give clear explanation. The tendency that the ratio of the doctors increases if Qp is lower is derived and the ratio of the masters increases if Qp is higher.
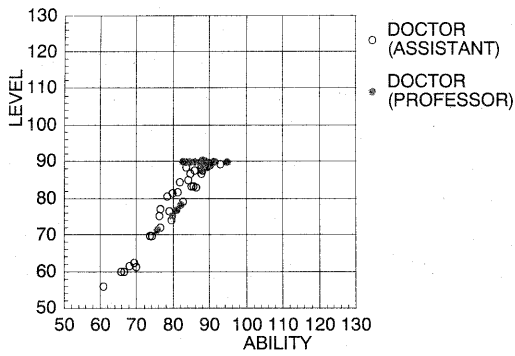
Figure 3 *The relation between the research capacity and the paper quality criterion (Qp = 3, Group-0)*
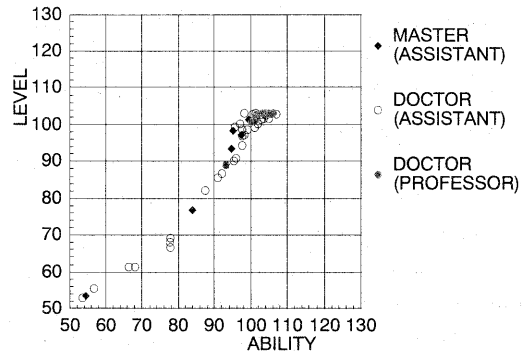

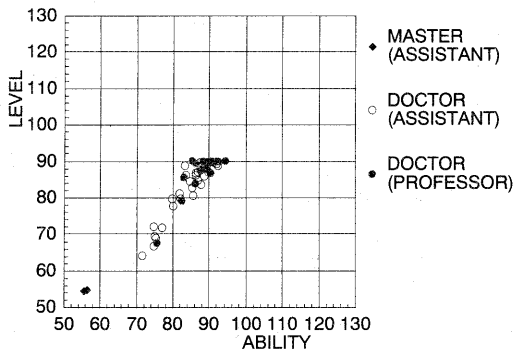**Figure 6** *The relation between the research capacity and the paper quality criterion (Qp = 8, Group-1)*

Figure 4 *The relation between the research capacity and the paper quality criterion (Qp = 3, Group-1)*
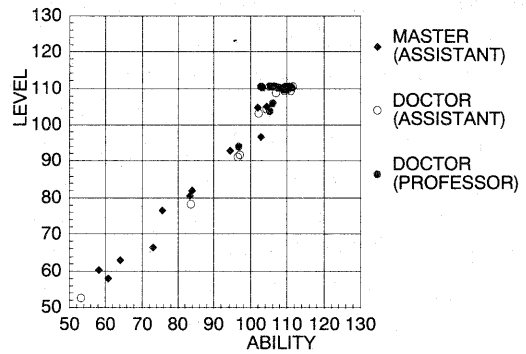

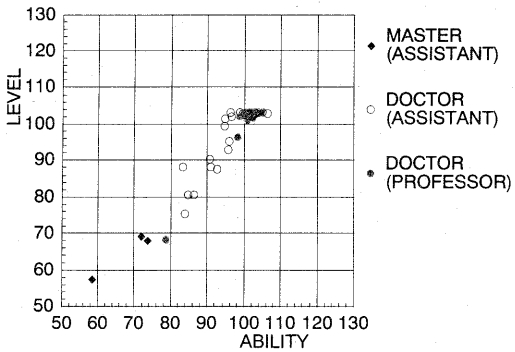**Figure 7** *The relation between the research capacity and the paper quality criterion (Qp = 13, Group-0)*

Figure 5 *The relation between the research capacity and the paper quality criterion (Qp = 8, Group-0)*
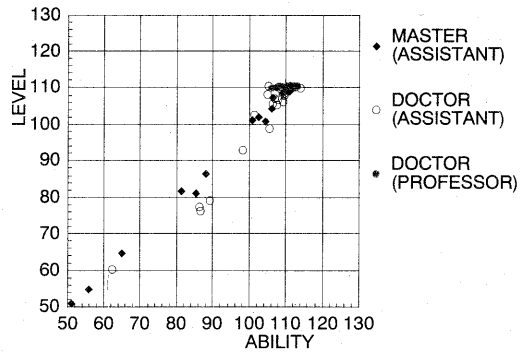

Figure 8 *The relation between the research capacity and the paper quality criterion (Qp = 13, Group-1)*
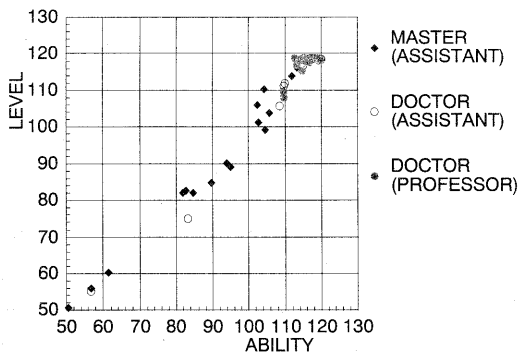
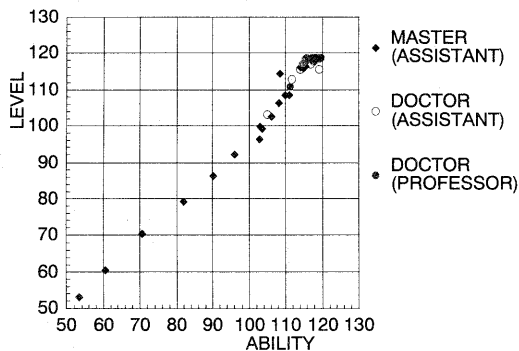**Figure 9** *The relation between the research capacity and the paper quality criterion (Qp = 18, Group-0)*

Figure 10 *The relation between the research capacity and the paper quality criterion (Qp = 18, Group-1)*

3.4 Effects of Inflation of Paper Quality Criterion

In the numerical studies, the doctors in Group-0 inflate the paper quality criterion when they referee the papers submitted by the researchers in Group-0. This means that the probability that a paper written by a researcher in Group-0 is accepted may be higher than the probability that a paper written by a researcher in Group-1 is accepted.

The comparison between the relation of the research capacity property and the paper quality criterion of the researchers in Group-0 and the relation in Group-1 let us observe the following things. Again, the observations are derived from just one trial of each of the cases. In the case that the number of the published papers required to be a doctor (Qp) is highest, i.e., $Qp = 18$, a master in Group-1 happens to become a doctor even though the

research capacity property and the paper quality criterion property are lower than those of some masters. Except the case that $Qp = 8$, it may be less hard for a researcher in Group-0 to become a doctor than the researchers in Group-1. Some paper may be qualified, by chance, to be published because of the inflation of the paper quality criteria. However, the rule that two or three researchers are requested to referee one paper may decrease the possibility that a researcher in Group-0 receives the benefit of the inflation in the paper quality criterion. In this sense, this rule works well. However, if only the doctors in Group-0, for some reason, refereed a paper written by a researcher in Group-0, the possibility would increase and the quality of the papers written by researchers in Group-0 would decrease.

4. Future Direction

It is one of the future directions that sophisticated machine-learning mechanisms are implemented in the research agent. The authors intend to let the agent self-organizes the mechanism coupling the perception and actions to achieve the agent's own goal. With the extended model, the maneuvers carried out by the researchers with having different goals would be investigated.

5. Conclusion

This paper explained the architecture of a multi agent type model of an academic association and reported some results of the numerical studies with the model. It might be derived from the results that the model produces the behavior interpreted as one of the characteristic phenomena in an academic association. That is, a macroscopic relation between the number of the papers required to become a doctor and the properties related to the quality of papers is produced from microscopic actions performed by the agents in the model.

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