A Generation Method of Reference Operation using Reinforcement Learning on Project Manager Skill-up Simulator

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Keywords: Project Management, Skill-up Simulator, Reinforcement Learning, Decision Tree.

Abstract: This paper addresses generating reference operation that a manager should carry out for improving a result of a certain project based on the project principle. The project principle is a group of rules to indicate what to do in situations of a project, and also necessary to generate the reference operation. First, the proposed method generates the project principle from optimal operations derived by reinforcement learning on automatically generated operations. And, the reference operation is generated by applying the project principle to a certain project model. Experimental results show that the proposed method can automatically generate the reference operation as well as manual generation.

1 INTRODUCTION

Along with increase of difficult projects where a complicated IT system is developed in a short time, it becomes important to educate project managers that have enough skills to manage the projects. Many project managers learn project management skills through PMBOK(Project Management Body Of Knowledge)(PMI, 2009) and literatures which indicate success and failure factors of projects(Horine, 2005). In addition, in order to make project managers acquire skills of planning and carrying out the project, it is important for them to face actual projects and solve issues of projects. Thus, many educational methods have been proposed such as OJT(On the Job Training), PBL(Project Based Learning)(Thomas, 2000), and RP(Role Playing)(Henry and LaFrance, 2006). But, effects of their methods depend on trainers and they take a lot of time to educate learners.

Recently, the efficient educational methods using simulators have been proposed such as SESAM(Drappa and Ludewig, 2000) and PMT(Davidovitch et al., 2007). Thus, we have developed a project manager skill-up simulator which can interact with a learner in order to take an action against issues such as explosive occurrence of bugs(Iwai et al., 2011). In this simulator, the learner can input actions such as "overtime directive" and

"collaborative work with expert members" based on the simulated situations in a project model. After finishing the simulation of the project model, this simulator outputs QCD(Quality, Cost, Delivery) as a result of an "operation" defined as a sequence of the actions. But, this simulator can not give feedback to the learner about whether each action in the operation was good or not. Since trainers can not investigate the reference operation in order to evaluate each learner's operation from practical viewpoints, there exists no way to strengthen his/her skills.

This paper addresses a generation method of such reference operation to support the evaluation. First, the proposed method generates the project principle based on operations that are automatically generated on various projects. Applying the generated project principle to a certain project model, the proposed method generates the reference operation.

2 PROBLEMS ON PROJECT MANAGER SKILL-UP SIMULATOR

2.1 Project Manager Skill-up Simulator

The target of this research is a project manager skill-up simulator that a learner can input actions and
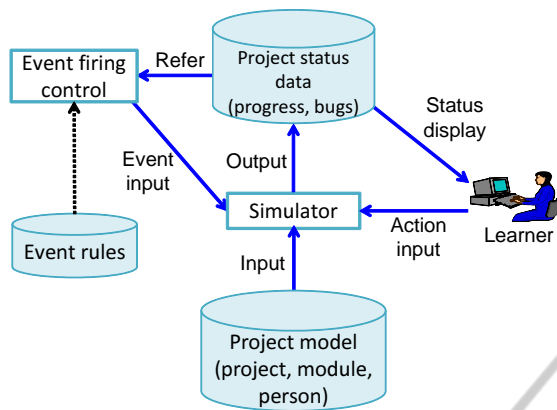
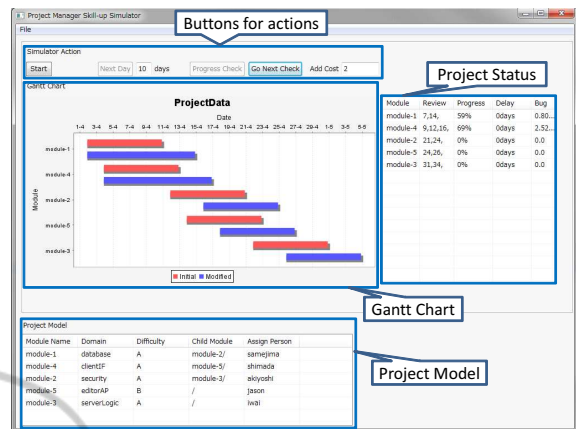Figure 1: Outline of project manager skill-up simulator.

Figure 2: An interface of simulator.

shows the result by the simulation of the operation as a sequence of the actions. Figure 1 shows the outline of the project manager skill-up simulator.

2.1.1 Project Model

When this simulator starts, this simulator shows the learner a project model. The project model mainly consists of "Project", "Module", and "Person" as they exist in the real project. "Project" is defined as a set of modules to be developed and members to be assigned to the project. "Module" is defined with a technical domain to develop, its difficulty ranked with {A(difficult), B(normal), C(easy)}, estimated man-hour, parents modules, and children modules. For example, Module 1 is shown as "DOMAIN: database, DIFFICULTY: A, MAN-HOUR: 10, PARENTS MODULE: Module 2, CHILDREN MODULE: Module 3, Module 4". "Person" is defined with a skill on technical domains ranked with {A(expert), B(normal), C(novice)}. For example, Person 1 is shown as "database: A, interface: A, server: A, security: C, editorAP: B".

2.1.2 Project Status Data

While simulating the project, this simulator calculates parameters of the project status such as progress and bugs. Figure 2 shows user interface of the simulator to input a user's actions and to output the project status. The module status is displayed with "Gantt chart" including two bars that represent initial planned duration and changed duration from starting date to completion date. In fact, mismatching between a module difficulty and a programmer's skill is a main cause of schedule delays and quality losses of a project. And the most important task as a project manager is to detect and predict such schedule delays and quality losses. The learner can take "check progress"

to check the number of existing bugs and whether the schedule is delayed or not. If project managers judge to improve the delay, project managers can input the actions of "overtime directive" and "collaborative work with expert members" after taking "check progress". To take "overtime directive" increases working hours, and to take "collaborative work with expert members" debugs detected bugs and does not generate new bugs.

After finishing all modules in the project model, this simulator outputs QCD as a result of the simulation. Q(Quality) is influenced by the quality losses including latent bugs. C(Cost) is an additional cost calculated from days spent for "overtime directive" and "collaborative work with expert members". D(Delivery) is influenced by the schedule delay.

2.1.3 Events

In order to adjust difficulty to a learner's performance, this simulator causes "Events" which harm the project status such as sudden bug explosion, sudden man-hour increase. These events happen when "Event firing control" detects the project to go smoothly based on the current project status.

2.2 Problem on Generating Reference Operation for Feedbacks of Evaluation

A learner gets the result of the operation, but can not know whether each action in the operation is good or not. So, it is required that the simulator shows feedbacks of the evaluations of the actions. Here, excellent project managers do not fail to conduct a operation based on the project principle that is a group of rules to improve the status of projects. The status is

shown by QCD, and the project principle sets which targets of QCD is improved. So, the rule in the project principle is a set of a status to be improved and a necessary action to improve the target of QCD called "learning target" for projects. A learning target is defined which viewpoints the learner should acquire. The decision making by project managers consists of two stages of operations: project managers check the progress and take actions based on the progress. From this viewpoint, there are two kinds of project principles: "check progress" and "take action".

This simulator can give feedback to the learner whether the learner's operation follows the project principle or not. But the learner's operation can not be compared directly with a project principle because situations and actions for them vary with projects. In order to compare the learner's operation, it is necessary to generate the reference operation which is an operation following the project principle.

So, the project principle needs to generate the reference operation. But, to generate the project principle takes a lot of time because trainers simulate and analyze many operations to get a good result for each project in order to generate the project principle which must be useful for various projects. This paper addresses how to generate such project principle and reference operation.

3 GENERATION METHOD OF REFERENCE OPERATION USING REINFORCEMENT LEARNING

3.1 Outline of Automatic Generation Method

We propose a generation method of reference operation using reinforcement learning and decision tree. Figure 3 shows the outline of the generation method.

In order to generate the reference operation based on the project principle, this method uses optimal operations which lead to the best results corresponding to a learning target set in advance. The optimal operations can be considered to include correct judgments and actions to improve the status of the project. Because QCD should be kept smaller by project management, an optimal operation is defined as the operation to minimize the objective function $f(operation)$ defined as follows:

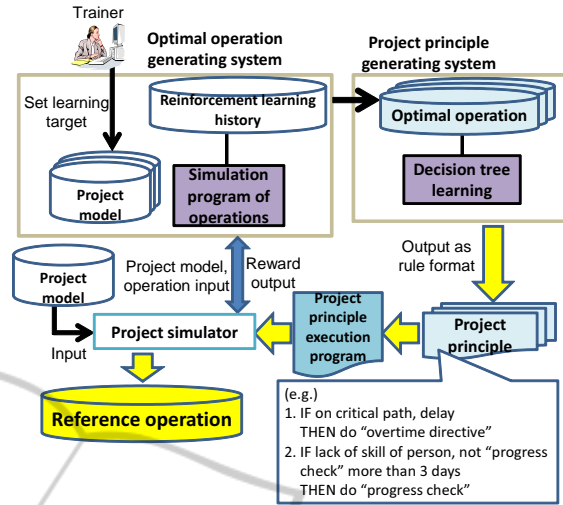$$f(operation) = \sum_{i \in LearningTarget} f_i(operation) \quad (1)$$

Figure 3: Outline of proposed method of the reference operation.

where *LearningTarget* includes Q, C or D, *operation* is a learner's operation, and $f_i(operation)$ is i outputted by a simulator after executing *operation*. For example, when a learning target is "Q and D", the objective function $f(operation) = f_Q(operation) + f_D(operation)$.

First, this method generates results for operations by using the simulation program of operations to simulate various types of operations automatically. Second, this method generates the optimal operations from the results by reinforcement learning that can calculate faster than brute force search. Third, this method generates the project principle as a group of rules based on optimal operations by using decision tree learning. Finally, the reference operation is generated by the project principle execution program which takes action following the project principle.

3.2 Optimal Operation Generating System

It is necessary for generating a project principle to use optimal operations for various types of projects. In order to generate an optimal operation, it is necessary to minimize the objective function as formula (1). But it takes a lot of time to generate the optimal operation using brute force search. So, the proposed method searches an operation to improve the status of the project. This search uses reinforcement learning which determines future actions so as to maximize reward based on past actions. The reinforcement learning, project state s_t (t as time) is a set of QCD given by simulator, action a is one of selectable actions in simulator, and reward $r(s_t, a)$ is defined as formula (2)

Table 1: Description $h_i(s_t,a)$.

$h_i(s_t,a)$	Description
$h_Q(s_t,a)$	Variation of bugs based on s_{t-1} divided by bug rate per day in taking no action
$h_C(s_t,a)$	Variation of costs based on s_{t-1} divided by costs per day in taking "overtime directive" and "collaborative work with expert members"
$h_D(s_t,a)$	Expected finishing dates on s_t divided by expected finishing dates in taking no action

and Table 1.

$$r(s_t,a) = -\sum_{i \in LearningTarget} h_i(s_t,a) \qquad (2)$$

In the reward, $h_Q(s_t,a)$ or $h_D(s_t,a)$ is given in comparison with Q or D in taking no action, and $h_C(s_t,a)$ is given in comparison with costs per day in taking "overtime directive" and "collaborative work with expert members". This formula means that the reward $r(s_t,a)$ gets better when the value of bugs or costs in s_t is smaller than one in s_{t-1}, or the expected finishing dates on s_t is early. For example, when learning target is "Q and D", reward $r(s_t,a) = -(h_Q(s_t,a) + h_D(s_t,a))$.

3.3 Project Principle Generating System

Figure 4 shows the outline of the project principle generating method. In order to generate the project principle corresponding to all aspects, the proposed method uses decision tree learning based on optimal operations. The proposed method generates the project principle from two decision trees, "check progress" and "take action", which are stages of the learner's decision-making in project management.

From the decision tree, a learner gets the information of class labels (leaf nodes shown in Figure 4) as actions and attributes(nodes in Figure 4) as shown Table 2. By using these decision trees, the project principle execution program written by Java codes is generated automatically to decide reference operation.

4 EVALUATION

4.1 Results of Experiment

In order to generate a project principle, we used 10 project models that have 4.5 modules in average, manpower of 4 people, 10 days for each module, and 30 days for development. We set the learning target to
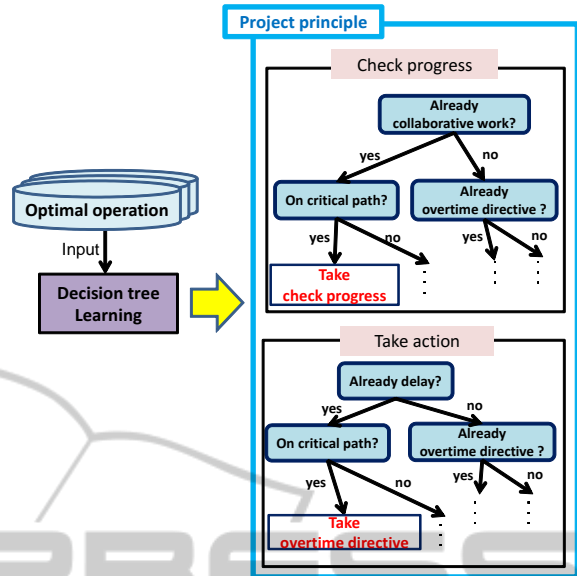

Figure 4: Outline of project principle generating method.

Table 2: The information a learner gets.

	The getting information before "check progress"
1.	The number of days since the last "Check progress"
2.	The difference between a module's difficulty and a programmer's skill
3.	Whether the module is on critical path
4.	Has "collaborative work" been taken?
5.	Has "overwork" been taken?

	The getting information after "check progress" with one before "check progress"
6.	Is the project delayed?
7.	Whether additional man-hour exist
8.	The number of bugs

"Q and D" because we assumed that a learner is experienced the project contained high standards for quality and delivery. And we experimented to compare the reference operation by manually generated project principle to one by the proposed method. For decision tree learning, we used WEKA which is one of the open source data mining tools(Hall et al., 2009).

Figure 5 shows the project model includes difficulty and skill of person assigned for each module, and Figure 6 shows the result of experiment. Figure 6 shows the result with the project principle generated by the proposed method is better than one with manually generated project principle. To generate the project principle manually took 360 minutes, while to generate one by the proposed method took 240 minutes. So, this experimental result showed the pro-
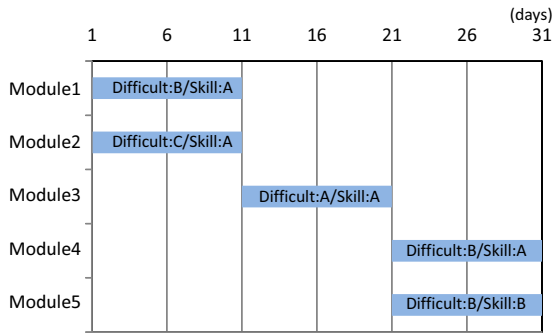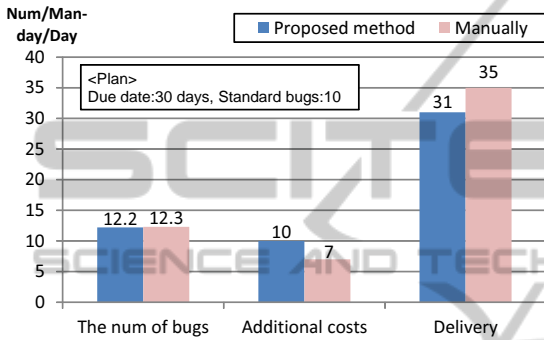
Figure 5: Detail of project model.

Figure 6: Result of experiment.

posed method generated the project principle and reference operation in reasonable time.

4.2 Discussion

In this experiment, the project principle generated manually has 13 rules, while the project principle generated by the proposed method has 24 rules. Figure 7 shows a part of the project principle by the proposed method.

The manually generated project principle shows that "check progress" is necessary every three days. However the project principle by the proposed method reflects project status in detailed manner. Expert project managers confirmed that it is possible to apply the project principle by the proposed method to various types of projects. But, they said that an operation for a real project does not contain many "check progress". On the other hand, the reference operation by the proposed method indicates that "check progress" should be taken many times, which may be improper actions in the operations. Here, we confirmed the result for the modified project principle that the number of "check progress" is decreased. The result in decreasing "check progress" is shown in Figure 8. Figure 8 shows that the result in applying the project principle generated by the proposed method is
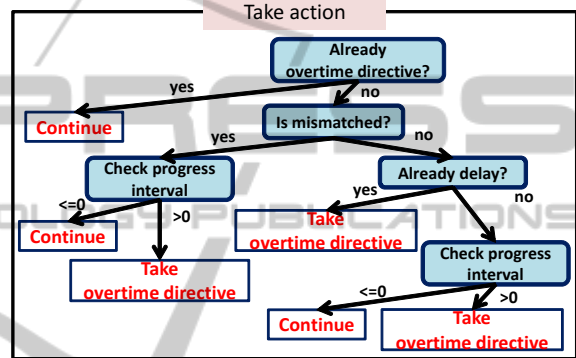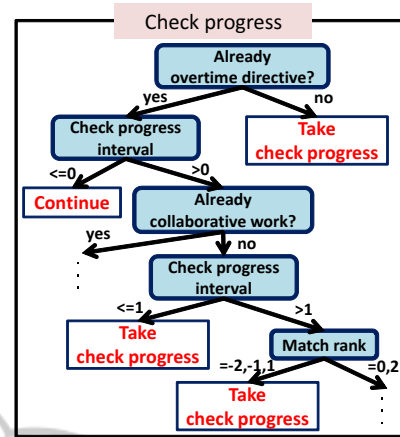

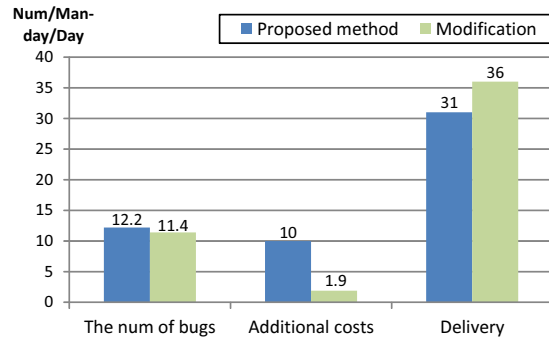Figure 7: Project principle generated by the proposed method.

Figure 8: The result in decreasing "check progress".

better than one manually in terms of Q and C. Thus, it is confirmed that the project principle arranged manually is more useful.

5 CONCLUSIONS

This paper addressed a generation method of reference operation to improve project results using reinforcement learning. The proposed method generates

the project principle which is a group of rules to indicate what to do in situations of the project automatically. And the reference operation is generated by applying the project principle to project models. The project principle is generated by optimal operations using reinforcement learning and decision tree learning. The experimental result with the project principle generated by the proposed method is better than one with manually generated project principle. To generate the project principle manually took 360 minutes, while to generate one by the proposed method took 240 minutes. So, this result showed that the proposed method generated the project principle and reference operation efficiently. Our future work is how to generate more useful project principle.

ACKNOWLEDGEMENTS

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