Project Management Informatics

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Abstract

Faculty are working with students on a research project developing a project management software program. This research project uses case-based reasoning (CBR), an artificial intelligence (AI) approach that overcomes most of the drawbacks of rule-based expert systems (e.g., codification of the knowledge base) by looking for previous cases that are similar to the current problem and reusing them to solve the problem. CBR has been successfully used in solving design, diagnoses, and prediction problems. The objective of this research is to develop a generic project management informatics system (PMIS) based on the CBR approach to assist project managers in evaluating project performance, predicting overruns, and recommending corrective actions. The PMIS will complement the functionality of existing project management tools and act as a decision-support tool, which benefits from the knowledge encapsulated in previous construction projects. Current project management tools, such as P3, Project Work Bench, and MS Project, are designed to perform well-structured tasks such as schedule calculations, resource allocation, and earned value computations. However, these tools cannot perform tasks that require personal judgment and experience, such as early diagnoses of time and cost overruns, reliable prediction of future deviations, and dependable suggestion of corrective actions. Knowledge-based systems have been developed to support these tasks using rule-based expert systems. However, these systems have serious limitations in their functionality, expandability, and knowledge acquisition. A “proof of concept” prototype of the PMIS will be developed for the construction domain because of the long history of construction project management and the availability of successful and unsuccessful case examples of construction projects.

1. Introduction

Project management informatics is an emerging area of study that blends the fields of Engineering Management, and Information Technology. Diverse and new software applications and networking media have pushed the value of competent project

management, supported through a new generation of tools, to center stage in government and industry. Today's project management contexts within which projects are embedded are complex and volatile. For example, the management of software development projects has evolved from the simple domain of specifying and developing software into *software engineering*. Project managers must now deal with complex software architectures tightly coupled to telecommunications architectures. By necessity, project management and control require more sophisticated tools to effectively meet these challenges.

The design of these new tools can draw upon the long history of project management in the construction industry, as well as lessons learned from past projects. Even though this industry has significant experience in project management, we continue to see project failures, cost overruns and schedule delays.

The information technologies supporting the emergence of project management informatics require further research and development. Informatics has been identified as a priority research area by the National Science Foundation (Directorate for Computer and Information Science and Engineering) and the Department of Defense. Therefore, faculty from the UNO College of Information Science and Technology and the UNL College of Engineering and Technology have joined together to investigate this research area collaboratively. This project brings together the Department of Construction Systems at UNL and the Department of Information Systems and Quantitative Analysis at UNO to leverage the skills and expertise from both groups.

2. Research Plan

2.1 Specific Aims

Our *long-term goal* is to develop a generic fully operational decision-support system that we call a Project Management Informatics System (PMIS). The PMIS will assist project managers in diagnosing project anomalies, predicting project progress, and recommending corrective actions. The unique feature of the proposed system is its ability to leverage the knowledge encapsulated in the large number of previous projects. This feature significantly reduces the dependency on traditional knowledge acquisition methodologies, and makes the system easy to update and applicable to different domains.

In this project, we will develop a "proof of concept" prototype of the PMIS for the construction engineering domain. We have selected this domain because of the long history of construction project management and the availability of raw data (project cases) from successful and unsuccessful examples of construction projects. Our *short-term objectives* are to:

1. Collect, filter, and classify the construction projects that will be used for system development,
2. Analyze project information to identify, problems, symptoms, and triggers,
3. Develop the data model required to represent and store project information in a reusable manner,
4. Build the inference engine required for knowledge acquisition, and
5. Verify and validate the accuracy, efficiency, and flexibility of the developed prototype.

During the one-year seed grant period, the first three objectives will be accomplished by a full-time graduate student working under the supervision of the co-PIs. Other short-term objectives as well as the long term goal will be accomplished when additional funding from external agencies is obtained.

2.2 Background and Significance

In the construction-related literature, most knowledge-based systems have supported the development of efficient construction plans for specific type of projects, such as modular high-rise buildings (Hendrickson et al., 1987, Chevallier and Russell, 2001), residential reinforced concrete buildings (Benjamin et al., 1990; Shaked and Warszawski, 1992), and power plant boilers (Dzeng and Tommelein, 1997). Some systems have been developed for reviewing construction schedules and/or recommending corrective actions, such as the schedule critique system developed for high rise buildings (De la Gaza and Ibbs, 1990) and automatic schedule review system developed for expressway construction (Dzeng et al., 2005). Those systems have been developed to examine project schedules based on the knowledge acquired from domain experts and represented as IF-THEN rules. The traditional knowledge acquisition methodology is cumbersome, time-consuming, and difficult to update. None of these systems can utilize the knowledge encapsulated in previous cases to analyze project anomalies, predict future performance and recommend corrective actions.

The development and validation of the proposed system is expected to be useful to project managers and students in many engineering domains such as construction engineering, software engineering, and architectural engineering. The new system is also expected to provide a more comprehensive theoretical framework for forecasting problems and identifying corrective actions.

2.3 Preliminary Results

A rule-based system called Project Management Advisor (PMA) was previously developed to support software engineering project management (Kwon and Dufner, 2002; Kwon, Dufner and Kwon, 2001; Dufner, Kwon and Hadidi, 1999). PMA was developed as a proof-of-concept prototype with functionality limited to identifying only few anomalies, such as schedule days, missing dependencies, lack of vacation time planned, and lack of sick time planned. PMA was also designed to provide alerts and recommend some corrective actions. The purpose of PMA was to test the feasibility and effectiveness of an intelligent rule-based system in identifying problems in software engineering project development, and to offer appropriate corrective actions to students and less experienced project managers. PMA, a field prototype, was evaluated and tested for accuracy using eleven project plans from a Fortune 500 company. Although PMA was able to accurately identify anomalies in project plans and propose appropriate corrective actions, the difficulty of knowledge acquisition from domain experts was a major obstacle towards expanding and/or updating its knowledge base.

2.4 Research Design and Methods

A case-based reasoning (CBR) approach is adopted in this research to eliminate the drawbacks of the rule-based expert systems described earlier. Case-based reasoning is a relatively new artificial intelligence (AI) approach that looks for previous cases that are

similar to the current problem and reuses them to solve the problem (Morcous et al., 2002). Each case records problem attributes and corresponding solutions.

The inference engine of a CBR system performs two main tasks: I) case retrieval by searching the case library for the case(s) that best match the current problem; and ii) case adaptation by revising the retrieved case(s) to fit the current problem context. A CBR system also supports the storage of new cases and the updating of existing cases enabling the system to "bootstrap itself" or learn.

To achieve our short-term objectives listed earlier, data from a large number of construction projects completed within the last seven years will be obtained from major construction companies in Omaha such as Peter Kiewit Sons. This information includes the as-planned, baseline, and as-built schedules as well as different cost and progress reports. Statistical tools will be used to ensure the consistency and completeness of the cases by filtering out those with missing information and grouping them according to their type, size, and complexity. The final set of projects will be analyzed to identify and categorize construction delays and cost overruns along with their causes, symptoms, and effects.

Root cause analysis and cause-effect analysis will be used to resolve the complexity of having multiple interacting causes. Cases of successful and unsuccessful projects will be represented using a product model developed specifically to standardize project management data and store it in a meaningful and reusable manner regardless of the project management tool used (i.e. P3 or MS project). A retrieval algorithm will be built on the top of the product model to index stored cases, query them when a new project is encountered, and measure the similarity between query and stored cases. Finally, a test set of unseen cases with well-known problems will be used to evaluate the efficiency and accuracy of the developed prototype and determine its potential as a decision-support tool for project management.

3. Summary

A team of faculty and students from the Peter Kiewit Institute at the University of Nebraska are beginning to develop a project management software program. The program will be initially focused on the construction engineering and management domain because of construction project availability for case-based examples. The objective is to develop a generic project management informatics system based on the case-based research approach to assist project and engineering managers in evaluating project performance, predicting overruns, and recommending corrective actions. The research project will use case-based reasoning to overcome most of the drawbacks of rule-based expert systems by applying information from previous cases that are similar to the current problem. The progress of this project and the planning for the coming year will be presented at the ASEE Midwest Regional Conference.

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