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A Framework for developing the automated management system of environmental complaints in construction projects

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Abstract: Vast quantities of environmental pollutants from construction projects are causing significant damage to nearby local communities and thus generate environmental complaints. The construction company, responsible for compensating and resolving environmental complaints, suffers economic damages due to additional expenditures and schedule delays in construction projects. Meanwhile, the construction industry can stagnate from a broader perspective. Therefore, this study aimed to propose a framework for developing an automated management system which consists of two models for environmental complaints in construction projects: (i) the prediction model: a model for predicting environmental complaints based on factors related to environmental complaints; and (ii) the prevention model: a model for providing construction companies with the optimal prevention measure to effectively prevent environmental complaints according to the results of the prediction model. In addition, the algorithm for integrating the developed models into the management system in construction projects was proposed. Eventually, the application of the management system to construction projects can ensure the profitability of construction companies and mitigate damage from environmental pollutants to the nearby local community.

Key words: Automated management system, Construction project, Environmental complaint, Prediction model, Prevention model

1. INTRODUCTION

In order to complete a construction project carried out via the cooperation of various stakeholders (i.e., construction company, contractors, and residents), it is essential to maintain a good relationship between the construction company and the residents around the construction site (i.e., nearby residents) [1]. However, nearby residents who suffer from vast quantities of environmental pollutants (e.g., noise, vibration, and dust) caused by construction equipment file civil complaints with government offices to minimize the damage from environmental pollutants [2-4]. Civil complaints about environmental pollutants (i.e., environmental complaints) can be simply resolved by reducing the amount of environmental pollutants. However, if nearby residents are subject to severe and sustained damage from environmental pollutants, the construction company is forced to suspend the project or pay compensation along with legal punishment [5,6]. In other words, the construction company may not be ensured profitability from the completion of the construction project due to the economic damage resulting from the process of resolving environmental complaints. Therefore, for the construction company to ensure profitability, it is necessary to predict and prevent environmental complaints filed by the nearby residents.

Despite the need to manage environmental complaints in construction projects, few studies were conducted regarding the management of complaints and disputes between construction companies and nearby residents. Some previous studies analyzed complaints and conflicts between construction companies (or owners) and contractors. Chou et al. [7] developed a model based on a genetic algorithm with a support vector machine that predicts whether a dispute will occur in public construction projects. Mohammadi and Birgonul [8] determined key risk factors for disputes and complaints in green construction projects based on expert interviews and surveys. Chaphalkar et al. [9] predicted the outcome of construction disputes through a neural network, and Liu et al. [10] developed a model for resolving construction disputes through a case-based reasoning approach.

In summary, several previous studies analyzed civil complaints between construction companies and contractors, but these previous studies have the following limitations. First, the subjects of civil complaints were limited to the internal groups of construction projects, and there was a lack of studies on environmental complaints filed by the external group (i.e., nearby residents). Second, previous studies developed methods to predict or resolve civil complaints, whereas studies to deal with the prediction and prevention of civil complaints at the same time was insufficient. In this regard, this study aimed to propose a framework for developing an automated management system capable of predicting and preventing environmental complaints filed due to environmental pollutants from construction projects.

2. AN AUTOMATED SYSTEM OF ENVIRONMENTAL COMPLAINTS IN CONSTRUCTION PROJECTS

This study proposed a framework for developing a system to automatically manage environmental complaints in construction projects from the perspective of construction companies (refer to Figure 1). This automated management system of environmental complaints consists of two models: (i) the prediction model; and (ii) the prevention model. The specific methods to develop the automated management system are as follows.

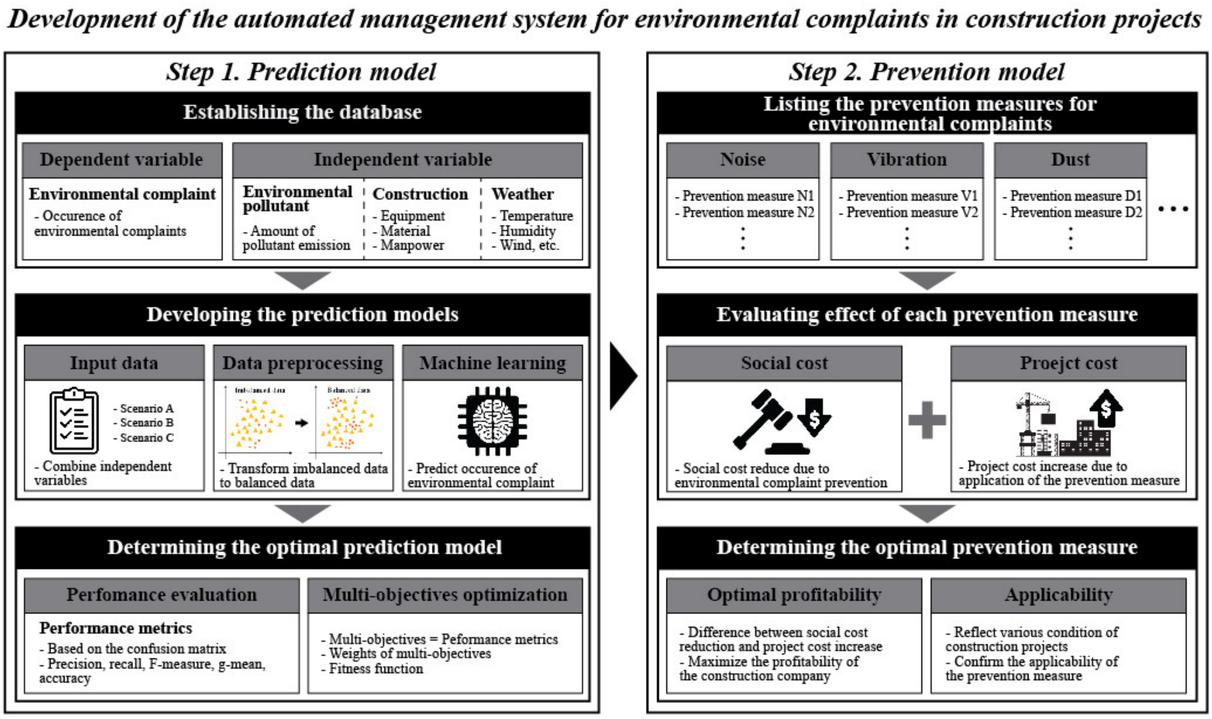

Figure 1. Research framework

2.1. Prediction model

The model that predicts the probability of occurrence of environmental complaints (i.e., prediction model) can be developed through three stages.

First, a database of the dependent variable (i.e., environmental complaint) and the independent variables (i.e., environmental pollutant, construction, and weather, etc.) should be established for prediction models to be developed. In prediction models, the dependent variables are used as the output data to be predicted, and the independent variables are used as the input data needed for the prediction. Since the number of occurrences of environmental complaints to be predicted is relatively lower than the number of non-occurrences, the established database is imbalanced.

Second, various prediction models can be developed depending on input data, data preprocessing, and machine learning. First of all, scenarios for the type and number of input data that affect the performance of the prediction model should be selected based on the collected independent variables [11]. Next, in order to develop and validate the prediction models, the database should be classified into a training set and a test set, and a k-fold stratified cross-validation that divides the proportions of minority and majority classes into a k number of subsets of equal size to effectively validate prediction models for an imbalanced database should be used [12]. In addition, since the prediction model developed based on the imbalanced training set has a limitation in that it derives biased results, a data processing method (i.e., oversampling and undersampling) should be determined to convert imbalanced data into balanced data [13,14]. Lastly, machine learning (i.e., logistic regression, support vector machine, random forest, etc.) to predict the probability that environmental complaints occur should be determined.

Third, the optimal prediction model with the best performance should be determined among the various developed prediction models. The predictive performance can be evaluated by inserting the test set into the prediction model to compare the predicted and actual values. In addition, confusion matrix-based performance metrics (i.e., precision, recall, F-measure, etc.) that can evaluate the predictive performance for imbalanced data should be used as evaluation index [15,16]. Finally, the optimal prediction model that reflects predictive performance in terms of several performance metrics should be determined using a multi-objective optimization approach [17,18].

2.2. Prevention model

The model that determines the optimal prevention measure for environmental complaints (i.e., prevention model) can be developed through three stages based on the prediction results of the developed optimal prediction model.

First, possible prevention measures should be listed by the type of environmental pollutants. The types of prevention measures and the impacts of prevention measures on the projects (e.g., amount of environmental pollutants, construction period and costs, etc.) should be listed all together.

Second, the listed prevention measures should be evaluated in two categories from economic aspects: (i) social cost; and (ii) project cost. The social cost refers to the total costs that the construction company pays compensation for environmental complaints. Changes in the expected social costs due to a decrease in the probability of occurrence of environmental complaints should be evaluated based on the application of the prevention measure (refer to Eq. (1)). The project cost refers to the total costs incurred in carrying out the construction project. Changes in the project cost due to the application of the prevention measure, including additional costs for the prevention measure, should be evaluated (refer to Eq. (2)).

$$\Delta SC = (ECP_A - ECP_B) \times ECC \quad (1)$$

$$\Delta PC = PMC + (PC_A - PC_B) \quad (1)$$

where ΔSC is the change in the social cost, ECP_A and ECP_B are the probabilities of environmental complaints after and before the application of the prevention measure, ECC is the compensation cost for the environmental complaint, ΔPC is the change in the project cost, PMC is the cost of the prevention measure, and PC_A and PC_B are the cost of the project after and before the application of the prevention measure.

Third, the optimal prevention measure should be determined from the evaluated prevention measures. First of all, the prevention measure capable of maximizing the profitability of the construction company should be selected in consideration of a decrease in social cost and an increase in project cost. Then, the applicability of prevention measures to the current construction project should be evaluated. Eventually, the prevention model should be designed to ensure the proper determination of the optimal prevention measure that can maximize the profitability of the construction company among the prevention measures applicable to the construction project.

2.3. Integration of the prediction and prevention models

This study proposed an algorithm to integrate the prediction and prevention models into the automated management system of environmental complaints (refer to Figure 2). The details of the algorithm are as follows.

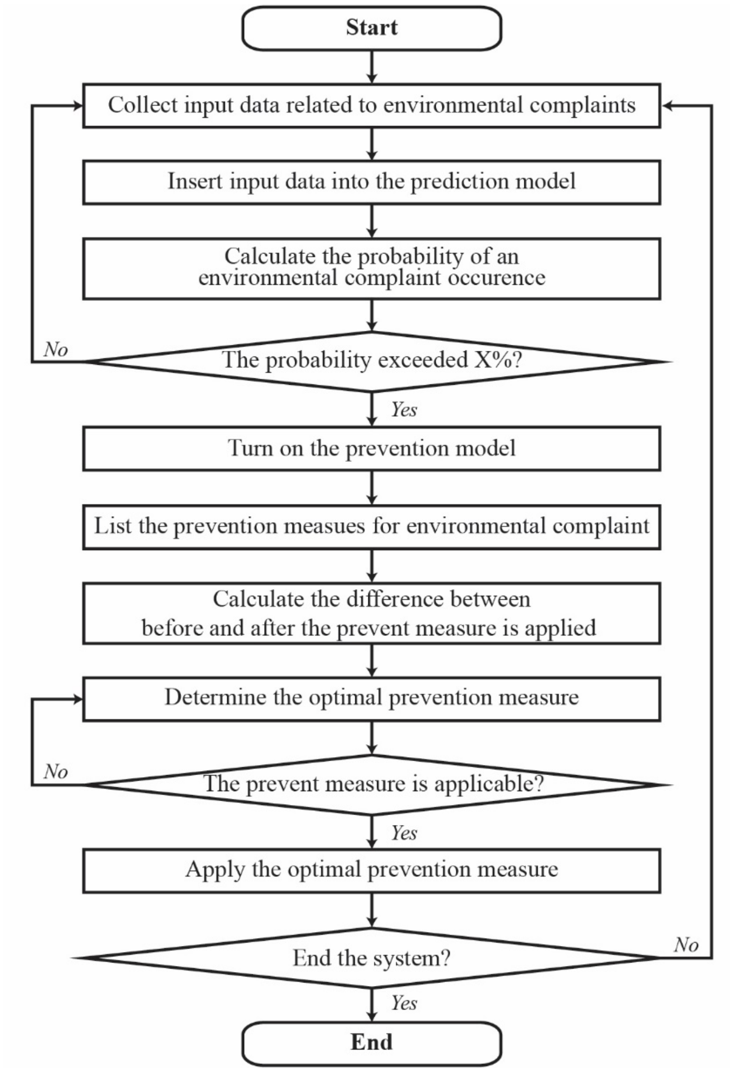

Figure 2. Integration algorithm for prediction and prevention models into the automated management system

First, the input data of the optimal prediction model should be collected using IoT-based sensor networks, cloud computing, etc.. The collected input data is automatically inserted into the prediction model, and the prediction model calculates the probability of occurrence of environmental complaints according to the input data.

Then, the prevention model works when the probability of occurrence of environmental complaints exceeds the probability X% (i.e., the minimum probability of occurrence of environmental complaints to which the prevention measure should be applied) set by the construction company in advance. In contrast, if the probability of occurrence of environmental complaints is less than X%, the prevention model does not work and returns to the first stage (i.e., data collection). When the prevention model works, all prevention measures to prevent environmental complaints are listed. Then, the decreasing social cost and increasing project cost are calculated according to the application of each measure to the construction project. Finally, the prevention model determines the optimal prevention measure of the construction company from economic aspects and evaluates the applicability of the optimal prevention measure in consideration of the current construction project conditions. If the optimal prediction measure is applicable, the construction company should apply the prevention measure to construction projects. However, if not, the alternative prevention measure should be selected instead. After applying the optimal prevention measure to the construction project, the construction company can keep the system running or terminate its operation. Through the above procedure, the automated management system of environmental complaints can be integrated and applied to actual construction projects.

3. CONCLUSION

This study proposed a framework for developing an automated management system that can predict and prevent environmental complaints in construction projects.

As a result, the developed automated management system of environmental complaints can make contributions to the construction industry and nearby local communities. First, the system manages environmental complaints, which serve as factors that reduce the profitability of a construction company, thus ensuring the profitability of the construction company and further activating the construction industry. Second, the fact that nearby residents do not file environmental complaints means that they suffer less damage from environmental pollutants from the construction project. This, in turn, suggests that the developed management system can be used to reduce damage to nearby local communities due to environmental pollutants from construction projects.

Despite the aforementioned contributions, this study only proposed a framework without a numerical application. Therefore, for future work, detailed research on the developed framework will be carried out on a systematic basis to establish an automated management system of environmental complaints. Furthermore, based on the evaluation and improvement through the application of the automated management system to various construction projects, the research team set the generalization and popularization of the automated management system as a tool for managing environmental complaints in the construction industry as its final goal.

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