

Application of Soft Computing Methods to Increase Sustainability in Construction

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1 Introduction

Construction industry has impacts on the environmental, social and economic aspect of sustainability. Thus, the aim of this paper is to present a brief review of the authors’ research on several construction sustainability issues, such as: sustainability assessment, bidding price, construction time, construction cost and energy consumption of buildings.

Sustainability assessment: The design phase is very important due to its providing drawings and specifications for the facility in accordance with the clients’ wishes and needs. There construction project managers can have a crucial role, particularly regarding their perception of sustainability issues (Zileska Pancovska, *et al.*, 2017).

Bidding price in construction: Construction companies usually acquire their work by winning a tender. Hence, having a model for prediction of the bidding price is useful as a support during the bid decision process in construction.

Construction time and cost are elements that are included in each contract regarding facilities construction, so the worldwide investigations are focused on: time/cost prediction, their overrun, the relation time-cost, their influencing factors, etc. (Petruseva, *et al.*, 2019)

Energy consumption: buildings are among the biggest users of energy, thus predicting the energy consumption during the stage of selecting the optimal design of the new building or old building reconstruction/renovation is of particular interest.

2 Methods

The methods which have been used for modelling are two soft computing methods (SCM): neural networks (NNs) and support vector machines (SVMs) as data-driven models and Bromilow “time-cost” (BTC) model as process-based model (as part of several hybrid models).

Because of their specific architecture which implements the intelligence found in nature, NNs and SVMs implement the idea of learning from experimental data. They are universal approximators of any multivariate nonlinear function, modelling unknown or partially known nonlinear complex systems or processes (Kecman, 2001). These methods have been used in almost every branch of civil engineering for the last three decades, demonstrating very successful results. There are many different types of NNs developed for different types of problems, some of them being: general regression NN (GRNN), radial basis function NN (RBF

NN), multilayer perceptron (MLP), polynomial NN, cascade correlation NN, probabilistic NN. In our research the most used NNs were: GRNN and RBF NN. GRNN was most often used because of its attractive characteristic to converge to the optimal solution very quickly, requiring only several samples for training.

Hybrid modelling, i.e. combining data-driven and process-based model has been very popular in the last few years, reporting very promising results. We developed several hybrid models for predicting time or cost of construction and the accuracy of the model was drastically improved, in comparison with when only data-driven method was used.

3 Results

By applying SCMs and hybrid modelling, models were developed for predicting: sustainability assessment, bidding price, construction time and cost (using hybrid modelling) and energy consumption of buildings. DTREG predictive modelling software was used for modelling (Sherrod, 2013a). The accuracy of the models was satisfied and was presented by the standard estimators: MAPE (mean absolute percentage error), the coefficient of determination R^2 (which presents the global fit of the model), and the coefficient of correlation between the actual and the predicted values. Part of the available/input data for each model was used for training and part of them was used for validating the model. The most used methods for validating were *k-fold cross validation* and *random percent*.

4 Conclusions

Sustainability aspects are complex and inter-connected, so their researching and incorporating in construction is an effortful process. Due to many influencing factors, their accurate prediction is not possible, but the prediction models are important as a support tool for the decision making processes. The models presented in this paper used soft computing methods: NNs, SVM and hybrid models composed of process-based model and data-driven model. The developed models gave a satisfied accuracy in predicting: manager's assessment of the sustainability in early design phase for the facility, bidding price, time and cost of construction and energy consumption of building.

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