JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT
ISSN 1392-3730/eISSN 1822-3605
2015 Volume 21(7): 881–892
doi:10.3846/13923730.2014.893922

PREDICTING PRODUCTIVITY LOSS CAUSED BY CHANGE ORDERS USING THE EVOLUTIONARY FUZZY SUPPORT VECTOR MACHINE INFERENCE MODEL

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Received 07 Dec 2012; accepted 19 Feb 2013

Abstract. Change orders in construction projects are very common and result in negative impacts on various project facets. The impact of change orders on labor productivity is particularly difficult to quantify. Traditional approaches are inadequate to calculate the complex input-output relationship necessary to measure the effect of change orders. This study develops the Evolutionary Fuzzy Support Vector Machines Inference Model (EFSIM) to more accurately predict change-order-related productivity losses. The EFSIM is an AI-based tool that combines fuzzy logic (FL), support vector machine (SVM), and fast messy genetic algorithm (fmGA). The SVM is utilized as a supervised learning technique to solve classification and regression problems; the FL is used to quantify vagueness and uncertainty; and the fmGA is applied to optimize model parameters. A case study is presented to demonstrate and validate EFSIM performance. Simulation results and our validation against previous studies demonstrate that the EFSIM predicts the impact of change orders significantly better than other AI-based tools including the artificial neural network (ANN), support vector machine (SVM), and evolutionary support vector machine inference model (ESIM).

Keywords: change orders, productivity loss, fuzzy logic, support vector machine, fast messy genetic algorithm.

Introduction

Changes during construction projects are very common, making construction one of the most complex industries. Changes can involve adding to or reducing the scope of project work or correcting or modifying an original design. Change orders in the construction industry have negative effects in aspects such as cost, quality, time, and organization. While most change order items (e.g. material, scheduling, rework, equipment) can be relatively easy to measure, quantifying the impact on labor productivity is typically more complicated (Hanna *et al.* 1999a).

Many studies have reported on the impact of change orders on labor productivity. The methods used in the literature to calculate productivity loss can be grouped into the 3 categories of (1) regression analysis (Leonard 1988; Moselhi *et al.* 1991; Ibbs 2005), (2) artificial neural network (ANN) (Moselhi *et al.* 2005), and (3) statistical-fuzzy (Hanna *et al.* 2002). Previous studies (Hanna *et al.* 2002; Moselhi *et al.* 2005) have reported that ANN and statistical-fuzzy methods outperform regression analysis. However, no method is suitable for calculating productivity loss because prediction accuracies are outside of acceptable limits.

Construction projects are complex undertakings full of uncertainty and vagueness. Developing a deterministic mathematical model to predict productivity loss is difficult and expensive. An inference model (Cheng, Wu 2009) offering high accuracy and low cost is one feasible approach to predicting productivity loss. Inference models derive new facts from historical data. The human brain can learn previous information and deduce new facts from that information. Artificial intelligence (AI) can be employed to develop models that simulate human brain functions. AI is concerned with computer systems able to handle complex problems using techniques such as Artificial Neural Network (ANN), Support Vector Machine (SVM), and Fuzzy Logic (FL). AI-based inference models thus offer a promising solution to predicting productivity loss.

Several AI hybrid systems have been developed in recent years that have solved various construction management problems (Cheng, Wu 2009; Cheng, Roy 2010).

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