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A unique intelligent approach for forecasting project completion time in oil refineries☆

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ABSTRACT

This study presents a hybrid approach for accurate forecasting of project completion time with noisy and uncertain safety factors in oil refineries. The hybrid approach is based on artificial neural network (ANN), fuzzy mathematical programming (FMP) and conventional regression. Three indictors, namely, number of occupational injuries, number of employees and ratio of maximum useful hours over useful hour per month are considered as inputs. Also, project completion time is considered as the main output. To achieve the objective of this study, five sets of data with respect to oil refinery construction projects in various cities of Iran are collected and analyzed through statistical methods. It is shown that for the actual case of this study, ANN presents lowest mean absolute percentage error (MAPE). Also, analysis of variance (ANOVA) is used to verify and validate the results of this study. This is the first study that presents a hybrid approach for accurate estimation and forecasting of project completion time with complex, noisy and uncertain occupational factors.

1. Introduction

Project completion time is an explicit mater but occupational injuries must be defined when it comes to oil refinery construction projects. Occupational injuries are an injury that would occur during the act of working for monetary remuneration. An occupational injury (or disease or illness) is defined by OSHA as, "any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to factors associated with employment". For several reasons, occupational diseases are difficult to recognize as opposite of occupational injuries (www.osha.com). Siziya, Muula, Ryan, and Rudatsikira (2010) proposed method to estimate the prevalence rates of occupational injuries and compensation, and determined factors associated with occupational injuries and compensation. Crook, Milner, Schultz, and Stringer (2002) introduced prognostic indicators of work disability in occupational back pain. A serious problem in Australia is Work-related injuries; McKenzie et al. (2010) introduced new method for finding out work-related injury in emergency department. Occupational injuries and industrial incidents are usually considered as a product of worker fault and/or hazardous worker behavior, organizational factors, and objective risk in the work environment (Glickman, 1983; Holcom & Lehman, 1993; Salminen, Sarrig, & Saarela, 1993; Sheehy & Chapman, 1987). Chang, Wu, Lee, Guo, and Chiu (2011) studied about common and serious occupational injury that can affect the outcome to return to work (RTW). Azadeh, Rouzbahman, Saberi, and Mohammad Fam (2011) proposed an Adaptive Neural Network (ADNN) algorithm for assessing and improving job satisfaction among operators with respect to HSE and ergonomics (HSEE) in a gas refinery. An integrated approach of HSE management system, based on fuzzy data envelopment analysis (FDEA), was proposed by Azadeh, HasaniFarmand, and JiryaeiSharahi (2012). Hassim and Hurme (2010) presented an Inherent occupational health index for assessing the health risks of process routes during process research and development stage.

☆ *Motivation and significance*: This is the first study that presents a hybrid approach with lowest relative error for accurate forecasting and estimation of oil refinery construction projects completion time by considering occupational injuries. Oil refinery construction projects have always been associated with occupational injuries and efficiency factors. Moreover, the completion of such projects may take several years. It is therefore quite essential to forecast completion time by incorporating safety factors. This would help managers and policy maker to have a better view and comprehension of the whole picture with respect to completion time versus occupational injuries.

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Project Completion time depends on several important factors. In some studies, the factors that can affect the occupational injuries are considered. Ciarapica and Giacchetta (2009) tested several factors that affect the occupational injuries and diseases such as sex, age, type of works, and physical activities in Italian industry. Several soft computing tools such as ANN and ANFIS are applied by predicting the responses. Also, statistical and soft computing methods were used to predict the occupational injuries in the different Italian industrial sectors by Fabiano, Curro, Reverberi, and Pastorino (2008). A model has been developed to predict the frequency and associated costs of occupational accidents in the offshore oil and gas industry (Atwood, Khan, & Veitch, 2006). Ambrose, Bartels, Kwitowski, Helinski, and Gallagher (2003) used simulation and human models to predict the machine injuries.

In this study a hybrid approach for accurate forecasting of project completion time is considered. This approach is based on artificial neural network (ANN), fuzzy mathematical programming (FMP) and conventional regression. Hybrid approach means that each of the above methods can be used for forecasting of project completion time. This approach is used for accurate forecasting of project completion time with noisy and uncertain safety factors in oil refineries (Azadeh & Motevali Haghighi, 2012). This remainder of the paper is organized as follow: in Section 2; the hybrid approach is introduced, and artificial neural network (ANN), fuzzy mathematical programming (FMP) and conventional regression are explained. The case study is presented in Section 3. Computational results of the hybrid approach are shown in Section 4 and conclusions are drawn in Section 5.

2. Method: the hybrid approach

According to the proposed approach, ANN, FMP, and conventional regression models are applied for forecasting and estimation of project completion time with safety factors. So, this approach is defined as hybrid approach because of ANN, FMP, and conventional regression models can be used for this problem, separately. The case of this study is actual oil refinery construction projects in Iran. Iran is a major producer of oil and gas in the world. These projects are vital to country's economy. At first, the data had to be preprocessed and transformed because it was quite noisy (step 1). After determining the input and output variables, related data were collected (step 2). Then, the data were preprocessed in order to decrease multiple correlations and eliminate the noise. The optimum value of n (minimum number of observation for the test period) was computed by using operational characteristic (OC) curve. With respect to Mean Absolute Percentage Error (MAPE), FMP models were compared and the best one was selected. Also, the proper regression model (from first, second, third, log-linear, etc.) was identified. In addition, several ANNs were developed through multi-layer perceptron (MLP) and the best one with minimum MAPE is selected for further considerations. The preferred model among the selected ANN, FMP and Regression was selected by the minimum value of MAPE (step 3). Finally, analysis of variance was conducted to verify and validate the results. Furthermore, the values of MAPE were calculated for neural network, fuzzy mathematical programming and regression by changing the number of train and test data sets (step 4). Then results of the soft computing methods and conventional regression were compared by MAPE.

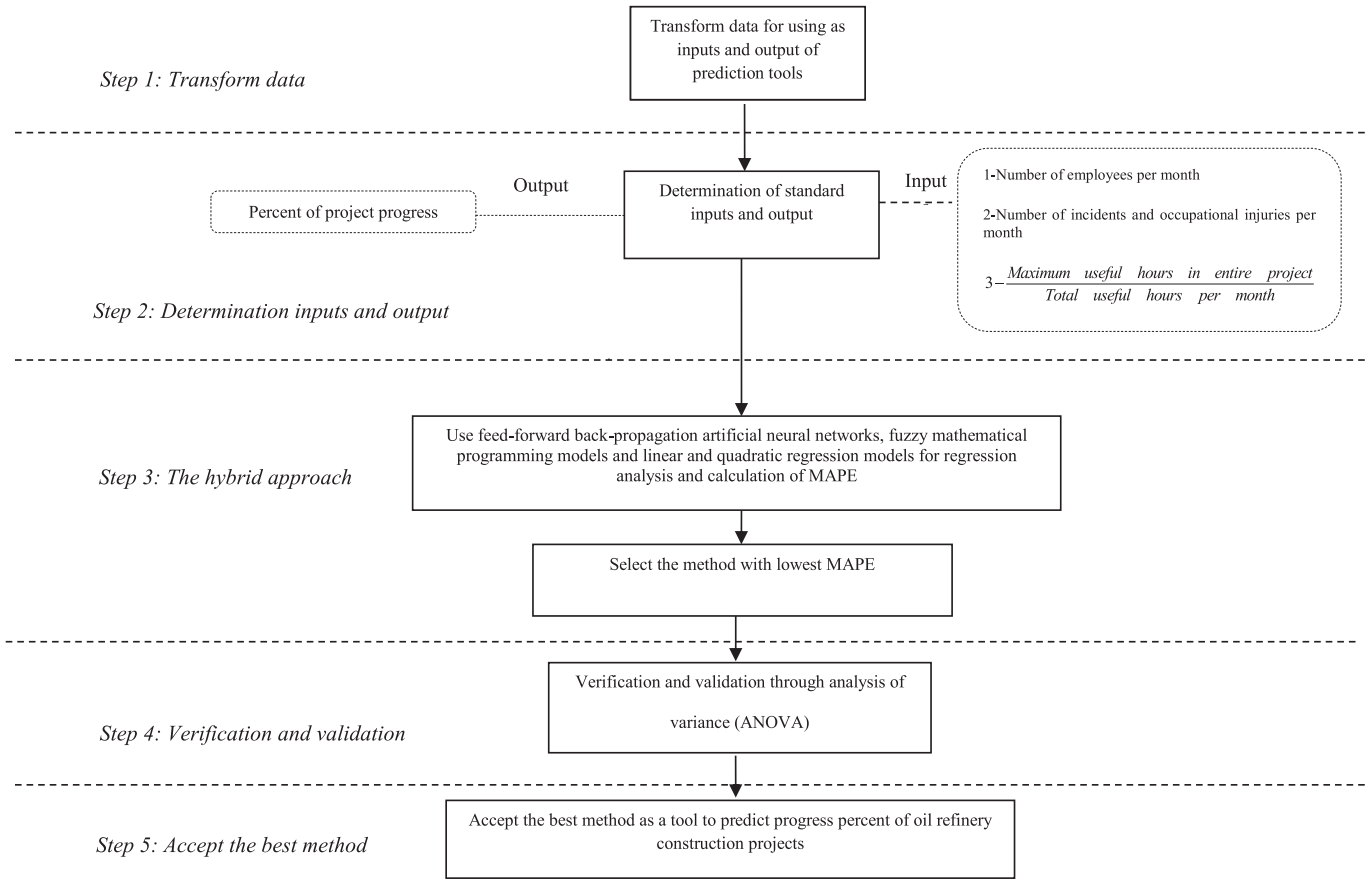

Fig. 1. The proposed approach for predicting progress percent of an oil refinery construction project.