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The Challenges of Nonparametric Cost Estimation of Construction Works With the Use of Artificial Intelligence Tools

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Abstract

Nonparametric cost estimation in construction projects with the use of artificial networks is presented as suitable mainly for the early estimates. These conceptual estimates are based on the variables – namely cost predictors that characterize the project or a facility. Data gathered on the basis of completed projects are combined together and applied to the current project cost estimation process. The aim of the paper is to discuss the opportunities and challenges of the approach based on the artificial intelligence tools to cost estimation of construction works. The proposed approach is based on the concept of nonparametric cost estimation and application of artificial neural networks. The author's idea and intention is to transfer the mechanisms of nonparametric cost estimating to the level of construction works. Neural networks, due to their general capabilities, seem to be a good tool to aid the proposed approach. The paper contains discussion of the proposed approach and its applicability.

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Keywords: artificial intelligence; neural networks; construction works; nonparametric cost estimation

1. Introduction

The aim of cost estimating is to forecast, approximate, assess or calculate the probable cost of a project computed on the basis of available information. The process of cost estimating in the whole cycle of a construction project is a matter of high importance as the cost analyses form a basis for lots of decisions important for the success of a project. Cost estimating classified on the basis of methodology may be classified as follows (compare [7], [15], [20]):

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- qualitative cost estimating:
  - cost estimating based on heuristic methods,
  - cost estimating based on expert judgements,
- quantitative cost estimating:
  - cost estimating based on statistical methods:
    - cost estimating based on parametric methods,
    - cost estimating based on nonparametric methods,
  - cost estimating based on analogous/comparative methods,
  - cost estimating based on analytical methods.

The classification above can be addressed to various branches of industry – in particular also to the construction. Variety of methods can be listed for both qualitative and quantitative approaches. This paper is devoted to the issues of cost estimating based on statistical methods. Concise comparison of parametric and nonparametric approach is presented in the paper. The author's main aim is to discuss the challenges and opportunities of nonparametric methods based on artificial intelligence applied for the cost estimating of construction works. Some results of the author's previous studies in this field are also reported and synthesized in the paper.

Nomenclature and abbreviations used in the text are set together in the box below.

Nomenclature

AI	artificial intelligence
ANN	artificial neural network
CER	cost estimating relationship
PCE	parametric cost estimating
NpCE	nonparametric cost estimating

2. Parametric and nonparametric cost estimating

According to the classification of cost estimating methods presented in the paragraph 1 both parametric and nonparametric cost estimating (PCE and NpCE) belong to the quantitative cot estimating based on the use of various statistical methods. The approaches have their roots in the regression analysis. General similarity of PCE and NpCE lies in the assumption that there exist a relationship between cost as dependent variable and cost predictors as depending variables. In case of both approaches the goal is to find a mathematical representation of such relationship with the use of known values of costs and cost predictors for similar completed projects.

A parametric estimate is comprised of cost estimating relationships (CERs) and other parametric estimating functions that provide logical and repeatable relationships between independent variables (such as design parameters or physical characteristics) and the dependent variable (cost) [3]. For the purposes of development of PCE model for a certain project CERs are initially assumed *a priori* either as linear or non-linear relationships. Examples of linear (1) and nonlinear (2) generic forms of such relationships can be given as follows (compare with e.g. [8]):

$$y = \beta_0 + x_1\beta_1 + x_2\beta_2 + \ldots + x_i\beta_i + \ldots + x_k\beta_k + \varepsilon \tag{1}$$

$$y = \beta_0 + x_1^{\alpha_1}\beta_1 + x_2^{\alpha 2}\beta_2 + \ldots + x_i^{\alpha_i}\beta_i + \ldots + x_k^{\alpha_k}\beta_k + \varepsilon \tag{2}$$

where:
y – dependent variable - estimated cost,
x_i – input variables (i=1,…,k) – cost predictors,
β_i, α_i – structural parameters of relationships derived from regression,
ε – random disturbance, for which expected value $E(\varepsilon) = 0$.