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BUILDING INFORMATICS NEURAL NETWORK AND REGRESSION HEURISTICS PROTOCOL FOR MAKING DECISIONS IN BUILDING CONSTRUCTION PROJECTS

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Building Informatics is a body of knowledge that uses the ICT computer system, digital systems, building information modeling, and state-of-the-art software in solving technical and management issues in building and construction fields. One of the modern methods used in data forecasting and modeling is Artificial Neural Networks, considering its advantage over traditional regression method. A data sample was taken of 1500 residential building projects' completion costs. Regression analysis was carried out and model validated with functionality and Jackknife re-sampling technique. 150 Questionnaires were used to capture data on factors influencing application of heuristics protocol for decisions in residential building construction projects and data samples were analyzed using severity index, ranking, and simple percentages. Analysis of data brought up some factors that influence effective application of heuristic protocol in solving decision problems in construction decision process. The linearity analysis was carried out on the model and results indicated high level of tolerance and -0.0876 lowest variation prediction quotients to 0.9878 highest variation quotients. Also, 0.069 regression model fitness coefficient (R-square) was generated with 0.9878 highest variation quotients with standard error of 0.045. The results data attests to the stability of the model generated and the model is flexible in accommodating new data and variables, thus, allows for continuous updating.

Keywords: Coefficient, Collinearity, Fitness, ICT, Updating, Expert system.

1 INTRODUCTION

The construction sector has been noted for activities that are cost intensive; since ancient times construction of building and facilities has been carried out with various cost components. Often, cost components of a building or construction work need to be packaged adequately for proper interpretation. Sometimes, systems are often used to interpret and decode cost packages in construction works in form of models. These models refer to as "building models." Skitmore (2003) and Brandon (1987) defined "building cost model" as the "symbolic representation of a building system expressing the content of the system in terms of cost influencing parameters." According to Skitmore (2003), the first model that was used in solving building related problems is called the cube method. The cube method was used about around 14 BC alongside methods which were used in solving cost related problems, such as the floor area method and the story enclosure method. Among all the model types, the story enclosure method was discovered to be more accurate in structure, form, and application (Rosen 1974). This was documented as one of the early works in the system of Hedonic equations and regression models.

1.1 Heuristic Cost Models Applications in Solving Construction Related Challenges

In the context of this study, different areas of application of cost models are presented. Their application could be summarized into two categories: the process application and application by product. There are two different schools of thought in cost modeling: product-based and process based. Skitmore (2003) defined product-based model as a system that usually models finished product, while process-based model on the other hand creates a model through synchronization of building process to synthesize a model. Similarly, there are areas of defect in the application of cost models in construction operations. For instance, Rosen (1974) opined that the area method of estimating item costs is deficient in being influenced by factors other than floor area. Also, it has overdependence on system antecedents to model real situation as contained in the Monte Carlo simulation methods. Finally, expert–based systems have been found to have strength in the areas of deficiency of regression models. It was discovered that their output has less error when compared with output of regression analysis; it generate less error between input and expected output, also, and tends to have variation error within the range of 2% to 4% while the parametric model (regression model) often has a variation error greater than 7% (Kim *et al.* 2004, Cattel, Bowen and Kaka, 2008).

2 REVIEW OF RELATED WORKS ON NON-TRADITIONAL MODELS [ANNs]

Artificial Neural Networks have been used in modeling cost variables in almost all areas of human endeavor. In this section, some of the articles reviewed cover the following areas: highway cost modeling, final construction cost modeling, risk analysis, and risk estimating among others. In Picard and De-Palma (2010), risk was identified on project sites, with the aid of Artificial Neural Networks, in the study, percentage change in the estimated cost from final cost prediction was carried out as an index of risk analysis and measurement. Also, in Kim *et al.* (2004), the estimating model in use at the early stage of construction works was examined and analyzed; between regression analysis and neural network, neural network was found in the study to have better prediction ability. Also, in Spooner and Setyawati (1974), a combination of regression and neural network models to generate a regression-based model was developed; likewise, a stock market return network model was developed by Thawornnwong and Enke (2004) using neural network. Moreover, Picard and De-Palma (2010) carried out research on a econometric model with the aim of developing hedonic price model. Regression model was used to generate hedonic regression model. The hedonic model was used in estimating demand and value of a specific good by classifying it into its constituent characteristics (Amusan 2012). Hedonic models are used in several applications such as real estate application, real estate appraisals, computation of consumer price index (CPI) and relative price index (RPI), among others. According to Amusan (2012), and Elfaki *et al. (*2014), in real estate economics, hedonic model is applicable in solving the problems of price determination and price adjudication (Amusan 2012). Hedonic models have ability to treat variables based on their separate identity or elasticity in case of a log model. To this end, the econometric model developed in this study toes the line of submissions of Picard and De-Palma (2010). Also, the hedonic related model adopted cost entropy and econometric approach to generate a model that incorporates heterogeneous variable of residential project for price and cost judgment.

3 RESEARCH METHODOLOGY

3.1 Source of Data Information

Two groups of samples were used in this study: 150 samples for qualitative aspect of data training parameters, that is, the criterion for effective prediction ability and Factors that influences the Application of Heuristic Protocol and Expert System in Construction Decision and samples for data training for Heuristic proposed model. One thousand (1000) samples were picked at random from 1500 samples of residential building projects completed within the past four (4) years at selected locations: Ogun State, Lagos State, and Federal Capital Territory (FCT) in Nigeria. These areas are regarded as economic nerve centers and regions of high construction activity. The initial and final costs of the sampled projects were extracted and adjusted with price index to 2017. The 1000 samples were adjusted with price and prevailing inflation index to be able to capture economic variable that influences building cost and was further used to train the Multi Layer Perceptron Neural network with Back Propagation system and Levenberg Marqua, this was for network configuration. From Table 1, 500 (50 percent) of the samples was used in model testing, while another set of 750 samples of the earlier adjusted/modified data was used in output prediction.

Table 1. Active cross validation performance for building projects.

Parameters	Active Cross Validation Performance	Cross Validation Performance
Mean Square Error	0.0583	0.000465
Normal Mean Square Error	0.0878	4546521.80
Regression Value ‘r’	0.9790	0.0465

The building project costs were selected for validation. The cross-validation performance of the cost samples treated was presented in Table 1 and 3. Regression value of 0.9790 was obtained while the Mean Square Error is 0.0583 and the Normal Mean Square Error is 0.0878. The error of 6% between the original values relative to predicted value is adjudged low enough for acceptance. The skewness of the data is normal and positive at 0.9790 (Afolabi *et al.* 2018).

Table 2. Regression coefficients of the developed model.

Parameters	Unstandardized Coefficients	Standard Coefficient		Collinearity Statistics
B(Constant)	Standard .Error	Beta	t	Significance
	4.1398	4.1587	9.953	.000

Notes: Dependent Variable: Neural Networks

3.2 Re-sampling

Re-sampling test was conducted on the model in order to ascertain the stability and the influence of outliers on the models’ stability. The results are presented in Tables 2 and 3; two models are presented here: model of as-built sum and neural network model. Neural model has standard error of 0.197 while as-built sum model has 0.312. Generally, the two models showed stability with high level of tolerance.

Table 3. Resampling test.

Dimension	Eigen value	Condition	Variance Proportion		
	Index	(Constant)	As Built Sum	Neural Network Sum	
1	3.923	1.000	.01	.00	.000
2	.088	8.759	.58	.018	.045
3	.087	16.995	.42	.030	.099

Factors that influence the application of heuristic protocol and expert system in construction decision are presented in Table 4. 150 questionnaires designed in Likert scale were administered on some respondents to harvest user perception on factors that influence the application of heuristic protocol and expert system in construction decision. "Preparation of cost budget limits for heuristic protocol investment" was ranked 1st, "inadequate knowledge about the profit on heuristic protocol application investment" was ranked 2nd, "high cost of employing ICT professionals" was ranked 3rd, and "lack of staff with appropriate skill and knowledge in ICT" was ranked 4th. Also, "cost of training professionals in cost expert application like neural network" was ranked 5th, while "inadequate education in ICT in educational institutions" and "lack of commitment by firms management towards ICT application in solving basic construction problems" were ranked 6th and 7th respectively, among others (Afolabi *et al.* 2018).

Table 4. Data on factors influencing application of heuristic protocol and expert system in construction decision.

Determinants/ Parameters	R.A.I	Rank
Budget limits for heuristic protocol investment	0.836	1st
Inadequate knowledge about the profit on heuristic protocol application investment	0.788	2nd
High cost of employing ICT professionals	0.776	3rd
Lack of staff with appropriate skill and knowledge in ICT	0.764	4th
Cost of training professionals in cost expert application like neural network	0.756	5th
Inadequate education in ICT in educational institutions	0.756	6th
Lack of commitment by firms management towards ICT application in solving basic construction problems	0.748	7th

4 CONCLUSIONS

After configuration of a neural network system that could be used for processing of residential building cost, the cost data was used to train neural network system and generate a suitable algorithm as shown in Figure 1. The neural output generated represents a predicted cost range for the office projects with regards to prevailing economic situation like inflation and building price index. This was factored into the as-built cost of the project and predicted upward for the period of six months. Thus, the specified range of prediction expressed for the model in the context of this study is six months, subject to constant economic variables. However, if economic variables change before the six-month prediction window period, the cost should be adjusted with the current economic variables. Cross validation analysis indicates -0.07403 lowest variation prediction quotients to 0.66639 highest variation quotients. Also, the regression coefficient (R-square) value for determining the model fitness is 0.035 with standard error of 0.397. Model fitness and standard error are often used as index to measure the nature of a regression model.

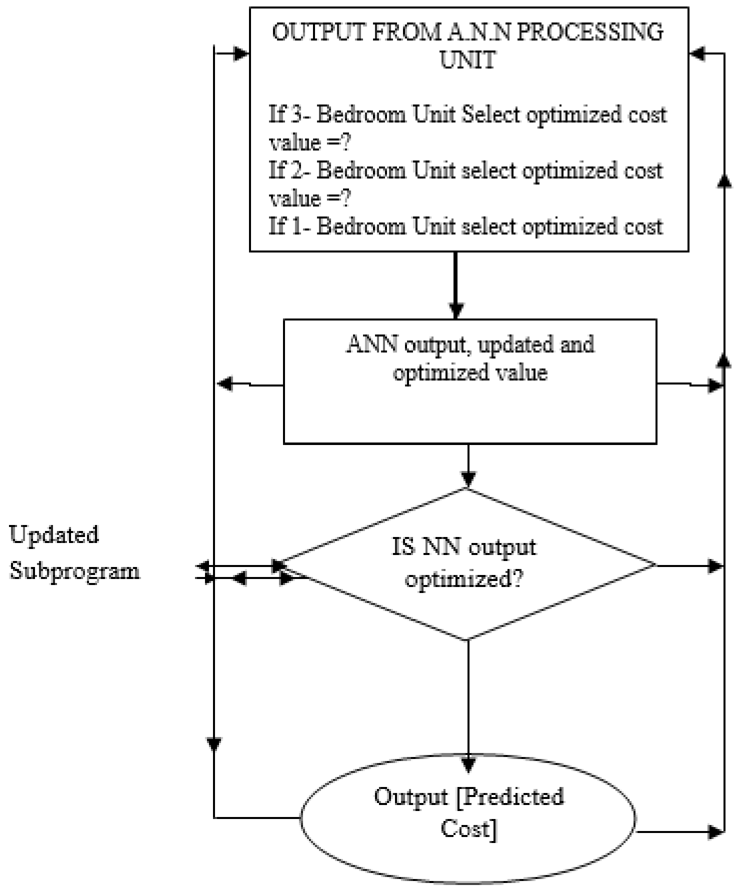

Figure 1. Algorithm for cost processing.

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