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A MODEL FOR THE PAVEMENT TEMPERATURE PREDICTION AT SPECIFIED DEPTH USING NEURAL NETWORKS

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Preliminary Note – Prethodno priopćenje

Earlier researches have established that the ambient temperature is one of the most important factors for pavement temperature analysis.This paper examines the existing models for predicting pavement temperatures at specified depth and formulates a new one using neural networks depending on the surface pavement temperature and depth. It was also conducted the validation of the model comparing predicted with measured temperatures.

Key words: pavement, temperature, model, predicting, neural networks, depth

INTRODUCTION

A classical comparison of information processing by a human and a computer is focused on the ability of pattern recognition and learning. The computer can calculate large numbers at high speeds but it cannot recognize something such as a classification problem, written text, data compression and a learning algorithm.

On the contrary, a human easily recognizes and deals with the challenges mentioned above by processing information with highly distributed transformations through thousands of interconnected neurons in the brain.

Generally speaking, an ANN is an informational system simulating the ability of a biological neural network by interconnecting many simple neurons (Figure 1). The neuron accepts inputs from a single or multiple sources and produces outputs by simple calculations, processing with a predetermined non-linear function.

Artificial neural network (ANN) models have been widely applied to various relevant civil engineering areas such as geotechnical engineering, water resources, coastal, structural engineering and many others, but never before for predicting pavement temperatures.

The primary characteristics of an ANN can be presented as following: (1) the ability of learning; (2) distributed memory; (3) fault tolerance and (4) operating in parallel, Figure 1 [1].

Compared to conventional digital computing techniques, and procedural and symbolic processing, neural networks are advantageous because they can learn from example and generalize solutions to new renderings of a problem, can adapt to fine changes in the nature of a problem, are tolerant to errors in the input data, can process information rapidly, and are readily transportable between computing systems.

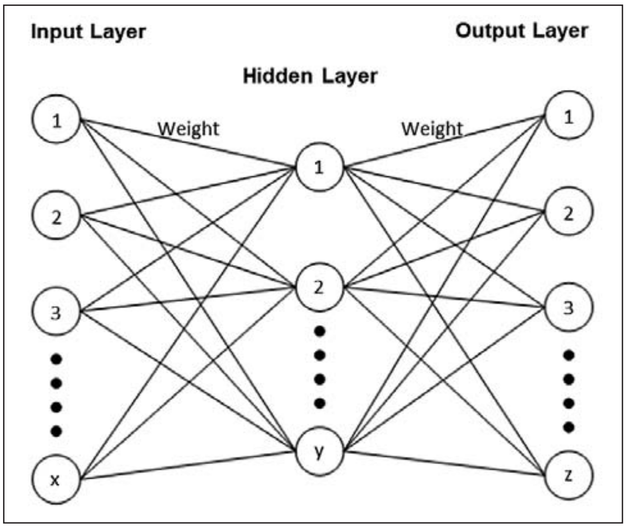

Figure 1 Structure of Artificial Neural Network Model [1]

Despite their limitations, neural networks offer a powerful means of solving poorly definied problems that have eluded solutions by conventional digital computing techniques. Problem of this type are commonplace in civil engineering [2].

Until today many authors are formed models using statistical data analysis to predict the pavement temperature at specified depth.

EXPERIMENTAL PART

Instrumentation

Data was measured during the experimental research by setting the six temperature measuring sensors at the depth of the flexible pavement structure (Figure 2), at the university campus, in the street Dr Ilije Đuričića, Novi Sad, Serbia [9].

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Table 1 **An overview of models for predicting pavement temperature at specified depth [3-8]**

Author	The publishing year	Statistical data analysis
Strategic Highway Research Program (SHRP)	1987	Yes
Mohseni A.	1998	Yes
Lukanen et al.	1998	Yes
Bosscher et al.	1998	Yes
Ovik et al.	1999	Yes
Park et al.	2001	Yes
Marshall et al.	2001	Yes
Denneman E.	2007	Yes

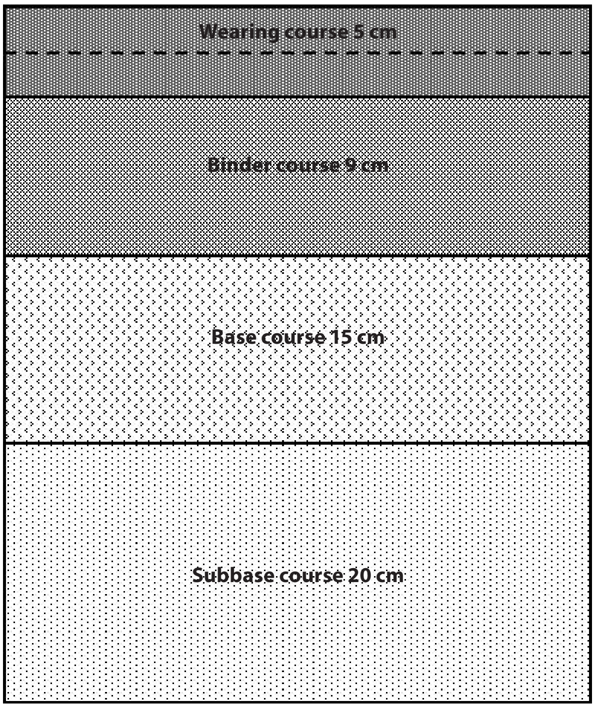

Figure 2 Overview of the analyzed pavement Structure [9]

Data utilized in model formation were gathered in the period December (2011 - 2012).

RESULTS AND DISCUSSION
Methodology and anticipated results

The model developed with the objective of predicting pavement temperature at depth is based on the neural networks analysis. Models are formed to predict maximum and minimum pavement temperatures at depth, depending on the maximum and minimum surface pavement temperature and depth using neural networks, Table 2 and Table 3.

Models formed using neural networks

The model predicting maximum and minimum pavement temperatures at specified depth can be presented by the following table.

Model validation

Based on the formulated model for predicting maximum and minimum pavement temperatures at specified depth (Table 2, Table 3), the model validation has been performed by comparing measured and predicted pavement temperatures at depth (Figure 3).

The mean absolute error (MAE) between measured and predicted maximum pavement temperatures at depth is 0,68580356 ^{o}C, and between measured and predicted minimum pavement temperatures MAE is 0,648050082 ^{o}C.

Also, it can be concluded that the models have formed by ANN predict pavement temperatures with better accuracy then models have formed by regression analysis [9].

CONCLUSION

The paper formulates new models for predicting minimum and maximum pavement temperatures at specified depth using the ANN, in dependence on the surface pavement temperature and pavement depth.

During the data analysis and the formation of the pavement temperature prediction model for specified depths, it has been determined that temperatures behave differently depending on the pavement surface temperature, daylight, pavement surface depth, and the part of the day.

Based on the correlation coefficient, standard model deviation and mean absolute error (MAE), it can be concluded that these models can be utilized with the adequate accuracy for predicting maximal and minimal pavement temperature at depth; yet the model for pre-

Table 2 **Model for predicting maximum pavement temperature at specified depth by ANN**

Index	Net. name	Training perf.	Test perf.	Training error	Test error	Training algorithm	Error function	Hidden activation	Output activation
1	MLP 2-4-1	0,993489	0,993301	0,000323	0,000332	BFGS 26	SOS	Tanh	Identity

Table 3 **Model for predicting minimum pavement temperature at specified depth by ANN**

Index	Net. name	Training perf.	Test perf.	Training error	Test error	Training algorithm	Error function	Hidden activation	Output activation
1	MLP 2-9-1	0,995712	0,995560	0,00013	0,00014	BFGS 161	SOS	Tanh	Exponential

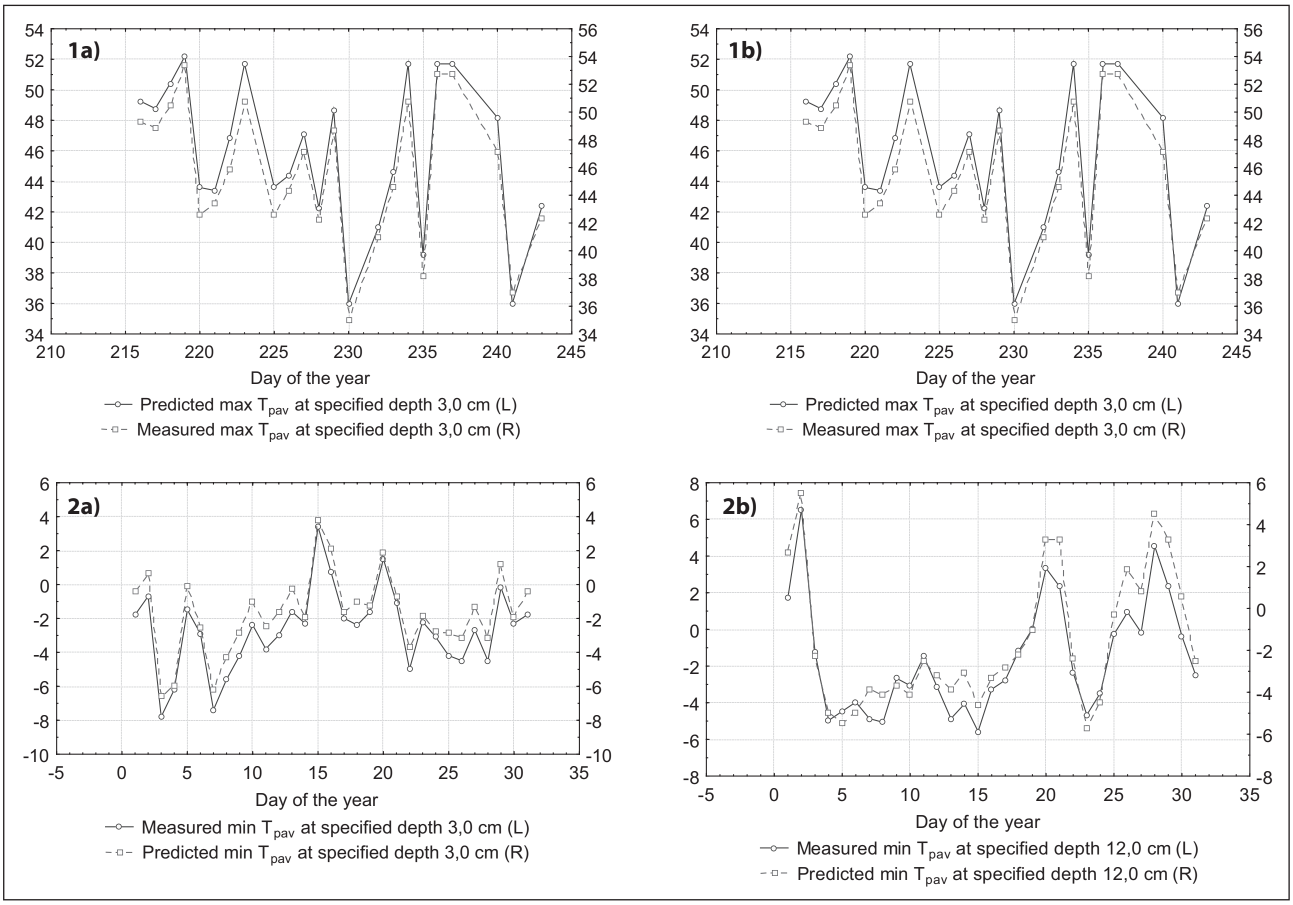

Figure 3 Model validation (for specified pavement depth: 3,0 and 12,0)

dicting minimal pavement temperature at certain depth provides a somewhat more accurate result.

Also it can be concluded that the models have formed by ANN predict pavement temperatures with better accuracy then models have formed by regression analysis.

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Note: The responsible translator for English language is J. Šafranj from University of Novi Sad, Serbia