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SOFTWARE DEVELOPMENT SOLUTION FOR PREDICTION ON TRIBOLOGICAL PROPERTIES OF DENTAL GLASS CERAMICS BASED ON JAVASCRIPT WEB FRAMEWORKS

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Throughout industrialisation, and consequently, in the Industry 4.0 period, the research community and scientific organisations strived to reduce many extensive tribological laboratory experiments. Nowadays, it is feasible to overcome this issue by incorporating adequate information and communication technologies and edge devices capabilities. This incorporation provides a possibility to solve complex non-linear problems and identify tribological properties based on previously determined experimental parameters' values, referred to related materials and stored in the appropriate databases. The paper's primary goal is reflected in the web-based JavaScript and MongoDB affordable software solution's development view and its application to predict tribological properties of dental glass ceramics in terms of wear rate and friction coefficient.

Keywords: *recurrent neural network, JavaScript, web based solution, dental glass ceramics, tribological properties.*

1. INTRODUCTION

The JavaScript programming language application has become more comprehensive in the last few decades, especially in different engineering application areas. Hence, in tribological experiments, it is possible to apply JavaScript frameworks modules that incorporate different prediction algorithms for tribological properties determination, i.e. wear rate and friction coefficient, according to the defined terms of the contact and materials tested and stored in appropriate databases. Previous studies show that the artificial neural network (ANN) prediction algorithms have been used for the prediction of biotribological dental glass Ceramic [1], prediction of surface treatment effects on the tribological performance of tool steels [2], as support for wear rate regression model [3], tribological properties of plasma nitride 316L stainless steel [4], etc.

Glass ceramics has become the most used dental materials in prosthetics, thanks to its excellent aesthetic characteristics, good mechanical strength and longevity of restorations. There are many different types of glass ceramics depending on their chemical, mechanical and optical characteristics [5].

The main goal is to present developing web-based JavaScript and MongoDB affordable software solution to predict tribological properties of dental glass ceramics in terms of wear rate and friction coefficient. The authors will try to show that the developing solution's application has quite acceptable results for all defined conditions.

2. MAIN APPLICATION PARTS

The main infrastructure parts that enable the entire solution's functioning are MongoDB, Node.js, Express.js and Brain.js. More will be said about these parts below.

In order to be able to use the cloud database in the future, MongoDB was utilised. MongoDB provides up-to-date information workflow and the allocation of resources. MongoDB belongs to the NoSQL class of databases, meaning that relational restrictions characterising SQL databases do not exist. Also, columns are excluded, while rows are represented as documents that are used to store data. In MongoDB, data are stored in a BSON format, presenting a binary JSON document as a reasonable solution for JavaScript web-based solution development.

Direct communication with the MongoDB database can only be performed through the Mongoose module, which further communicates with the Express.js and Node.js. Consequently, Express.js is the back-end component providing a communication channel between the back and front ends, while Node.js is a well-known JavaScirp runtime environment, providing the possibility for JavaScript to be run at the back-end.

The Brain.js module was applied within the software solution for the prediction of the tribological properties, operating within Node.js environment. This module uses several ANN algorithms, including recurrent neural network (RNN), applied in this software solution. RNN belongs to the ANN class, enhancing the traditional feedforward NN with loops in relations [6]. RNN diverge from classical feedforward NN because they can process the input data sequentially distributed to the network's recurrent hidden state, whose each activation in each subsequent step depends on the activation of the previous step. Therefore, RNNs are characterised by dynamic nature.

For the experimental tribological properties, the proposed sequence has the following form $etp = (etp^1, etp^2, \dots, etp^k)$, representing tribological properties obtained from previously conducted laboratory experiments. Consequently, the RNN can compute the hidden vector sequence as $\upsilon = (\upsilon^1, \upsilon^2, \dots, \upsilon^K)$, by repeating the following equation from $k = 1$ to K:

$$\upsilon^k = \delta(w_{i\upsilon} tp^k + W_{i\upsilon}\upsilon^{k-1} + b_\upsilon), \quad (1)$$

vector, and $W_{i\upsilon}\upsilon^{k-1}$ representing the context weight matrix of the hidden layer. Other dimensions are b_υ bias vector in the hidden layer and δ ( ) sigmoid or tan-sigmoid activation function in the hidden layer.

Finally, predicted tribological parameters could be calculated as:

$$t_p = W_{o\upsilon}\upsilon^K + b_o, \quad (2)$$

with $W_{o\upsilon}\upsilon^K$ representing the output-hidden weight matrix, and b_o representing the bias vector of the output layer. The goal is to present distinct experimental tribological characteristics and tribological properties as sequential data so that a trained RNN could be used as a prediction tool.

3. CONCLUSIONS

The model will be verified using experimental tribological values obtained by means of a nanotribometer. Recurrent neural network approach through Brain.js module will be used for mathematical modelling of input tribometer parameters which could be used to predict tribological results, i.e. wear rate and coefficient of friction values. Consequently, a comparison between experimental and predicted values will be conducted.

REFERENCES

[1] M. Pantić, A. Đorđević, M. Erić, S. Mitrović, M. Babić, D. Džunić, M. Stefanović: Application of artificial neural network in biotribological research of dental glass ceramic, Tribology in Industry, Vol. 40, No. 4, pp. 692-701, 2018.

[2] L. Cavaleri, P.G. Asteris, P.P. Psyllaki, M.G. Douvika, A.D. Skentou, N.M. Vaxevanidis: Prediction of surface treatment effects on the tribological performance of tool steels using artificial neural networks, Applied Sciences, Vol. 9, No. 14, Paper 2788, 2019.

[3] I.I. Argatov, Y.S. Chai: An artificial neural network supported regression model for wear rate, Tribology International, Vol. 138, pp. 211-214, 2019.

[4] A.F. Yetim, M.Y. Codur, M. Yazici: Using of artificial neural network for the prediction of tribological properties of plasma nitrided 316L stainless steel, Materials Letters, Vol. 158, pp. 170-173, 2015.

[5] J.Z. Shen, T. Kosmač: *Advanced Ceramics for Dentistry*, Butterworth-Heinemann, Waltham, 2014.

[6] L. Mou, P. Ghamisi, X.X. Zhu: Deep recurrent neural networks for hyperspectral image classification, IEEE Transactions on Geoscience and Remote Sensing, Vol. 55, No. 7, pp. 3639-3655, 2017.