SHEAR STRESS CLASSIFICATION FOR THE FINITE ELEMENT ANALYSIS OF HIP IMPLANT SURFACE TOPOGRAPHIES

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Abstract:

In order to perform numerical analysis of hip implant surface topographies several steps must be followed, such as defining model geometry values, creating a CAD model for a hip implant and femoral bone, creating a mesh for both models, defining material properties, and appropriate boundary conditions. This approach requires significant time and computational effort in order to achieve shear stress distribution for just one model, which is not enough when we are trying to find the optimal hip implant surface. A possible way to reduce time is to limit the number of models that are being analyzed using classification algorithms. The goal is to perform classification using 10 model parameters and based on the output to further analyze only models that are classified as below the threshold. Preliminary results indicate that this approach can be useful.

Keywords: classification, hip implant, surface topographies

1. Introduction

Over the past years, a number of hip implant surface topographies have been analysed using the Finite Element Method (FEM) [1, 2]. Although this approach is less time-consuming compared to experiments required in this area of research, there is still room for improvement. Nowadays, artificial intelligence is applied in this area as a way to perform a prescreening and determine which model should be analysed or to develop surrogate models. The aim of this paper is to analyse if the use of classification can be useful for the finite element analysis of the surface modification of titanium alloy used for hip implant.

2. Materials and Methods

For the problem considered in this paper several classification algorithms can be used. Those algorithms are Support Vector Machines (SVM), K- Nearest Neighbor (KNN), Decision Tree (DT), Random Forest (RF) and Boosted Tree (BT) [3]. An overview of the considered approach is presented in Figure 1. The idea is that we can use 10 defined model parameters and by employing different classification algorithms obtain information about whether it is expected that model shear stress value will be above or below a defined threshold value. Shear stress values are considered to be some of the most important parameters for this type of problem. Higher shear stress value means that there is a chance that the connection between the hip implant and femoral bone will not be strong enough and that additional surgeries will be required.

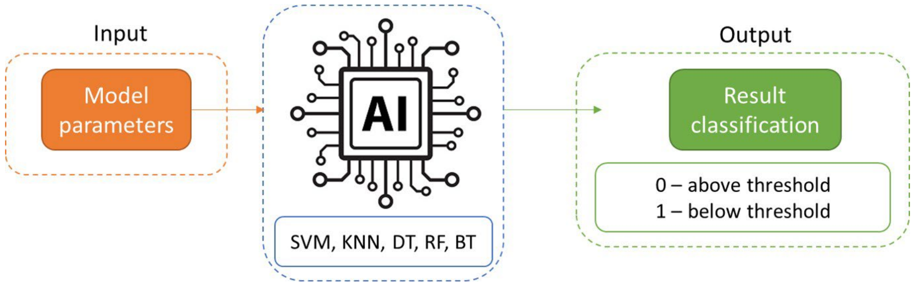

Fig. 1. Considered approach for the presented problem

The list of model parameters is given in Table 1.

Number	Parameter	Type	Value
1	Number of half cylinders lengthwise	Integer	>1
2	Number of half cylinder rows	Integer	>1
3	Half cylinder orientation (parallel to length or width of the model)	Integer	0 or 1
4	Distance between half cylinders lengthwise	Real	≥0
5	Distance between half cylinders widthwise	Real	≥0
6	Number of different radius values	Integer	1 or 2
7	Radius 1 value	Real	>0
8	Radius 2 value	Real	≥0
9	Distance from edge where loading is located	Real	≥0
10	Distance from the other edge of the model	Real	≥0

Table 1. List of input parameters

3. Discussion and Conclusions

Preliminary results indicate that the presented approach can be applied in the analysis of modified hip implant surfaces as it reduces time required for the analysis by providing initial classification and information if shear stress values would be above or below the defined threshold.

Acknowledgement: This research is supported by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 952603 - SGABU. This article reflects only the author's view. The Commission is not responsible for any use that may be made of the information it contains. The research was funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia, contract number [451-03-68/2022-14/200107 (Faculty of Engineering, University of Kragujevac)].

References

[1] Vulović A, Filipovic N, Computational analysis of hip implant surfaces, Journal of the Serbian Society for Computational Mechanics, 13(1): 109-119, 2019.
[2] Vulović A, Warchomicka FG, Filipović N, Finite Element Analysis of Surface Modification of Titanium Alloy Used for Hip Implant, THERMEC, 1544-1548, 2021.
[3] Soofi AA, Awan A, Classification techniques in machine learning: applications and issues. Journal of Basic and Applied Sciences, 13:459-65, 2017.