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# Towards a 2D cortical osseous tissue representation and generation at micro scale. A computational model for bone simulations

Francisco Daniel Pérez-Cano*, Adrián Luque-Luque, Juan José Jiménez-Delgado

*Computer Graphics and Geomatics Group, Campus Las Lagunillas S/N, Jaén 23071, Spain*

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ABSTRACT

*Background and objective:* the acquisition of microscopic images of human bones is a complex and expensive process. Moreover, the objective of obtaining a large data bank with microscopic images in order to carry out massive studies or to train automatic generation algorithms is not an option. Consequently, most of the current work focuses on the analysis of small regions captured by a microscope. The aim is the development of a tool to represent bone tissue at microscopic levels which is suitable for performing physical simulations, as well as for the diagnosis of various diseases. This work includes the whole process from the digitization of a human bone to the generation of bone tissue in a determined area of the bone selected through a cutting plane.

*Methods:* based on the anatomy of the bone structure, the parameters that allow the representation of the bone tissue at mesoscale level have been analyzed. Although the models are randomly generated, they are based on statistical parameters. The model generator is based on the analysis of images of bone tissue and its parameters, performing a representation of each of its relevant structures in a way that fulfils these parameters.

*Results:* the tool is useful for the virtual generation of bone tissue that satisfies the main characteristics of the cortical bone. The models obtained have been favorably evaluated in two stages. In the first stage, a scientific group has examined a set of images, in which images of the models generated were mixed with images obtained through traditional methods. Then, the physical characteristics of the generated tissue have been compared with the morphology of the bone tissue.

*Conclusions:* the model generator allows us to perform precise simulations in order to obtain realistic images with physical characteristics in accordance with reality. It is necessary to emphasize that even though the most relevant structures are included, the proposed model generator can be expanded to include new parameters or elements, so that it can be adapted to new needs. It could even break down randomness and parameterize it completely in order to allow the recreation of the tissue conditions of other studies.



## 1. Introduction

The complexity of the hierarchical structure of bones remains a challenge that has been restricting research in recent years. This adds to the difficulty of obtaining input data, such as microscopic computed tomography (CT) images or real bone models. This causes most studies to focus on whole bone, without taking into consideration the different microscopic structures that have a strong influence on the events that can occur on a bone, or use a small set of microscopic images which raises concerns as they can be insufficiently representative.

The objective of this study is the development of a tool for the representation of cortical bone tissue at microscopic levels accurate to the structures that make up the bone tissue in shape, size, density and distribution. This representation takes as its starting point a real bone to generate a 2D model so that, in addition to being represented, it can be analyzed and compared with other existing studies on real microscope images that are in the same dimension. In order to use real models as input, the process of conversion from CT scan to 3D model has been studied and implemented. The generation algorithm is based on the use of mean values, obtained from the literature, to estimate all the parameters associated with the bones without taking into account factors such as age, sex or

* Corresponding author.
*E-mail addresses:* fdperez@ujaen.es (F.D. Pérez-Cano), alluque@ujaen.es (A. Luque-Luque), juanjo@ujaen.es (J.J. Jiménez-Delgado).

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