Hybrid Skeleton Graph Analysis of Disordered Porous Media. Application to trabecular bone

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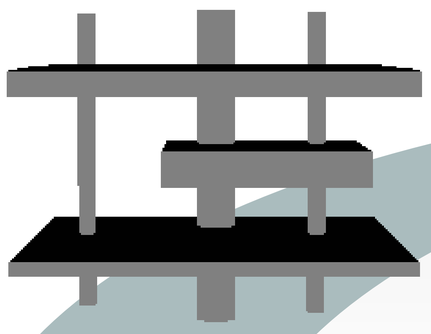
Abstract

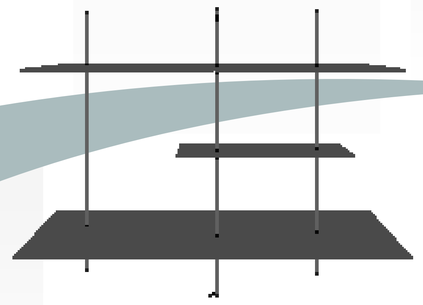
Hybrid Skeleton Graph Analysis (HSGA) is a new method for modeling disordered porous media. Recent work has shown that the line skeleton is a powerful tool for 3D structure characterization. However, as it generates only 1D curves, the geometry of the material is sometimes excessively approximated. Our algorithm is an improved solution as it considers the local shape of each element that composes the structure of the medium. It consists in an efficient combination of curve and surface thinning techniques. Features extracted from the new skeleton contain significant topological and morphological information. A clinical study carried out on trabecular bone samples demonstrates the ability of our method to discriminate between 2 different populations.

Principle



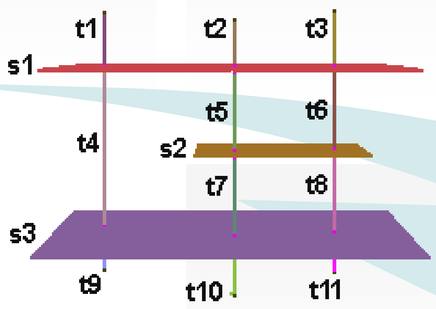
original object

test vector or bone sample



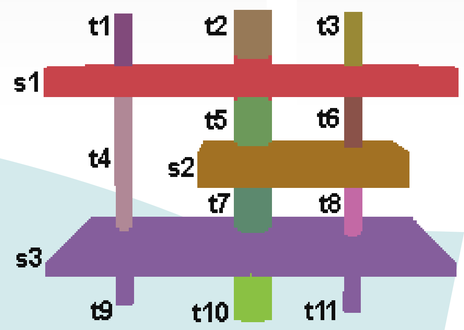
hybrid skeleton (1)

uses curve thinning for rods (1D) and surface thinning for plates (2D)



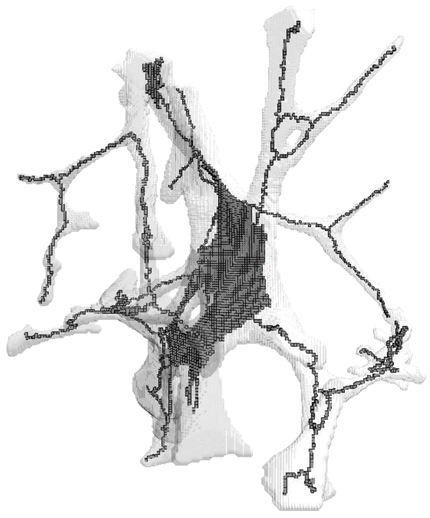
hybrid graph

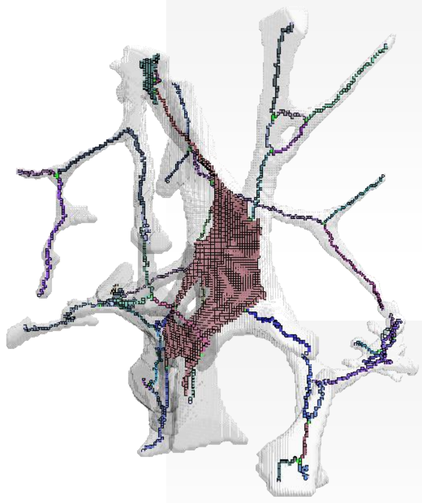
each structure element is classified and individualized

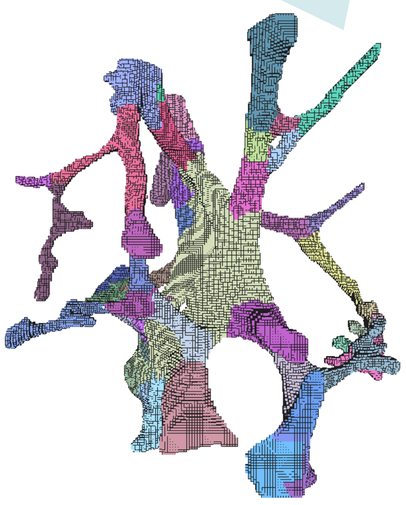


segmented graph

provides precise morphological and topological features

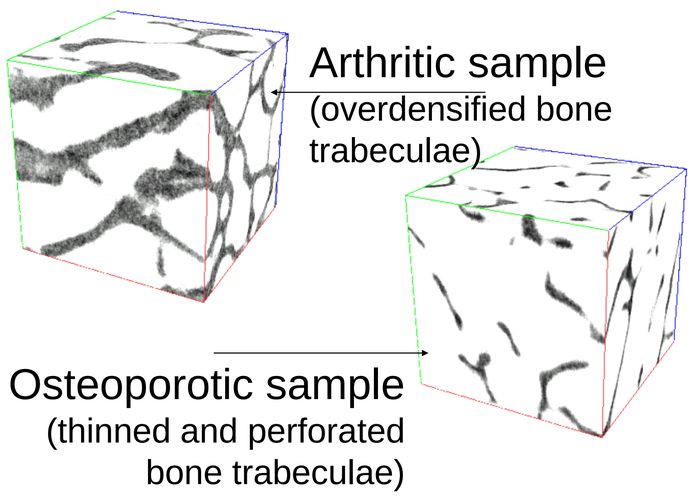






(1) G. Aufort, R. Jennane, R. Harba, "A new shape-dependant skeletonization method. Application to porous media", EUSIPCO'06, Florence (Italy), sept 2006.

Clinical study



Arthritic sample
(overdensified bone trabeculae)

Osteoporotic sample
(thinned and perforated bone trabeculae)

The study was carried out on 2 sets of trabecular bone samples (osteoporotic / arthritic). LSGA (2) and HSGA models have been compared. A bilateral hypothesis test was used to evaluate the discriminative power of each extracted feature.

	Student's |t| value	
Measured parameter	LSGA	HSGA
BV/TV	3.83	3.83
Conn.D (mm^{-3})	2.09	2.09
Tb.N	2.13	1.87
Tb.Th (mm)	3.53	2.95
SV/TV	2.58	2.99
Le.N	2.07	2.93
SL/TB	n.a.	1.72
Sl.Th (mm)	n.a.	3.37

$|t| < 2.92$ does not discriminate

The HSGA can discriminate 2 pathologically different populations. Work is in progress which intends to use the HSGA model for fast and precise mechanical studies using Finite Elements (FE).

(2) L. Pothuaud, P. Orion, E. Lespessailles, C. L. Benhamou and P. Levitz, "A new method for three-dimensional skeleton graph analysis of porous media : application to trabecular bone microarchitecture", Journal of microscopy, Vol. 199 Pt. 2, pp. 149-161, 2000.
G. Aufort, R. Jennane, R. Harba, C. L. Benhamou. "*Hybrid Skeleton Graph Analysis of Disordered Porous Media. Application to Trabecular Bone*" IEEE-ICASSP 2006, pp. 781-784, Toulouse (France), mai 2006.