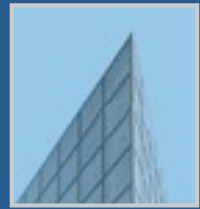




# Computational Analysis of Cortical Drift and Shape Changes in Human Bone Cross-sections

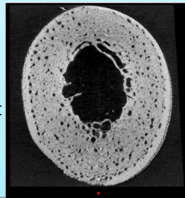
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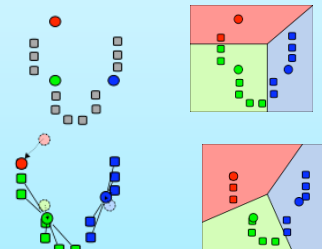
## Abstract

The goal of this project was to create an automated way to measure the thickness of the periosteal primary bone region (the area between the pores and the edge of the bone) in microCT images of cortical bone cross-sections. The resulting measurements will allow us to relate cortical drift with age, gender, health status and nutrition levels. The primary and secondary bone regions contain different pore densities. A previous Java program correctly identifies the inner boundary of the primary bone region. A C++ program was written that takes the Java program's output and calculates the thickness of the outer, primary region as a function of angle.



## Objective

- 1) Calculate thickness measurements from the inner boundary of the primary bone region to the edge of the bone at regular intervals using an automated approach.
- 2) Compute the similarity of the resulting shape distributions between all bone samples.
- 3) Supply the similarity metrics to a clustering algorithm to determine which bone samples have comparable internal structure.



## Process

- Once you enter the bone scan and run the Java program, the window in Figure 1 appears.
  - First you must choose a threshold. Basically, the picture is turned into a black and white image and you may adjust the threshold value in order to change the contrast of the image in order to segment pores in the bone.
  - Secondly, you must set the angle of orientation which ensures that all bones are aligned consistently. This defines the orientation of the red, white, and blue lines in the image at the bottom of the poster.
  - Next, a pore size in pixels must be specified. If the given minimum size is too small then the program will mistake graininess for pores and if the size is too big then it could mistake parts of the bone's inner core as a pore. The end result of this is shown in Figure 2.
- The program uses the Jarvis March convex hull algorithm to create the outer ring. This is similar to wrapping a string around a set of nails in a board. If you tie the string to the leftmost nail and hold it vertically then move the string clockwise until you hit the next, then the next, then the next, you end at the starting nail and you are left with a ring. Instead of nails, this program uses the pores.
- The program then exports the following information into text files:
  - The coordinate for the bone center
  - The coordinates for the line segments in the outer ring
  - The list of black pixels in the background
  - The orientation angle
- The C++ program is then started. The program uses the information from the text files to generate a sequence of radial lines emanating from the bone center. These lines are intersected with the outer ring line segments and the black background pixels. The Euclidean distance between these two intersection points is then calculated.

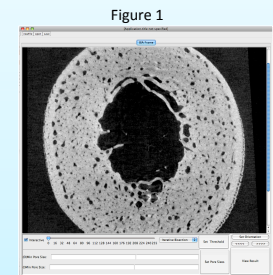
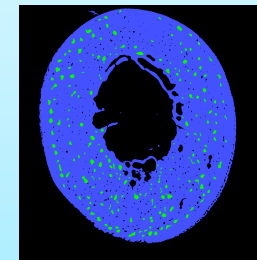


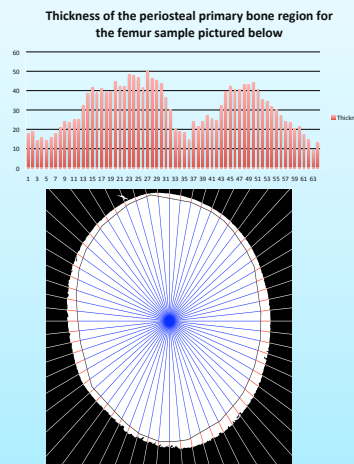
Figure 2



## Results

Ten microCT images of cortical bone cross-sections were analyzed. The thickness of the outer primary bone region was calculated for each sample as a function of angle. The similarity between the distributions was calculated and clustered. We were able to successfully cluster the specimens by gender.

- 6 samples were identified as male.
- 2 samples were identified as female.
- 2 of the male samples came back indeterminate



## Conclusion and Future Work

This stage of the research provides a proof of concept. We can show that the measurements from the C++ program are correct and we have evidence that the clustering algorithm is working as well.

For the future, we would like to explore other similarity metrics. The Earth Mover's Distance (EMD) algorithm seems to be a reasonable choice, but to date we have encountered some problems in implementing the EMD code.

More bone samples will be scanned and analyzed. Additional experiments will be run with the software we have created to discover correlations between internal bone structure and health status.

This research was conducted in collaboration with and the bone scans were provided by Dr. Haviva Goldman, DUCoM.