Ancestral state reconstruction for surfaces

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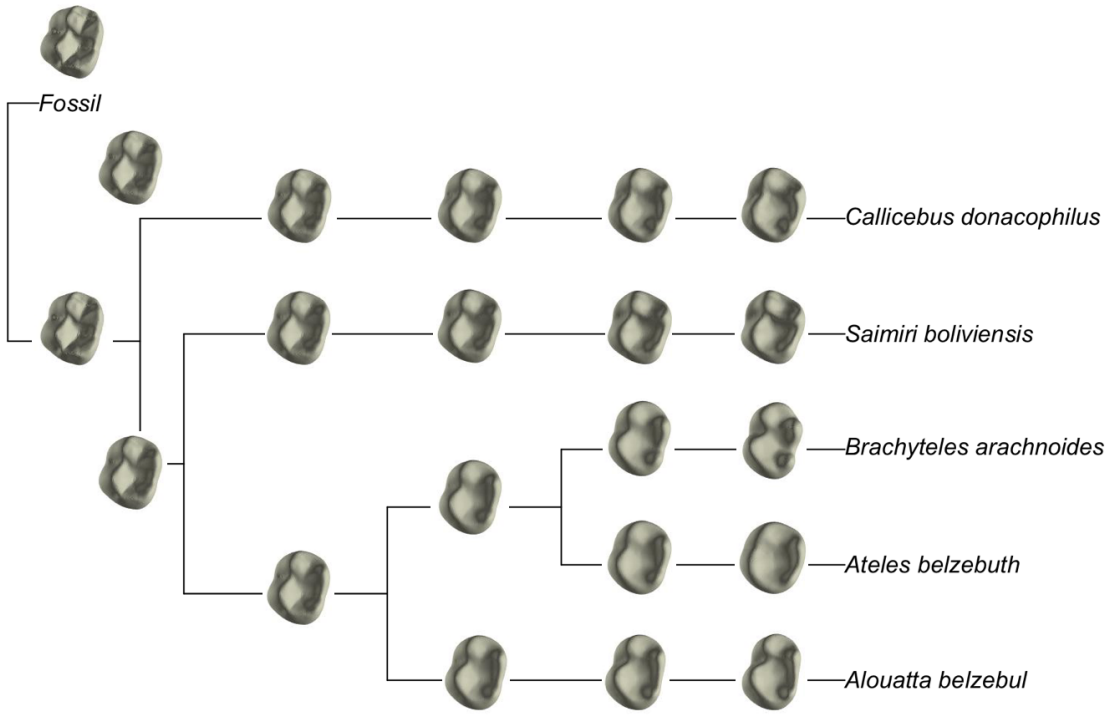
Evolutionary biologists studying and relating both animals that can be extant (i.e. presently living) or extinct (and known only through remains in the fossil record) are interested in detailed characterizations and questions concerning 2D surfaces embedded in 3D that provide interesting mathematical and algorithmic challenges. This project focuses on one such question.

Reconstructing ancestral states on a phylogenetic tree is an important approach for understanding evolutionary changes. Given anatomical surfaces for some collection of specimens and their phylogenetic tree, we describe our first attempts to reconstruct an ancestral surface.

On one hand, we propose a fully automated method for reconstructing anatomical surfaces. The algorithm consists of two steps: a) registering all given surfaces to a common template and simultaneously aligning them; b) computing a target surface as a weighted average of the surfaces from the previous step, with weights obtained from the phylogenetic tree using comparative biology methods.

On the other hand, we build a generative model for anatomical surfaces. After the automatic selection of a set of homologous landmarks on the input surfaces, we model the landmark distribution statistically. A generated target surface is an implicit surface computed from a randomly chosen set of landmarks according to the distribution we determined.



Joint work with: Ingrid Daubechies, Doug M. Boyer.