Forensic Morphometrics

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Abstract

For this project, our aim was to systematically discover, study, and identify a skeletal system, while contributing to the creation of an online database. This was accomplished with the help of a 3D laser scanner, which allowed us to construct a digital model of the skeleton. By studying the model and researching dichotomy keys, it was discovered to be a simpler river otter. The final model of the otter skeleton is to be added to an online database created by Devin Geraci. The database is projected to be of use in forensic analysis of bones by serving as a reference when differentiating between human and animal bones.

Objective

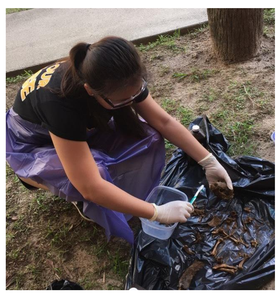
The objective of this research is to discover, study, and identify a skeletal system, while expanding an online database of 3D skeletal structures. The objective is achieved in two steps:

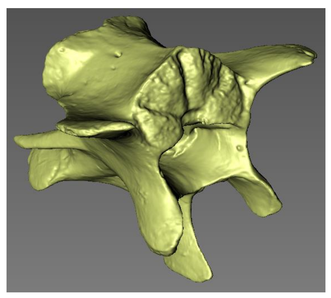
1. Excavate the bones.
2. Create a digital 3D model of the skeletal structure.

Process

Our project was a bit unorthodox in that we didn't have a strict set of guidelines. The first day, Dr. Slice walks in, hands us two full trash bags, and tells us to begin. Unbeknownst to us, the bags were full of two-year-old roadkill and dirt. Our job was to dig through the dirt and excavate the bones, identify them, and digitally reconstruct the skeleton. For the next few weeks, we sorted through soil, clay, dried flesh, and fur for the undisclosed skeleton. After exhuming the bones, we cleaned them with toothbrushes and sterilized them with hydrogen peroxide. Once the bones were prepared, we observed their structure and size. Researching dichotomy keys became the next step and it was revealed that the bones came from a simple river otter. After this discovery, we used the 3D laser scanner to construct digital models of each individual bone. I focused on studying the skull and vertebrae while my partner focused on studying a limb of the otter. Using 3D modeling software such as MeshLab, we reconstructed the skeletal system of the otter.





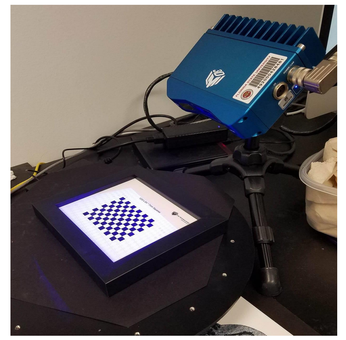
Morphometrics

Morphometrics is the field of multivariate statistical analysis concerned with the quantification of shape, the description of shape variability, the assessment of group differences in shape, and the covariation of shape with other variables. Morphometrics can be applied to many different fields, including but not limited to entomology, conservation biology, anthropology, forensic science, and medical science. Morphometric analyses are commonly performed on organisms, and are useful in analyzing their fossil record, the impact of mutations on shape, developmental changes in form, covariances between ecological factors and shape, as well for estimating quantitative-genetic parameters of shape. Morphometrics can be used to quantify a trait of evolutionary significance, and by detecting changes in the shape, deduce something of their function and evolutionary relationships. A major objective of morphometrics is to statistically test hypotheses about the factors that affect shape.

3D Laser Scanning Technology

The major tool used in this project was a 3DLMI Laser Scanner. Laser scanners work by using either a laser line or single laser point to scan across an object. A sensor picks up the laser light that is reflected off the object, and using trigonometric triangulation, calculates the distance from the object to the scanner. The distance between the laser source and the sensor is known very precisely, as well as the angle between the laser and the sensor. As the laser light reflects off the scanned object, the system can discern what angle it is returning to the sensor at, and therefore the distance from the laser source to the object's surface.

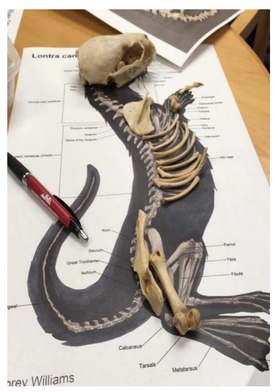
The scanner in our lab is a structured light scanner, which projects a pattern instead of a point or line onto a target surface. The distorted pattern due to shape is then acquired by a camera and used to reconstruct the object. Structured light scanners take a sequence of images with different patterns of light projected onto the object surface in order to create a full 3D point cloud. Objects must be stationary during image acquisition. For most situations, a single scan will not produce a complete model of the subject. Multiple scans, even hundreds, from many different directions are usually required to obtain information about all sides of the subject. These scans have to be brought into a common reference system, a process that is usually called alignment, and then merged or combined to create a complete model. This whole process, going from the single range map to the whole model, is usually known as the 3D scanning pipeline.

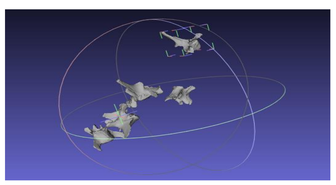
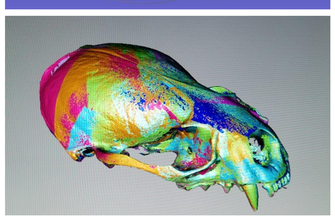


Results

The organism was discovered to be a river otter, as shown by multiple dichotomy keys and digital models. We created multiple 3D scans of different bones and layered them on top of one another to study and recreate the skeleton. Unfortunately, due to time constraints, we were unable to scan all the bones and reconstruct the entire skeletal system. However, we were able to scan the skull, some vertebrae, and a part of the pelvis.

We applied the studies of morphometrics in our project when using the 3D laser scanner to model the bones we found. I focused on scanning and studying the vertebrae and the skull. As shown below, we seem to have reconstructed the spine; however, not all pieces of vertebrae were found so there may be a few discrepancies. The original goal was to add the completed skeletal model to the online database of 3D skeletal structures. Regrettably, we underestimated the amount of time it would take to scan the bones, and we could not complete the skeleton. Nevertheless, we did take the scan of the cranium to be 3D printed.



Discussion for the Future

Morphometrics has and will always have an impact on the world. However, the specific impact for our project could be even more far-reaching. An online database of 3D skeletal structures could change the world. 3D scans of skeletal structures could help forensic analysts differentiate between an animal and a human bone or give museums the ability to reconstruct the skeleton of an organism. With the 3D scans, anyone could 3D print their own structure to study without having the actual bones right in front of them. An online database gives people access to more information that they can study and learn from.

Acknowledgements

Sources:

- Slice, Lecture 1 Powerpoint
- Fausto Bernardini, Holly E. Rushmeier (2002). "The 3D Model Acquisition Pipeline"(pdf). *Comput. Graph. Forum* 21 (2): 149–172