The open research CT Scan Archive

Creating an online archive of high-resolution CT images of museum specimens

The 'Open Research CT Scan Archive' is a collection of high resolution CT scans of human and non-human crania. Due to recent advances in 3-dimensional imaging software, detailed anatomical studies can be accomplished without ever having to rescan or handle any of the specimens again. The database is designed to continually grow and currently contains about 1200 scans. As each new scan is obtained it will be made available online in order to maximize its usefulness to researchers worldwide.

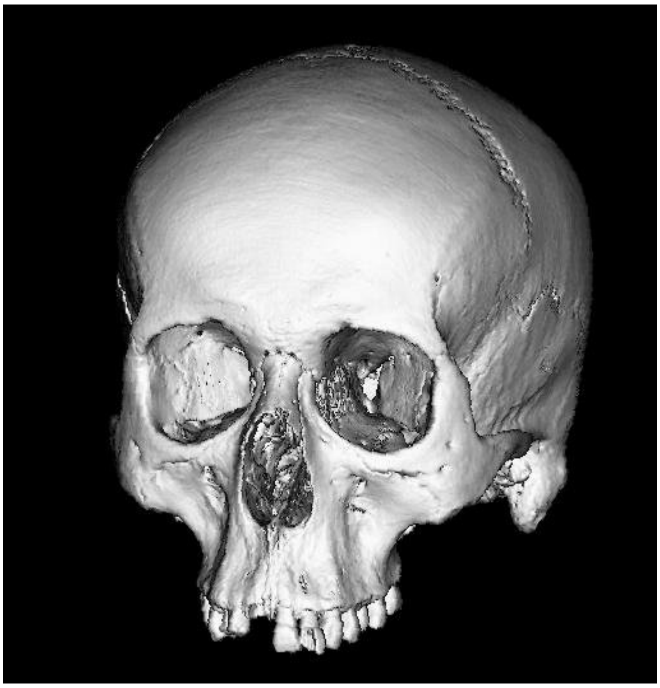

Figure 1: The rendered CT images, like this skull from the Penn Museum's Morton Collection, are useful in many areas of research. Volume, linear, and area measurements are all possible as well as many methods that allow comparison of specimens to each other.

Goals and aspirations:

The express purpose of the collection is to facilitate research in biology, skeletal biology, anthropology, medicine, and other related disciplines. It is hoped that the database will become a clearinghouse for CT data of all kinds, including CT's of fossil specimens. This database will allow us to better interpret such fossils by allowing us to place them in comparative perspective with other specimens.

Institutions have already contributed specimens to the collection, including:

- University of Pennsylvania Museum of Archaeology and Anthropology
- American Museum of Natural History
- Smithsonian Institution
- Columbia University Department of Anthropology

Specimens in the database:

The Samuel George Morton collection is housed and curated at the University of Pennsylvania Museum of Archaeology and Anthropology. The original Morton collection is composed of approximately 1200 human crania, most without mandibles, and collected from both archaeological and recent contexts (1820's to 1851). After Morton's death, his student, J. Aitken Meigs, continued with the collection which totals approximately 1800 crania.

In addition, the database includes scans of three modern human crania along with scans of their matching plaster endocasts created by Ralph Holloway at Columbia University.

The five orangutan crania in the database come from the Harrison and Hiller University of Pennsylvania Museum of Archaeology and Anthropology expedition to Borneo late in the 19th Century. All specimens were wild-shot, prepared in Borneo, and shipped to Philadelphia.

Most of the twenty chimpanzee (Pan troglodytes) specimens are from the American Museum of Natural History, from the von Lushen collection. The database also includes a few specimens from the University of Pennsylvania Museum of Archaeology and Anthropology, which were originally obtained as part of a gift from the Academy of Natural Sciences, Philadelphia. Unfortunately, no data accompanied the specimens on their age, sex, or geographic origin. All specimens date from the 1880s-1890s.

Figure 2: The CT archive contains not only contains human skulls and other skeletal elements, but also comparative primate materials like this chimpanzee skull.

Why CT?

The resolution possible from CT scanners is significantly finer than the degree of accuracy obtainable from direct measurements of the original specimen using calipers. Combined with currently available 3D visualization software, it is possible to take any measurement from the CT scans themselves. This means specimens never have to be touched again for research purposes, minimizing the likelihood of damaged. It also means that, given the appropriate software, research on these specimens can be done anywhere.

CT scans reconstruct internal structures that are not studied externally. Studies of the evolution of bipedalism, for example, have included analyses of the orientation of the inner ear. In the absence of CT, this would not be possible without destroying specimens.

Recent advances in 3D image analysis for clinical research allow for new and more powerful studies of complex geometry of the skull. For example, algorithms have been developed that allow several brains to be morphed, into a common coordinate system for use in functional brain imaging. This allows more accurate comparison of brain activation across individuals with brains of different sizes and shapes. We have begun applying these algorithms to create high-resolution 3D maps of individual variability in morphology.

Figure 3: The archive contains over 250 CT scans of children ranging in age from 8 fetal months to 16 years of age.

This information is routinely discarded in functional imaging studies once individual functional scans are morphed into the same brain space; however, it is an extremely rich source of information that can be used to study shape in much more sophisticated ways than has been possible previously.

Current research on this data:

Several studies have already begun on scans in the 'Open Research CT Scan Archive' database including studies on:

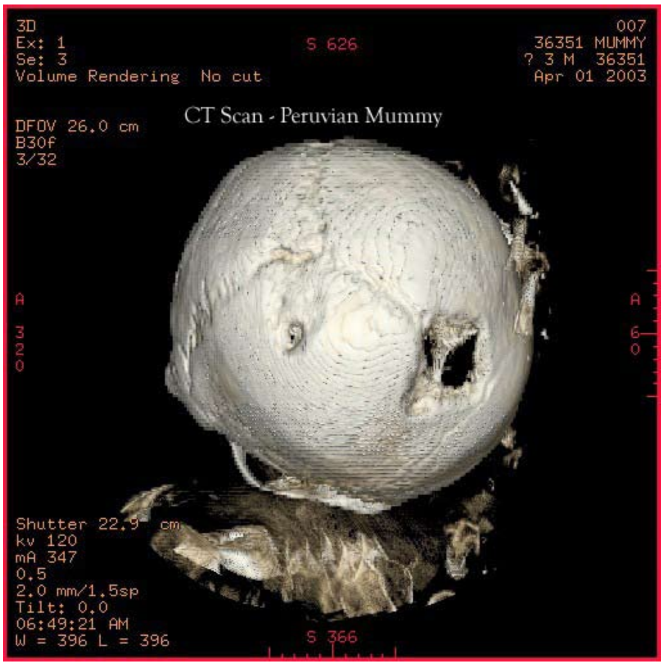

Figure 3: In addition to scanning the skeletal collections, the CT Open Source Archive project also images mummified remains in the Penn Museum collections. This Peruvian mummy was CT scanned and the wrappings removed virtually revealing 2 healed trepanations (one on the frontal bone and one on the parietal bone).

- How well do handmade plaster replicas of the endocranium (inside of the braincase) match the actual endocranial surface? Are there any systematic biases introduced by a plaster method?
- How do ape endocrania differ from human endocrania? By morphing ape and human images together, the differences between the two specimens can be characterized in 3 dimensions, on a voxel-by-voxel basis, maximizing the chance of extracting meaningful information from fossil endocasts.
- How does the placement of the foramen magnum (where the spinal cord exits the base of the skull) differ with respect to other features of the cranial base in bipedal humans vs. non-bipedal apes?
- What is the functional purpose of large supraorbital tori (brow ridges)? By morphing a large sample of modern human crania into a common coordinate system, one can describe the variability on voxel-by-voxel basis. One can then map the extent to which variability at each point correlates with things like the size of different aspects of the masticatory system.

Access and facilities:

The CT image database is stored on computers in the Open Research Scan Archive, which is housed in University of Pennsylvania Museum of Archaeology and Anthropology.

An online informational database is being constructed to allow researchers to search the collections based on user-defined criteria. The website address is: http://grape.anthro.upenn.edu/%7Elab/pennct/. Researchers would then either come to work on the data at our lab, or have their scans sent to their own labs on CD or DVD.

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References

1. And the University of Michigan, Dearborn, Department of Behavioral Sciences, Dearborn, MI 48128 USA