2019 Technology Fee Full Proposal

Title: Expanding Capacity for 3D Data Analysis

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Sponsoring Organization: College of Liberal Arts and Sciences; George A. Smathers Libraries; Florida Museum of Natural History (FLMNH); College of Medicine; College of Education

Purpose and Specific Objectives: Advances in Computed Tomography (CT) provides critical opportunities to improve educational innovation at UF for its students, faculty and staff. CT is a technique that produces high fidelity volumetric representations of living or inanimate objects, allowing enormous amounts of external and internal information to be recovered in three dimensions. Advances in 3D digitization coupled with new analytical techniques are rapidly transforming science and education. 3D innovations in technology have huge potential for fostering research initiatives and developing lifelong skills that will have an immediate impact on the student experience at UF and beyond. Indeed, UF has gained international prominence in CT-based research, particularly with respect to the biological sciences. Coursework and research opportunities in diverse fields from Anthropology to Zoology provide UF students the opportunity to engage in innovative and rewarding research efforts that are both transformative and meet high-impact educational practices (Kuh 2008).

As a research heavy institution, UF has the infrastructure, resources and talent to provide myriad opportunities for educational innovation using 3D data. As an emerging leader in this field, UF is poised to accelerate and foster innovation in 3D technology through collaborative assignments, projects, and research. New courses and planned workshops each semester using 3D technology coupled with funded PI-driven research highlight this potential. For example, UF is the lead institution for the multi-institutional NSF-funded openVertebrate (oVert) project that aims to digitize and disseminate vast numbers of museum specimens. However, there is a serious bottleneck with respect to access by students to workstations needed to learn the software and analyze these data. There are very few available high-end workstations with suitable software on the UF campus to process and utilize these data. Although six workstations with licenses for requisite software exist on campus at present, each of these have limited access which severely restricts the ability for students from diverse disciplines to familiarize themselves with 3D reconstruction techniques and engage in the time-consuming analysis of large 3D datasets, much less find time to manipulate and explore 3D data in new and innovative ways. **We request funds to install three 3D workstations with the high-end volumetric analysis software suite VG StudioMax (www.volumegraphics.com) in the George A. Smathers Libraries to maximize accessibility and foster innovation and collaboration using this emergent technology (two in the 3D Lab in Marston Science Library and one in the Health Science Center Library).**

A growing body of research utilizes 3D data, and CT scanning facilities are producing datasets for engineering, material sciences, geology, life sciences and more (Figure 1). These datasets are often made available through data portals (e.g., www.morphosource.org); however, there is a growing backlog of unanalyzed scan data due to the lack of available workstations at UF and the time-consuming nature of post-processing and analysis of 3D data. Using this technology, we can provide leadership and training to engage students in innovative research. UF has made major investments in CT technology. In 2015, UF's Office of Research invested in a high-resolution nanoscale CT-scanning machine (GE phoenix v|tome|x) that was installed at the Nanoscale Research Facility (NRF), which is a part of the Research Service Center (RSC) in the Herbert Wertheim College of Engineering. This nanoCT has one dedicated workstation with VG StudioMax software that operates in tandem for users to conduct 3D image

processing/reconstruction as needed whilst scanning. In addition, the new Digital Imaging Laboratory in the Florida Museum of Natural History (FLMNH) has three workstations that serve its students and staff. Ed Stanley (FLMNH) runs this lab and provides key resources and training for requisite post-processing and analysis, including course delivery. Indeed, over the past few years, CT-scanning conducted at UF has attracted so much international attention that UF hosted the second North American meeting of ToScA (Tomography for Scientific Advancement; via the Royal Microscopical Society-- www.rms.org.uk) earlier this spring. Through this 2019 Tech Fee Full Proposal, we aim to expand the capacity for 3D analysis at UF and make high-end workstations, software, and training more readily available to students, faculty, and staff, especially those outside of the FLMNH.

Impact/Benefit: Transformations in technology are only good if the data generated are accessible to students. The George A. Smathers Libraries provide an optimal environment to house these workstations to facilitate community and innovation for users learning and applying these tools towards myriad projects and assignments. In a recent report focused on 3D technology and higher education (Pomerantz 2018), emphasis was placed not only on acquiring resources, but also in providing 3D resources in public spaces. Active UF students from myriad disciplines (Table 1) are benefitting from the extensive resources and support available at UF. For example, the RSC provides assistance and support with instrumentation, including the nanoCT, when preliminary data are critical for the success of a proposal submission. In these circumstances, limited services can be provided by the RSC at no cost to the PI/investigator to generate data that can support the research proposal.

Workstations housed in the Marston Science Library (MSL) and the Health Science Center Library (HSCL) will provide novel and public environments for students to engage in using and learning 3D technology, and develop research projects to garner extramural funding. Further, 3D data will spark innovative new approaches to learning and pedagogy, and foster lifelong learning and skills for users of this technology. The MSL is a high-traffic centrally located space and has extended hours of operation that cater to a diverse student population. Its newly renovated 3D lab provides access to both laser and structured-light 3D scanners. The MSL 3D lab also has facilities designed to provide learners the opportunity to create virtual reality applications, analyze large research datasets, or develop collaborative projects. Similarly, the Health Sciences Center Library (HSCL) has extended hours of operation and caters to a diverse population of health sciences and biomedical engineering students, faculty and staff. The HSCL is also equipped with 3D scanning and printing facilities. The proposed equipment housed at the MSL (Sara Gonzalez) and HSCL (Sarah Meyer, Joe Wu) would complement available workstations using VG StudioMax software at the FLMNH and provide students increased opportunities to access and analyze the same 3D datasets on different workstations. The requested workstations will be on the Libraries' reservation system, which students already use to reserve study rooms and equipment. These workstations will be located in an ADA-compliant space to ensure maximum usability. Data will be stored remotely in compliance with UFIT best practices, either through UFIT storage systems (PI-based) or through external hard drives.

The shortage of high-end workstations to post-process 3D data is currently a major limiting factor with respect to student training and developing/reconstructing 3D data. Two courses in CLAS that are currently in rotation exemplify classes utilizing this technology: ANT6930/ANT4930 *Morphometrics* (Valerie DeLeon) and ZOO6927 *CT for Biologists* (Ed Stanley). Further, we intend to provide support to the UF community through additional coursework, training sessions and workshops, and online tutorials. Ed Stanley (FLMNH) and Volume Graphics representatives will promote training in post-processing nanoCT data. Similarly, a large component of HSCL's mission is to teach and to provide training resources for users in the Health Sciences. Students served span the colleges in the Health Science Center (Medicine, Dentistry, Nursing, Pharmacy, Public Health, and Veterinary Medicine) in addition to students across campus (e.g., Health and Human Performance, Biomedical Engineering).

Sustainability: The anticipated lifespan of the workstations is 5+ years (Dell offers a five-year warranty on the requested CPUs) and the software should last significantly longer and we anticipate heavy use by students engaged in 3D data research and training. As mentioned above, users of each library-based workstation will reserve access and sign in to a 'user log' following procedures already in place. The required login procedure will permit the student to identify what project they are working on and the associated PI, if applicable. These data will be analyzed systematically to assess usage of each workstation and determine how to future fund one-year

update/service agreements. Further, these data will permit best practices to garner PI and/or UF support with respect to requisite CPU upgrades (e.g., processors, graphic cards).

Timeline: Workstations and software will be purchased and set up in early Fall 2019 at the MSL and HSCL, and upon receipt of equipment will immediately be accessible by students.

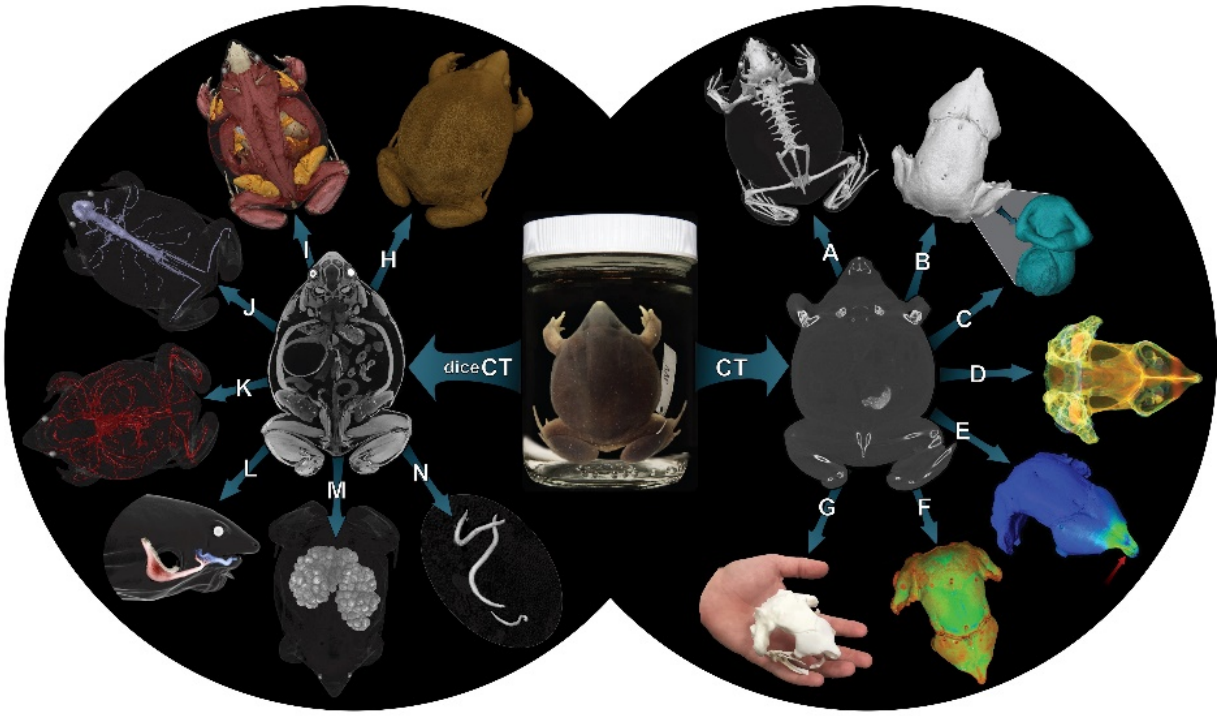

Figure 1. Diversity of data and analyses resulting from traditional computed tomography (CT) and diffusible iodine-based contrast-enhanced CT (diceCT) of a formalin-fixed, ethanol-stored frog specimen (genus *Hemisus*). A, qualitative morphology of skeleton; B, isolated cranium with, C, inner ear endocast; D, density analysis; E, Finite Element Analysis (*10*) showing distribution of stresses when force applied (red arrow); F, wall thickness analysis; G, 3D printed model of skull; H, external surface anatomy (similar to photogrammetry of specimens); soft-tissue anatomy including, I, skeletal muscles and glands, J, nervous system, K, cardiovascular system, and, L, intrinsic tongue muscles (blue, m. genioglossus; red, m. hyoglossus); natural history 'by-catch': M, eggs in oviducts, and, N, endoparasites (nematodes). All analyses and imaged produced using VG StudioMax 3.2.

References:

Johnson, S. (2010) *Where Good Ideas Come From: The Natural History of Innovation*. New York: Riverhead Books.

Kuh, G.D. (2008) *High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter*. Washington, DC: Association of American Colleges and Universities.

Pomerantz, J. (2018) *Learning in Three Dimensions: Report on the EDUCAUSE/HP Campus of the Future Project*. Louisville, CO: EDUCAUSE Center for Analysis and Research.

Table 1. UF student users of 3D data and their research project and faculty PI/mentor (in no particular order)

Student	Degree Status	Program	Project	PI
Paluh, Dan	PhD	Zoology (CLAS)	Andean Pouch Brooding Marsupial Frogs	Blackburn
Keeffe, Rachel	PhD	Zoology (CLAS)	Locomotor modes in frogs	Blackburn
Vallejo-Pareja, M.C.	PhD	Zoology (CLAS)	Diversity/evolution of frogs from Florida	Blackburn/Bloch
Singh, Amber	Ugrad	Zoology (CLAS)	Diversity/evolution of the inner ears of frogs	Blackburn
Singh, Amber	UGrad	Zoology (CLAS)	Digitization of *Titanoboa* , the world's largest snake	Bloch/Blackburn
Fuentes, Giovanni	UGrad	WEC (CALS)	Rattlesnake skull shape and ecology	Blackburn
Clancy, Keara	UGrad	WEC (CALS)	oVert creation of 3D models from CT-scans	Blackburn
Nielsen,Stuart	Postdoc	FLMNH	Taxonomy of Gopher Frogs in Florida	Blackburn
McClean, Bryan	Postdoc	FLMNH	Squirrel speciation and bacular anatomy	Blackburn
Early, Catherine	Postdoc	FLMNH	oVert	Blackburn
Morris, Abigail	UGrad	Zoology (CLAS)	Modeling frog jumping performance	Blackburn
Diaz, Sylvette	UGrad	Anim. Sci./WEC (CALS)	Skulls of snail-eating snakes	Blackburn
Ringer, Josh	PhD	WEC (CALS)	Fossil Cuban treefrogs from the Bahamas	Blackburn
Vitek, Natasha	PhD	Biology (CLAS)	Within-species evolution of small mammals	Bloch
Narducci, Rachel	PhD	Biology (CLAS)	Endocranial morphology of fossil armadillos	Bloch
Reigler, Mitchell	PhD	Geology (CLAS)	Reptiles diet and climate change	Bloch
Vinola, Lazaro	PhD	Biology (CLAS)	Evolution of Vertebrates in the Caribbean	Bloch
Ringer, Josh	PhD	WEC (CALS)	Big Data From Small Fossils	Bloch
Hoeflich, Jennifer	UGrad	Biology (CLAS)	Aquatic Paleo-habitats using teleost fish	Bloch
Toan Nguyen	UGrad	Engineering	Paleocene Vertebrate Fossils from Colombia	Bloch/Blackburn
misc. 8 students	UG/Grad	Anth, Bio, Geol (CLAS)	Early Pleistocene porcupine skeleton from Florida	Bloch
Dunn, Kristin	PhD	Entom. (IFAS)	Nano-CT scanning the light organs of fireflies	Branham
Fladeboe, Randee	PhD	Anthro (CLAS)	Macaw husbandry in the prehistoric southwest	Emery
Del Sol, Nicholas	PhD	Anthro (CLAS)	Turkey husbandry in Mesoamerica	Emery
Liu, Peng	PhD	PMCB (IFAS)	Distinctive features of transport paths in maize	Koch
Singer, Randy	PhD	Zoology (CLAS)	Mouth brooding in a deep-sea fish	Page
Bateman, Crain	PhD	Entom. (IFAS)	Mycangia morphology of Ambrosia beetles	Hulcr
Denton, John	Postdoc	FLMNH	Jaw morphology of Cookie cutter shark	Naylor
Yafuso, Erin	PhD	Env. Hort. (IFAS)	CT data of plant cuttings during propagation	Fisher
Williams, Jason	PhD	Entom. (IFAS)	Fossil and extant ant diversity	Lucky
Rocha, Fernanda	PhD	Dentistry	CT scanning to quantify tooth cavity growth	Gibson
Grant, Claudia	PhD	Education	3-D fossils for k–12 education	Antonenko
Ziegler, Michael	MS	Geology (CLAS)	Talking teeth (K-12 lessons on mammalian teeth)	Antonenko
Luo, Wenjing	PhD	Education	CT paleontological data and middle School learning	Antonenko
Cheng, Li	PhD	Education	3D printing and STEM k-12 education	Antonenko
Zaleski, Sarah	PhD	Anthro (CLAS)	Positional behavior and the thorax in newborn primates	DeLeon
Zaleski, Sarah	PhD	Anthro (CLAS)	Sexual dimorphism of the human pelvis	DeLeon
Cunningham, A.	PhD	Anthro (CLAS)	Cranial shape and identity in the African Diaspora	DeLeon
Selba, Molly	PhD	Anthro (CLAS)	Cranial dysmorphology in Kabuki syndrome mice	DeLeon
Selba, Molly	PhD	Anthro (CLAS)	Facial reduction in dogs, bats, and primates	DeLeon
Bryson, Emily	PhD	Anthro (CLAS)	Endocast morphology in newborn primates	DeLeon
Garcia, Sophia	UGrad	Anthro (CLAS)	Localizing the Fgfr2 mutation in mice	DeLeon
Smith, Jamie	UGrad	Anthro (CLAS)	Paranasal sinuses in the domestic dog	DeLeon
Galdamez, Gladys	UGrad	Anthro (CLAS)	Palatine bone morphology in newborn primates	DeLeon
Castro, Ricardo	UGrad	Chemistry (CLAS)	Cranial reconstruction of fossil Dolichicebus	DeLeon
Koeller, Krista	PhD	Zoology (CLAS)	Genomic mechanisms of limb loss in snake evolution	Cohn
Wiscovitch, A. B.	PhD	Biomed. Sci. (COM)	Sexually dimorphic organ development in mice	Cohn
Kircher, Bonnie	PhD	Zoology (CLAS)	Evolution of genital development	Cohn
Lewis, A. Kelsey	PhD	*Zoology (CLAS)*	Cell lineage of the external genitalia	Cohn
Lumia, Salvatore	UGrad	Microbio. (CLAS)	Patterning the embryonic gut	Cohn
Young, Vanessa	UGrad	Sociology (CLAS)	Cell type identity in the mammalian urogenital sinus	Cohn
Quinn, Julianna	UGrad	Biology (CLAS)	The role of Hand2 in genitourinary development	Cohn
Johnston, Caroline	UGrad	Classics (CLAS)	Gene expression in developing anogenital organs	Cohn
Prince, Dylan	UGrad	Psychology (CLAS)	Proteomic analysis of endocrine disruptor-exposed mouse fetuses	Cohn
Johnson, Margaret	UGrad	Chemistry (CLAS)	Mechanisms of sexually dimorphic skeletal development in *Anolis*	Cohn
Bittencourt, Julia	UGrad	Biology (CLAS)	Development of human and mouse lower urinary tract	Cohn
Gutierrez, Galaxy	UGrad	Biology (CLAS)	Cats as a model for mammalian dental development	Cohn
Geissler, Elise	PhD	Anthro (CLAS)	Spatial density variation in mammalian dentin	Daegling
Polvadore, Taylor	PhD	Anthro (CLAS)	Finite element analysis of the colobine proximal femur	Daegling
Lad, Susan	PhD (completed)	Anthro (CLAS)	Detection of secondary bone using microCT	Daegling
Deutsch, Ashley	MA	Anthro (CLAS)	Mandibular bone histology and diet in humans	Krigbaum
Lotze, Rachel	UGrad	Anthro (CLAS)	Assessing preservation of bone for radiocarbon dating	Krigbaum