

## Data for 3D printing enlarged museum specimens for the visually impaired

Anton du Plessis <sup>1,\*</sup>, Johan Els <sup>2</sup>, Stephan le Roux <sup>1,3</sup>, Muofhe Tshibalanganda <sup>1</sup>, Toni Pretorius <sup>4</sup>

<sup>1</sup> CT Scanner Facility, Stellenbosch University, Stellenbosch, South Africa 7602

<sup>2</sup> Department of Mechanical Engineering, Central University of Technology, Bloemfontein, South Africa 6001

<sup>3</sup> Bruker microCT, Kontich, Belgium

<sup>4</sup> National Museum, Bloemfontein, South Africa 9300

\* Corresponding author: Anton du Plessis, email: [anton2@sun.ac.za](mailto:anton2@sun.ac.za). Address: CT Scanner Facility, Central Analytical Facilities, Stellenbosch University, Private bag X1, Matieland, 7602, Stellenbosch, South Africa

ORCID IDs:

Anton du Plessis: 0000-0002-4370-8661; Johan Els: 0000-0002-4837-8892; Stephan le Roux: 0000-0002-5617-8137, Muofhe Tshibalanganda: 0000-0003-1933-5698

### Abstract

Museums are embracing new technologies and one of these is the use of 3D printing. 3D printing allows for creating physical replicas of items which may, due to great value or significance, not be handled by the public, or which are too small or fragile to be handled or even seen with the naked eye. One such application of new technologies has been welcomed by the National Museum in Bloemfontein, Free State, South Africa. Here, blown-up (enlarged) Museum specimens were 3D printed for various interactive exhibits that are aimed at increasing the accessibility of their permanent displays for visually impaired visitors who rely greatly on touch as a source of observation. A selection of scorpions, pseudoscorpions, mites and archetypal bird skulls were scanned, processed and 3D printed to produce enlarged, highly functional nylon models. This data paper provides the raw micro Computed Tomography (micro-CT) scan data and print ready STL files processed from this data. The STL files may be used in their current format and details of the printing are provided.

### Introduction

In general the use of 3D printed models for museum displays or research has been positively received as evidenced by numerous publications and in some instances, a preference for 3D printed models was indicated [1,2]. The use of micro Computed Tomography (micro-CT) in biological sciences was reviewed in [3] which also includes data sets of a Jackson's chameleon with 3D print files [4]. The use of micro-CT and 3D printing has been used successfully for non-invasive investigations as in [5,6] where 3D print replicas of the contents of an Egyptian mummified falcon were reproduced successfully.

### Materials and Methods

MicroCT and nanoCT scans were conducted at the Stellenbosch CT facility [7]. The smallest samples were scanned in the nanoCT and samples > 10 mm wide were scanned in the microCT instruments using optimized settings and voxel sizes appropriate to each sample. Image data was analyzed in Volume Graphics VGSTUDIO MAX 3.2 (VG Studio MAX, RRID:SCR\_017997). A de-noising was applied, followed by a surface determination function. In cases of noisy data, some cleanup was done according to visual inspection using morphological image tools (erode/dilate and region growing). The final STL (stereolithography) files were then processed in Materialise Magics (23.0.1.19 64 bit) software to

remove loose shells and reduce the number of triangles to ensure clean 3D models that can easily be scaled to any specific requirement.

The clean 3D models were produced in an EOS P385 Selective Laser Sintering system in white PA2200 Polyamide (Nylon) powder.

## **Data**

Photos of the final 3D printed objects are shown in Figure 1 with a comparative visual of a larger scorpion specimen in the three stages of the replication process found in Figure 2 and visually-impaired visitors handling the 3D printed replicas are shown in Figure 3. The CT data is provided in the form of image stacks with associated voxel size and other scan settings in the accompanying text file. The processed STL files used for printing are also provided with each scan data set and can be viewed with any 3D model viewer. The summary of all data provided is given in Table 1.



Figure 1: Photos of the final printed models for the Museum display, ready for surface finishing.























Figure 2: *Opisthophthalmus carinatus* (Robust burrower) production process. From left to right: Wet specimen (approximately 100mm), STL image, Nylon print (350 mm).



Figure 3: Members of the Free State Society for the Blind putting the 3D models through a trial run at a recent visit to the Museum. From left to right: Jan Andries Neethling (Museum Arachnologist), Anne de Beer, Pannie de Beer (Rendezvous Support Group).

Table 1: Data description summary, image stacks all 16 bit.

Scientific name (Taxon ID)	Image	Voxel size	Image stack size	STL file size
<b>Arachnida</b>				
<b>Scorpiones</b>				
<i>Opisthophthalmus carinatus</i> (NCBI:txid190115)		0.08000000	960 MB (1,007,004,206 bytes)	21 763 KB
<b>Pseudoscorpiones</b>				
Cheliferidae: <i>Beierius walliskewi</i> (gbifID: 2126726)		0.00399991	1.93 GB (2,080,320,334 bytes)	15 788 KB
Atemnidae: <i>Titanatemnus natalensis</i> (gbifID: 2126451)		0.00700001	2.31 GB (2,484,388,396 bytes)	12 272 KB
Feaeallidae: <i>Feaella capensis</i> (NCBI:txid2590491)		0.00199991	2.99 GB (3,218,034,562 bytes)	91 239 KB
Olpiidae: <i>Horus obscurus</i> (gbifID:2125067)		0.00399991	2.22 GB (2,394,603,554 bytes)	14 279 KB
<b>Acari</b>				
Oribotritiidae: <i>Indotritia retusa</i> (gbifID: 2188784)		0.00200000	387 MB (405,960,582 bytes)	15 131 KB
Nothridae: <i>Nothrus anauniensis</i> (NCBI:txid1685385)		0.00199991	499 MB (524,264,126 bytes)	8 263 KB
Neoliodidae: <i>Neoliodes terrestris</i> (gbifID: 2192854)		0.00199991	1.06 GB (1,144,736,558 bytes)	10 138 KB
Galumnidae: <i>Galumna capensis</i> (gbifID: 2193431)		0.00199991	760 MB (797,371,236 bytes)	5 721 KB

Crotoniidae: <i>camisia hamulifera</i> (gbifID:2192175)		0.00199991	1.13 GB (1,222,213,194 bytes)	12 717 KB
<b>Aves</b>				
Accipitridae: <i>Aquila verreauxii</i> (NCBI:txid252782)		0.07999998	2.20 GB (2,365,352,542 bytes)	54 682 KB
Ploceidae: <i>Euplectes progne</i> (NCBI:txid221973)		0.02700000	2.25 GB (2,427,044,488 bytes)	150 389 KB
Psittacidae: <i>Agapornis roseicollis</i> (NCBI:txid60468)		0.03300000	2.62 GB (2,822,618,674 bytes)	208 756 KB
Hirundinidae: <i>Hirundo spilodera</i> (NCBI:txid317141)		0.02000000	2.86 GB (3,079,714,774 bytes)	n/a
Sturnidae: <i>Onychognathus morio</i> (NCBI:txid381114)		0.04000000	1.61 GB (1,738,054,024 bytes)	81 143 KB
Threskiornthidae: <i>Plegadis falcinellus</i> (NCBI:txid52788)		0.09833335	2.01 GB (2,160,723,314 bytes)	3 520 KB
Threskiornthidae: <i>Platalea alba</i> (NCBI:txid33578)		0.15014335	681 MB (714,566,426 bytes)	81 073 KB
Laridae: <i>Larus californicus</i> (NCBI:txid126681)		0.06999998	1.33 GB (1,436,767,642 bytes)	39 469 KB
Phoenicopteridae: <i>Phoenicopus ruber</i> (NCBI:txid9217)		0.09800000	3.24 GB (3,485,882,170 bytes)	71 855 KB
Promeropidae: <i>Promerops gurneyi</i> (NCBI:txid670928)		0.03333333	4.64 GB (4,991,580,140 bytes)	57 879 KB

Interactive views of the 3D models are available in the sketchfab repository which enables CT images to be interactively explored. Figure 4. shows an example of an interactive CT sketchfab view of the *Opisthophthalmus carinatus* specimen.



## Opisthophthalmus Carinatus

3D Model



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◀ Triangles: 445.7k ♀ Vertices: 222.8k

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CT image of an *Opisthophthalmus carinatus* (scorpion) specimen

**Figure 4. Interactive CT image of an *Opisthophthalmus carinatus* (scorpion) specimen in sketchfab**  
<https://sketchfab.com/3d-models/opisthophthalmus-carinatus-4b99189013b1478aadf43b195c522e17>

### Conclusions

This data will be useful for Museums setting up similar displays, and the data may be used for other research purposes. The workflow may also be useful for similar projects elsewhere and we urge others to make their data available.

### Availability of Supporting Data

All the data including CT scan details, 3D surface rendered images in STL format, and interactive views of the 3D models are available in the associated GigaDB dataset [8]. 3D models are also available for view in Sketchfab (<https://sketchfab.com/GigaDB/collections/3d-printing-data-from-enlarged-museum-specimens>), and for download by the 3D printing community in thingiverse (<https://www.thingiverse.com/thing:3869332>).

### Abbreviations

GB: gigabytes; KB: kilobytes, MB: megabytes; micro-CT: micro Computed Tomography; STL: stereolithography files

### Competing interests

The authors declare that they have no competing interests.

### Authors' contributions

AdP drafted the manuscript. All authors made comments on the manuscript and all authors worked on the data.

### Acknowledgements

The active support and funding of the South African Department of Science and Innovation through the CSIR for the Collaborative Program in Additive Manufacturing, Contract No.: CSIR-NLC-CPAM-18-MOA-CUT-01, is gratefully acknowledged. Funding was also provided by the National Museum Bloemfontein.

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