Synthesys 3 (2013-2017) (http://www.synthesys.info/)

JRA 1 Moving from physical to digital collections

Report Objective 1: **Automated data collection from digital images.** Task 3

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Coordinator : P. Semal, Royal belgian Institute of natural Sciences

The aim of the Joint Research Activity (JRA) is to improve the quality of and increase access to digital collections and data within natural history institutions' virtual collections.

Objective 1: **Automated data collection from digital images.**

Task 3 : - High Resolution 3D colour image acquisition: Complementary approaches (colour surface scanning, photogrammetry) will be developed in order to provide complete information (3D and colour data) of the specimen.

The high resolution multimedia recording of small specimens is a real challenge for Natural History museums who are working on mass digitization programs. The quality of the resulting image, the cost of the equipment, the human work and the learning curve are important parameters in order to define a general digitization strategy.

We evaluated several techniques in order to allow the digitization of natural History specimens for a real scientific purpose. The goal is to produce images or virtual models which provide at least the same level of information than the direct observation of the specimen.

We tested :

1. the focus stacking with a new system of light which produces excellent image quality with no reflection on the specimen and don't need any post-treatment in an image editor. This allows to obtain semi-automated images of the specimens at low cost.
2. the micro-photogrammetry can be apply to small specimens like insects. The results show that the technology is not yet ready to produce high quality 3D models but the progress of the Agisoft photoscan software make that it will be possible to combine later the photogrammetry and the focus stacking.
3. We evaluated the RTI technology which allows to enhance small surface detail of structures
4. Finally we tested the minidome base on the same approach but which allow to obtain real 3D surface information.

To do :

1. Continuation of the evaluation of the minidome technology
2. Evaluation of the multi-spectral focus stacking

1. Focus stacking

We tested a low budget-high quality approach consisting of commercial products. We compared different software packages using the pictures produced from this set-up. In addition to this comparison we had a closer look at several available high-end solutions regarding focus stacking and compare them to our set-up.

We stressed also on the lighting of the specimen as it could be a real challenge for the reflective specimens (e.g. insect, enamel of teeth). We developed an indirect light using 2 flash situated below the specimen. This allows to obtain highly detailed pictures without reflection or overexposure

The results of this research were published in Zookzeys (Brecko *et al.*, 2014. ZooKeys 464: 1-23 doi: 10.3897/zookeys.464.8615.

Detailed view of a focus stacked image of a Phyllobius sp using indirect light

2. RTI

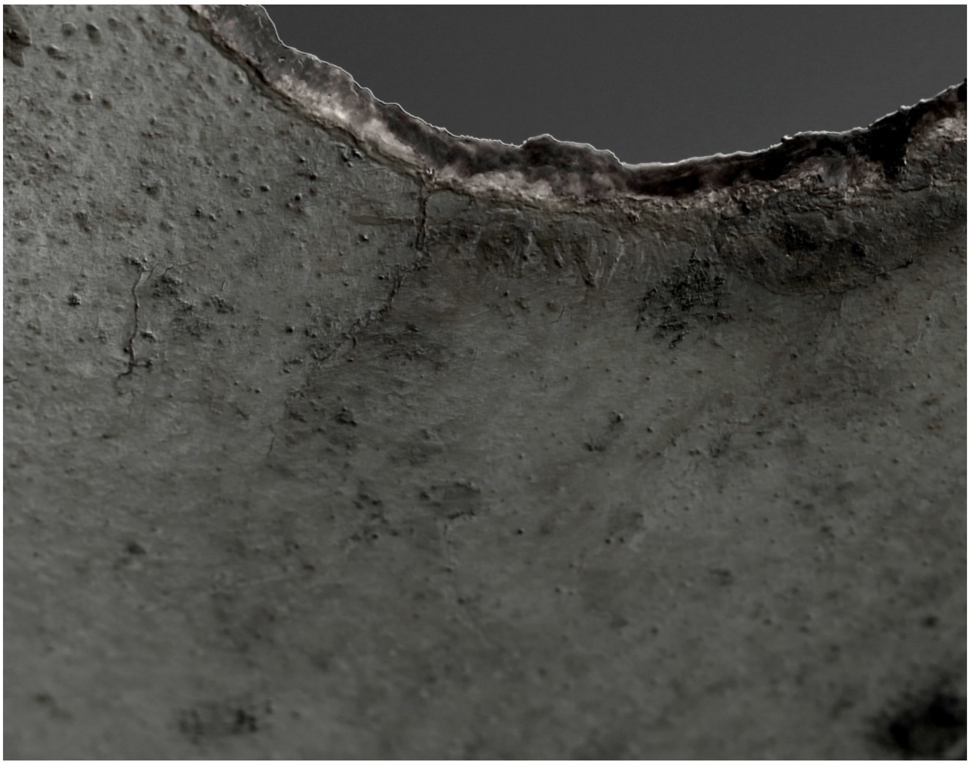
Reflectance Transformation Imaging (RTI) is a computational photographic method that captures a subject's surface shape and colour and enables the interactive re-lighting of the subject from any direction. This is not 3D but it allows to enhance small relief of the surface of the specimen.

The principle is very similar to the mini-dome (minus 3D reconstruction): the specimen has to be photographed with light coming from different angle (dome of light). The picture has to include 2 black or red spheres to allow to calibrate the pictures in RTIbuilder software. The result is viewable in a software called RTIviewer, which allow relighting of the specimen by the user with different type of map (diffuse, specular, etc.).

The RTI file is generated by the combinations of several pictures taken from the same point of view with light coming from different orientations. The RTI file resulting “knows” how light will reflect off the subject and has recoded every micro-relief on the surface. It is a complementary technique to other 3D digitization techniques which produces an astonishing level of surface detail.

We worked with the RTIbuilder and RTIviewer from the Cultural Heritage Imaging (CHI) website.

But instead of working with a flash, we used LED lights. We tested several lights (led flash-light, led 30 W, led 24 W, cold light) of different intensity and angle, but the results are quite similar between the different light sources. We tested RTI on different type of specimens: ammonites, skull, engraved reindeer, tooth, flint stone, cut marks… This techniques is practical to record small details and allow a complete record of the surface with a higher level of visible details than the 3D records.



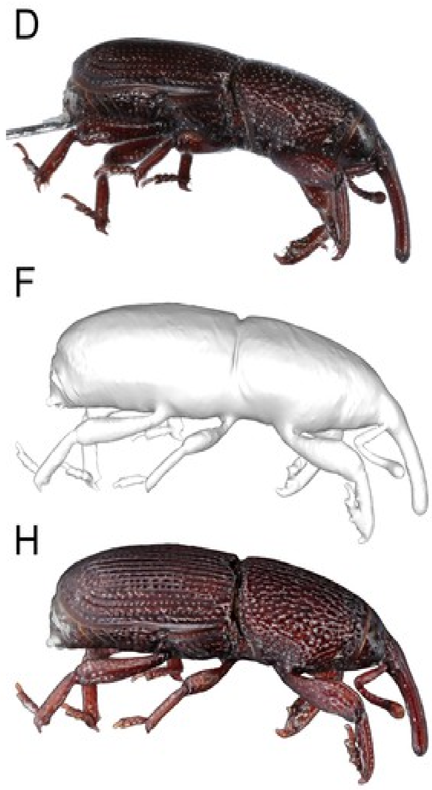
Specular snapshot from the RTIviewer. The pictures were taken with the 65mm lens, processed in the RTIbuilder with a PTM fitter. The use of RTI in this case allow us to see more clearly the claw in one side of the trepannation.

Two snapshot from the RTI viewer of an Ammonites of approx. 1 cm diameter, without and with specular. The pictures were taken with the Canon 600D with the 65 mm macro lens. The issue when taking picture for RTI at such magnification is that the smallest tremor during the capture create a small blur in the final result.

3. Micro-photogrammetry

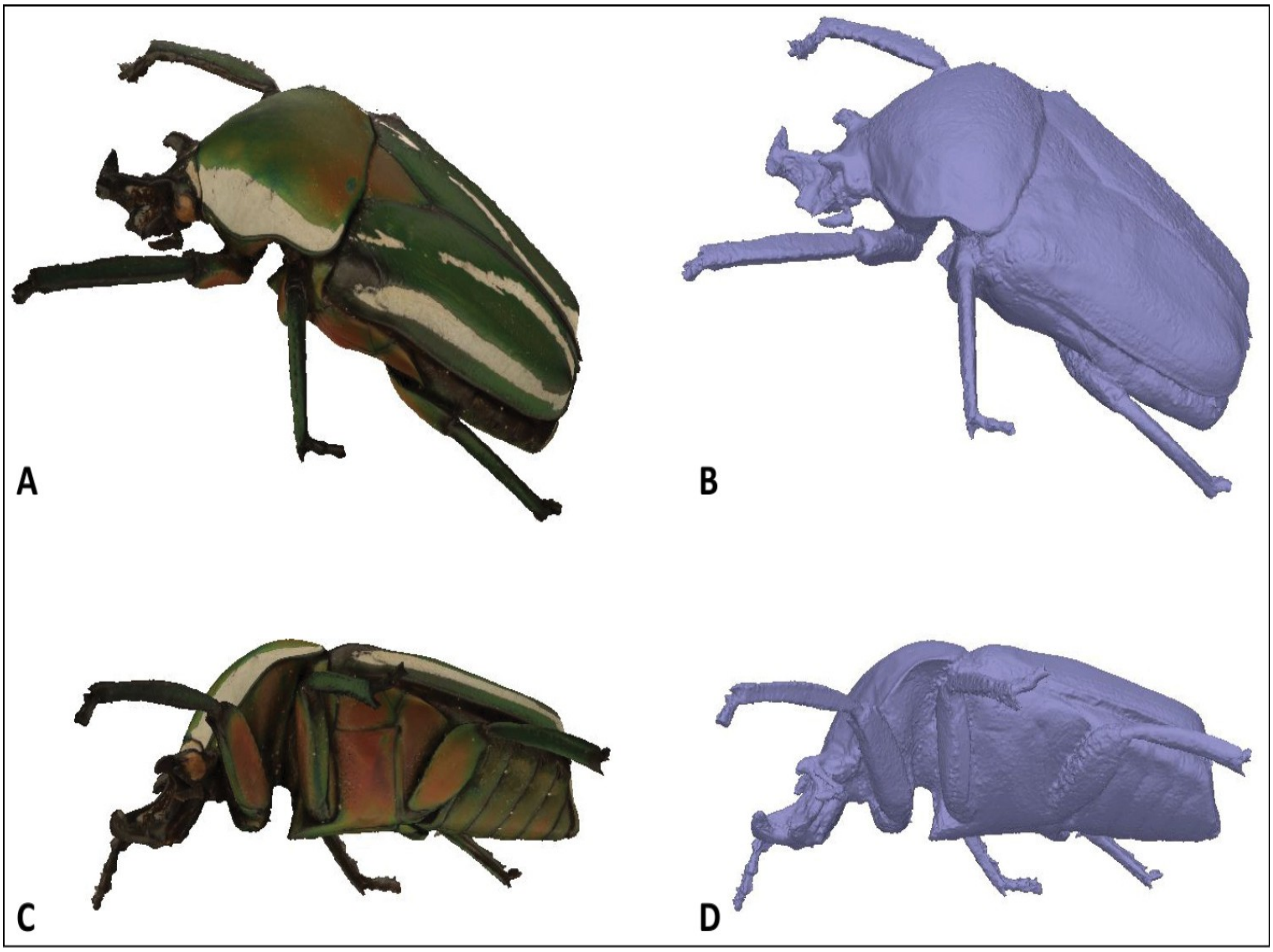
Photogrammetry is today used in several 3D digitization program as it is an easy and versatile technology. Recently photogrammetry was used to produce of 3D models of insects (**Nguyen et al. 2014**). We tried this approach as well, although we used a different software package, Agisoft Photoscan (www.agisoft.com). Previously the software had had difficulties in aligning images with a low depth of field. Recent software updates made the software package stronger and making insect 3D models is no longer an issue.
Compared with the models produced by Nguyen et al. 2014 with 3DSOM (now incorporated in BOB Capture, www.bigobjectbase.com/bob-capture), the Agisoft models have a more detailed model but far from detailed .

However, looking at the details provided by these models, both with and without texture, they are, even with the better resolution provided by the Agisoft Photoscan software compared to the BOB Capture models in (Model of a longhorn beetle similarly-sized to our *Dicranorrhina/* Areas with hairs or transparent parts lack any detail. In fact the only way to get a decent 3D model of an insect is by µCT scanning. Photogrammetry works very well in other fields of research but for species recognition and determination it is not (yet) precise enough, although they could be great educational models to show on websites or in museum exhibitions. Therefore we think that focus stacking is still a more appropriate way to digitize entomological specimens, as it delivers detail which scientists need for their research.



Nguyen CV, Lovell DR, Adcock M, La Salle J (2014) Capturing natural-colour 3D models of insects for species discovery and diagnostics. PLoS ONE 9(4): 1–11. doi: 10.1371/journal.pone.0094346

Figure 9. Comparison of natural-colour 3D reconstructions using (A) a small aperture and (B) a F/8 aperture with multi-focus image stacking.
D) multi-focus image stacking from 31 partial-focus images captured at distances 0.25 mm apart. E)-H) show screen shots of resulting 3D models without and with texture colour.

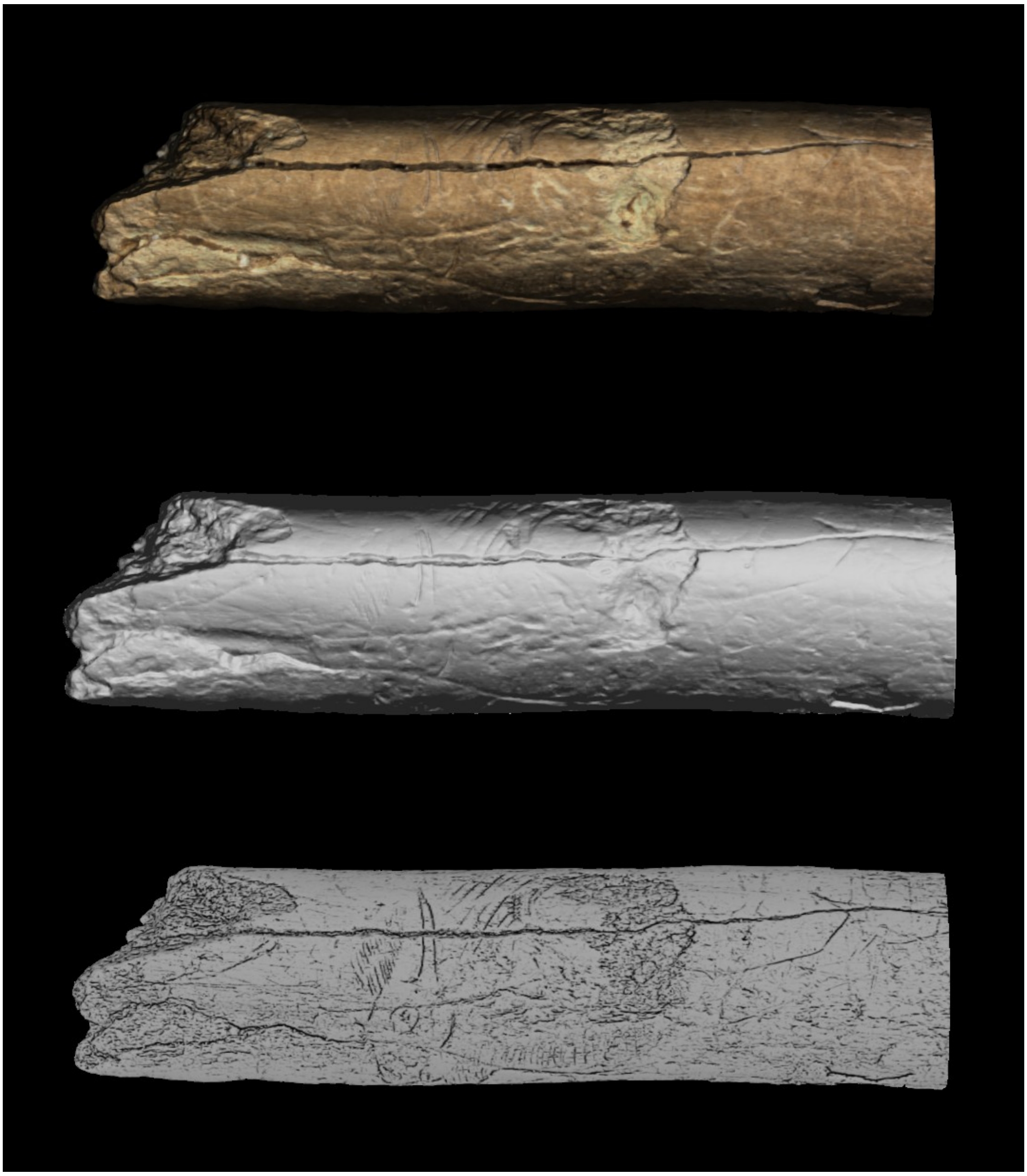


Brecko *et al.*, 2014. ZooKeys 464: 1-23 doi: 10.3897/zookeys.464.8615.

3D model of a *Dicranorrhina* sp. beetle. The left pictures (**A, C**) represent the 3D model with its texture, while the right pictures (**B, D**) are from the model with the mesh only and show the level of detail of the 3D model made in Agisoft Photoscan.

4. Minidome

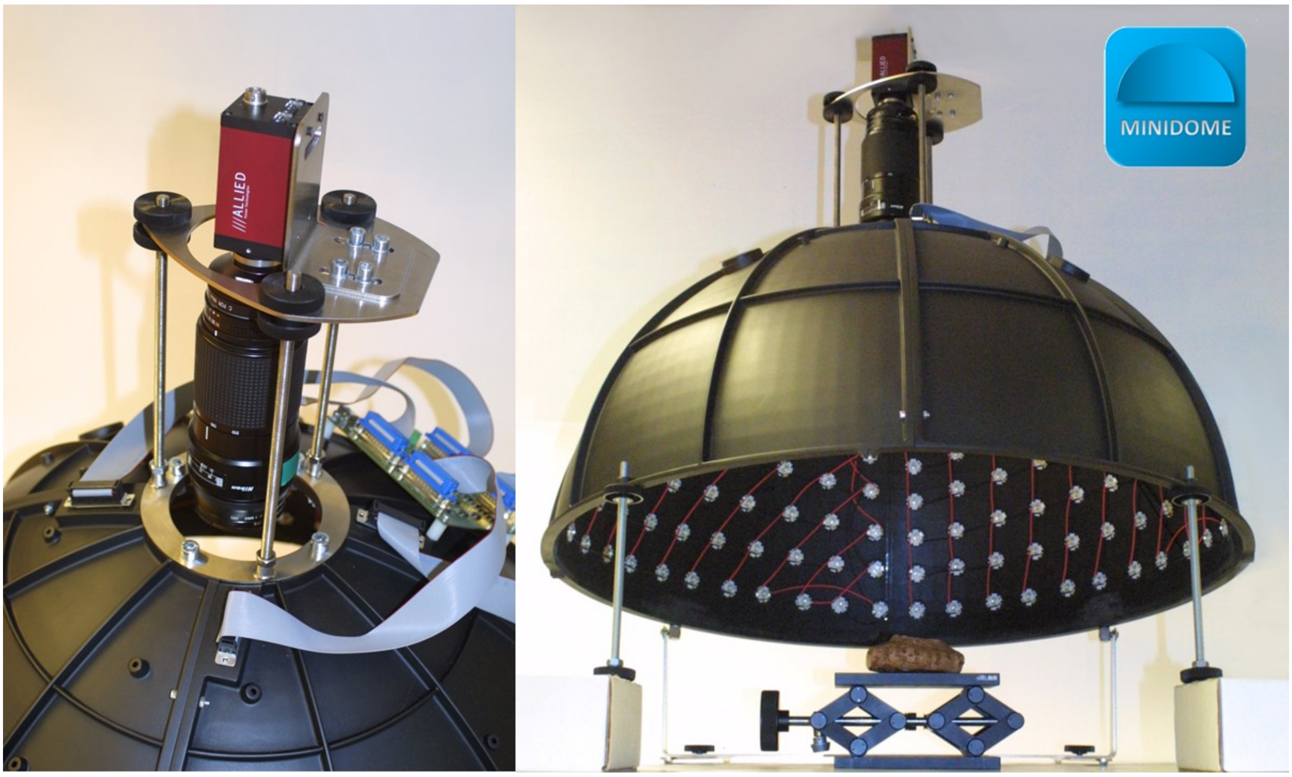
The MiniDome or Portable Light Dome is an automated 3D digitising solution, developed by VISICS at KULeuven. "It consists of a small, light-weight dome of light sources and a digital camera. It can carry both SLR cameras as machine vision cameras. The approach is geared towards an easy-to-use, relatively inexpensive solution for virtually inspection of objects, where both the 2D aspect (color, intensity, or other representations through filtering and relighting) as well as the 2D+/3D aspect (by estimating the 3D surface characteristics) are being considered. The results allow for photorealistic virtual re-lighting and non-photorealistic rendering of the objects in nearly real-time through the use of programmable graphics hardware."



3D model of a mobile palaeolithic art from le Trou des Nutons. Above: coloured surface model; middle: Surface with no texture; below automatic filter allowing to see and study the drawing of a bison. The acquisition was made with a 5 Mpx RGB machine vision camera.

5. To do

1) Testing of the minidome on other natural history collections specimens with the possible combination with focus stacking. We will use a **28 Mpx** RGB machine vision camera



2) Testing of multi-spectral focus stacking using near UV and near Infra red spectra with a de-filtered DSLR camera and filters.