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Project Gallery

The Nietulisko Małe Hoard in the light of modern documentation methods

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A total of 2848 denarii from the Nietulisko Małe Hoard, one of the largest hoards of Roman coins found in Poland, were digitised and documented using reflectance transformation imaging, highlighting the potential for this technology in numismatic research.

Keywords: Poland, Nietulisko Małe, Roman coins, reflectance transformation imaging, Segment Anything Model, hoard

Introduction

Discovered in 1939, the Nietulisko Małe I hoard is the largest hoard of Roman denarii known from the Polish territories. In 1942, it was bought by A. Siedlecki and subsequently lost following his death in 1945. In 1948, a tabular list of coins from the hoard was published with a short commentary by Wacław Makomaski, who had been able to study the coins in 1943. The hoard was said to comprise 3170 denarii from the reigns of Nero (AD 54–68) to Septimius Severus (AD 193–211). In 1995, the remains of a wooden chest containing Roman denarii were discovered buried in the cellar of a tenement house at 20 Szewska Street in Krakow. It was quickly established that these were denarii from the Nietulisko Małe I hoard, although the rediscovered set contained only 2759 coins. In 2000, Jagiellonian University acquired another 89 coins from Mrs H. Makomaski, Wacław's widow. Makomaski had acquired some of the coins from the hoard, perhaps as payment for their identification, though it remains uncertain how many of the missing 411 coins he originally possessed (Biborski *et al.* 2004).

There are currently 2848 coins from the hoard in the Jagiellonian University collection (Figure 1), and these are the focus of the project 'The Nietulisko Małe Hoard in the light of modern documentation methods' launched in 2021.

Documentation method and automated workflow

The first part of the project concerned the digitisation of the individual coins using multi-light image collections (Pintus *et al.* 2019) and reflectance transformation imaging (RTI),

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Figure 1. The coin hoard from Nietulisko Małe I (figure by M. Biborski (1999: fig. 2), reproduced with permission).

an established technology in numismatics (Mudge *et al.* 2005) used to create relightable images that enable virtual analysis of the coins. At least 30 photographs of the obverse and another 30 photographs of the reverse of each coin are required for RTI, each staged with light originating from a different direction. Thus, a minimum of 170 000 images were required for the entire hoard. For this reason, it was decided to use a dome with an integrated camera to automatically take the images (Wilk *et al.* 2024); this was further extended by an automated cloud-based system for processing the acquired data based on the CENAGIS (Center for Geospatial and Satellite Analysis at Warsaw University of Technology) infrastructure (Figure 2). The images were uploaded to a cloud drive, from which they were automatically processed using the Relight library (Ponchio *et al.* 2018) and published online using the M.A.RL.I.E. viewer (Jaspe-Villanueva *et al.* 2021) tool for RTI data visualisation in web browser; this allowed verification of the results on the next working day.

Numismatic description of the individual coins

The project also aimed to create a description for each coin, with the structure of database fields following the Numismatic Description Schema (nomisma.org) and the latest trends, including annotations of individual objects visible on coins (e.g. using deep neural networks; Anwar *et al.* 2021). Machine learning models for image segmentation, such as the SAM (Segment Anything Model, a general-purpose tool that can segment any object from an image; Kirillov *et al.* 2023) can recognise these objects. Due to its versatility and because there is no need to train the model, we implemented the SAM, although it was necessary to create a set of virtual images with various parameters for the position of the light source, as experimentation revealed that segmentation results varied considerably depending on the input illumination parameters (Figure 3).

Online database with RTI viewer

Publication of the hoard in the form of an online database compliant with nomisma.org ontology (Numishare application https://github.com/ewg118/numishare) is planned, with the possibility of an interactive display of RTI data together with SAM-derived image segmentation results. The previously published OpeNumisma portal (Avgousti *et al.* 2017) uses a database with a web interface to visualise RTI data, although the software used for website presentation (WebRTIViewer; Palma *et al.* 2014) is now outdated. Newer open-source tools aim to unify the RTI data storage and visualisation system, including Relight (Ponchio *et al.* 2018), which facilitates the construction and visualisation

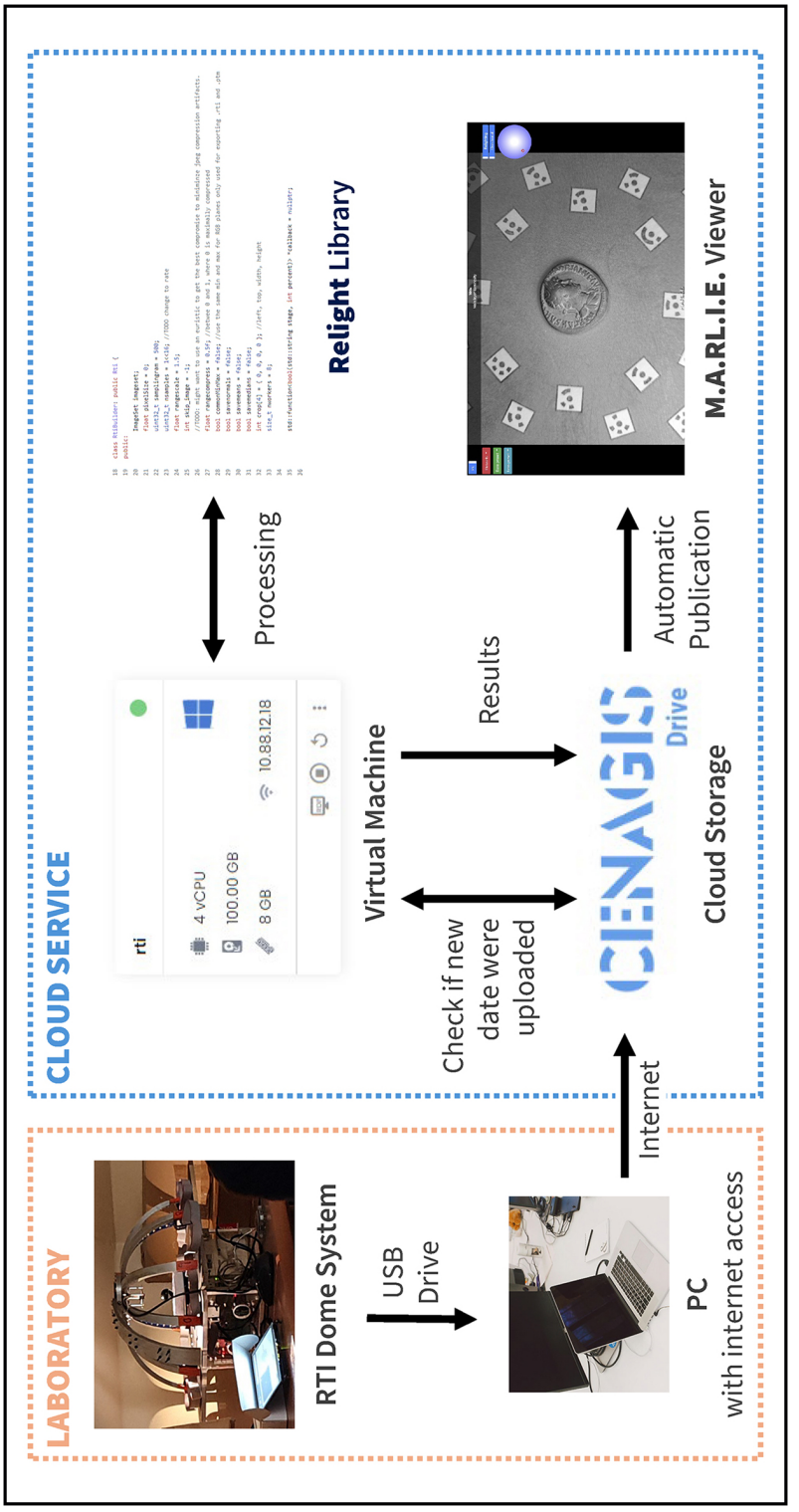

Figure 2. Workflow of automatic data processing with a cloud-based system within the CENAGIS infrastructure (figure by authors).

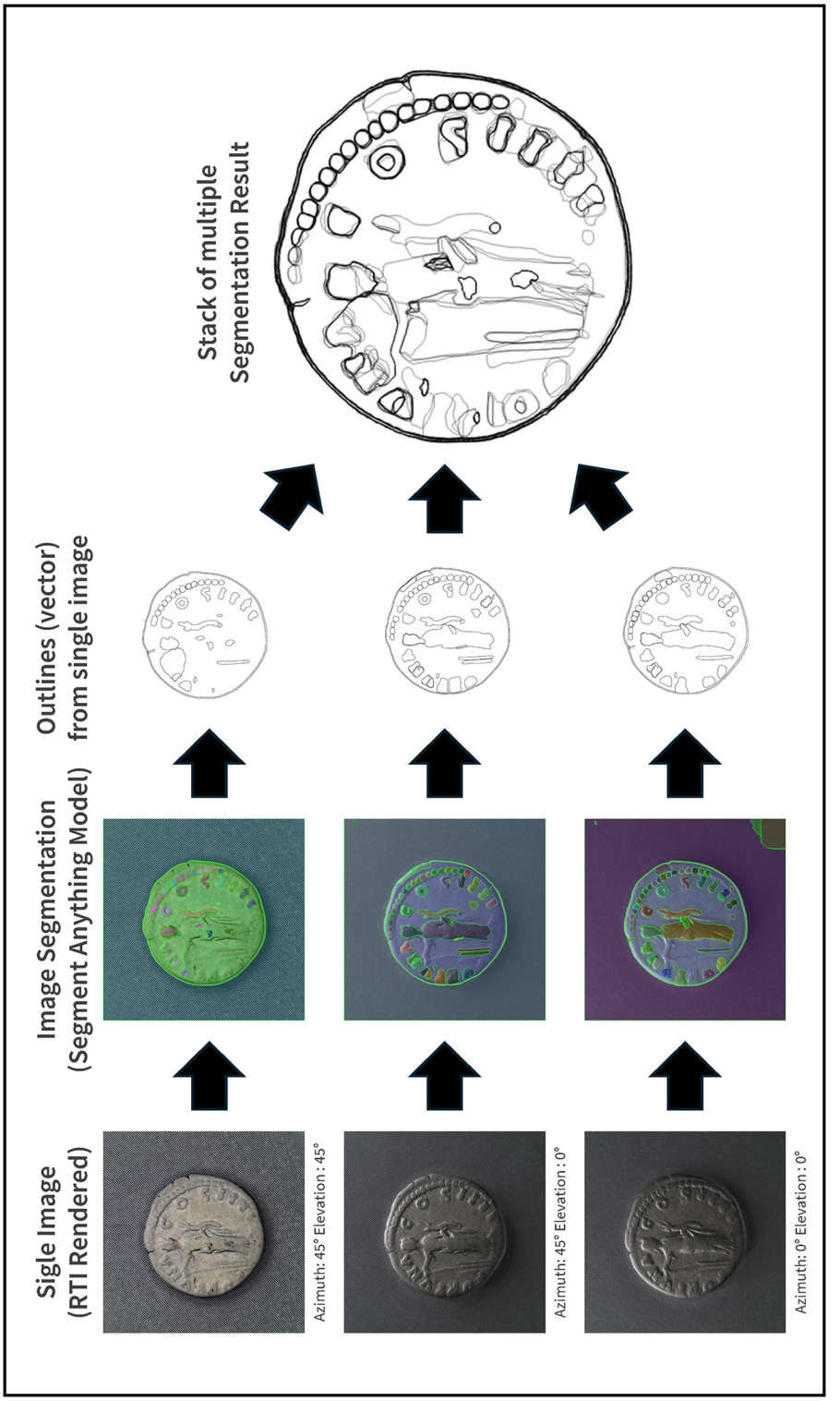

Figure 3. Segment Anything Model on the RTI documentation (figure by authors).

of RTI data. The M.A.RL.I.E. viewer (Jaspe-Villanueva *et al.* 2019) is another development that allows the addition of rasterised annotations. Our solution (Figure 4) relies on the open Leaflet library, natively used in Numishare, to display high-resolution coin images from the IIIF (International Image Interoperability Framework) server. We implemented a Relight-inspired WebGL plugin for Leaflet, allowing rendering and interactively displaying the relighted image in the web browser. The proposed solution not only provides a real-time image of each coin with a given illumination direction based on RTI data from the IIIF service inside the existing Numishare web interface but also allows vector annotations to be added in the future as a regular Leaflet vector layer to be easily presented (without additional implementation) against a relighted image visualisation.

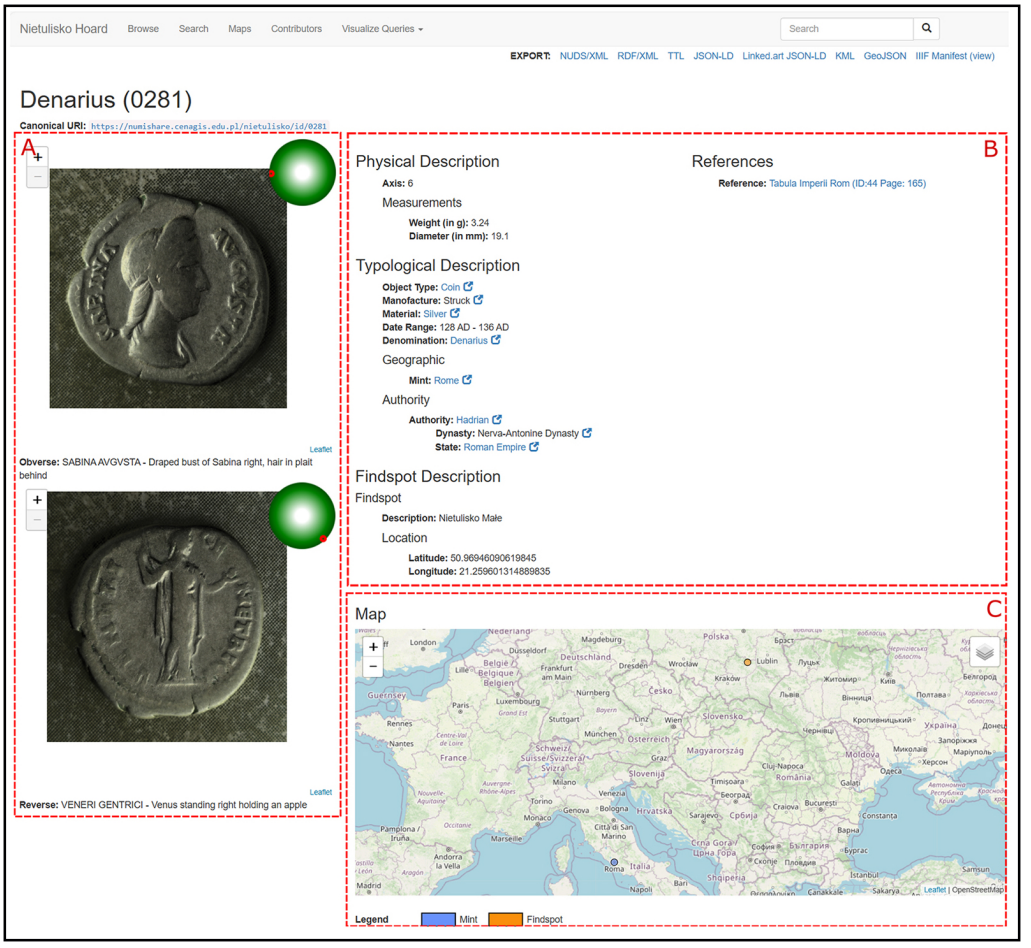

Figure 4. Our modification of the Numishare application—the image viewer is replaced with the RTI viewer based on the IIIF service (box A) and accompanied with attributes describing a specific coin (box B) and map (box C) with indication of the findspot (figure by authors).

Conclusion and future work

Use of RTI to document the largest surviving hoard of Roman denarii discovered in Poland demonstrates the utility of this technology for large-scale coin documentation and digital image processing in numismatic research. Application to the Nietulisko Małe Hoard allowed the development of a documentation standard for similar coin deposits. The last stage of the project will focus on making the coin database publicly available and properly integrated in the Nomisma network in Linked-Open-Data manner.

Future research plans include the development of a method for automatic assignment of description parts with specific elements visible on coins. The developed SAM detections can be subjected to a clustering process, by which semantic classes of identified objects will be created. After clustering, the classes can be described using natural language processing techniques in order to create connection between images and the legend and descriptive information contained in the database.

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