

Case Study

3D High-Tech Methods in Archaeology **The Constantine Project**

3D Scanning
3D Modelling
3D Reconstruction
3D Reproduction

The Constantine Colossus

3D High-Tech Methods in Archaeology

In 2004, Dr. Eckart Koehne from the Constantine exhibition society and archaeological surveying specialist Martin Schaich from *ArcTron 3D GmbH* developed a bold concept: to document the various fragments of the colossal statue of the Emperor Constantine remaining in Rome in three dimensions using a combination of archaeological research and innovative high-technology. The statue was then to be partially reconstructed and reproduced for the state exhibition in Trier.

This would allow one of the best-known monumental Imperial Roman statues in the world to be experienced in a whole new way during the exhibition.



Rome. The world-famous colossal fragments of the Constantine statue in the courtyard of the Capitoline Museum (Photos: *ArcTron 3D GmbH*).

This unique and ambitious project was begun in 2005 with the support of the Rhineland-Palatinate state bank, the state building society and Provinzial Versicherungen.

Constantine the Great commissioned the statue in the year 312 CE following his victory at the Battle of Milvian Bridge. The 12m high sculpture was erected between the Forum Romanum and the Colosseum in the new basilica built by his opponent, Maxentius.

With this statue, Constantine publicly and visibly declared his overthrow of the vanquished adversary.

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The monumental fragments of the statue were discovered in Rome in 1486 and weigh many tonnes. They have been in the courtyard of the Capitoline museum for more than 400 years and it was, therefore, not possible to loan them to the exhibition in Trier. The fragile marble surface was also not suited to the usual method of making reproductions using silicone casts.

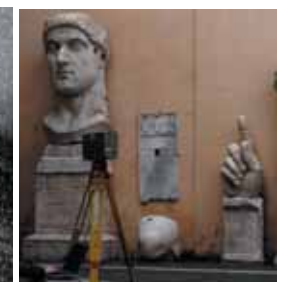
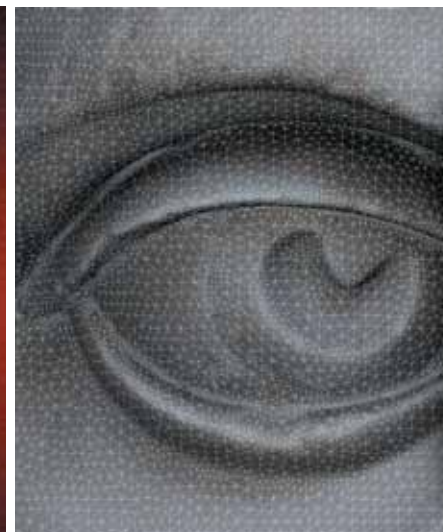


For these reasons, the surveying specialists from *ArcTron 3D* documented the statue elements at their location in Rome using non-contact 3D laser scanners.

Alongside 3D laser scanning, the main method of data capture employed was structured light scanning. Structured light scanners record objects in three dimensions with accuracies in the range of one tenth of a millimetre. This procedure was partly carried out at night as structured light projection is impaired by ambient light.



Renaissance drawing and digital model.



Computer-supported modelling of the monumental head. From wiremesh to photo-realistic 3D model.
(Graphics: ArcTron 3D GmbH).

The individual 3D scans - in total around 1000 separate recordings - were compiled on computer in a process lasting several weeks.

Each scan produces a point cloud containing several million measured points which exactly describes the surface geometries.

Specialist software is used to convert the point clouds into very fine, highly-detailed polygon meshes. Finally, photo-realistic surfaces are laid onto the mesh structure.



Laser scanner and structured light scanner during submillimetre-accuracy 3D documentation.
(Photos & graphics: ArcTron 3D GmbH).

Reconstructing the Statue

The 3D Visualisation of the Enthroned Imperial Statue

This project provides a multitude of opportunities for scientists to study the remaining parts - ten in total - in great detail and with the highest precision on computer. Several parts of the right leg and arm, a hand, a fragment of the chest and a curl from the statue's temple are preserved, besides the 3-metre-tall head and both feet.

The 3D models were analysed using aSPECT 3D, an application developed at *ArcTron* specifically for 3D documentation in archaeology, heritage conservation and restoration.

For the scientists from Rome, Trier and Regensburg involved in the project, the visualisation provided an ideal foundation for determining the positioning and composition of this complex 3D jigsaw, taking archaeological and structural considerations into account. Parts of an older statue were used in the construction of the colossus. Evidence of reworkings, proportional differences and other observations suggest that an earlier statue of a god or emperor was altered and reused.

The antique assembly of the immense statue must have been achieved by precisely fitting the individual sections together using the bracing and connecting techniques available at that time.

The results of our reconstruction can be seen in a partially transparent representation in which only the preserved fragments are depicted as solid bodies.



From rough 3D sketches incorporating the original fragments to the coloured reconstruction of the colossus.
(Graphics: ArcTron 3D GmbH).

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The reconstruction also demonstrates that the antique sculptors responsible for the statue created a technical masterpiece which can only be reproduced with the greatest difficulty, even when using modern technologies. The individual components of the 12-metre-high colossus, each weighing many tonnes, were fitted together with millimetre precision like a 3D mosaic on a massive wooden frame. The antique observer would have had the illusion of a single, consolidated figure.

The statue was composed of a variety of materials. The unclothed sections were made of marble, the gold-coloured robe and objects held in the hands, from bronze. Another important factor for the appearance of the model is that antique statues were generally painted. They would have made a very different impression than we, who are used to seeing plain marble statues, would expect.



Made possible by modern data networks: our Constantine colossus integrated in the new reconstruction of the Basilica Maxentius from the University of Virginia (*Graphics: ArcTron 3D GmbH & IATH, University of Virginia*).

The precise placement of the statue in the Basilica Maxentius is known from Renaissance drawings which show the foundations of the pedestal in the apse, at the western end of the building.

Consequently, we are now able to experience the statue in a model of the Basilica interior from the perspective of the antique observer. ArcTron has developed a 3D virtual reality environment which allows objects of this kind to be interactively viewed using 3D glasses.

Copying the Colossal Head

Manufacturing the 1:1 Copy in Marble

So how, at almost 3 metres tall and 6 tonnes in weight, was this detailed marble copy of the Constantine head produced?

In cooperation with *ArcTron 3D* (Regensburg), the Fraunhofer Institut (Berlin) and Prometheus GmbH (Berlin) and under the guidance of the sculptor Kai Draeger, a sequence of procedures was devised for the production of a high-precision marble copy of the head. This copy can now be admired at the exhibition.



The 25 tonne block for the marble copy was found at the famous Carrara marble quarries in Italy.
(Photos: Kai Draeger, Prometheus GmbH).

First of all, a suitable block of marble was selected from the Carrara quarries in Italy. The 25 tonne stone block was transported to the company Frankenschotter in the Altmuehl valley.

The profile was cut using a computer-controlled wire saw. This considerably reduced the volume of stone which had to be removed during the subsequent milling process.

The next stop on the journey was Schoenberg near Kiel. EEW is a company which specialises in building high-tech milling machines and was responsible for the next stage of processing.

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An advanced 5 axis CNC milling machine was employed which was capable of processing a block of marble of this size, incidentally also a world-first in technological achievement.



After rough machining with a contour saw, the head was ground using the 5 axis high-tech CNC milling machine at EEW in Kiel-Schoenberg. (Photos: Kai Draeger, Prometheus GmbH).

From the distinctive nose to the complex structure of the hair: to copy the original exactly, the machine had to go through a variety of grinding, drilling, scrubbing and smoothing programs in a procedure lasting a total of 520 hours.

To achieve this, digital data from the company DELCAM was converted into a format which could be read by the milling machine. Over 230 diverse programs and custom tools were developed for this complicated process.



Kiel and Berlin. After milling, the head was finished and artificially aged at a sculpture studio. (Photos: EEW Maschinenbau GmbH / Kai Draeger, Prometheus GmbH).

Once completed, the new Constantine was the very likeness of the Roman original! The sculptor Kai Draeger made the finishing touches at his studio in Berlin. Traditional tools and a special restoration technique were used to make the stone surface as similar as possible to the original, which has been marked by the ravages of time.

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All Roads Lead to Rome ...

The marble copy was transported to Trier at the beginning of May on a custom-made steel undercarriage. A special crane then hoisted the head into place at the state museum.

After the exhibition in Trier, the marble head will begin the long journey to Rome. The Capitoline museums will then have the option of replacing the original head, which in its present location in the courtyard is threatened by exhaust fumes and environmental influences, with the copy. However, a final decision has not been made.

Removing the original from its pedestal after 400 years would be a formidable task.

In cooperation with and on behalf of:

The Constantine exhibition society, Trier
under the leadership of Dr. Eckart Koehne

Project partners:

Project concept, 3D surveying, 3D modelling, 3D reconstruction, 3D visualisation

ArcTron 3D GmbH, Altenthann
under the leadership of Martin Schaich M.A.

CNC project leadership and sculptural design:

Prometheus GmbH, Berlin
under the leadership of Kai Draeger

CNC milling of the marble head:

EEW Maschinenbau GmbH, Schoenberg
under the leadership of Steffen Ehlert

CNC software & machine programming:

Delcam GmbH, Obertshausen

From 3D Scan to Postage Stamp

Our 3D graphics were so well received that they have been used as the basis for a small series of Constantine-themed stamps.



(Graphics: ArcTron 3D GmbH).

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