POLISH ASSOCIATION FOR SPATIAL INFORMATION
ANNALS OF GEOMATICS 2008 ❍ VOLUME VI ❍ NUMBER 1

A METHOD FOR RECONSTRUCTION OF SCULPTURES: THE ŠIBENIK CATHEDRAL PROJECT, CROATIA

METODA REKONSTRUKCJI RZEŹB: PROJEKT DOTYCZĄCY KATEDRY W SZYBENIKU, CHORWACJA

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Keywords: replica, cultural heritage, sculpture, cathedral, 3D model, graphic data
Słowa kluczowe: replika, dziedzictwo kulturowe, rzeźba, katedra, 3D model, dane graficzne

Introduction

The paper describes the process applied to the reconstruction of sculptural parts of St. Jacob's Cathedral in Šibenik, as an application of a system based on the so-called „BIS Machine" methodology. One of the aims of this work is to determine the effectiveness of this methodology for producing replicas of sculptural artefacts, such as those of St. Jacob's Cathedral.

The use of integrated, sophisticated and expensive methods should bring products good enough to replace originals, which are threatened by exposure to weather, damage or other unsuspected dangers.

Application of new technologies

The application of new technologies for protection and reconstruction of monuments becomes a key factor in the conservation process of cultural heritage.

The proposed "BIS Machine" approach (Kereković et al., 2004a) is presented on the Figure 1.

The whole reconstruction process comprises 3 phases:

1. Graphical data input by the use of photogrammetric imaging or scanning of the object (sculpture or architectural unit – a part) up to 1000:1 (Gomerčić, Jecić, 2000);

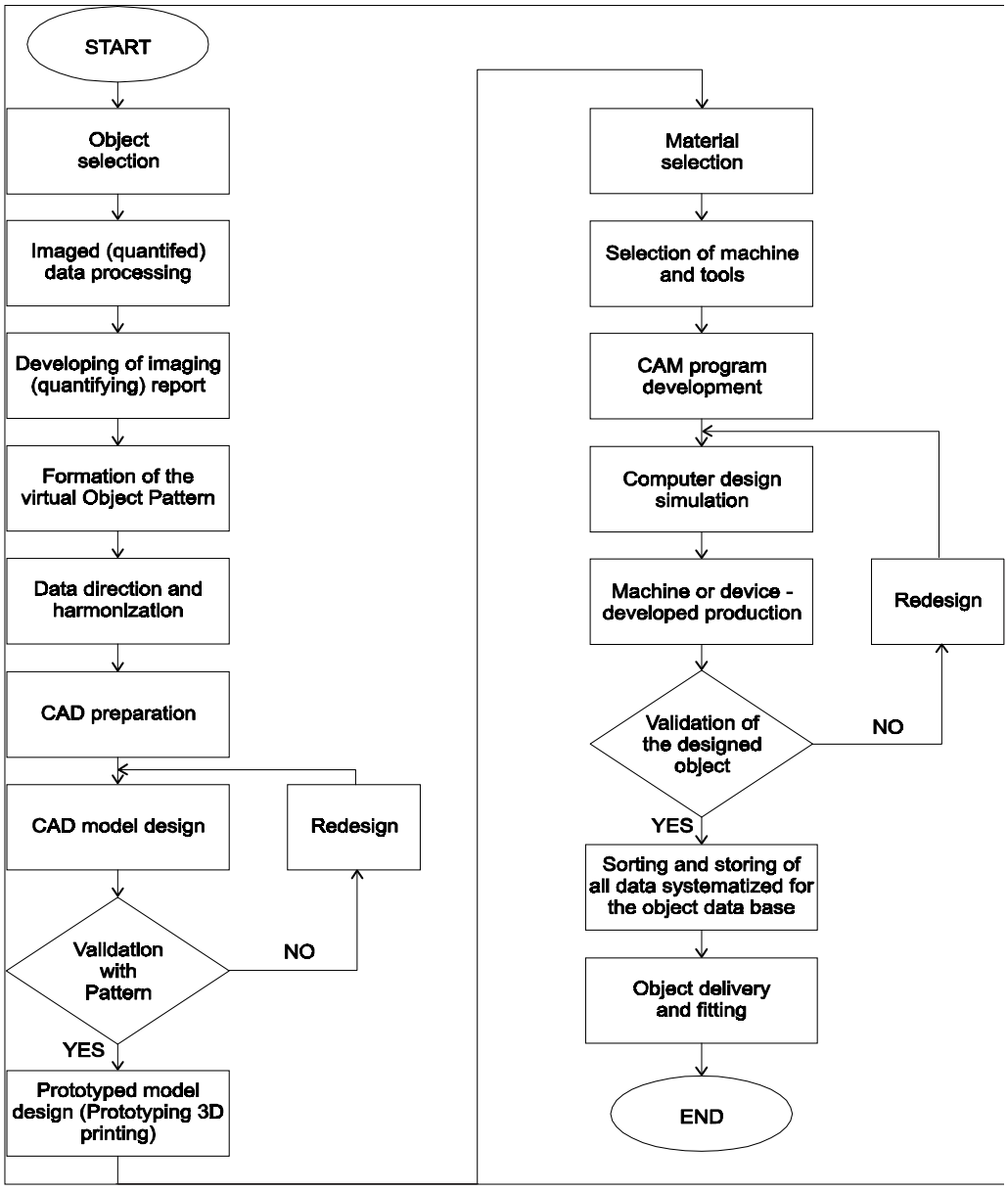

Figure 1. The diagram of the ”BIS Machine“ process flow

2. 3D computer modelling, to develop a precise model of the object such as might be produced using CAD (Computer Aided Design) or other software tools. There are several software firms (Kereković et al., 2004b) offering CAD integrated with CAM (Computer Aided Manufacturing);
3. Development of replicas of the object with the use of special and sophisticated CNC (Computerized Numerical Control) device, adapted to the material of the original object and which requires complex CAM program development and preparation. This device produces an object with micron precision and manufacturing speed over 1000 times higher than can be achieved by manual production (Pawlicki et al., 2004).

This approach offers a number of advantages such as: contact-free data capture, high precision, low design costs in reconstruction projects f and short design time, transparency in all phases of the project (Pawlicki et al., 2004) and support for quality design of replacements for parts of the original that may have been lost. The use of computer based methodology allows to keep the virtual object as database and to produce an infinite number of object replicas.

The advantages achieved are significant and they can be described in terms of professional potential and support for further research aimed at:

- Creation of high precision documentation;
- Creation of a management system for object documentation in line with the protection policy for individual artefacts;
- Creation of 3D imagery of the object for the purpose of creating replacements for damaged parts, until iterative expert consensus is reached on acceptance of the final version;
- Generation of high precision replicas, depending on the choice of material and technology;
- Display of valuable objects by means of virtual information transfer, providing for global accessibility to world heritage treasures, irrespective of social or material status of the public.

Compared with traditional methods (Gomerčić, Jecić, 2000) used for protection and preservation of monumental heritage and for replica production, the "BIS Machine" methodology enables:

- Accurate measurement of the object (precision up to 1 μm) without physical contact, ensuring protection against damage;
- Introduction of an integrated system supporting all managerial, constructional, architectural, informational, restoration, etc., tasks;
- Generation of a highly precise, virtual, three dimensional (3D) model as the basis for the preparation of permanent, highly detailed documentation;
- Complete and permanently preserved data for the production of highly precise replicas, including computer simulation of possible replacements for damaged sections;
- Generation of replicas ("original copies") using the same type of material and at high precision (up to 1 μm), providing for infinite replication at the same quality as the original;
- Acceleration of replica production, with significant reduction in preparation costs;
- Reduction of insurance costs for exhibitions and of insurance against destruction, possibly by exhibiting exact replicas;
- Permanent databases and documentation, with simple data storage.

The Šibenik Cathedral Project

Research for the Šibenik Cathedral project aimed at showing the possibilities of 3D digitisation, in terms of imaging, measuring, verification and validation of the procedures related to management of the monument and some of its valuable artefacts. The work on the cathedral was focused on the Western portal, a very valuable complex composition that serves as the main entrance of the Cathedral (Fig. 2). It includes 12 statues of the Apostles (Fig. 3), placed in similar special niches (Fig. 4 and 5). The research sought the answer to the question whether to return such valuable sculptures to their places in the portal or to replace them with precise replicas made from the same special type of stone. The history of one statue (Fig. 6, 7, 8, 9) is known in detail and the project has sought to:

- Compare the replica made by a standard method with the 3D model;
- Compare the replica made with new technology from the 3D model with the replica produced with the traditional method;
- Compare the replica produced with support of the BIS Machine method with the replica produced with the use of the standard method.

The comparison was performed with the use of the Best Fit method, deviation square minimisation and the results are displayed on colour maps showing the differences.

Study results

The use of the Best Fit method allowed to draw conclusions regarding the application of new technologies. Significant differences compared to the original were noted when the traditional replica production method was used (Fig. 10). The rapid prototyping ('standard') method produced minimal deviations (Fig. 11); this is especially noticeable in the 2D section analysis (Fig. 16). From figures 10–17 it is evident that there are significant advantages of the new technologies and the BIS Machine method in particular.

Conclusion

Analysis and comparison of these results indicates that the application of new technologies is very useful in the field of cultural monument reconstruction projects. As regards replica production divided into phases and procedures and results, the new method was tested on several examples where classic and new technologies were applied. Superior accuracy was achieved with the use of BIS Machine method – Figures 10,12,14,16. This will enable better management of the monument and of its highly valuable artefacts. It also raises a series of new questions as to the potential for the technology to be developed for:

1. Evaluation of fixed (non-movable) objects and units of cultural heritage;
2. Insurance policy for cultural heritage objects;
3. Security and protection of cultural heritage;
4. Database and 3D models of cultural heritage objects as the main focus of management and protection policy;

5. Cultural heritage management and protection as a profit-making project for the community;
6. Expert study of cultural heritage objects, supported by a strong 3D model and management system.

Figures 2–17 demonstrate the BIS Machine method results.

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Abstract

Important projects in cultural heritage reconstruction relating to St Jacob's church in Šibenik provided new options for the "BIS Machine" methodology. The first steps in this work were the validation of the 3D model and the production of replicas of several sculptures from the main portal. The whole reconstruction process comprises 3 phases: 1. Graphical data input; 2. 3D computer modelling and 3. Development of replicas of the object. These tasks were helpful in further developing the application of the „BIS Machine" and, with the aid of the information technology, enabled many questions concerning the production of copies or replicas to be answered.

Streszczenie

Istotny dla ochrony rekonstrukcji kulturowego dziedzictwa projekt rekonstrukcji Katedry Św. Jakuba w Szybeniku (Dalmacja) stał się wyzwaniem dla określenia nowych możliwości zastosowania metodologii wykorzystywanej w "BIS Machine". Zadanie polega na utworzeniu modelu 3D i produkcji replik kilku rzeźb z głównego portalu kościoła. Procedura obejmuje 3 kroki: 1) stworzenie trójwymiarowego skanu obiektu, 2) odwzorowanie cyfrowe trójwymiarowego obiektu i opracowanie dokumentacji oraz 3) wytworzenie duplikatu na obrabiarkach sterowanych numerycznie. Zastosowanie „BIS Machine" i technologii informatycznych umożliwia uzyskanie odpowiedzi na ważkie pytania związane z produkcją kopii i replik rzeźb w ogólności.

METODA U PROJEKTU OBNOVE SKULPTURA: PROJEKT ZA ŠIBENSKU KATEDRALU, R. HRVATSKA

Ključne riječi: replika, kulturna baština, skulputra, katedrala, informatika, istraživanje, 3D model, grafički podaci

Sažetak

Novi projekt kojim se nastavlja istraživanje razvojnih mogućnosti "BIS Machine" metode je onaj provođen na dijelu šibenske katedrale kao važnom objektu na kojem se testiraju nove zahtjevne opcije u obnovi spomenika kulture. Prije svega radi se o verifikaciji 3D modela i izrada replika za pojedine skulpture sa glavnog portala crkve kao eksperimenta i praktičnog istraživanja kojim će se bitno istražiti mogućnosti "BIS Machine" metode. Sama "BIS Machine" metoda se sastoji od: 1. Trodimenzionalnog skeniranja objekta; 2. Izrade virtualnog 3D modela objekta I; 3. Izrade replike objekta slijedom pripremljenog 3D modela. Očekujemo da projekt, koji se izvodi uz jaku informatičku potporu, ponudi kvalitetna riješenja kao odgovore na mnoga pitanja i dileme vezane za izradu kopija, odnosno replika.

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Figure 2. Cathedral in Šibenik – The main gate to the Cathedral

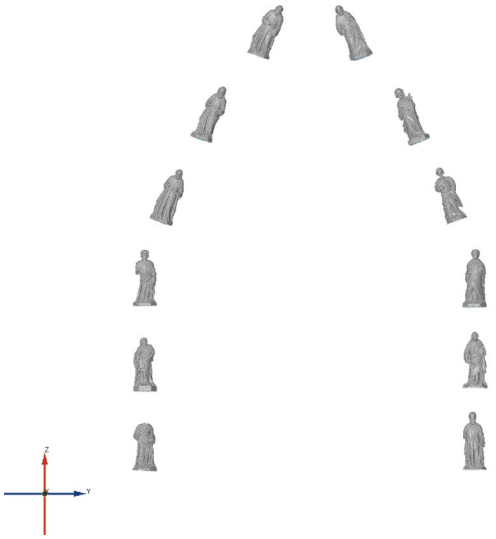

Figure 3. The Twelve Apostles Statues of the Cathedral's Portal in Šibenik

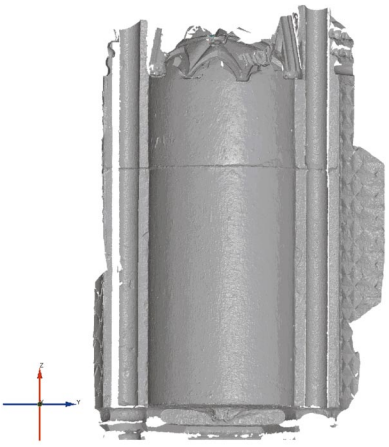

Figure 4. The Apostle and his niche

Figure 5. The Apostle placed in the niche

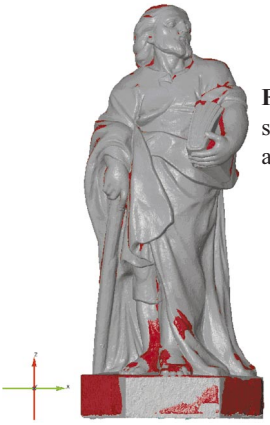

Figure 6. Overlay of original statue (in red) and a stone replica (in grey)

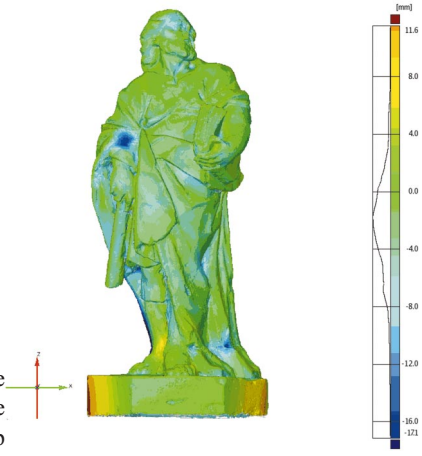

Figure 7. The results indicate surface deviation of the stone replica from the original statue as a colour map

Figure 8. Photogrammetric image of a statue – the original

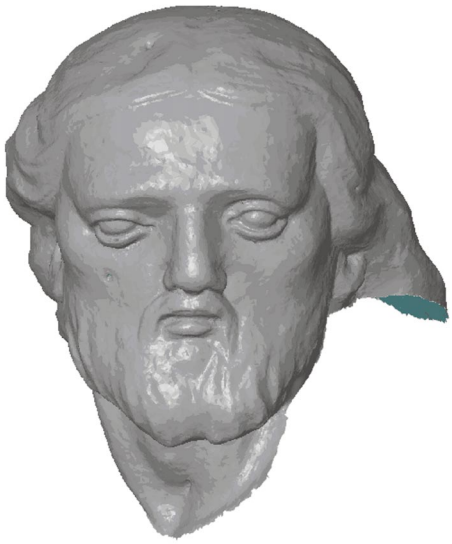

Figure 9. Photogrammetric image of a statue – the stone replica

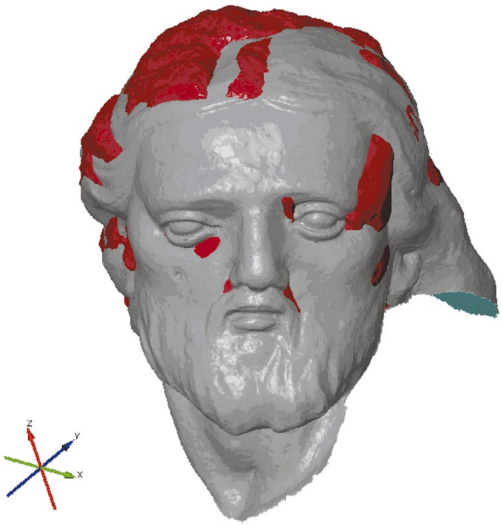

Figure 10. Overlay of original statue (in red) and the stone replica (in grey)

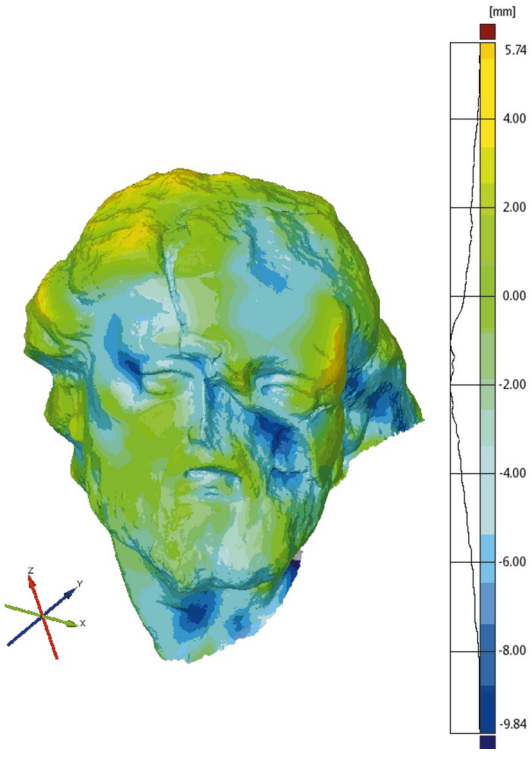

Figure 11. Results indicating surface deviation of the stone replica from the original statue – a colour map

Figure 12. Overlay of the original statue (in red) and the BIS replica (in grey)

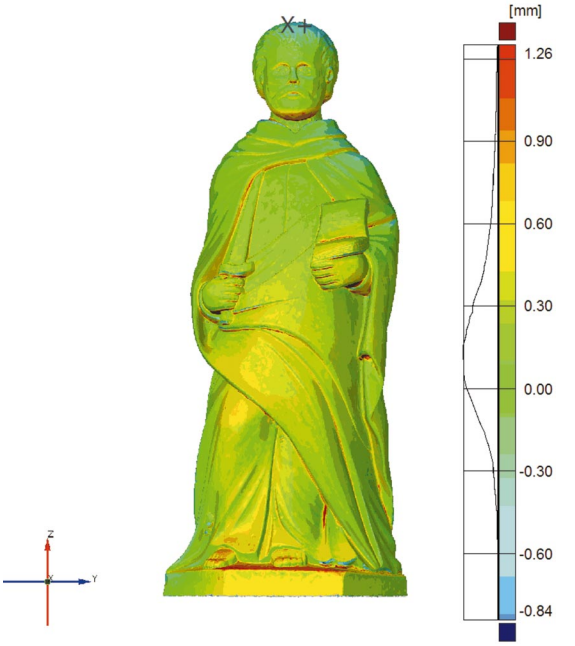

Figure 13. Results indicating surface deviation of the BIS replica from the original statue as a colour map

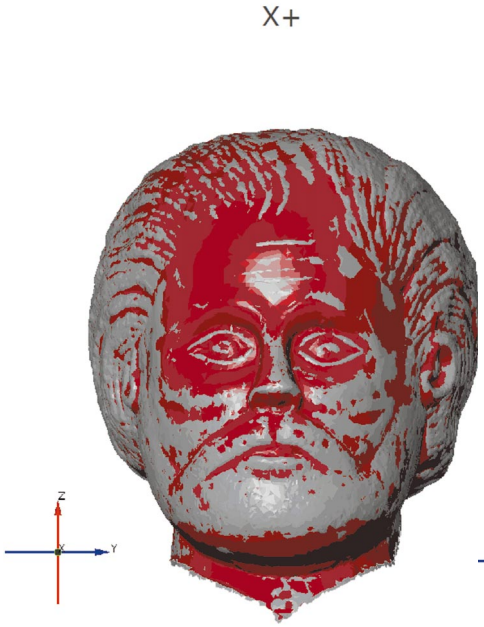

Figure 14. Overlay of the original statue (in red) and the BIS replica (in grey)

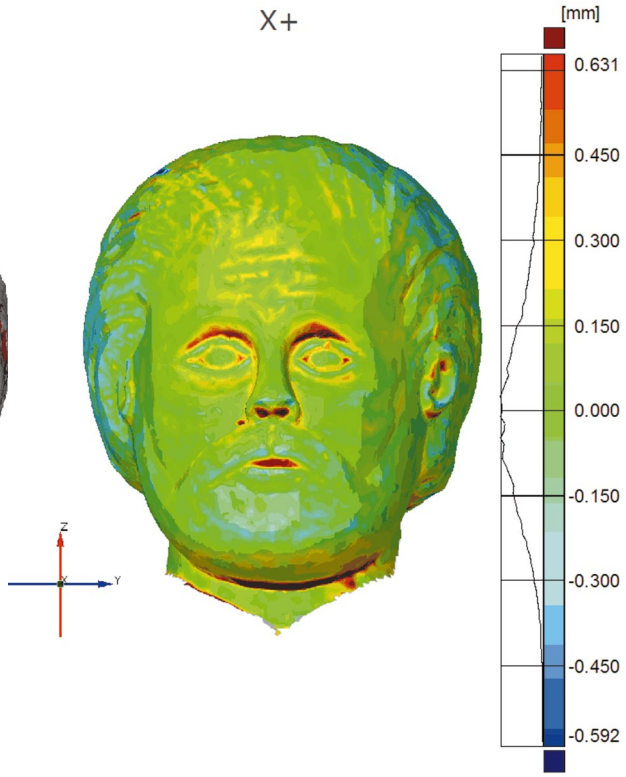

Figure 15. Results indicating surface deviation of the BIS replica from the original statue – a colour map

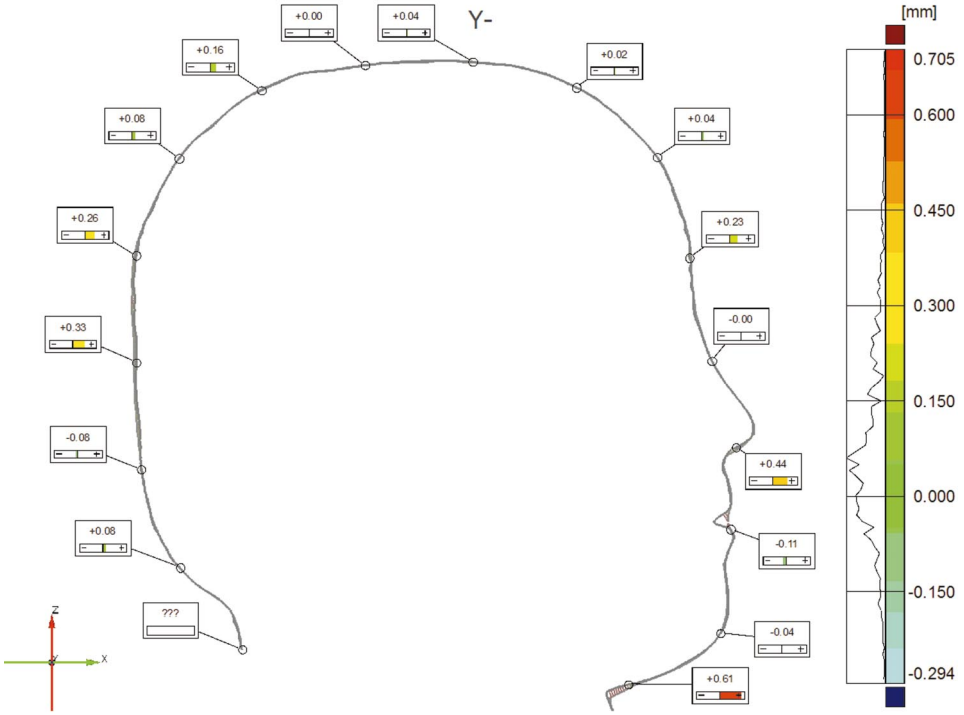

Figure 16. Results indicating surface deviation of the BIS replica to the original – section analysis

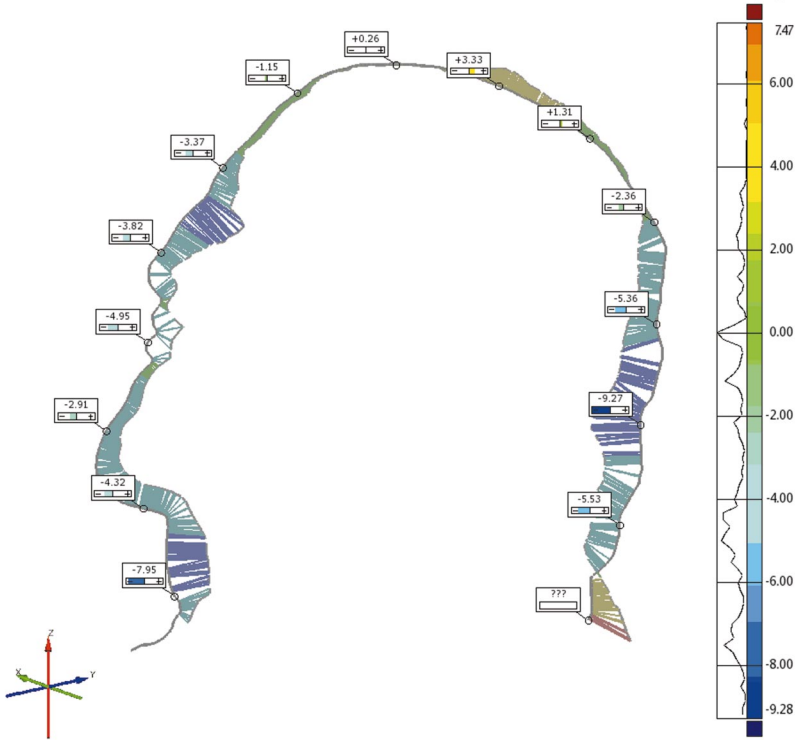

Figure 17. Results indicating surface deviation of the stone replica from the original – section analysis