

# The use of pictorial information in cultural heritage beyond visualisation

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Congress Visual Heritage, 12–15 November 2018, Vienna, Austria

12 November 2018

- 1 Visual information vs. written information
- 2 Use of 2D images
- 3 Methods for capturing 3D data
- 4 Use of 3D data for visualisation and augmented reality
- 5 Underwater 3D documentation
- 6 Volumetric models for 3D data
- 7 Monitoring of the preservation process of waterlogged wood
- 8 Preservation of new media art

- written information, in particular journal articles and published books, are to a large extent already digitised
- on the Internet one can very efficiently search for written information
- however, *pictorial information prevails* on the Internet
- a practical consequence of PICTORIAL TURN (Mitchell/Böhm, 1994)
  - ease of taking pictures
  - sharing of pictures with mobile devices
  - pictorial databases on the Internet
- search for similar pictorial information is still in its infancy

# Computer vision methods enable search of pictorial information

- computer vision algorithms enable *search of information contained in images*
- the classic approach is to hand craft algorithms for recognition of specific objects, for example human faces
- the more recent approach is to *use machine learning methods*
- machine learning algorithms learn to recognise objects based on training examples
- *deep neural networks* are the latest and most successful methods for learning/interpreting images

# Use of computer vision on 2D images in heritage context

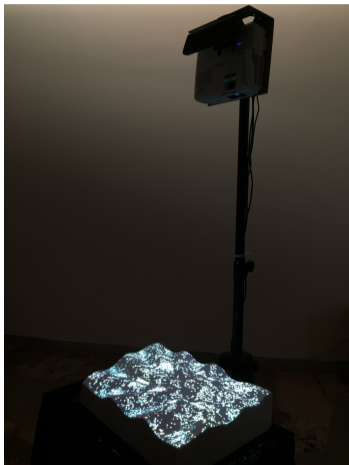
- for efficient search, segmentation of input images is necessary: object/background
- identification/categorisation
- digitalisation of existing image databases
- searching for similar objects in databases
- visual similarity (size, colour, texture, structure, shape, ...)
- detection of forgeries/authentication, based on visual/stylistic properties
- computational aesthetics (quantitative and formal evaluation)

- new sensors and methods for recovering 3D shape of objects and scenes
  - range image: 3D data as seen from a single view direction
  - 3D data/model: can be observed from any direction
  - format: dense 3D point clouds covered with photographic texture
- devices:
  - active sensors (i.e. illumination + capture)
  - hand held, robotic systems for bulk digitalisation
  - multi-image photogrammetry, practical for field work
  - aerial platforms

# Advantages of 3D data

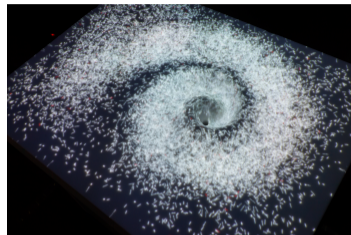
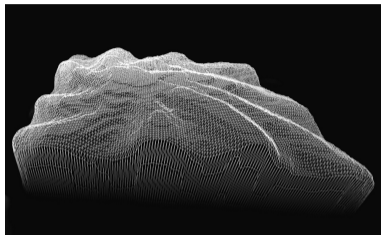
- viewing:
  - from any view direction
  - on screen, with VR devices (googles), holographic displays, ...
- making of 3D physical copies—3D printing
- use:
  - promotion
  - games, education
  - heritage protection, monitoring
  - better object analysis
  - comparison/search—but this requires advanced methods for interpretation of 3D data

# Virtual augmentation of real objects: video projection on physical objects



- stone sculpture + virtual water drops
- the 3D shape of the surface is constantly measured by the Microsoft Kinect sensor
- virtual water drops, projected by a video projector, are simulated to run over the surface and behave as real water drops
- F. Solina, B. Meden. **Light fountain – a virtually enhanced stone sculpture**. Digital Creativity 28 (2): 89-102, 2017

# Stone sculpture virtually enhanced with running “water” drops

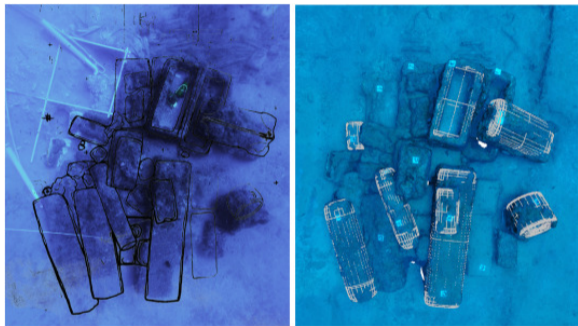


- LEFT: projected surface under the Kinect scanner and video projector can be interchanged
- MIDDLE: 3D model of the surface
- RIGHT: light paths of “virtual” rain conforms to the 3D shape of the surface
- *such augmentation can be seen by all observers without any additional devices*
- Video: <https://youtu.be/y6NAiX1Nm20>

# Methods for capturing 3D data underwater

- multi-image photogrammetry
- standard underwater photo/video equipment can be used
- handheld equipment—succeeding photos must overlap for at least about 50%
- matching of corresponding points in overlapping images and camera calibration is done automatically with computer vision methods
- fast and efficient: reducing the number of underwater hours makes the process safer
- cost effective: open source software for 3D reconstruction
- result: 3D point clouds + photographic texture:
  - for documentation of work in progress
  - for later detailed analysis of artefacts if they remain in situ (underwater)
  - visualisation for general public
  - promotion, education, monitoring, heritage protection

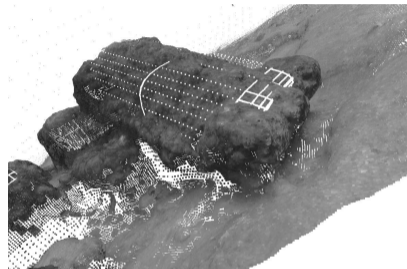
# Sarcophagi cargo from a 2nd/3rd century AD Roman shipwreck near island Brač, Croatia (survey: 2010–2012)



- LEFT: manual documentation
  - several divers, several hours underwater
  - tape measurements, drawings, all done underwater
- RIGHT: photogrammetric 3D documentation
  - single diver, one hour dive
  - covered 110 m<sup>2</sup> area with 900 photos

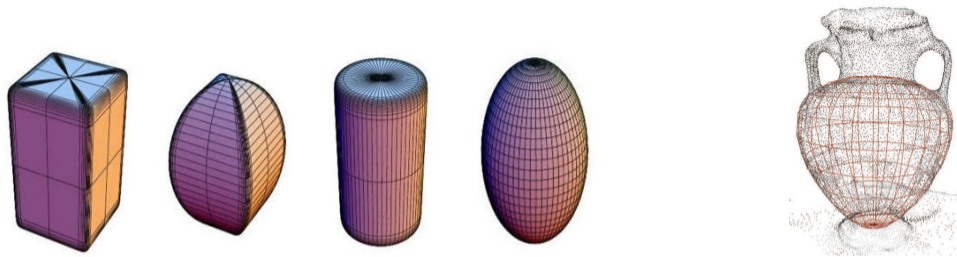
A Jaklič, M Erič, I Mihajlović, Ž Stopinšek, F Solina. **Volumetric models from 3D point clouds: The case study of sarcophagi cargo from a 2nd/3rd century AD Roman shipwreck near Sutivan on island Brač, Croatia.** *Journal of Archaeological Science* 62(Oct. 2015): 143–152, 2015

# Interpretation of 3D point clouds with volumetric models



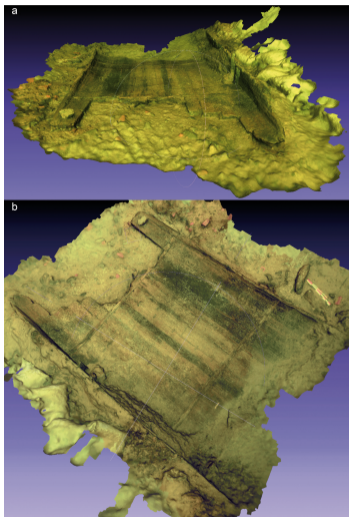
- volumetric models offer a level of abstraction which is advantageous for reasoning about the overall structure of the scene such as size and shape of the ship
- Superquadrics (uniform representation of cuboids, cylinders and ellipsoids) as 3D models

# Superquadric volumetric models



- concurrent segmentation and model recovery from 3D points, used in robotics research
- global and local deformations increase the shape expressive power
- original method of recovery of Superquadrics from 1990's will replace a deep neural network approach
- A Jaklič, A Leonardis, F Solina. **Segmentation and recovery of superquadrics**. Kluwer/Springer, 2000

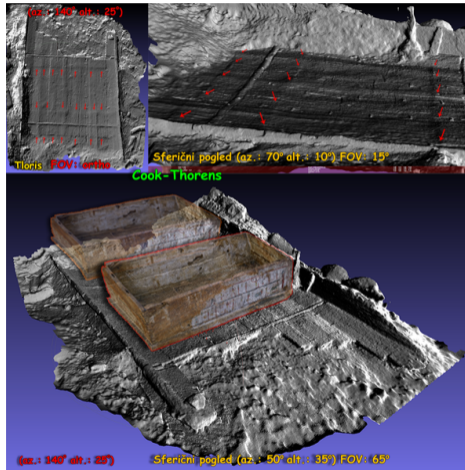
# Early Roman barge from Ljubljana river, built after AD 3



- the barge was only partially uncovered in 2008–2012
- use of multi-image photogrammetry for all documentation
- the barge remains in situ and the exposed parts were again covered with sand

M. Erič, A. Gaspari, K. Čufar, F. Solina, T. Verbič. **Early Roman barge from the Ljubljana river at Sinja Gorica.** *Arheološki vestnik* 65: 187–254, 2014

# Analysis of the 3D data with computer tools



- detailed analysis of the ship performed on the 3D data
- the 3D point cloud could not be automatically segmented into parts used for ship construction
- indentations on the wooden floor planks indicate the continuous use of wooden boxes for cargo
- 3D models of wooden boxes were made after boxes in the Archaeological Artefact Museum, Egyptian Section, at Sforza Castle, Milan, Italy

# Production of 2D drawings from 3D data



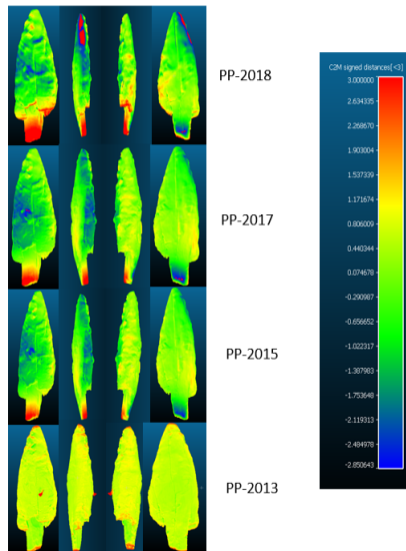
- 2D archeological drawings were derived from the 3D data for comparison with other Roman ships from the same period
- MeshLab, a software program for 3D mesh visualisation, processing and editing

# Monitoring of the preservation process of waterlogged wood



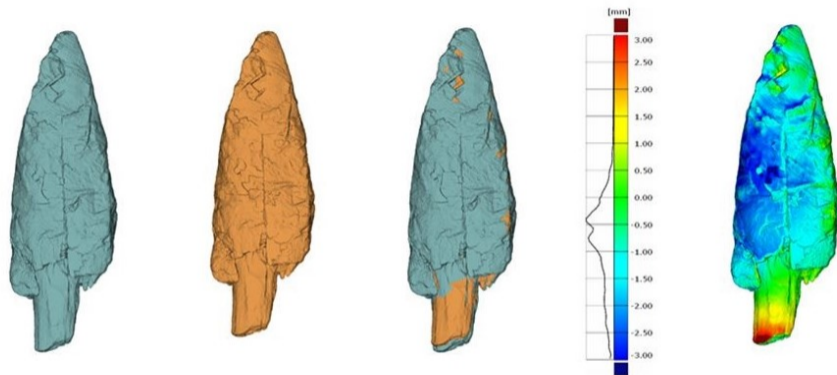
- in 2008 underwater archaeologists discovered a pointed object made of Yew wood in the Ljubljana river near Sinja Gorica, Slovenia
- radiocarbon dating determined the age of the artefact to 40.000 years
- conservation of waterlogged wooden artefacts is still evolving:
  - 1 conventional method by infusing melamine into the object
  - 2 placement of the object back into its original environment
- A Gaspari, M Erič, B Odar. **A Palaeolithic wooden point from Ljubljansko barje, Slovenia** In J Benjamin et al. (eds.) Submerged prehistory. Oxbow Books, Oxford, pp.186–192

# Comparison of five 3D models before, during and after the conservation



- five 3D models were taken during the entire conservation process
- LEFT: comparison of 3D models against the first model **PP-2009** from 2009
- use of CloudCompare software, developed for mechanical products
- monitoring of shrinkage and bending of wood

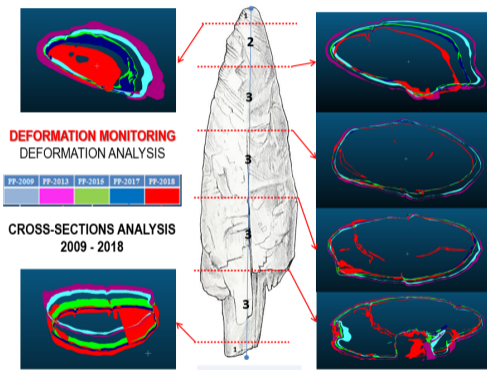
# Comparison of two 3D models just before and after the conservation



- E Guček Puhar, M Erič, K Kavkler, A Cramer, K Celec, L Korat, A Jaklič, F Solina. **Comparison and deformation analysis of five 3D models of the Palaeolithic wooden point from the Ljubljana river.**

Proceedings IEEE MetroArcheo 2018, pages: 444-449, 2018

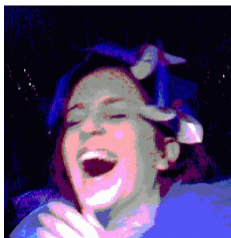
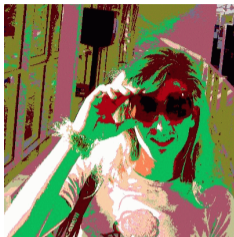
# Comparison of five 3D models of the palaeolithic point



- comparison of cross sections of all five 3D models at six positions (cross sections are not shown at the same scale)
- animated comparison of five 3D models  
<https://youtu.be/HZ-eMF6WZVY>

- digital art conservation is about conservation of *art that was already born in digital form*
- it should be treated as cultural heritage as any other art production
- ensuring long-term access
- *original components* (computer, electronic interfaces, digital control units, monitors, sensors, etc.) should be preserved along with the original software
- operating systems, programs, applications, sensors and any other *software components should be upgraded as necessary*
  - migration
  - emulation (video games)
- documenting all aspects of the work (texts, drawings, video, interviews, ...)
- computer-based art needs to be “updated” every 10–15 years to keep it in performing state

# Case study: interactive installation “15 seconds of fame” (2002–2017)



- “In the future everybody will be famous for 15 minutes” (Andy Warhol)
- F. Solina. **15 seconds of fame**. Leonardo, 37(2):105–110, 2004

## “15 seconds of fame”



- every 15 seconds a photo of observers in front of the installation is taken
- a face detection algorithm detects *all faces* in the photo
- one of the faces is selected *randomly*
- a randomly selected “pop-art” visual filter is applied to the face
- the generated portrait is displayed for 15 seconds
- every 15 seconds a new portrait is displayed

# Updated “15 seconds of fame”



## Installation in 2002:

- color-based face detection algorithm
- custom web server for sharing of portraits
- PC computer, digital photo camera
- monitor with aspect ratio 4 : 3



## Installation in 2017:

- state-of-the-art face detector (Viola and Jones, 2004)
- Facebook social network for sharing of portraits
- Raspberry Pi and Camera module
- all hardware built into the picture frame
- monitor with aspect ratio 2 : 1

B. Batagelj, F. Solina. **Preservation of an interactive computer-based art installation—a case study.**

International journal of arts & technology 10(3):206–230, 2017

- in line with the Pictorial turn paradigm the profusion of pictorial data will continue to increase
- capture of 3D data will become less complicated (e.g. new mobile devices!)
- 3D scanning and modelling already during archeological field work
- objects in cultural and museum collections will be scanned to form digital glyptotheques
- for monitoring of dimensional changes and deformation processes of cultural artefacts 3D data will be used
- computer vision methods for search of visually similar 3D objects will evolve
- segmentation of 3D data into coherent part-level models is necessary

THANK YOU!