SIGGRAPH2009 NEW ORLEANS

Computation & Cultural Heritage: Fundamentals and Applications

Low cost resources for image synthesis and image-based modeling

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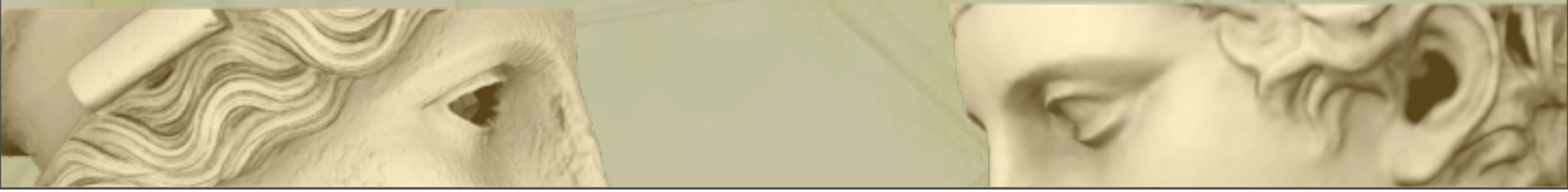
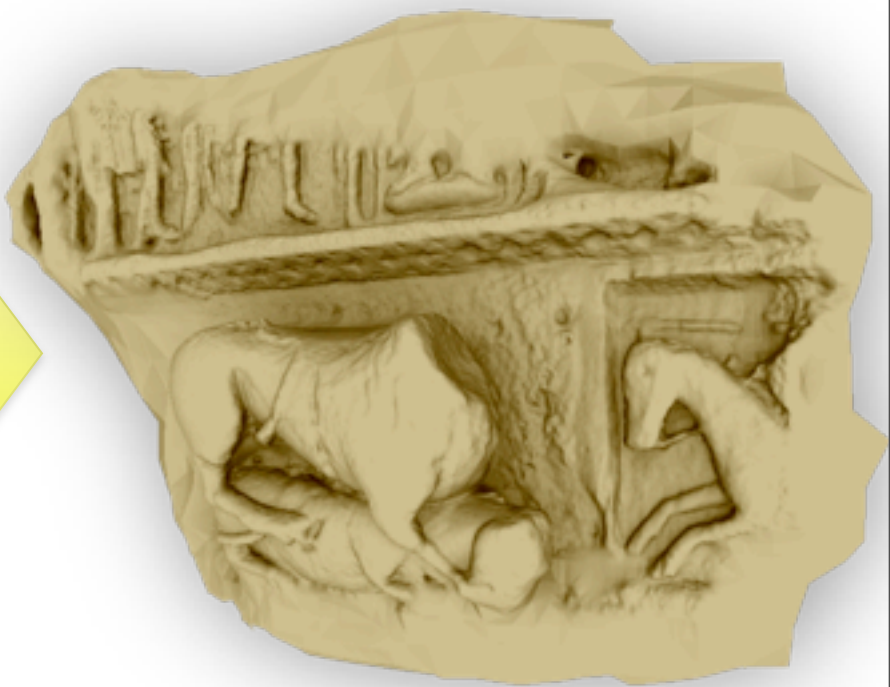
ISTI - CNR



From images to 3D



From images to 3D

- One of the long searched goals of Computer Vision
  - Image understanding
  - Scene reconstruction
  - Shape from {shading | focus | stereo | etc.}
  - **Structure from motion**
- Recent improvements boosting the technologies
  - High resolution digital cameras
  - Huge amount of processing power

Why it is important

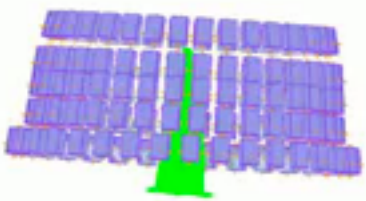
- Cheap
  - Hardware cost is no more an issue
- Robust, reliable HW
  - You can bring digital cameras everywhere, they are rugged tools that work in harsh conditions and unfriendly environments
- Well known tools
  - Taking good photos is not easy but is a broadly diffuse skill (CH people can re-use their photo skills)
- You do not capture only the shape
  - Most active 3D scanning technologies consider appearance/color as a ‘plus’ that has to be eventually managed in a separate step.
- Scale Independent technique
  - Just like photos it works for small and large objects (from coins to mountains)

A bit of theory

- Main structure:
  - Extract features from images
  - Find an initial solution for the structure of the scene and the motion of the cameras
  - Calibrate the cameras
  - Find a dense representation of the scene
- How does it work in practice
  - Many variant from more to less constrained
    - Calibrated stereo camera
    - Free hand camera acquisition
    - Unordered images from different cameras

Some Products

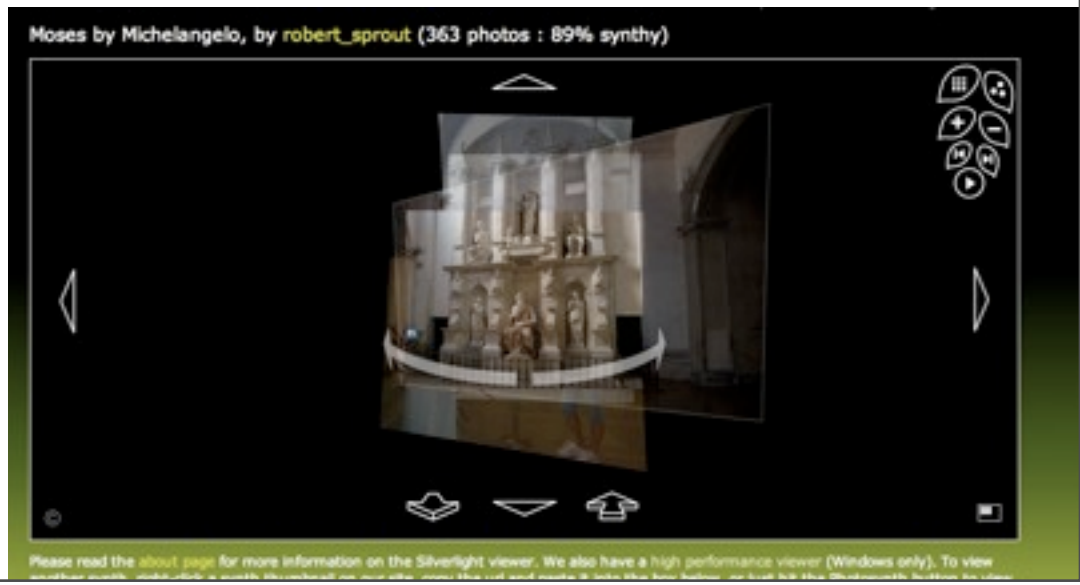
- Promising field -> commercial tools arising
- Menci ZScan
  - Tripod + rigid support + calibrated camera
- Adamtech 3D Analyst
  - Free Camera shooting + SfM
- PhotoModeler Scanner
  - Dense Map from uncalibrated photo pairs



Photosynth (Microsoft)

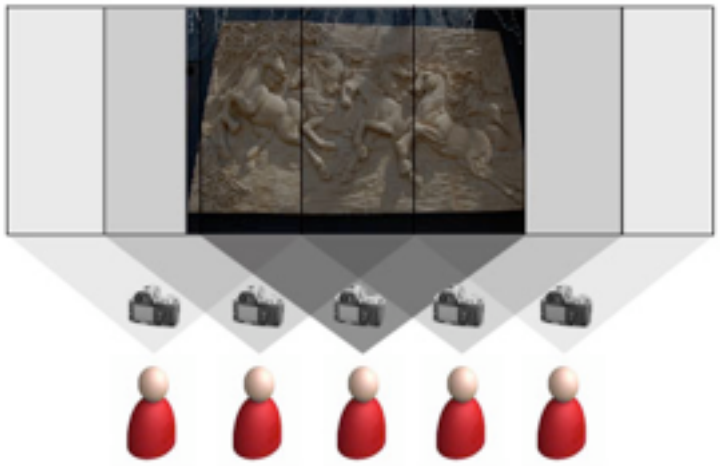
The most known example

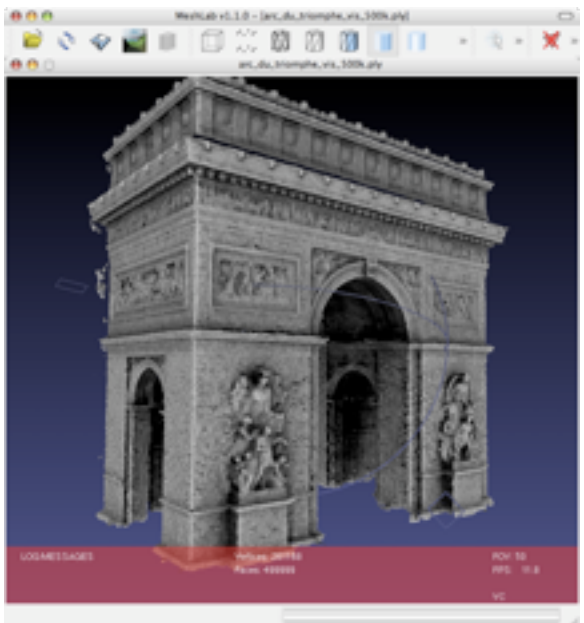
- Photo browsing oriented
- Limited 3D
  - (only the matched feature points are displayed)
- No need of complete coherence of data (quite robust on input datasets)



Web Oriented Services

- 3DSee
  - Require a photo stream mostly parallel to the object
- Arc3D
  - More on this later…



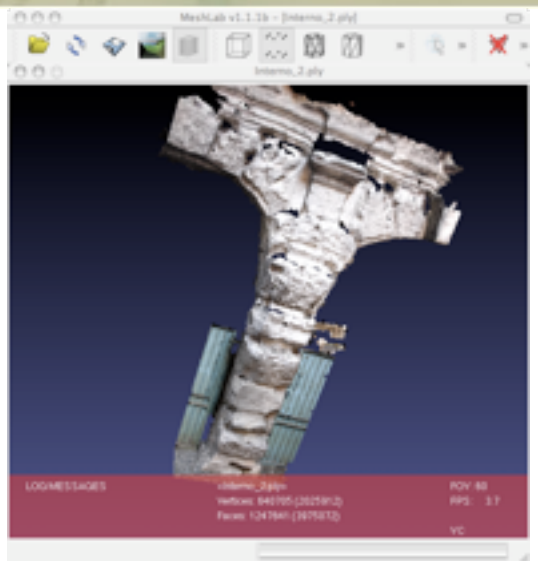


Bundler (Noah Snavely)

- The core of the Photosynth predecessor
- Currently open source
- Research tool (no fancy GUI)

A practical example: Arc3D

A free system for photo to 3D reconstruction



- **Arc3D (by KUL)**

  A free web-based 3D reconstruction service, you upload photos and you get sequences of aligned depth maps

- **MeshLab (by ISTI-CNR)**

  An open source mesh processing system for cleaning, aligning and merging meshes and range maps

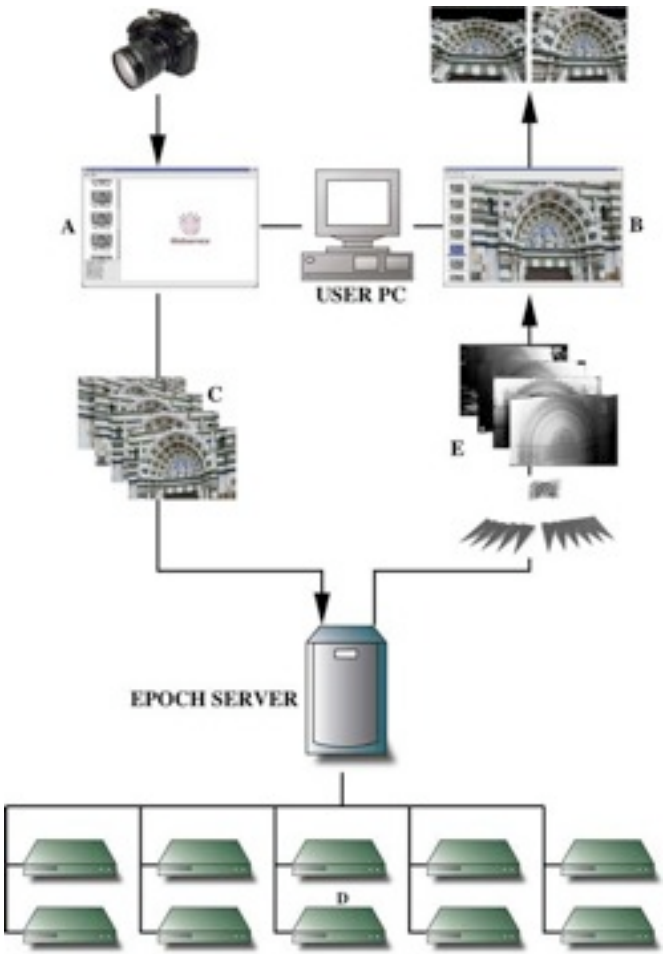
Arc3D: using it

1. Record a sequence of images of a scene or object
2. Upload the images to the ARC3D server

§ The server computes the 3D reconstruction

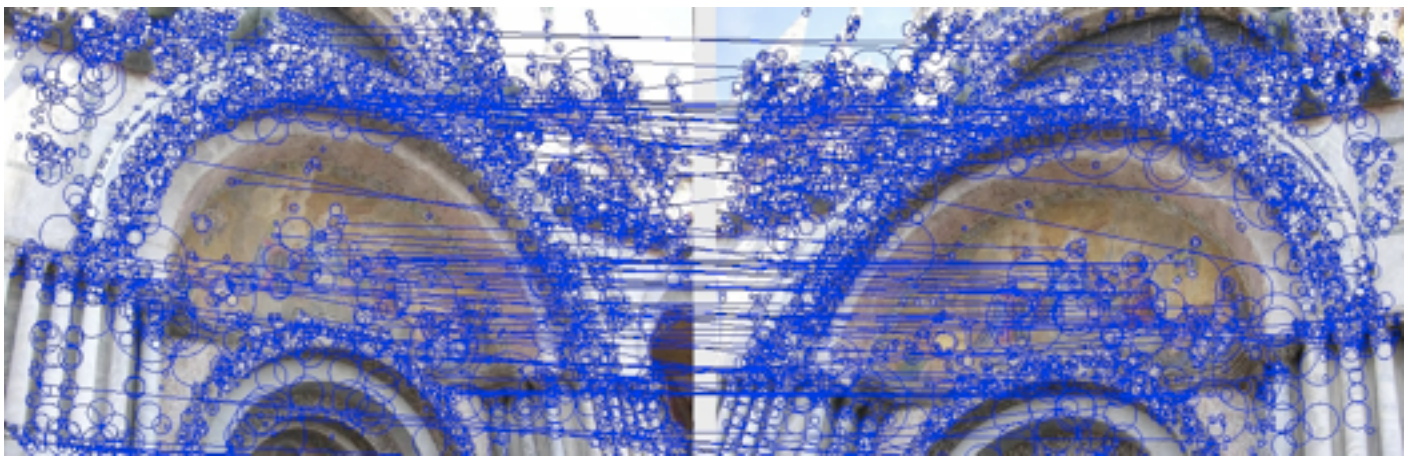
§ Download the results from the ARC website

§ Process and Visualize the results with *MeshLab*



Arc3D: How it works

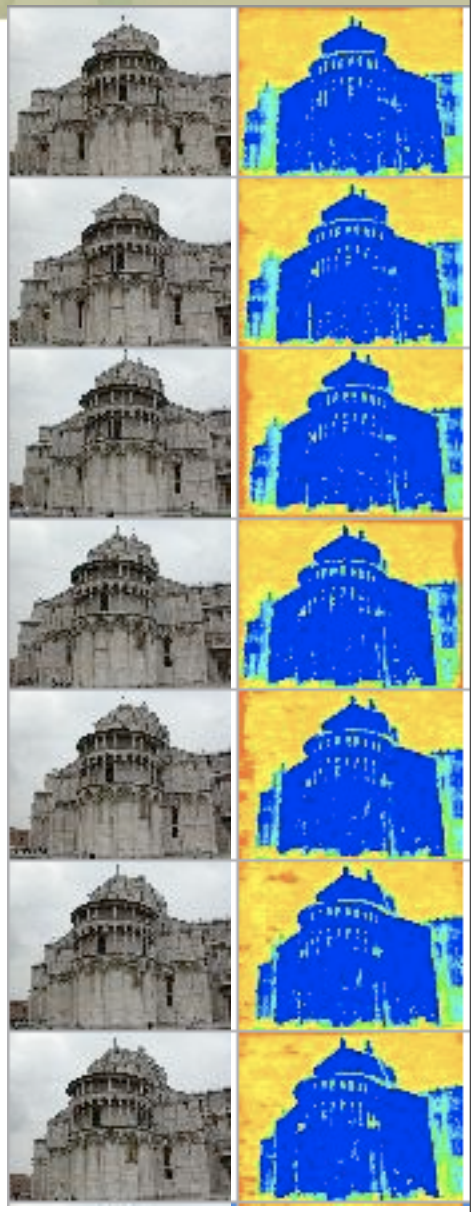
- The entire process is based on finding matches between images
- Given those matching, the geometry of selected points are computed (stereo-correspondence)
- A more dense sampling is produced (one depth for each pixel in the image)



Arc3D: processing the output

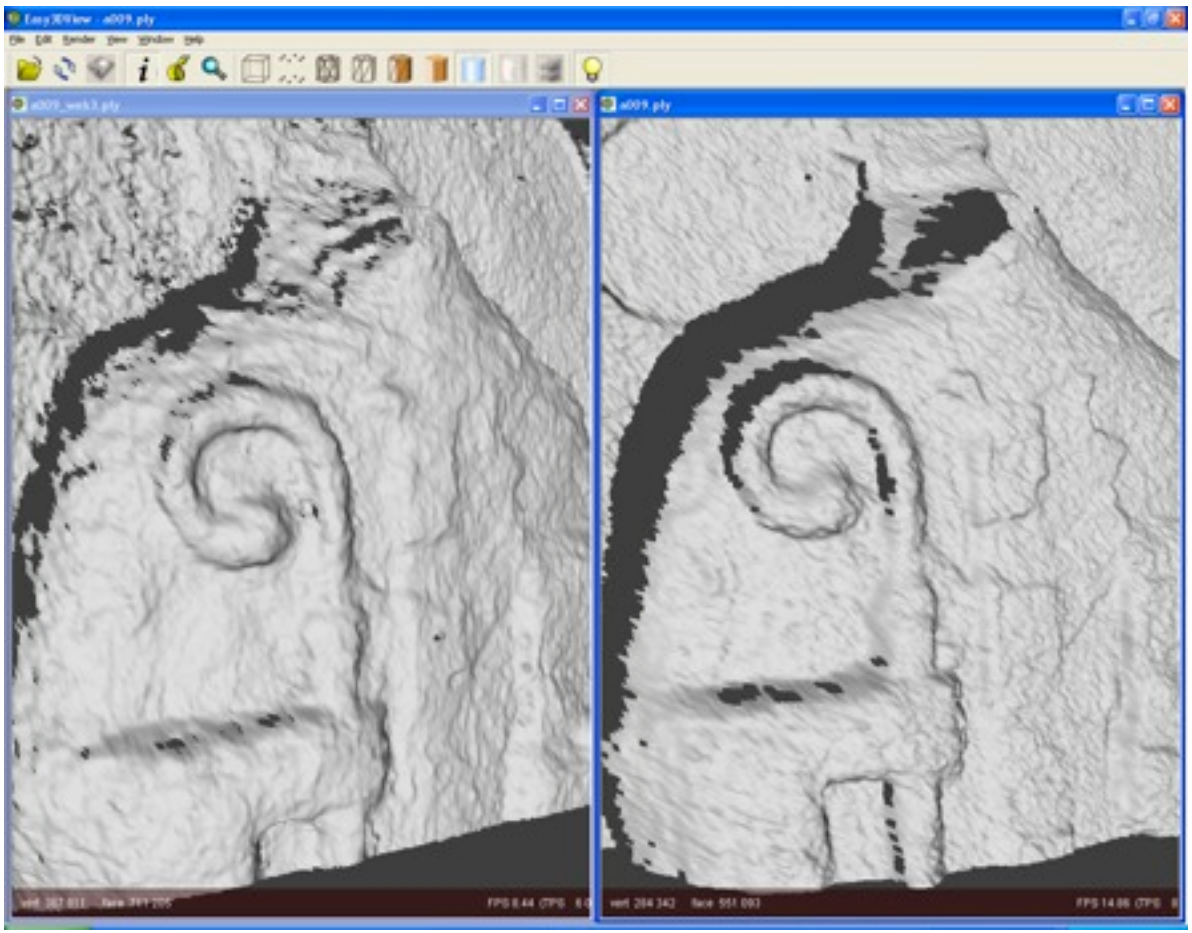
For each submitted image:

- View specification
- A RangeMap
  - an image with the distance from the camera for each pixel
  - a quality estimation for each pixel
- As usual all these rangemap must be
  - cleaned and filtered, integrated into a full model (using MeshLab)



A bit of comparison

- Result of multi-stereo matching (left, Arc3D) vs. triangulation laser scanner (right, limit conditions: 1.4 m, wide lenses)

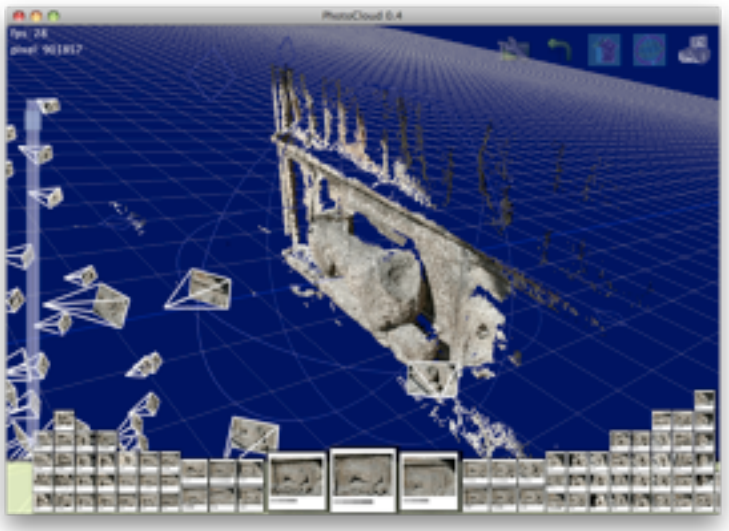


It can fail…

- No texture -> no feature -> no matching -> no 3D info (noise)
- Unstable appearance -> varying features -> no matching -> no 3D info
  - It works well on the classical dull, rough, aged feature rich objects we encounter in archeology (statues, vases, eroded architectural elements) ☺

PhotoCloud

- Allows to browse jointly a sampled 3D model (obtained from a set of photos) AND the photo set
- Main idea (similar to photosynth)
  - Exploiting the richness of the photo set to cover the scarceness of the data
- but
  - It relies on a structure-from-motion system that compute a dense 3D data streams
  - Open source



3D Photo Browsing

- New promising field
  Currently just two examples
- Need for:
  - Better tools for browsing (remotely)
    - Searching and selecting
    - navigating and visiting
    - presenting and enhancing
  - Tools for enriching (tagging, geolocating, embedding in other environments)
  - Collaborative tools for editing

Conclusions

- Photo to 3D
  - Huge potential in CH (but not limited to)
  - HW/SW: low cost you can forecast large diffusion,
  - Not far from standard photographic documentation
- Limitations
  - Quality of the result depends on the shape/texture of the object (more ‘fragile’ than active 3D scanning)
  - Mostly on the 3D side, but you can hide it: (In case of bad 3D data show the photo)