

3D TACTILE MODELS FROM PAINTINGS: AN ASSESSMENT OF POSSIBLE COMPUTER AIDED METHODOLOGIES



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MOTIVATION (1)

Visually impaired people, to a great extent, are prevented from accessing works of visual art.

Only a few museums host exhibitions dedicated to visually impaired people. Some well-known are:

The Tactile Museum "Omero" in Ancona (Italy); The Tactile Museum for the Blind, in Athens (Greece); The Typhlological Museum in Zagreb (Croatia); The Victoria & Albert Museum in London (UK);

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Most of the exhibitions dedicated to visually impaired people present reproductions of actually 3D objects like sculptures, buildings, etc.

There is only a very limited number of museums permanently presenting 3D reproductions of paintings (e.g. "Museo Anteros" in Bologna, Italy).



Mainly because:

1 - Criteria and methods to translate images into tactile language, are not yet completely encoded, especially when dealing with a work of art.

2 - Some kinds of reproductions are usually handmade and result to be quite expensive. Moreover, the artist must be specifically trained.

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Our goal is to make it easier to build a tactile 3D model from a painting by using a computer aided approach.

Additional consideration: 3D printing techniques are quickly becoming more and more affordable; In the near future everyone might have a 3D printer at home to quickly build this kind of 3D models.

However..... First, it is important to decide **what kind of representation we want to obtain**.

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WHAT KIND OF REPRESENTATION? (1)

Four different tactile representations are used for paintings, according to the state of art:



- 1. Tactile outline 2. Texturized relief





3. flat layered bas-relief

4. bas-relief



We asked the help of 24 blind people and of the Italian Union of the Blind, to assess what is the most "enjoyable" typology when dealing with a pictorial work of art.





What kind of representation? (2)

We selected two paintings and realized 4 tactile representations for each of them by using a computer-based (very) interactive reconstruction process.

In the reconstruction, all the suggestions provided in existing guidelines about object spacing, minimum relief, detail level, etc. were taken into account.



Giorgio Morandi (1890 – 1964) "Still Life"



Fernando Botero (1932 - ...) "Still life with fruit"







WHAT KIND OF REPRESENTATION? (3)

1. Tactile (relief) outline







3D model (STL)...ready to be printed by RP machine

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What kind of representation? (4)

2. Texturized Patterns





What kind of representation? (5)

3. Flat-layered bas-relief



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What kind of representation? (6)

4. Bas-relief



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WHAT KIND OF REPRESENTATION? (7)

Some examples. 3D printed using PolyJet technology.



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WHAT KIND OF REPRESENTATION? (8)

Physical prototypes were "explored" by a panel of **24 users** with a total visual deficit (15 congenital and 9 acquired).

3 kinds of exploration:

autonomous, partly guided and completely guided.









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WHAT KIND OF REPRESENTATION? (10)

1. Among the 4 kinds of representations, the bas-relief one is considered the **most meaningful and pleasant to explore**.



2. In the bas-relief representation, the different relief (height) assigned to objects ideally standing on different planes is considered very useful in discriminating foreground objects from middle ground and background ones. (in agreement with the bas-relief definition of the Renaissance and the studies performed at "Museo Anteros" by Loretta Secchi and Marco Marchesini)

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Workflow of a computer-based procedure for reconstructing a basrelief-like representation of a painting suitable for tactile exploration.

We considered the situation of paintings characterized by **central perspective** typical of Renaissance period (Renaissance art in Tuscany is our primary target).

In this case we imagined **3 main steps**:

- 1. Reconstruction of a schematic representation of the scene (similar to the flat-layered one) based on perspective-related information and approximating the figures and elements making up the scene by using different kinds of planes and other primitives.
- 2. Reconstruction of volumes of the "most relevant" elements in the scene also by using shading-related information.
- **3. Combination** of the two resulting reconstructions into a single 2.5 D model.





METHODOLOGY_STEP 0 (PRE-PROCESSING)

We started directly from an image, interactively segmented in regions we wanted to represent as planes or cylinders (for the moment spheres and cones were not considered).

Where necessary, textures where removed and noise reduction was performed.

Prototype software was developed using Matlab ® (still being improved and enriched with new functions)



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METHODOLOGY_STEP 0 (STARTING IMAGE)

Case Study:

Beato Angelico's Annunciation (San Marco Museum – Florence, Italy)



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Fresco (3.2 m x 2.3 m), placed in the upper floor of the Museum (former cloister), next to the friars' cells.



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METHODOLOGY_STEP 0 (STARTING IMAGE)

Starting, segmented image.



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STEP 1: Perspective-based reconstruction.



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Image based procedure working on gray gradients and starting from a base plane selected by the user among the image segments.



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Very simple and intuitive draft GUI for selecting, classifying (*plane, cylinder, horizontal, vertical, oblique*) and linking (*in contact with, free*) planar regions and primitives.







Final height map from step 1



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METHODOLOGY_STEP 2 (VOLUME GENERATION)

STEP 2: Volume generation

The user is supposed to use STEP 2 only for the main subjects, whose flat or primitive-derived representation is not sufficient.

Volume generation step is made, in its turn, of **3 contributions**:

- 1. Inflated surface;
- 2. Interactive Shape from Shading surface;
- 3. Fine detail Surface.





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METHODOLOGY_STEP 3 (COMBINATION)

STEP 3: Combination

By means of a GUI it is possible to interactively combine the contributions of:

- Perspective-based reconstruction;
- Inflated surface;
- SFS surface;
- Fine detail surface.



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METHODOLOGY_STEP 3 (COMBINATION)

The GUI is useful to decide the optimum weights for the different components and to assess how much relief is given to each object with respect to the others.

In this phase, the system prevents the user from generating, for a given object, a surface whose relief exceeds the one of other objects closer to the observer.





METHODOLOGY_BRIEF DEMONSTRATION VIDEO 1080P



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METHODOLOGY_BRIEF DEMONSTRATION VIDEO 720P



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METHODOLOGY_BRIEF DEMONSTRATION VIDEO





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METHODOLOGY_FINAL RESULT

Final result (after "some polygon editing")



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METHODOLOGY_FINAL RESULT

First reduced scale physical prototypes built to select optimal surface finishing and coating...





The entire Annunciation model (sized 800 mm x 575 mm x 50 mm) will be displayed, next to the fresco, at "Museo di San Marco" in January 2014

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More models on the way.....

Brancacci Chapel (Florence – Italy) "Healing of the Cripple and Raising of Tabitha" by Masolino da Panicale

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- Completely automatic segmentation strategies
- Memory efficient and faster implementation of SFS algorithm / surface from normal map
- Possible alternative approaches for SFS based on fast marching (usually very sensitive to noise and not the best choice where there's need to constrain the shape of the surface one wants to obtain or when shading is not "correct")
- Possible integration of our approach with the one proposed by *Reichinger et al.* to reconstruct the global scene structure.
- Input from neuroscientists in order to make the 3D reproduction more "effective" and to improve the aesthetic experience of the end users.

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3D TACTILE MODELS FROM PAINTINGS....

Thank you for your kind attention

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