

3D Reconstruction of Façade and the Statues of the Church “Maria Santissima dell’Elemosina” in Biancavilla

Simone Federico Tomasello and Miriam Caterina Pazzi

University of Catania, Department of Mathematics and Computer Science, Italy
Simone.Tomasello@gmail.com
PazziMiriam@gmail.com

Abstract

3D modelling plays a key role in the reconstruction of cultural heritage assets. It allows to give an idea of the original condition of a cultural heritage before time and weathering effects. This paper presents the 3D reconstruction of the church “Maria Santissima dell’Elemosina” through various software for modelling, as well as the acquisition and processing of elements. High resolution photos has been employed for faithful reproduction of the models details.

1. Introduction

Computer Graphic is a branch of science which is growing quickly through years and it allows to virtual recreate every kind of things, such as a simple asset to a very complex scene like a reconstruction of a statue, a specifically place or an humanoid character. In the last decade, 3D reconstruction of cultural heritage played a key role in the process of its digitization and exploitation [STG*12, ST13, SD13]. However, there are different kind of technologies that have been employed in this field to let the 3D digitization and the study of cultural heritage [GAF*07, SIDP13]. Among them, low cost scanners like Microsoft Kinect or Structure Sensor [STA*17, AGI*16], as well as more sophisticated device. A 3D scanner with high range camera is very expensive, but reproduce all the details with great precision. Nevertheless, to produce an hypothetical 3D reconstruction of an item in its original form, 3D graphic designers are essential. The purpose of this work is to promote various aspects related to the use of good modelling techniques and describe in details all the step for the reconstruction of the church “Maria Santissima dell’Elemosina”. This case study was almost entirely done from scratch, handling all the project by manual modelling for two reasons: eliminate most of the data problems from low budget hardware limitations (like holes on 3D mesh and Ngons) and reconstruct the entire Façade and Statues which are not easily accessible [KFH10]. The paper has been structure into two main parts: the first one concerns the modelling of the entire Façade of the Church and the churchyard, while the second one regards the modelling process for all the sculptures. The two types of modelling have required different approaches that have been described in details.

2. High Resolution Photos

To guarantee an accurate reconstruction of the entire church and the saints statues, a series of photos have been taken to capture the front side of the structure. These photos have been edited and stitched to reproduce the frontal view of the church. This allowed to study carefully of all the shapes, the details, the positions and the size of the angels placed between the decorations. Moreover, the proportions of the whole structure have been easily preserved. There are no detailed studies that reports what was done during the phase of the constructions so, the first and very important step was took all the information needed. At the end of the process that let us recreate the photo, Hugin software (<http://hugin.sourceforge.net> Figure 1) made an oversized image of about 14.000 pixels height resolution and over 9000 pixels for width at 150 DPI, after the processation of about 50 photos carefully taken with a Nikon D3000 reflex camera, and this allow to make an high detailed photo avoid any kind of artifacts [TvGG13].

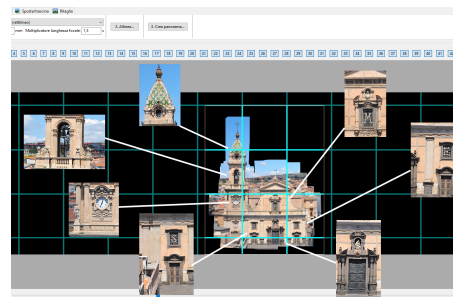


Figure 1: Here is a screenshot of Hugin Software with all resembled photos



Figure 2: Result from merging all photos together

3. Reconstruction of the Statues

At the study phase, the presence of high detailed decorations in both side (front and left) of the Church showed how complex and laborious work was done to recreate it all. The entire process of reconstruction needed a lot of hours spent trying to better organize the workflow to allow less complicated and fluent work to use all the resources we had in a better way. So, first the statues were categorized and subdivided by their position, from bottom to top, at this point we spotted four full-length statues, which are on the second order of the church, the half bust of Jesus the Redeemer, the statue of the Madonna with the child (Figure 3) and many faces of angels present in various places of the facade, above the door of the first order of the bell tower, under the columns placed next to the window with the letter M applied on this, on the large clock that is on all four sides of the bell tower and on the pediment. After that a poly-mesh was created, which is just a simple shape that reproduces the correct composition of the statues and also the basic form of it (this process takes the name “blocking”, which is nothing more than the creation of low poly shape of the mesh in 3D world). The Second step was to overlay this shape to the respective photo (taken from front view) and reshape it in a better way than the blocked mesh

one, being careful that this can match as better as possible the corresponding statue and, of course, another one photo taken from the side was very helpful to reproduce the volume. Using reference pictures taken from various angles, this has allowed to recreate the 3D mesh with high level of details, including all the little cracks that were created from atmospherical changes and continuous weather conditions that alterate the conservation of the statues. In this case study, the used software was Sculptris, which allowed to create a geometry with high detailed mesh only where we needed, thanks to the most efficient algorithms implemented in this software that can subdivide the mesh only where we needed to sculpt in a detailed way. This was very useful for dress creation and in particular to define drapes and to recreate hair and / or beard. This particular algorithm used for generated the mesh was very powerful and give us the liberty to subdivide the mesh only where we needed it, generating a final mesh with a less number of faces that one created using “simple subdivision”, which subdivide mesh in equal number of row and column. Final detailed mesh was then smoothed using the software Blender (<https://www.blender.org/>) and the “subdivision surface” modifier that is able to create a higher density mesh that exalt the details and let make another layer of sculpting process just to add an higher level of detail. At this point, the mesh was completed and next step was to reproduce the accurate physical material, which is a process needed to reproduce (in the last step of render) all the reaction of material with the bounce of the lights. So first needed thing was create the UV isle, which is the process that reverse all the mesh from the 3D space to the 2D space. This process was very hard because of the complexity of the mesh. In this case, we opted for an automatic process of unwrap that reverse the mesh in the 2D space using the boundaries of the entire shape, and with the final result we were able to reproduce an optimal texture mapping using to put most accurate details into the entire surface [RN10]. Blender has a lot of material preset that use procedural textures created using common algorithms like “noise generator”, “voronoi” and others. In this case, the noise generator better worked for all the little details that are visible on the surface of all the statues, a voronoi generator blended with the noise generator created all the scratch into the 3D model and, at last, all of these preset created were used with different kind of textures channel, in order they are: Diffuse channel, that let change the base color of the 3D model; Normal channel, that reproduce little details created on the mesh, baked into the texture; Occlusion channel, that let know better where geometry has to be “occluded” by lights; Specular channel, that is important to reproduce the specularly reaction of the surface, according to the bouncing of the light into that; Displacement channel, which use one of the most heavy computation texture that change physically the position of each vertex defined into the world, what we mean is that with this texture, we were able to create all the micro and macro details directly into the 3D mesh previously created, to fit better the final results. Last step adopted in this case study was to use an engine that let us render all the models and both navigate digitally around these 3D statues in real-time, and to make this possible we choose Unreal Engine 4, which is a game engine used not only to develop videogames, but also to create architectural works like this. To allow the engine recognize all the 3D models created, the files must be exported from Blender to Unreal, and the better file format used for this kind of work is the .fbx file (a standard format for 3D object), which incapsulate all

the informations about each vertex position, materials applied to the faces and references of the textures linked to the materials. The proposition of the statues in 3D world needed to be illuminated, and we used a tri-point light system which is a technique mostly used to better illuminate a single object, and for this we need to create one light that is putted on the left side of the model, this light is common as a key light, the second one was put on the right side and this light take the name of fill light, third light is on the back of the model, and take the name of rim light, which better exalt all the 3D object. Also it was created an environment light system based on photo taken around the church, very useful to reproduce in most efficiently way the global illumination. Finally, the environment was ready to be rendered in real time with Unreal Engine 4, allowing us to take various snapshot from different angle of view.



Figure 3: Side by Side comparison about real photo (left) and real-time rendering (right) of Madonna Statue



Figure 4: Side by Side comparison about real photo (left) and real-time rendering (right) of half bust of Jesus Statue and an angel on the bottom



Figure 5: Side by Side comparison about real photo (left) and real-time rendering (right) of Saint Placido Statue



Figure 6: Side by Side comparison about real photo (left) and real-time rendering (right) of Saint Caterina Statue



Figure 7: Side by Side comparison about real photo (left) and real-time rendering (right) of Saint Zenone Statue



Figure 9: A photo of the lost hand about Saint Giuseppe Statue, virtually reconstructed on the render above

4. Reconstruction of the Church

The second part of this case study is about the global reconstruction of the external environment of the church. First, a pre-production phase was done just to organize all the work. To proceed in the best way, the entire church was (imaginary) sliced into different pieces, as mentioned below.



Figure 8: Side by Side comparison about real photo (left) and real-time rendering (right) of Saint Giuseppe Statue

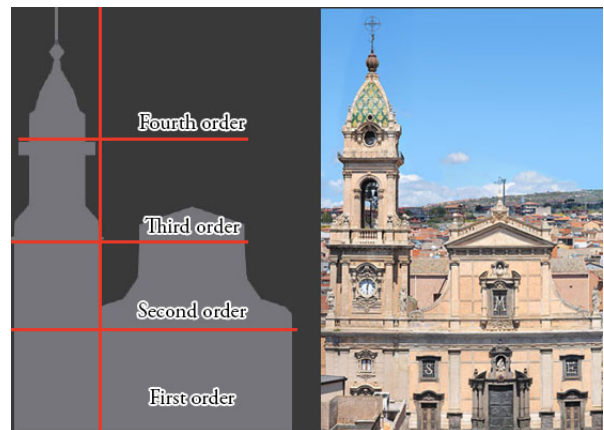


Figure 10: Blocking of the 3D model of the church

4.1. First order

As said before in the chapter relative the saints, in the first phase of the reconstruction it was done the creation of all the shapes just using the "blocking" system adopted to reproduce, with a low poly mesh, all the items that are visible outside the church. After this, next step was to create details all around the mesh created, in particular the decorations of the columns at both side of the central door and, of course, the top side of this. Same work was done for the other two doors that are located at left and right from the principal one. Finally, there are two windows putted upon each of side doors, that report the letter S (for "Santissima") and E (for "Elemosina"). The complex phase of the reconstruction was to reproduce all the decorations that are visible in all the three doors, especially in the center one. To better reproduce all the details, another photoshoot was done just in front of each doors, and in this case, we can analyze in detail the first and central one. To do this, a sequence of about ten images were taken so the next step was to align them inside Photoshop, taking care to overlap a single central photo of the door to better fit the result. Aligned all together and set them to preserve the perspective, it was later generated a 8K resolution photo that was converted into greyscale one.



Figure 11: Side by Side comparison about real photo (left), the four textures extracted from the 8K photo (center) and real-time rendering (right) of the main door

With this photo, it could be possible to reproduce all the textures needed for the door, and a Normal Map, Specular, Roughness and Color were created starting from the first one. These textures were created using Bitmap2Material, which allowed to convert with a lossless quality these images. Imported them into Substance Painter, the generation process of the final material was done using, for a base color, a material that reproduce the physical behavior of bronze and metal, and finally a mix-up with the textures previously generated from the grayscale one, let us create the final 3D mesh with this material applied on it, generated the door that looks like the real one.



Figure 12: Side by Side comparison about real photo (up) and real-time rendering (down) of the first order



Figure 13: Another point of view rendering about the first order of the Church



Figure 14: Rendering from the bottom of the Church

4.2. Second order

As mentioned before, the second order of the Church include two big column that continues from the bottom and reproduce the exact composition of the Church, giving a good form and nice shape, also there are a lot of decorations putted on both side of this order and, finally, there is another one big windows with a M (which means “Maria”) putted in front of that and, analyzing this also thanks to the photo created before, we spot that a tabernacle is present to embrace the torso of Jesus Christ (created during the phase “reconstruction of the Saints”), and a couple of angels putted together with all decorations. Analyzing this window, we can see that there are a lot of little decorations realized thanks to a manual modelling process executed by one of the author of this article. Entire process requested a lot of time and, like the other cases studied before, it was putted a background photo to help during the modeling phase to recreate and reproduce as better as possible every single details. Final result is visible below and report two screen showing, side by side, the similitude between them.



Figure 15: Side by Side comparison about real photo (up) and real-time rendering (down) of the second order



Figure 16: Close up and Side by Side comparison about middle bust of Jesus Christ inside his tabernacle

4.3. Third order

This is the last part of the Church, the top one. In this order, there are a lot of decorations that fit in a smooth way with the rest of this architectural complex. In this part, the focus will be into the metope, which is visible in the full photo, and it was very difficult to recreate the shape because of their high position into the space. So the study was extended to other church that report a similar decorations and thanks to a good research done with Google Images, all the results was compared with the church reconstruction of this case study. These images showed how the shapes would be and, of course, all the entire modeling process was done after this. Final result show how are they positioned into the top of the Church, and using a photo taken from a specifically point of view, a render image was generated to better compare the 3D reconstruction to the real one, as showed below.

Same thing was done for the cross putted on the top of the Church but, in this case, a simply front view photo was necessary to allow the correct recreations of the shape and the decorations.



Figure 17: Different rendering of all Church (from first to the third order)

4.4. Bell tower

This is the last piece of Church entirely modeled from scratch, started from the base (first order of the bell tower) through the hill (fourth order of the bell tower). As said before in the earlier chapters, photos are fundamental to allow the correct proportions of the shapes and details, what we want to describe in a detailed way is the creation process of both two clocks that are positioned at the second order of the bell tower. If you see the photo, you can notice how very detailed are they, including not only the clock, but also four angels putted on the four directions with windblown from their mouth. In additions to this, another angel on the top of the clock was modeled and, finally, three of four full size statues are positioned in both side of the Church (the front one and the other that is visible directly from the square (called "Piazza Roma").



Figure 18: Clock Tower placed in the middle of the Bell Tower, comparison between real photo (left) and the final rendering (right)



Figure 19: Bell Tower Side by Side between real photo (up) and the final rendering (down)

Another part of the entire reconstruction that required a lot of work was the creation of the third order, the one that contains all the bells (nine, in this Church). The difficulty seen during this phase were especially the proportions of the structure, at this level, because there wasn't enough photograph material to work with it. The final approach was to take different photos from the "Piazza Roma" and let compared them with the frontal photo, to have a better view of the entire building and, from this, it was created a basilar shape starting from the front. Adopting mirror modifiers from the center (using Blender), an easy and proportioned shape (from four sides) was created and then the detailed process done was very affordable. Last thing was the recreation of the first bell, that was not much harder to do because from the frontal photo is possible to see the main one, and from this, the creation of the shape was simply done creating a curve using "Bezier Curve", transport the rotation with "Screw Modifier" and a little thickness was adopted to better create a solid, using "Solidify Modifier" that was helpful to make the object with a thickness. Then, after having done the Unwrap of the mesh, the creation process of the material was demanded to Substance Painter, which has a set built inside that can easily reproduce basic materials without any issues, and a similar bronze material was used to reproduce the physical corrected appearance, added some scratches and a little dirt mask to create the final result.



Figure 20: Rendering of the Church from the bottom

Going more over (on the top) there are a lot of chromatic plugs that are graceful putted together to reproduce a cross pattern with only two colors, green and yellow. They also refine better the hill of the tower because of the headland shape that, at the end, embrace another one cross that declare the first (and the second) end of the positioning of it. All these chromatic plugs were manually putted there also in 3D world, and the combination of colors were done using two different materials that can reproduce their secular-ity in reaction of the direct and indirect light bounce. As mentioned before, on the top (and final headland) there is a cross that was entirely realized with iron and bronze and, with this, there is also a weathervane with two years reported on this, they represents the year which it was putted on the top of the church (first time and, after a downfall, the second time).



Figure 21: Different rendering of the Church

5. Executable file

Having realized (almost in the manually way) the entire Church with all the statues, last thing we do was to make an executable file, which allows users to navigate inside 3D world where we put all together ([DMCS11]). Thanks to this executable file, you can run it with a PC (windows OS needed) and use simply a keyboard and a mouse to move around the world, and you can fly like a bird to see with a better perspective all the details that were recreated with this work and, in addition, thanks to a VR glass like Oculus Rift or HTC Vive, you can see everything like you were there, in the exact position where the Church is located. In this way, everybody could better appreciate everything we described above and, of course, we think that taking a near look at the structure could be a good, new experience.

6. Conclusion

Manual modeling takes a lot of time to reproduce in the best way a complex mesh with every little details like this, and a skilled 3D artist is needed to recreate everything from the scratch. Otherwise, there are different software which allows to recreate a 3D polymesh starting from photos (like PhotoScan) that can reproduce a cloud point which could be converted to a static mesh, with the final result looks like almost the same as the real world one. The difference between manual and automatic processing is that with the first one, you could modify the entire 3D mesh and textures, fix everything when needed without issues and also, thanks to the better modeling workflow (which is the use of quad mesh) the improvements on the 3D model could be done more easily, and in the textures you can add more details were needed. Further more, the automatic way built a very complex 3D model that, in most of the case, better reproduce all the scanned object and recreate high detailed mesh with an incredible amount of details in geometry, but this can't easily modified because of the heavy polymesh generated (which contains triangulated mesh that are harder to modify and, sometimes, create ngon mesh which makes artifacts during rendering). Also, in addition to the automatic generated mesh, a manual work must be done to fit the holes that occasionally could be created from the scans (and relative textures), clean and reduce the generated mesh in order to optimize the final 3D model for less time needed during render phase and a heavy mesh generated like this is worst for real time engine, which needed that the mesh must be very clean and without any issues. Last, but not least, the scan must be taken when no clouds occlude the sun so the light should be constant, generating a 3D mesh that catch illuminated textures, and this doesn't allow to create different illumination of the environment, because the final result has shadows and lights baked directly onto the textures, avoid the possibility of create different illumination (sunlight and nightlight) and the use of dynamic shadows, which bring in life the environment inside the 3D world. In this case study, the main goal was to reproduce a complex mesh that could run in real-time inside a game engine and, for this, a manual modeling better fit the starting point. According to the fidelity of entire reconstruction of the Church and all the Statues, a totally fruition of a work like this could be one of the future way we know today to better take a look at a 3D reconstruction with a full immersion inside the virtual world directly from our home and, for the best afford and, again, for a best immersivity, we suggest to use a VR glass that could transport you directly inside the 3D world and, with this technology, you can see everything we realized just in the same way you are there, directly from the bottom (or any perspective you like to see) of the Church. The process of digitalization of cultural heritage mixed with a fruition like this can, surely, let better understand what we lost when we can't see these things directly from where they are located, also this kind of work could be used to enjoy an hypothetical reconstruction of a site, a statue and moreover, all of this thanks to the growing technology that allow us to do works like this and, in the near future, we hope that we could better appreciate virtual cultural heritage reproduction (like this [SST08]) in support of the images and videos generated before this.



Figure 22: Final rendering directly from the executable project

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