Scanning and Printing a 3D Portrait of President Barack Obama

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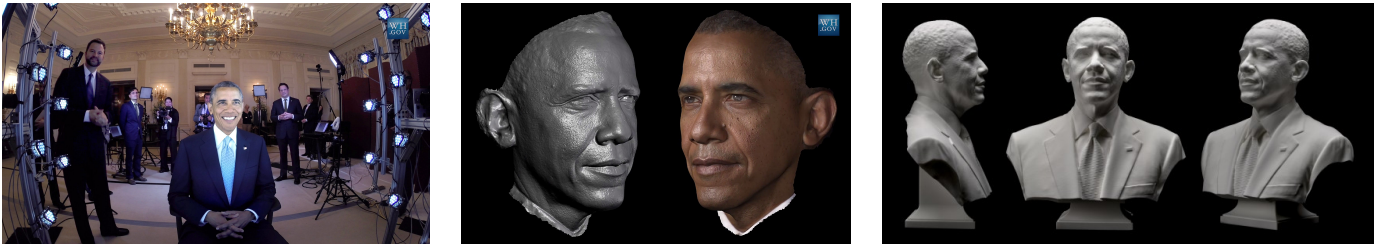
Figure 1: *(Left) President Obama sits within the mobile Light Stage in the White House as the hand-held scanning team stands ready. (Center) High-resolution facial geometry, with and without texture maps. (Right) Three views of the completed life-sized 3D printed bust.*

Introduction   On June 9th, 2014, we traveled to the State Dining Room of The White House to create a 3D Portrait of President Barack Obama using state-of-the-art 3D scanning and printing technology, producing the modern equivalent of the plaster life masks of President Lincoln from the 1860's.

3D Scanning   For the first stage of scanning, the USC Institute for Creative Technologies assembled a mobile Light Stage with eight Canon 1DX DSLRs and 50 custom LED light sources mounted to a quarter-circle of aluminum scaffolding. During each of three facial scans taking one second, the cameras captured 10 photographs each under different polarized gradient lighting conditions [Ghosh et al. 2011] for a total of 80 photographs per scan. Cross-polarized lighting was recorded with all lights on and used to subtract diffuse skin reflectance from the parallel-polarized gradient images to provide surface orientation measurements from the specular reflection. Afterwards, a hybrid stereo correspondence and photometric stereo algorithm processed the imagery into 0.1mm resolution 3D models of the President's facial geometry and reflectance from ear to ear.

With the goal of producing a full bust of President Obama, we augmented the Light Stage technology with an additional process to capture the top and the back of the head, as well as part of the torso. For the second stage of the portrait, we asked the President to sit still while two team members circled him with hand-held Artec Eva scanners. These scanners capture video of a pattern of light which deforms when it is projected on a subject. Based on the deformation, algorithms reconstruct this data into color 3D geometry. A round of hand-held photography ensured that detail that is difficult to resolve for the hand-held scanners would not be lost.

Model Processing   While it took 15 minutes for the plaster to dry on President Lincoln's face, our team took just over 7 minutes from the time President Obama entered the room to finish the data capture for the first presidential 3D Portrait using 21st century technology. That same night, the team huddled in a pad-locked Smithsonian conference room to transfer data from memory cards to processing stations, evaluate the data, and start preliminary post-processing. There was considerable relief when we were able to confirm that all the data had been optimally captured.

As a next step, all data from the scanning session was sent to Autodesk, where under extraordinary time constraints, the light stage, hand scanned, and photographic data were combined and post-processed. The Autodesk team put together a 3D model by fitting together the different pieces like a puzzle: they precisely registered the geometries from the different data sources into a unified 3D space, and normalized the color information from each scan to prevent visible seams of different types of color in the final model. Last but not least, a digital sculptor added a plinth to complete the bust. Within 72 hours, the process resulted in a master file of 15 million triangles, which yielded print-ready files for an Obama bust and a life mask, as well as photorealistic 3D models for digital viewing.

3D Printing   The files for 3D printing were transferred to 3D Systems. For the 1:1 bust, in a process called Selective Laser Sintering (SLS), a laser melted nylon powder into a highly accurate and durable print. Given the size of print (the bust stands 19 inches tall, and weighs almost 13 pounds), the printing process took 42 hours, after which the print cooled down for 24 hours. A 3D printed bust and a life mask were ready to be picked up at a 3D Systems facility in Langhorne, PA on the evening of Tuesday, June 17th, just in time for the White House Maker Faire.

Results   We unveiled the presidential 3D portrait on June 18th at the White House Maker Faire, where the President had his first opportunity to inspect the bust. The 3D printed portrait was first publicly exhibited in the Smithsonian Castle in December 2014. The 3D printed bust, life-mask, and all underlying 3D data have been accessioned into the Smithsonians National Portrait Gallery.

Conclusion   The Lincoln life masks which inspired the presidential portrait bridge the 150 years from the present to the life and times of the 16th President of the United States. In his face, we see reflected the history the President shaped and witnessed. At the Smithsonian, taking the long view is a way of life as we strive preserve the artifacts testifying to our history, art and culture. We hope that decades and centuries from today, the 3D portrait of the 44th President will speak to future generations in the same way that Lincoln's life masks speak to us today.

References

GHOSH, A., FYFFE, G., TUNWATTANAPONG, B., BUSCH, J., YU, X., AND DEBEVEC, P. 2011. Multiview face capture using polarized spherical gradient illumination. In *Proceedings of the 2011 SIGGRAPH Asia Conference*, ACM, New York, NY, USA, SA '11, 129:1–129:10.

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