A Novel Approach to Design 3D Models in Medical Education

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Abstract

In this paper, we describe a novel process for creating high-resolution, 3D PDF, 3D printed, and holographic anatomic and pathology models using inexpensive *consumer grade electronics*, which can be incorporated in any undergraduate or graduate medical school curriculum.

Keywords 3D models · Hologram · Holographic pyramid · Medical education · Anatomy · Pathology

Medical educators today face challenges that include the needs of a new generation of learners, demands for developing new competencies in contemporary medical school curricula, and the instructional limitations of “social distancing” due to the COVID-19 pandemic [1]. Although computer-assisted learning offers the promise of addressing those challenges, its benefits have not been fully explored in contemporary medical education. Virtual computer simulation, 3D modeling, and 3D printing tools are among these technological advances [2]. However, its utilization in medical school curricula is scarce primarily because of the need of high-cost equipment required to create, produce, and display these models [3].

We used large, unfixed gross specimens from the *Michael E. DeBakey Hospital, Houston, Texas*, to create the 3D models including: (1) *surgical resections*: (a) thyroidectomy for goiter, (b) partial hepatectomy for hepatocellular carcinoma, (c) colectomy for colon cancer, (d) nephrectomy for kidney atrophy, and (e) laryngectomy for cancer, and (2) *organs obtained during autopsy procedures*: (a) colon, (b) brain, (c) heart, and (d) lungs. All patient information was removed during image acquisition and/or naming of computer files.

In Fig. 1a and provided as Online Resource 1, we illustrate the workflow process. After placing the specimen on the grossing workbench under direct LED light to avoid shadows, we

acquire photographs of the model using Trnio (www.trnio.com) on an iPhone XS max (Apple Inc., Cupertino, CA) (Fig. 1b). We took sequential images of each specimen following the guided instructions within the application itself. To create the 3D scans, a minimum of 40 images (at a distance of approximately 30 cm) were taken for each specimen. The acquisition process took an average of 5 min and uploading to the Trnio server lasted ~ 10 min (Fig. 1b). During our procedure, two autopsy specimens, brain and heart, were rescanned because the mesh reconstructions were found to be incomplete. The acquired model was then exported from the Trnio application to a personal computer (Apple MacBook Pro, Apple Inc, Cupertino, CA) as an object file (.obj). Post processing was performed using Meshmixer software (2017 Autodesk, version 3.5.474) to improve the overall appearance of the models, post processing included the removal of the white dissection mat background, correction of minor gaps in the model, and smoothing the model contours (Fig. 1c). We used this final model to create (1) a dynamic interactive 3D PDF file model (Fig. 1d), (2) 3D-printed model (Fig. 1e), and (3) holographic model (Fig. 1f–h). The dynamic interactive 3D PDF model was created by simply importing the .obj file into Adobe photoshop (Adobe, San Jose, CA) and exported as .u3d file. The 3D print model was created by slicing the file using CURA (Ultimaker, Waltham, MA, USA) software and printed on a *Creality CR10-S* printer (Creality, Shenzhen, China) in white Polylactic Acid filament (PLA) (Fig. 1e) taking an average time to print of 13 h (6–28 h) and an estimated cost of less than US\$10 per model.

The holographic pyramid is a device that can display images and videos producing the illusion of a 3D hologram (Fig. 1f). We created a holographic pyramid using 4 clear acrylic sheets glued at a 45° to fit a 10.5-inch tablet

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Fig. 1 **a** General workflow for 3D model creation. **b** An example of a nephrectomy specimen acquisition and processing using smartphone device. **c** Image postprocessing showing a laryngectomy specimen after removing the white dissecting mat and fixing minor imperfections. **d** Screen capture of a dynamic interactive 3D file (3D PDF file). **e** 3D-printed model of a laryngectomy specimen. **f** Holographic pyramid dimensions (A: 2.6 cm, B: 16.9 cm, C: 10.1 cm, D: 12.4 cm). **g** Example of animation rotated at 45° using powerpoint (Microsoft powerpoint 2010, Redmond, WA). **h** A virtual image displayed in the holographic pyramid

(Fig. 1f). A 3D animation movie of the model using *Blender* (www.blender.org) was made. Finally, a movie was generated by pasting four copies of the animation rotated by 90° using PowerPoint and uploaded to a tablet (Fig. 1g, h and Online Resource 1).

Our approach produces inexpensive interactive virtual 3D models, 3D-printed models, and 3D holograms of anatomical specimens, all of which may be utilized in various instructional modalities. Further studies are needed to assess the potential impact of this technology on the acquisition of anatomical knowledge and relevant competencies by medical students.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s40670-021-01262-6>.

Declarations

Ethics Approval Approved by Institutional Board Review H-24715

Consent to Participate Approved by Institutional Board Review H-24715

Consent for Publication Approved by Institutional Board Review H-24715

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