

Waffle Structure Display Mannequins Produced using Rhino Software
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Introduction: Creating unique dress forms for display can be an exciting way to exhibit design work effectively, innovatively, and in a way that supports the conceptual basis for the designs. New technologies provide methods to create custom-made forms with moderate investments in time and materials. The propose of this project was to fulfill specific creative design needs for a solo exhibition, the designer wanted mannequins that (1) were a replication of a specific body, (2) could be suspended from the ceiling and (3) utilized only biodegradable materials.

Literature Review: In researching what methods are out there for making custom forms for display we found some patents for unique displays. One 1931 patent talked about how the new form would allow fabric to drape better, it was made of metal and had rivets at the shoulder, elbow and hip joints so the limbs could aid in display (U.S.Patent 1,833,503). Another form circa 1989 was cut from sheet metal, the idea was it could be shipped flat and when it arrived at the place for display it would transform to a 3 dimensional form (U.S.Patent 4,798,317). An article in the journal *History News* gave instructions for homemade display forms, one involving chicken wire formed to the body and once removed covering the wire with plaster. Through a survey of current custom mannequins on the internet, it was discovered that the company FabTextiles (2017) created a set of freestanding waffle structure mannequins. A waffle structure is when select X and Y planes are notched and joined to create a 3D object and is most often associated with model building in the field of architecture (Schabel, 2007; Vazakas, 2014). FabTextiles used 123D Make software to generate a waffle structure from vertical planes, compiled the segments in Rhino, and then laser cut the sections from 3mm MDF board. Other research has been done on the production of custom half scale dress forms using laser cut foam (Vuruskan and Ashdown, 2017). In this method 3D body scans were digitally divided into half inch horizontal sections using Geomagic Studio. These sections were cut from half inch high density foam on a Kern laser machine, stacked on half inch dowels, glued, and covered with knit fabric. The same study looked at producing half scale forms using 3D printing. ABS-M filament was used as the printing material; these 3D printed forms were then covered with a quarter inch layer of cotton batting and a final layer of a tightly woven linen (Vuruskan and Ashdown, 2017). We decided that a waffle structure form laser cut from biodegradable MDF board was the best solution for the exhibit goals of the designer.

Methods and Results: The process began with the sample production of a half scale waffle structure mannequin using a 3D body scan from the university's database. The scan was reduced by 50% in Geomagic and imported into Rhino, a relatively affordable 3D manipulation software, to create both vertical and horizontal slices. Rhino is a command driven program, so it took several iterations to learn the process and produce the desired 3D form. A YouTube video by Daniel Eisinger (2015) provided a useful guide for the development of the waffle structure in Rhino; the resulting half scale mannequin was laser cut out of poster board and needed to be glued to support the joints.

To produce the final full-scale mannequin a 3D scan of the designer's body was taken using the Vitus XL Human Solutions scanner and the scan was imported into Rhino to create the vertical and horizontal slices and to generate the joining cut outs. Once the image was imported into Rhino, the first step was to check to make sure the structure was closed (watertight). Any holes were filled using the FillMeshHoles command and slices were created with the PlanarSrf command. Once the X and Y crosscut sections were created they were exported into Adobe Illustrator and prepared for laser cutting. Using a Kern laser cutter we cut the form out of the material desired for the exhibition; in this case we used quarter inch MDF board.

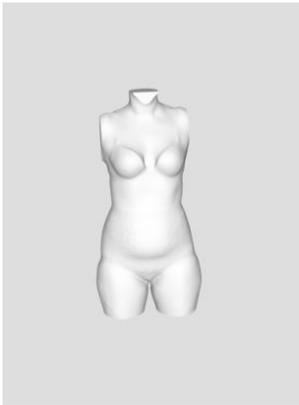


Figure1. 3D body scan used for final mannequin



Figure2. Laser cut MDF board



Figure3. Final mannequin

Discussion: Through our work we made three interesting discoveries that may be of interest to others wishing to develop their own waffle structure mannequin. First, with Rhino using the plugin program Grasshopper other designers can quickly facilitate the creation of the cutouts for the waffle structure. Using Grasshopper, you can create a macro to save the steps needed to form the joining cutouts in the slices for your unique form. Second the production of mannequins is not limited to MDF board. Cardboard, Plexiglas, poster board and other interesting substrates that are able to be laser cut would be suitable for this process. Third, this method could be used to make unique forms for displaying clothing from different time periods using a body shape silhouette appropriate for the period. By scanning a person wearing the appropriate undergarments and standing in the posture for the period, the correct silhouette could be achieved. These forms could be made of materials that would not damage clothing through off gassing of harmful toxins, and a soft knit cover could also be put on the form to further protect historic garments.

Conclusion: With care and creativity unique display forms can be made. Forms can be made from a variety of materials and in almost any posture, giving you unlimited freedom to display your work.

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