Quimo: A Deformable Material to Support Freeform Modeling in Spatial Augmented Reality Environments

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ABSTRACT

This poster discusses a new free-form modeling material called Quimo (Quick Mock-up), designed for use in spatial augmented reality environments. Quimo is a white malleable material that can be sculpted and deformed with bare hands into an approximate model. The material is white in color, retains its shape once sculpted, and allows for later modification. Projecting imagery onto the surface of the low-fidelity mock-up allows for detailed prototype visualizations to be presented.

Keywords: Spatial Augmented Reality, Industrial Design, Deformable Surface, Quimo

Index Terms: H.5.2 [Information interfaces and Presentation]: Graphical User interfaces—Input Devices and Strategies; I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction Techniques

1 INTRODUCTION

We have been exploring how Spatial Augmented Reality (SAR) [5] can be integrated into the industrial design process [2]. We have also been investigating organic interfaces through the use of Digital Foam [7, 8]. Extending these concepts with further insights from the industrial design community, we have developed a material for prototyping that combines the natural sculpting properties of clay-like substances with intricate detail properties provided by SAR. Both the clay-like and intricate detail properties work in concert to provide physical-plus-virtual feedback to the designer.

This new material, called Quimo (Quick Mock-up), is an innovative free-form modeling material designed for use with SAR. The key application for Quimo is to support a novel prototyping technique, allowing industrial designers to generate reusable low-fidelity mock-ups early in the design process. Quimo is a white malleable material that can be moulded with bare hands to produce low-fidelity physical prototypes (Quimo mock-up shown in Figure 1 (right)). Unlike clay, Quimo comes in sheet form allowing hollow physical models to be constructed by cutting and bending the material into shape. Employing SAR to project imagery onto these low-fidelity mock-ups allows for complex surface appearances to be presented.

2 BACKGROUND

Pugh's Total Design Model [4] and Pahl and Beitz's model of design [3] are two commonly applied design methodologies. The concept phase is where solutions to design specifications are generated. The typical process during the concept stage is to: 1) generate ideas, 2) create concepts that embody the ideas, 3) evaluate the concepts, and 4) select the most promising concepts. Using CAD and design applications to express conceptual currently ideas is common place. Since the model itself is still in the concept stage, the dimensions and appearance of the model are often not well defined. The designer explores different materials, colors, textures and dimensions repeatedly to find the best way to visualize a concept.

Augmented Reality (AR) has shown potential to enhance product design, construction, and evaluation for industrial designers. Wang et. al [9] describe an AR system for the design and evaluation of functional assemblies. AR has been used for industrial building acceptance tasks [6]. AR is also used in the design process; for example Augmented Foam [1] uses a head worn display to overlay material properties on a foam mock-up of a product. SAR [5] is where perspectively correct computer graphics are added to surfaces using projectors. Compared to other AR display technologies, SAR does not require the designer to wear or carry display equipment. SAR does require physical surfaces to project onto, the design prototypes are well suited for this projection.

3 QUIMO IN THE DESIGN PROCESS

This poster explores a new mock-up material and the techniques employed during mock-up creation. Quimo has similar malleability and shape retaining properties to clay, but is in malleable sheet form. The surface properties of the material allow for the application of virtual textures to be registered to the prototype in a SAR environment.

Our goal has been to explore how the concept phase of the modeling methodology can be enriched using SAR technologies to allow designers to visualize their concepts with higher detail and provide a more flexible modeling environment.

Figure 1: Quimo modelling material mock-up next to a non-deformable material.

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The existing industrial design concept phase modeling process is repetitive requiring re-painting of prototypes to visualize different appearances. Once materials such as clay are painted it is difficult to modify the physical appearance since the paint will crack and reduce the appearance quality. In comparison, when using Quimo and SAR for concept development both the physical model and appearance can be altered without requiring a new prototype do be constructed.

4 Creating Mock-ups with Quimo

Quimo is constructed using a sheet of aluminum mesh wire coated with white silicone to create a hybrid modeling surface. The mesh wire was chosen for its shape preserving property and the white malleable silicone coating since it can be moulded into shapes and provides a good projection surface.

Modeling with Quimo involves three basic processes; cutting, bonding and sculpting. Cutting Quimo is performed using regular scissors. This allows both curved and straight cuts to be easily performed.

The silicone material repels most types of glues and tapes, so we have looked into techniques for bonding the material. When joining two pieces of material together, we found stapling pieces to be a robust technique, since the staples wrap around the inner aluminum mesh. Another successful approach for tight corners is the use of cable ties (tie-wraps) to join pieces together. It is also possible to glue two pieces of Quimo together by using liquid silicone as a bonding material.

Sculpting the shape of Quimo can be easily achieved using either bare hands or tools. A bare hand technique that can be used is draping the material over an object and forming around it with your hands. Pinching the material allows a ridge to form that is useful for building up features. As with clay sculpting, tools are also very effective in shaping Quimo. A ruler can be used to create straight folds by bending it around the ruler's edge. We also noticed that when handling Quimo, talcum powder can be used to prevent dust or dirt from sticking to the silicone surface. Since the talcum powder is white it is also suitable for projected images and slightly reduces the reflective surface of the silicon.

5 Quimo Material Implementation

This section describes the construction details of the Quimo material. Quimo is constructed using two materials: Smooth-On EcoFlex 30[1] and Amaco Wireform (aluminum mesh wire). The mesh wire is regularly used for free-form modeling, but lacks the white surface that is required for SAR. EcoFlex 30 fulfills this requirement. It is lightweight, will cure into a smooth surface area and can be stretched at least as much as the mesh-wire can. It also allows for integrating the markers in the material.

Figure 2 illustrates the layered structure of Quimo. Two flat sheets of EcoFlex are created, by pouring the Ecoflex liquid in an open topped box of the desired dimensions. After mixing the two components of Ecoflex it takes approximately 4 hours to cure. Next, liquid Ecoflex is added on top of one of the two sheets and distributed evenly. A flat sheet of mesh-wire is added to this liquid layer of Ecoflex. The top layer of Quimo is made with the second sheet of cured Ecoflex that was created previously. The liquid Ecoflex in the middle layer will bond all pieces together. To squeeze out excess liquid we added weight on the top layer. After another 4 hours the middle layer will be cured and the Quimo material is ready for use.

6 Conclusion and Future Work

In this poster we have presented Quimo, a malleable modeling material allowing traditional hand modeling and projected digital imagery to be combined. We have described how the concept design phase, used by industrial designers, can be enriched using Quimo and SAR allowing for continuous changes of the visual appearance and shape without the need to build new mock-ups.

In future implementations it will be possible to save the entire process of mock-up creation. A designer can then improve their skills by watching the process in retrospect, this allows for the comparison of the design process between novices and experts. The difference can then result in instructional guidelines. Additionally, the virtual models obtained from the deformed Quimo surface can be saved and imported into CAD software for later use in the design process.

[1] http://www.smooth-on.com

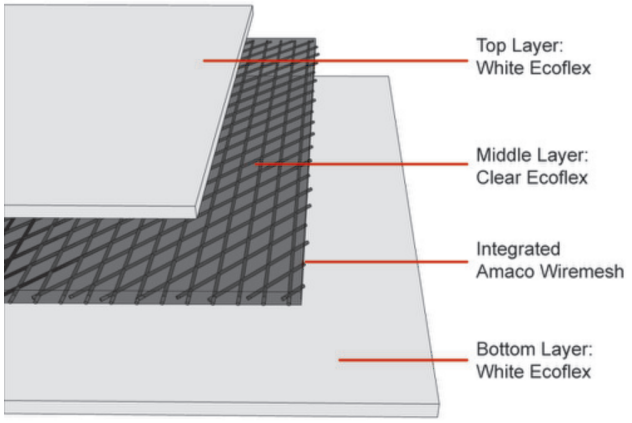

Figure 2: Cutaway showing the layers that comprise Quimo. The layers are bonded while the center Ecoflex layer is liquid.

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