THESIS PROJECT PORTFOLIO

Design of an Alternative Method to Create Custom Ocular Prosthetics

(Technical Report)

Utilizing 3D Technology in the Ocularistry Industry to Improve Accessibility, Affordability, and Patient Comfort

(STS Research Paper)

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Infants have a preference for watching human eyes compared with other parts of the face and body. At our most instinctual level, humans are hardwired to interpret feelings and understand situations by looking at eyes. When circumstances such as trauma, cancer, or complications related to diabetes warrant the removal of an eye, a crucial part of a patient's face is lost. Fortunately, there are options that allow patients to regain some sense of normalcy post-enucleation (surgical removal of the eye), but none are ideal. The current standard of care is buying a custom ocular prosthesis, which requires an extensive fitting process. My technical and science, technology, and society (STS) research focus on three different but inherently-related problems related to custom ocular prosthetics. The first problems, addressed in my technical research, are the excessive waste of resources–materials, time, and money– as well as patient discomfort that occurs in the custom ocular prosthesis fabrication process. I propose the use of photogrammetry, a non-contact 3D scanning method, to streamline the fabrication process, reducing the use of resources and mitigating patient distress. The third problem, which is the focus of my STS research, is the exorbitantly high price of an ocular prosthesis, which privileges patients able to afford the high price and marginalizes others. My research seeks to understand the conditions that allow ocularistry to operate as a monopoly and resist updating its technology. Using Actor Network Theory (ANT) as a framework, I will address the roles of the ocular prosthesis, ocularists (the craftsmen who make prosthetic eyes), patients, and sister industry (anaplastology) in creating the current stagnant state of ocularistry.

My technical project will explore an alternative ocular prosthesis fabrication process that will optimize resource use and eliminate the need for a painful socket impression to be taken. For the proposed process, the required software and background knowledge is minimal, making it accessible and simple to implement. First, to create an accurate mesh model, images will need to

be taken 180° around the front of the face. Tests to optimize lighting, number of photos, and lens type have been performed and will be included in the report. RealityCapture was chosen as the ideal photogrammetry software due to its low cost and ease of use. Once in RealityCapture (optimal settings provided in the report), a mesh model can easily be generated and exported as an object (obj) file to MeshMixer. MeshMixer is used to manipulate the mesh model and determine the shape of the prosthesis. The model is first duplicated, one of which is mirrored so that the non-enucleated eye is on both sides, and the two are aligned. A simple boolean difference returns the shape of the prosthesis based on the missing volume. The method has been verified by artificially enucleating computer-generated imagery (CGI) models using a gaussian function and returning the correct prosthesis size and shape, confirmed using statistical analysis. The final prosthesis will be printed in a biocompatible resin using stereolithography, but that is beyond the scope of the current research.

In my STS research, ANT is used to evaluate the factors that contribute to the stagnant state of the ocularistry industry. The first actor, the ocular prosthesis, is highly detailed and accurate, which justifies its pricing. I will include the results of studies on patient satisfaction with their prosthesis to establish the influence of the quality of the prosthesis on the industry as a whole. Secondly, ocularists shape the industry, largely because of trade secrets and lack of oversight from the Food and Drug Administration (FDA). As such, ocularists have the advantage of pricing the prosthesis the way they see fit since so few people know the trade. Thirdly, patients play an important role in allowing ocularistry to thrive; patients face the psychological burden of reestablishing their sense of self, making them more willing to endure the painful and expensive fitting process despite the financial obstacles. This is evidenced by studies on hardships related to adjusting to everyday life that patients face post-enucleation. Finally, the

existence of a similar industry called anaplastology influences ocularistry. Unlike ocularistry, anaplastology obtains custom topographical information using 3D scanning devices and is capable of handling more complex eye-related cases, reducing the incentive to update the technology used in ocularistry.

In both my technical and STS research, achievements were made to advance the field of ocularistry. Initially, the goal of my technical project was to 3D print a custom ocular prosthesis using the scans from an enucleated patient. Due to the need to adequately verify the accuracy and precision of each step of the process, the goal was changed to producing a custom ocular prosthesis of an artificially enucleated model. With the new goal in mind, my capstone partner and I were able to complete the project. In the future, the process will need to be tested on actual patients with special consideration given to the potential effect of skin tones on the quality of the model. Although, flaws in the method still remain. The method is not effective in patients with two enucleated sockets and may be inadequate in capturing the details of irregularities in the socket. On the other hand, the STS research, which sought to understand the state of ocularistry, was successful in evaluating the four main actors that influenced the industry. To strengthen my STS research, it would have been helpful to obtain more perspectives from ocularists and ophthalmologists in formal interviews. Also, more data is needed on the pricing of an ocular prosthesis to thoughtfully explore the differences that exist within the field. Likewise, the pricing of prosthetic devices made by anaplastologists was omitted in the report, but could provide valuable context and may be helpful to the paper's argument.

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