Head Mount for Retinal Surgery Robot

Jerry Gonzalez, Renan Ichi, Ryan Lam, Sarah LeBaron, Ryan Nielsen
Advisor: Dr. Jake Abbott

Project Intro & Goals
During retinal surgery, when the sedated patient breathes, the surgeon must compensate for movement. If the patient snores, the surgeon must remove their instruments from the eye to avoid damage to the retina. A specially designed pillow helps reduce these movements, but retinal surgery is so delicate that breathing and snoring still cause complications.

Our objectives are to make a head mount that can:
• Remain fixed during these motions
• Mount a small telemanipulated surgical robot
• Keep the surgical instrument still relative to the patient

How to accomplish this?
Granular materials exhibit a jamming phase transition when they reach a certain density, acting like a single solid. We have utilized this transition by filling a balloon, shaped around an adult head, with coffee or sand to form a granular jamming pod. This pod is then fit around the patient’s head and threaded through a helmet-like shell. The robot is mounted on the shell. By pulling a vacuum within the pod the grains jam together forming a rigid connection from head to robot.

Granular Jamming
By evacuating the grain-filled pod, the rubber balloon pulls slightly inward, raising the grain density within the pod. At this increased density, the grains are prevented from sliding because of their contact with other grains or the pod walls. The grains effectively lock together, forming a rigid structure capable of lifting an object. Our pods are filled with coffee and sand due to rigidity and pod lifespan concerns.

Coffee vs. Sand
Coffee is volatile and reacts with latex, decreasing the lifespan of the granular jamming pods. Sand was considered as a granular material to solve this problem. From preliminary testing, concrete sand shows desirable qualities. Further testing will be performed to more thoroughly compare the two grains.

Granular Pod Manufacturing
A destructible mold was made using EVA foam shaped to the contours of an adult head and covered in oil based clay. The completed mold was then covered in multiple layers of liquid latex and allowed to cure. When the latex cured, the mold was destroyed and taken out through a large port. The granular material was placed into the pod and the large port sealed. The vacuum port was opened and a vacuum hose attached.

Testing & Results
The device was mounted onto a team member wearing a pair of goggles. A point was drawn on the goggles. The person then simulated breathing and snoring. The change in distance between the instrument tip and the goggle point was then measured.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Specifications</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement</td>
<td>&lt;20um</td>
<td></td>
</tr>
<tr>
<td>Attaches Robot</td>
<td>Binary</td>
<td>Yes</td>
</tr>
<tr>
<td>Surgical Area Kept Clear</td>
<td>Binary</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Future improvements
Acceleration data from patient movement will be gathered for more accurate force calculations.
The inclusion of an adjustable helmet may improve movement rigidity and head mount.
Utilizing existing hospital vacuum systems will remove the external pump.

Applications
• Subretinal injection of stem cells
• Retinal surgery with improved safety
• Improved corneal-transplant surgery