The Effect of Latency on Digital Vitreoretinal Surgery

David Ta Kim MD FRCSC
David R. Chow MD FRCSC

1St. Michael’s Hospital – University of Toronto
2Toronto Retina Institute
Financial Disclosures

Dr. David Ta Kim
• No financial disclosures

Dr. David R. Chow
• Alcon Laboratories, Inc.: Consultant/Advisor, Lecture Fees
  • However studies were done independently and no financial interest in this data.
• Allergan: Consultant/Advisor, Lecture Fees
• Bausch+Lomb: Lecture Fees
• Bayer Healthcare Pharmaceuticals: Consultant/Advisor
• DORC International, bv/Dutch Ophthalmic, USA: Lecture Fees
• Katalyst: Consultant/Advisor, Designer of 3D printer Customized Forceps
• Optovue: Lecture Fees, Synergetics, Inc.: Patents/Royalty
• Roche: Consultant/Advisor
Summary

• Latency found in current versions of digital vitreoretinal surgery platforms are below the thresholds found to negatively affecting performance for the majority of users
Background

- Three-dimensional heads-up display (3D HUD) surgical platforms have been and continue to be developed for a variety of surgical fields such as ophthalmology, general surgery, and urology\textsuperscript{1-3}

- Potential advantages\textsuperscript{1,4-7}
  - Ergonomics
  - Surgical teaching
  - Stereopsis
  - Lateral resolution
  - Digital manipulation of images in real time

- Potential disadvantages\textsuperscript{8,9}
  - Learning curve
  - Cost
  - Latency between what the surgeon does and what the surgeon sees

Background

• To the best of our knowledge, there have been no publications on different levels of latency in digital vitreoretinal surgery

• The effect of latency on surgery has been studied in the laparoscopy literature^{10-18}
  • Different tasks
  • Looked at latencies of 200 - 1000 ms (current 3D HUD platforms for VR are at 70 ms or even less)
Objectives

• What is the effect of latency on surgical performance using a three-dimensional heads-up display (3D HUD) visualization system for vitreoretinal surgery
Methods

• Equipment
  • 3D camera mounted on a microscope
  • 27-inch 1080p 3D monitor
  • Video latency generator connected between the camera
Methods

1. Suturing task:
   • Place a suture through plastic foam using 7-0 Prolene ass a suturing needle throw plastic foam and then to tie a surgeon’s knot.

2. Peeling task:
   • Peel off a coat of film simulating ILM in a model eye using 23G ILM forceps
Methods

• 4 levels of latency
  • 50 ms
    • Inherent level of latency of the camera-monitor system
  • 66 ms
  • 90 ms
  • 122 ms
    • Maximum added latency using the video latency generator
• The order of the level of latency was randomized and blinded to the participant
Methods

• Outcomes
  • Task completion time (objective)
  • “Usability” with a questionnaire used in a previous latency study in the laparoscopy literature\(^\text{18}\) (subjective)

## Results

<table>
<thead>
<tr>
<th>Baseline Demographics of Participants</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
</tr>
<tr>
<td>Male</td>
<td>23</td>
</tr>
<tr>
<td><strong>Background</strong></td>
<td></td>
</tr>
<tr>
<td>Vitreoretinal surgeons</td>
<td>5</td>
</tr>
<tr>
<td>Vitreoretinal surgery fellows</td>
<td>7</td>
</tr>
<tr>
<td>Ophthalmologists</td>
<td>3</td>
</tr>
<tr>
<td>Ophthalmology residents</td>
<td>11</td>
</tr>
<tr>
<td>Non-ophthalmology residents</td>
<td>4</td>
</tr>
<tr>
<td>Medical Student</td>
<td>1</td>
</tr>
<tr>
<td><strong>With VR experience</strong></td>
<td></td>
</tr>
<tr>
<td>With Heads-Up 3D Visualization</td>
<td>8</td>
</tr>
<tr>
<td>Without Heads-Up 3D Visualization</td>
<td>4</td>
</tr>
<tr>
<td><strong>Without VR experience</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
</tr>
<tr>
<td><strong>Total Participants</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
</tr>
</tbody>
</table>
Results (Task Completion Time)

For suturing, no statistical difference between completion times at 66, 90, and 122 ms of latency when compared to 50 ms.

For peeling, no statistical difference between completion times at 66, 90, and 122 ms of latency when compared to 50 ms.
Results ("Usability")

For suturing, usability at 122 ms statistically different compared to 50 ms (overall and all subgroups). No difference at 66 and 90 when compared to 50 ms.

For peeling, no statistically significant difference in usability at 66, 90, and 122 ms of latency when compared to 50 ms.
Results

• Suturing more affected by latency than peeling
  • Suturing: fast jerky movement?
  • Peeling: slow and study movement?

• Experience with a task seemed to lessen the effect of latency
  • Participants with VR training were less affected by latency than those without VR training
  • Furthermore, among those with VR training, those who were regular users of a 3D HUD were even less affected.
    • Due to being used to performing surgery with a certain level of latency?
    • Neuroadaptation?
Results

• The level of latency that adversely affects performance and usability for suturing is somewhere between 90 ms and 122 ms while for peeling is somewhere above 122 ms

• Both of these thresholds are higher than the latency seen in both the current platforms for Digital Vitreoretinal Surgery, which have approximately 70 ms of latency or less.¹⁹

Conclusion

• Latency found in current versions of digital vitreoretinal surgery platforms are below the thresholds found to negatively affecting performance for the majority of users