AR-Assisted Medical Training:

Tutorial Generation & Eye Gaze Tracking Analysis

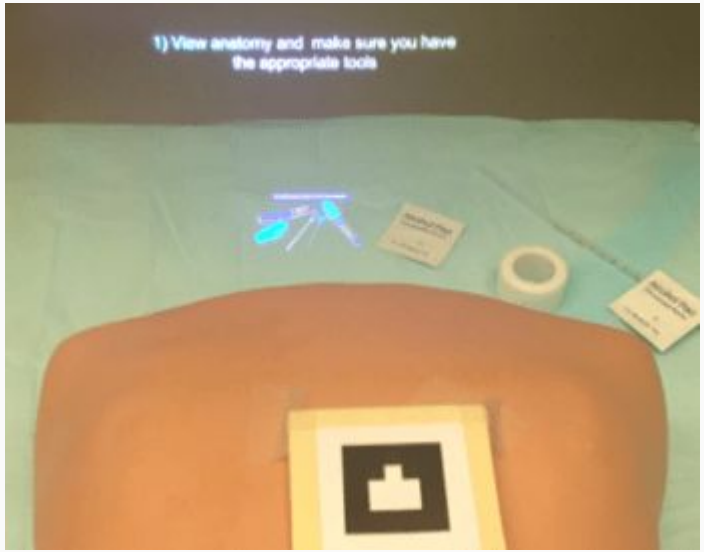
Team members: Prateek Bhatnagar and Allan Wang
Mentors: Ehsan Azimi, Chien-Ming Huang, Peter Kazanzides, and Nassir Navab

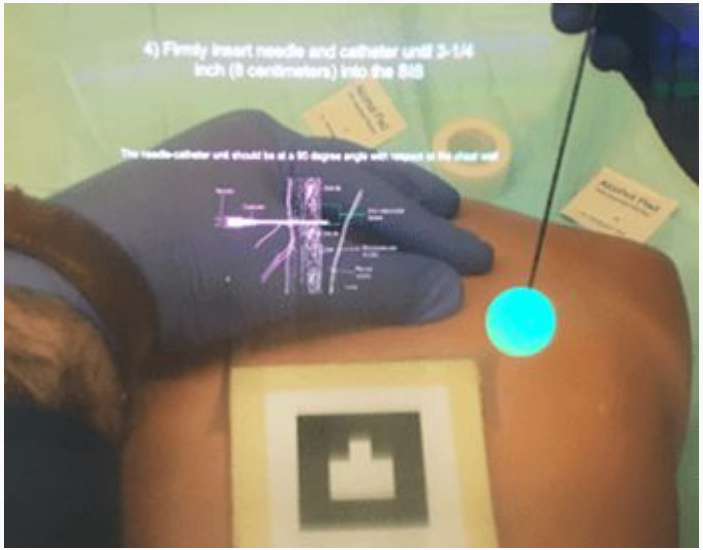
Goals

- Create a software tool to facilitate the **semi-automated creation** of medical training tutorials
  - Capture speech and visual data
  - Provide a user-friendly AR interface through which JSON training files may be generated
- Use **eye gaze tracking data** to facilitate performance analysis
  - Generate heatmap while user is being trained

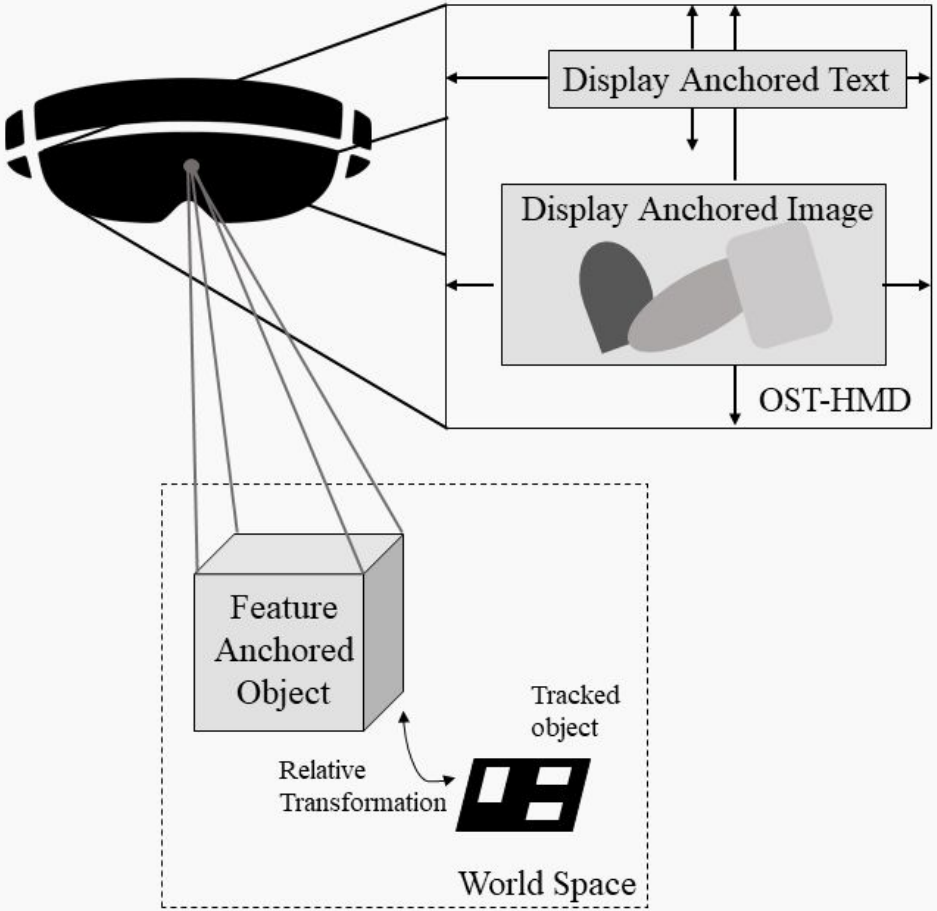
Background

- HMDs have been used for treatment, education, rehabilitation, and surgery
- The current framework stores step-by-step instructions for various procedures
- Instructions and visual aids are displayed as graphical overlays in the HMDs to the trainees



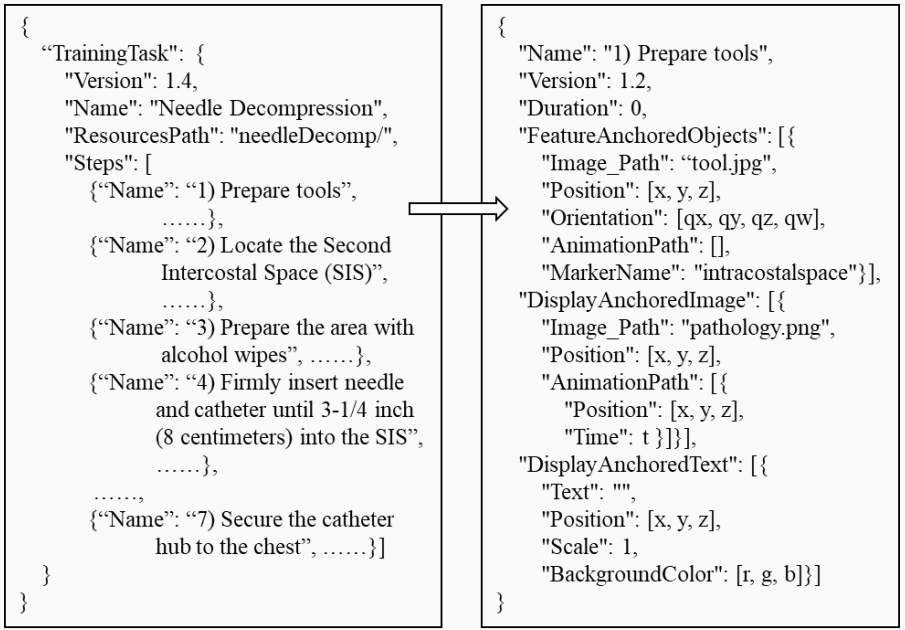


Actual User View



Virtual Overlay and Camera Image

Current state

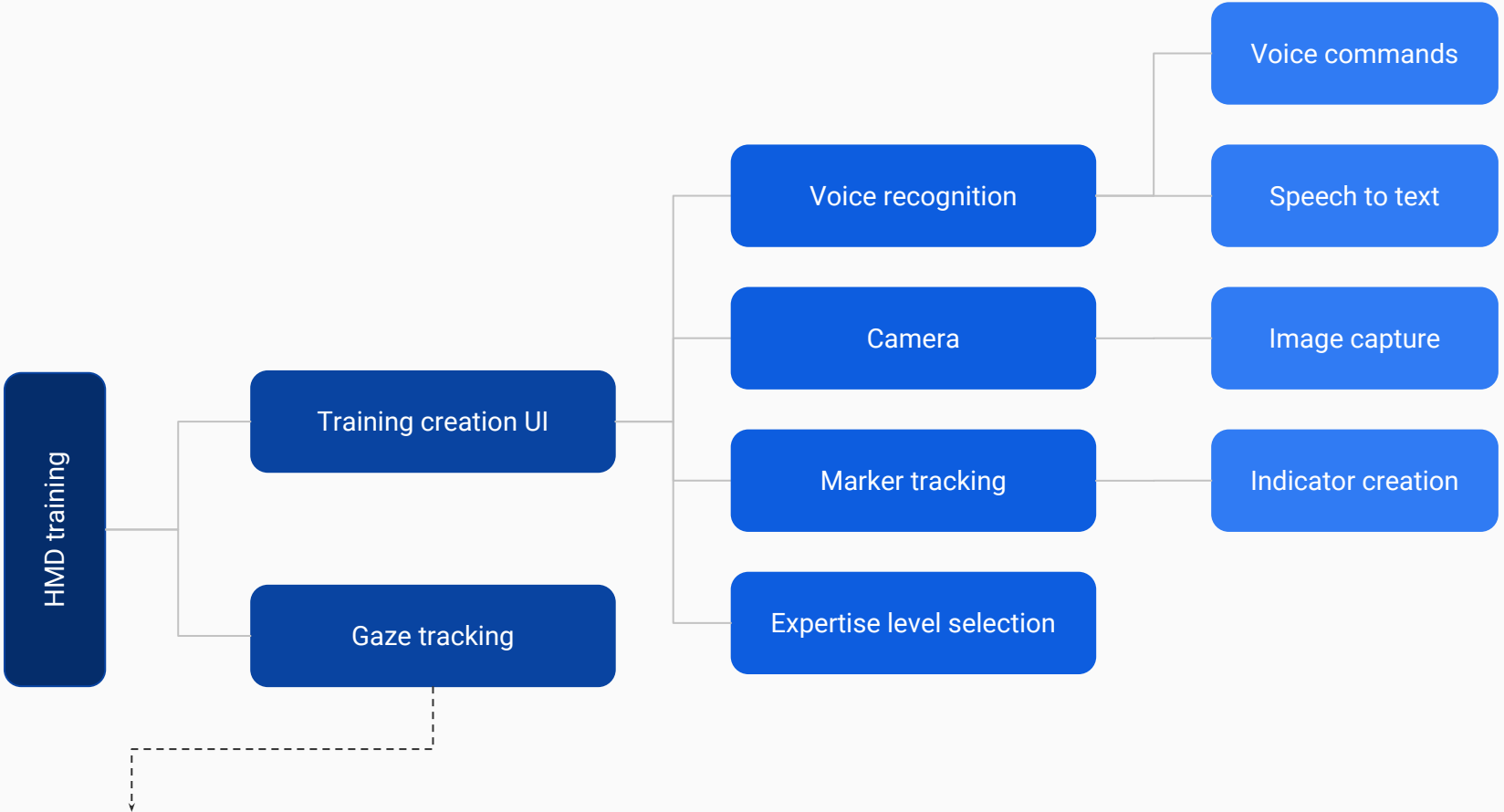


- Microsoft HoloLens
- Currently must have a medical professional manually specify steps and reference images
- JSON files are relatively difficult to create/edit
- Our project seeks to facilitate the generation of training data

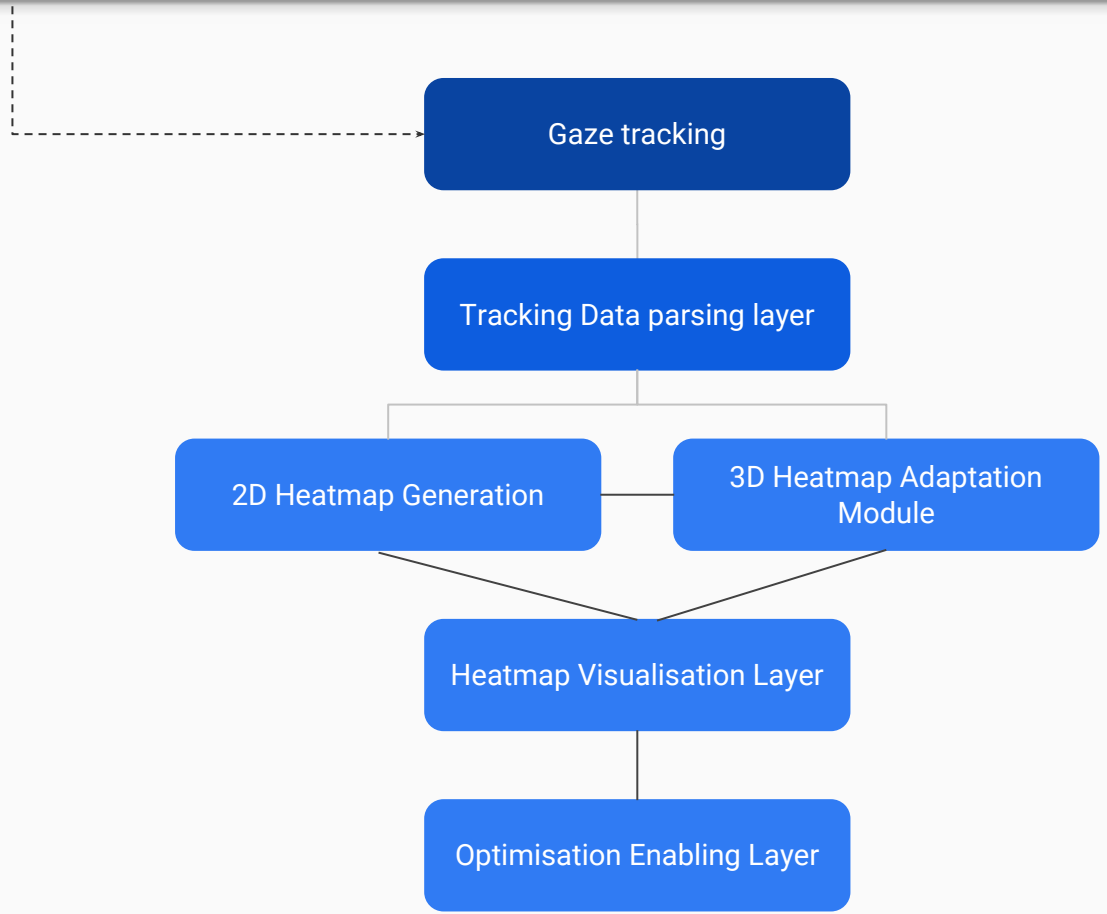
Technical Approach

- The content generation tool will be developed on **Unity**
  - Visual Studio with Windows 10 SDK
  - Vuforia (Unity extension)
- Use Pupil Labs HoloLens Binocular Add-on for gaze tracking
  - Functions/libraries are in **C/C++**
  - These are held together with **Python** (Cython)

Planned Modules



Planned Modules (continued)



Deliverables

- **Minimum**
  - Working demo of tutorial editor
    - *Speech-to-text*
    - Generation of *2D heatmap* of gaze
- **Expected**
  - Working demo of tutorial editor
    - Speech-to-text
    - *Image capture*
  - Generation of 2D and 3D heatmap of of gaze
    - Ability to view heatmap data in using a graphical aid - either within the Hololens or some interactive 3D environment
- **Maximum**
  - Working demo of tutorial editor
    - Speech-to-text
    - Image capture
    - *Marker creation*
    - *Expertise levels*
  - Using 3D and 2D gaze tracking heatmaps to optimize processes
  - Testing with ventriculostomy procedure under guidance of medical professional

Dependencies

01

Access to HoloLens and Pupil Labs HoloLens Binocular Add-on

- Submit LCSR form for Robotorium access
- Contact Dr. Huang for access to his lab
- **Complete**

02

Access to existing codebase (GitLab)

- Email Ehsan for Git invite
- **Complete**

03

Installation of toolkits and Unity SDK

- Visual Studio
- Hololens Emulator
- Unity
- Vuforia
- **Partially complete; 1 laptop**
- **Contingency - Seek mentors' aid for setup**
- **Expected resolution by - February 25**

04

Neurosurgeon to try out a demo

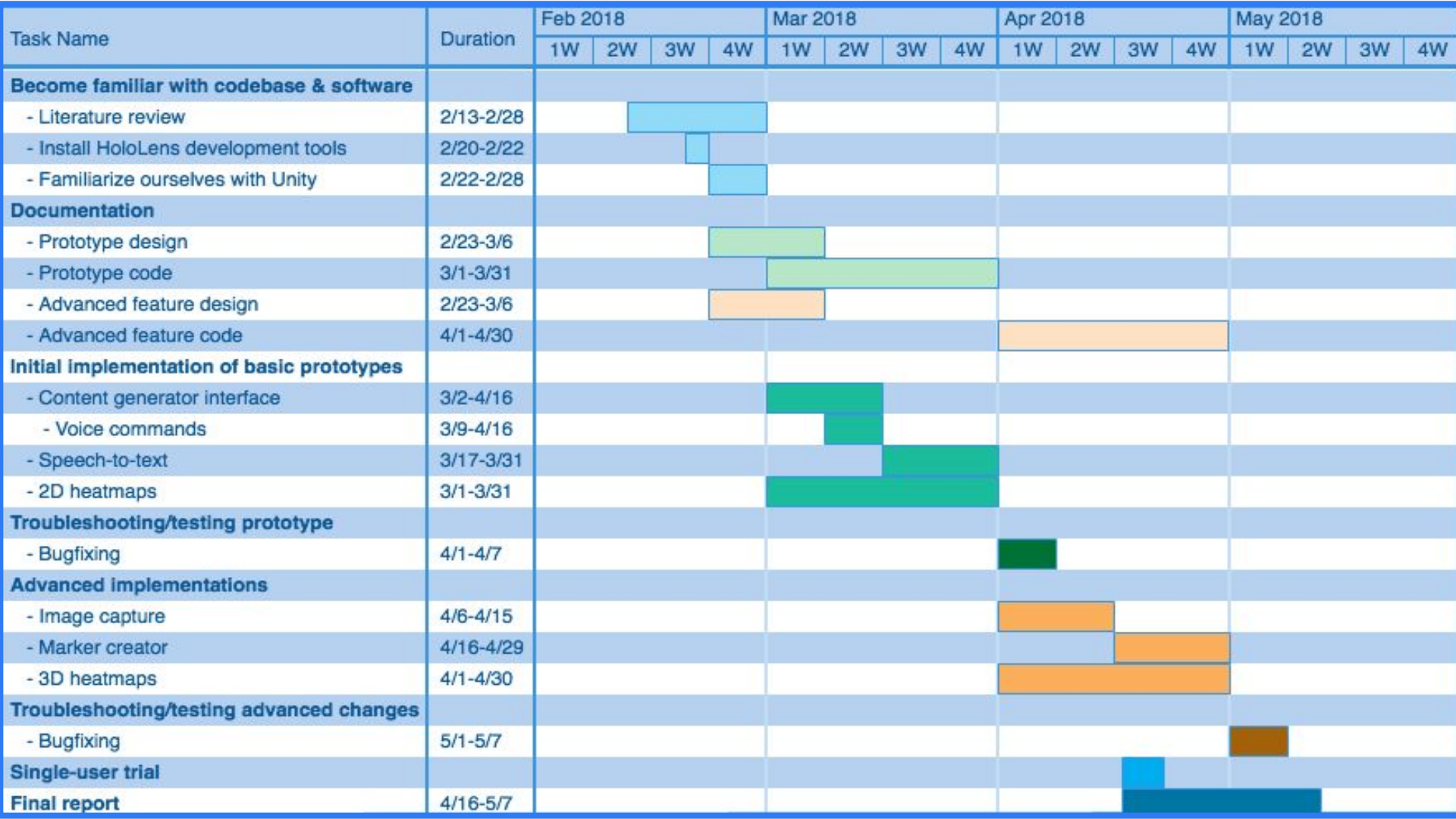
- Get contact info at next meeting with mentors - February 27
- Email/call neurosurgeon to set up date - March 1
- Have single-user trial of demo - Mid-April
  - Ventriculostomy

Management Plan

- Weekly meetings with collaborating team
  - Tuesdays after class (3pm)
  - Discuss integration
  - Review compatibility
- Biweekly meetings with mentors
  - Updates on progress
  - Conflict and dependency resolution
- Source control
  - Develop on a branch of existing codebase
  - GitLab repository

Milestones

March 18	March 31	April 15	April 28	May 6
User Interface • Able to accept voice commands • Synchronizing with video feed	**Text-to-Speech & 2D Heatmaps** • Able to generate text-based tutorials • Gaze-tracking implemented with 2D heatmaps	**Image Capture, Working Demo & Single User Trial** • Tutorials include both text and images • Have neurosurgeon create training module	**Marker Creation & 3D Heatmaps** • Implement ability to create virtual markers • 3D heatmaps added	**Final Report & Demo** • Have demo ready for live demonstration • Complete final report and presentation


Task Name
Duration
Feb 2018
Mar 2018
Apr 2018
May 2018
1W 2W 3W 4W 1W 2W 3W 4W 1W 2W 3W 4W 1W 2W 3W 4W
Become familiar with codebase & software
- Literature review 2/13-2/28
- Install HoloLens development tools 2/20-2/22
- Familiarize ourselves with Unity 2/22-2/28
Documentation
- Prototype design 2/23-3/6
- Prototype code 3/1-3/31
- Advanced feature design 2/23-3/6
- Advanced feature code 4/1-4/30
Initial implementation of basic prototypes
- Content generator interface 3/2-4/16
- Voice commands 3/9-4/16
- Speech-to-text 3/17-3/31
- 2D heatmaps 3/1-3/31
Troubleshooting/testing prototype
- Bugfixing 4/1-4/7
Advanced implementations
- Image capture 4/6-4/15
- Marker creator 4/16-4/29
- 3D heatmaps 4/1-4/30
Troubleshooting/testing advanced changes
- Bugfixing 5/1-5/7
Single-user trial
Final report 4/16-5/7

References

1. Evaluation of Optical See-Through Head-Mounted Displays in Training for Critical Care and Trauma.
2. Microsoft Mixed Reality: https://developer.microsoft.com/en-us/windows/mixed-reality/
    a. Mixed Reality Tools: https://developer.microsoft.com/en-us/windows/mixed-reality/install_the_tools
    b. Microsoft Mixed Reality Academy: https://developer.microsoft.com/en-us/windows/mixed-reality/academy
3. Pupil Labs Documentation: https://docs.pupil-labs.com/

Reading List

1. Evaluation of Optical See-Through Head-Mounted Displays in Training for Critical Care and Trauma.
2. Kato, H., & Billinghurst, M. (1999). Marker Tracking and HMD Calibration for a Video-Based Augmented Reality Conferencing System. In Proceedings of the 2Nd IEEE and ACM International Workshop on Augmented Reality (p. 85--). Washington, DC, USA: IEEE Computer Society. Retrieved from http://dl.acm.org/citation.cfm?id=857202.858134
3. Birt, J., Cowling, M., & Moore, E. (2015). Augmenting distance education skills development in paramedic science through mixed media visualisation.
4. Armstrong, D. G., Rankin, T. M., Giovinco, N. A., Mills, J. L., & Matsuoka, Y. (2014). A heads-up display for diabetic limb salvage surgery: a view through the google looking glass. Journal of Diabetes Science and Technology, 8(5), 951–6. https://doi.org/10.1177/1932296814535561
5. Tai, B. L., Rooney, D., Stephenson, F., Liao, P.-S., Sagher, O., Shih, A. J., & Savastano, L. E. (2015). Development of a 3D-printed external ventricular drain placement simulator: technical note. Journal of Neurosurgery, 123(4), 1070–6. https://doi.org/10.3171/2014.12.JNS141867
6. Atkins, M. S., Tien, G., Khan, R. S. A., Meneghetti, A., & Zheng, B. (2013). What do surgeons see: capturing and synchronizing eye gaze for surgery applications. Surgical Innovation, 20(3), 241–8. https://doi.org/10.1177/1553350612449075
7. Kersten-Oertel, M., Jannin, P., & Collins, D. L. (2012). DVV: a taxonomy for mixed reality visualization in image guided surgery. IEEE Transactions on Visualization and Computer Graphics, 18(2), 332–52. https://doi.org/10.1109/TVCG.2011.50
8. Eck, U., Stefan, P., Laga, H., Sandor, C., Fallavollita, P., & Navab, N. (2016). Exploring Visuo-Haptic Augmented Reality User Interfaces for Stereo-Tactic Neurosurgery Planning. In G. Zheng, H. Liao, P. Jannin, P. Cattin, & S.-L. Lee (Eds.), Medical Imaging and Augmented Reality (pp. 208–220). Cham: Springer International Publishing.