Intraoperative Visualization of Radioactivity: The Mixed Reality Neoprobe

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INTRODUCTION

- In cases of head and neck melanoma, surgeons seek to remove the first "sentinel" draining lymph node to check if a melanoma has metastasized.
- In current practices, surgeons inject the tumor area with a radioactive substance or dye that spreads via lymph nodes and can be detected by a handheld radiation detector, the neoprobe.
- However, the detector can only register the amount of radiation in counts per second and cannot create an image of where the radiation is coming from to find and extract the lymph node.
- **GOAL: To depict extent and location of radiation sources onto the patient using mixed reality for surgeons to better facilitate sentinel node sampling.**

METHODS

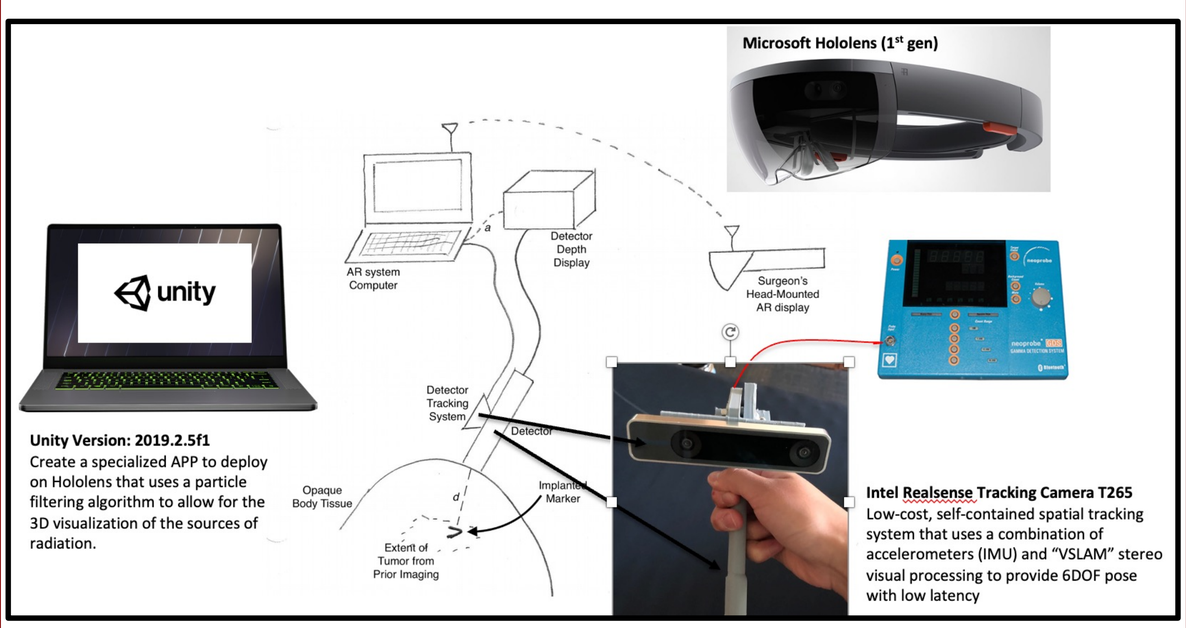

Figure 1: Displays the current project setup.

- The Intel T265 tracker will be attached to the probe detector to relay the detector's position to the AR system.
- Given the probe's location and sensitivity reading, the most probably locations where particles should exist in the particle cloud will be calculated.
- Additional probe measurements can be taken from other vantage points to filter the cloud until particles congregate at the true location of the radiation source in the body.

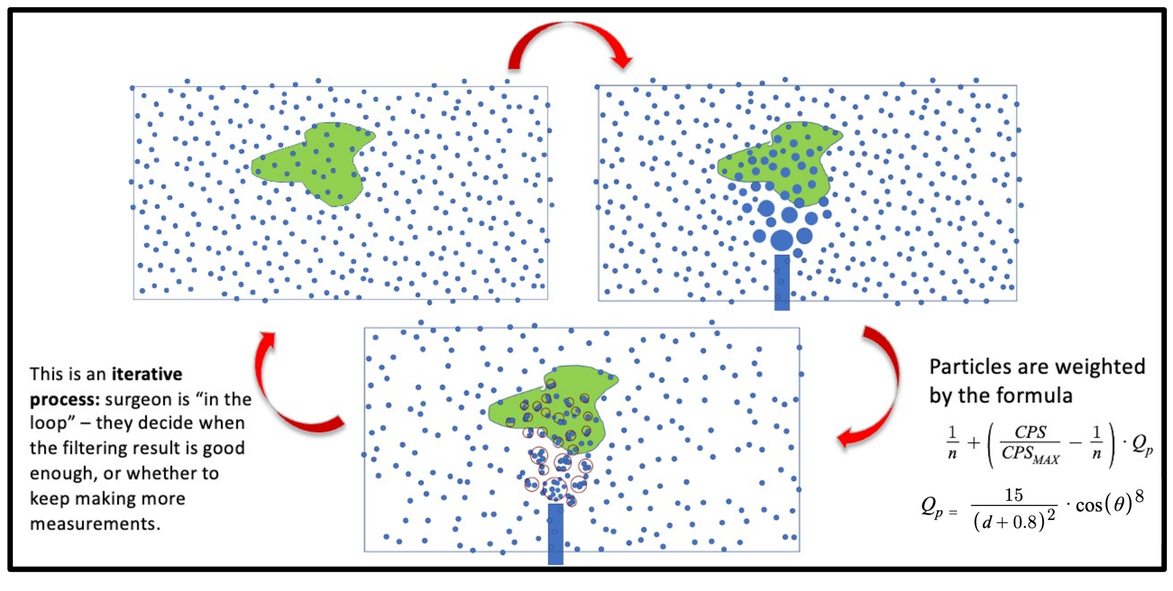

Figure 2: Displays the particle filtering algorithm to be used.

RESULTS & DISCUSSION

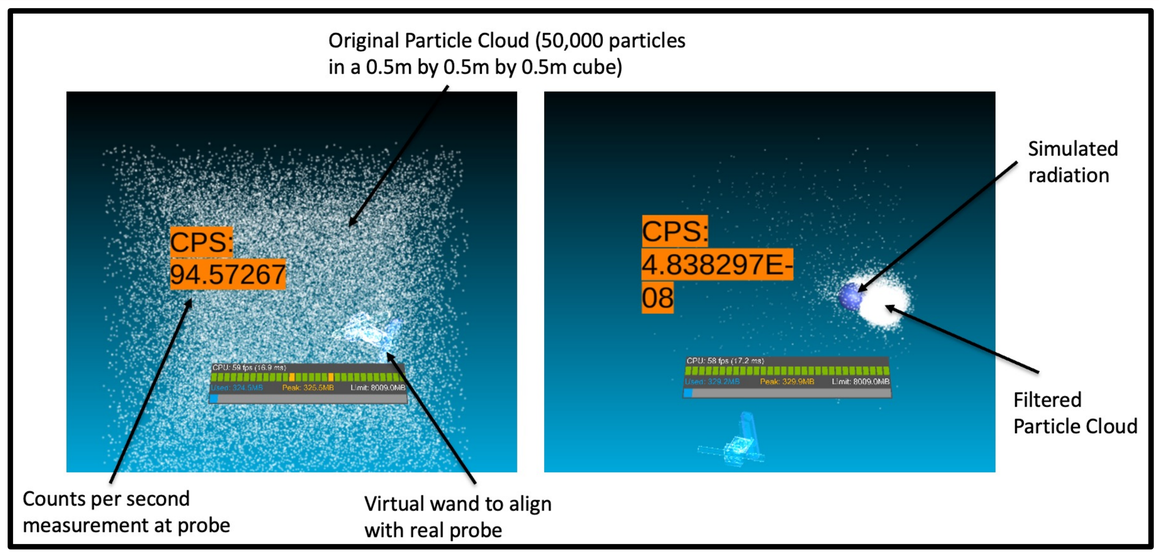

Figure 3: The Unity program aligns a real probe to a virtual wand and uses the virtual wand to filter a cloud of particles, getting as close as possible to the source of radiation.

- The processing speed for 50,000 particles in a 0.5-meter cube is around 2.5 seconds. There is room for efficiency improvement.

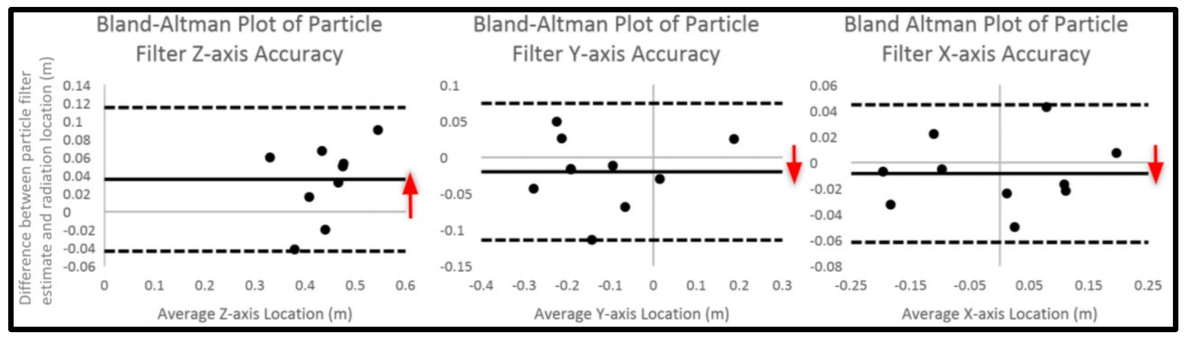

Figure 4: The Bland-Altman plots compare the location of the radiation source to the centroid of the particle cloud in the x, y, and z directions.

- All 10 data points for all axes fall within the 95% confidence interval of the lines of agreement. However, the bias of the Z axis is larger than that of the X and Y.
- The particle filtering algorithm accuracy must be improved; this can be tackled by optimizing the number of particles, the weighting function, and measurement noise parameters.
- Future simulation testing should involve multiple sources and shapes of radiation.

CONCLUSION

- The project is a working proof of concept for a heads-up display of radioactivity that persists even after a surgeon puts down their probe and picks up their scalpel and forceps.
- In this prototype, the surgeon is in control and actively refining measurements.

NEXT STEPS

- Conduct user studies and obtain feedback from expert sources.
- Experiment with other ways of tracking the probe.
- Electronically integrate the real probe's output with Unity.