# Project16

# VR Guided Surgery
# SDF based guidance and safety

Team: Hisashi Ishida, Juan Barragan Antonio

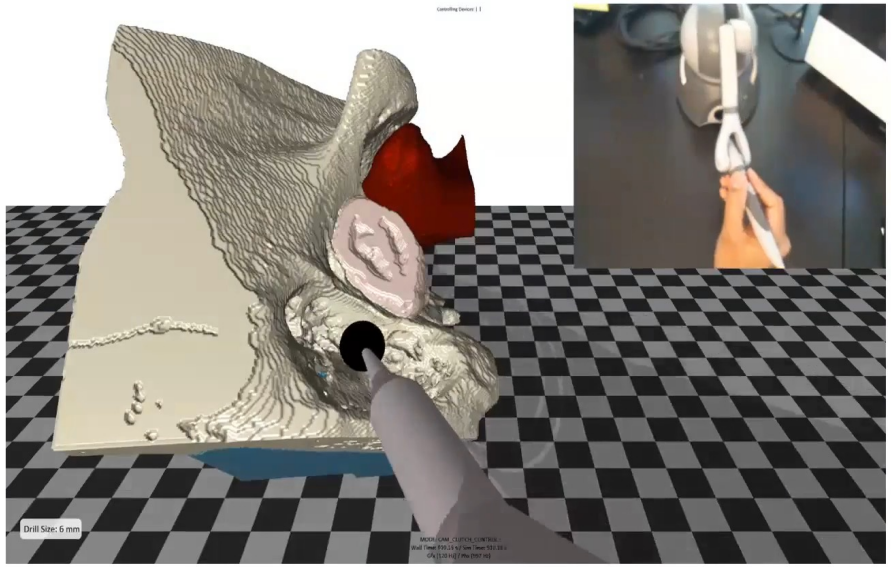
Mentors: Max Li, Adnan Munawar,
Prof. Misha Kazhdan, Prof. Russ Taylor

 600.456/496/656 CIS2 Spring 2022. Copyright R. H. Taylor

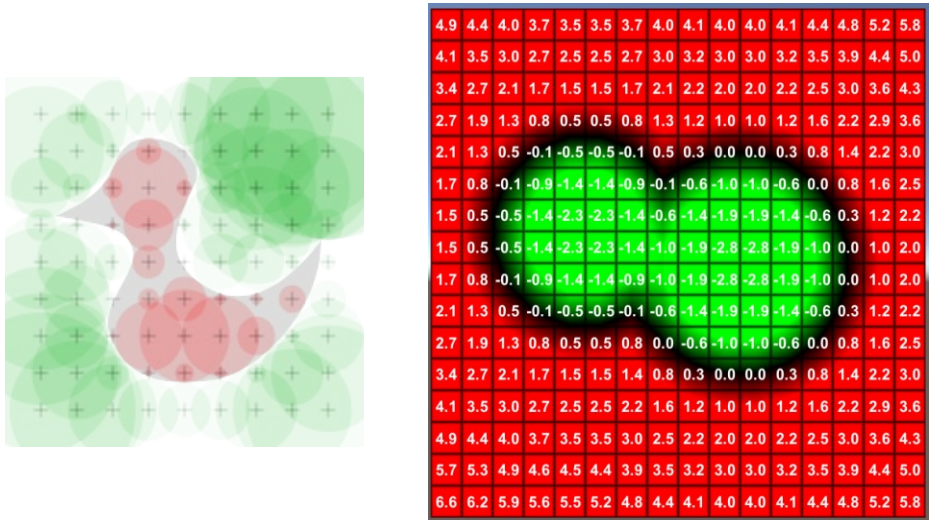


# Project Overview

**Goal: Evaluate the effectiveness of feedback modalities based on SDFs to improve situational awareness on virtual drilling**




Volumetric Drill Simulation [1]




Signed Distance Field [2]

[1] Munawar, A., Li, Z., Kunjam, P., Nagururu, N., Ding, A.S., Kazanzides, P., Looi, T., Creighton, F.X., Taylor, R.H. and Unberath, M., 2021. Virtual reality for synergistic surgical training and data generation. (https://www.youtube.com/watch?v=jnonLwxW2Cg)
[2] T. Saito and J.-I. Toriwaki, "New algorithms for euclidean distance transformation of an n-dimensional digitized picture with applications," Pattern Recognition, vol. 27, no. 11, pp. 1551–1565, Nov. 1994, doi: 10.1016/0031-3203(94)90133-3.

# Project Goals and deliverables

**Goal: Evaluate the effectiveness of feedback modalities based on SDFs to improve situational awareness on virtual drilling**

| | Deliverable |
|---|---|
| Minimum | Creating an AMBF plugin to calculate SDFs for static objects in the volumetric drilling simulation. |
| Expected | Develop SDF based feedback modalities to improve situational awareness.<br>• Developing haptic based feedback modalities.<br>• Developing visual based feedback modalities. |
| Maximum 1 | Internal user study and/or conference paper. |
| Maximum 2 | Optimizing algorithms to calculate SDFs of objects changing overtime in real-time, e.g., the drilling volume. |


600.456/496/656 CIS2 Spring 2022. Copyright R. H. Taylor

# Project phases

## 1. SDF for static volumes (Offline SDF calculation) ~Mar. ~~14~~12

a) Familiarize with methods to calculate the signed distance fields. (https://github.com/mkazhdan/EDT)
b) Integrate SDF functions with AMBF using plugins.

## 2. Use SDF to improve situational awareness of the user. ~Apr. 27

a) Provide Visual feedback.
b) Haptic Feedback.
c) Perform a user study (optional).

## 3. SDF for changing volumes (Online SDF calculation) ~May. 17

a) Optimizing algorithms to calculate SDF for volumes that change over time


600.456/496/656 CIS2 Spring 2022. Copyright R. H. Taylor

# Dependencies

| Dependency | Status | Fallback/Prevention | Needed by | Effect |
|---|---|---|---|---|
| Access to a Linux workstation | Obtained | N/A | 02/18/2022 | Delay in all milestones. |
| Access to haptic device | ~~In progress~~ Obtained | Focus only on visual feedback mechanisms. | 03/23/2022 | Delay in haptic feedback development. |
| IRB approval | In progress | N/A | 03/31/2022 | Delay in internal user study. |
| VR device | Obtained | Using 2D screen | 03/31/2022 | Delay in internal user study. |

# Project phases

## 1. SDF for static volumes (Offline SDF calculation) ~Mar. 14

a) Familiarize with methods to calculate the Euclidean Distance Transform. (https://github.com/mkazhdan/EDT)
b) Integrate SDF functions with AMBF using plugins.

## 2. Use SDF to improve situational awareness of the user. ~Apr. 27

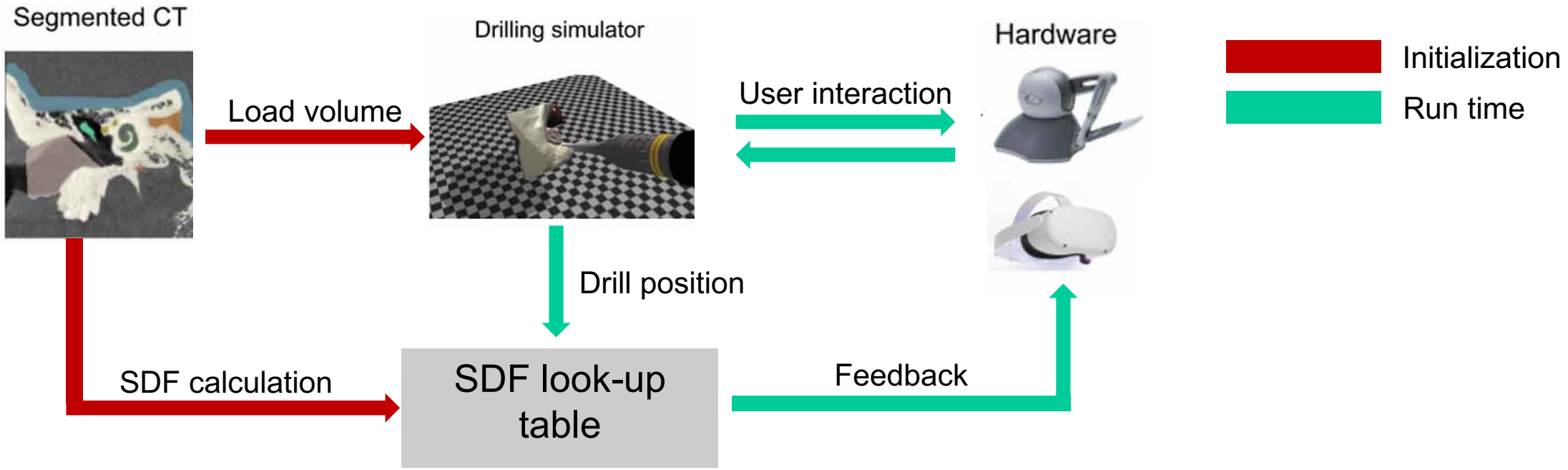
a) Provide Visual feedback.
b) Haptic Feedback.
c) Perform a user study (optional).

## 3. SDF for changing volumes (Online SDF calculation) ~May. 17

a) Optimizing algorithms to calculate SDF for volumes that change over time

# Technical overview

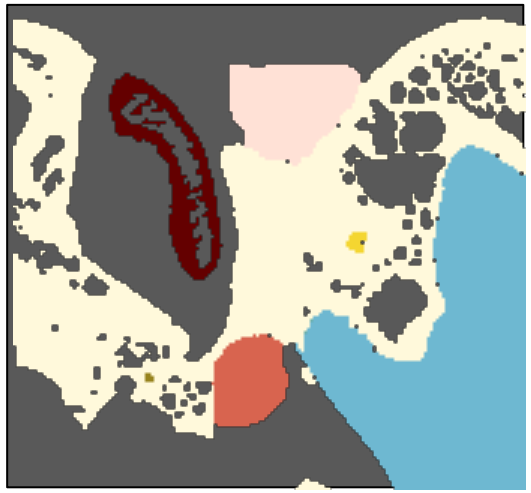
- Phase 1: SDF calculation for static objects & software integration architecture.




- SDF calculation for volumes represented by a voxel grid based on [Saito and Toriwaki, 1994][2].
- SDF functions will be loaded as a shared library to AMBF.

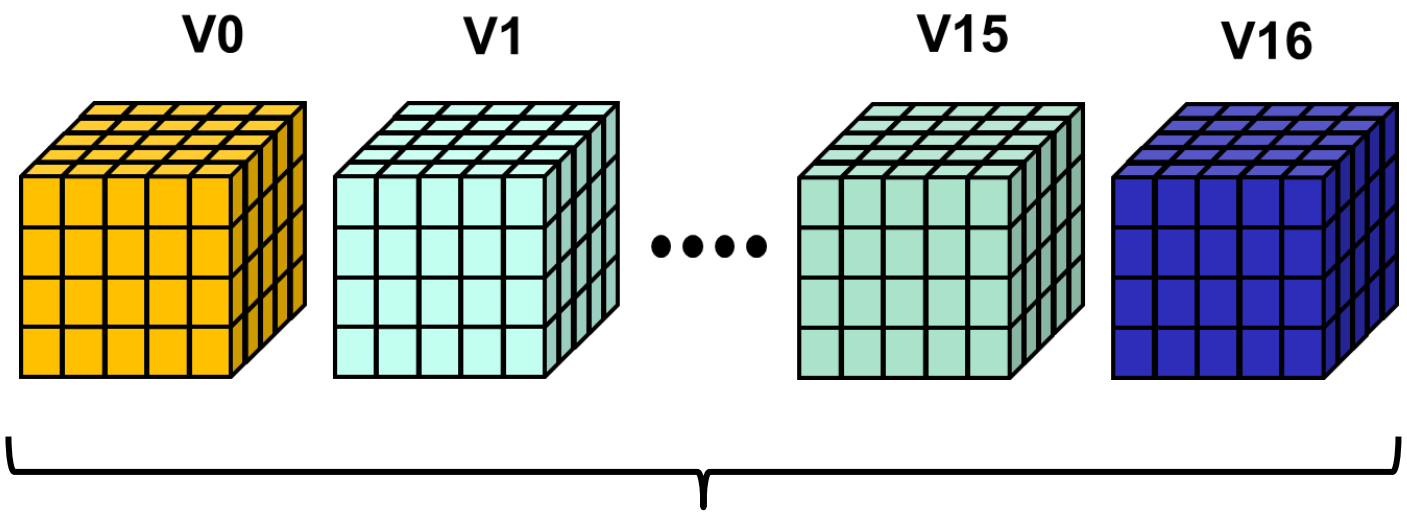
# Technical overview: Offline calculation of SDF

Anatomy representation



SDF module

SDF maps for each anatomical structure.

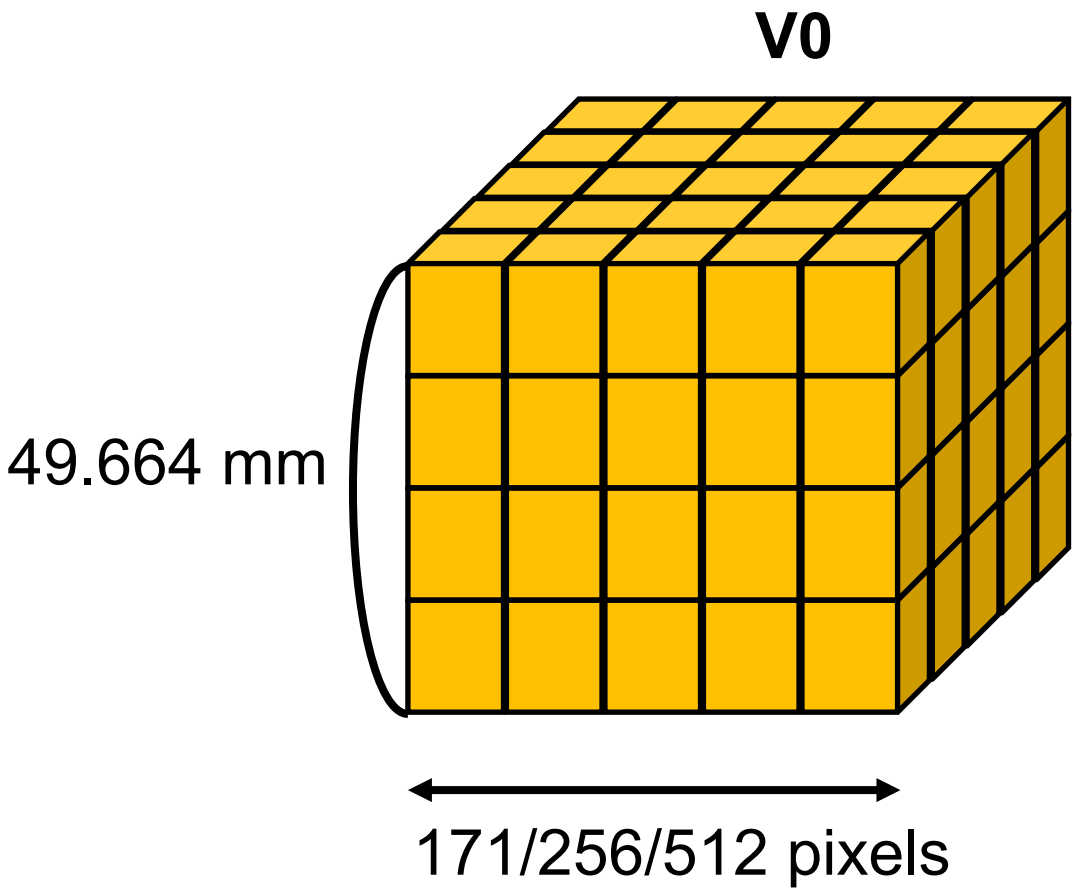



Design parameters
- 16 different anatomical structures
- SDF Resolution 171/256/512
- Size SDF cube: 49.664 mm^3
- Zero-padding: 0

# Technical overview: Offline calculation of SDF

**Design parameters**

- SDF Resolution 171/256/512
- Size SDF cube: 49.664 mm
- Zero-padding: 0

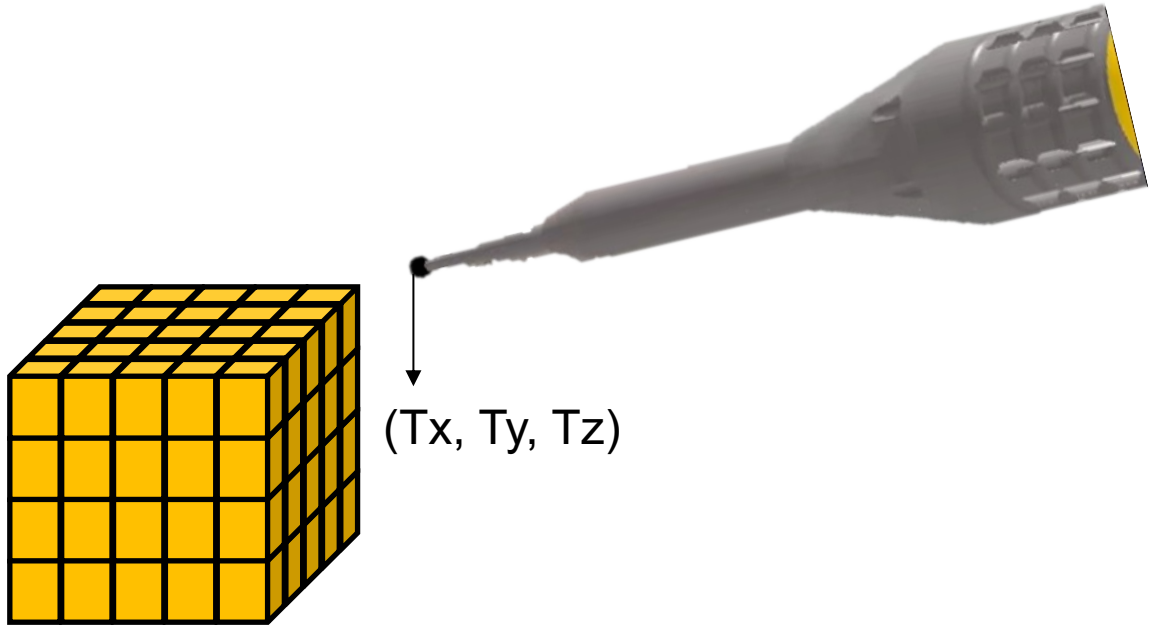




600.456/496/656 CIS2 Spring 2022. Copyright R. H. Taylor

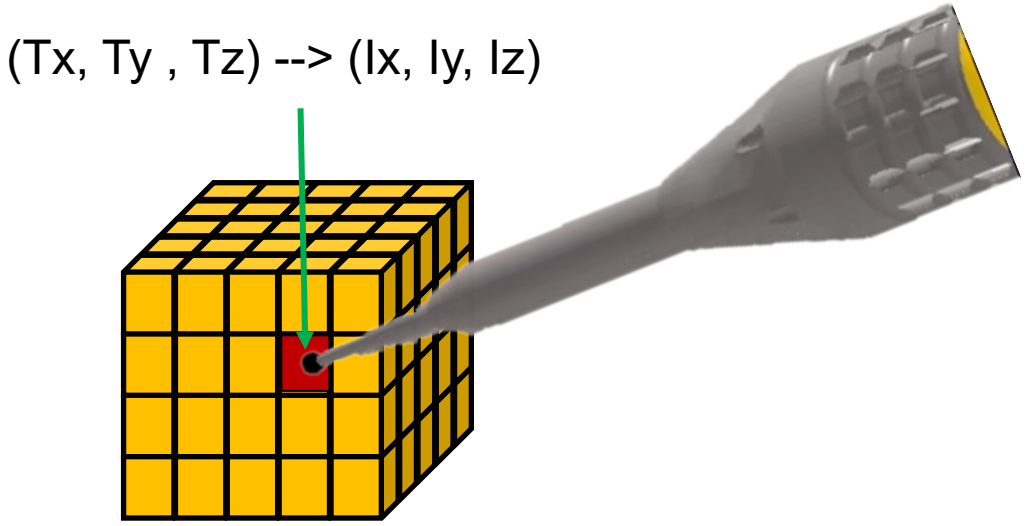
# Technical overview: Using SDF at runtime.

## Outside the SDF grid




- No distance information when drill tooltip is outside of SDF grid.

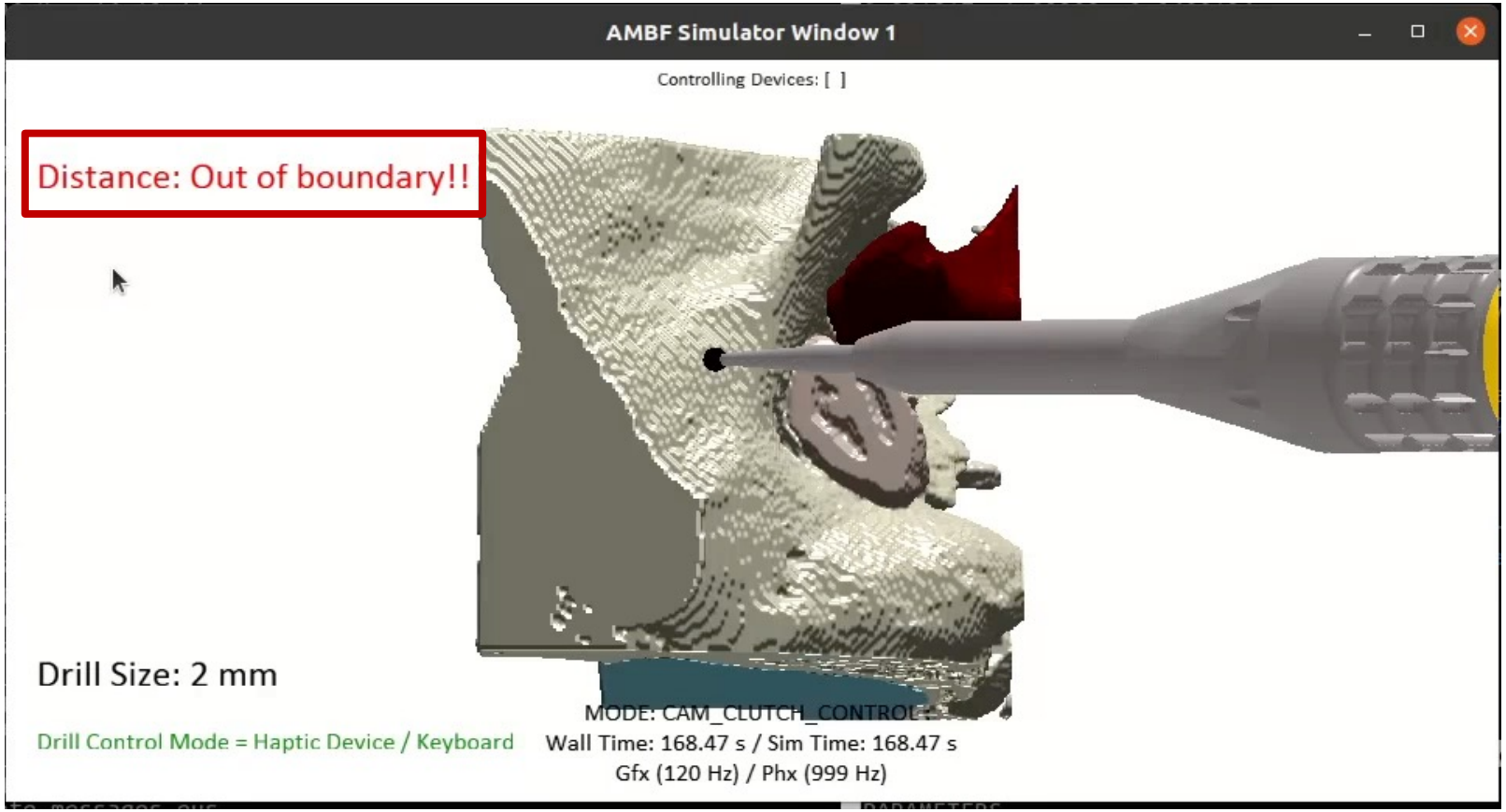
## Inside the SDF grid




- When inside the grid a conversion between tooltip coordinates and voxel grid index is needed to access the distance data.

# Current Progress

- Provide distance between Tool tip and the critical structure(blue)
  - SDF resolution: 171
  - Controlled using keyboard



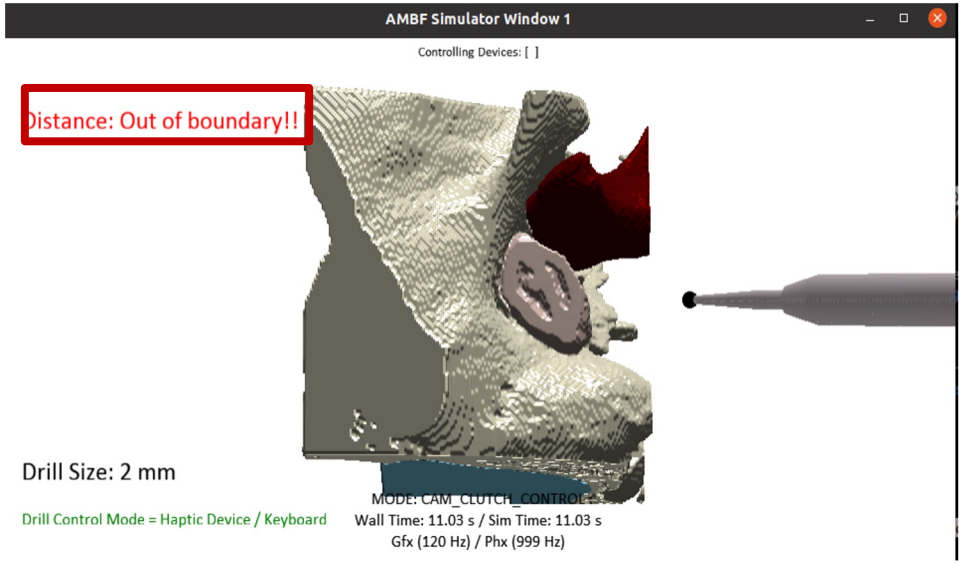


600.456/496/656 CIS2 Spring 2022. Copyright R. H. Taylor

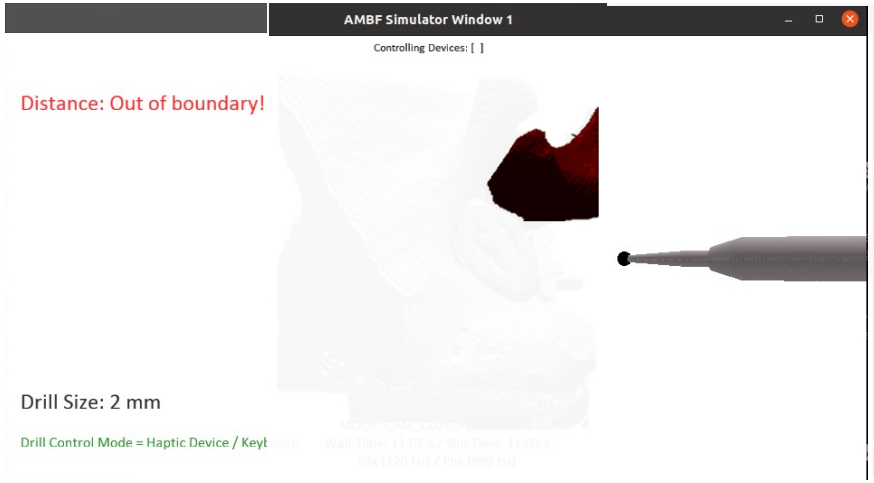
# Current problems

- Limited SDF workspace
  - Expand the size of volume(zero-padding)
  - Find the appropriate SDF resolution

  **Important parameters for Online SDF calculation(Phase3)**




- Effective visual feedback
  - Toggle the opacity of the bone and highlight the critical structure





600.456/496/656 CIS2 Spring 2022. Copyright R. H. Taylor

# Next steps

## 1. SDF for static volumes (Offline SDF calculation) ~Mar. 14

a) Familiarize with methods to calculate the Euclidean Distance Transform. (https://github.com/mkazhdan/EDT)
b) Integrate SDF functions with AMBF using plugins.

## 2. Use SDF to improve situational awareness of the user. ~Apr. 27

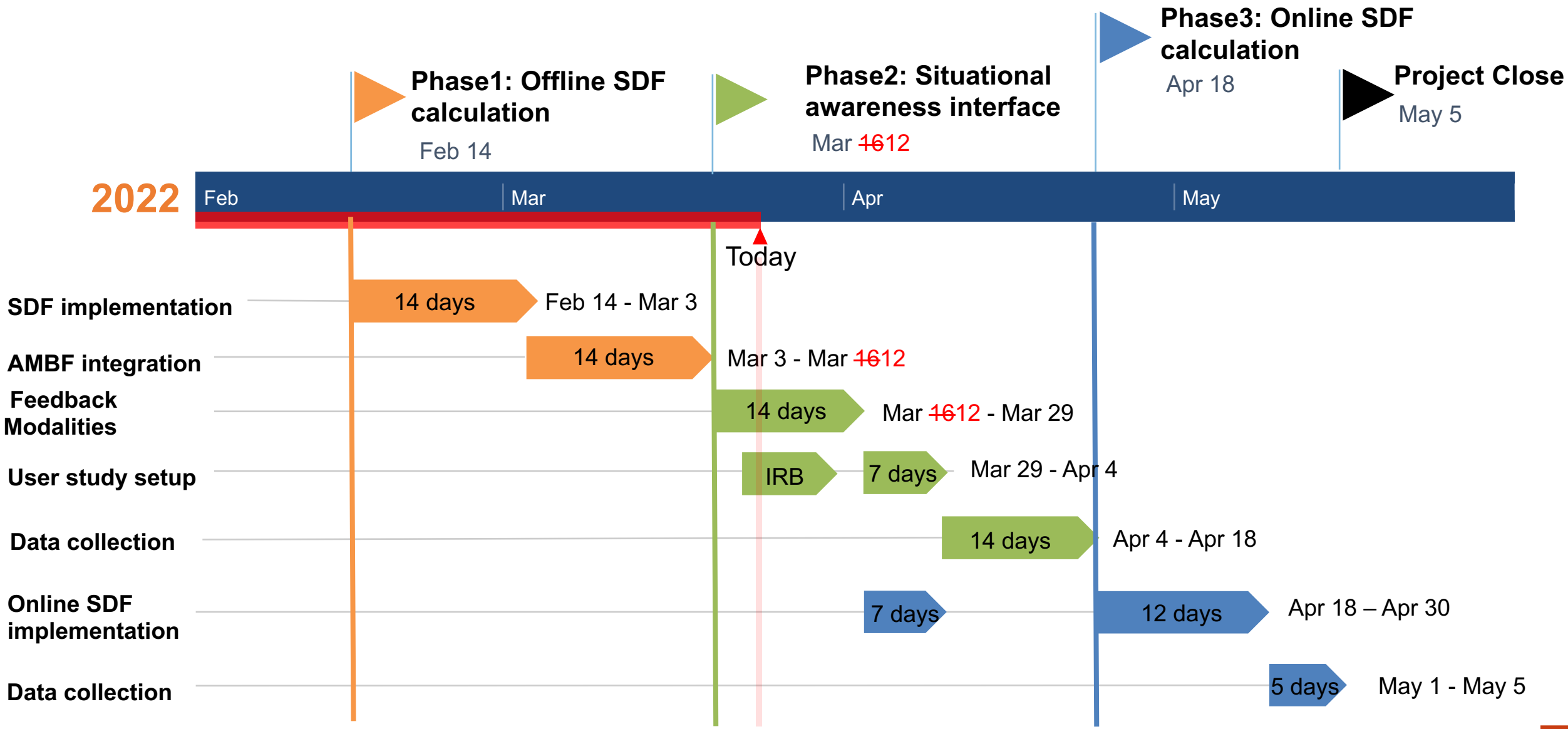
a) Provide Visual feedback.
b) Haptic Feedback.
c) Perform a user study (optional).

## 3. SDF for changing volumes (Online SDF calculation) ~May. 17

a) Optimizing algorithms to calculate SDF for volumes that change over time

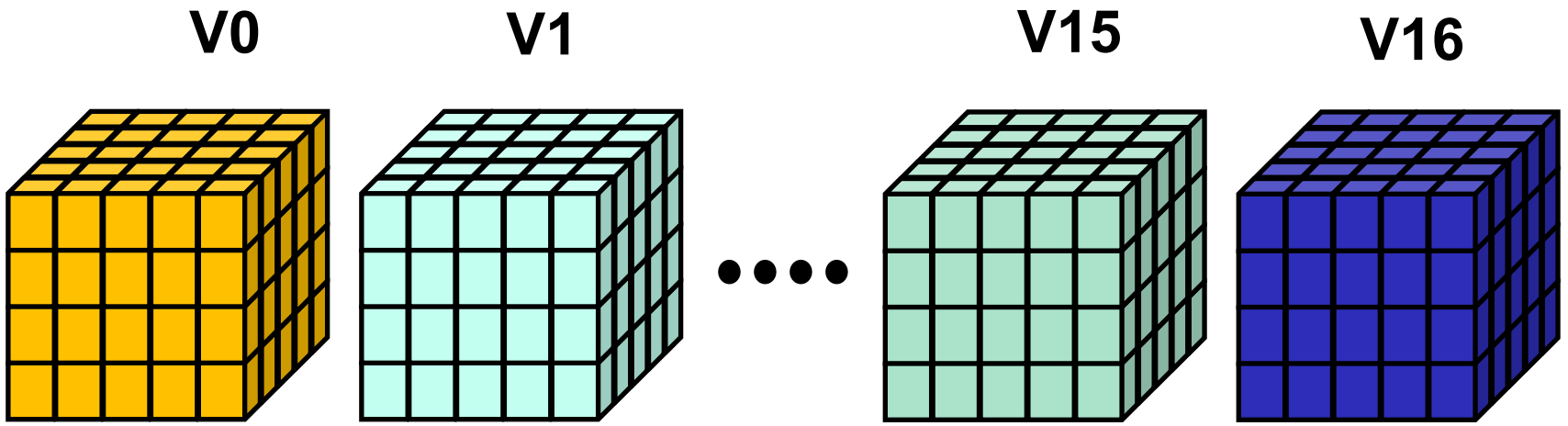

600.456/496/656 CIS2 Spring 2022. Copyright R. H. Taylor

# Updated Gantt chart





600.456/496/656 CIS2 Spring 2022. Copyright R. H. Taylor





600.456/496/656 CIS2 Spring 2022. Copyright R. H. Taylor