

Point Cloud Alignment through Mid-Air Gestures on a Stereoscopic Display

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Motivation & Basic Idea

- ▶ 2D desktop applications for manual 3D point cloud registration suffer from impaired depth perception and inconvenient interaction

- ▶ We propose a user-centered alternative to desktop applications for manual point cloud registration

An setup consisting of a **stereoscopic display** and an **external hand tracker**

Interaction techniques for point cloud alignment in 3D space, including visual feedback during alignment

A proof-of-concept prototype in a **surgical use case**

- ▶ This allows for enhanced depth perception and natural interaction without the need for body worn devices or handheld controllers
- ▶ Use case benefits from the sterility and intuitiveness of mid-air gesture interaction in 3D space

System & Interaction Design

Our design space includes three essential aspects for manual 3D point cloud alignment:

- ▶ **3D Model Transformation, Alignment Guidance, and 3D Navigation**

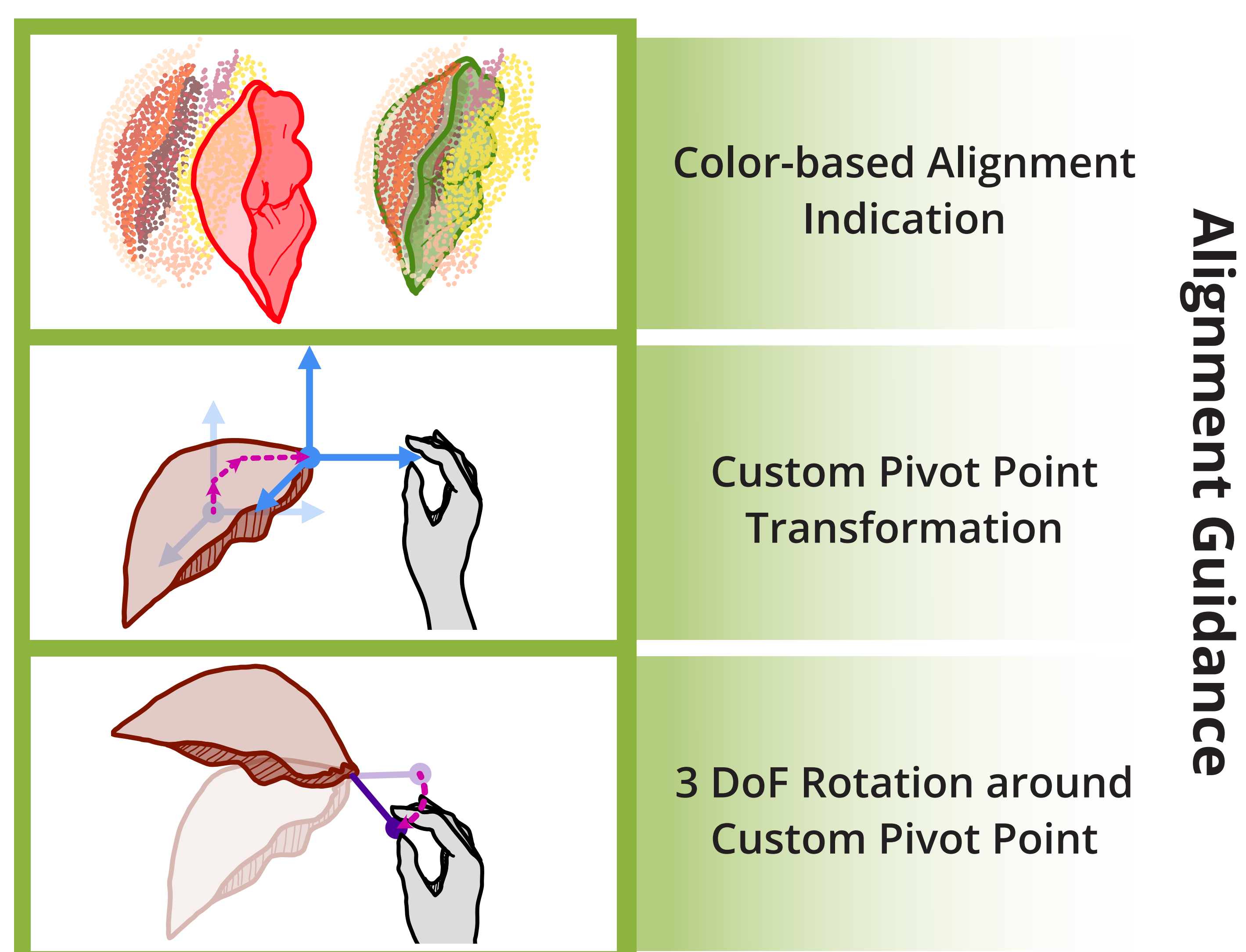
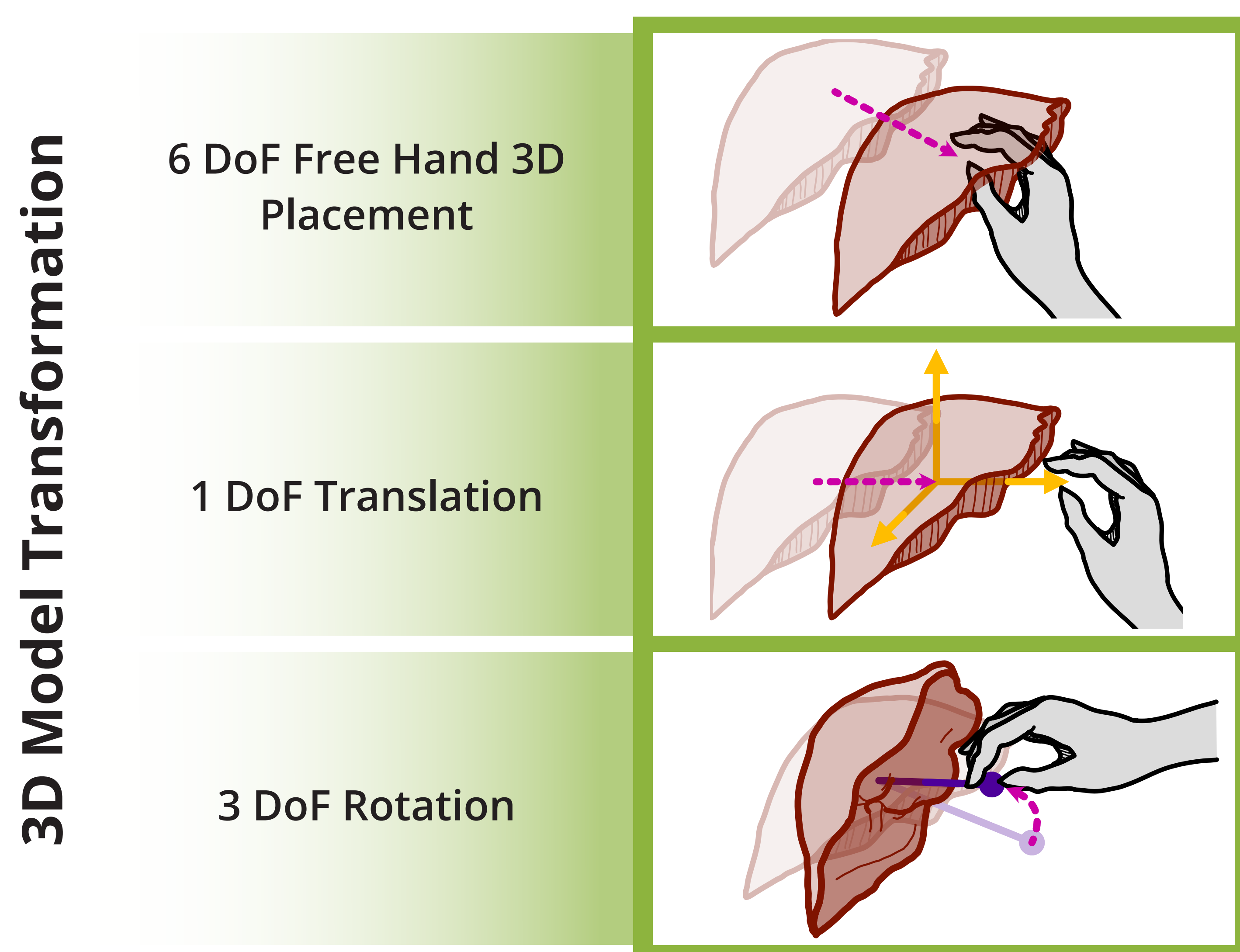


Fig. 1: A user interacting with our proposed system. It consists of a stereoscopic display and a hand tracking device.

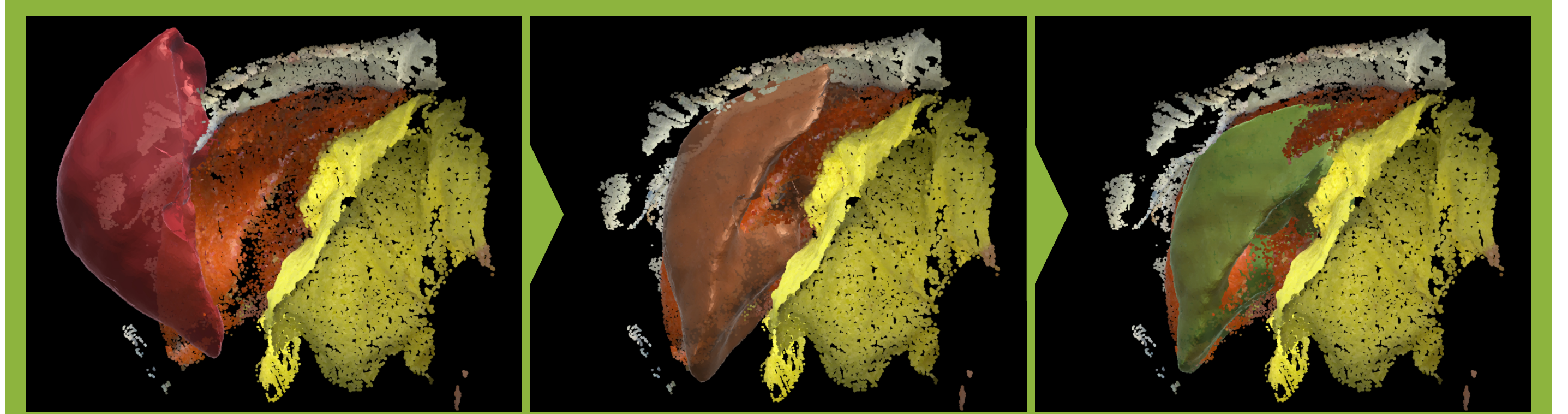
Fig. 2: A close-up of the same system. A liver model, a point cloud, the tracked hand of the user, and transformation widgets are visible.



Prototype & Implementation

- ▶ Created in Unity 3D Engine, runs on a LookingGlass display with a Leap Motion Controller (see Fig. 1)
- ▶ Preoperative liver point cloud model by OpenCAS
- ▶ Intraoperative environment point cloud created by scanning a human body phantom with a stereo laparoscope using ORB-SLAM2 and a custom point cloud fusion module
- ▶ Color-based alignment guidance (see Fig. 3) through a simulated point to-plane evaluation ICP with Unity built-in methods, allowing for 60 fps

Fig. 3: Our color-based alignment guidance feature, which changes the color of the liver model over a gradient between red (left) and green (right).



Future Work & Outlook

Our current design and prototype are a first exploration into alternative interfaces for natural and intuitive manual point cloud alignment.

Possible improvements:

- ▶ Alternative and additional guidance features, e.g., colored point cloud, or indications for transformation to lead to better alignment
- ▶ Alternative mode switches, e.g., all interaction with one hand, or using the non-dominant hand to change modes
- ▶ Additional use cases

Evaluation possibilities:

- ▶ Comparison study with an already existing desktop based system
- ▶ Component analysis study to figure out which components (i.e., stereoscopic display, hand gestures) can improve performance and user experience