HOLOBONE: VIRTUAL BONE CUT ALIGNMENT

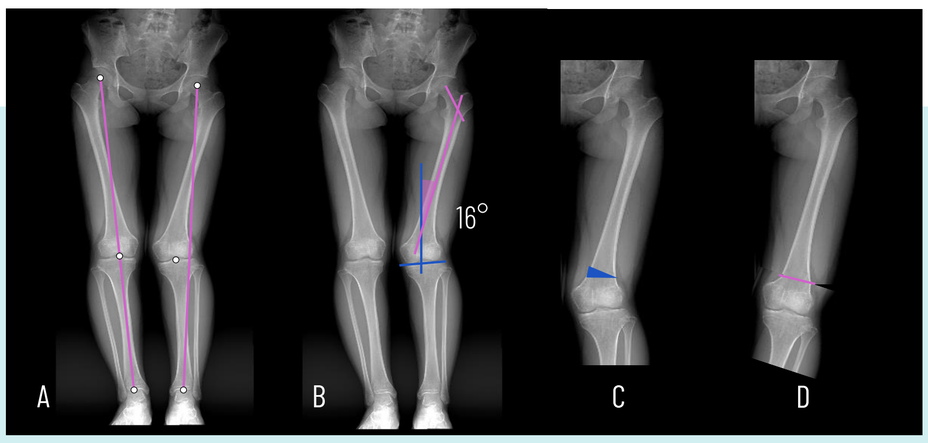
Daniel Woortman, Mikkeline Elleby, Philipp Gerstner, Saatusan Sabesan
Supervisors: Matthias Rüger, Javier Narbona Cárceles

1 INTRODUCTION

Bone surgery techniques require precise measurements and cuts (osteotomies) on the patient's bone. During a pre-planning step, surgeons draw planes and angles on top of the bone (e.g. from X-rays), to determine the location and orientation of a deformation. From this, the positions and angles of one or more cuts are determined. Then the cut parameters are enforced during the operation with calipers, goniometers, and wires through the bone. These century old techniques have the following disadvantages:

- lack in precision
- are uncomfortable
- need many X-ray checks resulting in a lot of radiation exposure

Mixed Reality presents an opportunity to revolutionize this process. Our goal is to facilitate and increase precision for bone surgery techniques with a MR app, while minimizing X-ray checks.

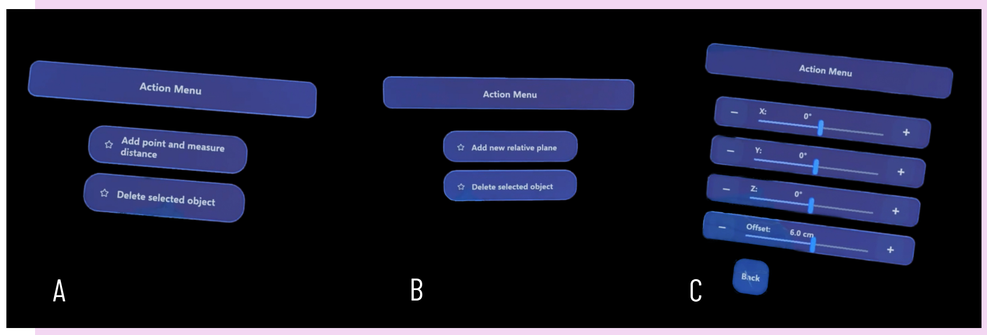


Example: Hip femoral valgus osteotomy. (A) shows a patient with a left inward-bent knee (valgus) because the dots don't align. The malalignment is in the femur, with the correction angle determined (B). With this, the blue wedge in (C) will be cut out. The realigned bone is shown in (D).

3 OUR APP

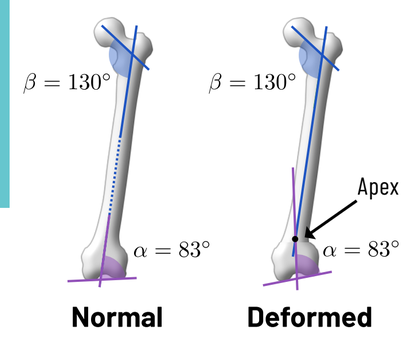
Our app is built for the Hololens 2 Device. Its features include:

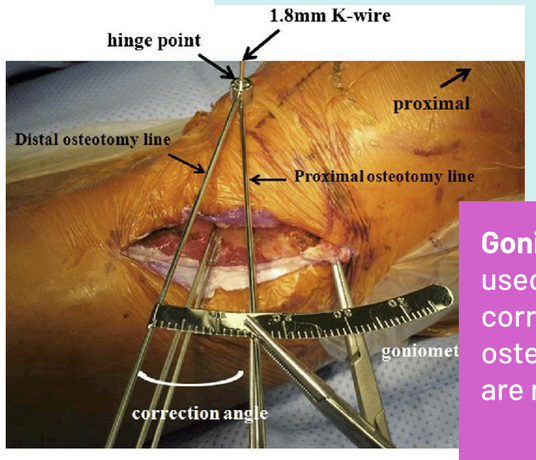
- Adding overlays: points and planes
- Measuring or displaying distance between points
- Rotating a child plane in reference to its parent plane
- Precise controls for rotation/offset adjustment
- Anchoring the overlays to the bone through an attached qr code



Menus. When selecting an object, these options pop up. (A) when selecting a point, we can add another point and measure the distance between them. (B) when selecting a plane, we can add a relative plane to it. (C) Selecting a relative plane allows precise positioning controls, with angle and offset relative to the parent plane.

A femur bone. Predefined bone angles α, β and positions are placed on the bone. If the lines are parallel and meet, the bone is normal. If they meet at a point called the apex, the bone is deformed. The deformation angle is the angle of the 2 lines.

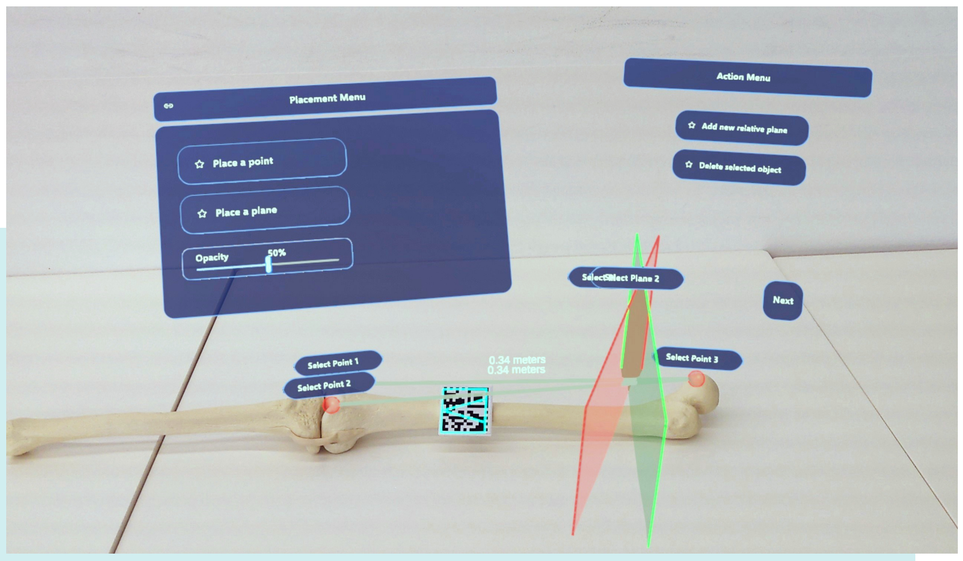




Goniometer in action. A goniometer is used during a procedure to define the correction angle along with the osteonomy cut lines. Inserted wires are needed, seen at the top.

2 PROPOSED METHOD

The idea is to provide surgeons with a mixed reality app used to overlay virtual calibrating elements on top of the patient's bone. This can then be used when performing the operation, ideally eliminating the need for measurement tools and wires.



App in Action. This screenshot shows the full capabilities of our app, with the placement and action menus, qr code tracking, points, planes, and distance measurement.

4 CONCLUSION & FUTURE

Our app represents a first prototype to guide the surgeon during bone surgeries. In the future, the following could further improve the system:

- Surgical tools: by applying trackers on them, the app could tell the distance and orientation of the tool to a virtual line or plane.
- The ability to share the overlaid information between several surgeons or assistants to improve collaboration
- Improve the accuracy of the tracking system

Bone and surgery images kindly provided by Javier Narbona Cárceles.
Lukas Jud, Javad Fotouhi, Octavian Andronic, Alexander Aichmair, Greg Osgood, Nassir Navab, and Mazda Farshad. Applicability of augmented reality in orthopedic surgery–a systematic review. BMC musculoskeletal disorders, 21:1–13, 2020.
Microsoft. Microsoft hololens. https://www.microsoft.com/en-us/hololens/.