



Real-time Needle Steering in Response to Rolling Vein Deformation by a 9-DOF Image-Guided Autonomous Venipuncture Robot

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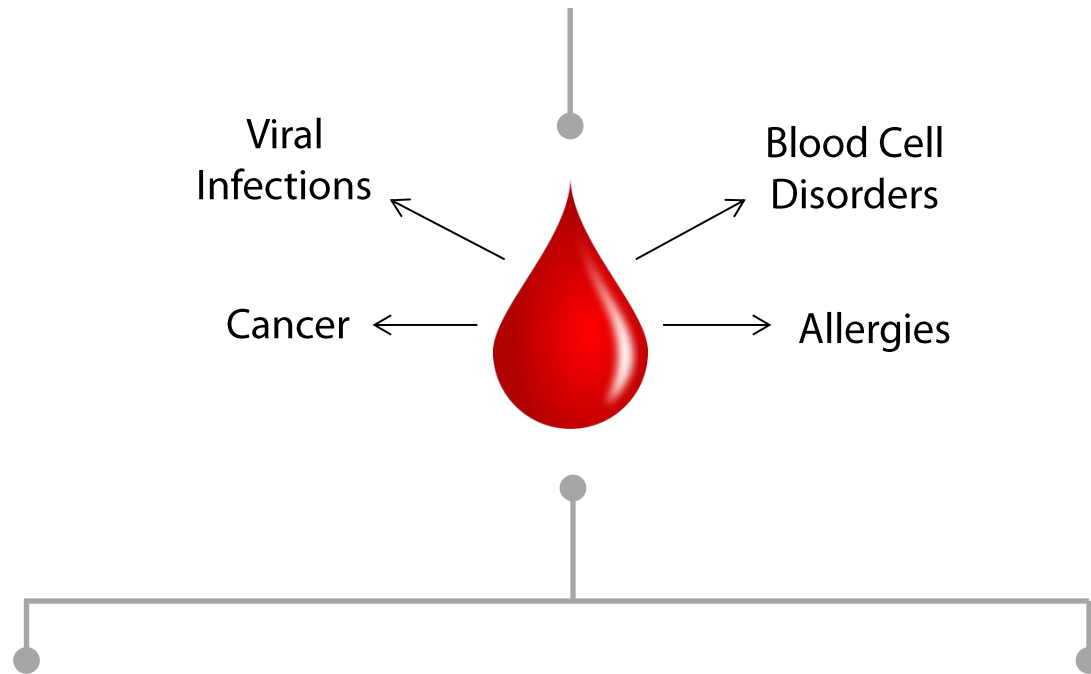


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Venipuncture | Cornerstone of Modern Medicine

Most common medical routine performed in the world

9/10 patients admitted to the hospital require venipuncture^[1,2]



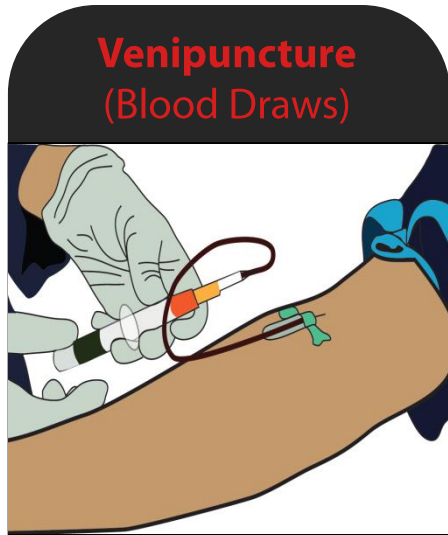
#1 Cause of Patient Injury^[3]

- 1B failed sticks per year

#1 Cause of Clinician Injury^[4]

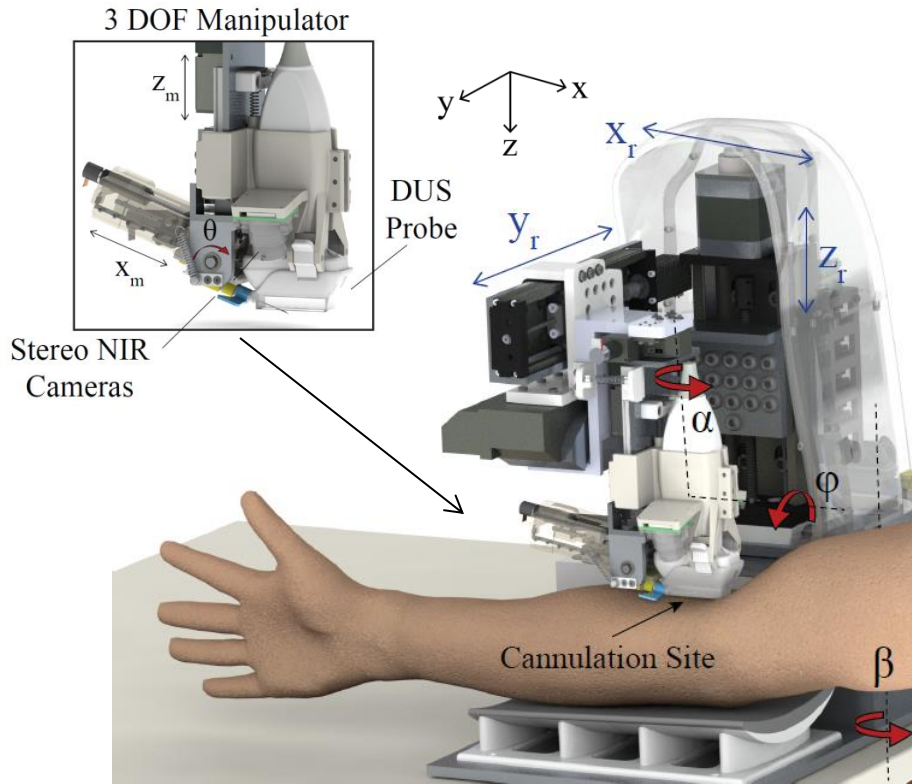
- 1M sharps injuries per year

Medical Robots | Diagnostic Testing Integration



Venipuncture Robot | The VenousPro™

A portable, image-guided medical robot that improves the quality, safety, and cost-effectiveness of venous access in a fully automated fashion



Graphical User Interface | Clinical Protocol

This venipuncture is for
Sam's check-up.

Two samples will be drawn
for Hct and WBC.

Prep for procedure

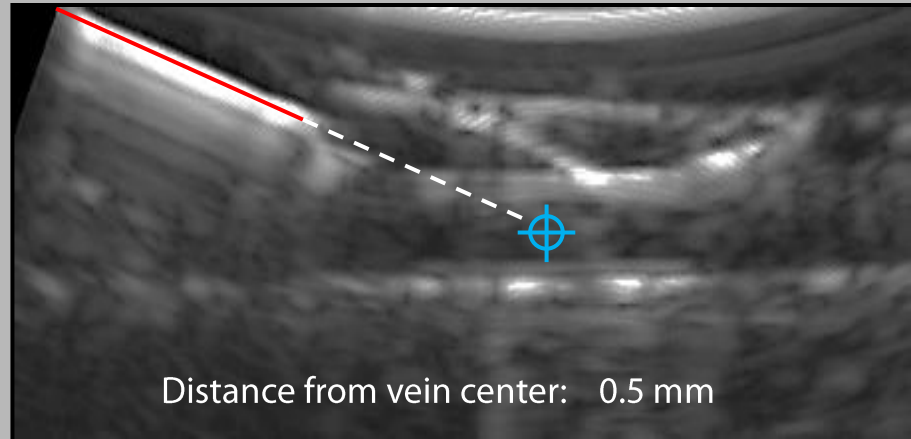
Scan and select vein

Confirm with Doppler

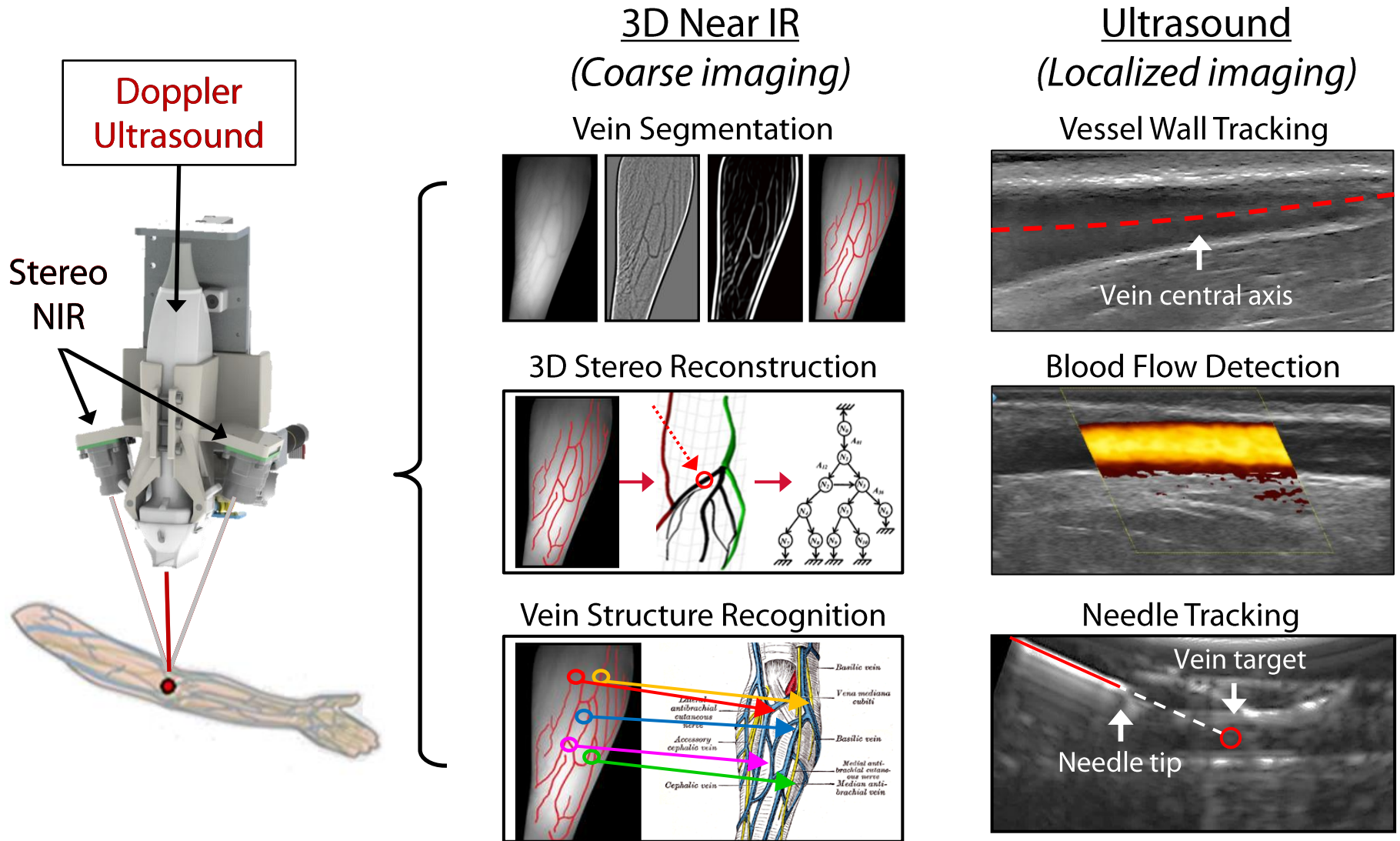
Place cannula

Collect samples

Track needle tip in ultrasound image:

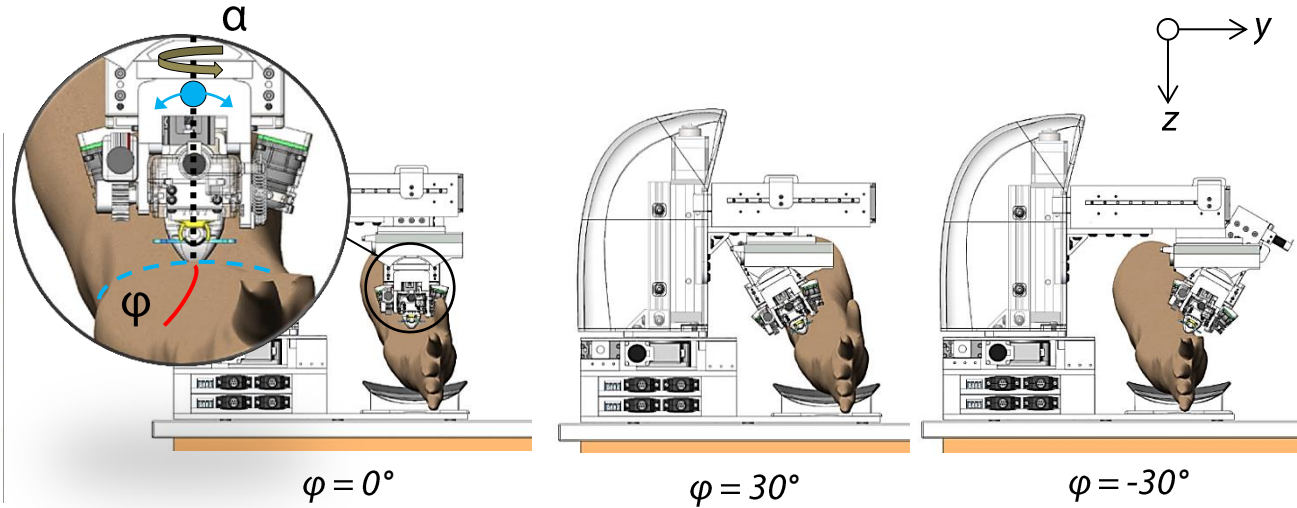
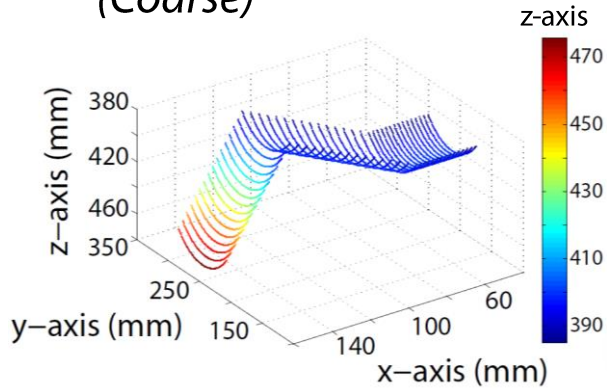


Bimodal Imaging | Near-infrared & Ultrasound

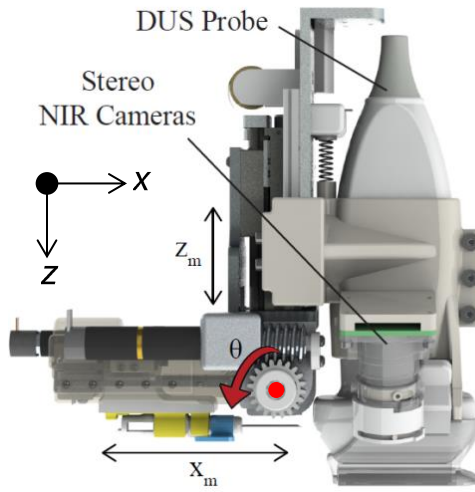
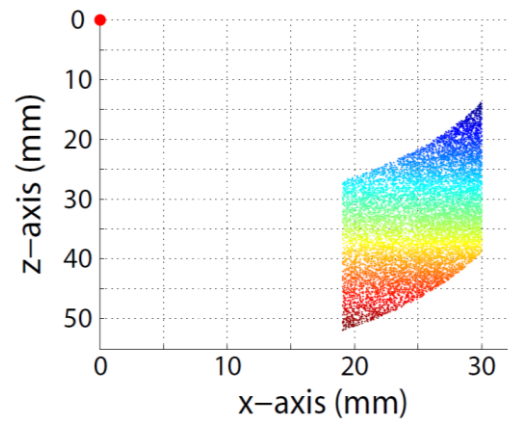


Robotic System | Gantry & Manipulator

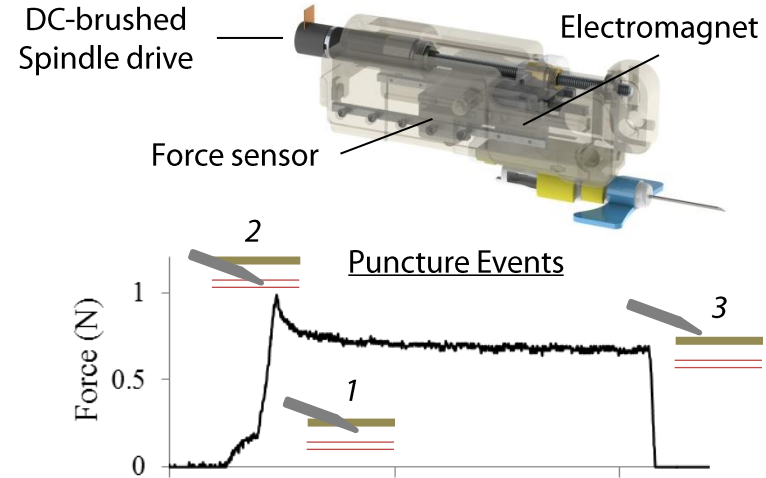
Base Positioner (Coarse)



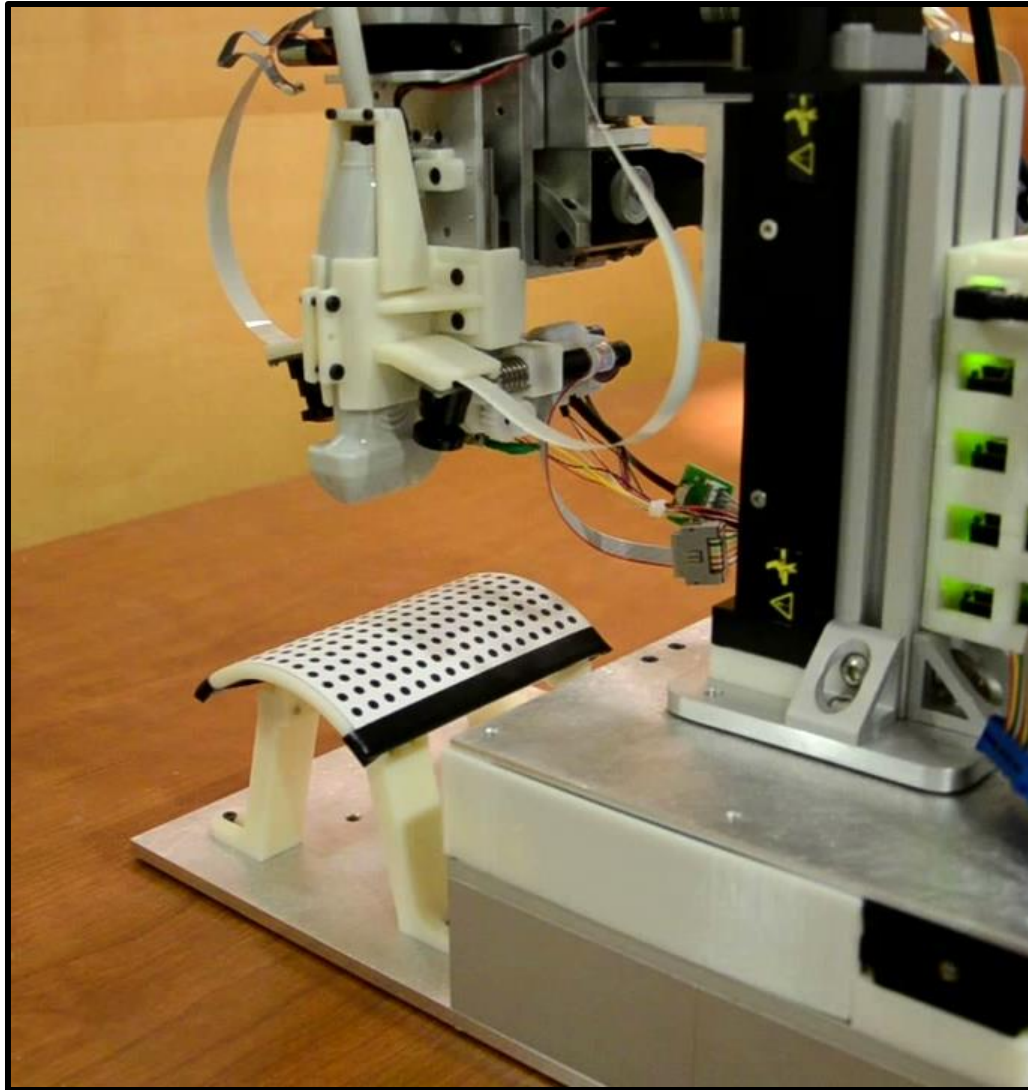
Manipulator (Localized)



Needle Insertion Mechanism



Robotic System | Motion Testing

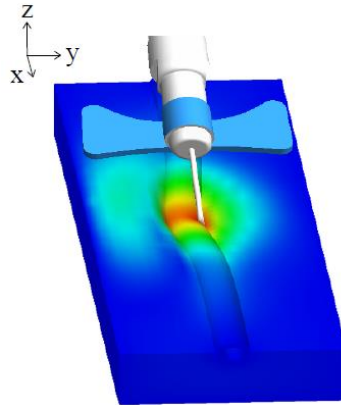


4.5x Speed-up

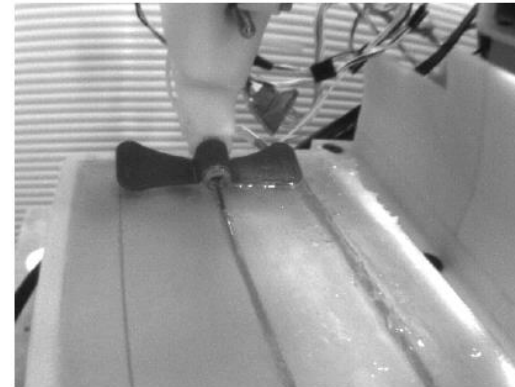
In vitro Phantom Testing | Methods

- Simulations and *in vitro* phantoms were developed to investigate three needle insertion conditions:
 1. **On-axis** – needle aligned with medial axis of vein
 - *Ideal venipuncture*
 2. **Off-axis slip** – slip at the interface between the needle and vein
 - *Seen in patients with poorly anchored or rolling veins*
 3. **Off-axis no-slip**
 - *Seen in patients with stiff, hardened veins*

SolidWorks Simulation

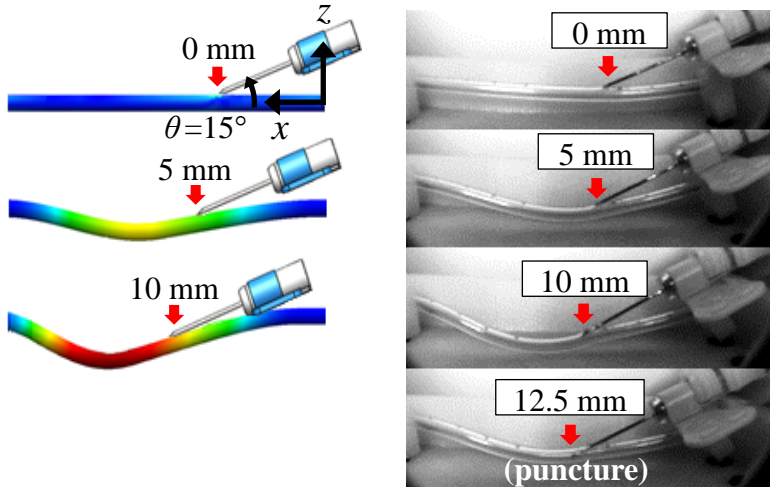


In vitro Phantom Cannulation

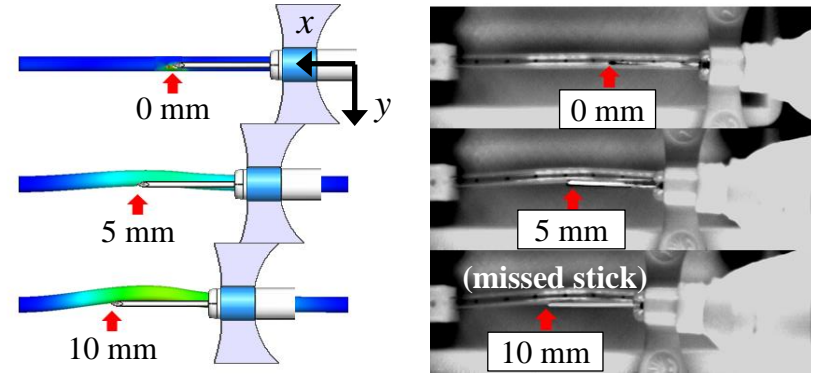


In vitro Phantom Testing | Results

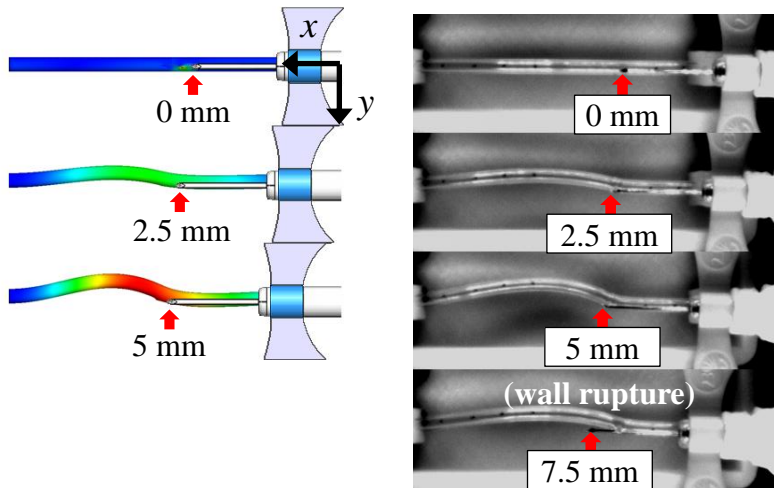
On-axis (side view)



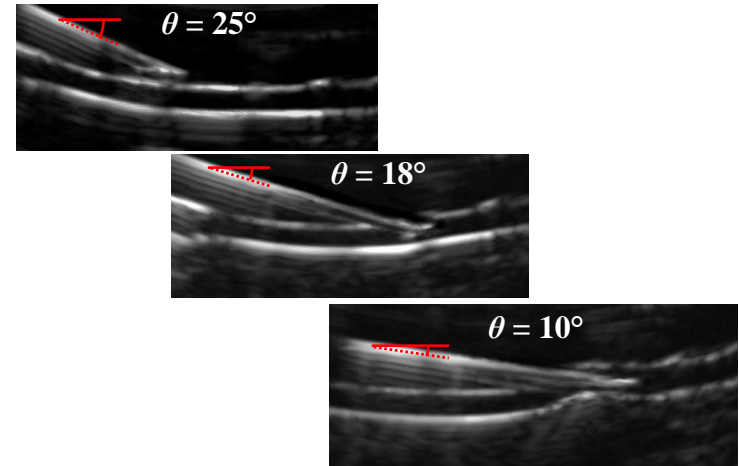
Off-axis slip (top view)



Off-axis no slip (top view)

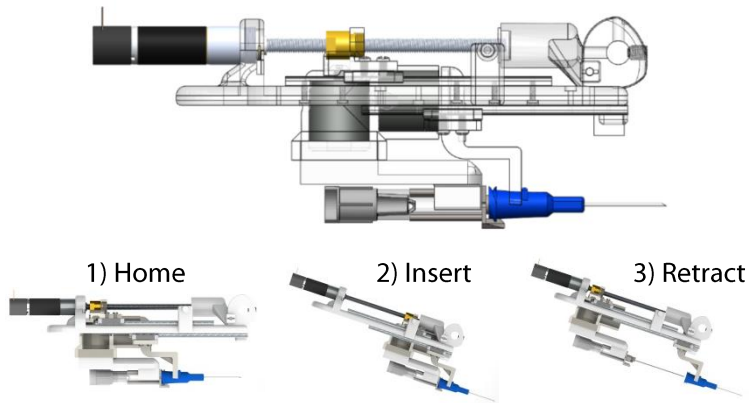


Needle Steering (side, longitudinal view)

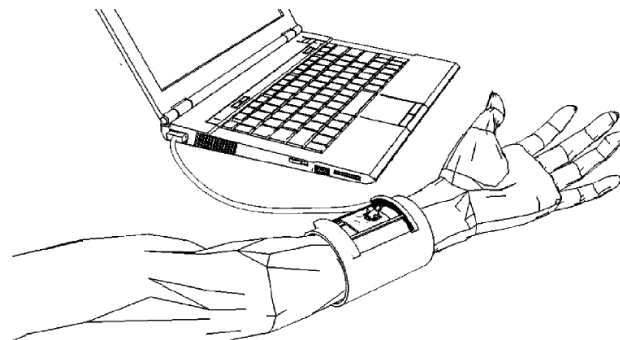


Future Directions | Extend Clinical Functionality

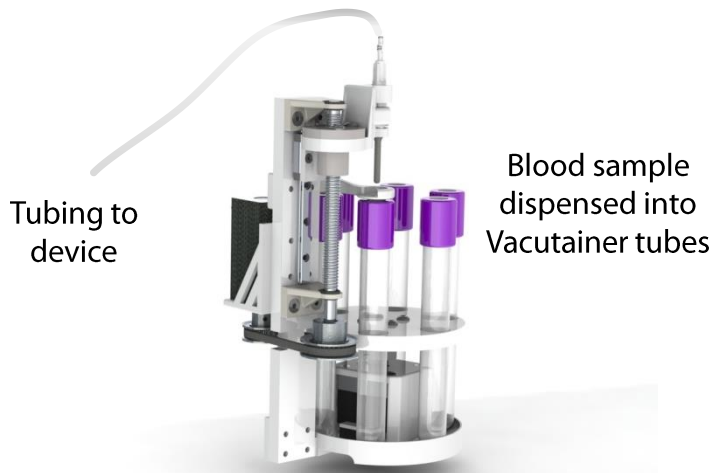
IV Catheter Insertions



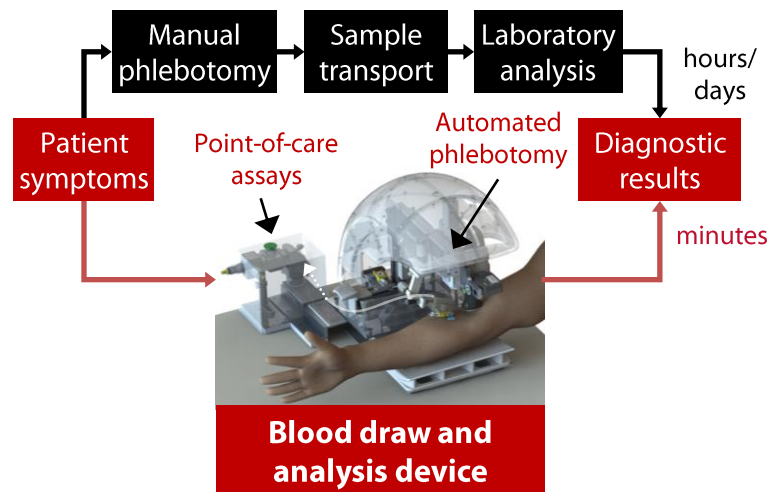
Device Miniaturization



Blood Sample Handling Unit



Blood Diagnostics Integration



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