# Ultrasound Needle Detection Using Mobile Imaging

***Computer Integrated Surgery II***
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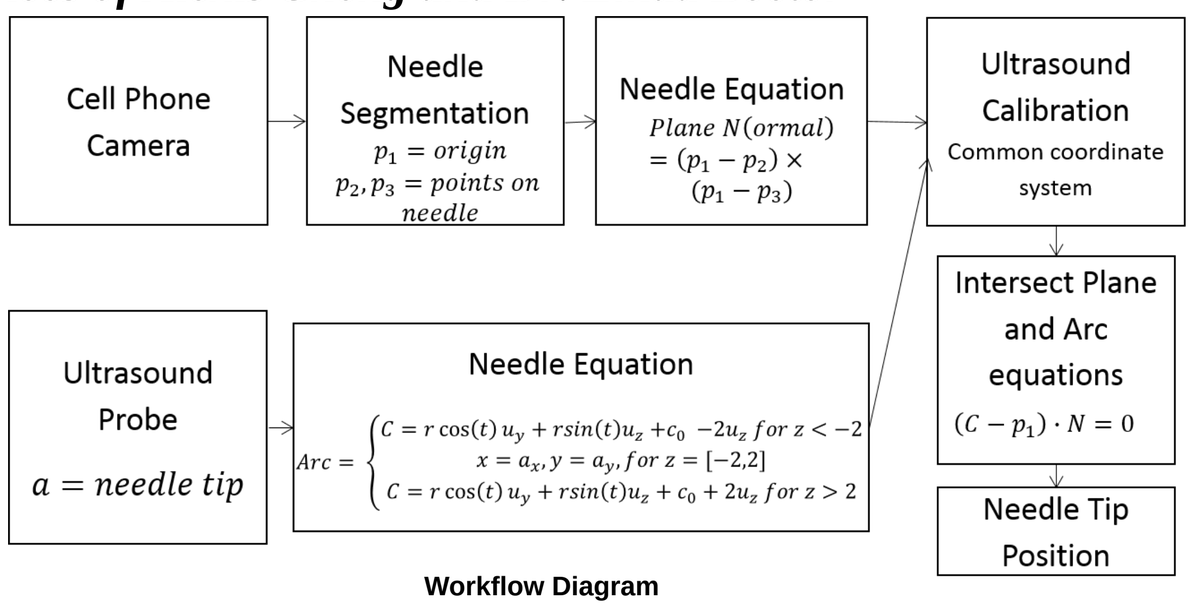
## Introduction

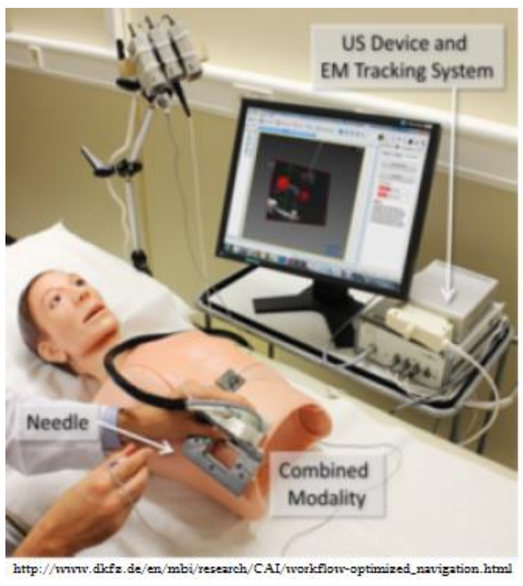
- There is a need for intraoperative tracking of surgical tools, specifically the tracking of pieces such as needle tips while inside the patient's body.
- A method was developed to localize a needle-tip using a combination of ultrasound (US) imaging and conventional camera images.
- The goal of the project is to detect and track tools intraoperatively.




**Workflow Diagram**

## The Problem

- Needle-tip tracking allows the surgeon to more accurately reach their designated target and more safely perform their surgical task.
- US image-based and Electromagnetic tracking-based methods are two conventional methods to provide intraoperative needle-tip tracking.
- Both of these methods have problems.



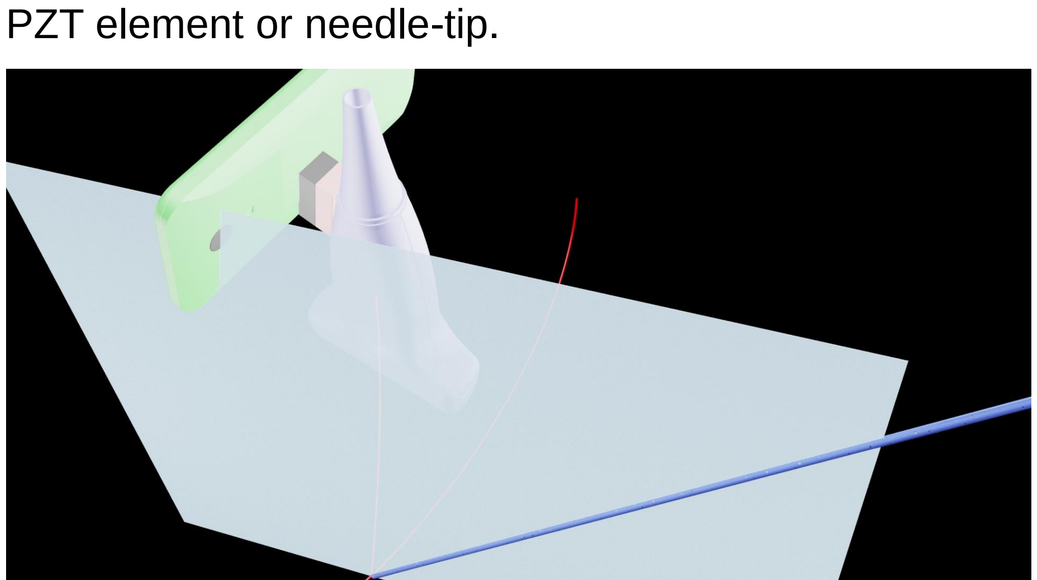

http://www.dkfz.de/en/mbi/research/CAI/workflow-optimized_navigation.html

•US images have a limited field of view and cannot track needle-tips that are outside its imaging plane.

•Electromagnetic tracking-based methods require integrating additional hardware into the surgical workspace.

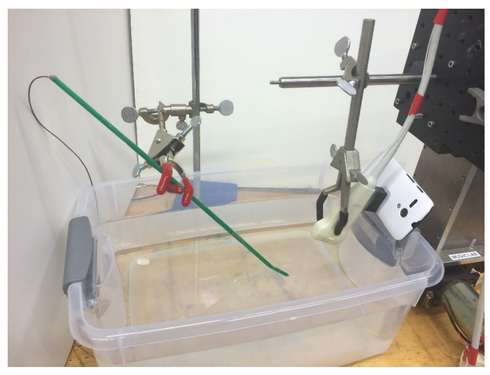
## The Solution

- An active piezoelectro (PZT) element is attached to the tool tip, transmitting synchronized pulses to the receiving US transducer.
  - These received pulses give us: the transducer element closest to the PZT element, the distance between this transducer element and the PZT element
  - This information can be used to generate a subset of positions (arc) where the PZT element may lie with respect to the ultrasound image.
- A camera is attached to the US transducer, capturing an image of the external portion of the needle.
  - This image gives us a plane that the needle lies on and that intersects with the camera.
- By transforming the plane and the arc into the same coordinate system using a pre-computed ultrasound calibration, one can then compute the intersection of the plane and the arc. In most cases, there will be a single intersection point indicating the position of the PZT element or needle-tip.



## Outcomes and Results

### Experimental Setup

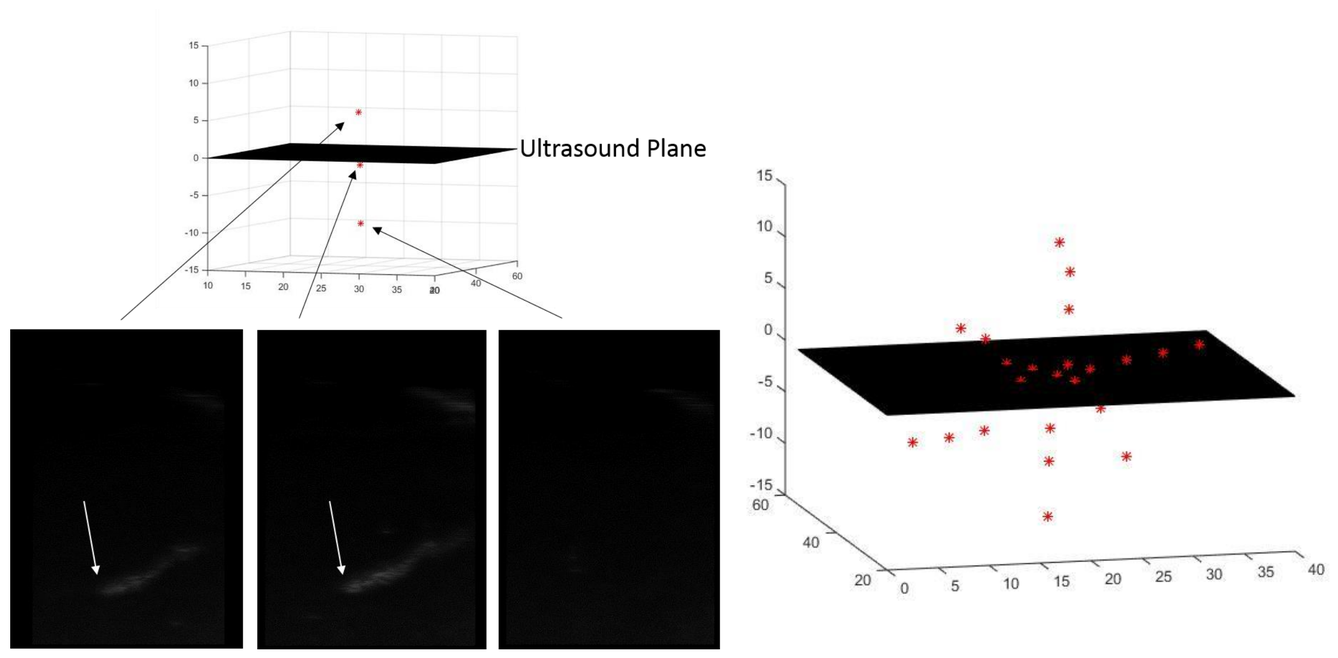


- A "needle" with US emitting tip was fixed in two different poses while a cell phone mounted US probe was moved in linear 4mm steps in the 3 orthogonal directions independently.
- Accuracy was measured by how out-of-plane computed points were that were experimentally placed in-plane.
- Precision was measured by the relative distance between two calculated points compared to the known distance (4mm).

### Results

| Accuracy | RMSE |
|---|---|
| Pose 1 | 0.6333 mm |
| Pose 2 | 0.1752 mm |

| Precision | |
|---|---|
| RMSE | 0.8608 mm |
| Std Dev. | 0.8600 mm |




**(LEFT) Example of 3 positions of the needle in standard B-Mode imaging (Below) compared the positions obtained by our method (Above). Notice on the B-Mode images that the left and center images look similar, and the right image is not visible at all.**

**(RIGHT) The position of the needle in pose 2 with respect to the US probe as it is moved.**

## Future Work

- Implement the programs to operate in real-time as a mobile app.

## Credits

- Phillip – Method implementation and analysis
- Bofeng – Needle segmentation and animation

## Publications

- Guo, Xiaoyu, et al. "Active Echo: A New Paradigm for Ultrasound Calibration." *Medical Image Computing and Computer-Assisted Intervention–MICCAI 2014*. Springer International Publishing, 2014. 397-404.
- Cheng, Alexis, et al. "Active point out-of-plane ultrasound calibration." SPIE Medical Imaging Conference, Orlando, 21-26 February 2015. 9415-30.

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