Needle Embedded Ultrasound Imaging

Computer Integrated Surgery II
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Introduction

The system we improved upon consists of a single disc shaped PZT element mounted to the tip of a 14G lumbar puncture introducer needle. The system creates a B-mode image by pulsing the element while sweeping it through tissue and tracking its angular position. Realtime scan conversion and beamforming algorithms were created in Matlab. The beamformed imaging algorithm uses a technique known as backprojection which allows for a detailed image to be constructed from a single, unfocused beam swept over the field of interest.

The Problem

The lumbar puncture (LP) is a clinical diagnostic technique involving the collection of cerebrospinal fluid (CSF) from the subarachnoid space in a patient. In order to successfully collect CSF, clinicians have to blindly yet accurately navigate a needle through the L3-L5 intervertebral space, epidural space, dura mater, and arachnoid mater whilst avoiding nerves, blood vessels, and bone. More than 400,000 LP's are performed annually but nearly 23.3% end in failure due to the myriad of challenges. These failures lead to misdiagnoses, treatment delays, and subsequent unnecessary and dangerous follow-up procedures.

The Solution

- In order to obtain clinically useful images, realtime processing must produce high resolution and spatially accurate results.

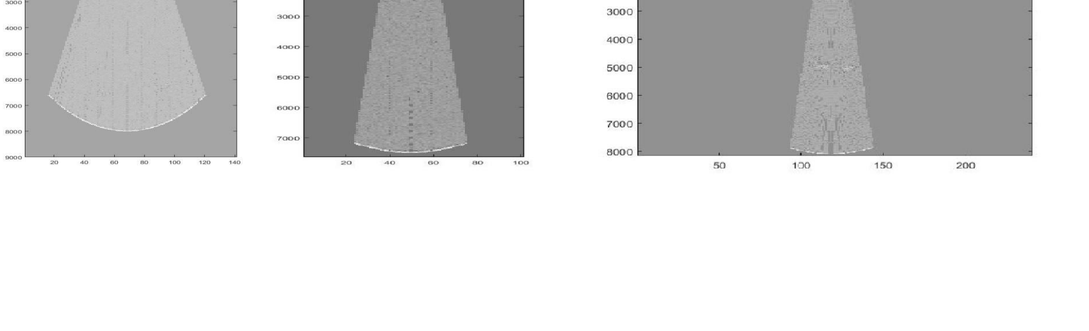
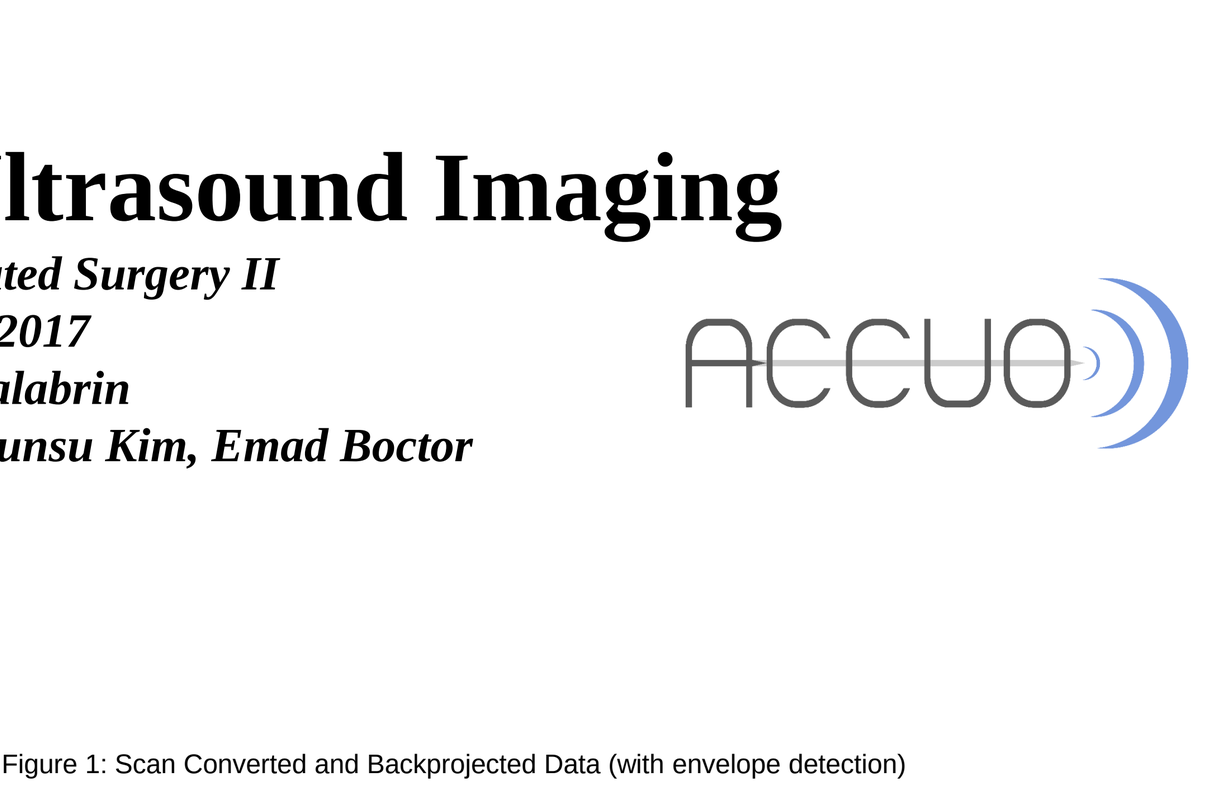


Figure 1: Raw Data

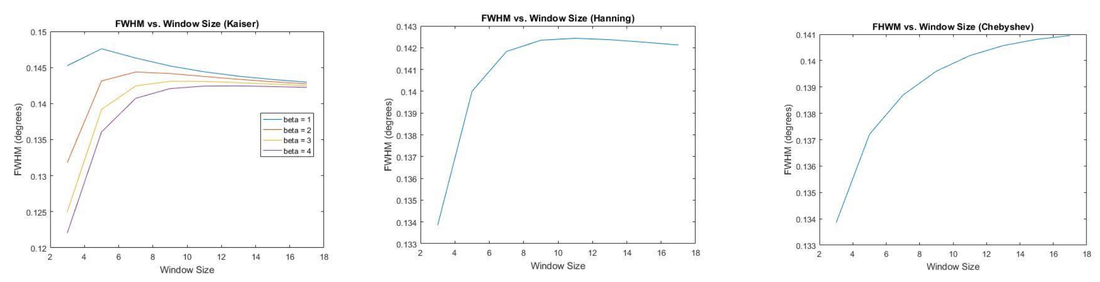
Figure 2: Scan Converted Data

Figure 1: Scan Converted and Backprojected Data (with envelope detection)



Outcomes and Results

- Working realtime scan conversion and backprojection algorithms were created and tested.




```
for l = 1:numberOfLines %reading A-lines one by one
    beamformedData(:, l) = rawData(:, l);
    %iterate through window for this a line
    for w = l - ((windowSize-1)/2): l + ((windowSize-1)/2)
        %make sure adjacent a line is valid
        if w > 0 && w <= numberOfLines
           width = depthOfNeedle*sind(abs(l-w)*angleDist);
            %iterate down a line
            for s = 1:samplesPerLine
                    beamformedData(s, w) = beamformedData(s, w) + apodWindow(w - l + (windowSize - 1)/2 + 1)*rawData(s, l);
                    count(s, w) = count(s, w) + 1;
            end
        end

    end
    beamformedData = beamformedData./count;
```

Future Work

- Integrate into realtime setup to confirm clinical usefulness. (Introduce better angle handling)
- Improve scan conversion to ensure spatial accuracy and compare to ground truth.
- Investigate the affects of medium and target material on backprojection.
- Introduce angle checking to increase signal to noise ratio.

Lessons Learned

- Start with simulations!

Credits

- Ernest – Adapting existing and creating new scan conversion and back projection code, Data Analysis.
- Kai and Younsu – Technical and Conceptual Guidance

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