

Development of Surgical Navigation Device for Arthroscopic Cartilage Repair

Introduction

Articular cartilage is very important for the pain free functioning of this joint. Damage to this tissue, in the form of a cartilage defect, is very painful and is speculated to be a precursor to osteoarthritis [1]. Due its avascular nature, this tissue is unable to repair itself causing surgery to be the main option for treatment [1]. Current surgical algorithms use defect area as the primary attribute to determine which procedure to use for each patient [2,3,4]. Unfortunately, current techniques of calculating defect area are very poor, with errors ranging from -78.81% to 236.61% for surgeon area estimation, the current gold standard [5]. Brockmeier previously developed a cartilage navigation system to improve surgeon accuracy in calculating defect area [6]. However, when this system was used in cadaver knees it failed due to slipping of the surgical probe leading a larger area calculation and tracing of the defect multiple times leading to a cumulative area calculation. This goal of this project was to improve these previously developed system. The objectives of this project were: (1) **Improve the MATLAB code of the previous system of overcome these tracing issues;** (2) **Create new functions to increase the usability of the device;** (3) **Validate the system.**

Surgical Navigation System

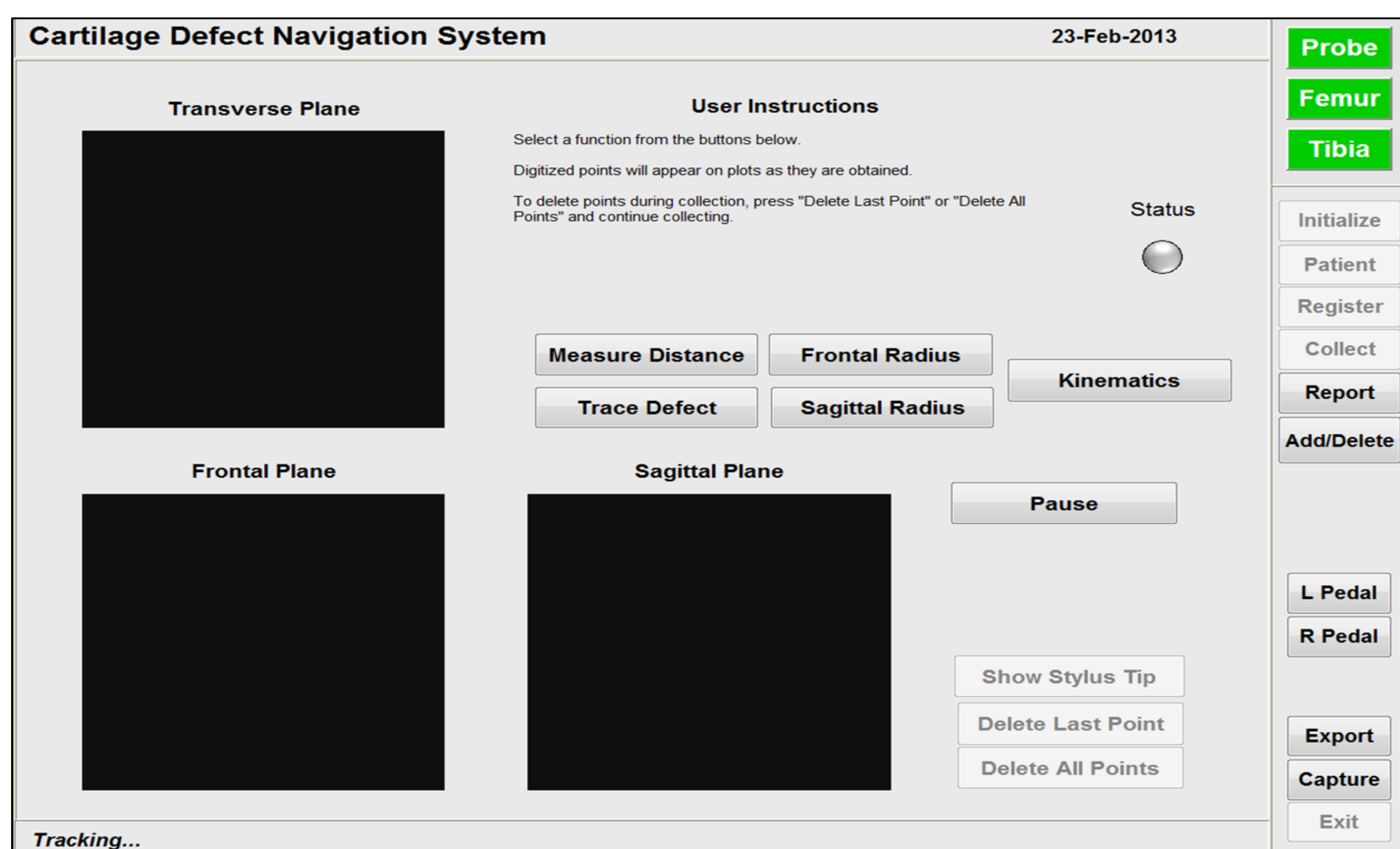
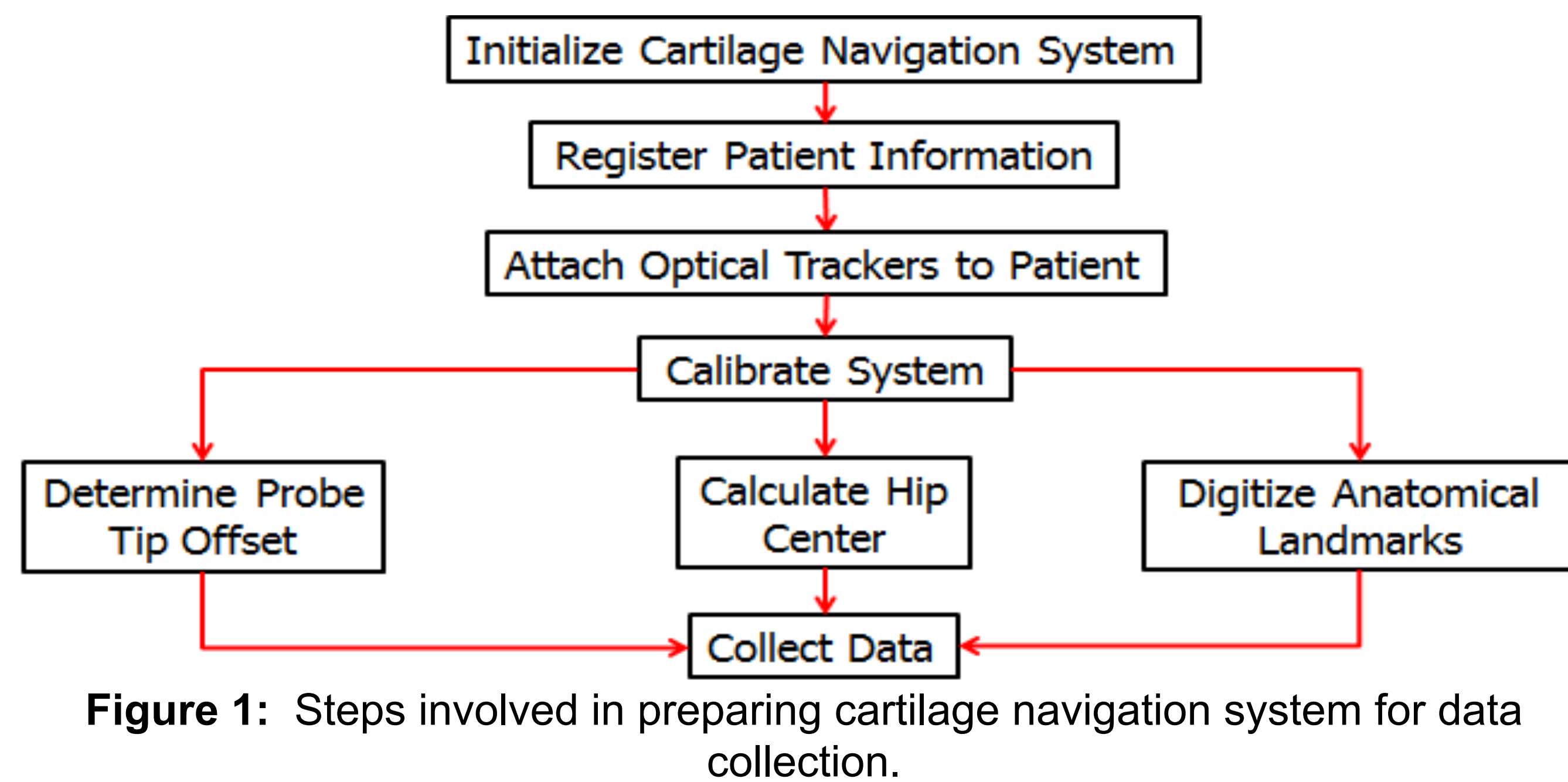


Figure 2: Data collection panel of cartilage surgical navigation system.

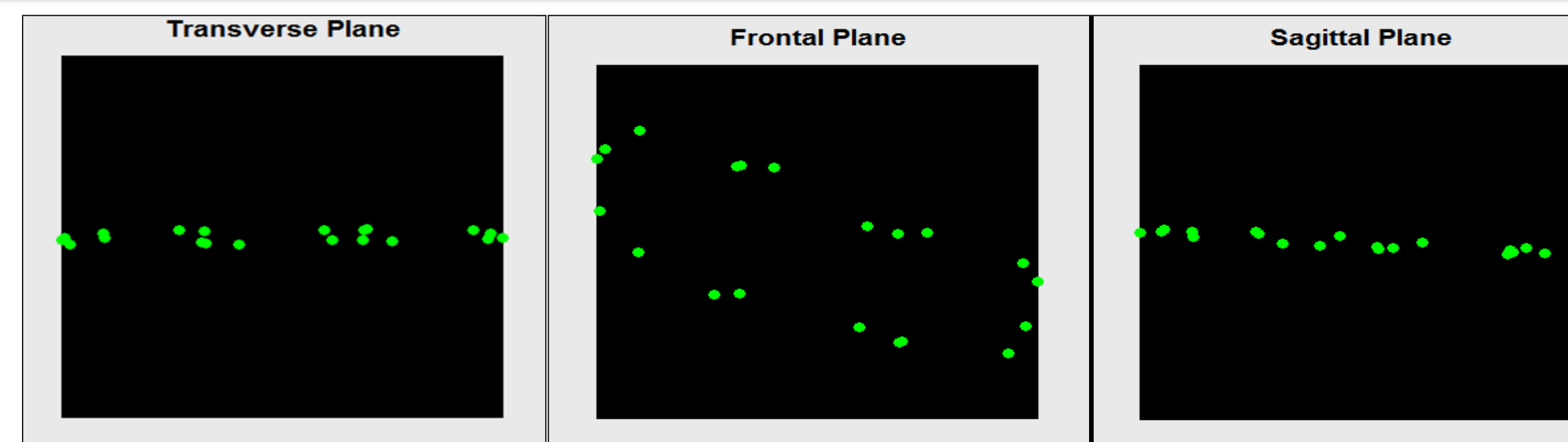


Figure 3: Plotting of probe tip as user traces the boundary of a two dimensional shape.

New System Features

REORDER_POINTS.M

Allows user to trace defect multiple times to generate defect boundary.

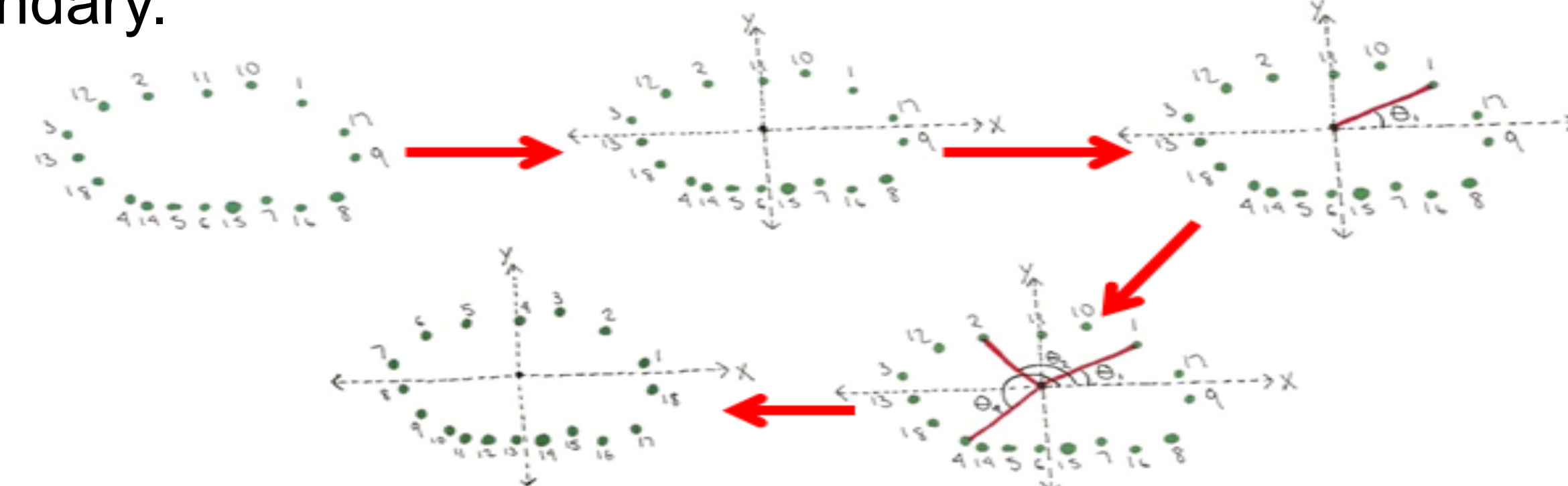


Figure 4: Flow of *reorder_points.m* function. This function reorders the data points to allow the data spline fit to function properly.

Modify Points Panel

Allows user to remove unwanted points from the data set after tracing.

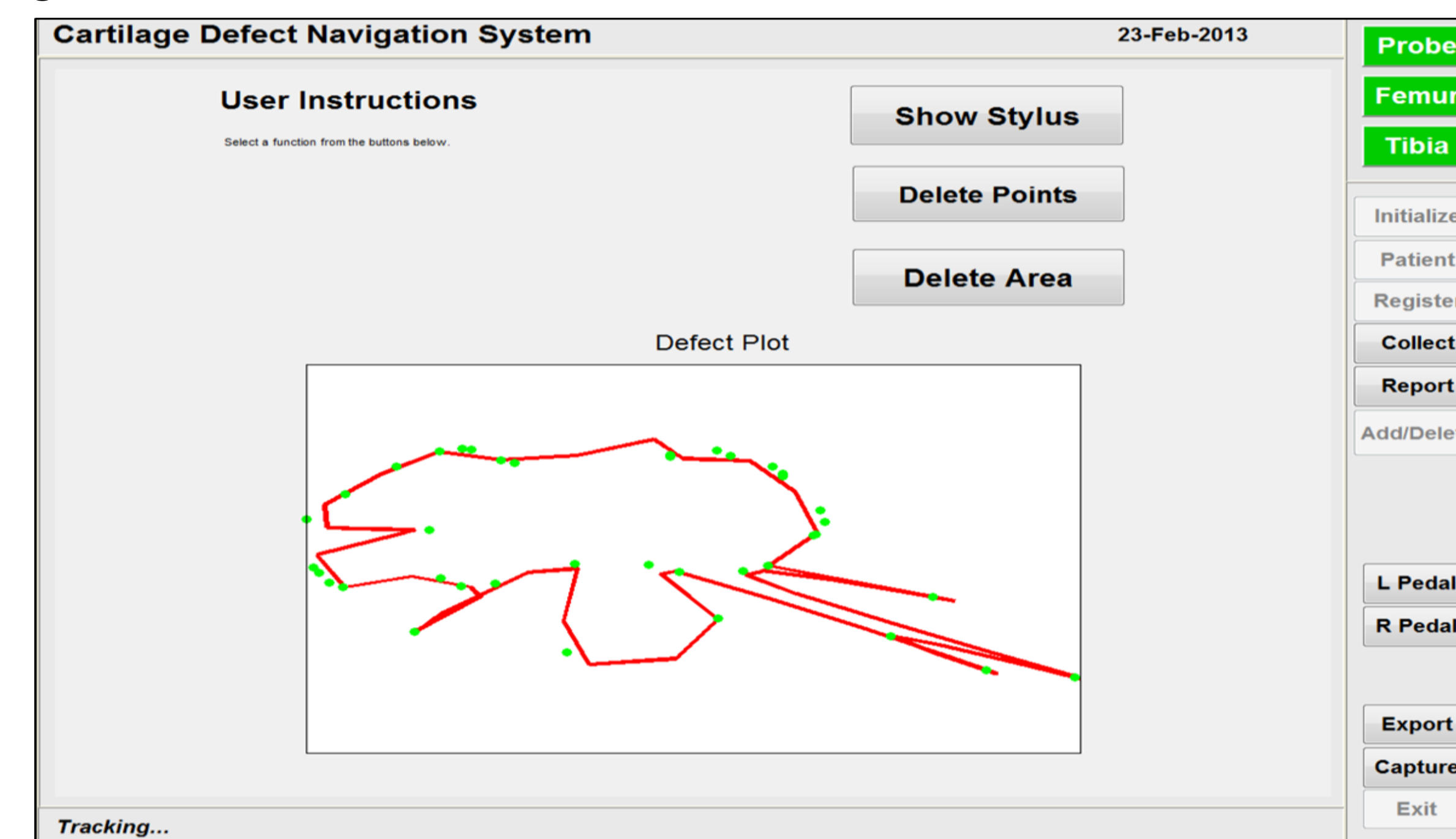


Figure 5: Modify points panel of cartilage surgical navigation system.

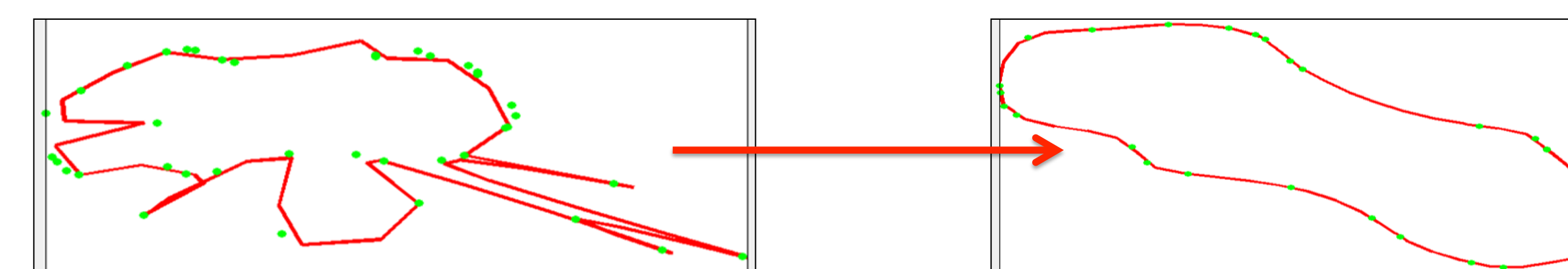


Figure 6: By modifying the points in the data set the user is able to generate a better approximation of the defect area.

Validation Methods

- System tested using shapes cut into plastic and artificial defects cut into Sawbones knees, both of known area
- 4 different techniques:
 - Ruler
 - 5 mm arthroscopic probe
 - Retractable probe with 2 mm markings
 - Cartilage navigation system
- Error threshold was set at 5%
- Measurements compared to ground-truth measurement

Results

Average Percent Error for All Shapes

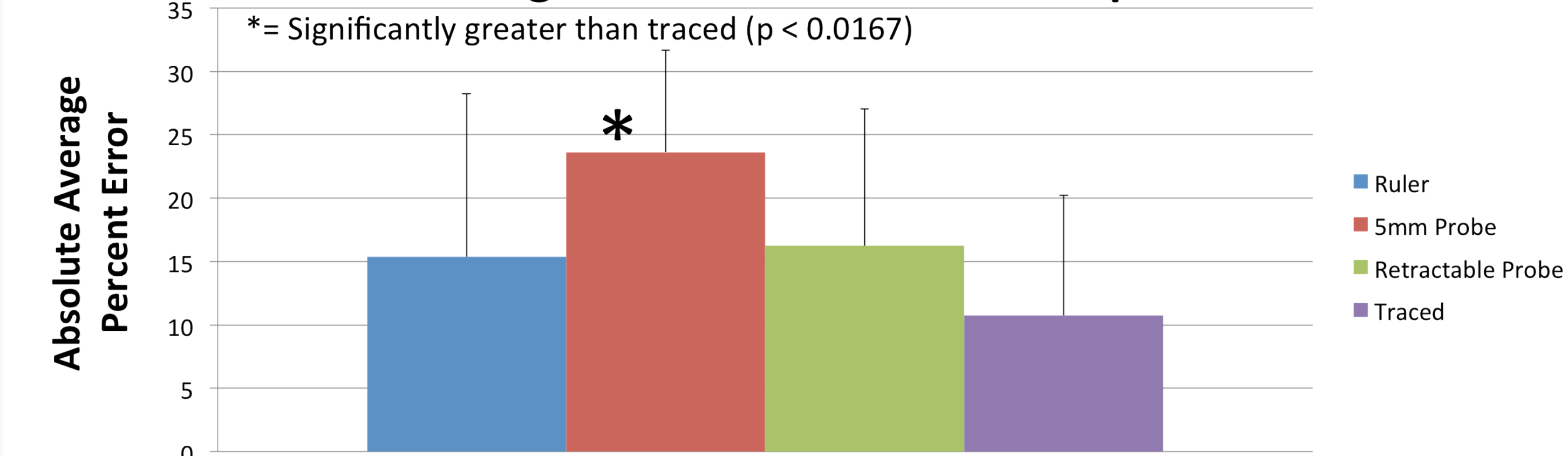


Figure 7: Absolute average percent error for all shapes tested.

Average Percent Error for Abnormal Shapes

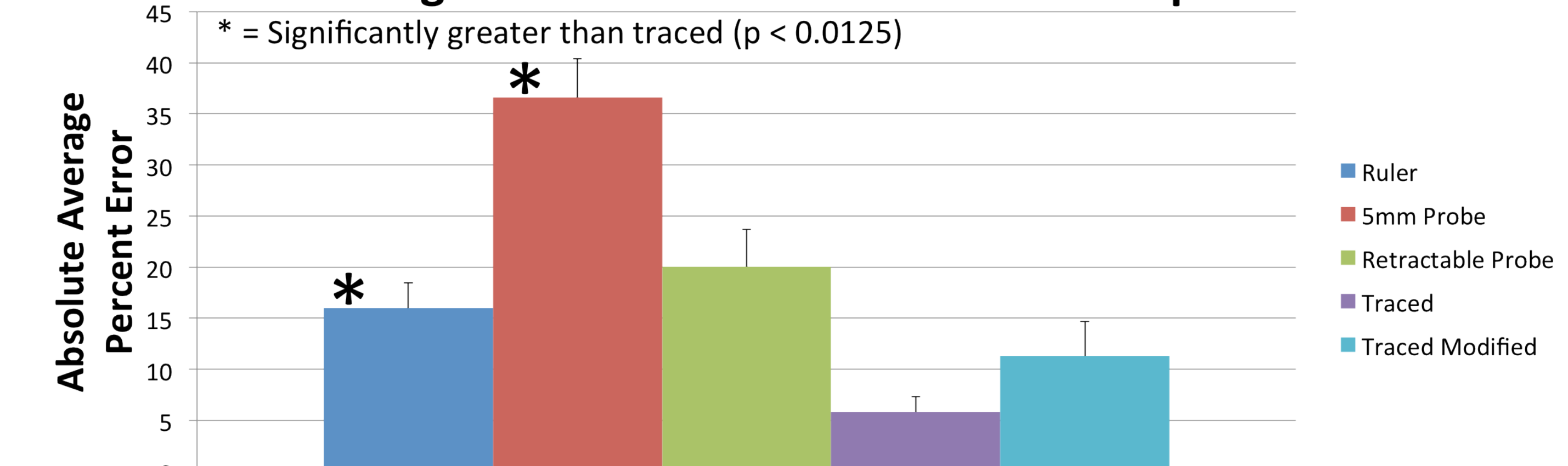


Figure 8: Absolute average percent error for abnormal shapes.

Average Percent Error for Sawbones Defects

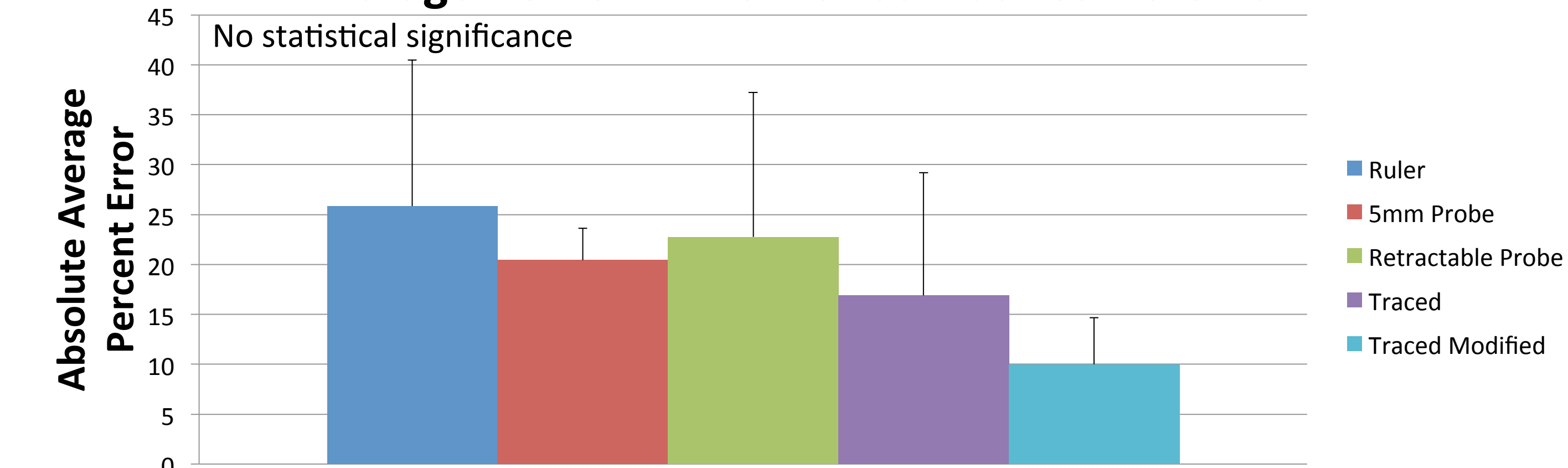


Figure 9: Absolute average percent error for Sawbones defects.

Causes of System Error

Not collecting enough points

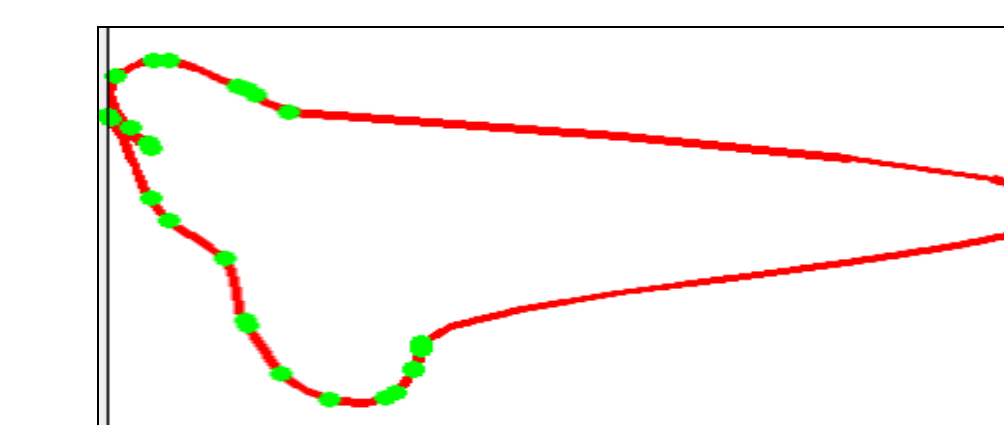


Figure 10: User did not collect enough data points to fully approximate the defect boundary. This leads to an overestimation in the defect boundary.

Not properly modifying points

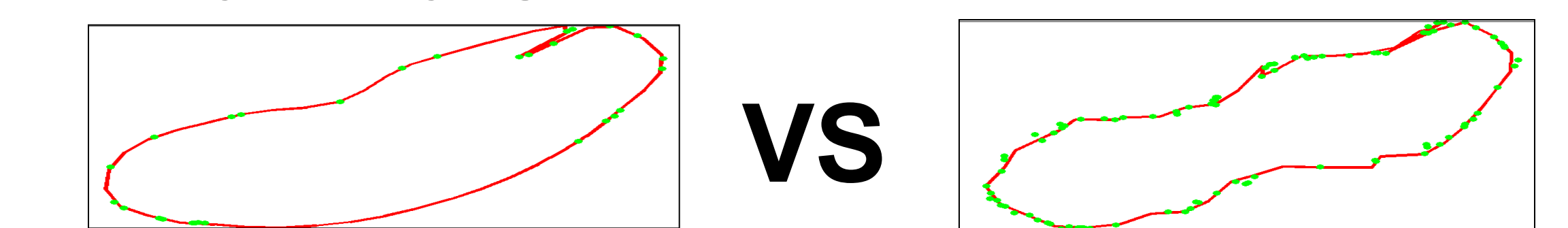


Figure 11: Two different tracings of the same defect. The difference is the number of points used to represent both.

Conclusions

- Navigation system an improvement on current techniques
- System not as accurate as anticipated
- System can be modified to increase accuracy
 - Increasing number of points collected
 - Improving the two dimensional approximation of the device

References

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