Snakes Versus ConnectPixels: Segmentation of IR Images for Breast Cancer Detection

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OBJECTIVE

Develop and compare the accuracy of two methods of automated segmentation used to isolate the breast region of the patients' infrared images; increasing the accuracy of segmentation is important because it limits the area for tumor search, thereby increasing efficiency and reducing false positives.

INTRODUCTION

- The overall study utilizes infrared (IR) imaging for tumor detection in breasts as an adjunct to mammography. Our long term goal is to provide a replicable scientific method for analysis of thermal images, including standardization of segmentation. Automated segmentation would remedy this and would allow for an efficient registration and crop of all images, with minimal manual input.
- A previous segmentation method [1] was used to determine which pixels would be considered edge pixels. This study improves upon the earlier segmentation method by: 1) including the creation of user-input bounds for breast ellipse detection as a method of constraint, 2) eliminating noise in Canny edge detection, and 3) standardizing the code to eliminate the need to follow a different protocol for small and large breasts. The edge pixels are used as an input for the connectPixels function.
- The other segmentation method used, snakes, was based on a more basic version of the same name [2] which was improved to detect the curve of the breast in IR images by being more sensitive to lower contrast boundaries.

METHODS AND RESULTS

- Thermal images of 15 breast cancer patients and 24 normal volunteers were acquired over a fifteen-minute imaging period and analyzed with MATLAB.
- Two pixel connection methods, connectPixels and snakes, were compared to determine which formed boundaries that more closely approximated the natural outline of the breast.
- Performance was measured for each method using the Jaccard Similarity Index (JSI), with manual segmentation as truth (JSI is a built in MATLAB function). The results of JSI are provided in the discussion.

METHODS AND RESULTS (CONT.)

snakes

The snakes algorithm is a common image analysis technique for segmentation [2]. Snakes is an active contour that fits a curve based on the internal forces of the curve and the external forces of the image data. These forces either promote or restrain deformation of an energy-minimizing polynomial approximation line towards object contours, picking out an object outline from within the noisy 2D image [3].
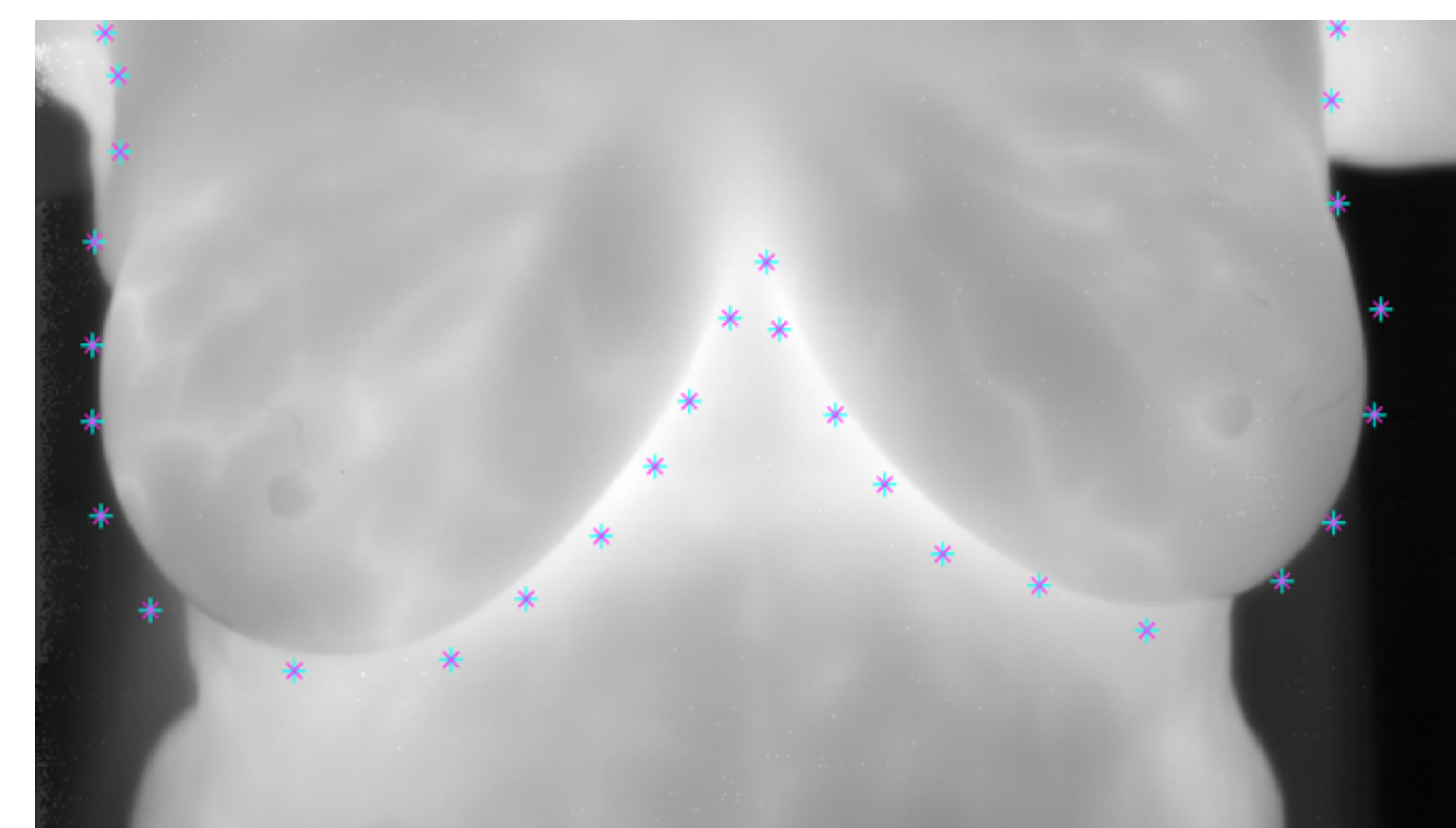

Figure 1. Patient 12's snake input. The blue points are manually inputted by clicking on the image. It is optimal to click as close to the curve of interest as possible. The best crops are found have had 20-30 points selected by the user.
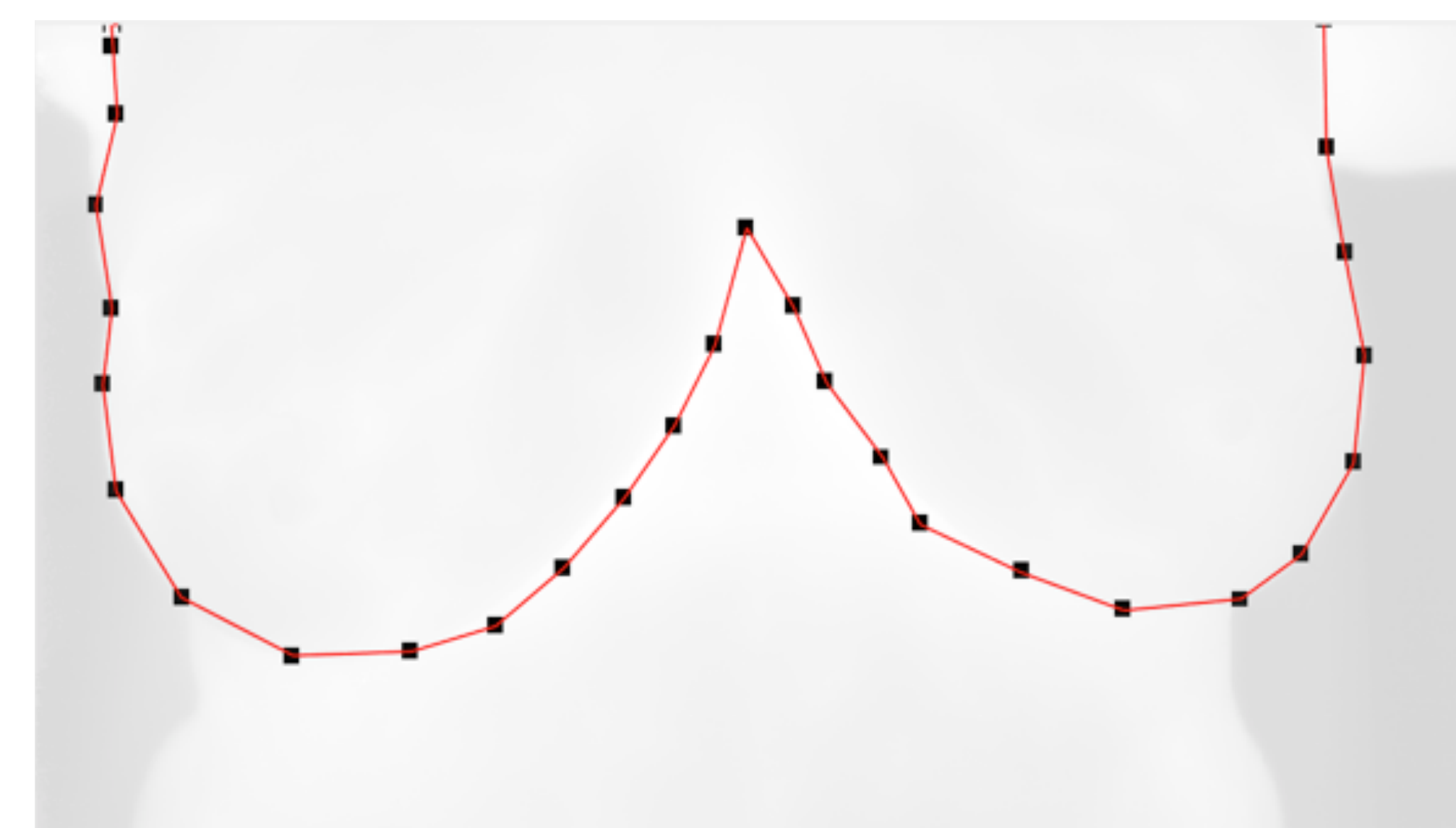

Figure 2. Post snakes being run for Patient 12. The red line has connected the resulting points. This red line is what we use as a border to crop the breast region from the rest of the image.
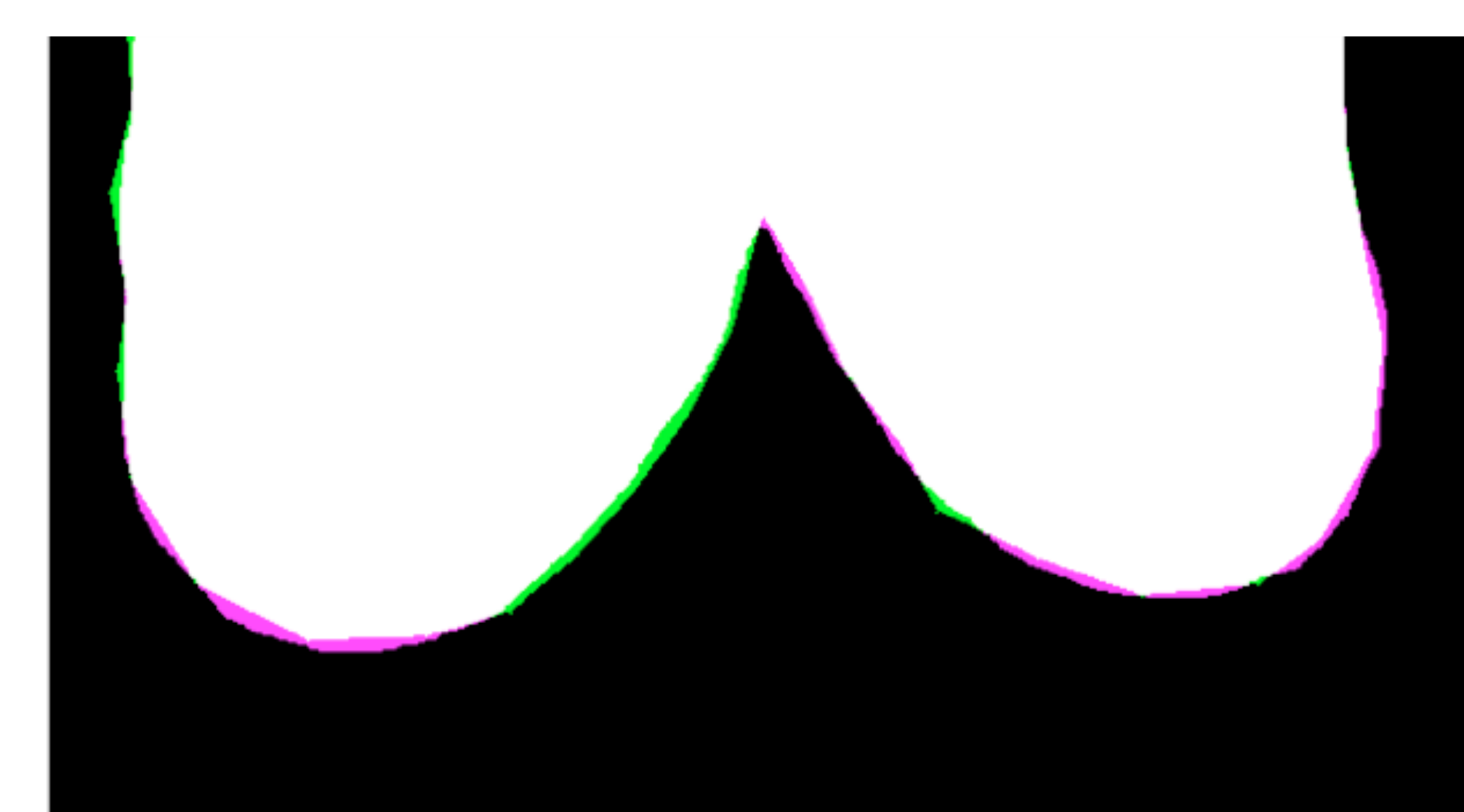

Figure 3. Jaccard Comparison Results for Patient 12's snakes and truth image. The magenta and green are the regions that do not match. Magenta is what is present exclusively in truth and green is what is present exclusively in snakes.

connectPixels

A combination of Canny, ellipse, and Laplacian of Gaussian (LoG) edge detections, and detection of the warmest five percent of pixels produced pixels that were weighted using a point system. These output pixels that passed the point system were labeled as edge pixels.
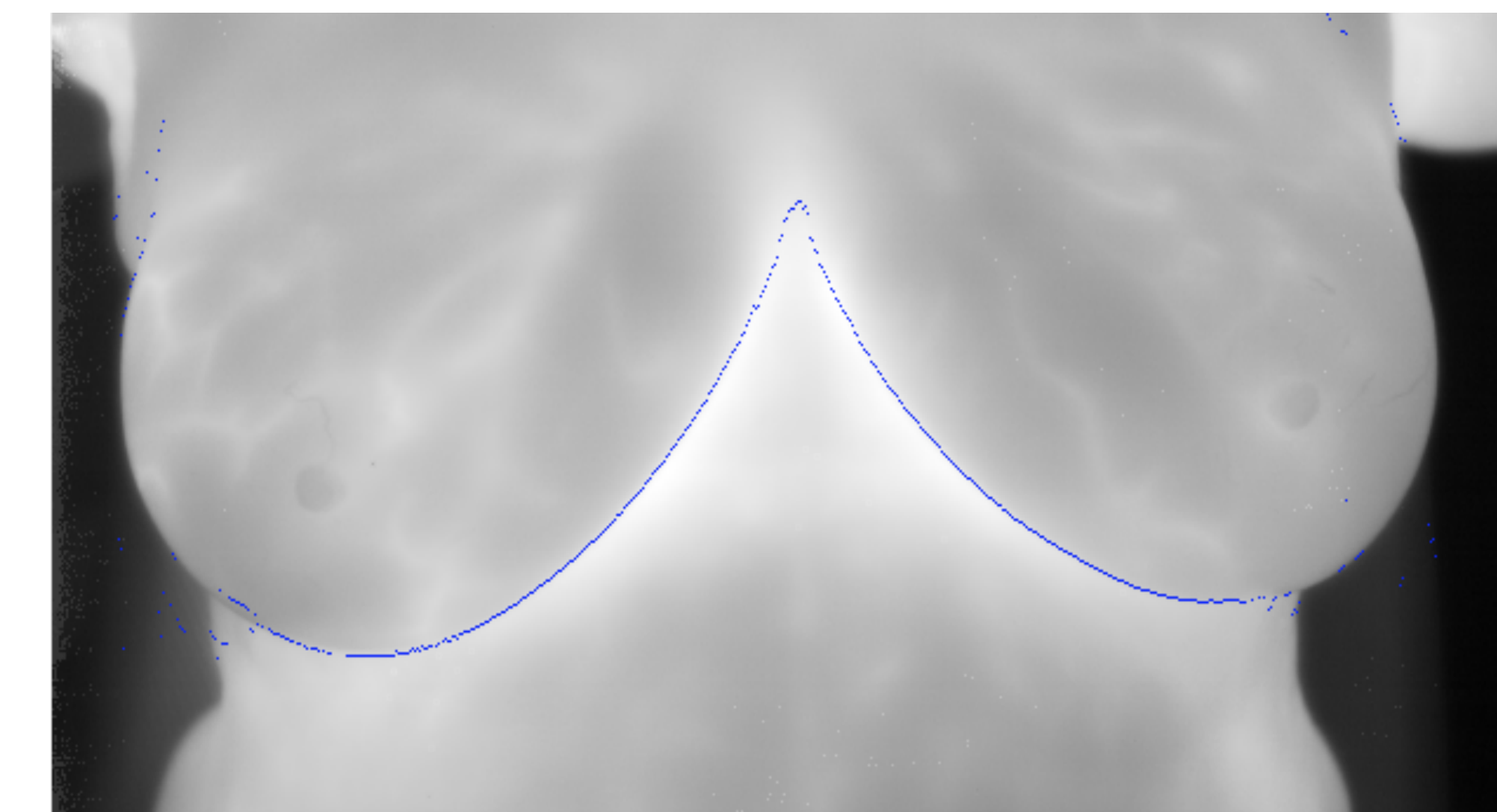

Figure 4. Patient 12's connectPixels input. The blue edge pixels are determined by a combination of edge detection methods.

ConnectPixels connected edge pixels by 1) stepping through each one, 2) determining whether the closest pixel should be above or below it, 3) locating the closest pixel within a specified radius, and 4) connecting the edge pixel to its closest edge pixel by drawing a line between them with the function linept [4].
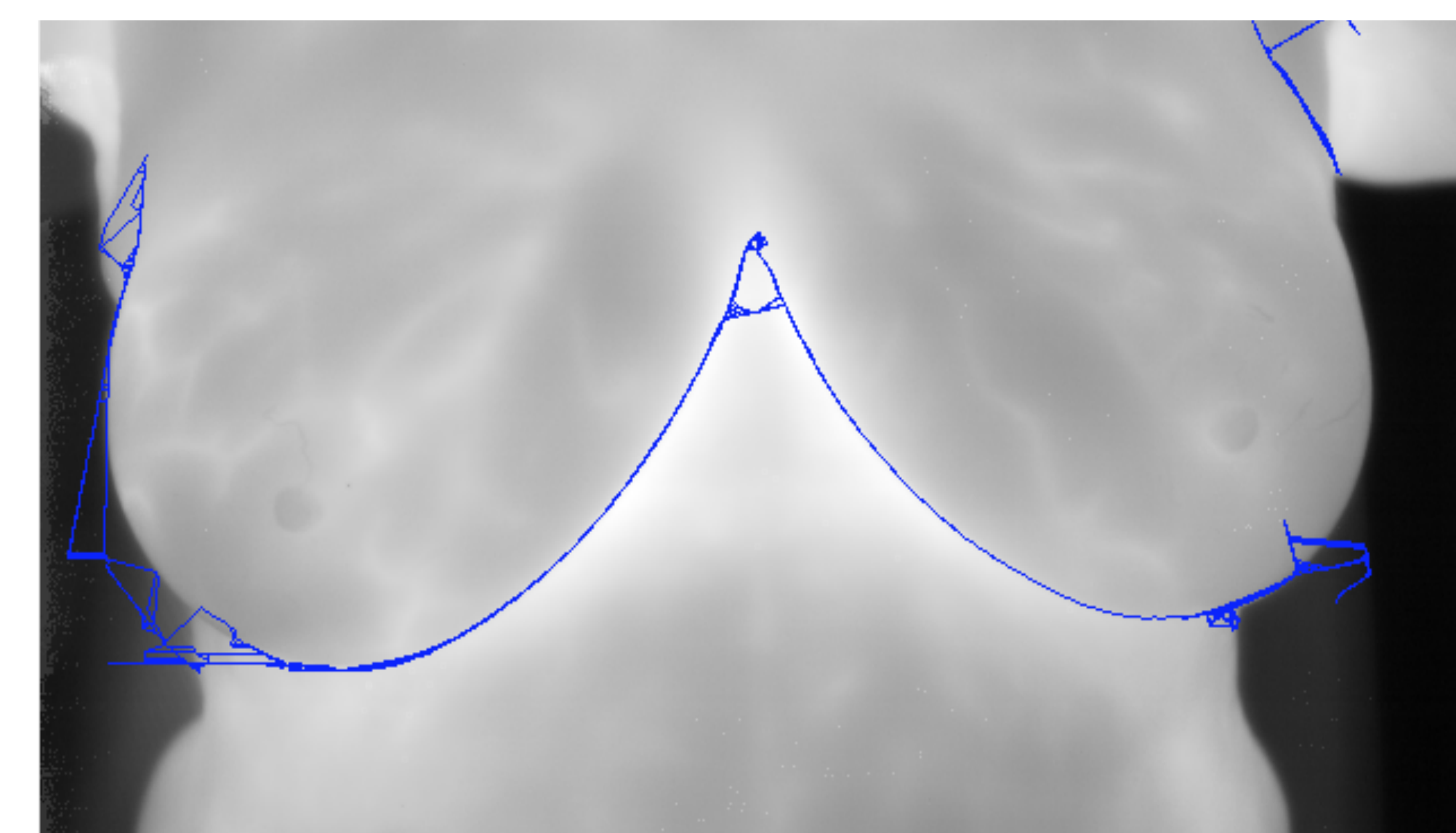

Figure 5. Post connectPixels being run for Patient 12. The blue line has connected the input (edge) pixels. This blue line is what we use as a border (along with a user selected topline connection) to crop the breast region from the rest of the image.
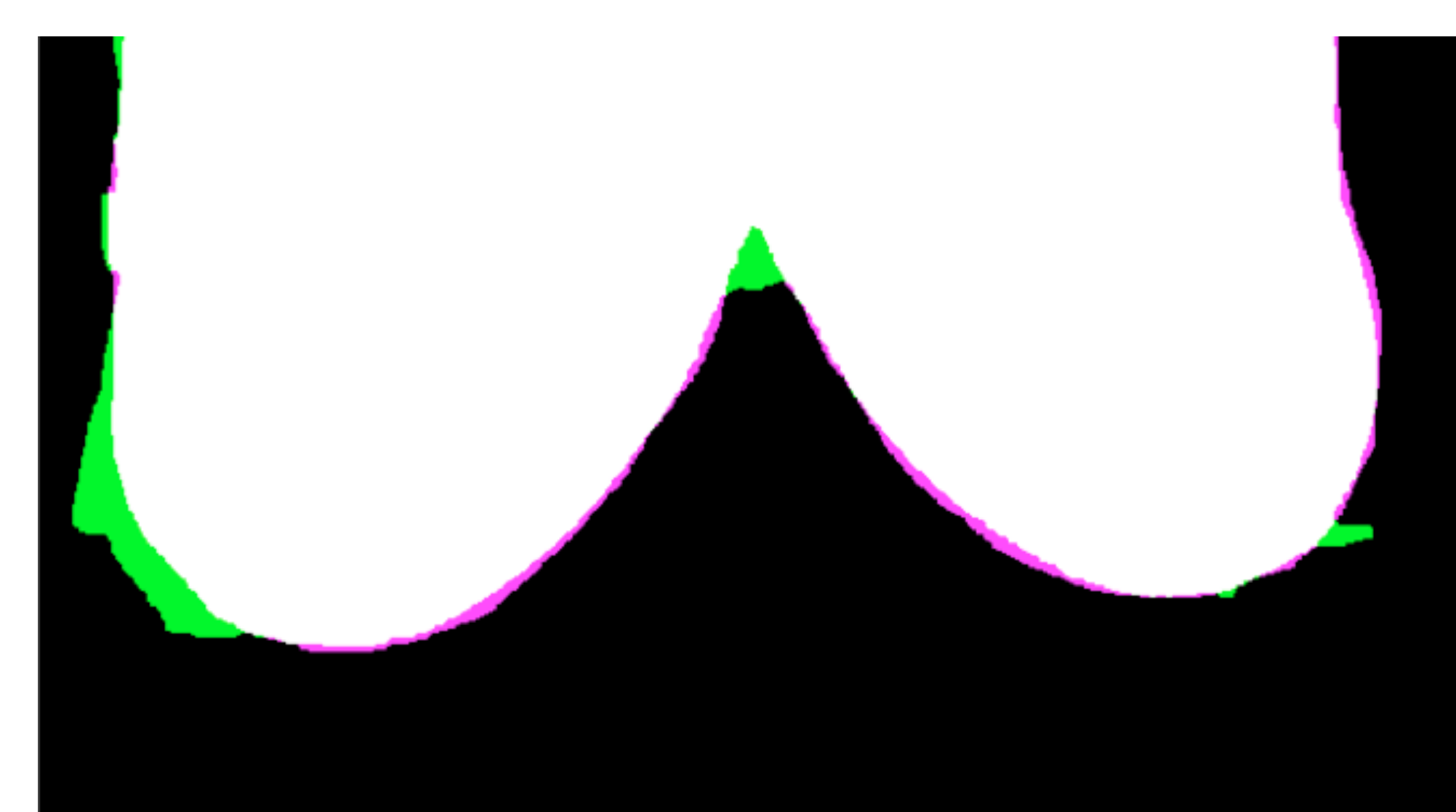

Figure 6. Jaccard Comparison Results for Patient 12's connectPixels and truth image. The magenta and green are the regions that do not match. Magenta is what is present exclusively in truth and green is what is present exclusively in connectPixels.
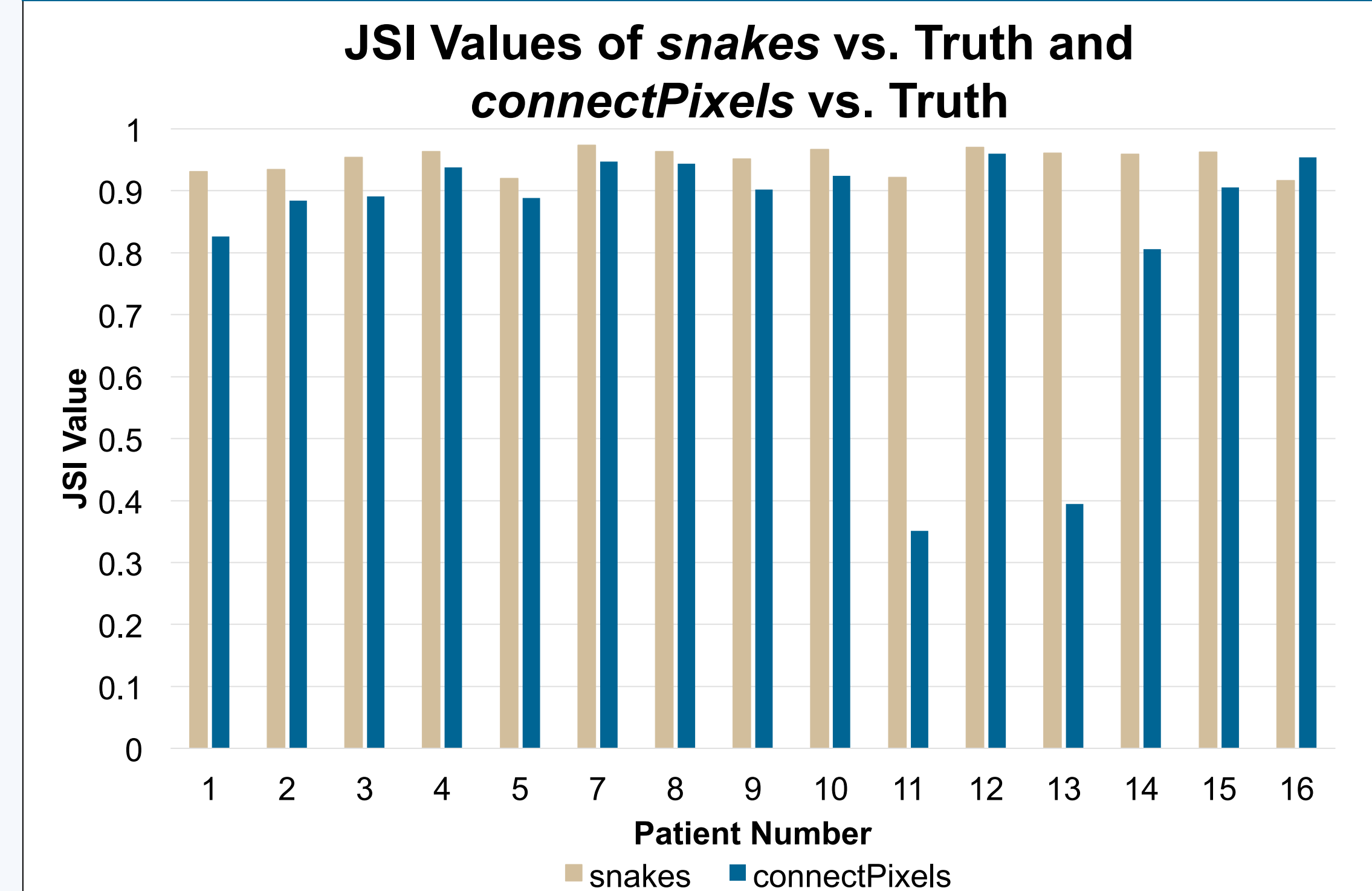
DISCUSSION AND CONCLUSION

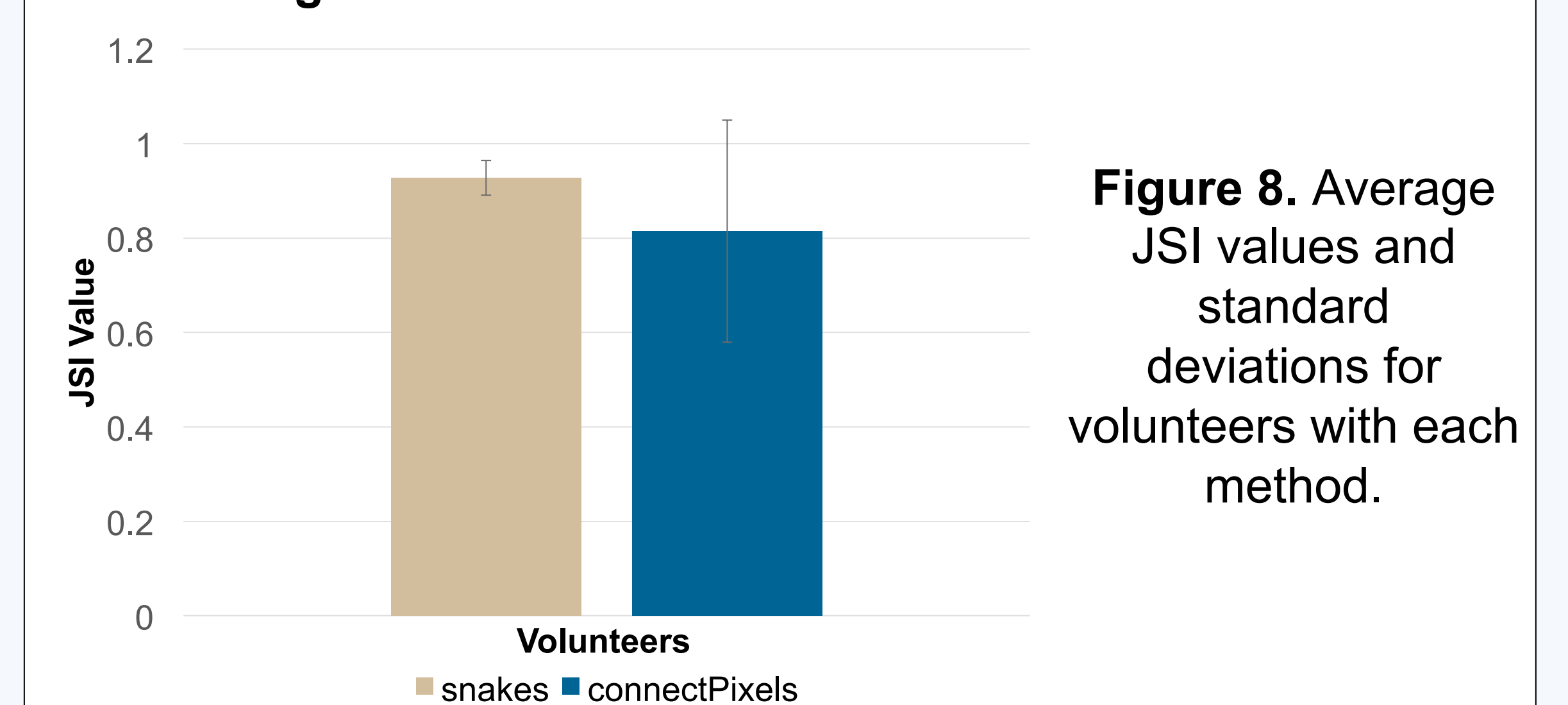**Figure 7.** JSI values for each of the 15 patients.

Figure 8. Average JSI values and standard deviations for volunteers with each method.

- snakes proved to be a closer match to truth than connectPixels. Although connectPixels required less manual input than snakes, it was less successful since connectPixels had difficulty processing images of smaller breasts, and especially volunteer images. Future studies could focus on eliminating this issue.
- The overall positive results proved that automatic segmentation could be further developed to be as accurate, and potentially replace, manual segmentation used for cluster analysis of thermographic breast images.

FUTURE RESEARCH

Future studies will focus on automating the segmentation further by reducing the manual input required, thus making the cropping process less user dependent. The connectPixels method could be developed further to be more accommodating of different breast sizes and ultimately, help develop a more uniform cropping method.

REFERENCES

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[4] C. Georges. connect two pixels. 17 May 2014. https://www.mathworks.com/matlabcentral/fileexchange/4177-connect-two-pixels