6-2017

Improving Quality of Patient Care Through Automated Nerve Segmentation

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Objective

Build a model that can segment a collection of nerves called the *Brachial Plexus* in ultrasound images to increase accuracy of placement of indwelling catheters while reducing and improving pain levels for surgical patients.

Background and Significance

Continuous peripheral nerve blocks (CPNBs) are the only available medium-to long-term method to block evoked pain in patients following surgery. A CPNB is an indwelling catheter that mitigates pain by administering anesthesia in the region of the affected nerve while decreasing nausea, vomiting, and incidence of post surgery chronic pain syndromes. The ability to accurately identify nerve structures in ultrasound images is a critical step for proper insertion. With machine learning techniques, models can be constructed that identify nerve structures from large datasets of patient ultra sound images to aid medical professionals during catheter placement [1].

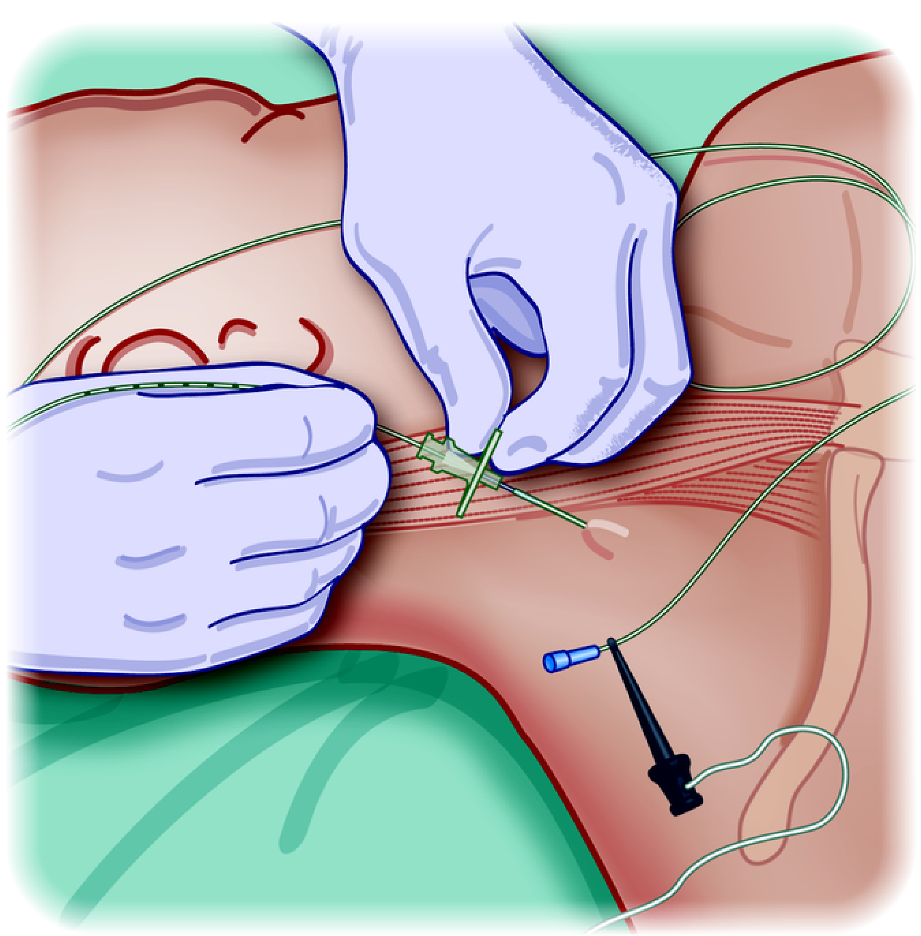

Figure 1: Indwelling catheter inserted into pain site [1]

Evaluation and Accuracy

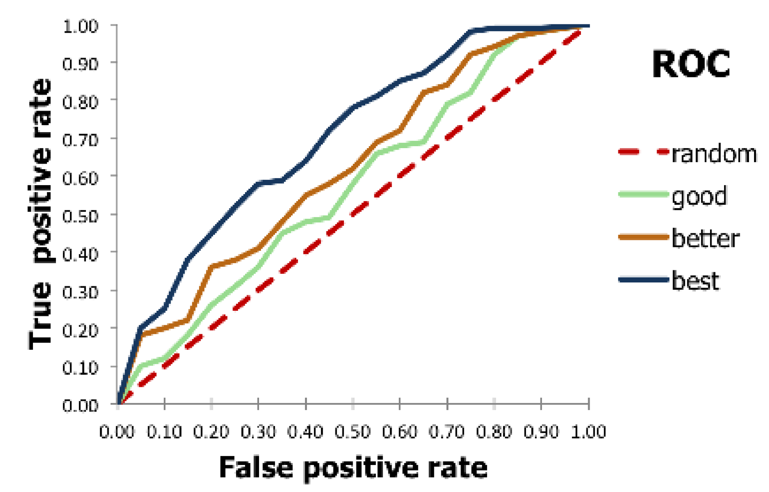

Figure 2: Receiver Operating Characteristic Curve [2]

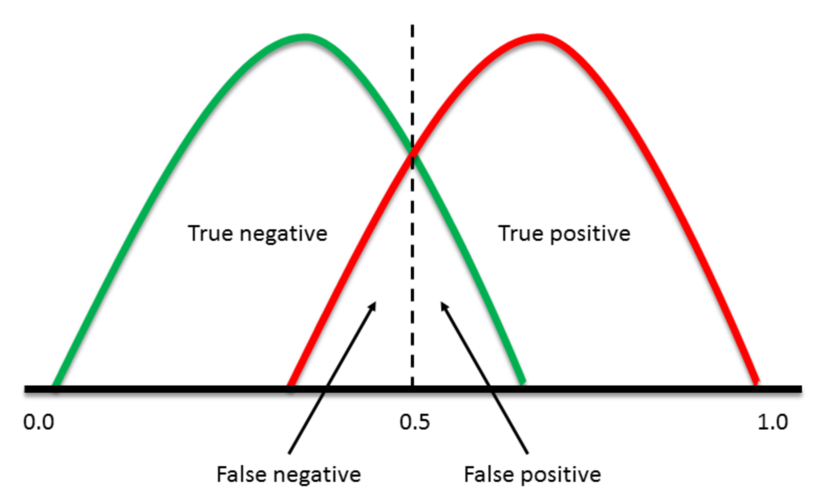

Figure 3: Overlapping dataset analysis figure [2]

False positive and false negative classifications (figure 3) can result in improper catheter placement, exposing the patient to more risk. Evaluation can indicate the proficiency and accuracy of a trained algorithm. Figure 2 includes an example of a Receiver Operating Characteristic (ROC) providing an analysis method to select optimal models.

Algorithms

$$s_x^2 = \frac{1}{n}\sum_{i=1}^{n} x_i^2 - x^2 \tag{1}$$

$$\frac{2 * |X \cap Y|}{|X| + |Y|} \tag{2}$$

A common approach in machine learning, least squares regression (1) is model that assumes a linear relationship between input variables (x) and a single output variable (y). The Dice Coefficient (2) is a method of evaluating a model output against the ground truth.

Materials and Methods

Machine learning algorithms extract input features from large datasets and construct models that can predict outputs. The data required for this project included two sets of ultrasound images: the first set (5636) of which included the annotated region of the brachial plexus, the second set (5508) of which included unannotated brachial plexus regions. The role of algorithm is to learn how the data is related to the outcome, thus training a model that can be tested and used against data not included in its training (learning) phase.

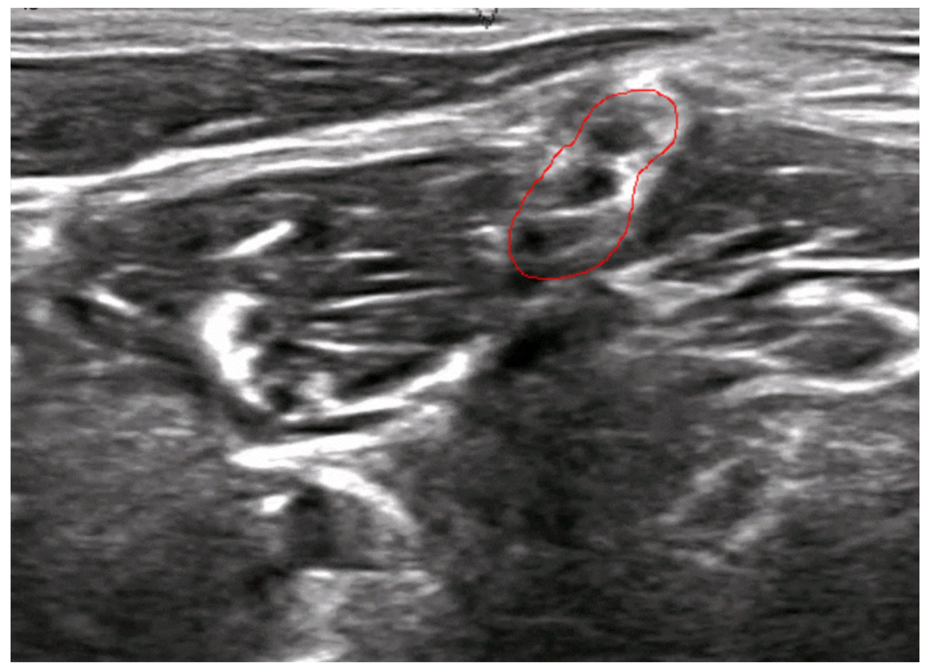

Figure 4: Annotated ultrasound image of brachial plexus

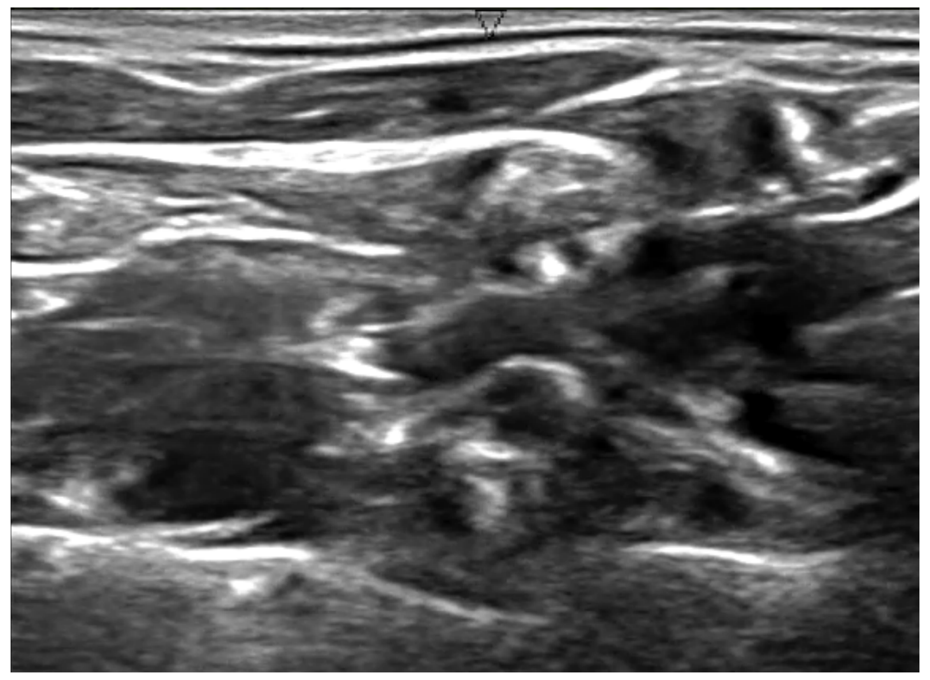

Figure 5: Unannotated ultrasound image to test algorithm

Datasets (images) courtesy of Kaggle.com

Conclusion

Machine-learning-aided detection and classification in medical imaging is of increasing importance to patient care. The rapid expansion is a consequence of the need for more accurate, cost-effective, and less invasive treatment. Methods as described in this poster create a model to solve detection and classification of new data, as well as provide an evaluation process for accuracy and inaccuracy to enhance consistency and reliability in patient care.

Future Research

1. Produce results from least squares regression method
2. Increase efficiency with more advanced algorithms
3. Broaden the scope and target of this algorithm

References

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MedCalc.

Acknowledgements

The authors acknowledge the support of the Semiconductor Research Corporation (SRC) Education Alliance (award #2009-UR-2032G) and Maseeh College of Engineering and Computer Science (MCECS) through the Undergraduate Research and Mentoring.

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