

Phillip Oh

Critical Review: Needle Localization using a Moving Stylet/Catheter in  
Ultrasound-Guided Regional Anesthesia: a Feasibility Study

Ultrasound needle guidance is important for surgeons to make sure that the appropriate needle target is found and to protect patient's vital structures from the needle itself. This paper describes a method of localizing a needle tip position using an ultrasound and a moving stylet in order to solve some of the issues brought by current methods of ultrasound based guidance methods. As our project's main goal coincides with this paper's main goal of ultrasound needle guidance, there may be some important takeaways from some of the ways that this group approached the problem.

The experimental setup used an ultrasound probe and a Tuohy epidural needle, along with three types of insertions: a plastic stylet, steel stylet, or plastic catheter. The needle was placed on a guide on the ultrasound probe, which keeps it in plane with the ultrasound image. Two different media were used to test this method: water as well as bovine muscle tissue. The stylet/catheter was moved within the cannula in 5mm increments, with 10 sets of data points taken, from fully inserted to fully removed.

The basic algorithm uses a set of two ultrasound images as its data input. The two images are of the stylet in one position and then moved to another position. The difference of these two images is performed in order to remove some background from the tissue, then edge detection is done to find the needle. The initialization set uses a Hough transform to calculate the axis of the needle, and localizes the motion to the needle axis, in order to remove the influence of any tissue motion. The equation of the needle is found using a polynomial fit to find the shaft trajectory, and the further of the two stylet points is the position of the stylet tip after the movement is performed.

The needle tip position is found after performing this method on the full range of stylet positions, where the needle tip is the furthest point along the needle.

The ground truth was chosen as the shaft orientation manually selected on the B-mode image and the needle location is found by the actual measured distance the stylet tip is from the needle tip. The results show .51 mm RMSE in the needle tip in a water bath using the plastic stylet and a .33 mm RMSE in the needle tip in the tissue, these results being the best tool in their respective medium.

Some aspects of the paper that were well done was the explanation of the algorithm, in that the overall picture was concisely but clearly explained. However, some of the details were unclear, such as what the difference was done, whether it was between two positions of the stylet, or two continuous readings from the ultrasound. The method is useful in that the equipment needed is a needle and catheter, which will probably be necessary for other parts of any medical procedure this method would be used with, and an ultrasound. No other equipment is necessary aside from a computer able to perform these computations.

Some criticisms of the method was that it required the needle to be within the ultrasound plane, which limits the movement of the needle and requires both ultrasound and needle to be moved simultaneously. Another point is that the process of moving the stylet up and down the cannula to localize the needle must be done whenever the needle is moved to find the new tip of the needle and must be done when the needle is fixed, which means it will be difficult to perform real time. However, the paper is a feasibility study, and these are criticisms to be further explored if a method like this is to become used in the clinical setting.

Some criticism of their methods was that there could have been more sample points taken, as there was only 10 for each stylet/medium pairing. A statistical analysis of the significance of the differences could also have been helpful, which was not provided. Another criticism is that they mention methods to localize the motion, but within the trials, there is no mention of the water or tissue moving (as the tissue was not living tissue), and therefore may be safe to assume that the movement noise portion of their technique was not tested fully.

This paper was helpful in providing some insight into other approaches that people have done to solve the problem our project hopes to solve. However, the main issue, which seems to be needle visibility due to needle reflectance is solved differently in our project: while they use the moving stylet method to localize the shaft, we use an active source at the needle tip, so that we do not rely on the echo from any signal from the ultrasound probe itself. Some takeaways from this method could be ways of reducing some error in B-mode images, which we use in locating the active echo point, instead of a line, as well as somewhat of a guideline to perform our analysis of our technique and some baseline numbers for acceptable levels of precision.