Machine Learning Report – Modeling Acoustic Waves in Nonhomogeneous Mediums Project

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After doing research on machine learning, situation does not exactly fit into the situation of either: machine learning is used in the research space or the other which is that machine learning is not used in the space. Machine learning is in the infancy of application in ultrasound imaging. Machine learning has been tried with ultrasound imaging, but the research is at a point where different machine algorithms have been used for various functions without leading to any definite conclusion that most of researchers in the field agree on. So, I will write about what researchers think machine learning can take ultrasound technology and then I will write the situation machine learning is in right now and why machine learning could be limited.

Typical machine learning algorithms of segmentation, registration, tracking, and content retrieval; would work well with the needs presented by ultrasound imaging. Segmentation would be helpful for defining the boundaries between organs or specific muscle tissues in the body from an image. This can be used for programming in the back end of image algorithms so when an ultrasound image is taken, you can up some contrast at the boundary of the heart, for example, so an image can be understood easier for the average person. Another example I find interesting would be for robotic surgery. Ultrasound imaging could become an option for robotic surgery if segmentation with machine learning is possible because the ability for a machine to accurately identify organs, the blade, etc. with a sensor that does not have the risks of radiation or require high magnetic fields like an MRI could open up possibilities for robotic surgery that we have not seen before. Segmentation would be difficult due to ultrasound data often has noise in the form of speckles, shadows, and missing boundaries. Machine learning could, conveniently, possible offer a solution to the issue of noise with ultrasound images. Algorithms can check image quality and assess useful "biomarkers", i.e. recognizing key biological

features to understand where the image is coming from and make a guess of a higher resolution image from multiple noise filled images (a simple way to think about it is that it recognizes some biomarker and then constructs a high resolution image from super imposing high resolution areas from multiple images).

Ultrasound is typically used in a setting of a two or three dimensional feed of image data on display that an expert would interpret. There is an interesting debate if the goal of machine learning would be used to try to out right replace the need for an expert to interpret the image or assist in making the imaging easier to read by adjusting contrasting, colorizing the image, or noise correction. All of these functions from machine learning theoretically lead to better disease detection and more precise understanding from the image which might lead ultrasound to be more practical for a wider variety of uses. So this leads into the topic of how could we quantify how useful machine learning is to ultrasound imaging.

The main weakness of machine learning would probably be the issue of data. Medical data is difficult to come by due to the ethics of releasing someone's personal data to medical research. Researchers think that there may not be enough data to have a supervised machine learning algorithm to be able to form a strong enough set of weights. Also, it would be a large task to label all the data points too because each image would most likely have to be inspected by an expert with ultrasound images. While machine learning has some promising functionalities that can be useful, there is enough reason to doubt if there is enough data at this time for machine learning to be effective at this time. Perhaps a dataset large enough does exist, but as time goes on there will be a higher probably that there will be enough data points for a machine learning algorithm to run. So Unsupervised Machine Learning is of more interest to the field now versus the Supervised Machine Learning.

In my research, machine learning is applicable. For ultrasound simulation, I would probably use it for creating simulations to mimic real life simulations or for creating higher resolution with image correction in real time. The interesting part is that my research could potentially make machine learning more viable by using simulated images to train a machine to try to get around the limitation of the lack of data in the field. [1][2][3]

[1]   S. Liu *et al.*, "Deep Learning in Medical Ultrasound Analysis: A Review," *Engineering*, vol. 5, no. 2, pp. 261–275, Apr. 2019.

[2]   L. J. Brattain, B. A. Telfer, M. Dhyani, J. R. Grajo, and A. E. Samir, "Machine learning for medical ultrasound: status, methods, and future opportunities.," *Abdom. Radiol. (New York)*, vol. 43, no. 4, pp. 786–799, 2018.

[3]   Q. Huang, F. Zhang, and X. Li, "Machine Learning in Ultrasound Computer-Aided Diagnostic Systems: A Survey.," *Biomed Res. Int.*, vol. 2018, p. 5137904, 2018.

Links to Sources:

[1] https://www.sciencedirect.com/science/article/pii/S2095809918301887

[2] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5886811/

[3] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5857346/