Machine Learning for Automated Ultrasound-Guided Infant Lumbar Puncture

Background / Objectives:

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Lumbar puncture (LP), also known as spinal tap, is a procedure used to diagnose or treat various health conditions. For this procedure, a hollow needle is inserted in the lower back and into the space surrounding the spinal column, to extract cerebrospinal fluid (CSF) or inject therapeutics. One common use case of LP is to diagnose meningitis in infants, yet the success rate of this procedure in infants is remarkably low (50-60%). Studies have shown that preprocedural ultrasound imaging can improve procedure success by allowing physicians to view the vertebral interspace directly; however, reading ultrasound images requires special expertise, which many physicians lack. To aid physicians in reading ultrasound images of the vertebral interspace, we aim to develop artificial intelligence models to automatically identify key features within these images, such as spinal cord and fluid.

Objectives:
1. Develop a model framework to assess image quality and identify spinal cord/fluid within single-frame ultrasound images.
2. Identify optimal computer vision model architectures for the above multi-label task.
3. Generalize models to achieve optimal performance over a variety of ultrasound image batches, ensuring maximum clinical relevance.

Goals:

1. Leverage literature to determine best practices for ultrasound image pre-processing.
2. Adapt existing computer vision models to determine image quality and the existence of spinal cord/fluid.
3. Fine-tune computer vision models to achieve the best results over ultrasound images collected by a variety of physicians.

Technical Indicators:

1. Take a video of spinal ultrasound as input.
2. Split video into frames and store the resulting set of images.
3. Feed images into the computer vision model to generate a set of classes for each image.
4. Generate a combined set of scores based on the distribution of classes among the images.
5. If the overall quality of the images is deemed to be poor, instruct the user to try taking another video. Otherwise, alert the user of spinal cord/fluid presence.

Stakeholders:

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- Ritvik Khandelwal
- David Kessler, MD
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Business Value:

1. Improved success of lumbar puncture procedures in infants.
2. Reduced need for extensive physician training to properly read ultrasound images.

Project Milestones:

1. Study Development (TBA)
2. Carryout study (TBA)
3. Evaluate study results (TBA)
4. Disseminate results (TBA)