Classification of Neonatal Brain Ultrasound Scans Using Deep Convolutional Neural Networks

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Motivation

Neonatal neurosonography (NS) is a non-invasive medical imaging technique used to evaluate the neonatal or infant brain for abnormalities (e.g., hydrocephalus, hemorrhages, infections) using ultrasound imaging[1]. Conventionally, ultrasound images of the neonatal brain are acquired through the anterior fontanelle, an opening in the skull present in infants. Recent work has demonstrated success in annotating a broader class of radiological images using deep convolutional neural network (CNN) analysis of medical images[2]. However, these methods have been difficult to apply to ultrasound images due to their unique noise properties and arbitrary measurement angle.

Medical Data

With the assistance of pediatric radiologist Dr. Safwan Halabi, we have over 200,000 NS images, corresponding to 333 patients, along with their medical reports. Each report was manually tagged with keywords (e.g., “normal”, “hemorrhage”, “ventriculomegaly”, etc.).

Learning Pipeline

NLP was used to extract relevant text from the medical reports. An additional 2039 textual medical reports were obtained from the LPCH PACS, and the entire corpus of 2372 reports was used to generate a vocabulary of 1543 unique recurring words. Latent Dirichlet allocation[3] (LDA) was used to model each document as pertaining to a mixture of 10 latent “topics”. The model was trained on the 2039 textual medical reports.

Architectures

The Deep CNN Architecture trained a subset of the image data to classify ‘normal’ or ‘not normal’ with 77% accuracy. More training will be done using the full dataset on the Deep CNN network along with other architectures such as AlexNet[7]. The LDA model classified medical reports as ‘normal’ or ‘not normal’ with 84% accuracy. More training will be done using the full dataset on the LDA network along with other architectures such as AlexNet[7].

Report Natural Language Processing (NLP)

NLP was used to extract relevant text from the medical reports.

Ultrasound Images

- Physician’s Impression
- Radiologist Raw Report

- Image and video data
- DICOM Header Data

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Top Words for Selected Topic

<table>
<thead>
<tr>
<th>Topic</th>
<th>Top Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>bilateral small hemorrhage periventricular</td>
</tr>
<tr>
<td>5</td>
<td>region note lesions a mass</td>
</tr>
<tr>
<td>7</td>
<td>mass increase indigo cerebral_artery intracranial</td>
</tr>
<tr>
<td>8</td>
<td>normal head ultrasound unremark</td>
</tr>
<tr>
<td>9</td>
<td>echogenic fluid incresa white_mastis ischemic</td>
</tr>
</tbody>
</table>

Results

The Deep CNN Architecture trained a subset of the image data to classify ‘normal’ or ‘not normal’ with 77% accuracy. More training will be done using the full dataset on the Deep CNN network along with other architectures such as AlexNet[7].

The LDA model classified medical reports as ‘normal’ or ‘not normal’ with 84% accuracy. More training will be done using the full dataset on the LDA network along with other architectures such as AlexNet[7].

References:

[1] AVM Practice Parameter for the Performance of Neurosonography in Neonates and Infants