Classification of Neonatal Brain Ultrasound Scans Using Deep Convolutional Neural Networks

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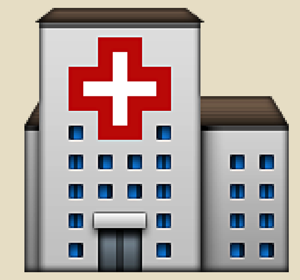
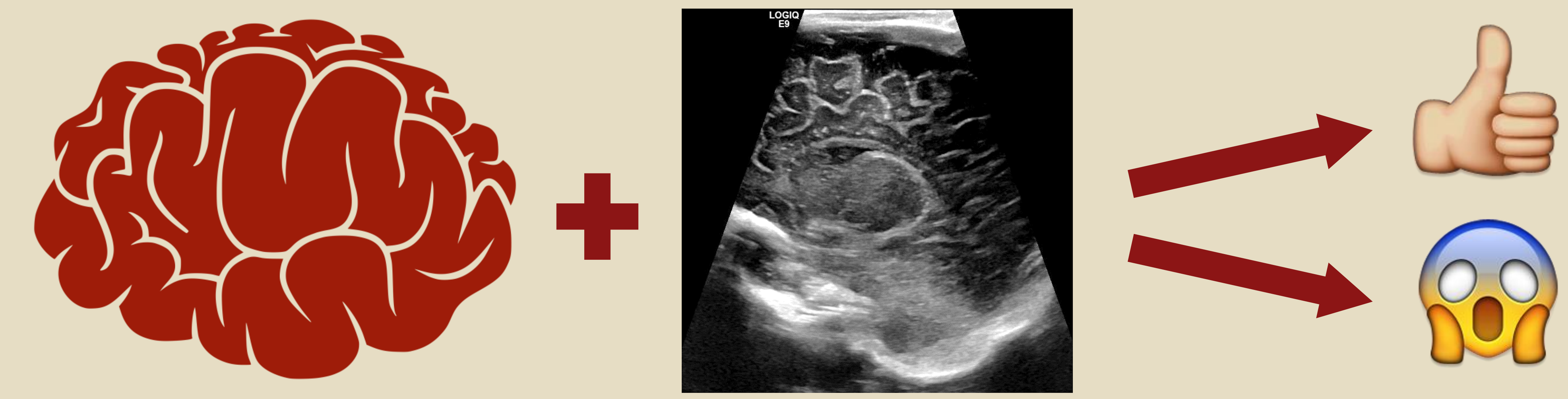
Motivation



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.

Project Goal

Using NLP and CNNs, we will extract useful information from a pre-existing dataset of medical data to classify new Ultrasound Images as 'Normal' or 'Something Wrong'



Trained Neural Network **New Patient Images** **Classification**

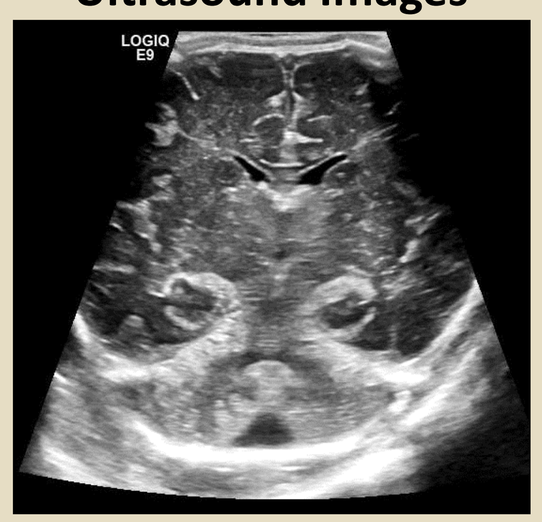
Medical Data

Lucile Packard Children's Hospital Stanford

Medical Reports

- **Physician's Impression**
- **Radiologist Raw Report**

Ultrasound Images

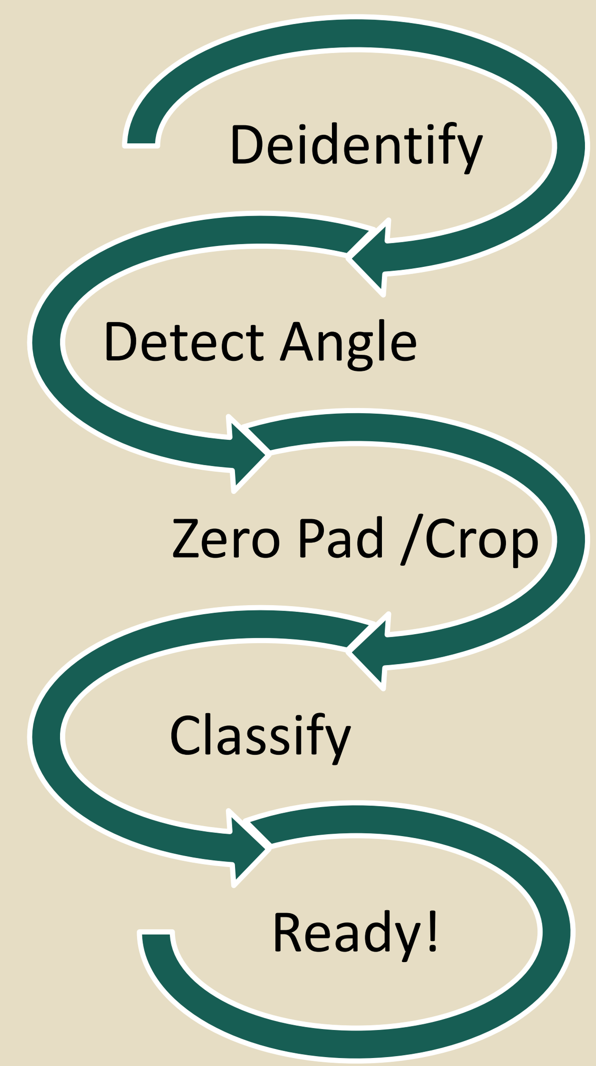


- **Image and video data**
- **DICOM Header Data**

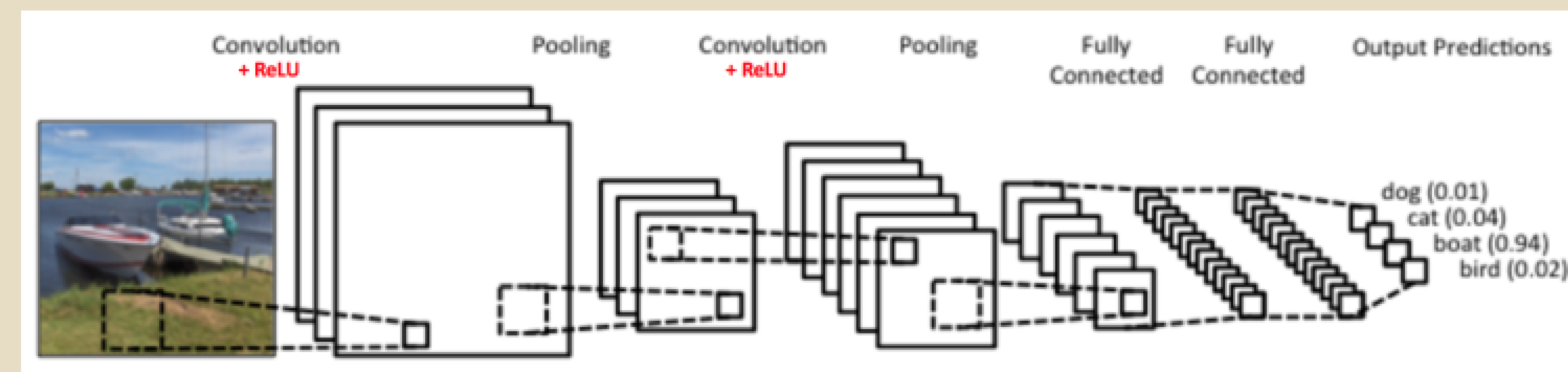
With the assistance of pediatric radiologist Dr. Safwan Halabi, we have over 200,000 NS images, corresponding to 333 patients, along with their medical reports. Each report was manually tagged with keywords (e.g., "normal", "hemorrhage", "ventriculomegaly", etc.).

Learning Pipeline

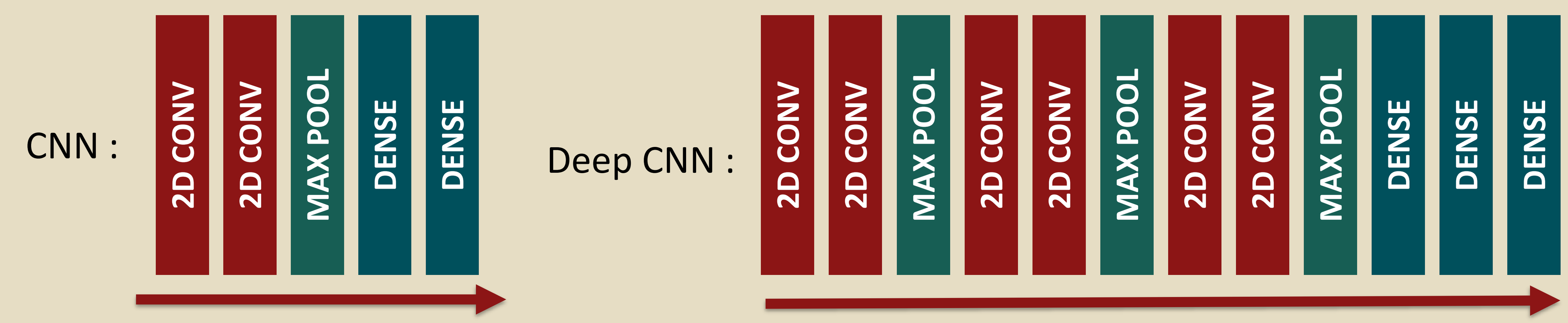
Preprocessing



Convolutional Neural Network

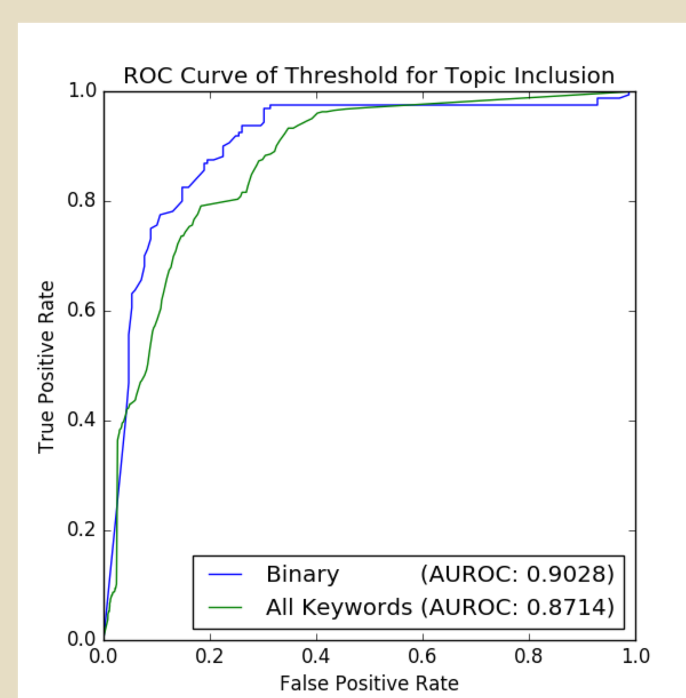


Architectures



Report Natural Language Processing (NLP)

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 text-only reports, and the resulting topics were manually tagged with keywords. The model was then used to generate topics for the 333 reports in the test set. The keywords associated with the predicted topics were tested against the manually tagged keywords in a binary classification and a full keyword comparison task.



Top Words for Selected Topics
Topic 0: bilater small hemorrhag periventricular
Topic 5: region note lesion x mass
Topic 7: resist increas indic cerebral_arteri intracrani
Topic 8: normal head_ultrasound unremark
Topic 9: echogen find increas white_matt ischem

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 and assigned keywords with 74% accuracy for a topic probability threshold of 0.25. The area under the ROC curve was found to be 0.90 and 0.87 for the binary and full keyword tasks, respectively.

References:

[1] AIUM Practice Parameter for the Performance of Neurosonography in Neonates and Infants
[2] Shin, H. C., Lu, L., Kim, L., Seff, A., Yao, J., & Summers, R. M. (2015). Interleaved text/image Deep Mining on a large-scale radiology database. *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, *7-12- 2015*, 1090–1099. http://doi.org/10.1109/CVPR.2015.7298712)
[3] D. M. Blei, A. Y. Ng, and M. I. Jordan. Latent dirichlet allocation. *Journal of Machine Learning Research*, 3:993– 1022, 2003.
[4] Moses Charikar, Kevin Chen, Martin Farach-Colton, *Finding Frequent Items in Data Streams* , Rutgers Computer Science, Google Preceedings
[5] Clarifai Technology (https://www.clarifai.com/technology) for CNN image
[6] Kiros,R, Zhu, Y. , Salakhutdinov, R, Zemel, R, Torralba, A. , Urtasun, R. Fidler, S. *Skip-Thought Vectors* University of Toronto, 2015
[7] Krizhevsky, A., Sutskever, I., Hinton, G. *ImageNet Classification with Deep Convolutional Neural Networks*, University of Toronto,