Using Artificial Intelligence to Interpret Pneumonia CXR (chest X ray) Findings in Children with a Phone Application Platform

Russel Thompson,[1] Jason Li,[2] Kaihong Wang,[2] Lauren Etter,[3] Ingrid Camelo,[4] Ilse Castro,[5] Bindu Setty,[5] Hailey, Chang,[5] Margrit Betke,[2] Rachel Pieciak,[6] Christopher Gill[6]
College of Engineering, Worcester Polytechnical Institute[1] School of Arts and Sciences, Boston University[2], College of Engineering, Boston University[3], Pediatric Infectious Diseases Department, University of Massachussetts[4], Radiology Department, Boston Medical Center[5], School of Public Health, Boston University[6]

BACKGROUND

Globally, pneumonia is the leading cause of death in children <5. In hospital settings CXRAY is the most widely available tool.

There is a need to simplify and expedite its interpretation due to constrains about internet access and on-site health care workers with training to interpret the images.

Convolutional networks with built in training techniques for classifying X-ray images as normal or abnormal based on open-source datasets can be used for this purpose.

The model can be mounted on a simulated mobile app to make CXR image interpretation possible. But the processing power of cellphones is rate limiting.

MATERIALS AND METHODS

We used 6543 CX-ray images from the PERCH (Pneumonia Etiology Research for Child Health) project including children 0-59months with pneumonia to train the model.

ResNet-50 convolutional neural network was used to sort, process it and categorize each as normal (no pneumonia)l or abnormal (pneumonia).

To minimize processing requirements, the model was optimized for mobile deployment using the *Tensor Flow Lite (TF Lite) Task Library.* The model interfaces are designed for each task to reach the best performance and usability when deployed on a simulated mobile application.

This allows the model to classify X-rays in real time through the App using the phones' native camera.

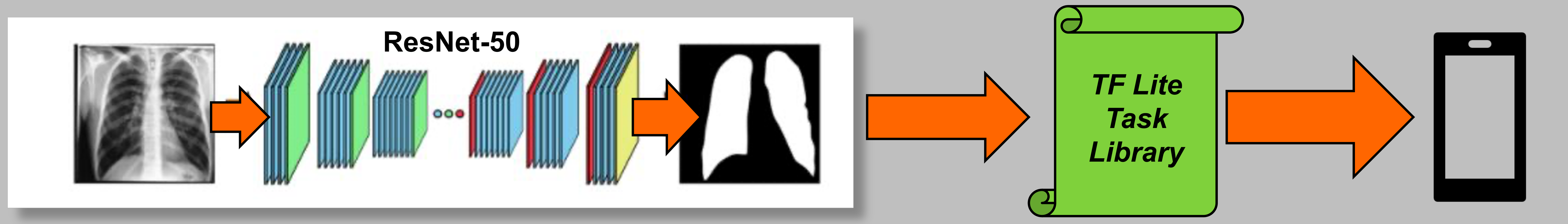

Fig 1. Model architecture, from loading images for classification, to optimization and final interpretation on App

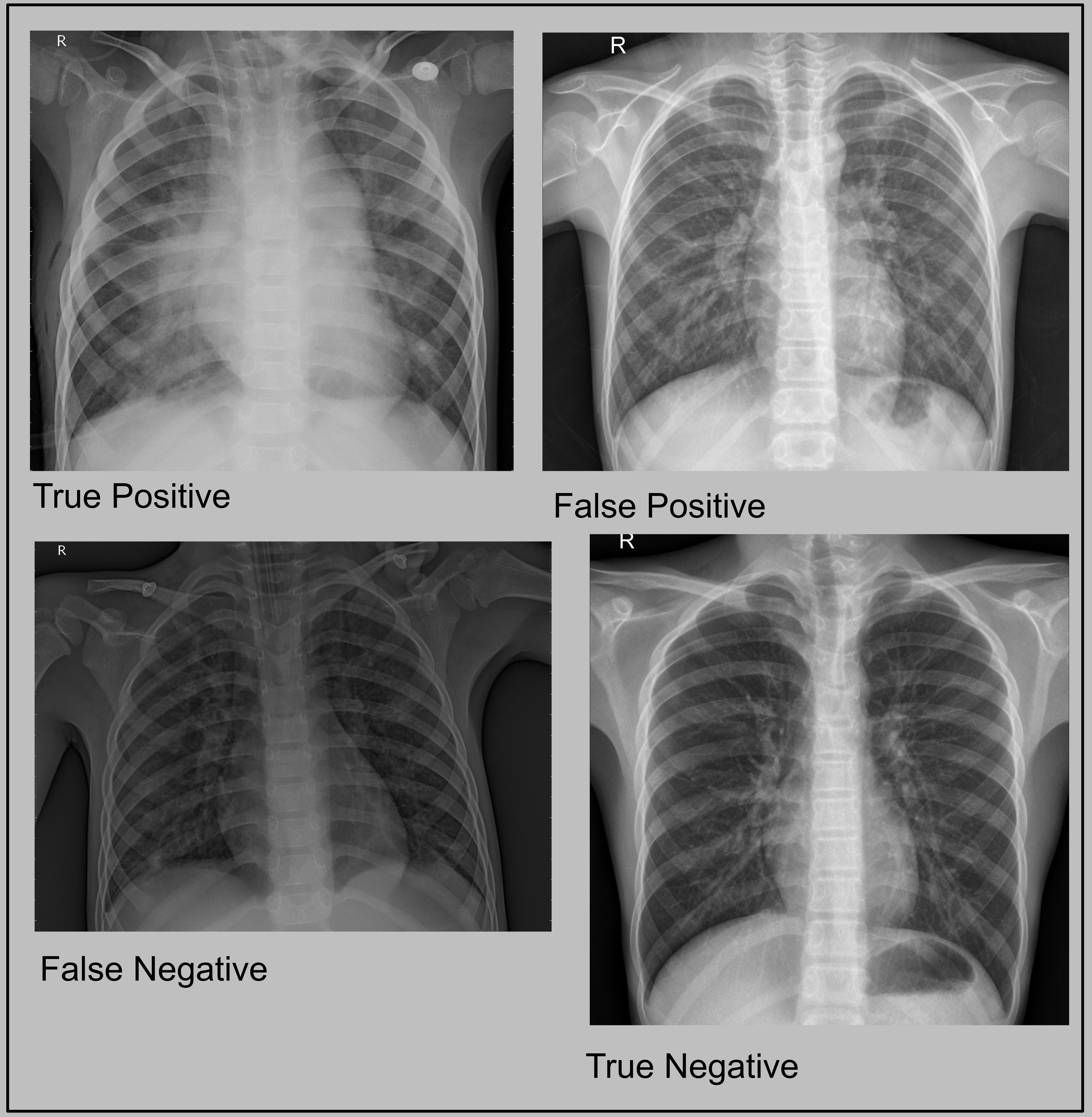

Fig 2. Confusion matrix examples of True Positive, True Negative, and False Negative.

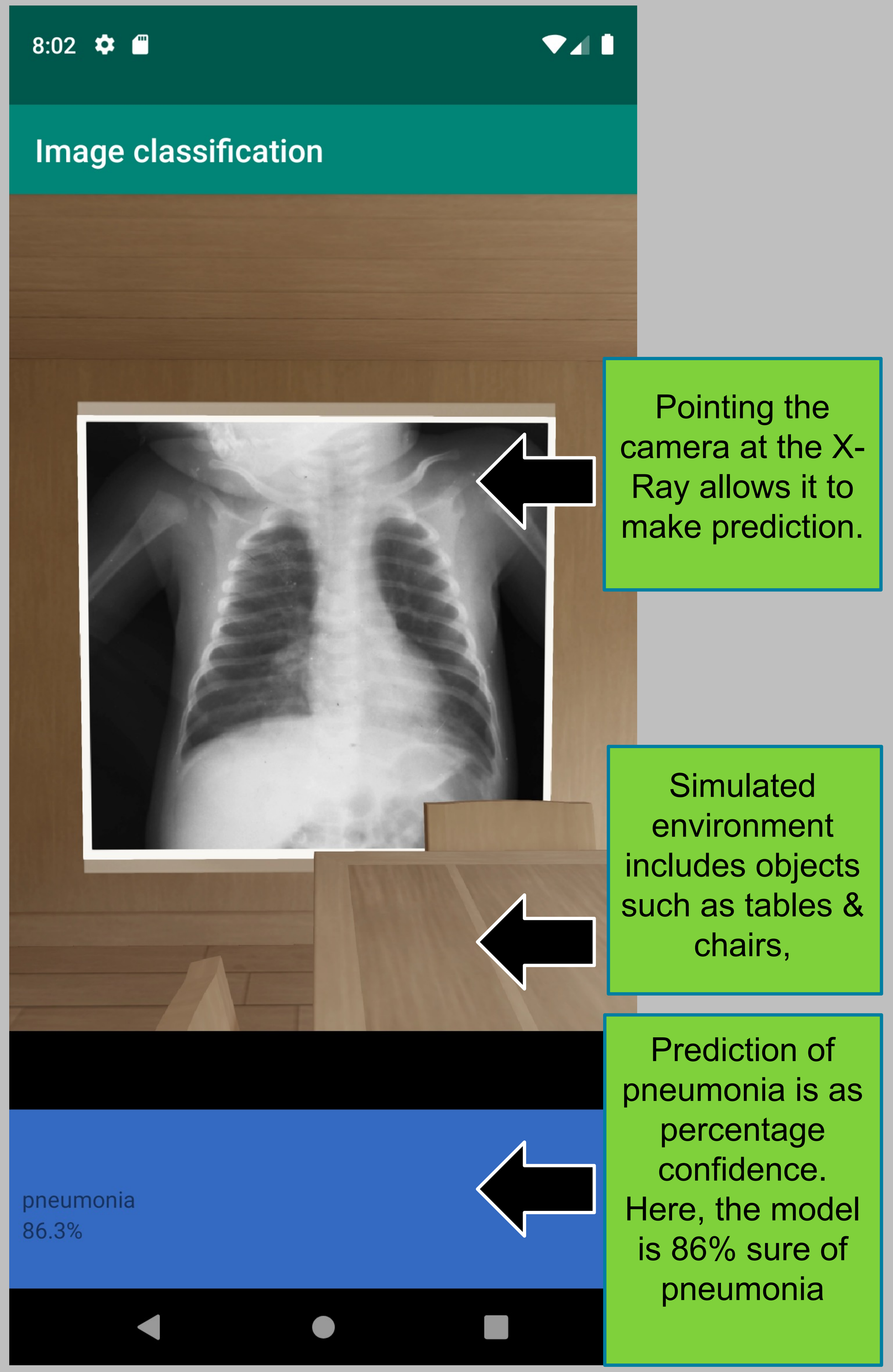

Fig 3. Example of App in use within the standard android simulated environment.

RESULTS

Using 5-fold cross validation upon the 6543 CXR images, the pre-transformed ResNet-50 model performed achieved 94% accuracy, with a specificity of 92.1% and a sensitivity of 97%.

After undergoing the TF Lite conversion, the model achieved 91.12% accuracy, 90.7% specificity and 96.0% sensitivity to detect pneumonia findings present in the CXRs in the same 5-fold cross-validation tests.

This performance was further tested by placing CXRs in the android device simulated environment to test probable real world camera usage behaviors. Upon a random sample of 20 images split evenly between pneumonia and non pneumonia, the model properly classified 18 of the images within the simulated environment, including 10 of the non pneumonia and 8 of the pneumonia positive ones.

CONCLUSION

A model can be created and trained to recognize abnormal findings by using convolutional networks. Such classification can be done with high sensitivity ~ 96.0% by incorporating a previously loaded artificial intelligence recognition patterns into a mobile phone App.
The application's performance in the simulated environment supports that the TF Lite model is still able to accurately classify images when using a device's camera.

REFERENCES

1. Ayan E, Karabulut B, Ünver HM. Diagnosis of Pediatric Pneumonia with Ensemble of Deep Convolutional Neural Networks in Chest X-Ray Images. Arab J Sci Eng. 2021 Sep 12:1-17. doi: 10.1007/s13369-021-06127-z. Epub ahead of print.
2. Maior CBS, Santana JMM, Lins ID, Moura MJC (2021) Convolutional neural network model based on radiological images to support COVID-19 diagnosis: Evaluating database biases. PLoS ONE 16(3): e0247839. https://doi.org/10.1371/journal.pone.0247839.
3. 3. Rahimzadeh M and Attar A. A modified deep convolutional neural network for detecting COVID-19 and pneumonia from chest X-ray images based on the concatenation of Xception and ResNet50V2,. Informatics in Medicine Unlocked, Volume 19, 2020. https://doi.org/10.1016/j.imu.2020.100360.
4. 4. Umar Ibrahim A, Ozsoz M, Serte S, Al-Turjman F, Habeeb Kolapo S. Convolutional neural network for diagnosis of viral pneumonia and COVID-19 alike diseases [published online ahead of print, 2021 Apr 26]. Expert Syst. 2021;e12705. doi:10.1111/exsy.12705