Using Machine Learning to Objectively Determine Results of Colorimetric Assays from Cell Phone Photos with Ambient Lighting

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Abstract:

The focus of this study is to design a machine learning model that can classify alcohol test strips as positive or negative from cell phone photos taken under non-standard conditions. A software algorithm that can objectively determine results from colorimetric assays under non-standard conditions will improve the accessibility and portability of these strips, supporting point-of-care testing. To do this, the team is currently training a model from images of test strips. The accuracy of classifying the samples under these conditions will be evaluated and is expected to be able to adequately provide qualitative results.

Background:

1. Lateral flow immunoassays (LFA) are currently one of the most prominent methods for early detection of diseases within point-of-care testing due to their inexpensive cost, quick response time, and portability [1].
2. Current solutions typically consist of creating a reader that can standardize the conditions of the strips before they are measured in some way, which adds to the cost and decreases the portability and accessibility of LFAs.
3. Machine learning techniques such as deep learning and computational neural networks have previously been used and shown to be successful for medical imaging processing and analysis [2].

Methods:

Videos of strips taken under different backgrounds, lighting, and angles

Data Collection: Videos→ Photos

Model Selected: Convolutional Neural Network (CNN)

Training Data: 5,000 positive 5,000 negative
Testing Data: 1,000 positive 1,000 negative
Confusion Matrix: 100 images
(50 positive, 50 negative)

Keras | TensorFlow | Spyder

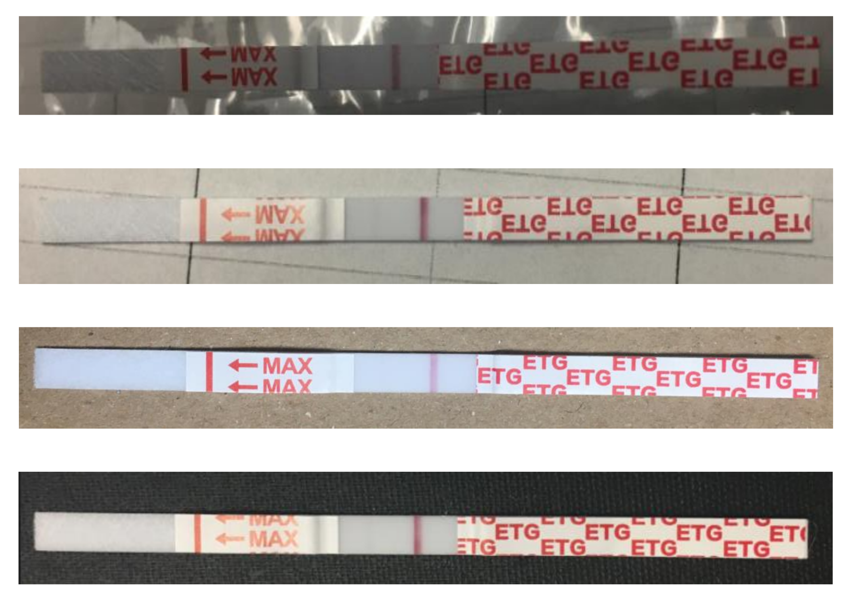

Figure 1. Different backgrounds and lighting conditions under which videos of the strips were taken

Results:

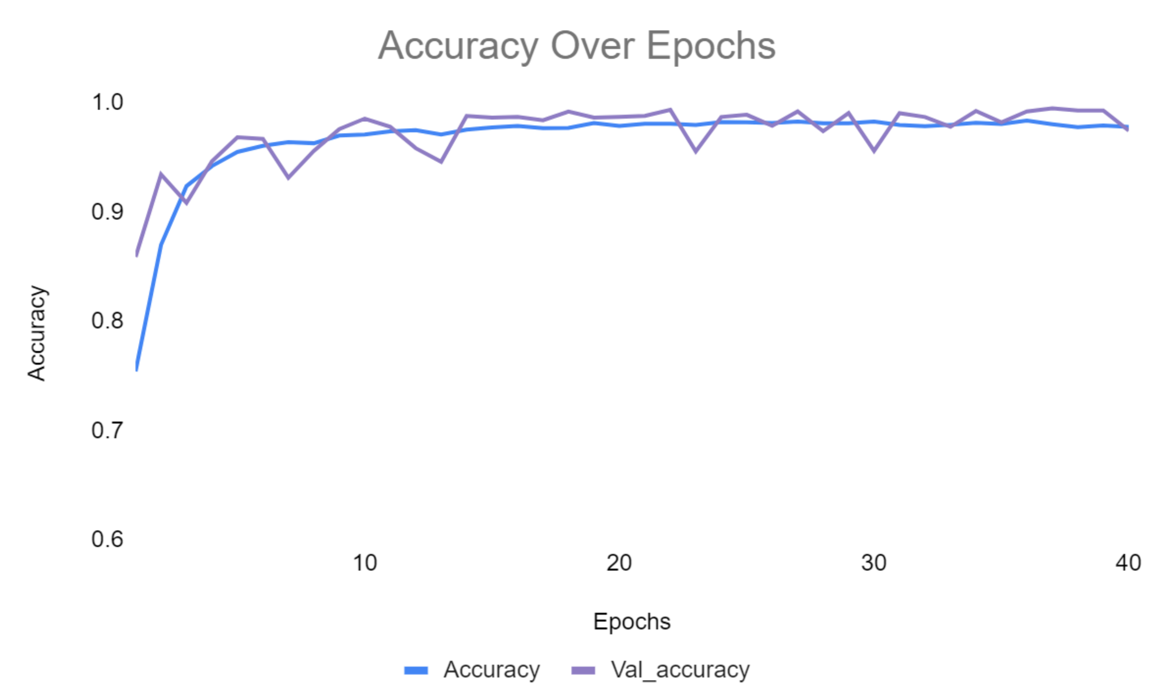

Figure 2. This figure shows the accuracy of the model for the training and validation data over epochs. After 20 epochs, the validated accuracy fluctuates between 95% and 99%.

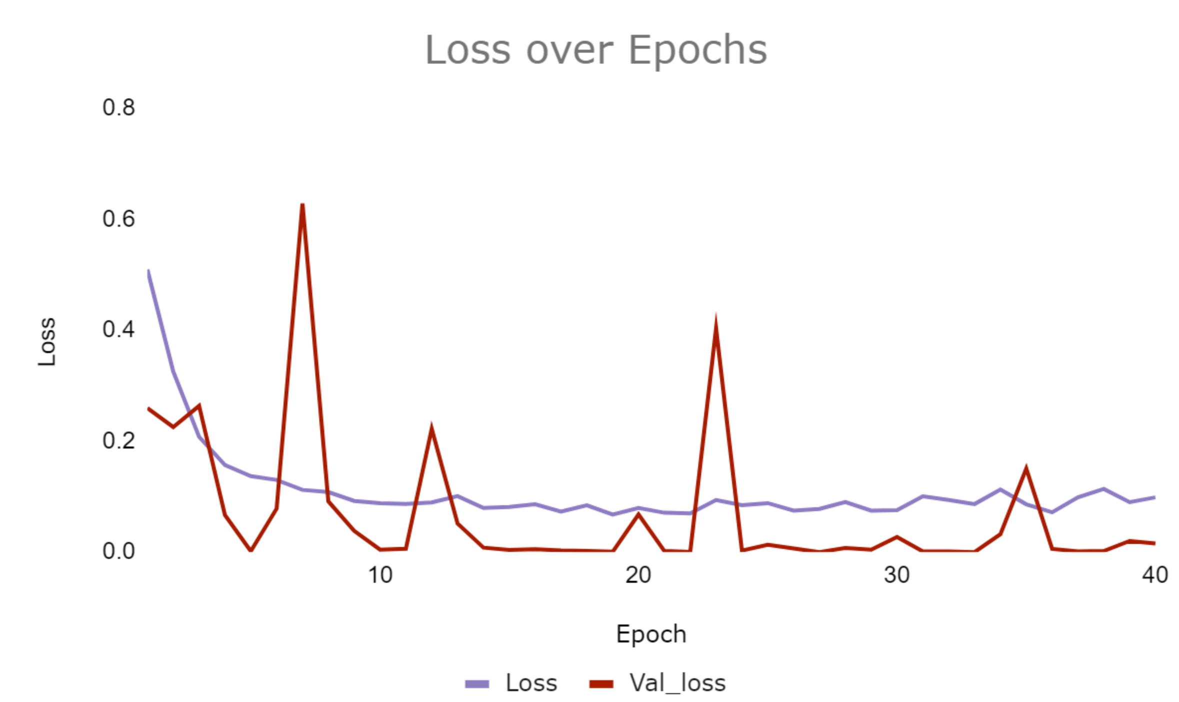

Figure 3. This figure shows the training and validation loss functions. After 8 epochs, the loss of the training data stays below 0.1. There is a large amount of variability within the validation loss function with periodic spikes.

Future Work:

- Create a model that is able to qualitatively estimate the amount of antigen present
- Detect when results are invalid
- Increase accuracy
- Create one model for several types of test strips that work through a similar mechanism (i.e. ETG, fentanyl, morphine, etc.)

Acknowledgements:

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References:

[1] Koczula, K. M., & Gallotta, A. (2016). Lateral flow assays. *Essays in biochemistry*, *60*(1), 111–120. https://doi.org/10.1042/EBC20150012

[2] Razzak, Muhammad & Naz, Saeeda & Zaib, Ahmad. (2018). Deep Learning for Medical Image Processing: Overview, Challenges and the Future. Retrieved from https://arxiv.org/abs/1704.06825

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