Black Box to automatically annotate images

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1. **Motivation**

With the fast development of camera technology, millions of medical images are taken either in a clinical trial or biomedical research. However, to do downstream analysis with these images, labeled images are needed. I want to resolve this issue by designing a black box (model) to automatically annotate images because manually labeling millions of images is impossible.

1. **Data Description**

To test and experiment with my new model (black box), I chose the medical benchmark dataset, MedMNIST, A Large-Scale Lightweight Benchmark for 2D and 3D Biomedical Image collection. I chose the two datasets from it to implement the binary classification task. One is the chest dataset. Another is the breast dataset. Text, letter

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Graphical user interface, text, application

Description automatically generated

1. **Design Model**

I used three stages to build this new model pipeline. The first stage is to directly apply the zero-shot CLIP (contrastive language image pre-trained) model to the mixture dataset of chest and breast. I get the prediction classification results. I treat the labels from the first step as “true labels” to the mixture dataset and feed them together into a convolutional neural network. The second stage is to train this CNN with these “true labels.” The third stage is to evaluate this combined model and compare it with the zero-shot model only. I figured the workflow (pipeline) of this three-stage modeling like the below plot; the orange box represents the main stages (models), and the blue box represents the operations. I also used a detailed model architecture plot for the zero-shot CLIP model and Convolutional Neural Network. The CLIP pre-trained model is trained to maximize the cosine similarity score between paired image and its text caption and learn the image encoder and text encoder. The convolutional neural network is to learn the different local image patterns while reducing the resolutions and using cross-entropy to minimize the loss function.

Feed Images into CLIP

A picture containing diagram

Description automatically generated

Stratified split the mixture dataset into training and test set

Diagram

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4. Feed Training and prediction into CNN

Diagram

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Apply the trained model on the test to compare with results from CLIP only

Feed zero-shot prediction into CNN

Chart, box and whisker chart

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1. **The new model results as compared to the CLIP model only**

To generalize the experimental results and show my new model improved the annotation accuracy, I tested the new model 30 times on the different random training and test set. As the left boxplot shows, my new model, on average, improves the held-out test set 6% and 8% F1 score on this chest and breast binary task. My new model can correct wrong labels generated by CLIP because CNN is powerful enough to learn the general pattern for each category from the majority of correct labels and images. This can be shown in the below graph: the CLIP model mislabels the third and fourth images as breast; however, my new model can correct some mislabeling images; for example, it predicts the third and fourth as a chest.

A picture containing graphical user interface

Description automatically generated

1. **Next steps**: I plan to employ Monai pre-trained medical image models in the current zero-shot CLIP architecture once OpenAI publishes its training codes.