BLG 506E – COMPUTER VISION

Final Project Presentation

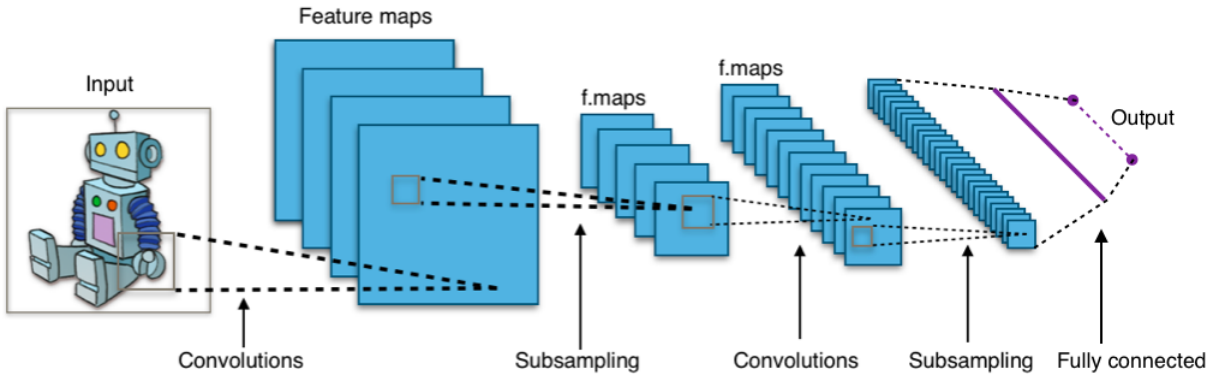
BURAK BOZDAĞ - 504211552

About the Project

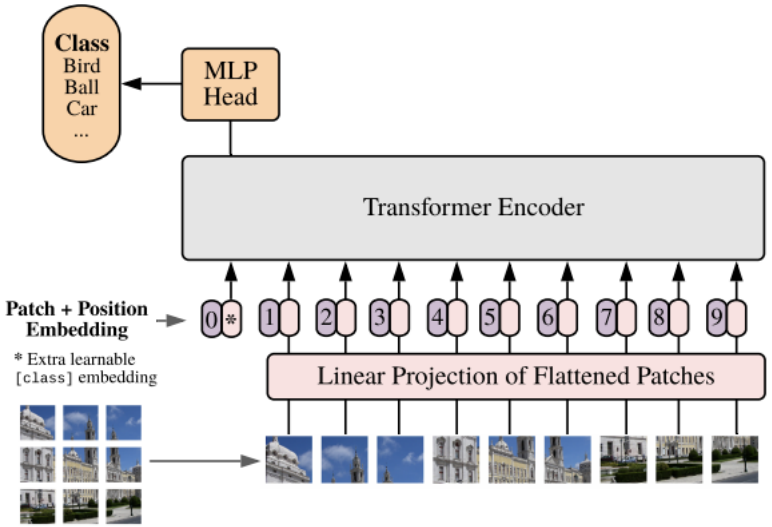
Classifying Chest X-Ray Images Using CNN and Transformer Based Architectures

Comparing CNN and transformer models for classifying patients as normal or infected

CNN



Vision Transformer (ViT)



Motivation

- CNN is a standard in CV
- Transformer based models in NLP

- A. Dosovitsky et al., "An Image is Worth 16x16 Words: Transformers for Image Recognition at Scale", 2021. Available: https://openreview.net/forum?id=YicbFdNTTy.
- Transformers applied directly to image patches and pre-trained on large datasets work really well on image classification.

- Find out which is better for classifying x-ray images

Applied Processes and Methods

- TensorFlow, Keras
- Examining Dataset
- Data Augmentation
- ViT Evaluation
- CNN Evaluation

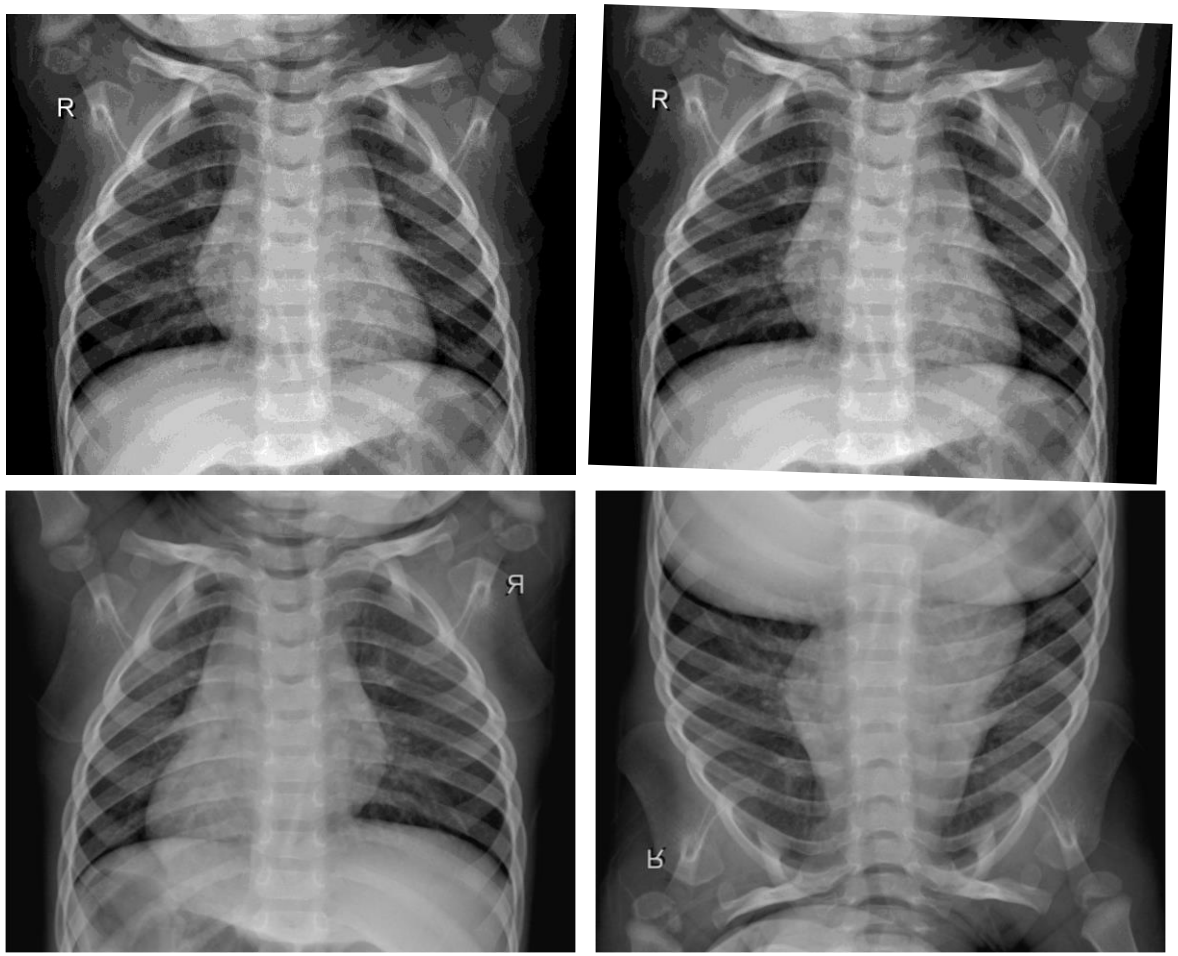
Dataset

- Chest X-Ray Images (Pneumonia) [1]
- 5856 JPEG images (1.15 GB)
- 5216 train
- 16 validation
- 624 test

```
(amd_gpu) PS C:\Users\Burak\Desktop\BLG506E-CV\Project> python .\chest_xray.py
2022-12-04 12:27:44.250691: I tensorflow/c/logging.cc:34] Successfully opened
2022-12-04 12:27:44.250771: I tensorflow/c/logging.cc:34] Successfully opened
2022-12-04 12:27:44.252886: I tensorflow/c/logging.cc:34] Successfully opened
2022-12-04 12:27:44.391692: I tensorflow/c/logging.cc:34] DirectML device enume
Found 5216 images belonging to 2 classes.
Found 16 images belonging to 2 classes.
Found 624 images belonging to 2 classes.
```

Data Augmentation

- Rescale = 1/255
- Zoom Range = 0.1
- Rotation Range = 0.2
- Horizontal-Vertical Flip
- 224x224 WxH



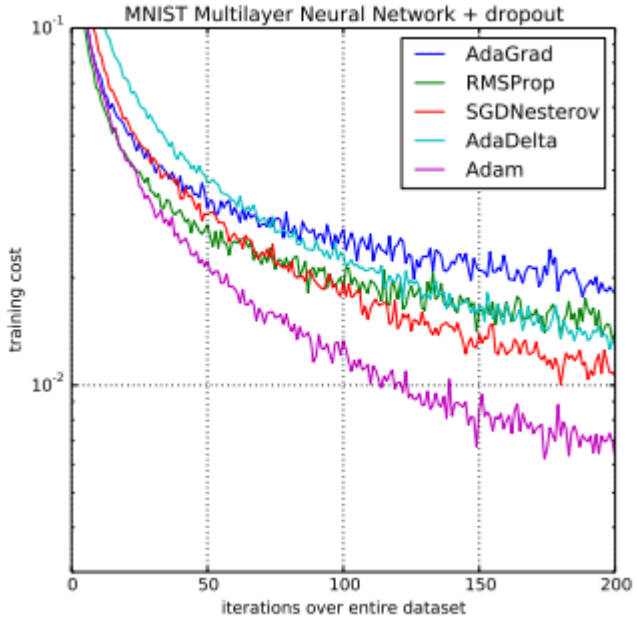
Model Evaluations

- Callbacks:
  - Monitoring Validation Loss
  - Reduce LR
  - Early Stopping
  - Model Checkpoint
- ViT-B/16 and AlexNet architectures
- AlexNet Layers: Input, 2 x Conv2D-MaxPool2D, 3 x Conv2D, MaxPool2D, Flatten, 3 x Dense
- ViT Layers: Input, Conv2D, Reshape, 12 x Transformer Encoders, Normalization, Lambda, Dense

Model Evaluations

- Optimizer: Adam
- Loss: Binary Cross-Entropy
- Max. # of 50 Epochs

$$H_p(q) = -\frac{1}{N}\sum_{i=1}^{N} y_i \cdot log(p(y_i)) + (1 - y_i) \cdot log(1 - p(y_i))$$



AlexNet CNN

```
652/652 [==============================] - 77s 117ms/step - loss: 0.5682 - accuracy: 0.7483 - val_loss: 0.7117 - val_accuracy: 0.5000 - lr: 1.0000e-04
Epoch 2/50
652/652 [==============================] - 73s 111ms/step - loss: 0.3283 - accuracy: 0.8549 - val_loss: 0.5677 - val_accuracy: 0.7500 - lr: 1.0000e-04
Epoch 3/50
652/652 [==============================] - 71s 109ms/step - loss: 0.2509 - accuracy: 0.8915 - val_loss: 0.6540 - val_accuracy: 0.6875 - lr: 1.0000e-04
Epoch 4/50
652/652 [==============================] - 71s 109ms/step - loss: 0.2069 - accuracy: 0.9172 - val_loss: 1.1559 - val_accuracy: 0.6250 - lr: 1.0000e-04
Epoch 5/50
652/652 [==============================] - 71s 109ms/step - loss: 0.1732 - accuracy: 0.9314 - val_loss: 1.1629 - val_accuracy: 0.6250 - lr: 1.0000e-04
Epoch 6/50
652/652 [==============================] - 71s 109ms/step - loss: 0.1627 - accuracy: 0.9387 - val_loss: 0.3617 - val_accuracy: 0.8750 - lr: 1.0000e-04
Epoch 7/50
652/652 [==============================] - 71s 108ms/step - loss: 0.1544 - accuracy: 0.9398 - val_loss: 1.2463 - val_accuracy: 0.5625 - lr: 1.0000e-04
Epoch 8/50
652/652 [==============================] - 71s 109ms/step - loss: 0.1460 - accuracy: 0.9434 - val_loss: 1.7335 - val_accuracy: 0.5625 - lr: 1.0000e-04
Epoch 9/50
652/652 [==============================] - 73s 112ms/step - loss: 0.1341 - accuracy: 0.9492 - val_loss: 1.1260 - val_accuracy: 0.6250 - lr: 1.0000e-04
Epoch 10/50
652/652 [==============================] - 79s 122ms/step - loss: 0.1363 - accuracy: 0.9502 - val_loss: 0.7715 - val_accuracy: 0.6250 - lr: 1.0000e-04
Epoch 11/50
652/652 [==============================] - ETA: 0s - loss: 0.1245 - accuracy: 0.9534
Epoch 11: ReduceLROnPlateau reducing learning rate to 2.4999999368446888e-05.
652/652 [==============================] - 75s 115ms/step - loss: 0.1245 - accuracy: 0.9534 - val_loss: 1.3580 - val_accuracy: 0.5625 - lr: 1.0000e-04
Epoch 12/50
652/652 [==============================] - 76s 116ms/step - loss: 0.1030 - accuracy: 0.9624 - val_loss: 0.5273 - val_accuracy: 0.6875 - lr: 2.5000e-05
Epoch 13/50
652/652 [==============================] - 75s 115ms/step - loss: 0.0996 - accuracy: 0.9643 - val_loss: 0.5989 - val_accuracy: 0.6875 - lr: 2.5000e-05
Epoch 14/50
652/652 [==============================] - 71s 108ms/step - loss: 0.0985 - accuracy: 0.9620 - val_loss: 0.7465 - val_accuracy: 0.6875 - lr: 2.5000e-05
Epoch 15/50
652/652 [==============================] - ETA: 0s - loss: 0.0959 - accuracy: 0.9618Restoring model weights from the end of the best epoch: 6.
652/652 [==============================] - 71s 108ms/step - loss: 0.0959 - accuracy: 0.9618 - val_loss: 0.8386 - val_accuracy: 0.6250 - lr: 2.5000e-05
Epoch 15: early stopping
2/2 [==============================] - 0s 113ms/step - loss: 0.7458 - accuracy: 0.6875
```

Vision Transformer

```
652/652 [==============================] - 281s 410ms/step - loss: 0.1844 - accuracy: 0.9273 - val_loss: 0.4784 - val_accuracy: 0.9375 - lr: 1.0000e-04
Epoch 2/50
652/652 [==============================] - 264s 405ms/step - loss: 0.1078 - accuracy: 0.9615 - val_loss: 0.0347 - val_accuracy: 1.0000 - lr: 1.0000e-04
Epoch 3/50
652/652 [==============================] - 261s 400ms/step - loss: 0.0837 - accuracy: 0.9686 - val_loss: 0.5374 - val_accuracy: 0.8750 - lr: 1.0000e-04
Epoch 4/50
652/652 [==============================] - 261s 400ms/step - loss: 0.0868 - accuracy: 0.9663 - val_loss: 0.4417 - val_accuracy: 0.7500 - lr: 1.0000e-04
Epoch 5/50
652/652 [==============================] - 262s 401ms/step - loss: 0.0773 - accuracy: 0.9701 - val_loss: 0.4511 - val_accuracy: 0.8125 - lr: 1.0000e-04
Epoch 6/50
652/652 [==============================] - 265s 406ms/step - loss: 0.0648 - accuracy: 0.9766 - val_loss: 0.0164 - val_accuracy: 1.0000 - lr: 1.0000e-04
Epoch 7/50
652/652 [==============================] - 261s 399ms/step - loss: 0.0656 - accuracy: 0.9757 - val_loss: 0.5679 - val_accuracy: 0.8750 - lr: 1.0000e-04
Epoch 8/50
652/652 [==============================] - 262s 402ms/step - loss: 0.0659 - accuracy: 0.9762 - val_loss: 0.4500 - val_accuracy: 0.8125 - lr: 1.0000e-04
Epoch 9/50
652/652 [==============================] - 252s 386ms/step - loss: 0.0878 - accuracy: 0.9666 - val_loss: 0.1248 - val_accuracy: 1.0000 - lr: 1.0000e-04
Epoch 10/50
652/652 [==============================] - 252s 386ms/step - loss: 0.0601 - accuracy: 0.9781 - val_loss: 0.9072 - val_accuracy: 0.7500 - lr: 1.0000e-04
Epoch 11/50
652/652 [==============================] - ETA: 0s - loss: 0.0785 - accuracy: 0.9688
Epoch 11: ReduceLROnPlateau reducing learning rate to 2.4999999368446888e-05.
652/652 [==============================] - 252s 386ms/step - loss: 0.0785 - accuracy: 0.9688 - val_loss: 0.0600 - val_accuracy: 1.0000 - lr: 1.0000e-04
Epoch 12/50
652/652 [==============================] - 252s 386ms/step - loss: 0.0307 - accuracy: 0.9893 - val_loss: 0.2823 - val_accuracy: 0.8750 - lr: 2.5000e-05
Epoch 13/50
652/652 [==============================] - 252s 386ms/step - loss: 0.0310 - accuracy: 0.9904 - val_loss: 0.0616 - val_accuracy: 1.0000 - lr: 2.5000e-05
Epoch 14/50
652/652 [==============================] - 253s 387ms/step - loss: 0.0233 - accuracy: 0.9912 - val_loss: 0.1084 - val_accuracy: 0.9375 - lr: 2.5000e-05
Epoch 15/50
652/652 [==============================] - ETA: 0s - loss: 0.0234 - accuracy: 0.9906Restoring model weights from the end of the best epoch: 6.
652/652 [==============================] - 253s 387ms/step - loss: 0.0234 - accuracy: 0.9906 - val_loss: 0.1377 - val_accuracy: 0.9375 - lr: 2.5000e-05
Epoch 15: early stopping
2/2 [==============================] - 0s 139ms/step - loss: 0.0620 - accuracy: 1.0000
```

Results

- 0: Healthy
- 1: Pneumonia

- AlexNet: 0.89
- ViT: 0.93

	precision	recall	f1-score	support
0	0.92	0.78	0.84	234
1	0.88	0.96	0.92	390
accuracy			0.89	624
macro avg	0.90	0.87	0.88	624
weighted avg	0.90	0.89	0.89	624

AlexNet CNN

	precision	recall	f1-score	support
0	0.97	0.83	0.89	234
1	0.91	0.98	0.94	390
accuracy			0.93	624
macro avg	0.94	0.91	0.92	624
weighted avg	0.93	0.93	0.93	624

Vision Transformer

Conclusion

- Setting up AlexNet and ViT models
- Data augmentation
- Model evaluations
- Comparing CNN and ViT
  - Faster training: AlexNet
  - More accurate: ViT

References

[1] D. S. Kermany, et al., *Identifying Medical Diagnoses and Treatable Diseases by Image-Based Deep Learning*, 2018. [Online]. Available: https://www.cell.com/cell/fulltext/S0092-8674(18)30154-5.