Melanoma Detection Using Deep Learning

Deep Phuyal

University of Mississippi

dphuyal@go.olemiss.edu

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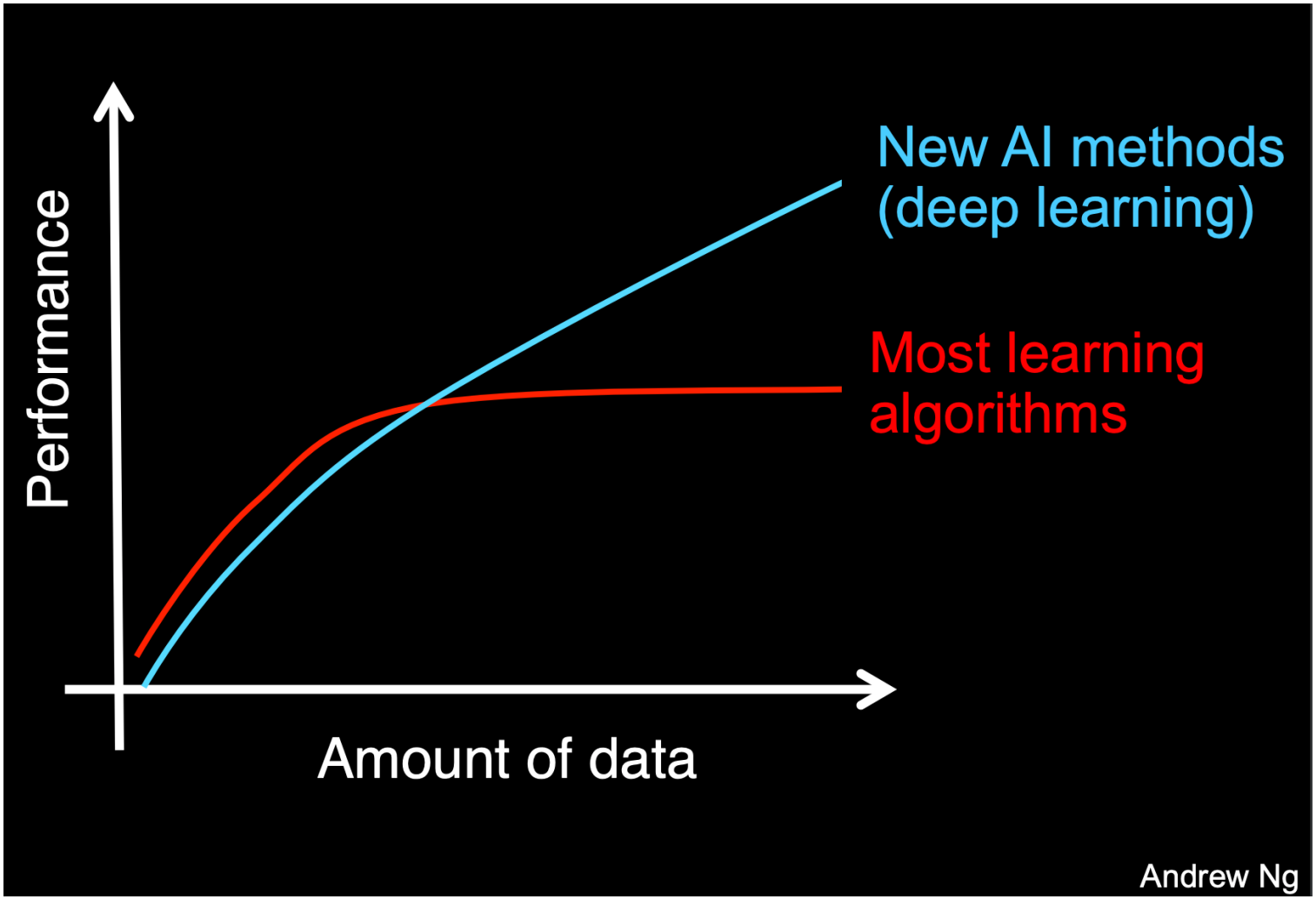
Overview

Overview

What is Deep Learning?

- A part of machine learning field of data representations
- Utilizes learning algorithms that extract features from data by using a cascade of layers that mimic the neural networks of our brain
- "Learns" with tons of input examples

What is Deep Learning?



Overview

What are CNNs?

- Convolutional Neural Networks (CNNs), are a category of Neural Networks
- Excels in areas of image recognition and classification
- Comprised of four main procedures
  - Convolution Layer
  - Activation Function(ReLu)
  - Pooling
  - Classification

What are CNNs?

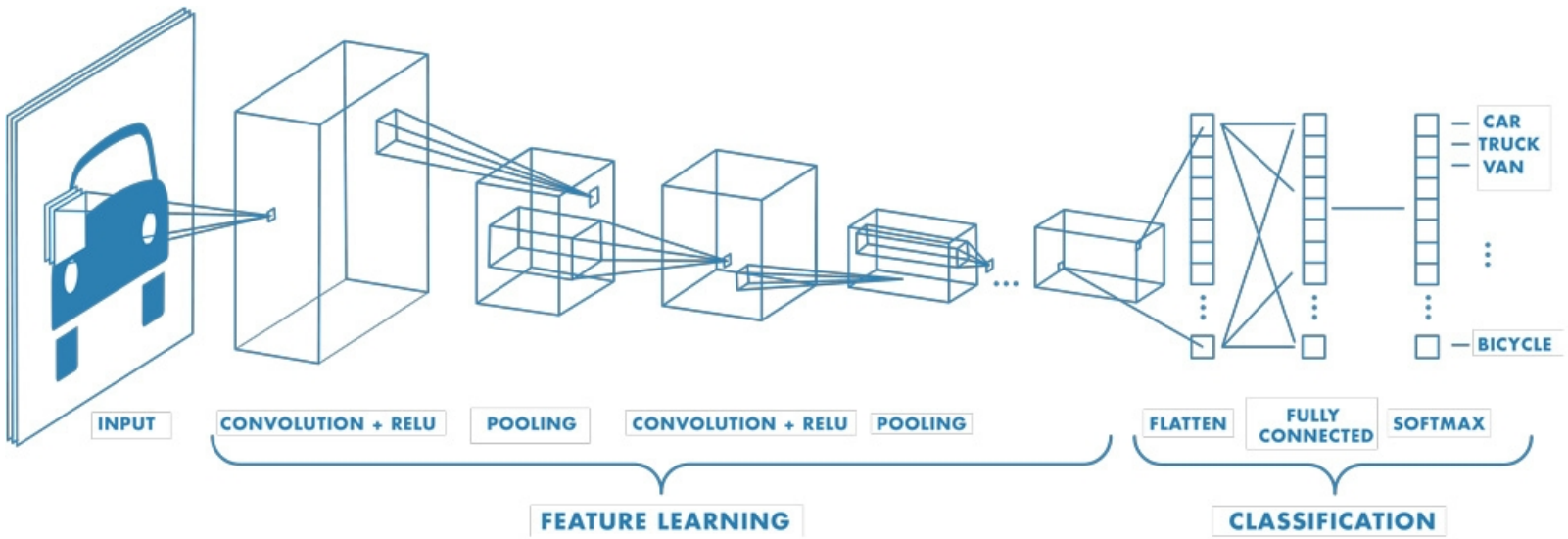


Figure: Example of a CNN

Overview

What is Melanoma?

- Responsible for 75% of skin cancer deaths
- American Cancer Society predicts over 100,000 new cases in 2020
- Can be cured with minor surgery

What is Melanoma?

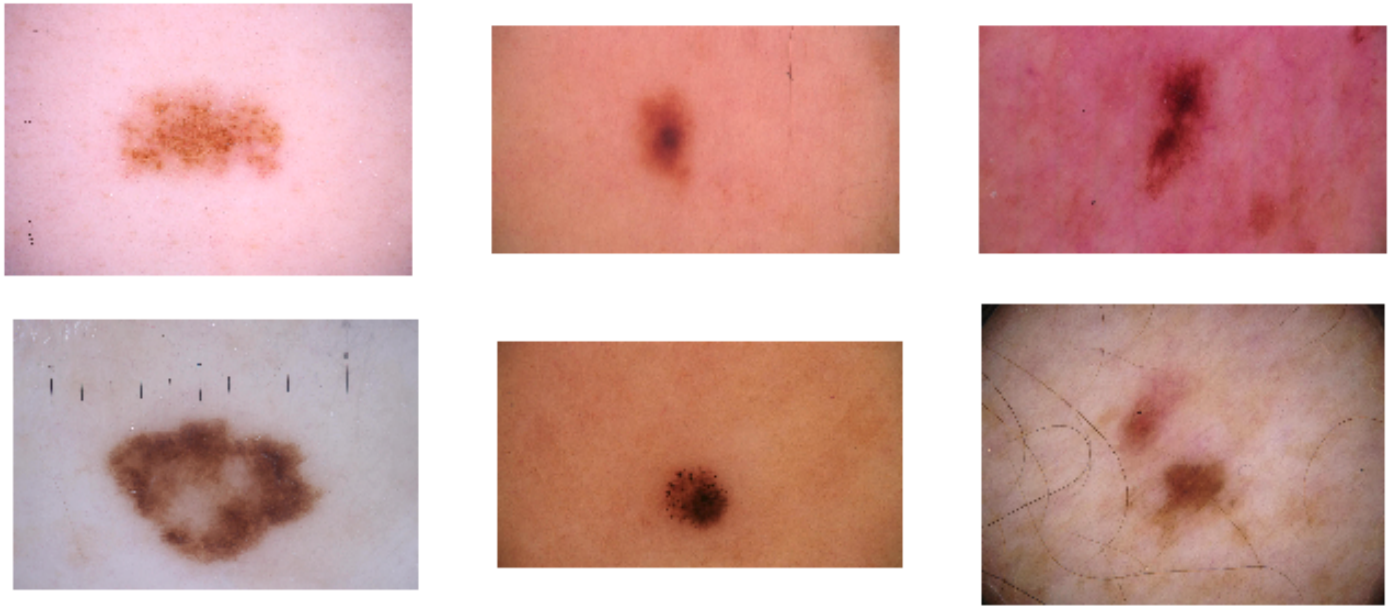


Figure: Example Benign and Melanoma Images

Overview

Project Goal

- Build a binary classifier to detect melanoma in images of skin lesions using deep CNN models
- Use images within the same patient
- Use patient-level contextual information (metadata)
- AUC evaluation metric

Overview

Dataset Overview

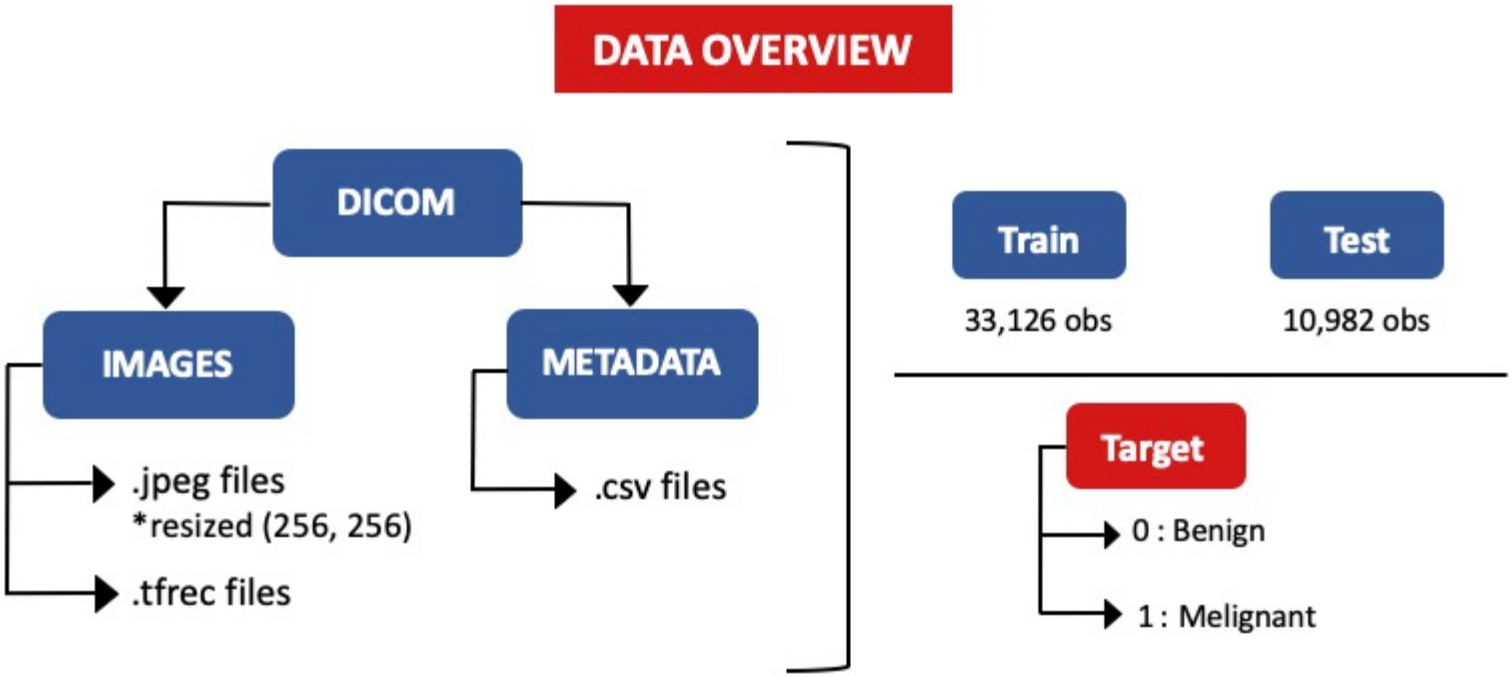


Figure: Overview of SIIM-ISIC Dataset

SIIM-ISIC Dataset

	image_name	patient_id	sex	age_approx	anatom_site_general_challenge	diagnosis	benign_malignant	target
0	ISIC_5714411	IP_4399955	female	55.0	torso	melanoma	malignant	1
1	ISIC_0280912	IP_5831170	male	70.0	torso	melanoma	malignant	1
2	ISIC_3713085	IP_1122600	female	65.0	lower extremity	unknown	benign	0
3	ISIC_6670764	IP_9544996	female	35.0	torso	unknown	benign	0
4	ISIC_4183926	IP_8329991	male	35.0	lower extremity	unknown	benign	0
5	ISIC_4009870	IP_1395856	male	75.0	head/neck	melanoma	malignant	1

	image_name	patient_id	sex	age_approx	anatom_site_general_challenge
0	ISIC_0052060	IP_3579794	male	70.0	NaN
1	ISIC_0052349	IP_7782715	male	40.0	lower extremity
2	ISIC_0058510	IP_7960270	female	55.0	torso
3	ISIC_0073313	IP_6375035	female	50.0	torso
4	ISIC_0073502	IP_0589375	female	45.0	lower extremity
5	ISIC_0074618	IP_4438996	male	50.0	lower extremity

Figure: Sample train and test data

SIIM-ISIC Dataset

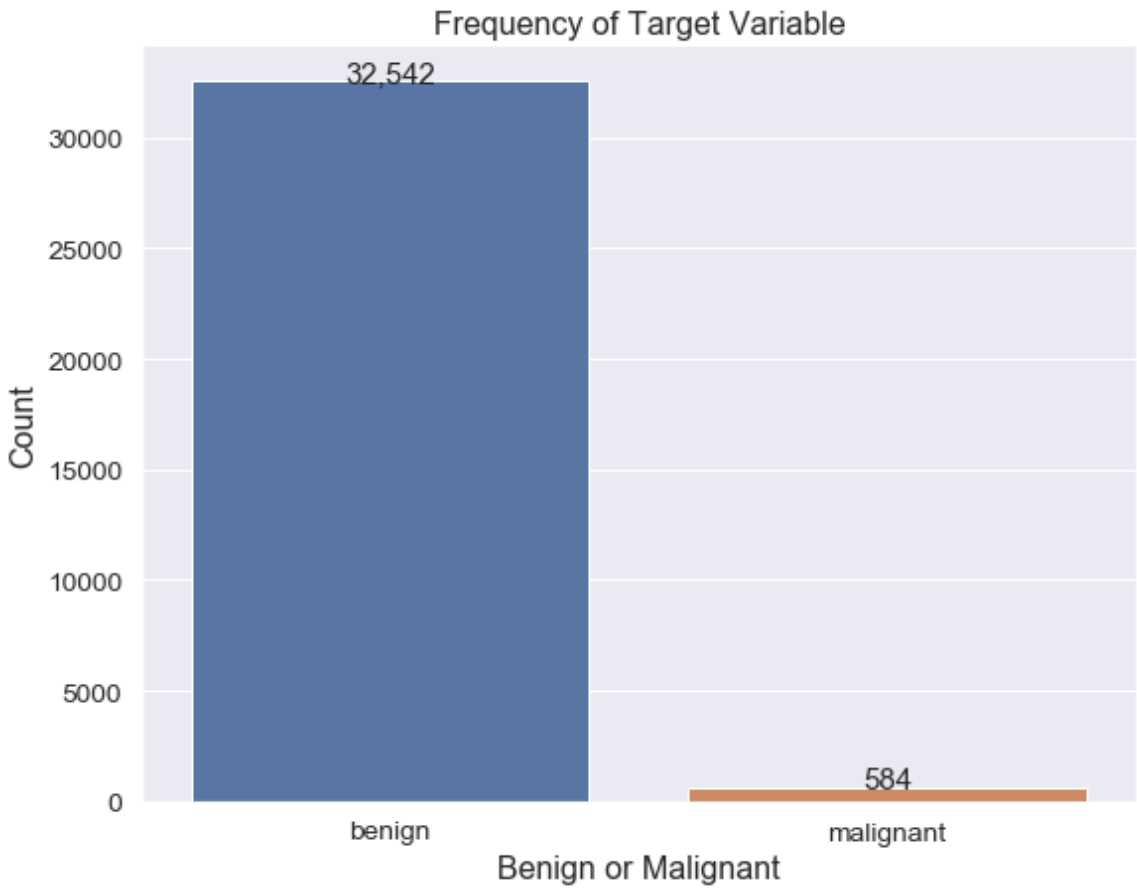


Figure: Distribution of Benign and Malignant Images

SIIM-ISIC Dataset

- **Challenges:**
  - Highly imbalanced dataset caused unstable AUC metric
  - Only 1.76% positive samples
  - Some missing data
- **Solution:**
  - 5k additional positive samples from last year's data
  - Data imputation
  - GroupKFold cross-validation on combined data
  - Data augmentation

SIIM-ISIC Dataset

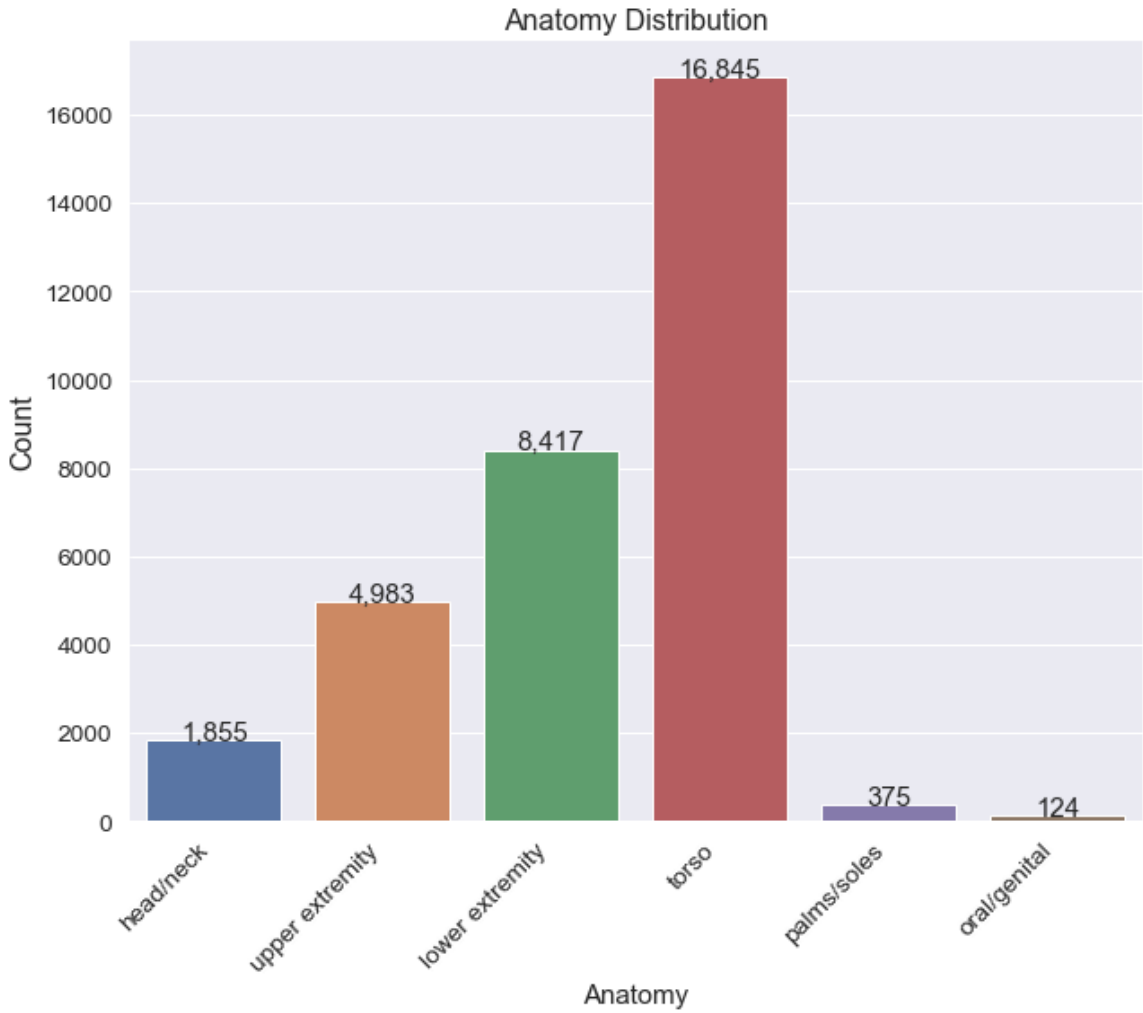


Figure: Distribution of Anatomy Feature in Training Set

Data Augmentation

- **Albumentations:**
  - A fast, popular, and flexible open source library
  - An easy-to-use wrapper around other augmentation libraries
  - Some transforms: Transpose, VerticleFlip, HorizontalFlip, Rotate, RandomBrightness
- **Microscope**:
  - Applied to the images taken through microscope

Overview

ResNet-50 Model

- A CNN that is 50 layers deep
- Uses skip connections (residuals) to resolve vanishing gradient problem
- Trained on ImageNet dataset
- 1000-way fully connected layer with softmax

ResNet-50 Model Schema

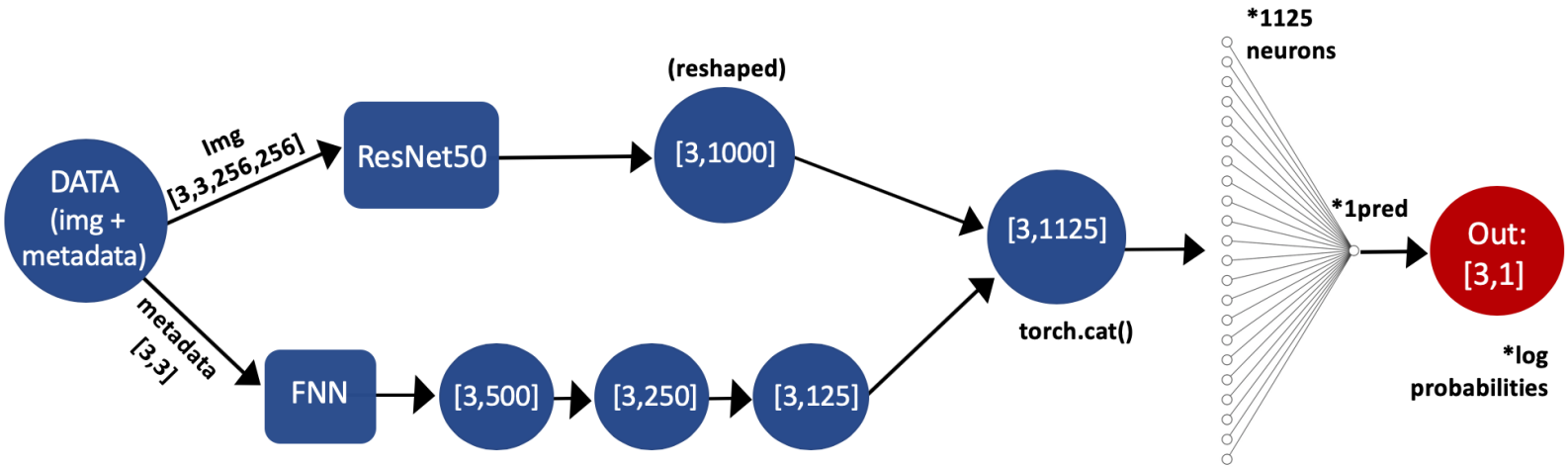


Figure: ResNet-50 Model Schema with Metadata

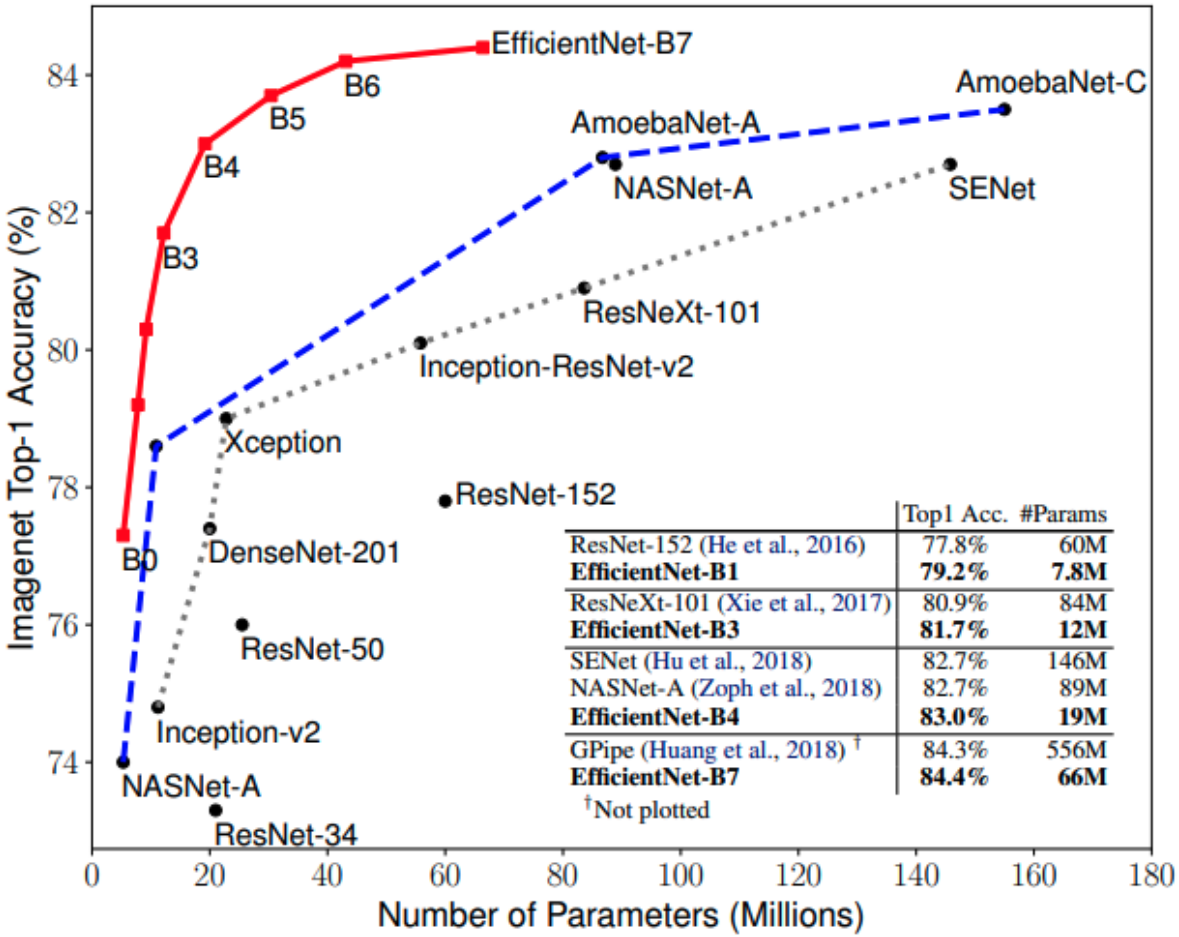
ResNet-50 Training Setup

- Removed softmax layer
- AdamW optimizer
- Batch size 64, number of epochs 24
- Initial learning rate 0.0005
- Learning rate scheduler
- BCEWithLogitsLoss function

EfficientNet Family Models

- Developed by Google brain team in 2019
- EfficientNet-B0 to B7
- Uses compound scaling
- Achieved state-of-art result on ImageNet

EfficientNet Family Models



	Top1 Acc.	#Params
ResNet-152 (He et al., 2016)	77.8%	60M
EfficientNet-B1	**79.2%**	**7.8M**
ResNeXt-101 (Xie et al., 2017)	80.9%	84M
EfficientNet-B3	**81.7%**	**12M**
SENet (Hu et al., 2018)	82.7%	146M
NASNet-A (Zoph et al., 2018)	82.7%	89M
EfficientNet-B4	**83.0%**	**19M**
GPipe (Huang et al., 2018) †	84.3%	556M
EfficientNet-B7	**84.4%**	**66M**

†Not plotted

Figure: Various Models Size vs ImageNet Accuracy

EfficientNet Models Schema

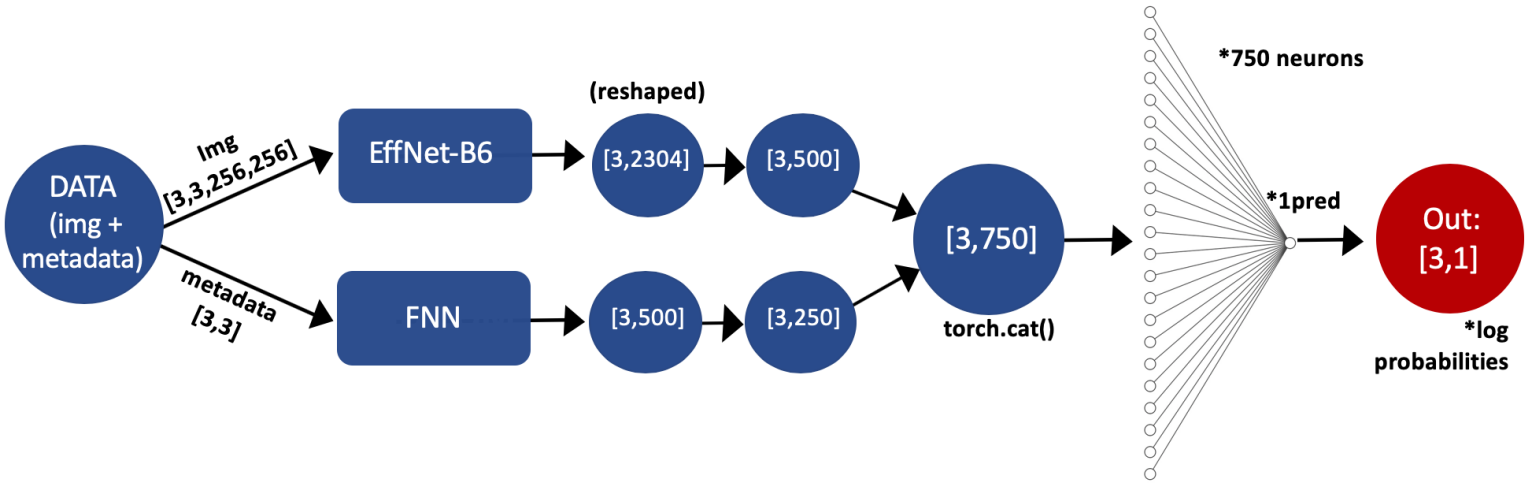


Figure: EfficientNet-B6 Schema with Metadata

EfficientNet Models Training Setup

- Removed softmax layer
- AdamW optimizer
- 64 batch size and 24 epochs for EfficientNet-B2
- 32 batch size and 15 epochs for EfficientNet-B3 and B4
- 16 batch size and 15 epochs for EfficientNet-B6
- Learning rate scheduler

Experiment Setup

Development Environment

- Two AWS instances with NVIDIA T4 Tensor Core GPU
- Ubuntu 18.04.5 LTS
- Cuda 10.0.130
- PyTorch 1.6.0
- Python 3.8.5
- Pandas 1.1.2
- Numpy 1.19.1
- Kaggle API 1.5.8
- VS Code 1.51.1

Overview

Results

Model	Fold	Avg. Train Accuracy	Avg. Valid Accuracy	Avg. AUC
ResNet-50	1	0.956	0.943	0.865
	2	0.954	0.973	0.919
	3	0.954	0.966	0.900
	4	0.927	0.951	0.856
	5	0.941	0.951	0.873
EfficientNet-B2	1	0.960	0.958	0.901
	2	0.958	0.977	0.920
	3	0.961	0.973	0.912
	4	0.967	0.975	0.924
	5	0.967	0.971	0.915
EfficientNet-B3	1	0.955	0.971	0.909
	2	0.959	0.970	0.914
	3	0.962	0.970	0.900
	4	0.952	0.966	0.916
	5	0.963	0.977	0.933
EfficientNet-B4	1	0.959	0.973	0.923
	2	0.965	0.974	0.928
	3	0.960	0.968	0.894
	4	0.957	0.973	0.915
	5	0.962	0.974	0.933
EfficientNet-B6	1	0.962	0.973	0.923
	2	0.959	0.968	0.920
	3	0.962	0.970	0.913
	4	0.960	0.970	0.914
	5	0.960	0.973	0.929

Figure: Table of performance comparison of EfficientNet models and ResNet-50 model

Results

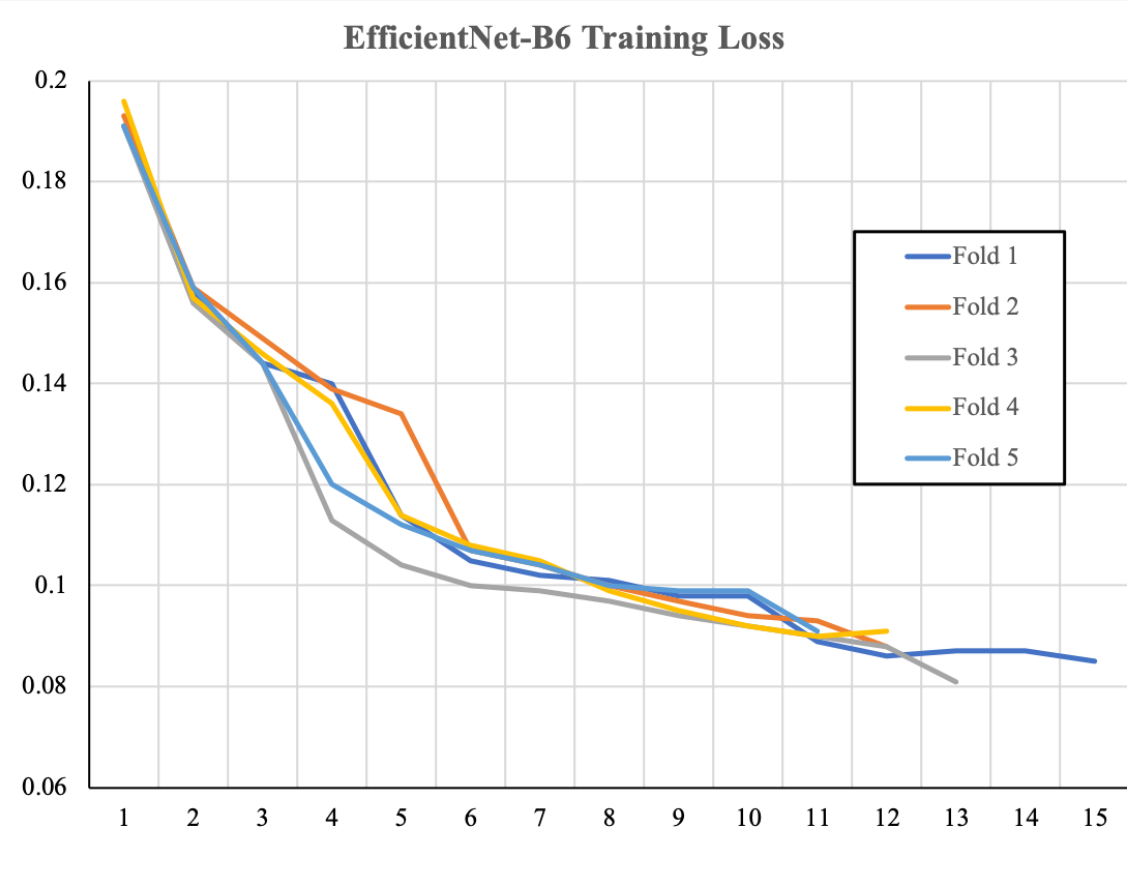


Figure: Line graph of EfficientNet-B6 Training Loss on 5-folds

Results

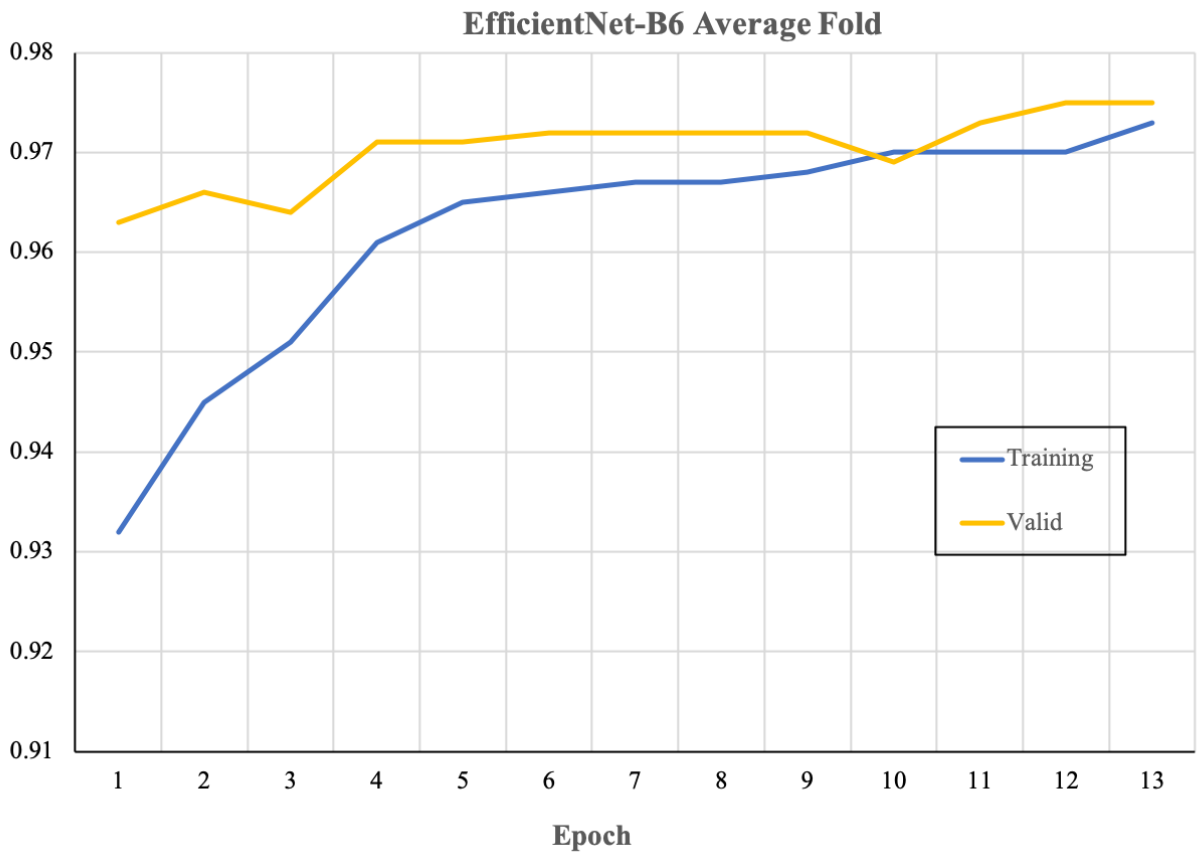


Figure: Line graph of EfficientNet-B6 Training and Valid Accuracy

Results

- Training time ranged from 8 hours - 29 hours
- EfficientNet-B6 had the best performance
- Best private leaderboard and public leaderboard score **0.8688** and **0.8819**
- EfficientNet models outperformed ResNet-50

Overview

Conclusion and Future Plans

- A good performing classifier can be built to detect melanoma
- EfficientNet models yields great results
- **Future plans:**
  - a website/user interface
  - incorporate ensemble learning
  - train on multiple image sizes
  - train EfficientNet-B7
  - pseudo hair augmentation

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Questions?