Multi-label Tagging of ISS Satellite Images

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Project Task

- Provide the TERC Windows on Earth team with a program that can analyze the images from the ISS and automatically tag them with 12 basic tags with a high level of accuracy
- Aid TERC in tagging the thousands of images they receive every day. At present they are only able to tag less than 1% of these images manually

Approach

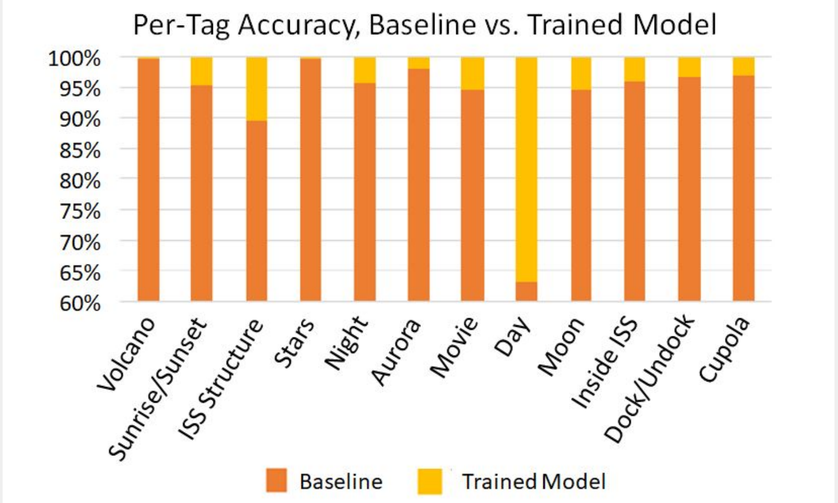
- Neural network architecture based on out-of-the-box ResNet50 implement-ation pre-trained on ImageNet
- Architecture is implemented in Python using the Keras library built on top of TensorFlow
- Froze standard top layers of ResNet50
- Replaced the output layer with a new layer of density twelve to account for the twelve categories
- Classification model uses the sigmoid activation function and a binary cross-entropy loss defined as:

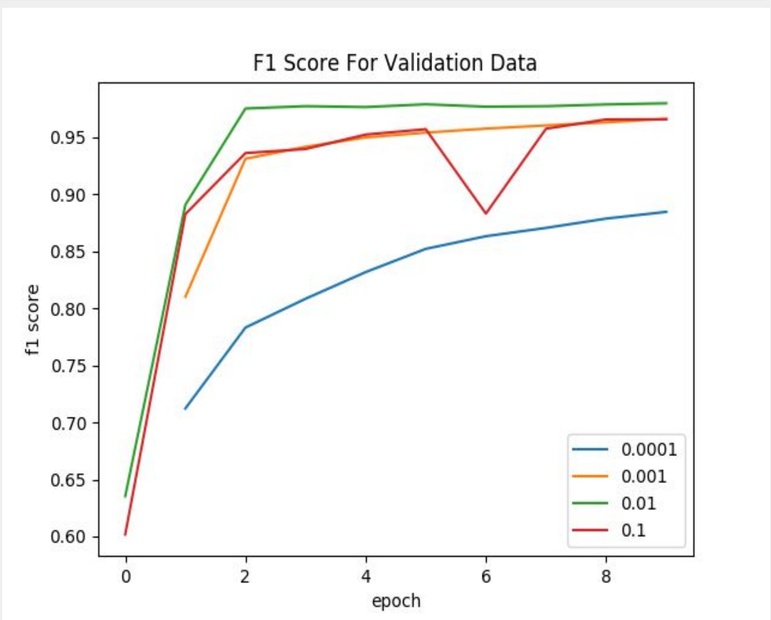
$$\mathrm{L(p)} = -(\mathrm{y}\ \log(p) + (1-y)\log(1-p))$$

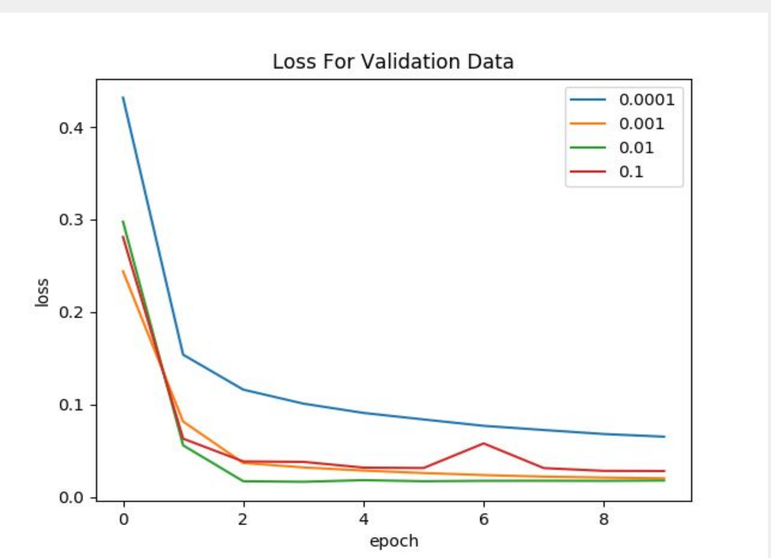
Evaluation

- Trained the model for 10 epochs on multiple learning rates ranging from .1 to .0001 to determine which learning rate worked best for our model
- Model trained on learning rate of α= .01 for 100 epochs
- Achieves 99.5%+ accuracy on individual tags
- Achieves 98.27% overall accuracy on test data. Overall accuracy indicates that the model predicted every label correctly for a given image (all true positives and negatives)
- Comparative baseline method considers the labels that occur in a majority of the images and assigns them to every image. Model outperforms baseline for all categories

Category	Accuracy			
	Baseline	$\alpha = 0.001$	$\alpha = 0.01$	Test
Volcano	0.9965	0.9977	0.9985	0.9992
Sunrise/Sunset	0.9555	0.9965	0.9977	0.9992
ISS Structure	0.8879	0.9916	0.9950	0.9962
Stars	0.9954	0.9977	0.9988	0.9992
Night	0.9501	0.9981	0.9942	0.9965
Aurora	0.9800	0.9992	0.9992	0.9992
Movie	0.9466	0.9934	0.9896	0.9965
Day	0.6190	0.9873	0.9919	0.9961
Moon	0.9389	0.9988	0.9985	0.9988
Inside ISS	0.9558	0.9977	0.9988	0.9985
Dock/Undock	0.9585	0.9962	0.9977	0.9985
Cupola	0.9697	0.9988	0.9977	0.9981
Overall	N/A	0.9647	0.9658	0.9827







Summary & Conclusion

- Satellite images from the ISS will be automatically tagged with 12 predetermined tags using a Convolutional Neural Network (CNN)
- Images are resized and run through a trained CNN that is fine-tuned from a pretrained ResNet50 model
- The loss function is a binary cross-entropy loss with an output layer of density twelve to provide a classification for each of the twelve tags
- After training and running on test data, per-tag accuracy on test data is at least 99.5% for each tag
- Overall accuracy on test data is 98.27%
- Model yields very high accuracy and will ideally be of value to TERC to automate and expedite image tagging

Dataset & Metric

- Training data consists of 13,026 images provided by TERC
- Images are shuffled and randomly assigned to training, validation and testing sets at a 60/20/20 split
- Each image is resized to 224 x 224, the standard input size for ResNet50
- Image tags are obtained from the file's EXIF metadata
- TERC provided a baseline goal of 80% accuracy for each tag
- Binary accuracy and F1 score are used to measure the success of model. F1 score is defined as:

$$F1 = 2\frac{Precision * Recall}{Precision + Recall}$$

- Results reported for per-tag classification accuracy and overall tagging accuracy

Github

https://github.com/ferrys/terc