Spectral Image Classification with Deep Learning -- on Keras Model and Multiple Datasets

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Abstract

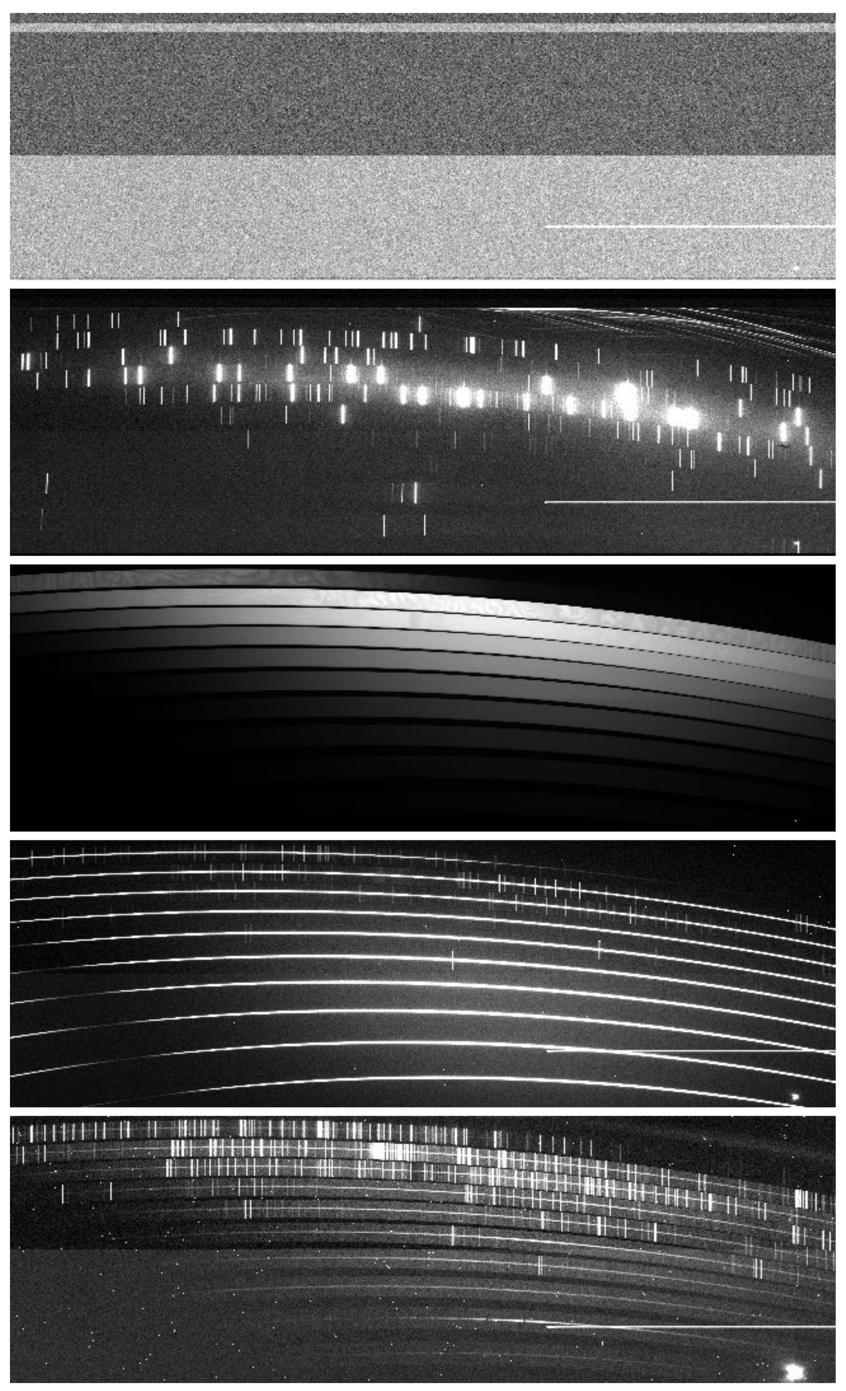
We develop a new version of a convolutional neural network (CNN) model based on Spectral Image Typer (SPIT) code, to classify spectral images with five types of Bias, Arc, Flat, Science, and Standard. This a newer deep learning model is built with TensorFlow 2.0 + Keras to simplify and optimize the CNN structure and training process. Rather than training on PNG images, the model loads image data from a compressed numpy array, which significantly increases the time of image loading. The newer model also solves the noticeable science frame misclassification issue of the previous model and increases the accuracy on validating and testing. The previous version of SPIT was trained solely on 2004 human-classified images taken with the Kast spectrometer at Lick Observatory. Our new model is designed to accept various datasets of spectral images, for example, ESI data from the Keck Observatory. We also modify the codebase into a scalable deep learning model with a higher potential for further improvements, assisted by more generalized preprocessing and training methods.

Datasets

“Kast”: This full set contains around 20000 spectral images.

“ESI”: On the current stage, ESI refers to a partial set of 500 spectral images.

Five classes preview:



Bias Class

Arc Class

Flat Class

Standard Class

Science Class

Preprocessing and Training

The raw image datasets are given in *.fits* format, which has special optional features for scientific data. In the previous version, the SPIT convert all fits files into PNG images. This leads to an large set of data files that are difficult to manage and transfer. We improved this process by transforming fits files directly into a numpy array zip (.npz). In this way, the data is easier and more efficient to read and save.

Fits files → ~~PNGs~~ → Image array (zip)

The new version also allows the model with best validation accuracy in the progress of training. Part of our team focuses on experimenting of new CNN models, and the other part focuses on introducing new datasets into SPIT.

Results and Conclusion

First of all, the results show that the simplified preprocessing works well on saving image loading time and disk memory.

Furthermore, the newly structured CNN has an test accuracy of 98.57%, improved slightly comparing to that of the previous version (98.2%). The partial set of ESI works perfectly on this model. The DenseNet also gives 100% accuracy on ESI test. Combining with the experiment on DenseNet that other teammates found better for Kast (>99% accuracy), the DenseNet is more reliable for the current version SPIT.

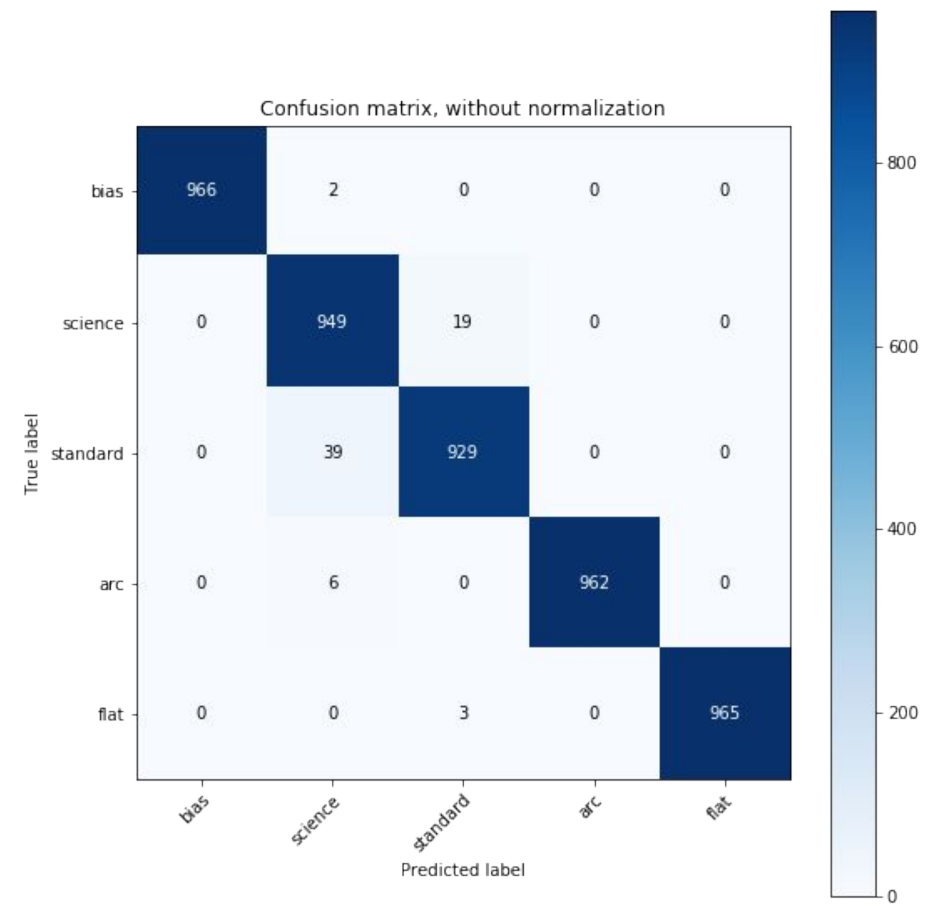


Figure 1: The confusion matrix of Kast trained on newly structured CNN in TF 2.0 and Keras

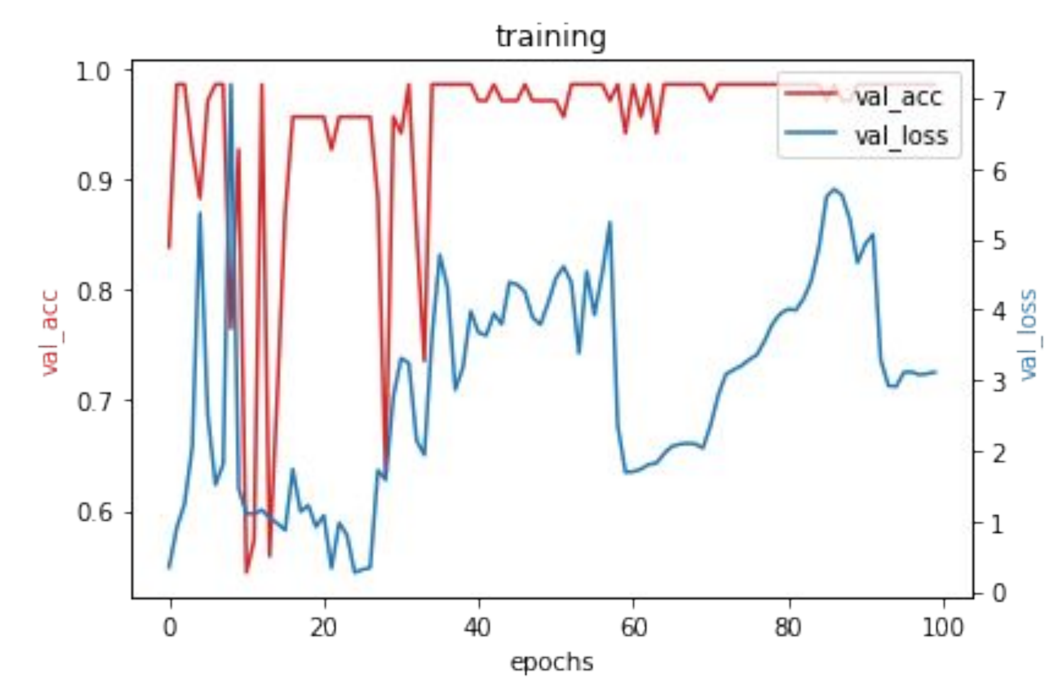


Figure 2: Validation accuracy vs. Validation loss of ESI traininon basic CNN structure

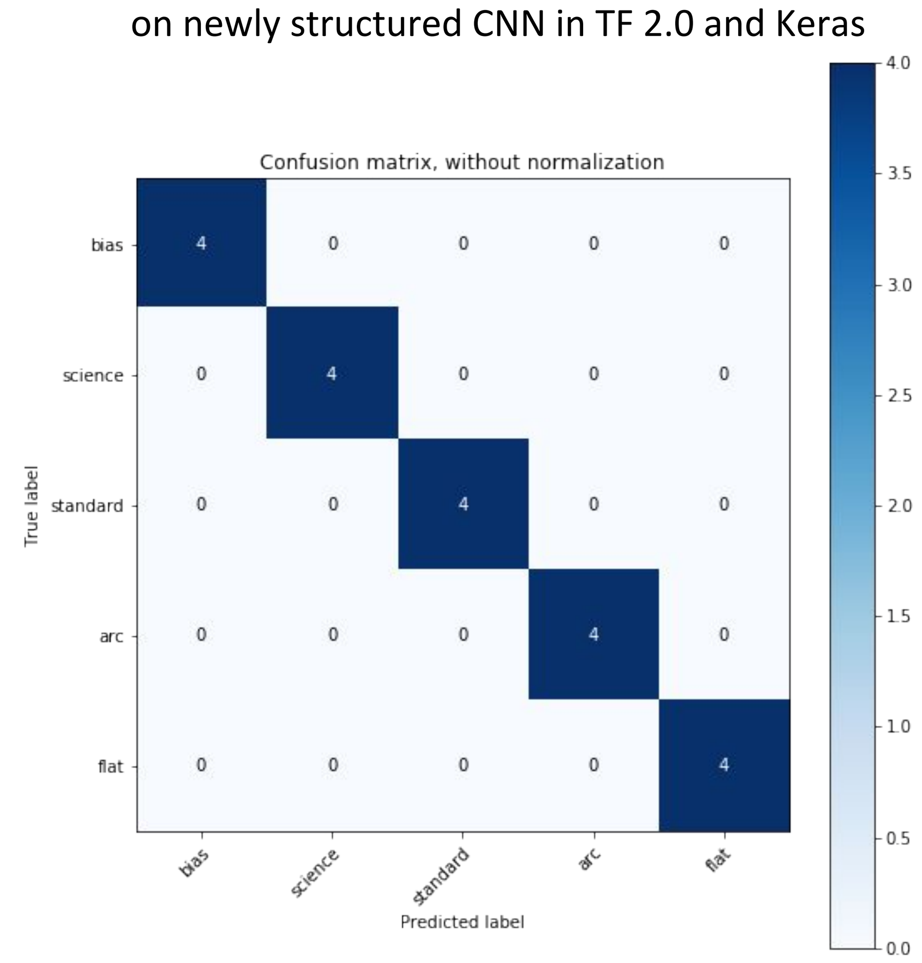


Figure 3: The confusion matrix of unbalanced ESI data trained on newly structured CNN in TF 2.0 and Kera; Same result on DenseNet

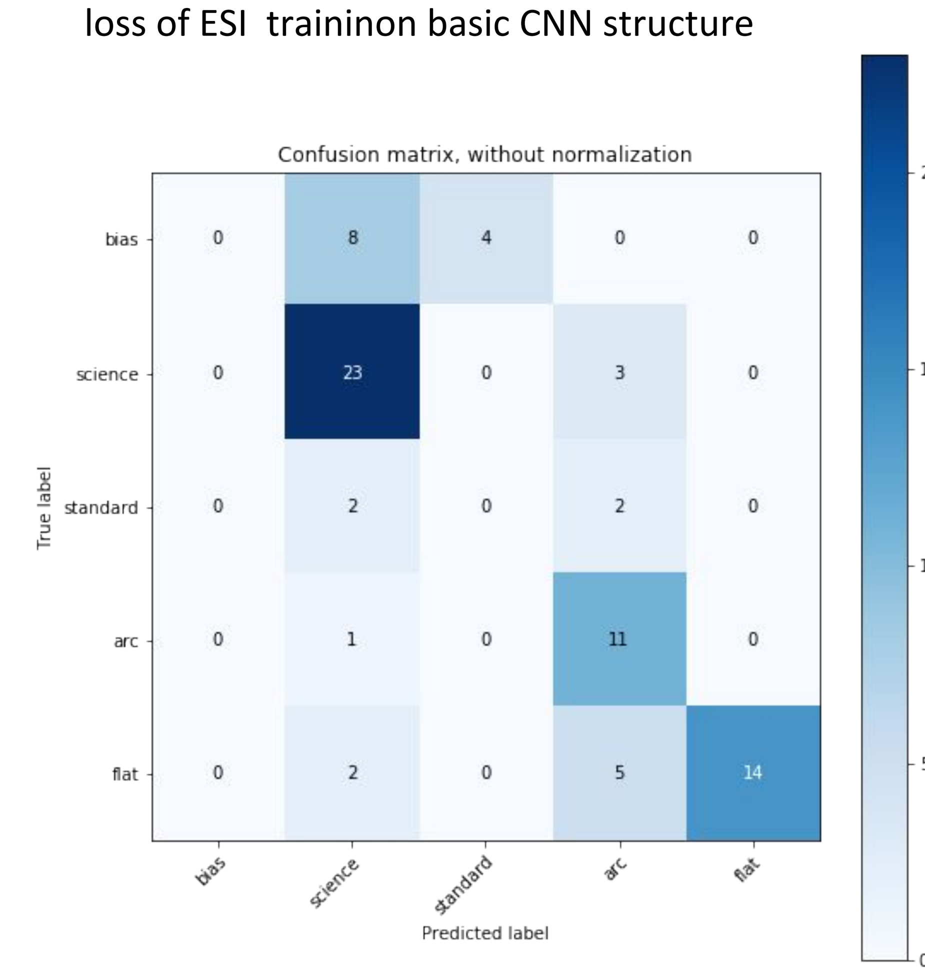


Figure 4: The confusion matrix of ESI trained on Kast-trained model

Future Work

We would explore further on more ESI spectral images to see if the misclassification issue would appear in larger, balanced dataset, and different parameters on DenseNet or any other structure experimented. In addition to this, we would try to generalize more functions that are easy to apply to more datasets.

Reference

[1] Jankov, V., & Prochaska, J. X. (2018). Spectral Image Classification with Deep Learning. *Publications of the Astronomical Society of the Pacific*, *130*(991), 094501. doi: 10.1088/1538-3873/aace98

[2] Pypeit/spit. Retrieved from https://github.com/pypeit/spit