A multi-size convolutional neural network for the recognition of optical transient

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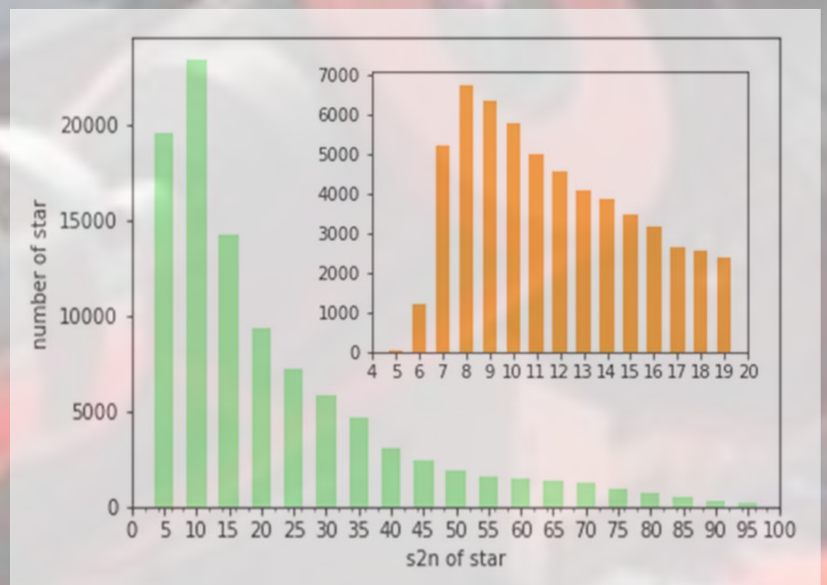
Purpose

In order to solve the problem that the false recognition rate of the existing algorithms is too high when recognizing optical transient with different scale, this paper applies the multi-scale convolution neural network to the recognition of optical transient. The network extract features from multiple different scales of the target at the same time, which further enriches the feature space of transient recognition.

Transient Candidate Sample

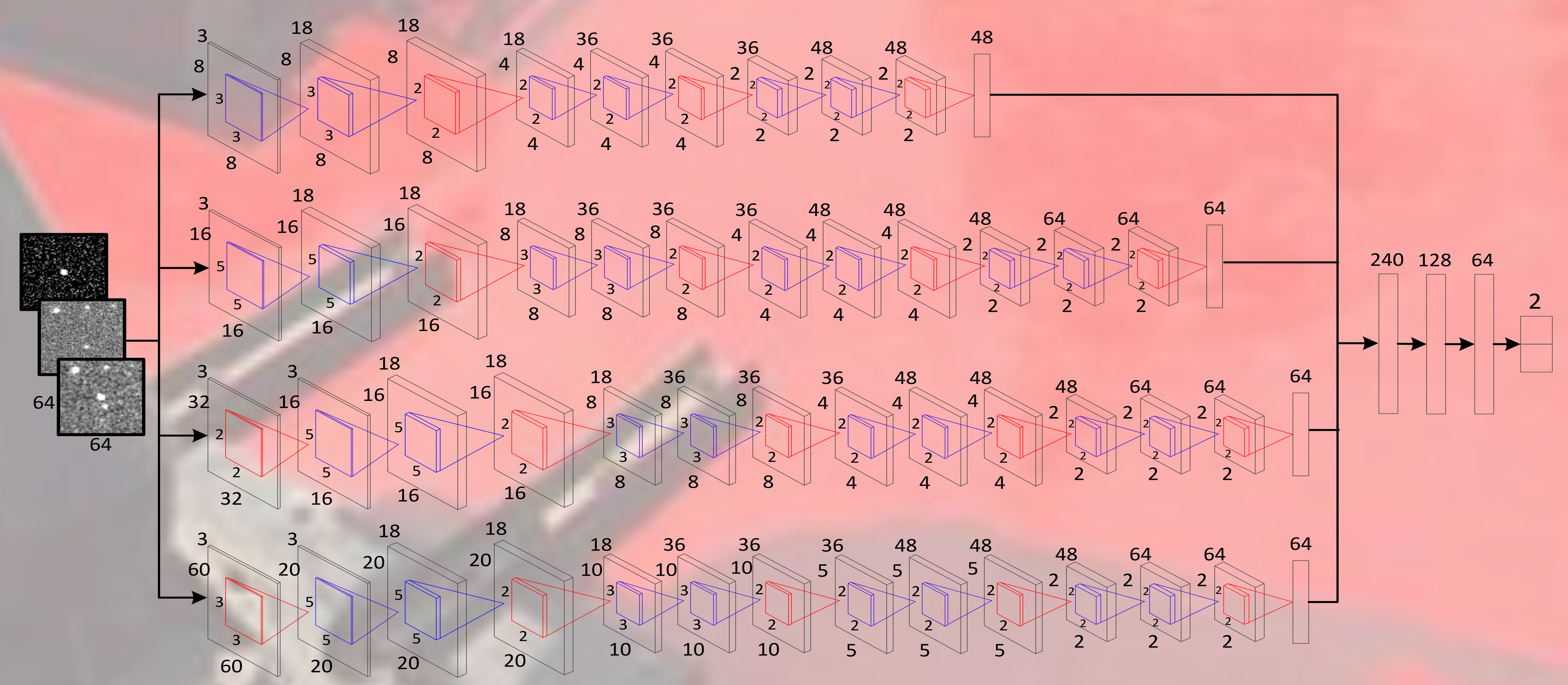
Flare Star   Residual   Bright Star Residual   Defect



The SNR distribution of simulated real samples

To solve the shortage of training samples, considering the brightness and point spread function distribution of transient, 198000 transient samples are generated by using the real observation image of Ground Wide Angle Cameras (GWAC), including 99000 simulated true transient samples and 99000 really fake transient samples.

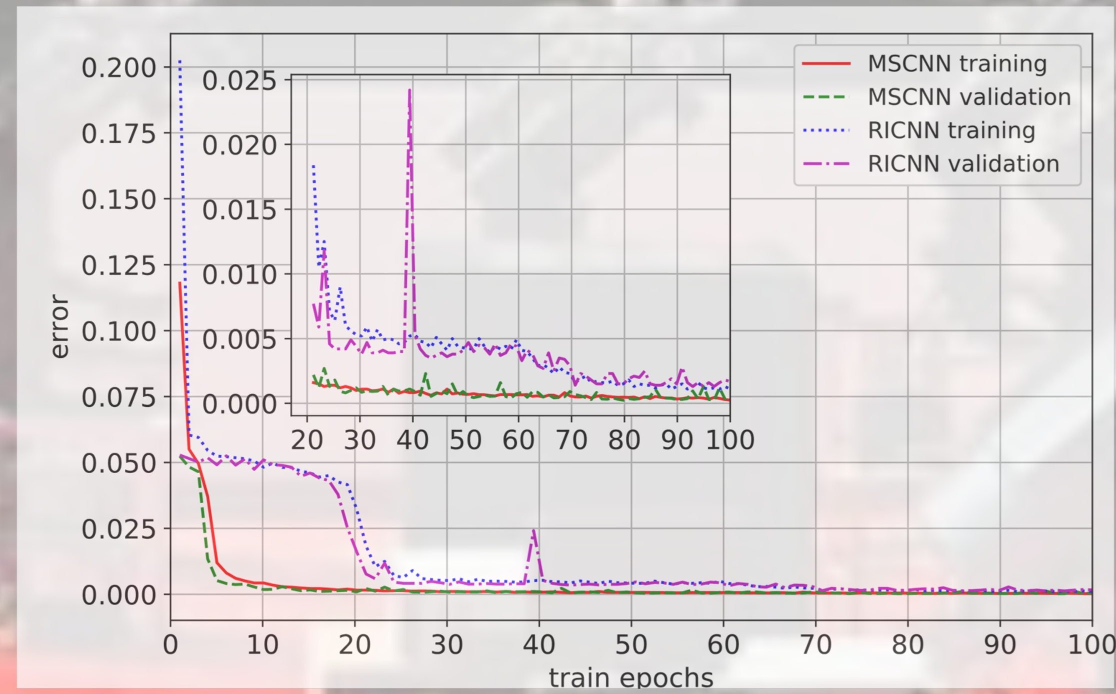
The Model of Multi-size Convolution Neural Network



Blue represents convolution layer and red represents pooling layer. The network contains four branches of different scales, which are used to extract the feature information of different scales of transient targets.

Performance Compare of Different Model

Multi-Scale Convolutional Neural Network (MSCNN), Rotation Invariant Convolutional Neural Network (RICNN), Random Forest (RF)



Graph on the Left is the Training and Validation error curve of MSCNN and RICNN. MSCNN has better performance in convergence speed, training and verification accuracy than RICNN. X-axis is training epochs number, Y-axis is error rate. The small graph is the partially detailed display of large graph.

Model	Recognition Speed(ms/100)	accuracy	precision	recall	f1_score
RF	0.5	99.84%	99.88%	99.81%	99.84%
RICNN	58	99.87%	99.81%	99.93%	99.87%
MSCNN	25	99.9596%	99.9591%	99.9591%	99.9591%

The test results of the above table show that the accuracy, precision, recall rate and f1-score of the MSCNN are above 99.95%, and the error rate is about two thirds lower than that of the RICNN and RF.

Conclusion and Future Improvement

The recognition accuracy basically meets the real-time recognition requirements of GWAC, which provides a guarantee for the scientific goal's achievement of GWAC, and can provide a reference of transient identification problems for other large FOV projects in the world such as PTF, LSST, etc. There are various types of transients in the GWAC system, and the shape of those transients may change as the variation of weather conditions, time, hardware performance, etc. Although the sample set used in training does not fully cover all types of transients, its sample size is large enough to contain the most types, which indicate that the trained model can correctly recognize most transients. In the future, different types of transients will be collected gradually, and the number of training samples will be enriched, which can further improve the recognition accuracy of the model. Finally, this model has been applied to the actual recognition flow of GWAC, and the filtering rate for the transients with large-scale is about 100%. In the winter of 2018, we found more than a dozen of transient with a drastic change of magnitude during half an hour.