An Evaluation of a Convolutional Neural Network for Classifying Images from In-situ, High-Resolution Cloud Probes

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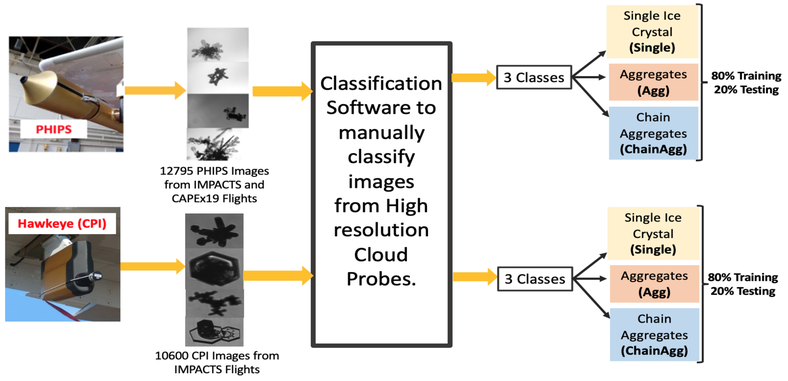
Motivation and Objective

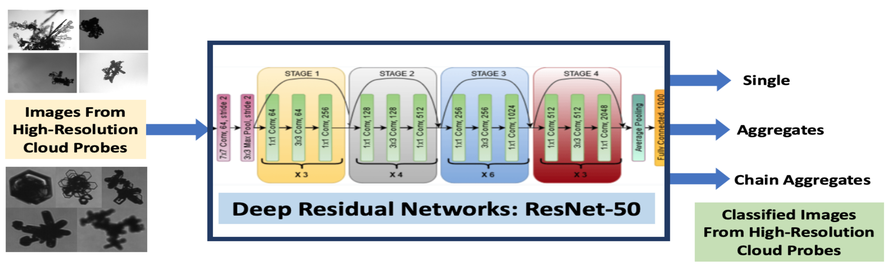
- Identifying ice crystals' properties leads to a better understanding of the microphysical processes.
- Classifying ice crystals by habit provides information about their origins.
- Traditional classification methods require large amount of scientist's time.
- Given the sizable dataset collected from High-Resolution Cloud Probes such as Particle Habit Imaginary and Polar Scattering (PHIPS) and Cloud Particle Imager (CPI) during recent field projects such as CAPEx19 and IMPACTS, there is a need for an automated classification approach.

Objective: Develop Convolutional Neural Network (CNN) models to classify the cloud probe images gathered during field projects with an attributed confidence and evaluate its performance.

Dataset

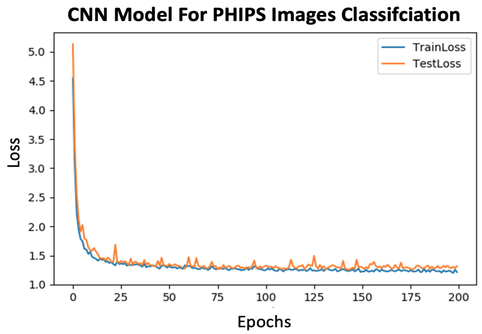


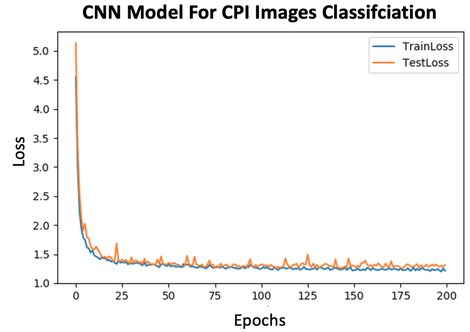
Method



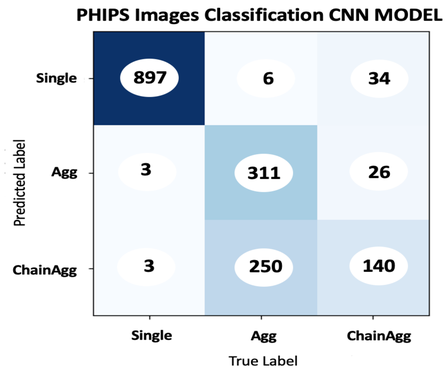
Results

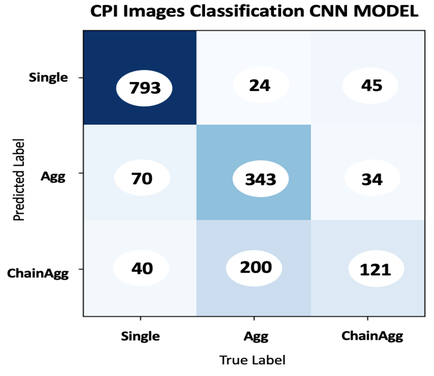
Models Metrics: Loss Function





Models Evaluation per Class: Confusion Matrix and Statistical Measures





PHIPS Images Classification CNN Model

Class	True Positive	True Negative	False Positive	False Negative	Sensitivity (%)	Specificity (%)	Accuracy (%)
Single	897	727	40	6	99.3	94.7	97.2
Chain Agg	140	1217	253	60	70	82.7	81.2
Agg	311	1076	29	256	54.8	97.3	79.9

CPI Images Classification CNN Model

Class	True Positive	True Negative	False Positive	False Negative	Sensitivity (%)	Specificity (%)	Accuracy (%)
Single	793	698	69	110	88	90.9	89.2
Chain Agg	121	1230	104	79	60.5	92.2	88
Agg	343	999	240	224	60.4	80.6	74.3

Conclusion

- A good fit for both CNN models: training and test loss decrease to a point of stability with a minimal gap between two final loss values.
- Global good agreement between true label and predicted label all the classes for both CNN models.
- The PHIPS and CPI images classification CNN models show a good performance for single ice crystal followed by chain aggregates and aggregates.
- The CPI and PHIPS images classification CNN Model's sensitivity and accuracy for aggregates are still low comparing to the other classes.

Future Work

- Train the developed models with more PHIPS and CPI images collected during the IMPACTS field project flights with more aggregates and chain aggregates images.
- Refine the dataset considered to train the model to include several other classes.