Dept. of Earth and
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Classification of Satellite Images Using Deep Learning Models

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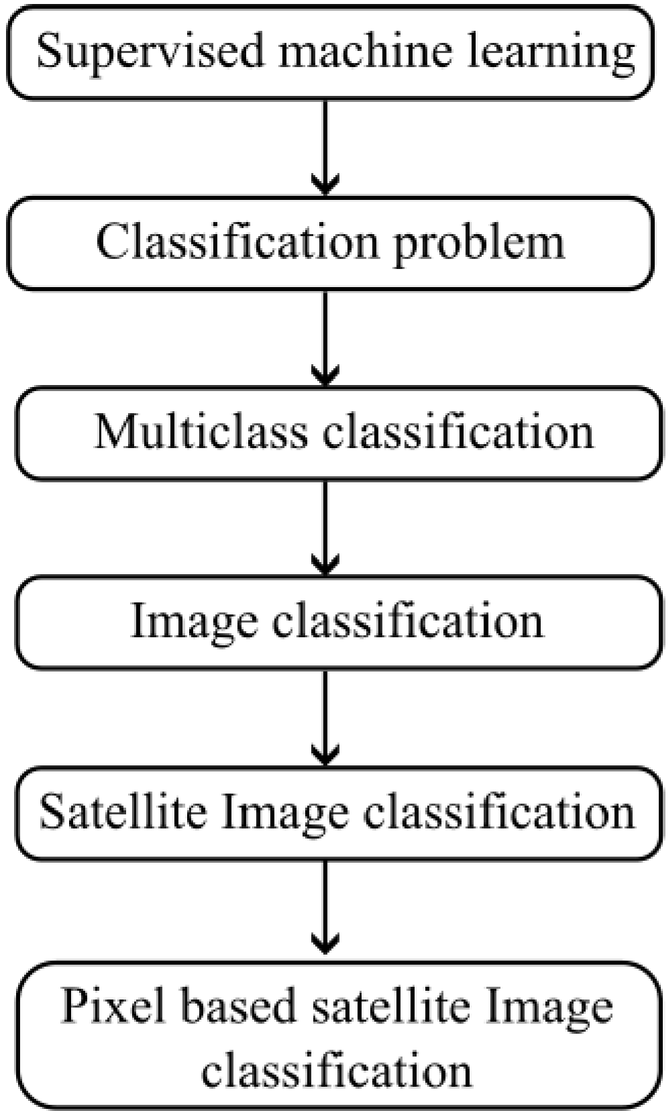
Introduction

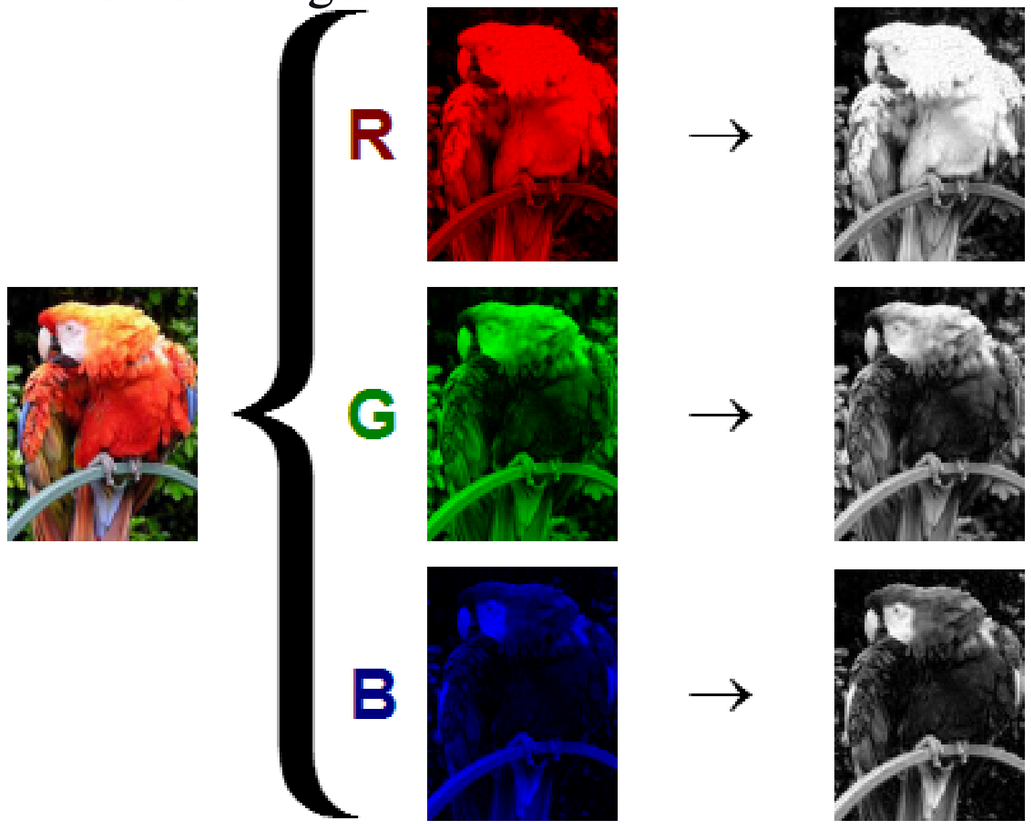
Introduction

- Classification of satellite images



- RBG channels

RGB channels represent the intensity of the Red, Green, and Blue colors in each pixel of an image, combining to produce a full-color image.

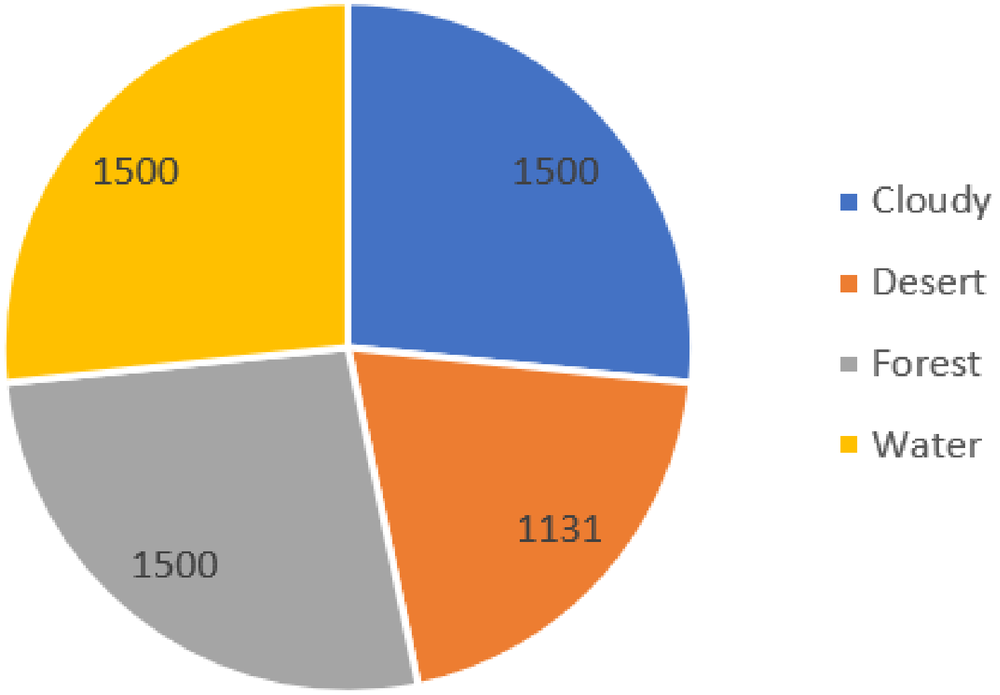


Dataset

The dataset

About the dataset

- The given dataset is derived from RSI-CB, a large-scale image classification benchmark dataset based on crowd-sourced data.
- The dataset has 4 different classes mixed from Sensors and Google map snapshots.
- The classes are: Cloudy, Dessert, Green Area, and Water.
- The distribution of the classes is as follows:



Exploratory data analysis

Exploratory data analysis

Channels in different classes

- The “Cloudy” class has 4 channels and the remaining classes have 3 channels.
- In the Cloudy class, this extra channel has value 0, which indicates transparency.
- To make the data uniform, extra channel with value 255, indicating opaqueness is synthetically introduced.

Data visualization

(a) Cloudy

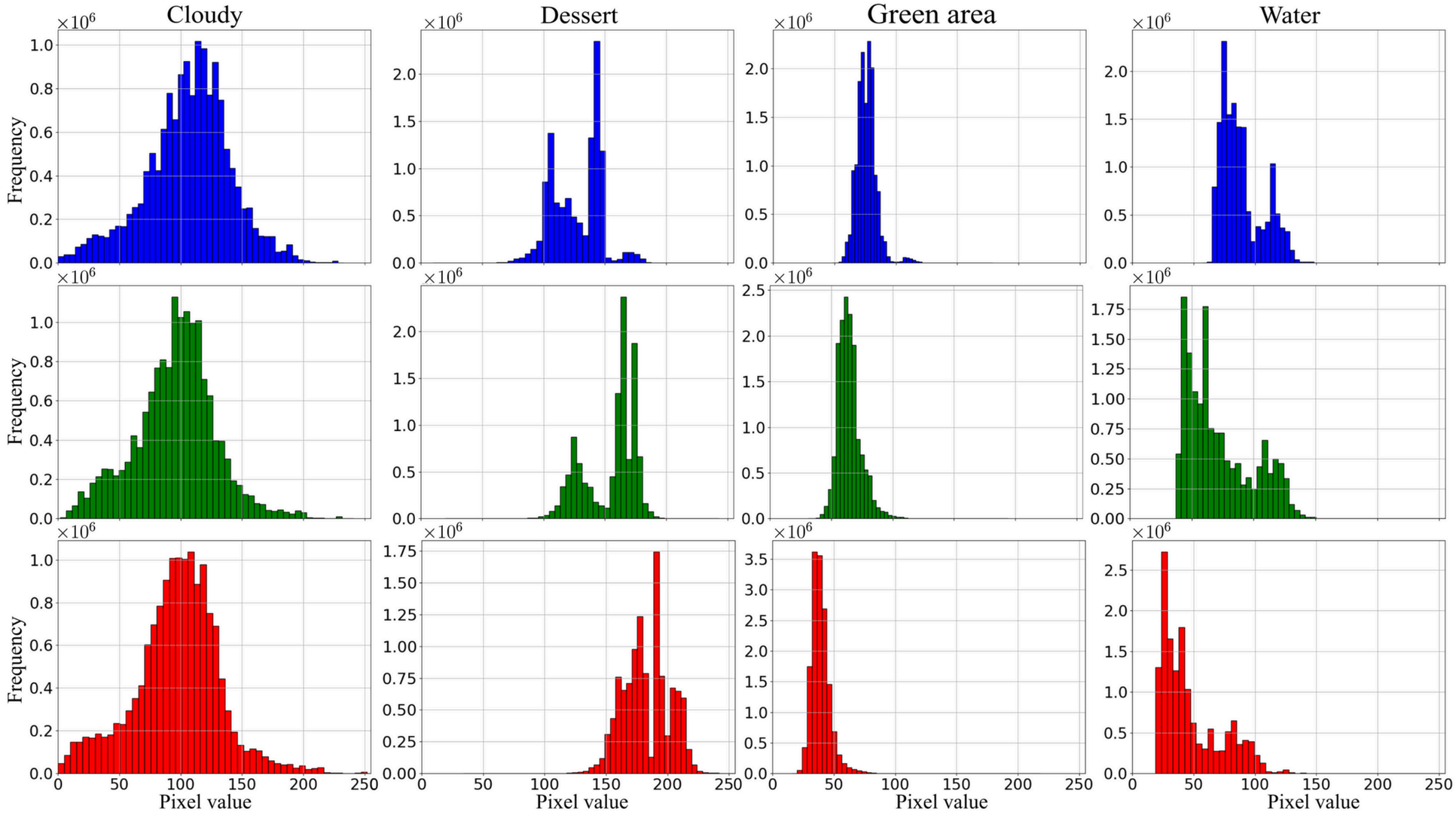
(b) Desert

(c) Green area

(d) Water

Exploratory data analysis

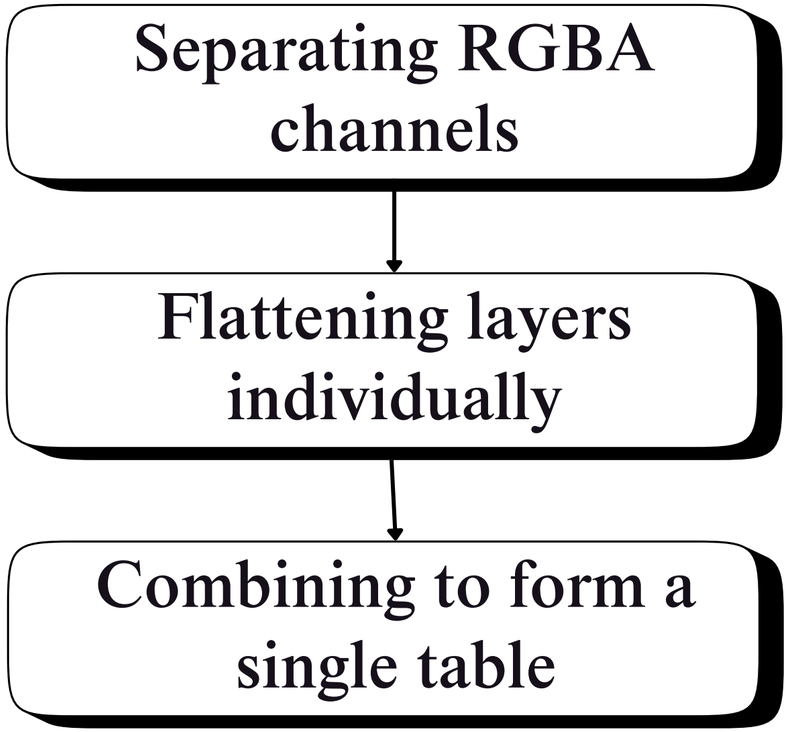
- RGB channel signatures



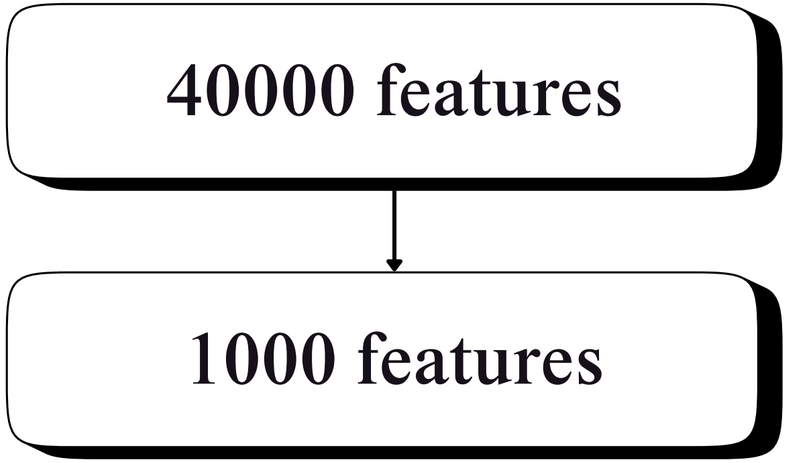
Model Development

Data preprocessing

- Converting data into tabular form



- Dimensionality reduction using Principal Component Analysis



Models

Models and their hyperparameters considered

Model	Hyperparameters	Values considered	Best parameter
XGBoost	n_estimators	{100, 150, 200}	200
	max_depth	{3, 6, 10}	6
	learning_rate	{0.01, 0.1}	0.1
	gamma	{0,0.1}	0
	subsample	{0.8, 1}	1
Logistic Regression	C	{0.1, 1, 10	0.1
	penalty	{'l1', 'l2', 'elasticnet'}	'l1'
	solver	{'liblinear', 'lbfgs'}	'liblinear
SVC	C	{1, 10, 20}	10
	kernal	{'linear', 'rbf'}	'rbf'
	gamma	{'scale', 'auto'}	'auto'

Models

Models and their hyperparameters considered

Decision Tree	criterion	{'gini', 'entropy'}	'entropy'
	max_depth	{None, 5, 10, 20}	None
	min_samples_split	{2, 10, 20}	10
	min_samples_leaf	{1, 5, 10}	1
Random Forest	n_estimators	{50, 100, 200}	200
	max_depth	{10, 20, 30}	20
	min_samples_split	{2, 10, 20}	2
	min_samples_leaf	{1, 5, 10}	1
	max_features	{'auto', 'sqrt', 'log2'}	'sqrt'

Results

Evaluation metrics

1. Accuracy: The proportion of correctly classified instances out of all instances.

$$\text{Accuracy} = \frac{\text{Correct predictions}}{\text{All predictions}}$$

2. Precision: The proportion of true positive predictions out of all positive predictions made by the model.

3. Recall: The proportion of true positive predictions out of all actual positive instances.

$$\text{Precision}_{\text{Class A}} = \frac{TP_{\text{Class A}}}{TP_{\text{Class A}} + FP_{\text{Class A}}}$$

$$\text{Recall}_{\text{Class A}} = \frac{TP_{\text{Class A}}}{TP_{\text{Class A}} + FN_{\text{Class A}}}$$

Image credits:https://www.evidentlyai.com/classification-metrics/multi-class-metrics

Evaluation metrics

Multiclass precision and recall

$$\text{Precision}_{\text{Macro-average}} = \frac{\text{Precision}_{\text{Class A}} + \text{Precision}_{\text{Class B}} + \ldots \text{Precision}_{\text{Class N}}}{N}$$

$$\text{Recall}_{\text{Macro-average}} = \frac{\text{Recall}_{\text{Class A}} + \text{Recall}_{\text{Class B}} + \ldots \text{Recall}_{\text{Class N}}}{N}$$

Image credits:https://www.evidentlyai.com/classification-metrics/multi-class-metrics

Evaluation metrics

F1-measure

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

Results

Evaluation metrics of best-performing hyperparameters of each model

Model	Accuracy	Precision	Recall	F1-Score
Xgboost	98	98	98	98
Losgistic Regression	86	87	87	87
SVC	79	81	80	80
Decision Tree	94	95	95	95
Random Forest	94	95	95	95
CNN	87	90	88	87

Results

Detailed analysis of the best performing tuned model

Classification Report:

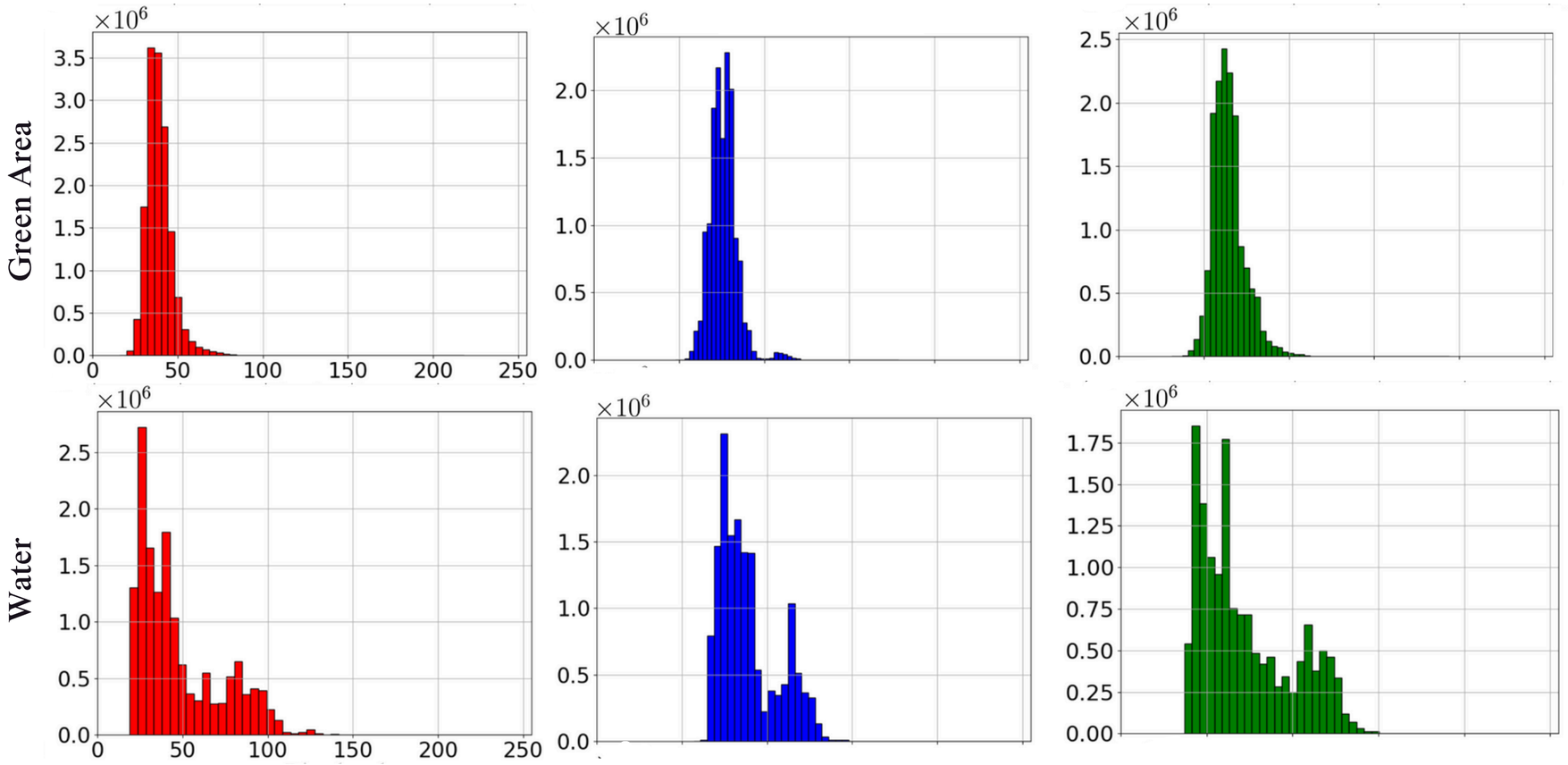
	precision	recall	f1-score	support
cloudy	1.00	1.00	1.00	502
desert	1.00	1.00	1.00	288
green_area	0.96	0.97	0.97	436
water	0.97	0.96	0.97	464
accuracy			0.98	1690
macro avg	0.98	0.98	0.98	1690
weighted avg	0.98	0.98	0.98	1690

- Perfect scores for ‘Cloudy’ and ‘Desert’ and the complementary precision and recall for ‘Green Area’ and ‘Water’ indicates the model is getting confused between these two classes

Results

Detailed analysis of the best performing tuned model

- The reason for this could be the similarity of peak of these two classes in the pixel intensity histograms



Limitations & future work

Limitations and future work

Limitations

- No spatial or geographical context was provided in the dataset.
- There are not sufficient data points to employ deep learning models.

Future work

- The same machine learning workflow can be implemented to satellite image datasets with a higher number of classes.
- Hyperparameter can be tuned for various regions or for a global scale.

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Thank you for listening!