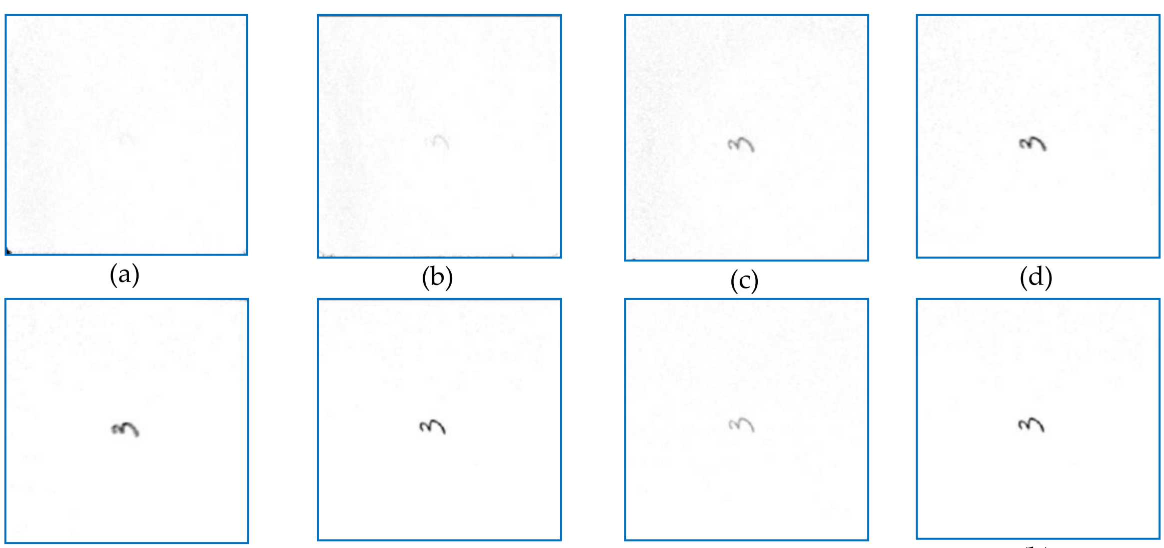
Supplementary Material

Adaptive CNN Ensemble for Complex Multispectral Image Analysis

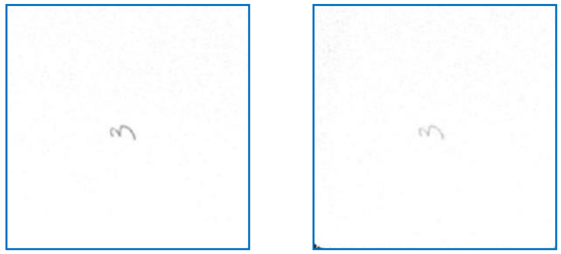
1) Extended MNIST Multispectral Dataset (EMMD) Architecture and Visualization

The concept of image dataset can be generalized to higher-order matrices. For example, image dataset contains Height, Width and Channels. The grey-scale image is a mono channel image, can be represented by two-dimensional matrix such as Height x Width. In the grey-scale image, each element of the matrix represents the intensity pixel value from 0 to 255. Whereas, in case of the color image, the dimensionality of the matrix is increased by one (1), such as Height ×Width ×Channel (if a color image is stored in the RGB format, then it has three (3) channels. Individual channel (Red, Green and Blue) is a Height x Width matrix, where each element of the matrix represents the intensity of pixel values 0 to 255. Similar is the case with the multispectral image. The multispectral image possesses more than three channels (Red, Green, Blue, Short Infra, Infra etc.). Each of the channels possesses its unique information (rate of reflectance) regarding the object in the form of Height x Width matrix. In the multispectral image, the number of channels depends on the size of the spectral band. Therefore, another way to view a single image in our proposed Extended Multispectral MNIST Dataset (EMMD) as a matrix of order 350 × 350 ×10, where 350 x 350 is a Height ×Width matrix and 10 is the number of channels (Channel-0 to Channel-9). Here, the individual channel of the multispectral image contains 350 x 350 pixels with intensity values 0 to 255. In each sample image, ten (10) channels represent ten (10) spectral bands, as shown in Figure 4. In the EMMD dataset, we kept each channel individually. Individual channels may be productive to test the multispectral models up to 10 different spectral bands. Multispectral classification algorithms are meant to identify features based on changes in their appearance (grey tone brightness) from image to image. Where differences between images are minimal (high correlation, data redundancy). The number of spectral bands and their content may change from application to application. It is dependent on the spectral qualities of the material studied. The same is the case with EMMD dataset. Therefore, EMMD can act as a generic testbed for various types of multispectral analysis-based applications.



(a) (b) (c) (d)

(e) (f) (g) (h)



(i) (j)

Figure 1. Visualization of Individual Channel (0 to 9) for the Multispectral Image from Extended MNIST dataset, (a) Channel-0 for digit three (3), (b) Channel-1 for digit three (3), (c) Channel-2 for digit three (3), (d) Channel-3 for digit three (3), (e) Channel-4 for digit three (3), (f) Channel-5 for digit three (3), (g) Channel-6 for digit three (3), (h) Channel-7 for digit three (3), (i) Channel-8 for digit three (3), (j) Channel-9 for digit three (3).

2) Inference Model

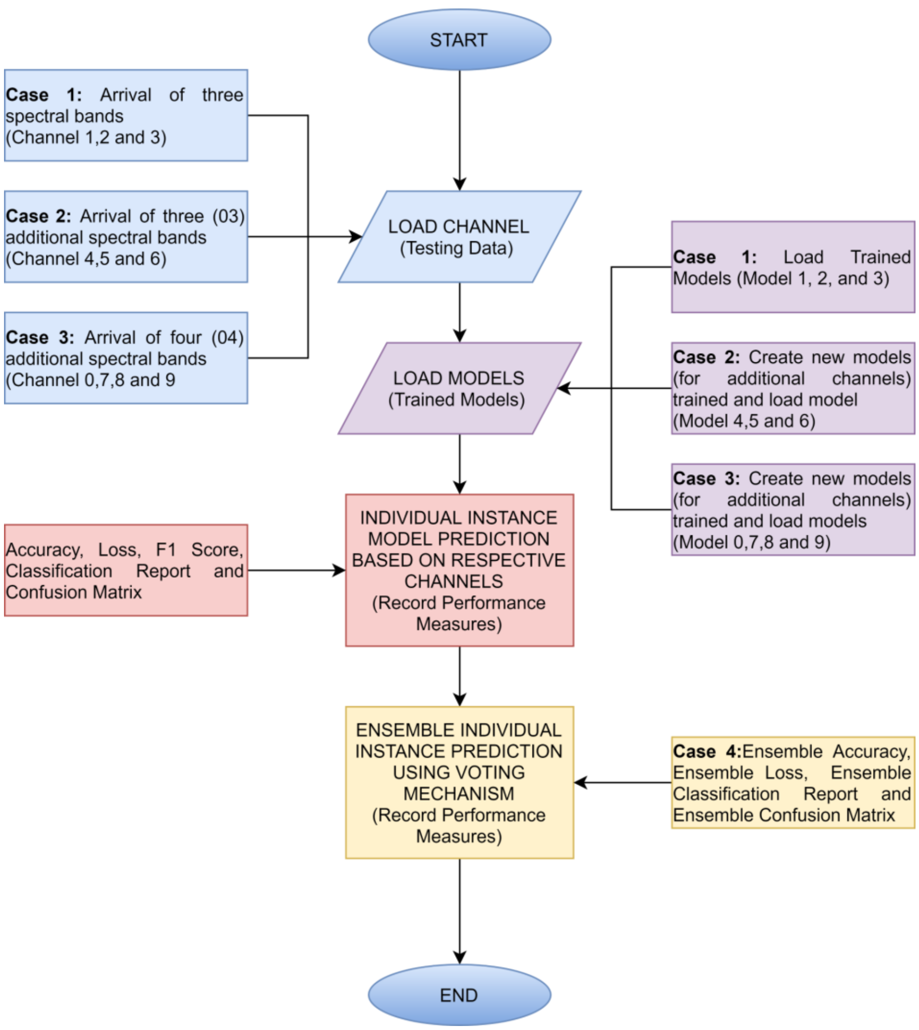


Figure 2. Inference algorithm to validate the performance of under four (4) cases.

3) Performance Evaluation Measures

Table. 2. Performance Measures and Specifications

Performance Measures		Specifications
Testing Accuracy		The accuracy measure of Testing Data (unseen model data)
Testing Loss		The loss is a summation of the errors made for each example in training or validation sets. Indicating how wrong the model's prediction was on a single example. If the model's prediction is perfect, the loss is zero; otherwise, the loss is more significant.
F1-Score		A weighted average or harmonic mean of precision and recall $F1\ Score = 2\frac{(Precision\ *\ Recall)}{(Precision +\ Recall)}$
Classification Report	The precision of the respective class output	The condition of the model is accurate (how many of the selected objects were correct) $Precision = \frac{True\ Positive}{True\ Positive + False\ Positives}$
	Recall of respective class output	The condition of the model is complete (how many of the objects that should have selected were selected) $\text{Recall} = \frac{True\ Positive}{True\ Positive + False\ Negative}$
	F1-Score of respective class output	A weighted average or harmonic mean of precision and recall for respective class outputs
	Support	True samples reported in respective output class
Confusion Matrix		The confusion matrix shows the possible confusion faced (True Positive, True Negative, False Positive and False Negative) by the trained model