Project Design Phase-II
(DataFlow Diagram)

```
                    ┌─────────────────────────────┐
                    │            Start            │
                    └─────────────────────────────┘
                                  │
                              Input Data
                                  │
        ┌─────────────────────────────────────────────────────────┐
        │          Raw image of Handwritten digit Data            │
        └─────────────────────────────────────────────────────────┘
                                  │
                                  │                          NO
                                ◇◇◇◇◇
                              ◇       ◇
                            ◇  Is image  ◇───────────┐
                            ◇ in colored ◇           │
                              ◇ (RGB)  ◇
                                ◇◇◇◇◇
                                  │
                    ┌─────────────────────────────┐
   YES              │  Transfer RGB image to Binary │
                    └─────────────────────────────┘
                                  │
        ┌─────────────────────────────────────────────────────────┐
        │              Data Augumentation                         │
        │   (Down Sampling the image to 28*28 pixels)             │
        └─────────────────────────────────────────────────────────┘
                                  │
                    ┌─────────────────────────────┐
                    │      Threshold the Image     │
                    └─────────────────────────────┘
                                  │
        ┌─────────────────────────────────────────────────────────┐
        │       Recognize the image by pre-trained CNN            │
        └─────────────────────────────────────────────────────────┘
                                  │
                    ┌─────────────────────────────┐
                    │  Displat the recognition result │
                    └─────────────────────────────┘
```
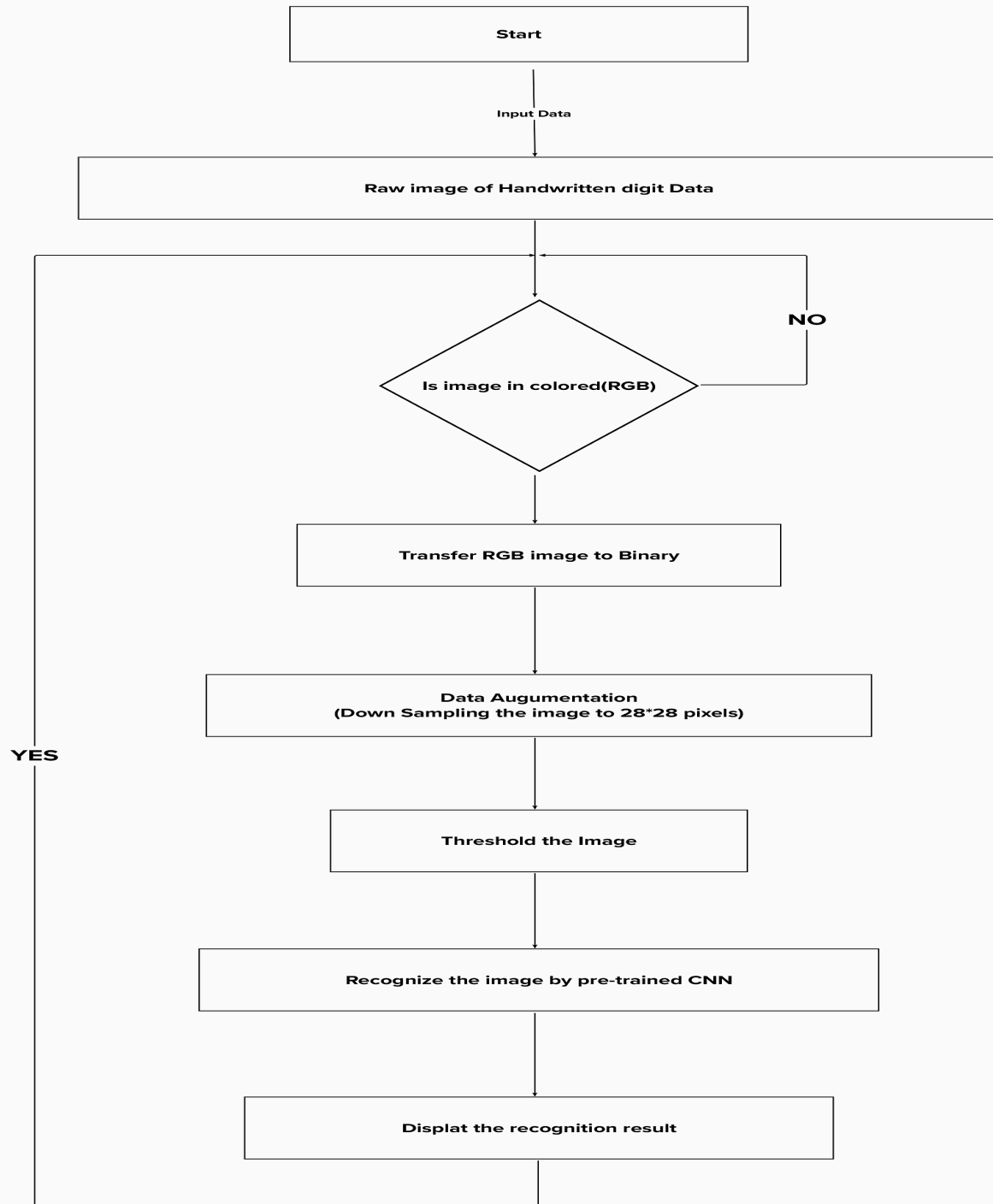
## DataFlow Diagram Description:

A. Pre-Processing:

The role of the pre-processing step is it performs various tasks on the input image. It basically upgrades the image by making it reasonable for segmentation. The fundamental motivation behind pre-processing is to take off a fascinating example from the background. For the most part, noise filtering, smoothing and standardization are to be done in this stage. The pre-processing additionally characterizes a smaller portrayal of the example. Binarization changes over a gray scale image into a binary image.

The initial approach to the training set images that are to be processed in order to reduce the data, by thresholding them into a binary image. The Figure 2 shows a sample of images taken from the MNIST database.
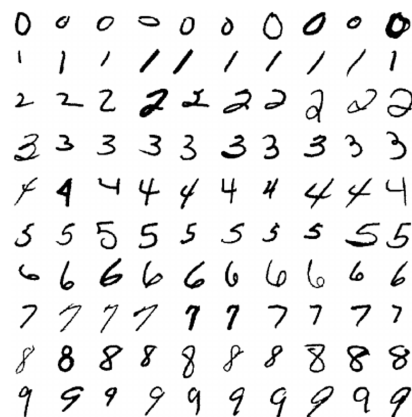
Sample images taken from MNIST database.

B. Segmentation:

Once the pre-processing of the input images is completed, sub-images of individual digits are formed from the sequence of images. Pre-processed digit images are segmented into a sub-image of individual digits, which are assigned a number to each digit. Each individual digit is resized into pixels. In this step an edge detection technique is being used for segmentation of dataset images.

C. Feature Extraction:

After the completion of pre-processing stage and segmentation stage, the pre-processed images are represented in the form of a matrix which contains pixels of the images that are of very large size. In this way it will be valuable to represent the digits in the images which contain the necessary information. This activity is called feature extraction. In the feature extraction stage redundancy from the data is removed.

D. Classification and Recognition:

In the classification and recognition step the extracted feature vectors are taken as an individual input to each of the following classifiers. In order to showcase the working system model extracted features are combined and defined using following three classifiers:

- K-Nearest Neighbor
- Random Forest Classifier
- Support Vector Machine

E. CNN:

Within Deep Learning, a Convolutional Neural Network or CNN is **a type of artificial neural network, which is widely used for image/object recognition and classification**. Deep Learning thus recognizes objects in an image by using a CNN.