

# CSE 421 – Embedded Machine Learning

## Homework 4 – Q3 (Section 11.8): Handwritten Digit Recognition

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### 1. Objective

This task focuses on handwritten digit recognition using grayscale image data. The objective is to distinguish the digit zero from all other digits using a lightweight model suitable for embedded systems.

### 2. Dataset and Feature Extraction

The MNIST dataset is used in this experiment. Each image is a 28x28 grayscale digit. Hu invariant moments are computed from each image to capture global shape characteristics. Seven Hu moments are extracted and normalized using z-score normalization based on the training set.

### 3. Model

A single-neuron logistic regression model with sigmoid activation is trained on the Hu moment features. Binary cross-entropy loss and the Adam optimizer are used. Class weighting is applied to reduce false negatives for the digit zero.

### 4. Results

The model achieved an accuracy of 0.8488 on the MNIST test set. The number of false negatives is 35. The confusion matrix (rows = true label, columns = predicted label) is shown below.

[ 945 35]  
[1477 7543]

### 5. Embedded Implementation Plan (Mbed/STM32)

The trained weights, bias, and normalization parameters are exported to C source code. On the STM32 platform, Hu moments are computed from the input image, normalized using the stored mean and standard deviation, and evaluated using the logistic regression model. The output probability is thresholded to obtain the final decision.

## **6. Conclusion**

This experiment shows that simple shape-based features combined with a minimal neural model can achieve strong performance for digit recognition while remaining suitable for embedded deployment.