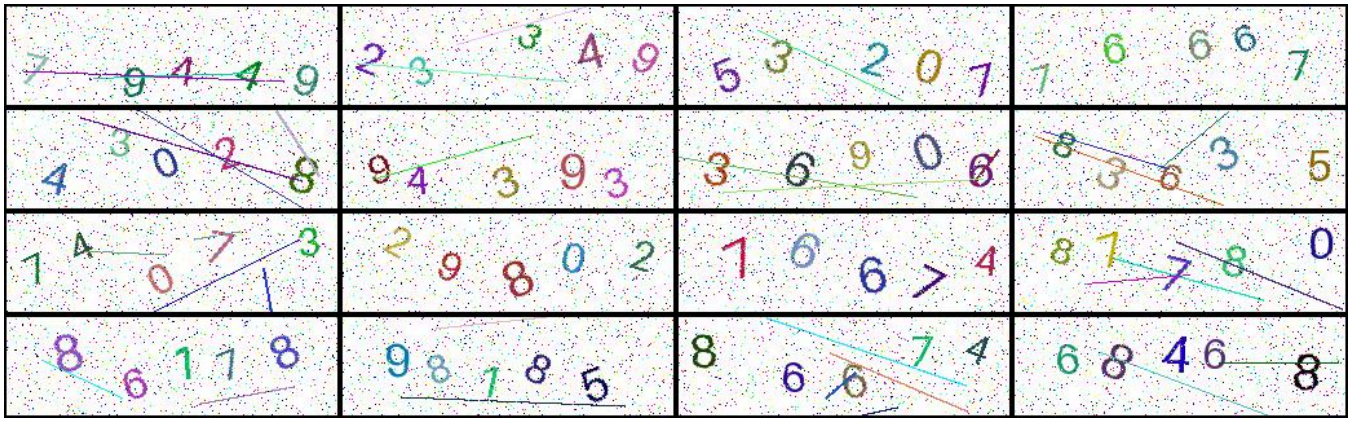
上海科技大学
ShanghaiTech University

CS172 Assignment 1: 🔐 CAPTCHAs

Shanghaitech University 2024 Fall Computer Vision I

This assignment is due on Nov.10 2024 at 11.59 pm

If you have an unavoidable delay for this assignment, you will need to provide a reasonable reason for the delay by email (`zhangchx12024@shanghaitech.edu.cn`) at least one week in advance. A seven-day delay (Nov.17 2024) is acceptable. For assignments that do not submit an extension request by the last week (Nov.3 2024), we will deduct points as appropriate.



🚨 Plagiarism Warning

This is an individual assignment. **Plagiarism is strictly prohibited** . Any form of copying or uncredited code-sharing will be treated as an academic violation. The code you submit must be **entirely your own**. You are encouraged to discuss concepts with your peers, but you must write the code yourself. Submissions will be checked for plagiarism using automated tools.

Consequences of plagiarism may include:

- Receiving zero points for this assignment.
- Facing further disciplinary actions as per your institution's academic policies.

📘 Introduction

Welcome to the first assignment of CS172. In this assignment, you will implement a neural network model to recognize verification codes (*CAPTCHAs*). This will require you to get familiar with neural network fundamentals, image processing, and training pipelines.

Verification codes are commonly used for security purposes. In this assignment, you will build a model to identify these codes from images.

In this assignment, you will:

- Generate synthetic verification code images.
- Preprocess CAPTCHA images.
- Build a neural network that can classify each character in the verification code.
- Train your model on a dataset of verification code images.
- Evaluate the performance of your model and experiment with different architectures and parameters.

🗂️ Files in this assignment

- `main.ipynb` This is the main Jupyter notebook where you'll run the whole pipeline. It contains step-by-step instructions. **Remember to complete the discussion part**.
- `cs172/generate.py` Code for generating synthetic CAPTCHA images. You will modify this to adjust image parameters.
- `cs172/datasets.py` Contains functions for loading and preprocessing the dataset. This file defines a custom PyTorch dataset class to handle verification code images and labels.
- `cs172/networks.py` Contains different neural network architectures. You will implement various architectures here and experiment with different configurations.
- `cs172/utils.py` Utility functions to help with data visualization, model evaluation, and other helper functions.
- `cs172/metrics.py` Utility file containing performance metrics such as accuracy to evaluate your model.
- `cs172/pipeline.py` Functions where you will write your training loop, handle model checkpoints, and integrate data loaders, metrics, and optimizers.

- `samples/` Sample test data folder.
- `README.md` You are reading it!
- `requirements.txt` Lists the Python libraries you need to install to run the assignment.

📝 Assignment Parts

⚙ Part 0: Setup

Make sure you have the necessary dependencies installed:

```
conda create -n 172a1 python=3.8
conda activate 172a1
pip install -r requirements.txt
```

🖼️ Part 1: Data Generation (25 pt)

In this part, you will generate synthetic CAPTCHA images in `generate.py`. Each image will contain random **Arabic numerals (0-9)**. You will:

- Define the parameters for generating the images (e.g. noise level, noise type).
- Modify `generate.py` to generate images with varying characteristics.
- Save the generated images and their corresponding labels in the `data/` folder.

📊 Part 2: Dataset Class and Data Preprocessing (15 pt)

Once you have generated the dataset, you will load and preprocess the images using the `dataset.py` file. You will:

- Implement a custom dataset class using PyTorch's `torch.utils.data.Dataset` to handle image loading and labeling.
- Preprocess the images by **resizing**, **normalizing**, and converting them into a format suitable for neural network input.
- Use the `DataLoader` class to batch the data and split it into training, validation, and test sets.

🏗️ Part 3: Model Building (25 pt)

In this part, you will build your neural networks using PyTorch. You will:

- Implement several neural network architectures in `networks.py`
    - Start with simple CNN architectures (e.g., 2-3 convolutional layers).
    - Then, experiment with more complex architectures by adding layers such as batch normalization, pooling, or dropout.
- Return to `main.ipynb` to train and evaluate the models.

🎯 Part 4: Training the Model (15 pt)

In `pipeline.py`, you will train your model on the generated dataset by:

- Defining the loss function (e.g., Cross Entropy Loss) and optimizer (e.g., Adam).
- Run back propagation and gradient descent algorithm.
- Monitoring the loss and accuracy during training and making adjustments if necessary.
- Use regularization techniques to prevent overfitting.

📈 Part 5: Evaluation (20 pt)

After training, you will evaluate your model on the test set. You will:

- Report the accuracy of the model on unseen test data.
- Visualize some predictions and compare them with the ground truth labels.
- Investigate and analyze failure cases (incorrect predictions) to understand how to improve the model.
- To optimize the performance, you will experiment with various hyperparameters such as Learning rates, Batch sizes. Network architecture (e.g., number of layers, filter sizes, and activations). Report the best-performing model configuration and analyze its results.

📤 Submission

Please submit the following files :

- Export `main.ipynb` as a `pdf` file to **BlackBoard**. **Remember to complete the discussion part in the notebook**.
- Submit a `zip` file (`ChineseName-StudentID.zip`) of your entire project directory (**WITHOUT DATA FOLDER !!!**) to ShanghaiTech EPAN. Make sure your `main.ipynb` can be run directly and matched with the output of your `pdf` file, we will check it.

Repeat!

This assignment is due on Nov.10 2024 at 11.59 pm

If you have an unavoidable delay for this assignment, you will need to provide a reasonable reason for the delay by email (`zhangchx12024@shanghaitech.edu.cn`) at least one week in advance. A seven-day delay (Nov.17 2024) is acceptable. For assignments that do not submit an extension request by the last week (Nov.3 2024), we will deduct points as appropriate.

Good luck, and have fun with the assignment! 🎉