Deep Learning Coursework Guidance

*Note: Deep Learning Final Project Report

Name
dept. name of organization
name of organization
email address

***Abstract*—This course work focuses on two tasks: pose classification and depth estimation for microrobots using monocular microscopic images.**

***Index Terms*—Deep Learning Coursework**

I. Introduction

A. Background

Microscopic imaging plays a crucial role in fields such as biomedicine, nanotechnology, and microrobotics, where objects of interest exist at micro- or nanoscale dimensions. The datasets generated from such imaging techniques often capture highly detailed spatial information about micro-objects or microrobots under a variety of conditions, including differences in orientation and focus.

Microscopic datasets used for tasks like pose classification and depth estimation introduce unique challenges. For instance, transparent or semi-transparent objects, such as microrobots, often exhibit low-contrast boundaries, which complicates feature extraction. Moreover, the data is significantly influenced by the optical properties of the microscope and camera setup.

Potential Challenges:

- Absence of stereo or multi-view information, limiting the ability to reconstruct 3D shapes.
- Scarcity of labeled data due to the reliance on manual annotation and the complexity of experimental setups.
- Dependence on handcrafted features, which are highly sensitive to variations in imaging conditions.

Two tasks for coursework:

1) Pose Classification: Pose classification identifies the discrete orientation or configuration of an object in space. In microrobotics, it is vital for tasks such as trajectory planning, manipulation, and monitoring.

Recent advances in deep learning, particularly CNNs, enable automatic feature learning from raw image data, significantly improving pose classification.

2) Depth Estimation: Depth estimation predicts the distance of an object from the imaging plane along the optical axis. This is critical for 3D manipulation, tracking, and automation.

Note: Integrating pose classification and depth estimation into a unified framework enhances automation capabilities in microscopic systems.

II. Tasks and Methodology

A. Task 1: Data Preparation and Preprocessing

Objectives:

1) Understand the dataset structure.
2) Prepare data for input into deep learning models.

Steps:

1) **Data Loading:** Write scripts to read images from the `Image/` folder and parse `Label.txt` for depth and pose labels. The `Label.txt` file links each image to specific pitch angle, roll angle, and depth regression values.
2) **Exploratory Data Analysis:** Visualize sample images and analyze label distribution.
3) **Augmentation:** Optional.
4) **Normalization:** Normalize pixel intensities and standardize depth values.
5) **Data Splitting:** Split data into 60% training, 20% validation, and 20% testing sets, ensuring balanced pose class distribution.

B. Task 2: Pose Estimation (Classification)

Objectives:

1) Design and implement a deep learning model for pose classification.
2) Evaluate performance using classification metrics.

Steps:

1) **Model Design:** Implement and compare at least three CNN architectures.
2) **Model Optimization and Regulation:** Optional
3) **Evaluation:** Measure Accuracy, Precision, Recall, F1 Score, and Confusion Matrix.
4) **Error Analysis:** Identify patterns in misclassified samples.

C. Task 3: Depth Estimation (Regression)

Objectives:

1) Build a regression model for depth estimation.
2) Achieve submicron accuracy.

Notes or link for marking. If none, delete this.

Steps:

1) **Model Design:** Output a single continuous value for depth prediction.
2) **Advanced Training Strategy:** (Optional)
3) **Evaluation:** Measure RMSE and compare results across architectures.
4) **Error Analysis:** Visualize prediction errors and discuss edge cases.

D. Task 4: Hyperparameter Tuning (Optional)

Objectives:

1) Optimize performance through systematic hyperparameter tuning.
2) Justify selected hyperparameters based on experiments.

E. Task 5: Evaluation and Reporting

Objectives:

1) Present results with clarity and depth.
2) Provide insights into performance, limitations, and future directions.

Steps:

1) **Test Set Evaluation:** We will test your model performance in our new dataset.
2) **Final Report:** Prepare an IEEE-formatted document with sections including Abstract, Introduction, Objectives, Methodology, Experiments, Evaluation, Conclusions, and Future Work.

III. Deliverables (Submissions)

1) **Code:** Scripts for data preprocessing, model training, evaluation, and tuning.
2) **Models:** Models for testing
3) **Report:** IEEE-formatted doble-column document (3–6 pages) with results and insights.