CS5330 Pattern Recognition and Computer Vision

Term Project: Computer Vision Project

Objectives:

1. *Develop practical skills* in computer vision and pattern recognition through hands-on implementation and experimentation.
2. Compare *methodologies by evaluating* traditional machine learning and deep learning techniques for computer vision.
3. Foster *critical thinking* in assessing approaches, addressing challenges, and proposing solutions.
4. Enhance communication skills in conveying technical concepts and project findings.

This will be a group project by 4 students for one semester. This term project aims to give students hands-on experience in applying pattern recognition and computer vision techniques. Students will work in teams to explore a specific problem, implement relevant algorithms, and evaluate their performance using a collected dataset.

Select types of Projects (after forming a group)

1. **Type 1: Engineering Project**
   - In this project, groups choose an interesting topic in computer vision and develop a real-world application or proof of concept. The project involves implementing a system that demonstrate the selected computer vision technique.
   - **Requirements**:
     - Select a practical CV topic.
     - Develop an application or proof of concept using
       - live WebCam
       - Web applications
       - Standalone system
       - Cell phone application
       - Others.
     - Showcase a functional system or prototype.
   - **Example**: An autonomous vehicle system that recognizes traffic signs using real-time WebCam input and controls navigation accordingly.

2. **Option 2: Re-producing Project**
   - Groups select a recent research paper (published within the last 3 years) from top computer vision conferences. The task is to replicate the results presented in the paper while adding a novel contribution, such as using a different dataset or providing additional comparisons. The paper should be published in the following conferences:
     - Conference on Computer Vision and Pattern Recognition (CVPR)
     - International Conference on Computer Vision (ICCV)
     - European Conference on Computer Vision (ECCV)
     - NeurIPS (Conference on Neural Information Processing Systems)
     - Asian Conference on Computer Vision (ACCV)
     - International Conference on Image Processing (ICIP)

        - Contact an instructor if your selected paper is not in the list.
    - **Requirements**:
        - Choose a recent paper from a top CV conference.
        - Reproduce the research results in the paper.
        - Add a unique contribution (e.g., new dataset, extended experiments, etc.).
    - **Example**: Reproducing a paper on object detection using YOLO and contributing by training it on a new custom dataset of aerial images for wildfire detection.

3. **Option 3: Research Project**
    - In this project, Groups define and conduct original research in a specific area of computer vision. This includes formulating a research problem, proposing a solution, conducting experiments, and evaluating the results. The final output is expected to be a draft paper suitable for submission to a CV conference.
    - **Requirements**:
        - Identify a novel CV research problem.
        - Propose a solution and run experiments to validate it.
        - Draft a research paper with results and discussion.
    - **Example**: Researching a novel algorithm for 3D human pose estimation using monocular video, conducting experiments, and drafting a conference-ready paper.

Phase 1 (15%): Form Group and Brain-Storming - Due: September 25, 2024 (Wednesday)

- First, you need to find your project partner and sign in by September 18. After your team is formed, you need to sign in a group on Canvas (Menu → People → Project Group). If you do not find your partner, an instructor will assign your team during a class on September 19.

- Each group needs to bring any idea of computer vision project that can be addressed by using machine learning and computer vision techniques. That includes:
    - Selecting type of project from:
        - Engineering Project
        - Reproducing Project
        - Research Project
    - Defining problems
        - What can you address in this project?
        - What are the expected results of project?
        - Your problem should include one or more from types of CV problems:
            - Classification
            - Detection (objects or others)
            - Recognition
            - Segmentation
            - Generation
            - Prediction
            - Others
        - Clearly mention what type(s) of problem your project is
    - Collecting datasets

        - What are the characteristics of the data set
        - How to collect the data set
        - Sample data (images, videos, or others)
        - Are ground truth data (or labeled or annotated data) needed? If yes, are there labeled data.
    - Ideas to solve the problems
        - What kinds of computer vision techniques can be applied to address the problems
        - Any existing solutions or tools
    - Conducting literature survey
        - Find relevant problems and publications

- Make 5~10 pages of Presentation file as a report including:
    - Project title(s)
    - Project members
    - Project Type
    - Defining Problem(s)
    - Dataset(s)
    - Ideas to solve the problem(s)
    - Related works

- Then, submit the PPT file to Canvas
    - PPT, PPTX or PDF file format ONLY

- Submit 5 min presentation video to Canvas
    - ONLY video link will be accepted (do not upload entire video)

Phase 2 (20%): Preparing Proposal – Due: October 9, 2024 (Wednesday)

- Prepare a proposal using a template: A proposal template can be found at Canvas

  0. Project Title
  1. Introduction
  2. Problem Definitions
  3. Related works (literature survey)
  4. Data Set
  5. Computer Vision Algorithms
  6. Evaluation Plan
  7. Project Plan and Members' Roles
  8. Conclusions

- In addition, in your proposal you need to consider how to prepare the final deliverable of following outputs

  1. Poster using PowerPoint (24 x 36 inches): Some templates can be found at Canvas. Also, you can build your own poster with 24 x 36 inches size
  2. Write-up
  3. Project Github Repo (Source code management)
  4. Data set

- Prepare 5 ~ 10 pages of Powerpoint file for the presentation
- Then, submit the PPT file to Canvas

    - PPT, PPTX or PDF file format ONLY
- Submit 5 min presentation video to Canvas
    - ONLY video link will be accepted (do not upload entire video)

Phase 3 (35%): Implementation – Due: November 13, 2024 (Wednesday)

In this phase, you will implement the solution to the problem you proposed in Phases 1 and 2. This phase is critical as it demonstrates your ability to apply theoretical knowledge in a practical setting.

1. **Project Implementation**
    - **Objective:** Develop and implement a working solution that addresses the problem statement, and objectives outlined in the earlier phases.
    - **Requirements:**
        - You may use any programming language, provided it is compatible with OpenCV for computer vision tasks.
        - The implementation should include all aspects of the project, from data preprocessing and feature extraction to model training and evaluation.
        - Ensure that the solution is robust and can handle real-world data scenarios effectively.
    - **Guidelines:**
        - **Modular Code Structure:** Organize your code into modules (e.g., data loading, preprocessing, model definition, training, evaluation) for clarity and maintainability.
        - **Documentation:** Include comprehensive comments and documentation within the code to explain the purpose and functionality of different components.
        - **Testing and Validation:** Implement thorough testing, including unit tests and validation with different data subsets, to ensure the reliability of your implementation.

2. **Source Code and Dataset Submission**
    - **Source Code Submission**
        - Upload all your source code files to your project's GitHub repository. Ensure the repository is public or accessible to the instructor.
        - Include a detailed README file that outlines:
            - The purpose of the project
            - Instructions for setting up the environment and running the code
            - Dependencies and installation instructions
            - A brief description of each module and script
            - Any special considerations or known issues
    - **Dataset Submission**
        - If your dataset is large, upload it to a suitable cloud storage service such as Google Drive, Dropbox, or any other web hard.
        - Provide a link to the dataset in your GitHub repository's README file. Ensure that the dataset is accessible and properly documented, including a description of its contents, structure, and any preprocessing steps applied
    - **Additional Considerations**
        - **Version Control:** Use Git effectively to manage your code. Regularly commit changes with descriptive messages and use branches for different features or experiments.

- **Collaboration:** If working in a group, ensure that contributions are clearly documented. Each member's contributions should be identifiable through commits and code sections.

Phase 4 (30%): Presentation of Project – Due: December 4, 2024

1. Poster (36 x 24 inches PowerPoint file). You can use one of templates provided on Canvas.
   - Due: December 4 (Wednesday)
   - PPT, PPTX or PDF file format ONLY

2. Writing-up (using 2 columns IEEE format). You must use IEEE format.
   - https://www.ieee.org/conferences/publishing/templates.html
   - Due: December 4 (Wednesday)
   - PPT, PPTX or PDF file format ONLY

3. Submit 5 min presentation video to Canvas
   - ONLY video link will be accepted (do not upload entire video)

Submission

You will submit your program using Github repo and Canvas.

Grading

15% Phase 1
20% Phase 2
35% Phase 3
30% Phase 4

1. **Form Group and Brainstorming (15%)**
   - Clarity of problem statement (5%)
     - 5: Exceptionally clear and precise problem statement, with well-defined scope.
     - 3: Generally clear but with minor ambiguities; scope mostly defined.
     - 1: Vague or unclear problem statement; poorly defined scope.
   - Justification for chosen problem (10%)
     - 9-10: Strong, well-articulated justification with comprehensive discussion of relevance and importance.
     - 7-8: Clear and logical reasons, covering relevance and impact with minor gaps.
     - 5-6: Basic justification with some reasoning, limited depth.
     - 1-4: Weak or minimal justification; reasons are vague or poorly explained.

2. **Preparing Proposal (20%)**
   - Problem Statement and Objectives (5%)
     - 5: Clear and specific problem statement with well-defined, relevant objectives.
     - 3: General problem statement with somewhat defined objectives.

    - 1: Vague problem statement with unclear or missing objectives
  - Depth and relevance of literature review (5%)
    - 5: Comprehensive and relevant review, showing clear understanding of the field.
    - 3: Adequate review covering key studies, but lacks depth.
    - 1: Limited review with significant gaps or outdated references.
  - Methodology Outline (5%)
    - 5: Detailed and logical methodology, well-justified and feasible.
    - 3: Basic methodology with some details, generally feasible.
    - 1: Vague or incomplete methodology, feasibility unclear.
  - Feasibility and Innovation (5%)
    - 5: Highly feasible with innovative elements.
    - 3: Feasible with some innovation.
    - 1: Feasibility issues with little to no innovation.

3. **Implementation & Evaluation (40%)**
  - Implementation Quality (15%)
    - 13-15: Robust, efficient, accurate implementations with good framework usage.
    - 10-12: Mostly correct, minor issues, appropriate use of frameworks.
    - 7-9: Functional but with errors; only one approach is well-executed.
    - 4-6: Significant issues, poor integration, minimal framework usage.
    - 0-3: Non-functional or missing significant components.
  - Model Performance and Evaluation (15%)
    - 13-15: Comprehensive evaluation, multiple models compared, optimized performance.
    - 10-12: Good evaluation, model comparison present, some optimization.
    - 7-9: Basic evaluation, limited comparison, minimal optimization.
    - 4-6: Inadequate evaluation, little comparison, no optimization.
    - 0-3: No meaningful evaluation or comparison.
  - Analysis and Interpretation of Results (5%)
    - 5: Insightful analysis, identifies strengths/weaknesses, discusses implications.
    - 4: Good analysis, covers most key points, some depth.
    - 3: Basic analysis, limited depth, few key findings.
    - 1-2: Minimal analysis, lacks key findings or depth.
    - 0: No analysis provided.
  - Documentation and Code Quality (5%)
    - 5: Well-documented, organized, readable, and maintainable code.
    - 4: Mostly documented, generally organized, minor readability issues.
    - 3: Minimal documentation, some organization issues, moderate readability.
    - 1-2: Little documentation, poor organization, difficult to read.
    - 0: No documentation, poorly organized, unreadable code.

4. **Final Report & Presentation (20%)**
  - Poster (10%)
    - Design and layout (3%)
    - Content Quality (5%)
    - Clarity and conciseness (2%)
  - Writing-Up (IEEE 2-Column Format) (15%)
    - Adherence to IEEE Format (3%)
    - Content Quality and Completeness (7%)

    - Clarity of Writing and Technical Language (3%)
    - References and Citations (2%)
- 5-Minute Presentation Video (5%)
    - Presentation Content (2%)
    - Delivery and Engagement (2%)
    - Use of Visual Aids and Media (1%)