A. Road Segmentation using Computer Vision

Road segmentation is one of the critical steps of lane detection, involving the identification of the road from images or video frames. Figure 1 shows the expected output of applying segmentation to an image or video frame extracted from a digital video recorder. Based on the expected output, it can be observed that the road is segmented and highlighted in blue. Some additional processing can then be carried out to identify the lane from the segments (i.e., lane detection).

Figure 1: Original image or video frame (left), and the sample output after segmentation (right) [1].

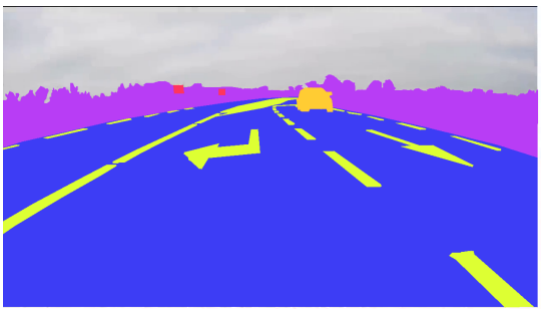
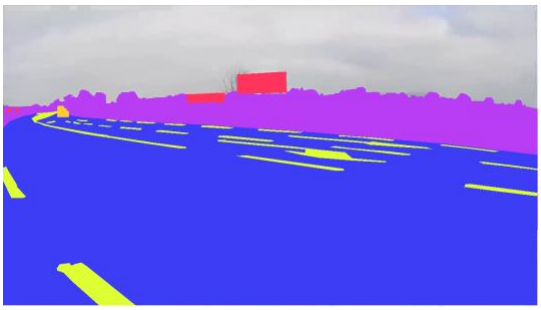
Lane detection not only that it plays an important role in autonomous vehicles, as autonomous vehicles rely on accurate lane detection for navigation, it also helps in advanced driver assistance systems for lane departure warning. Figure 2 shows some sample outputs of lane detection.

Figure 2: Visualisation of current lane (in red) and drivable lane (in blue) [2].

In this project, you are required to study existing computer vision-based systems or algorithms for road segmentation and develop one yourself. You will be developing your own system or algorithm and

evaluating its performance using the road segmentation dataset prepared by TrainingData [1]. Some of the images or video frames and the ground truths (or answers) are shown in Table 1.

Table 1: Sample images or video frames and their respective ground truths [1].

No	Sample Image	Mask (Ground Truth)
00		
10		

B. Expectations

Part I: Literature Review

This is an individual project divided into two parts. The first part involves reviewing and comparing (i) existing **computer vision-based systems or algorithms** for road segmentation, and (ii) the performance metrics typically adopted. Completing this should (i) give you some ideas on the purpose of road segmentation, (ii) the general steps involved in road segmentation, and (iii) how to quantify the outcomes or results you obtained.

Part II: Development

For the second part, the main task is to (i) **develop your own computer vision-based system or algorithm for road segmentation using Python and OpenCV**, and (ii) **evaluate its performance by applying it to images from the road segmentation dataset prepared by TrainingData** [3].

When developing your system or algorithm, you can either (i) design it based on an existing system or algorithm you have studied and try to improve it, or (ii) combine different algorithms, including those learned in class, to create a new one. Please note that you must highlight the differences between your system or algorithm and the existing ones. It is acceptable if the modifications do not help in improving the performance, as long as you identify the cause and explain why.

To-do List:

No.	Description	√
1	Review and compare various systems or algorithms for road segmentation.	
2	Identify performance metrics normally adopted to evaluate the systems or algorithms.	
3	Submit your literature review to Turnitin before 14th June 2024, 11:59PM.	
4	Download the road segmentation dataset from here.	
5	Develop a computer vision-based system or algorithm for road segmentation.	
6	Evaluate its performance based on the performance metrics identified.	
7	Submit your report to Turnitin before 29th July 2024, 11:59PM.	
8	Submit your code to eLearn before 29th July 2024, 11:59PM.	

C. Deliverables

No.	Description	Weightage
1	Literature Review in Standard Report Format Format: Single-Column Font Size: 12 Point Spacing: Single	20%
2	Development of Road Segmentation System or Algorithm	15%
3	Project Report in IEEE Format (Template Provided)	5%

D. Submissions

The submission links will be created one week before the deadline on eLearn. For the literature review and the project report, please directly submit them to their respective Turnitin link on eLearn. In addition to these, please submit a copy of all the deliverables above to another submission link that will be created on eLearn. Please remember **not** to submit your program to Turnitin. Failure to adhere to this instruction will result in no marks being awarded.

E. References

[1] TrainingData, "Road Segmentation Dataset", Kaggle. Accessed: 13th May 2024. [Photo]. Available: https://www.kaggle.com/datasets/trainingdatapro/roads-segmentation-dataset.

[2] D. G., Lee, "Fast Drivable Areas Estimation with Multi-Task Learning for Real-Time Autonomous Driving Assistant", Applied Sciences, vol. 11, no. 22, 2021. Accessed: 13th May 2024. [Online]. Available: https://doi.org/10.3390/app112210713.

F. Marking Rubrics for Part I: Literature Review (20%)

Criteria	Unsatisfactory (0-3)	Satisfactory (4-6)	Good (7-10)
Literature Search and Relevance of Literature (2%)	Review at most three existing systems, techniques, or algorithms and all the reviews are not relevant to the project aim. Articles are mostly selected from informal sources of information such as blogs, unverified websites and/or non-peer reviewed sources.	Review at least four systems, techniques, or algorithms and most of them is relevant to the project aim. Majority of the articles are selected from academic, scholarly peer-reviewed journal or conference articles, or trusted sources.	Review at least five existing systems, techniques, or algorithms and all of them is relevant to the project aim. All the articles are selected from academic, scholarly peer-reviewed journal or conference articles, or trusted sources.
Comprehension and Summary (6%)	Limited understanding and incomplete summary of key concepts. Key concepts are misunderstood or not fully explained. Summary lacks coherence and may contain inaccuracies.	Adequate understanding and summary of key concepts. Key concepts are generally understood, but some important details may be missing from the summary. Summary provides a basic overview of the literature but lacks depth.	Clear understanding and concise summarization of key concepts. Key concepts are accurately understood and effectively summarized. Summary provides a comprehensive overview of the literature, capturing essential details and insights.
Critical Analysis (6%)	Limited critical evaluation of approaches and limitations. Analysis lacks depth and may rely on surface-level observations.	Some critical evaluation of approaches and limitations. Analysis demonstrates a basic understanding of strengths, weaknesses, and implications of different approaches.	Thorough critical evaluation of approaches and limitations. Analysis is insightful and demonstrates a deep understanding of the strengths, weaknesses, and implications of different approaches.
Clarity and Organization (4%)	Writing lacks clarity and organization. Ideas are presented in a disorganized manner, making it difficult to follow the argument. Sentence structure and	Writing is clear but lacks consistent organization. Ideas are generally well-presented but may be scattered or repetitive in places. Sentence	Clear writing with consistent organization of ideas. Ideas are logically organized and clearly presented, facilitating understanding.

	grammar may impede understanding.	structure and grammar are generally correct but may require improvement for greater clarity.	Sentence structure and grammar are strong, enhancing readability and flow.
Citation and References (2%)	No in-text citations or reference list, or there are many errors in in-text citations or reference list. Mismatch of citations and references.	With a few errors (<3) in the reference list or in-text citations. Missing of a few (<3) references that should have been included.	Error free reference list and in-text citations. No missing of references.

G. Marking Rubric for Part II: Development of Road Segmentation System or Algorithm (20%)

Report Writing (5%)

You have to submit a report using the double-column IEEE format with no more than 6 pages, that consists of the following:

1) Introduction
   - Clear definition of the problem.
   - Explain why it is important to solve the problem.
   - Describe the difference(s) between your proposed algorithm and existing algorithms.
2) Methodology and Proposed Algorithm
   - Description of steps taken to develop the system or the proposed algorithm.
   - Description and justification of the design of the system or the proposed algorithm.
3) Results and Discussions
   - Describe the experimental setup.
   - Describe the results.
   - Discussions of the results.
4) References

Criteria	Unsatisfactory (0-3)	Satisfactory (4-6)	Excellent (7-10)
Introduction (10%)	Introduction is missing or lacks clarity in explaining the purpose and scope of the project. It may not provide sufficient background information on road segmentation or the motivation for the system development.	Introduction provides a basic overview of the project, including its purpose, scope, and background information road segmentation. It sets the context for the report but could be more concise or engaging.	Introduction is well-written and effectively sets the stage for the report, clearly explaining the project's objectives, significance, and relevance to road segmentation using computer vision. It engages the reader and generates interest in the topic.

Methodology and Approach (40%)	Methodology and approach are poorly described or lack detail, making it difficult to understand how the system was developed or implemented. Key steps or algorithms may be omitted or poorly explained.	Methodology and approach are adequately described, providing a clear overview of the steps followed in developing the system. It outlines the key algorithms, techniques, and tools used but may lack some detail or clarity in explanations.	Methodology and approach are thoroughly described, offering a comprehensive overview of the steps taken to develop the system. It provides detailed explanations of the key algorithms, techniques, and tools used, making it easy for the reader to follow the development process.
Results and Discussion (40%)	Results and discussion are missing or lack meaningful analysis of the system's performance or effectiveness. It may not include any empirical results or visualizations to support the findings.	Results and discussion provide some analysis of the system's performance or effectiveness, presenting empirical results or visualizations to support the findings. However, the analysis may be superficial or lacking in depth.	Results and discussion offer a comprehensive analysis of the system's performance or effectiveness, providing insightful interpretation of empirical results or visualizations. It includes detailed discussions, or observations to evaluate the system's strengths and limitations effectively.
Writing Style and Clarity (10%)	Writing style is poor, with numerous grammatical errors, unclear phrasing, or awkward sentence structures. It may be difficult to understand or follow the flow of ideas.	Writing style is generally clear but may contain some grammatical errors, awkward phrasing, or inconsistencies in tone or voice. It may require some effort to understand or follow the flow of ideas.	Writing style is polished and engaging, with clear phrasing, proper grammar, and consistent tone or voice throughout the report. It is easy to understand and follow the flow of ideas, enhancing readability and comprehension.

OpenCV and Python Program (15%)

Criteria	Unsatisfactory (0-3)	Satisfactory (4-6)	Excellent (7-10)
Code Quality (20%)	Code is poorly structured, lacks comments or documentation, and may contain numerous redundancies or inefficiencies. Variable names and formatting are inconsistent.	Code is reasonably structured and contains some comments or documentation to explain key sections or functions. It generally follows best practices but may contain a few redundancies or inefficiencies. Variable names and formatting are generally consistent.	Code is well-structured and thoroughly documented with clear comments explaining its logic and functionality. It follows best practices for programming, with efficient algorithms and minimal redundancies. Variable names and formatting are consistent and descriptive.
Accuracy (20%)	Road segmentation results are inaccurate or inconsistent, with frequent misclassifications or errors in identifying road areas. It may struggle to segment roads under certain conditions or in complex environments.	Road segmentation results are generally accurate but may exhibit some inconsistencies or occasional errors in identifying road areas. It performs adequately under most conditions.	Road segmentation results are highly accurate and reliable, with minimal errors or inconsistencies in identifying road areas. It demonstrates robust performance across a wide range of conditions and environments.
Error Handling (20%)	Program lacks robust error handling and may crash or produce unexpected behavior when encountering errors or exceptions. It does not provide informative error messages or feedback to the user.	Program includes basic error handling to handle common exceptions or errors gracefully. It provides some feedback to the user in case of errors but may not cover all possible failure scenarios.	Program includes comprehensive error handling to anticipate and handle various exceptions or errors effectively. It provides informative error messages and feedback to the user, guiding them on how to resolve issues or mitigate failures.
Minimal Human Intervention (20%)	Program requires significant manual intervention or adjustment to function properly. It relies heavily on user input or	Program requires some manual intervention or adjustment to optimize performance but can operate semi-autonomously with minimal user input. It	Program operates autonomously with minimal human intervention. It can accurately perform road segmentation and adapt to changing

	tuning parameters for road segmentation.	may require occasional parameter tuning or adjustments for specific scenarios.	conditions without requiring constant parameter tuning or manual adjustments.
Advanced Algorithms and Techniques (20%)	Program implements basic algorithms and techniques covered in class, with no significant modifications or advancements. It shows limited understanding of advanced concepts.	Program implements some modifications or advancements to the algorithms and techniques covered in class. It demonstrates a reasonable understanding of advanced concepts but may not fully leverage their potential.	Program demonstrates significant modifications or advancements to the algorithms and techniques covered in class. It incorporates innovative solutions or optimizations, showing a deep understanding of advanced concepts and their practical applications.