A Project Report

On

Human-Machine Interaction for Two-Wheeler Bikers

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Certificate

This is to certify that the project report entitled "HMI for Two-Wheeler Bikers" submitted by Mr. Yashaswi Singh (Roll NO: SE21UCAM017), Mr. Ashwin Baduni (Roll NO: SE21UCAM003), Mr. Rama Kashyap Eddu (Roll NO: SE21UCSE058), Mr. Rahul Chiguru (Roll NO: SE21UECM084), Mr. Daksh Thawani (Roll NO: SE21UCAM004) in partial fulfillment of the requirements of the course PR 3201, Project Course, embodies the work done by him/her under my supervision and guidance.

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ABSTRACT

This work delves into the realm of Human-Machine Interaction (HMI) with a focus on enhancing the safety and performance of two-wheeler bikers. Acknowledging the unique challenges faced by riders in dynamic and unpredictable traffic environments, the study aims to develop intuitive and responsive interfaces between bikers and their vehicles. The investigation also explores the design and evaluation of user-friendly interfaces that promote situational awareness, facilitate seamless information transfer, and contribute to proactive decision-making.

To obtain dash-cam videos from bikes, assess the rider's driving based on key aspects of the recorded video, and finally provide a detailed report, we will analyse the speed changes with respect to time, determine the angle of turns to detect sharp turns, identify and classify relevant objects in the video as either stationary or mobile, and calculate the relative movement with respect to these objects to ensure the rider's safety. Additionally, we will track the route via GPS to gather path information, which will help pinpoint the locations where mistakes were made. By grading the performance based on specific parameters that affect a rider's safety, assigning weights to these parameters, and generating a safety score, we will create an easy-to-understand report summary that highlights the key findings and provides actionable insights.

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1 Project Description

This work delves into the realm of Human-Machine Interaction (HMI) with a focus on enhancing the safety and performance of two-wheeler bikers. Acknowledging the unique challenges faced by riders in dynamic and unpredictable traffic environments, the study aims to develop intuitive and responsive interfaces between bikers and their vehicles. The investigation also explores the design and evaluation of user-friendly interfaces that promote situational awareness, facilitate seamless information transfer, and contribute to proactive decision-making.

2 Goal

To obtain dash-cam videos from bikes and then assess the driving of the rider based on the key aspects of the recorded video and finally give a detailed report.

3 Objectives

1. Speed: how the speed changes w.r.t. time.
2. Direction: determining the angle of turning to detect sharp turns.
3. Object Detection: find and determine relevant objects in the video.
4. Object Classification: classify objects as stationary or mobile.
5. Relative Movement With Respect To Said Object: this is needed to deal with such scenarios:
   (a) if the rider goes too close to a stationary object, it should be acceptable.
   (b) if the object is moving, we will have to calculate the relative distance of rider from the object to ensure rider's safety.
6. Path Tracking Of The Route Via GPS:
   we need the information about path because that will help us while making the report summary of the journey, we will be able to pin-point the locations where a mistake was made.
7. Grading the Performances:

There are certain parameters on which a rider's safety depends. Those parameters will be assigned weights and then a safety score will be generated.

8. Giving A Report Summary:
   Using the graded performance, an easy-to-understand report will be made.

4 The Ideation Process

This section contains the ideas we initially had in order to complete all the objectives mentioned in section 1. Here, will also give a brief overview of the algorithms that we dropped or chose and also the reason(s) to do the same (wherever necessary).

4.1 Speed

4.1.1 Optical Flow

Optical flow refers to the pattern of apparent motion of objects, surfaces, and edges in a visual scene caused by the relative motion between an observer and the scene. It is typically represented as a vector field where each vector describes the motion of a point from one image frame to the next. Advantages:

1. Motion Detection: Helps in detecting and estimating motion, which is useful in video compression, surveillance, and navigation systems.
2. Object Tracking: Facilitates the tracking of objects across frames in video sequences, essential for applications in robotics and autonomous vehicles.
3. Depth Estimation: Contributes to depth perception in stereo vision systems, enhancing the understanding of scene geometry.
4. Image Segmentation: Assists in segmenting moving objects from the background, aiding in video editing and augmented reality.

Disadvantages:

1. Computational Complexity: Often requires significant computational resources, especially for real-time applications.
2. Sensitivity to Noise: Performance can degrade with image noise, poor lighting, or occlusions in the visual scene.
3. Assumption Limitations: Many optical flow algorithms assume constant brightness and small motion between frames, which may not hold true in real-world scenarios.
4. Error Accumulation: Errors can accumulate over time, particularly in long video sequences, leading to drift in motion estimation.

We chose not to go with Optical Flow mainly because it required a lot of training.

4.1.2 GPS

We chose this method to get the data regarding speed because it was easy to collect, and would give us the ready-made data.

4.2 Direction

4.2.1 Image Segmentation and Optical Flow

Image segmentation is the process of partitioning an image into multiple segments or regions, often to simplify or change the representation of an image into something more meaningful and easier to analyze. This technique is commonly used to locate objects and boundaries (lines, curves, etc.) within images. Advantages:

1. Object Detection: Facilitates the detection and identification of objects within an image, which is crucial for tasks like medical imaging, autonomous driving, and surveillance.

2. Simplified Analysis: Simplifies the image by reducing the amount of data to be processed, making analysis more manageable.

3. Improved Accuracy: Enhances the accuracy of image interpretation tasks by focusing on specific regions of interest.

4. Automation: Enables automated processing and analysis in various applications such as pattern recognition and machine learning.

Disadvantages:

1. Computational Cost: Can be computationally expensive, especially for high-resolution images and complex algorithms.

2. Dependence on Quality: Performance is highly dependent on the quality of the input image; noise, poor lighting, and other distortions can significantly affect the results.

3. Ambiguity: In some cases, segmentation may not be straightforward due to the ambiguity in object boundaries, leading to potential inaccuracies.

4. Algorithm Selection: The effectiveness of segmentation heavily relies on the choice of the algorithm, which may need to be tailored for specific types of images or applications.

Despite the fact that it has some disadvantages, we chose to go with it because it was suitable for our purpose.

4.3 Object Detection

4.3.1 YOLO (You Only Look Once)

YOLO is a real-time object detection system that uses a single neural network to predict bounding boxes and class probabilities directly from full images in one evaluation. It is known for its speed and accuracy in detecting and localizing multiple objects within an image. Advantages:

1. Speed: Extremely fast, capable of processing images in real-time, making it ideal for applications requiring quick detection, such as autonomous driving and video surveillance.
2. Unified Architecture: Uses a single network for detection, which simplifies the pipeline compared to traditional methods that use separate components for region proposal and classification.
3. High Accuracy: Maintains a high level of accuracy in object detection, with good performance on both large and small objects.
4. End-to-End Training: Can be trained end-to-end directly on detection performance, optimizing the network more effectively for the detection task.

Disadvantages:

1. Localization Error: Sometimes struggles with the precise localization of objects, especially small or densely packed objects.
2. Detection of Small Objects: Less effective in detecting small objects within the image due to the coarse grid it uses to predict bounding boxes.
3. Overlapping Objects: Can have difficulty distinguishing overlapping objects, leading to lower detection accuracy in crowded scenes.
4. Rigidity: The grid-based approach can limit the detection performance in complex scenarios where objects are not aligned well with grid cells.

We dropped the idea of using YOLO because it was too heavy.

4.3.2 Color or Feature Based Object Detection

Color or feature-based object detection involves identifying objects within an image by analyzing their color properties or distinctive features. Color-based detection relies on the color information of objects, while feature-based detection uses specific attributes like edges, corners, textures, or key points to identify objects. Advantages:

1. Simplicity: Often simpler and less computationally intensive compared to more advanced methods like deep learning-based detection.

2. Real-Time Performance: Can be implemented to run in real-time on less powerful hardware, making it suitable for applications with limited computational resources.
3. Robustness to Lighting Conditions: Feature-based methods, particularly those using edges and corners, can be more robust to variations in lighting compared to color-based methods.
4. Specificity: Effective for detecting objects with distinctive color patterns or unique features, leading to accurate detection in controlled environments.

Disadvantages:

1. Sensitivity to Variability: Color-based detection can be highly sensitive to changes in lighting, shadows, and reflections, leading to inaccuracies.
2. Limited Scope: Not effective for detecting objects without distinctive color or feature patterns, limiting its applicability in diverse scenarios.
3. Cluttered Backgrounds: Struggles in cluttered or complex backgrounds where the color or features of the object may blend with the surroundings.
4. Scalability: Feature-based detection methods can struggle with scale variations and may require multiple scales to be considered, increasing complexity.

We dropped the idea of using Color or Feature Based Object Detection because it lacked accuracy.

4.3.3 Pixel Based Object Detection

Pixel-based object detection identifies objects by analyzing individual pixels or small groups of pixels in an image. This method often involves examining the color, intensity, or other pixel-level attributes to differentiate objects from the background. Advantages:

1. Fine Detail Analysis: Allows for very fine-grained analysis of images, capturing details at the pixel level which can be crucial for tasks requiring high precision.
2. Simplicity: Often simpler to implement and understand compared to more complex algorithms, making it accessible for various applications.
3. Low Computational Requirements: Can be less computationally intensive, suitable for applications with limited processing power.
4. Immediate Response: Capable of real-time performance for applications needing immediate analysis, such as certain medical imaging tasks.

Disadvantages:

1. Sensitivity to Noise: Highly susceptible to image noise, lighting variations, and other artifacts, which can lead to inaccurate detection.

2. Context Ignorance: Does not take into account the broader context of the image, which can result in difficulties distinguishing objects from the background, especially in cluttered scenes.
3. Limited Robustness: Can struggle with detecting objects that have varying colors or appearances, as it relies heavily on pixel-level attributes.
4. Scalability Issues: May not scale well to larger images or more complex scenes where pixel-level differences are subtle and require higher-level understanding.

We chose to go with the idea of using Pixel Based Object Detection because it was fast and provided better accuracy.

4.4 Object Classification

For this, we thought of going with YOLO (explained in 4.3.1) but it would be unnecessarily heavy, so we decided to stick with the basic determination of whether the object is stationary or not. Unlike YOLO, which would give us some irrelevant information, this method will be light weight and will provide us only the relevant information.

4.5 Relative Movement With Respect To Said Object

The idea was to find a GitHub repository that would be intensive and very accurate in detecting how far the object is.

4.6 Path Tracking Of The Route Via GPS

We chose to use GPS services for this because they would perfectly serve our purpose

4.7 Grading Performances

Given below are the parameters which will be assigned an appropriate weight and then a safety function would calculate the overall grade and will declare the ride as very safe, safe, dangerous and very dangerous:

1. Speed Changes:
   (a) Acceleration/Deceleration: Sudden or frequent acceleration and deceleration can indicate risky behaviour.
   (b) Consistency of Speed: Maintaining a steady speed within safe limits is considered safer than frequent changes in speed.
2. Sharp Turns:
   (a) Frequency and Severity of Sharp Turns: High frequency or severity of sharp turns can suggest aggressive riding.

(b) Turn Speed: The speed at which turns are taken; lower speeds indicate safer handling.

3. Distance to Other Vehicles:

   (a) Following Distance: Keeping a safe distance from the vehicle ahead is crucial for reaction time and collision avoidance.

   (b) Lateral Distance: Maintaining a safe distance from vehicles in adjacent lanes.

4. Lane Changes:

   (a) Frequency of Lane Changes: Frequent lane changes can be a sign of aggressive riding.

   (b) Smoothness of Lane Changes: Smooth and well-signaled lane changes indicate safer behaviour.

5. Stop Sign/Signal Compliance:

   (a) Compliance Rate: Adherence to stop signs and traffic signals is critical for safety.

   (b) Rolling Stops: Assessing whether the rider makes full stops or just slows down at stop signs.

6. Speeding:

   (a) Speed Limit Adherence: Riding within the speed limit is a key safety indicator.

   (b) Over-speeding Instances: Frequency and extent of riding over the speed limit.

7. Rider Fatigue:

   (a) Riding Duration without Breaks: Long rides without breaks can lead to fatigue, increasing the risk of accidents.

   (b) Time of Day: Riding late at night or early in the morning when fatigue is more likely.

8. Environmental Awareness:

   (a) Reaction to Road Conditions: Ability to adapt to changing road conditions (e.g., wet or icy roads).

   (b) Use of Safety Gear: Consistent use of helmets, gloves, and other protective gear.

9. Distraction:

   (a) Phone Usage: Instances of phone use or other distractions while riding.

(b) Attention to Traffic Signals: Timely responses to traffic lights and signs.

10. Braking Patterns:

    (a) Sudden Braking: Frequency of sudden, hard braking events can indicate poor anticipation of traffic flow.

    (b) Gradual Braking: Smoother braking patterns suggest safer, more controlled riding.

11. Vehicle Condition:

    (a) Maintenance Status: Regular maintenance checks and timely repairs can prevent mechanical failures.

    (b) Tire Condition: Proper tire inflation and tread depth are crucial for safety.

12. Adverse Weather Handling:

    (a) Riding Behaviour in Bad Weather: Caution and reduced speeds in adverse weather conditions indicate safer riding practices.

4.8 Giving Report Summary

By reading the overall grade assigned to a ride, an easy-to-read & understand report will be generated which will show the rider his/her mistakes, location where the rider committed the mistakes, etc.

5 Status of Implementation

Out of the 8 objectives mentioned in section 3, we tried to implement the following five but couldn't succeed:

1. Speed detection via GPS.
2. Path tracking of the route via GPS.
3. Object detection.
4. object classification.
5. Grading the performances, assigning weights using fuzzy logic.

Following steps were the part of our implementation process:

1. Finding appropriate GitHub repositories and extracting useful parts of the codes.
2. Refactoring, adding, changing or editing the codes from the GitHub Repositories.
3. trying to integrate the codes to make it serve our purpose.

6 Conclusion

We learnt a lot of stuff while we were in the Ideation stage- new concepts, new algorithms, etc. Errors while implementing the codes played a major role to build a strong understanding of the various aspects of this project. Another valuable outcome of this project is that we now have a very good idea about how to proceed, formulate and then implement the steps.

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