Dynamic Hand Gesture Detection: Literature Review

1.Introduction

Hand gesture detection in vehicles is of great importance as it offers great benefits. It enhances human safety by allowing drivers to control functions without taking their hands completely off the steering wheel or eyes off the road. It also improves accessibility for individuals with physical impairments and reduces the cognitive load required for operating vehicle controls, leading to better concentration. Drivers task is always controlling the vehicle, minimal attention can be used for controlling other function which is where HMI comes into place. Furthermore, dynamic hand gesture detection drives towards autonomous in vehicles by providing a standardized method for human-vehicle interaction in the era of advanced technologies.

A literature review and benchmarking are crucial for a project as they provide a comprehensive understanding of existing research, identify gaps for innovation, and set realistic goals. They help in defining system specifications by analyzing common gestures, methodologies, and performance metrics used in previous studies. This process ensures the project builds upon existing knowledge and enhances its credibility and efficiency.

2.Literature Review:

2.1 Gesture Recognition in Automotive Context:

- In the context of automotive applications, gesture recognition has gained significant attention as a means of enhancing user interaction and improving safety. Dynamic hand gestures play a crucial role in this domain, enabling drivers and passengers to control various vehicle functions without diverting their attention from the road.
- Other than in automotive, hand gesture detection has applications in human-computer interaction, gaming and entertainment, and healthcare and rehabilitation, sign language recognition, smart homes and IoT, and virtual/augmented reality.
- However, there are several challenges associated with dynamic hand gesture recognition in the automotive context that needs to be considered. Nevertheless, with advancements in technology, these challenges can be overcome.

- Some of the challenges that needs to be taken into consideration are varying lighting Conditions, real-time processing requirements, hand pose and viewpoint variability robustness to environmental factors, multi-user scenarios

2.2 Dynamic Hand Gestures in Current Vehicles:

Gesture	Description	Contextual Information	Models
Swiping gesture	Swiping towards left, right, down,up hand movement to navigate screens	Used for scrolling through options or lists	BMW, Audi, Volksvagen, Jaguar, Ford
Rotating gesture(Clockwise, anti-clockwise)	Circular hand movement to adjust audio volume or settings	Used for controlling volume or settings	BMW, Ford
Pointing gesture	Extending index finger to select an item or option	Accepting	BMW, Volksvagen, Ford, Mercedes
Two-finger peace gesture	Extending index and middle fingers in a peace sign gesture	Used for answering or rejecting phone calls	BMW, Mercedes Benz, Ford
Ok gesture	Thumb and index finger forming a circle	Used for confirming or signaling approval	Ford
Thumb pointing left gesture	Extending the thumb and pointing it towards the left side	Used for indicating farward	BMW
Thumb pointing right gesture	Extending the thumb and pointing it towards the right side	Used for indicating backwards	BMW
Pinching gesture	Bringing thumb and index finger together to zoom in or out	Used for zooming in or out on maps or screens	BMW
Palm wave gesture	Open hand movement to accept or dismiss notifications	Used for accepting or dismissing notifications	

Thumb-up gesture	Thumb raised as a sign of approval or liking	Used for approving or liking a feature	
Thumb-down gesture	Thumb pointed downwards to indicate disapproval	Used for rejecting or disliking a feature	
Pushing gesture	Forward hand movement to confirm a selection or action	Used for confirming choices or actions	
Pulling gesture	Backward hand movement to cancel or undo an action	Used for canceling or undoing previous actions	

2.3 Gesture Recognition Techniques and Algorithms

Various techniques and algorithms have been explored in gesture recognition.

2.3.1 Sensor-Based Techniques:

Sensor-based techniques utilize wearable sensors, such as inertial measurement units (IMUs), to capture hand motion data. These sensors typically include accelerometers, gyroscopes, and magnetometers to measure various aspects of hand movement.

Advantages:

- Real time processing, robustness, gesture diversity
- Precise motion tracking data,
- Not affected by lighting conditions.

Limitations:

- Lack of Detailed Hand Shape Information.
- Battery life of wearable sensors.

2.3.2 Depth-based techniques:

Uses depth sensors, such as Mikrosoft Kinect to capture hand movements in three dimensions. These sensors provide depth information, enabling more accurate and robust gesture recognition compared to traditional 2D vision-based approaches.

Advantages:

- Robustness to lighting conditions
- Partial occlusion handling
- Accurate depth information.

Limitations:

- Limited filed of view and sensing range, bad performance at reflective surfaces.

2.3.3 Deep learning Based Approaches:

By using deep learning based approaches such as Neural Networks based techniques, gesture detection can be done. In our case, we are approaching this technique by using MediaPipe framework developed by google.

Advantages:

- Can learn complex patterns and variations in hand movements.
- Works well with different users and gestures with sufficient available data.
- Can get greater accuracy with well performing model.

Limitations:

- It requires large dataset to get maximum accuracy.
- Requires high computational resources during training the model.

3 Analysis and Conclusion

3.1 Gestures

The gestures presented in section 2.2 are widely used and considered the most common ones in the automotive industry. The identification of these gestures was sourced from the official websites of specific automobile companies and from various articles as unfortunately, no standardized publication containing the latest list of gestures in automobile models was available at the time of research. In our study, gathering data on all the listed gestures in live and training the dataset allows us to determine which gestures perform well in gesture prediction and which do not. Based on these insights, we can then choose the most suitable gestures for deployment.

3.2 Approach

The deep learning based approach outperforms all other methods when considering the latest advancements in technology. Moreover, this approach takes into account the comfort and feasibility for the user executing the gestures. Unlike sensor-based (glove) and depth camera approaches, it doesn't require additional hardware, making it more convenient. Additionally, maintenance is less with the deep learning based approach compared to other alternatives.

Initially, hand gestures data is collected and processed through the mediapipe framework to extract hand landmarks. Subsequently, this data is forwarded to a neural network for training the dataset. Finally, only well-executed gestures will be selected, while the undesirable ones will be left. The chosen gestures will then be employed to integrate into the system.

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