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The Implementation of Steering Angle Estimation on Miniature Raspberry Pi-based Autonomous Car

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Propose

- Implement the mini Raspberry Pi-based autonomous car
- Use the Hough transform for lane detection
- Estimate the steering angle with a simple method

Method

Lane Detection Algorithm: The algorithm consists of capturing images, converting images into HSV color space, masking images, detecting canny edges, marking the region of interest, and detecting lines by using Hough transform.

Steering Angle Estimation: The mini-car has to be steered and able to keep hold of itself in the middle of the lane. To achieve motion planning, reference line detection is firstly operated, and the real-time lane detection and steering angle calculations are then carried out. The steering angle can be calculated as following equations.

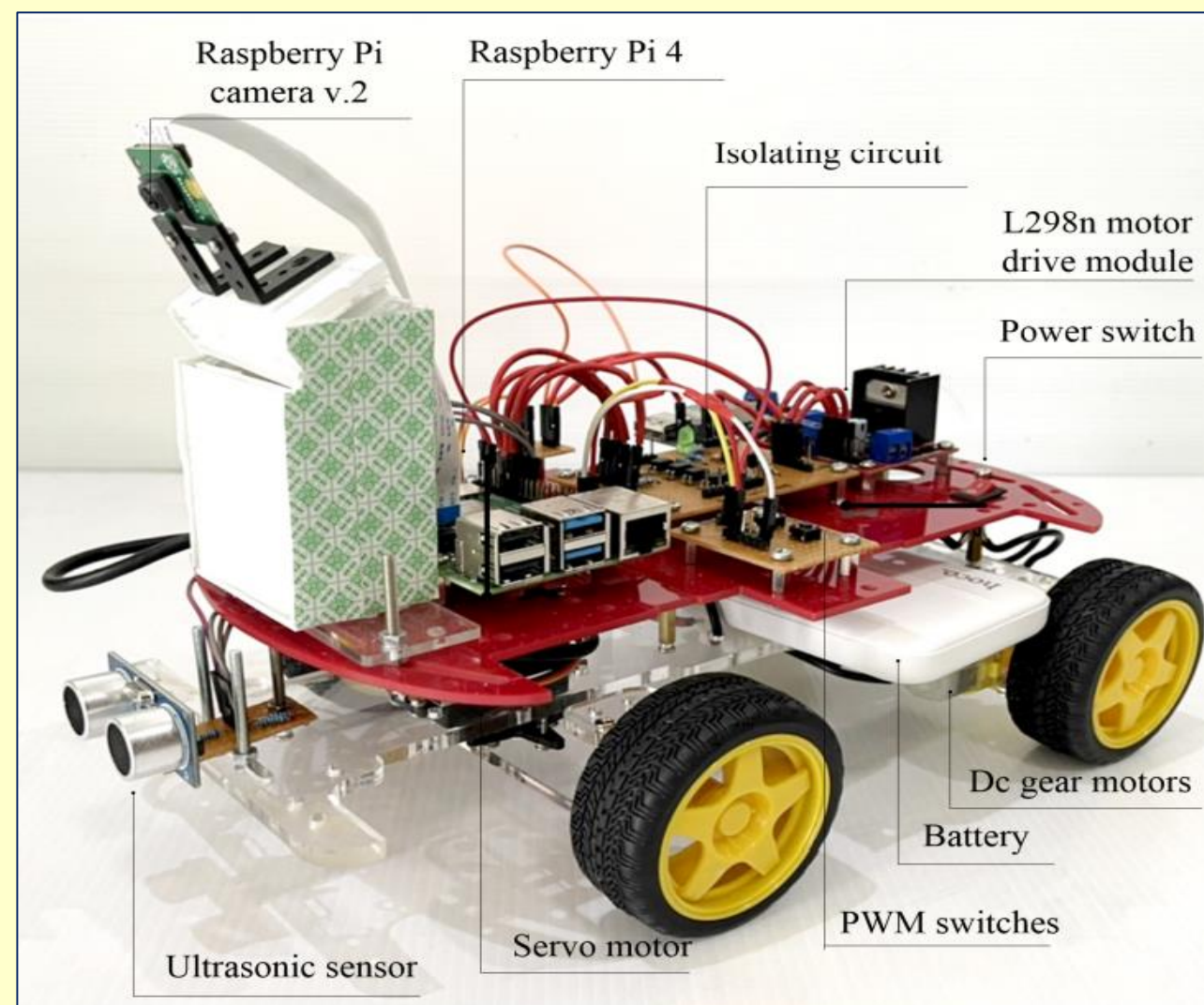
$$\theta_s = \begin{cases} \theta_{Rref} - \theta_{Dl} & \text{for right turn} \\ \theta_{Lref} - \theta_{Dl} & \text{for left turn.} \end{cases}$$

$$\theta_{Rref} = \tan^{-1}(m_{Rref})$$

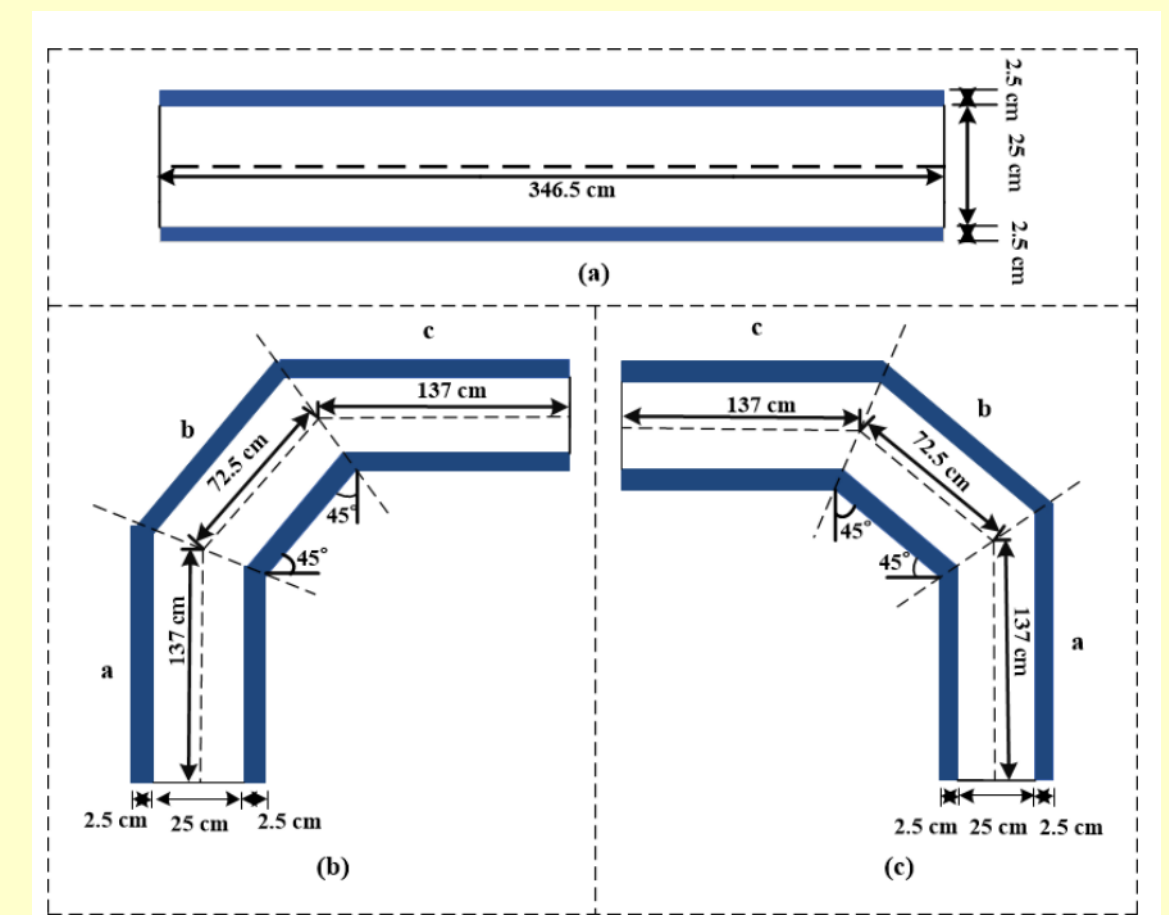
$$\theta_{Lref} = \tan^{-1}(m_{Lref})$$

$$\theta_{Dl} = \tan^{-1}(m_{Dl})$$

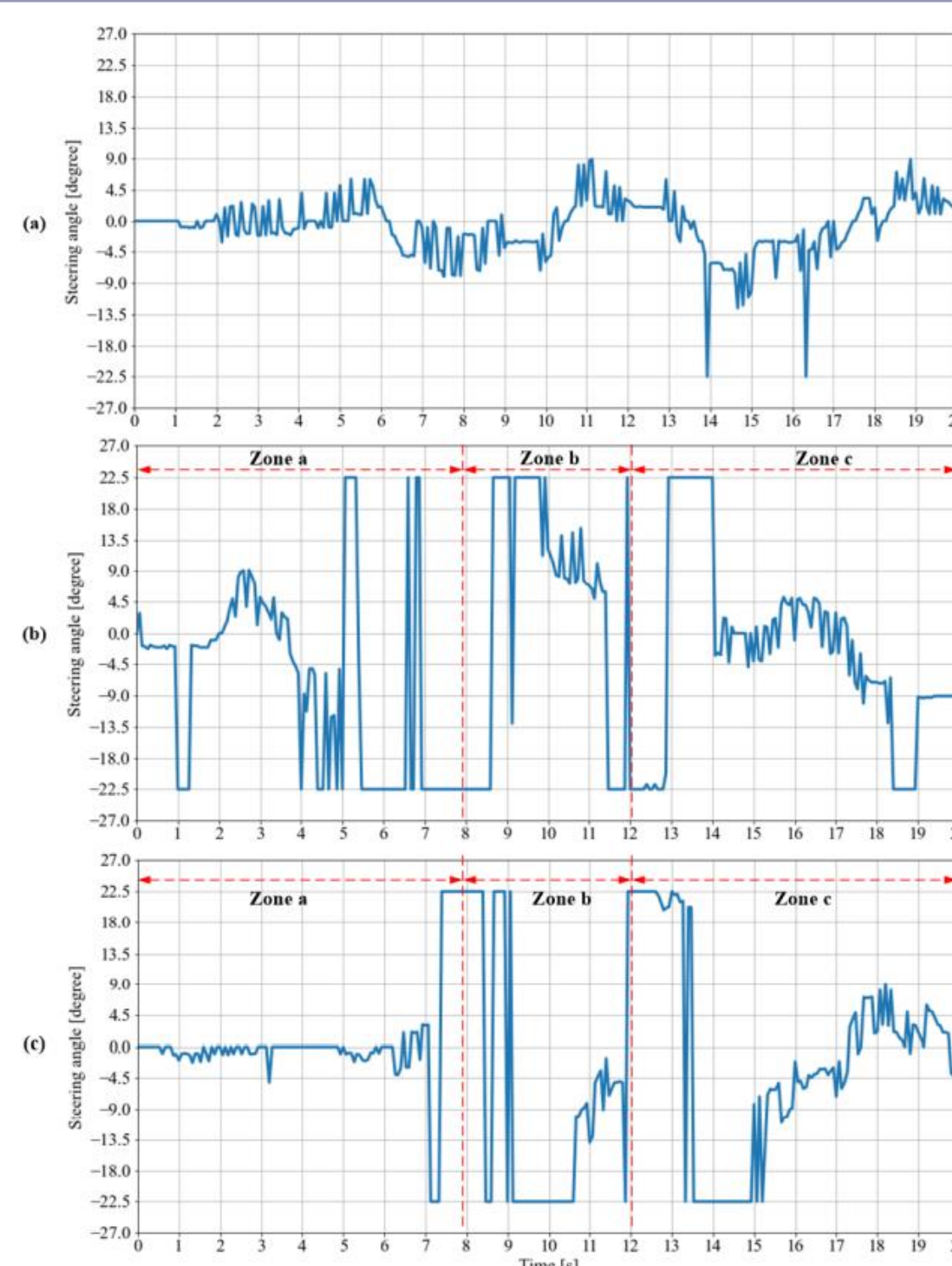
Experimental results



Hardware configuration

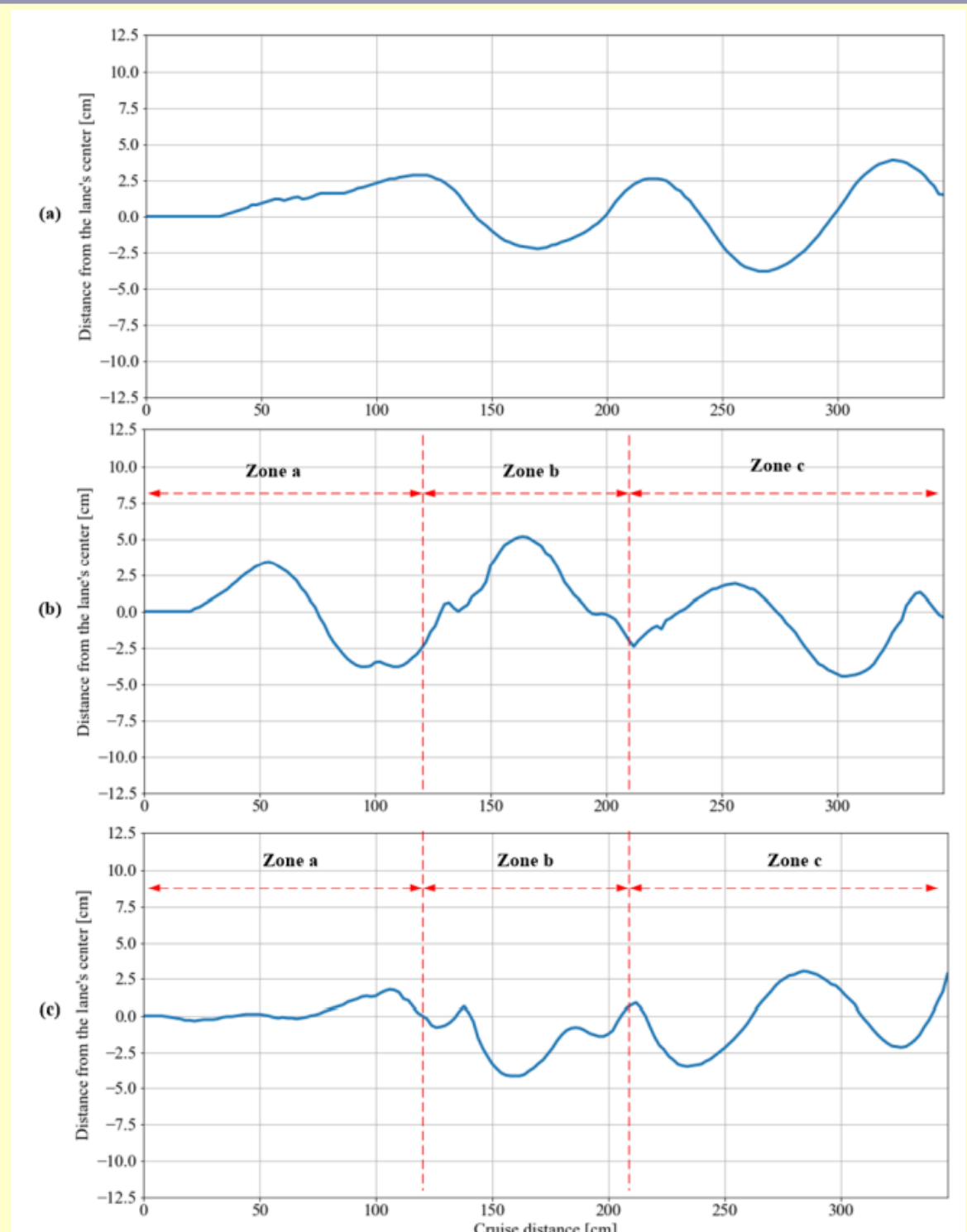


Different types of lane directions in this study



The steering angle during the car's movement

The miniature autonomous car can be driven according to the steering angle command and keep itself in the lane without the complexities of steering angle extraction.



The capability of the car to keep itself inside the lane

The results show that the line's marker resembles a sinusoidal wave with a small amplitude and low change frequency, indicating that the car can travel inside the lane smoothly.

Summary

The use of steering angle estimation to accomplish a Raspberry Pi-based autonomous car drive is proposed in this work. The Hough transform is utilized to detect the lane lines, and the OpenCV library is used to process the collected images. To estimate steering angle, just compare reference lines, which are only determined once, with a single detected line. The servo motor is instructed to drive the Raspberry Pi-based autonomous automobile forward using this anticipated steering angle. The proposed strategy can compel the car to maintain a proper angle and keep it moving forward within the lane, according to the experimental results.