Overview

Key concepts

Methodology(maybe 2)

results(comparision)

Standard Tuning of a PID Controller

[https://ieeexplore.ieee.org/document/6356728/](https://sci-hub.ru/https://ieeexplore.ieee.org/document/6356728/)

**Summary**

The research paper by Abedini and Zarabadipour (2011) focuses on the tuning of an optimal Proportional-Integral-Derivative (PID) controller for a DC motor using the Iterative Feedback Tuning (IFT) method. This study is significant in the field of control systems as PID controllers are widely used in various industrial applications due to their simplicity and effectiveness. However, tuning these controllers to achieve optimal performance can be challenging.

**Key Concepts**

PID Controller: A control loop mechanism employing feedback that is widely used in industrial control systems. It continuously calculates an error value and applies a correction based on proportional, integral, and derivative terms.

DC Motor: A rotary electrical machine that converts direct current electrical energy into mechanical energy. DC motors are commonly used in various applications due to their precise control over speed and position.

Iterative Feedback Tuning (IFT): A method for tuning controller parameters iteratively to achieve desired performance. It does not require a model of the plant, making it suitable for systems where obtaining an accurate model is difficult.

### **Methodology**

The authors employed the IFT method to tune the PID controller for a DC motor. The process involved the following steps:

* Initial parameters of the PID controller were set.
* The system's performance was evaluated by applying a reference input and measuring the output.
* The error between the desired and actual output was calculated.
* Based on this error, the PID parameters were adjusted iteratively to minimize the error.

### **Findings**

The study demonstrated that the IFT method could effectively tune the PID controller for the DC motor, resulting in improved performance. The tuned controller showed better response characteristics, such as reduced overshoot and settling time, compared to the initial settings.

**Conclusion**

The research highlights the effectiveness of the IFT method in tuning PID controllers for DC motors. This approach can be particularly useful in practical applications where obtaining a precise model of the system is challenging. The iterative nature of the IFT method ensures that the controller parameters are optimized based on actual system performance, leading to enhanced control accuracy.

Tuning with an LLM

<https://arxiv.org/pdf/2405.13547>

**Summary**

The research article introduces HighwayLLM, a novel approach combining Large Language Models (LLMs) with Reinforcement Learning (RL) and Proportional-Integral-Derivative (PID) control to enhance decision-making and navigation in autonomous highway driving. The study emphasizes the importance of explainable and safe decision-making in autonomous vehicles (AVs), addressing the complexity and unpredictability of highway environments.

**Key Concepts**

Autonomous Driving (AD): The technology enabling vehicles to navigate and operate without human intervention. AD systems must handle complex decision-making, environment perception, and dynamic adaptation while ensuring safety.

Large Language Models (LLMs): AI models designed to understand, generate, and interpret human language. In this study, LLMs are used to predict future waypoints for the ego-vehicle’s navigation, enhancing the explainability of decisions.

Reinforcement Learning (RL): A machine learning approach where an agent learns to make decisions by interacting with its environment and receiving feedback. The RL model in this study serves as a high-level planner for meta-level actions.

Proportional-Integral-Derivative (PID) Controller: A control loop mechanism that continuously calculates an error value and applies corrections. In this study, it guides the vehicle to the waypoints predicted by the LLM agent.

Methodology

The authors developed HighwayLLM, which integrates an LLM with a pre-trained RL model and a PID controller. The process involved:

* Using the RL model to make high-level decisions (e.g., lane changes).
* Employing the LLM to predict future states of the vehicle based on current state information and historical data.
* Utilizing a PID controller to navigate the vehicle to the predicted waypoints.
* Ensuring safety and interpretability by combining the outputs from RL and LLM.

Findings

The study showed that HighwayLLM could make safe, collision-free, and explainable predictions for the ego-vehicle's next states. Key results include:

Collision Reduction: The LLM-based trajectory planner significantly reduced the number of collisions compared to the RL-only approach.

Velocity Improvement: The vehicle maintained higher average velocities with the LLM integration, indicating more efficient navigation.

Interpretability: The LLM provided reasoning for its decisions, enhancing the transparency and trustworthiness of the AV’s actions.

Conclusion

The integration of LLMs with RL and PID controllers in HighwayLLM enhances decision-making and navigation for autonomous highway driving. This approach not only improves safety and efficiency but also addresses the black-box nature of traditional RL methods by providing explainable reasoning behind decisions.

Future Research

Future studies could explore:

Extending the HighwayLLM approach to other driving environments and conditions.

Developing an end-to-end trainable pipeline to fine-tune the LLM with RL feedback.

Investigating the scalability and robustness of the proposed method in real-world scenarios.

3.

A computer vision-based lane detection approach for an autonomous vehicle using the image hough transformation and the edge features

<https://www.researchgate.net/publication/363468475_A_computer_vision-based_lane_detection_approach_for_an_autonomous_vehicle_using_the_image_hough_transformation_and_the_edge_features>  
**Summary**

The research paper presents a method for detecting lanes in real-time on high-speed video images using computer vision techniques. The proposed approach utilizes image processing steps, including the Hough transformation and edge detection features, to accurately identify lane markings in various lighting and weather conditions.

### **Key Concepts**

1. **Lane Detection Systems**: These systems play a crucial role in autonomous driving by ensuring the vehicle stays within the lane, thus enhancing safety and reducing the risk of accidents caused by human errors such as distraction or fatigue.
2. **Computer Vision Techniques**: Methods like edge detection and the Hough transform are employed to identify lane markings in video images. These techniques are advantageous due to their cost-effectiveness and capability to process visual information in real-time.
3. **Edge Detection**: A technique used to identify the boundaries of objects within images by detecting discontinuities in brightness. The Canny edge detection algorithm is used in this study for its effectiveness in extracting clear edges.
4. **Hough Transformation**: A feature extraction technique used in image analysis to detect simple shapes, such as lines and circles. In this study, it is used to identify the main lines of the road.

### **Methodology**

The proposed lane detection approach involves three main steps:

1. **Preprocessing**: The input image is preprocessed to reduce noise, convert from RGB to greyscale, and then to a binary image.
2. **Region of Interest (ROI) Selection**: A trapezoidal mask is applied to select a polygonal region in front of the vehicle where lane markings are expected.
3. **Edge Detection and Hough Transform**: The Canny edge detection technique is used to identify edges within the ROI, followed by the Hough transform to detect the road's main lines.

### **Findings**

The proposed algorithm was evaluated using the IROADS database, which includes diverse road conditions such as sunny, rainy, snowy, and tunnel environments. Key findings include:

* **Accuracy**: The method achieved an overall detection accuracy of 96.78%, demonstrating robustness across different lighting conditions.
* **Processing Speed**: The algorithm processes each frame in approximately 28 milliseconds, making it suitable for real-time applications.

### **Conclusion**

The study presents an effective and efficient method for lane detection using computer vision techniques. The combination of preprocessing, edge detection, and Hough transform enables accurate lane identification in various environmental conditions. This method is a significant contribution to the field of autonomous driving, providing a reliable tool for enhancing vehicle safety.

### **Future Research**

Future work could focus on integrating the proposed method with tracking algorithms to improve the continuity and robustness of lane detection. Additionally, exploring the use of temporal information from previous frames could further enhance detection accuracy in challenging conditions such as tunnels and heavy traffic.

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Other Papers:  
<https://ieeexplore.ieee.org/document/9930515>

* 1. <https://arxiv.org/pdf/2405.13547>

Using AI to tune- after 4

1. <https://arxiv.org/pdf/2405.01504> \*
2. <https://ieeexplore.ieee.org/document/8204247> (<https://sci-hub.ru/https://ieeexplore.ieee.org/document/8204247>)
   1. <https://sci-hub.ru/https://ieeexplore.ieee.org/document/6785216>

Anti windup methods to improve tuning

1. <https://sci-hub.ru/https://ieeexplore.ieee.org/document/6356728/>

A standard tuning method using iterative feedback - first

Third - A computer vision-based lane detection approach for an autonomous vehicle using the image hough transformation and the edge features