Introduction to Unmanned Vehicle Systems
Fall 2019

AUVSI Student Competition Homework

Deliverable 3:

Competition Name: Intelligent Ground Vehicle Competition (IGVC) with Rulebook 2019.
Challenge: Auto-Nav Course

1. Systems needed for the Guidance, Navigation and Control (GNC):

The systems for GNC are important to identify the position and orientation of the UGV vehicle and compute the control commands for the perfect lane following.

Navigation system:

It is a filter that integrated information from encoders, GPS, gyroscopes, accelerometers, magnetometer measurements and finds the current location of our vehicle with respect to a reference. So, we first need to know the position and orientation of our vehicle at the starting point of the track to get our reference value. The GPS gives the position and the magnetometer is used to determine the orientation. The encoder reading will be used to determine the configuration of our vehicle. The method of Dead Reckoning is used for estimating advancing position and orientation based on wheel speed from encoder readings. The right and left encoder counts show the wheel speed calculation for moving in any direction.

- **Motor Controllers:**
  As an interface between the main computer and the drive motors, motor controllers are to be chosen. Each of the two drive wheels is driven by one of these motor controllers, which can supply up to 60A. In addition to their high current capabilities, the motor controllers have numerous integrated features and software libraries, drastically simplifying their use. Beyond simple PWM control, they are capable of precise velocity control using a PID loop and are designed to directly receive quadrature encoder feedback without any additional hardware or programming.
  Furthermore, the motor controllers can tune the PID constants automatically, allowing the team to avoid the lengthy process of finding the optimal settings. These motor controllers are even able to monitor motor current, voltage, and board temperature, automatically limiting the motor's current draw to safe values.

- **Encoders:**
  The magnetic encoders can be used to obtain wheel odometry. These encoders will be mounted on the back of each drive motor and use a Hall effect sensor coupled with a magnetic puck attached to the shaft of the motor to determine its speed and direction. This data is transmitted to the motor controllers, which use the odometry as feedback for their PID loops. Wheel odometry is also sent to the main computer for state estimation.

Guidance system:

The guidance system takes in the commanded position and computes the desired translational and angular/rotational velocities for the vehicle to reach the desired position.

There are two significant strategies that are to be considered while implementing the guidance system:

1. Constant commanded speed always must be less than the Max Speed
2. Commanded speeds is reduced when the vehicle is close to the wayPoint

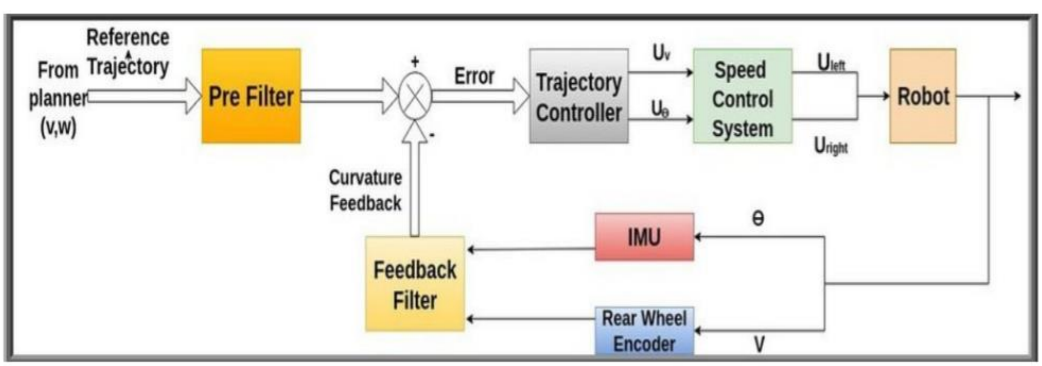
The speed control system and the curvature control system are the main control systems of the UVS vehicle. The control system is implemented on the motor controller. The speed control system tries to reject the environmental disturbances and tracks the given speed. The linear and angular velocities, as received by the planner are converted to differential velocities.

Controls system:

Lane following is a control system that keeps the vehicle travelling within a marked lane while maintaining a user set speed or safe distance from the obstacles. The lane following system includes combined longitudinal and lateral control of the vehicle. Longitudinal control maintains a user set speed and keeps a safe distance from the obstacles along the path. Lateral control keeps the vehicle travelling along the centerline of its lane. Both the controls in our vehicle are controlled by the left and right encoders which are equally responsible for the direction and PWM duty cycles for maintaining the direction of the vehicle.

The **PID (Proportional-Integral-Derivative)** control scheme is chosen because of its ease of implementation and the degree of freedom of tuning three parameters to achieve better performance. The speed feedback is obtained using the two front wheel encoders.

The experimentally tuned PID control scheme was verified by simulations on MATLAB. Using system identification techniques, a transfer function model was obtained for the two DC motors. The utility of the motor controller helps in tuning the performance of the speed control system. The following block diagram explains the implemented control scheme.



Control system block diagram