3.2 Manipulators

Manipulators are the devices in the vehicle that allow for actuation of controls usually controlled by a human driver. Development and implementation of manipulators is a task fit for a team of both mechanical and electrical engineers. To aid future development of manipulators for the driverless system, research into possible solutions has been conducted. Additionally the relevant requirements and restrictions defined by the Formula Student ruleset have been identified.

3.2.1 Steering actuator

In order to control a steering wheel a servo is needed. A servo is a motor which is controlled by a closed loop feedback system typically consisting of an incremental or absolute position encoder. Things to be considered when selecting an appropriate servo for steering include size, cost, torque, speed and resolution. Resolution and precision are important to make sure the vehicle is turning with the desired radius. Precise positional data for odometry gives the vehicle a better indication of where it is and where it is headed. This is important for mapping and navigation purposes.

Torque and speed are dependent factors. A gearing can be used to increase speed and thereby reduce torque or vice versa. A high torque is required to ensure that the the wheels can always be turned. However, speed is also important as it puts a limit on how fast the vehicle can change its heading and thereby how fast it can complete a lap. Above average vehicles at Formula Student competitions require a torque of between 4-11 N m to turn the steering wheel at stand-still. [Ste10] The vehicle's future rack and pinion designed by Vermilion Racing team members Mathias Tandrup Lamm and Asger Wang Henriksen will have turning radius of 240 degrees. One of the top teams, AMZ, appear to turn the steering wheel all the way from left to right in $< 1\,\mathrm{s}$. [AMZ] It is now possible to calculate the necessary motor power using the equation for power of a rotating body

$$P = T\omega \tag{3.8}$$

$$P = \frac{240^\circ}{\mathrm{s}} \cdot 11\ \mathrm{N\,m} = \frac{4\pi}{3}\mathrm{rad/s} \cdot 11\ \mathrm{N\,m} = 46\,\mathrm{W} \tag{3.9}$$

Adding a safety-factor of 100% on turn speed as well as torque the power requirement becomes

$$46\,\mathrm{W} \cdot 2 \cdot 2 = 184\,\mathrm{W} \tag{3.10}$$

As detailed in Appendix E, the Odrive appears to be the ideal solution for this application as it can be powered from the vehicle's 24 V low voltage system. The Odrive is compatible with any 24 V 3-phase brushless motor. Furthermore it features CAN communication, which allows it to be controlled through the already existing CAN-bus, and the data from the encoder can be reported over CAN. This encoder data could substitute the currently utilised steering wheel potentiometer for increased precision.