Non-linear Model Predictive Control for High-speed Autonomous Racing

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Methods and Results

1st Direction - Software
Development of Non-linear Model Predictive Control algorithms (MPC), using Ipopt (optimizing software).

Characteristics and assumptions:
- Perfect localization
- Absence of other vehicles
- Small number of finite time steps
- Bicycle model
- Use of Euler’s method

\[
\begin{align*}
    x_{t+1} &= x_t + v_t \cos(\theta_t) \\
    y_{t+1} &= y_t + v_t \sin(\theta_t) \\
    \theta_{t+1} &= \theta_t + \omega_t
\end{align*}
\]

2nd Direction - Hardware
Development of a lane detection algorithm and direct implementation on our current test robot, Anki Cozmo. The following methods are used:

- Hough Transform
- Polygon Center

Take-aways
- Need for high-speed calculations
- Projecting a 2D center of the lane on a 3D environment.

Next Steps / Future Work
- Integration of individual components and testing in simulation (Carla).
- Implementation of the algorithms with the aid of simulated sensors.
- Deployment of an autonomous miniature racecar based only on its onboard sensors at high speed potentially with adversarial obstacles.

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