Path Planning for Autonomous Vehicles based on Nonlinear MPC with using a Kinematic Bicycle Model

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MECH 6325 - MPC
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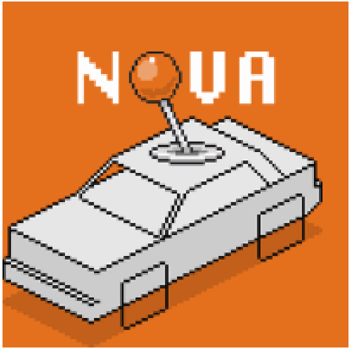
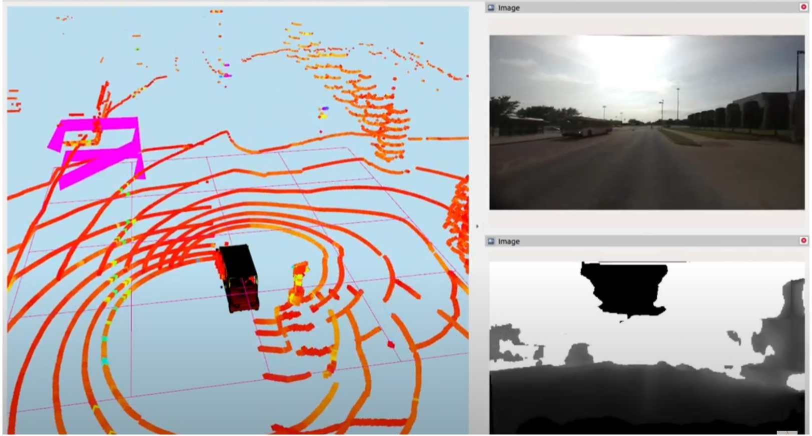
Outline

Outline

NOVA: Hail Bopp [1]

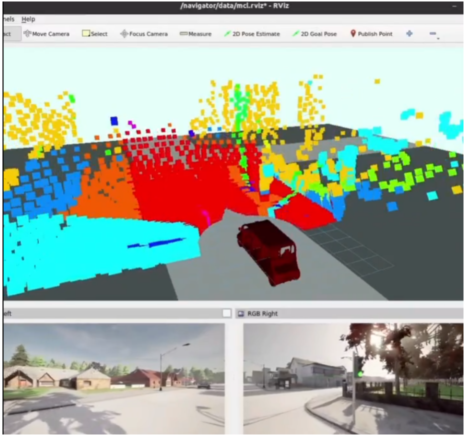


NOVA: Perception [1]



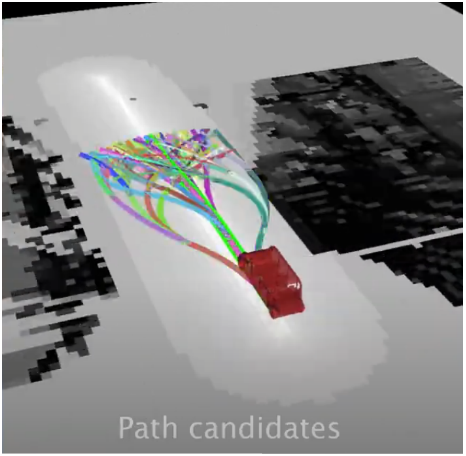
NOVA: Navigator [1]

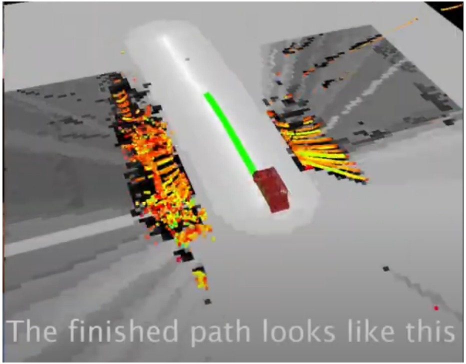
- Navigator is the self-driving software stack being developed by NOVA.
- Simulations done in then deployed to Hail Bopp.



Path Planning Objective [1]

Current Approach (random path generation and ranking)





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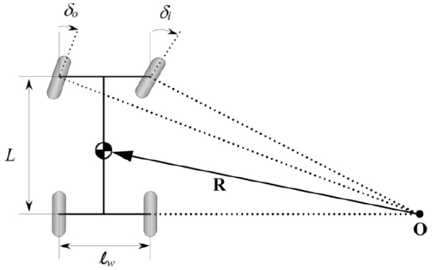
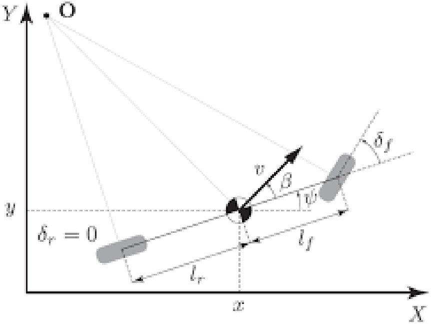
Vehicle Kinematic Models

Akerman Steering Model

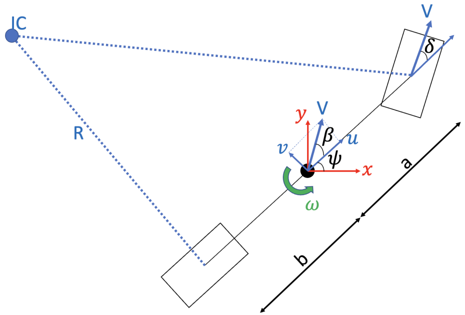


Bicycle Approximation



$$\delta \approx \frac{\delta_o + \delta_i}{2}$$

Kinematic Bicycle Model



Simple nonlinear kinematics model equations:

$$\begin{cases} \dot{x} = V\cos(\psi + \beta) \\ \dot{y} = V\sin(\psi + \beta) \\ \dot{\psi} = \dfrac{V\cos(\beta)}{l_f + l_r}(\tan(\delta_f) - \tan(\delta_r)) \\ \dot{\theta} = \psi \end{cases} \tag{1}$$

where

$$\beta = \tan^{-1}\left(\frac{l_f\tan(\delta_r) + l_r\tan(\delta_f)}{l_f + l_r}\right) \tag{2}$$

$\delta_r = 0$, $l_f = a = 0.7[m]$, and $l_r = b = 0.7[m]$.

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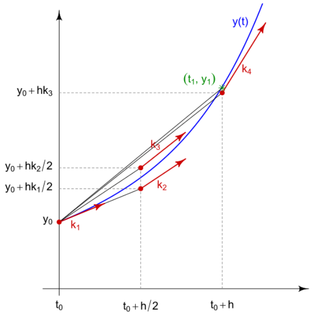
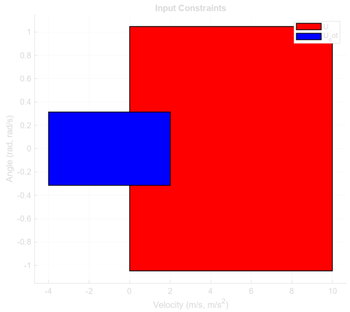
Model Constraints



Discretized at 1 [s] intervals using **RK4 method** (other methods didn't work w/out much smaller time increments) [2]

Input Constraints



$V \in [0, 10]$ [m/s] $\theta \in \pm\pi/3$ [rad] $\dot{V} \in [-4, 2]$ $[\mathrm{m/s}\hat{2}]$ $\dot{\theta} \in \pm\pi/10$ [rad/s]

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Solver: Min Y unstructured: 204 [s] w/ IPOPT

Bibliography I

- NOVA.
  nova-utd.github.io, 2023.
- everyone.
  Runge–kutta methods.