Bicycle Model

Ueli Wechsler

# Kinematic Bicycle Model

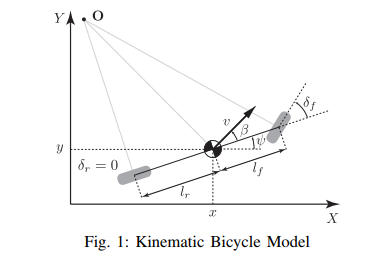
As a first approximation of the Car model in the Simulation, we will use the kinematic bicycle model derived in (Rajamani 2006).

This kinematic bicycle model allows describing the lateral motion of a vehicle under certain assumptions. It provides a mathematical describtion of the vehicle motion without considering the forces that affect the motion. The eom are purely based on geometric relationships governing the system.

**Assumptions:**

* Veloctiy vectors at point A and B are in the direction of the orientation of the front and rear wheels. i.e. slip angles are equal to zero. Which is a reasonable assumption for low speed motion of vehicle (e.g. for vehicle with less than 5 m/s)
* beta: angle of the current velocity of the center of mass with respect to the longitudinal axis of the car.
* : front steer angle
* acceleration of the center of mass in the same direction as the velocity

An illustration of the model was used in (Kong 2015) which is shown here:



Copied from (Kong et al. 2015)

The resulting continuous time kinematic bicycle model equation are.

with the state vector and input vector .

Using the Euler Discretizatoion the discrete time kinematic bicycle model writes as:

Which defines the nonlinear model:

For further calculations we need the derivative with respect to the states and inputs. To do this the chain rule and the following results were used , and

# 

# Dynamics Model

The coordinates of the inertial frame can be calculated by using:

# References

Rajamani, Rajesh. 2006. *Vehicle Dynamics and Control*. Mechanical Engineering Series. New York: Springer Science.

Kong, Jason, Mark Pfeiffer, Georg Schildbach, and Francesco Borrelli. 2015. “Kinematic and Dynamic Vehicle Models for Autonomous Driving Control Design”. In *2015 IEEE Intelligent Vehicles Symposium (IV)*, 1094–99. Seoul, South Korea: IEEE. doi:10.1109/IVS.2015.7225830.