Chapter 6

Non holonomic vehicles

Low and high level vehicle control depends on the vehicle structure. Planning and control execution of trajectories by non holonomic vehicles require the study of their kinematics model and environment conditions.

Autonomous maneuvering on non holonomic vehicles for moving in a structured dynamic environment is studied by Paromchick, Garnier and Laugier. The problem faced up is the autonomous maneuvering for lane following, changing and parallel parking. Motion generation and vehicle control is split in three phases: localization, planning and execution. The vehicle kinematics determine the constraints to define possible trajectories based on the mission and range measurement of environmental objects.

Khatib, Jaouni, Chatila and Laumond proposed a dynamic path structure that they call a deformable structure to deal with environment changing conditions. The goal is to define a methodology linking planning and execution taking into consideration the vehicle structure. The work is an evolution of the method called elastic band that has been adapted from holonomic to non holonomic robots. The method considers distance to obstacles and uses convex potential functions to increase reactivity to deal with environment changes.

The paper of Lamiraux and Laumond addresses the problem of parametrizing a path with respect to time to generate a trajectory for a mobile robot towing a trailer. They present a numerical algorithm where they introduce the movement constraints for velocity and acceleration. The motion planning and control system is based on three main steps: non-holonomic path planning, trajectory computation that is the main objective of the paper, and feedback control.
Autonomous maneuvers of a nonholonomic vehicle

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Abstract: Maneuvers of a nonholonomic vehicle in a structured dynamic environment are considered. The paper focuses on motion generation and control methods to autonomously perform lane following/changing and parallel parking maneuvers. Lane following/changing involves the tracking of a nominal trajectory in the traffic lane, and the generation and tracking of local lane-changing trajectories, for instance, for obstacle avoidance. Parallel parking involves a controlled sequence of motions, in order to localize a sufficient parking space, obtain a convenient start location for the vehicle and perform a parallel parking maneuver. The methods developed are tested on an automatic electric vehicle.

1. Introduction
The autonomous maneuvering of nonholonomic vehicles in dynamic environments is being studied by many research teams. The state-of-the-art of this domain reflects approaches of various complexity. A generalized approach involves planning a global path within an available map of the environment. Because of the computational costs, global planning is usually performed off-line. The subsequent following of the planned nominal trajectory involves reactive capabilities, in order to avoid collisions with unexpected obstacles. These two behaviors (trajectory following and obstacle avoidance) are in conflict, their simultaneous operation can lead to an oscillatory motion of the vehicle. However, if a nominal trajectory which is obstructed by an obstacle can be modified locally to avoid the obstacle and then return to the nominal trajectory, the oscillations can be eliminated. This issue is studied in the present paper using the example of lane following/changing maneuvers in a traffic environment.

A practical approach to motion generation and control for autonomous parallel parking in a traffic environment is also considered. Its key idea is to carry out a “Localization-Planning-Execution” cycle until a specified “parked” location of the vehicle relative to its environment is reached. The approach is based on range measurements to environmental objects around the vehicle. Feasible controls (steering angle and locomotion velocity) that correspond to a nominal trajectory leading to the “parked” location are planned and executed in real time. Once the motion has been carried out, the sensor data is used to decide whether the “parked” location has been reached and the parking maneuver is completed. This research work contributes to the French PRAXITELE