Séminaires ISIR

Zvi Shiller

Campus Jussieu, 4 place Jussieu, Paris
Salle de réunion H20

Pendant son séjour à l'ISIR, Pr Zvi Shiller (Ariel University) donnera ces 3 séminaires :

1) **Mardi 14 mai à 14h en 304**
Motion planning in dynamic environments

2) **Mardi 21 mai à 14h en H20**
Optimal trajectory planning of road and off-road vehicles

3) **Vendredi 24 mai à 11h en 304**
On-Line Obstacle Avoidance at High Speeds

1) Tuesday 14
Motion planning in dynamic environments

Dynamic environments represent a wide range of applications where robots need to navigate among static and moving obstacles or other robots. Examples of such applications include navigation through road traffic, navigating through crowds, aircraft flying around busy airports, and ships entering and leaving busy ports. Common to these applications is the need to generate a collision-free trajectory rather than a collision-free path that solves the equivalent static problem.

One technique to solving the collision avoidance problem in dynamic environments is to plan the trajectory in the robot's velocity space. To this end, the obstacles are mapped to their equivalent "velocity obstacles," which represent the set of forbidden velocities that would cause collision between the robot and each obstacle in some future time. This reduces the collision avoidance problem to selecting velocities that do not penetrate any velocity obstacle at any time.

In this talk, the concept of velocity obstacles will be introduced first for obstacles moving along linear trajectories, followed by an extension to general trajectories. The issue of the time horizon used to generate the velocity obstacle will be introduced and its impact on the trajectories obtained will be discussed. In the context of road traffic, the velocity obstacles can be used to warn the driver of imminent collisions and to plan efficient lane change avoidance maneuvers. This concept will be demonstrated for on-line motion planning in very crowded static and dynamic environments.

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Sous la co-tutelle de

2) Tuesday 21
Optimal trajectory planning of road and off-road vehicles

Autonomous vehicles are destined to replace human drivers in the not too far future as Google is already operating a driverless car on public roads, and major car companies are developing commercial automated vehicles. A major technology component of automated vehicles is a trajectory planner that drives the vehicle to a desired destination while accounting for the vehicle's dynamic behavior, obstacles, and road conditions.

In this talk, the problem of trajectory planning for the typically nonlinear vehicle model will be discussed for road and for off-road applications. A physics-based motion planner will be presented that accounts for vehicle dynamics and road/terrain topography. It is based on first determining the vehicle's performance envelope, in the form of velocity and acceleration limits, which guide the selection of a time optimal trajectory. The optimal trajectories serve as the upper bound for the vehicle's motion, under which tracking accuracy and vehicle stability can be ensured. The physics-based planner will be presented, together with recent experimental results that demonstrate the high tracking accuracy achieved when following the optimal trajectories.

3) Friday 24
On-Line Obstacle Avoidance at High Speeds

An efficient algorithm for online avoidance of static obstacles that accounts for robot dynamics and actuator constraints is presented. The robot trajectory (path and speed) is generated incrementally by avoiding obstacles optimally one at a time, thus reducing the original problem from one that avoids m obstacles to m simpler problems that avoid one obstacle each. The computational complexity of this planner is therefore linear in the number of obstacles, instead of the typical exponential complexity of traditional geometric planners.

This approach is quite general and applicable to any cost function and to any robot dynamics; it is treated here for minimum time motions, a planar point mass robot, and circular obstacles. Numerical experiments demonstrate the algorithm for very cluttered environments (70 obstacles) and narrow passages. The solutions obtained were on average 35% slower than the global optimal time due to the velocity limit imposed to ensure safety. Upper and lower bounds on the motion time and on path length were derived as functions of the Euclidean distance between the end points and the average obstacle size.

Comparing a kinematic version of this algorithm to RRT and RRT* planners shows a three order of magnitude advantage in computation time when reaching similar path optimality levels. The algorithm will be demonstrated for dynamic and kinematic voidance of circular obstacles, together with recent experiments using a differential drive mobile robot that avoids known obstacles at high-speeds.

Bio : Professor Shiller is the founder of the Department of Mechanical Engineering and Mechatronics at Ariel University and the director of the Paslin Laboratory for Robotics and Autonomous Vehicles. He earned the BA engineering degree from Tel Aviv University, and the MS and Sc.D. degrees from MIT, all in Mechanical Engineering. Before joining Ariel University in 2001, he served fourteen years on the faculty of the Department of Mechanical and Aerospace Engineering at UCLA where he lead the teaching and research activities in Robotics and directed the Laboratory for Robotics and Automation. Professor Shiller's research activities have focused on robot motion planning, dynamics and control, including time-optimal-motion control and obstacle avoidance. His recent work applies these methods to the navigation and trajectory planning of off-road vehicles, planetary rovers, and intelligent road vehicles. Prof. Shiller is the founding chair of the Israeli Robotics Association.

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