Problem set #1 16.412J Cognitive Robotics
Axel Kilian Spring 2005

Part A: Topics of Fascination

Robotic articulated systems for mobility
Robotic articulated structures other then humanoids robots, for instance in vehicle design. There has been a lot of research done in humanoid robotic systems for the obvious challenge of replicating some, or all of our human motorist and perceptual skills largely driven by the interest to replace or assist humans in dangerous or demanding task from fighting wars to assisted living.
Sports often act as catalyst in pushing technologic development in relation to human activity forward. Sort equipment also often acts as an extension of the body augmenting human movement and reach or interacting with the body.

Negotiating human control input and robotic autonomous control
How to translate human control input into a robotic articulated structure resulting in "legal" moves that do not put the structure into danger but still try to follow the human intention as closely as possible within the constraints of the system.

Teaching Robotic articulation beyond copying movements as a recorded motion.
If a robotic structure can articulate itself over several degrees of freedom, expression becomes a possibility, just like an instrument offers a range of possibilities of being played some better then others an articulated structure offer a range of often redundant motion paths leading to the same result. Is there such a thing as graceful robotic movement? Graceful of course can be defined on many levels, for instance from the perspective of energy efficiency, shortest path, continuity of movement, acceleration, appearance of movement path, registration with some external cue etc. But how to design and teach such graceful motion is probably a challenge I would be interested in exploring.

Part D:

Real-Time Randomized Path Planning for Robot Navigation

James Bruce and Manuela M. Veloso Computer Science Department Carnegie Mellon University 5000 Forbes Avenue Pittsburgh PA 15213, USA {jbruce,mmv}@cs.cmu.edu

Reason to select the paper: The exploration of random trees for path planning in highly dynamic domains could serve as a relevant precedent for driving the articulated vehicle.

Major contributions: Improve the efficiency of rapidly exploring large state spaces without tiling. This improved path planning speed in combination with kinodynamic path planners.

Strength: Clear illustration of the RRT path planning technique for the robo soccer domain.

Weaknesses: The paper lacks an explanation in detail of how the randomized paths are generated in a generalized fashion from the robots navigation constraints.

Relationship to the other two papers: The path planning addresses higher level navigational task that look into the future and are only partially influenced by the constraints of the embodiment of the robot itself. The randomly generated paths are all valid paths though and therefore do not have to be translated into robot specific actions.

How is it applicable to the cognitive system I develop?

It is crucial for the vehicle to be able at anytime to scan the possible moves it can make next in reaction to possible user input and choose the one that gets it closest to the goal. Since the vehicle is riding on spatially highly constraint streets at relatively high speeds it is important to configure RRT so the randomly generated paths are as close as continuous as possible within the road boundaries.

The paper demonstrates the advantage of rapidly exploring random trees (RRT) in highly dynamic domains, in this case robo soccer. The advantage of employing RRT is to turn a reactive system into high performance path planning system.

A control structure for autonomous model helicopter navigation

Gilbert Lai, Kingsley Fregence, David Wang

Reason to select the paper: The paper addresses autonomous control systems in a model-sized helicopter, which is related to the articulated chassis problem I am trying to address. The paper lays out a hierarchical software architecture that structures the problem into different layers.

Major contributions: Three layer hierarchical functional control structure

Strength: Clear layout of the problem domain and focus on the lower level helicopter dynamics specific to this particular type of robot.

Weaknesses: The paper deviates very little from the conventional control layer hierarchy in comparison to other papers I came across.

Relationship to the other two papers: This paper addresses much more the robo-soccer paper the lower level robot specific issues in autonomous control systems

How is it applicable to the cognitive system I develop: The model helicopter is a good example of a semi autonomous scale model exhibiting a number of degrees of freedom and the paper illustrates the controller architecture used in a straight forward fashion.

Human-Machine Cooperative Telemanipulation with Motion and Force Scaling Using Task-Oriented Virtual Tool Dynamics

Tomotaka Itoh, *Member, IEEE*, Kazuhiro Kosuge, *Member, IEEE*, and Toshio Fukuda, *Fellow, IEEE*

Major contributions: The realization of a new human robotic Telemanipulation system with motion and force scaling based on semi autonomous virtual tool dynamic.

Strength: The paper addresses clearly how the mapping of movements at human scale and strength can be mapped scale independent onto a range of telemanipulated devices using virtual tool dynamics.

Relationship to the other two papers: Where the first paper addresses higher level path planning issues in relationship to a dynamic environment and the helicopter paper demonstrates robot specific dynamics details for the control system the telemanipulation paper addresses the issue of human machine interaction and the very important aspect of scaling of forces. The human interaction can have an impact on all levels of the control architecture and thereby a crucial component of any autonomous system that will be interacting with humans.

How is it applicable to the cognitive system I develop: The articulated car should be capable of processing human input to its chassis articulation as it is navigating the roads in addition to the autonomous stability control. In addition the control movements of the driver would have to be scaled up both in the range of motion as well as in the force to allow the driver to experience driving as a body like extension. The introduction of a virtual chassis model to negotiate the driver based interaction with the control mechanism and the articulation of the car chassis seems like a promising technique to avoid oscillation and feedback problems.

Part E:

Project for the cognitive robot

I am developing an articulated chassis for a ongoing group project that is exploring the possibility of deploying an articulated chassis for a sportive vehicle.

One of the challenges is the mapping of the body movement onto the articulated chassis in a way that allows for the exploration of new steering movements but at the same time does not endanger the stability of the vehicle. The articulated vehicle should be capable of operating autonomously in response to high level user input as for instance accelerate, decelerate and steering input while keeping its balance and safe driving dynamics. In addition a user should be able to override or augment the robotic control with human input with the goal to allow for individual variations of the autonomously controlled moves.

The project has a crude but functioning servomotor based mockup to test the interplay of the range of degrees of freedom. The goal of the final project would be to develop a simple software architecture that translates user steering input into the appropriate chassis movement using for instance an acceleration sensor for feedback and a simple path planning strategy to explore the range of possible motions to match the user input with the robotic chassis.