Current Projects at the MLR lab

Marc Toussaint, Dec 19, 2018

This is a list of MSc projects I am interested in supervising. Students need to have visited some of our courses (esp. ML, Robotics). Some projects require solid coding, but some are also more theory oriented (esp the Control Theory one).

IntCDC Cluster (in coop w Sawodny): Planning quasi-static construction sequences

Starting point is the Logic-Geometric Programming framework for sequential manipulation. One of the most interesting questions is what models to use to constrain interactions with the environment. A very promising (in terms of being simple but powerful) is quasi-static interactions. – The student needs to love constrained optimization, coding, robots and physics equations.

IntCDC Cluster (in coop w Achim Menges): Optimization of Fibre Networks

In IntCDC, robots are weaving carbon fibre threads to long-span buildings. They (partners in this cluster) don't really have a clue of how to optimize the structure and geometry of these 3D carbon fibre constructions. We have ideas for constrained optimization formulations. The impact of this could be huge. – The student needs to love constrained optimization, architecture applications, geometry.

(in coop w Daniel Weiskopf): Explaining and Visualizing NLP solutions

Constrained optimization has many applications, including in robotics and design. A core problem with formulating optimization problems (i.e. specifying the costs and constraints of an NLP), is that it is hard to understand the solutions that an optimizer comes up with. The KKT conditions are differentiable, and in principle solutions should be 'explainable'. This project explores fundamentally how optimization algorithms can not only output a solution, but also a (visual) explanation for this solution. That is, an explanation for why the found solution is a solution, or what make a certain configuration infeasible, where the costs come from, and how the solution would change if you modify parameters of the solution. The goal is to develop visualization techniques that allow the user to intuitively grasp solutions. In turn, this supports the user to more easily specify optimization problem.

Control Theory: Stochastic Optimal Control when the dynamics are an NLP

Robot manipulation means that robots create contacts, and thereby stay in a constrained submanifold. It is not clear how to properly formulate stochastic optimal control through such constrained manipulation. I believe that a key is to formulated the process dynamics as an NLP – that raises the question of how to then do control. This project explores this idea, first aiming for the simplest possible SOC methods (brute force sampling), just to evaluate the problem formulation itself. Then talk to control theorists in this area to learn about more efficient approaches. – The student needs to love control theory, and have a solid prior education in control.

Robotic AI: Training Perception for Physical Reasoning

To enable physical reasoning and sequential manipulation planning, the robot needs a certain description/perception of the scene. We set up a basic perception pipeline that can extract and model objects. This project explores to use this basic pipeline to collect data to train a complementary perception pipeline. The learned models should not replace the old pipeline but

complement it. – The students needs to love computer vision, and ideally have experience with CNNs.

Software project: Interactive Robot Coding Based on ry

For a team: The goal is not a particular software that solves one problem; but a (python) library that allows you to script/operate very efficiently and interactively any robot behavior. The key question is what abstractions to provide for the use to interactively operate the robot. To make sense for us, this needs to build on the RAI software (see github) as underlying engine, for which there already are python bindings (see rai-python). – Students need to love interactive coding, robots, be good with threading and interactively scripting concurrent processes.

(PUT ON HOLD) SIMPLE Reinforcement Learning

As a counter-movement to main-stream deep RL, this approach explores very basic and simple approaches to RL problems which are strict reductions to (sequential) supervised learning problems. This includes throwing away the discounting dogma and rethinking what the value function could represent. – The student should love reliable, understandable, solid methods.

Projects with Jim Mainprice

See his personal homepage for projects with Jim.