Topics for Master Theses

Intelligent and Mobile Robotics
Czech Technical University in Prague
Czech Institute of Informatics, Robotics and Cybernetics
Intelligent and Mobile Robotics Group

http://imr.ciirc.cvut.cz
Visual Teach-and-replay Navigation System based on Deep Learning

Supervisor: Luis G. Camara (luis.gomez.camara@cvut.cz)

**Problem:** Implementation of a tech-and-replay navigation system using as a core a state-of-the-art, deep learning visual place recognition system.

**Approach:** Use place recognition to calculate the robot’s location and pose and hence navigate it through a previously recorded path. No odometry measurements will be in principle needed.

**Requirements:** Python and OpenCV. Some knowledge of ROS and CNNs is advantageous.
Benchmarks Do Matter: Creating and Testing Image Datasets for Visual Place Recognition and Loop Closure

Supervisor: Luis G. Camara (luis.gomez.camara@cvut.cz)

**Problem:** Creation of sequences of reference and query images that can be used to test visual place recognition approaches in mobile robotics environments.

**Approach:** Record with a handheld or robot-mounted device sequence of images corresponding to 2 traverses of the same path, which can be indoors, outdoors or both. Testing the created datasets using several visual place recognition implementations.

**Requirements:** Python and OpenCV. Familiarity with cameras and image editing.

![Ground truth sequence](image1.png)

![Query sequence](image2.png)

![Comparison of visual place recognition approaches](image3.png)
**Problem:** Ensure flexible implementation of collaborative robots by allowing picking parts from unknown location at low cost.

**Approach:** Use RGBD consumer cameras (e.g. Intel RealSense) and possible mechanical artifacts or end-stop switches.

**Requirements:** C++ or Python
Mobile manipulation with Husky and UR5
Supervisor: Karel Košnar (karel.kosnar@cvut.cz)

**Problem:** Assume a mobile robot with a robotic hand operating in an everyday environment acting as a helper.

**Approach:** Develop a framework for mobile manipulation (during movement of the robot).

**Requirements:** C++ (ROS is welcome but not required)
Use of simulator for end-to-end learning CNN in context of grasping

Supervisor: Karel Košnar (karel.kosnar@cvut.cz)

**Problem:** Learning of CNN is time demanding especially if deal with a real world object.

**Approach:** Design a framework to incorporate the simulation in the learning of CNN and verify them within the grasping task.

**Requirements:** C++ or python, robotic simulator (CNN welcome)
Use of simulated data for learning CNN in context of bin picking

Supervisor: Karel Košnar (karel.kosnar@cvut.cz)

Problem: Learning of CNN is time demanding especially if deal with a real world object.

Approach: Design a framework to incorporate simulated realistic images into the learning of CNN and verify them within the bin picking task.

Requirements: C++ or python (CNN is welcome but not required)
Random Bin Picking

Supervisor: Karel Košnar (karel.kosnar@cvut.cz)

**Problem:** Pick one object from a pile of objects using only the camera.

**Approach:** Compare the approaches existing within the IMR and improve them.

**Requirements:** C++ or python, CNN
Mobile robot localization using up-looking camera
Supervisor: Karel Košnar (karel.kosnar@cvut.cz)

**Problem:** Ceiling is usually the most stable part of the environment. Therefore, it is logical choice to use it for mobile robot localization.

**Approach:** Develop a algorithm for map creation (with known position) and robot localization.

**Requirements:** C++ or python, (ROS welcome)
Inspection planning in the polygonal domain
Supervisor: Miroslav Kulich (kulich@cvut.cz)

**Problem:** Assume a mobile robot with a limited sensor range operating in an environment represented as a polygon with holes. Find the shortest possible path from which all points of the environment are visible.

**Approach:** Develop a combination of a metaheuristic with computational geometry methods to solve the problem.

**Requirements:** C++ (knowledge of metaheuristics/computational geometry is not needed, the student will be acquainted with the methods during the solution of the topic)
Planning delivery routes for postmans

Supervisor: Miroslav Kulich (kulich@cvut.cz)

**Problem:** Given a graph of a city/district, delivery requests, and depots, find the optimal routes for a team of deliverymen satisfying given constraints.

**Approach:** Implement/develop a metaheuristic to solve the problem.

**Requirements:** C++ (knowledge of metaheuristics/computational geometry is not needed, the student will be acquainted with the methods during the solution of the topic)
Exploration of an unknown environment

Supervisor: Miroslav Kulich (kulich@cvut.cz)

Problem: Navigate a mobile robot in an unknown environment in order to build a model of this environment in minimal time.

Approach: Study various exploration strategies in simulation and with a real robot.

Requirements: C++
• Recent joint project with the Faculty of Civil Engineering
• Long-term goal is to create a system self-assembling given patterns from a set of tiles
• Example problems: optimization of tile interaction rules, mechanical design of self-assembly system
• In a case of interest, please contact the supervisor to discuss further possibilities
Robotic manipulation with uncertainties

Supervisor: Viktor Kozák (viktor.kozak@cvut.cz)

**Problem:** Soft materials pose a challenge to standard robot manipulation tasks (i.e. Pick & Place). Advanced detection and manipulation approaches are necessary to account for uncertainties in object localization and changes to its center of gravity during the manipulation.

**Approach:** Develop a visual object detection method for robotic manipulation that takes into account the behavior of a flexible object during robotic manipulation.

**Requirements:** Python. Basic knowledge of image-processing and OpenCV.
Ground robot navigation

Supervisor: Jan Chudoba (jan.chudoba@cvut.cz)

Robot navigation in structured terrain, terrain mapping
Visual navigation methods and data fusion with 3D lidar data
Planning for omni-directional platform with satisfying common conventions
Robust mapping of the robot work environment with utilization of CAD plans
Identification, modelling and control of an UAV
Trajectory following for small UAV with known localization
Interior environment mapping with an UAV
Visual odometry device for UAV localization
3D terrain mapping using stereometry
Mutual localization of UAVs using radio modules