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Abstract:

Four research directions related to unmanned systems can be identified. Safe Operation in Dynamic Environments: navigation in dynamic, structured and semi-structured traditional and ambient environments; 3D Perception: efficient representation of 3D data, 6DOF scan registration, scanning-while-moving, semantic mapping, and fusion of visual and range information; Robotic Map Learning: learning of spatial and appearance-based maps; Robot Vision: mapping of visual data to consistent internal models for change detection, visual SLAM, appearance-based localization and people tracking.

Figure 1: AASS Learning Systems lab

Detailed research information:

Research Directions

The research focus of the AASS Learning Systems lab (see Figure 1) is on the development of algorithms and robotic systems for real-world tasks. In order to achieve a high level of autonomy under different and varying environmental conditions the approaches developed are characterized by learning and fusion of information from different sensor modalities. We consider "traditional" environments as well as environments populated with networked and distributed intelligent artefacts. The long-term aim is to better understand perceptual, biological, and physical processes through the help of robots, using them indirectly as a model or directly as a tool for experimentation. Six major directions of our research can be identified:

- Mobile Robot Olfaction,
  concerning all aspects of airborne chemical sensing with mobile robots and stationary gas sensors in natural environments. This includes in particular gas source localization and Bayesian gas distribution modelling (addressed in the DHRS-CIM project); statistical gas distribution modelling of pollution levels in urban environments (DustBot project); and time dependent gas distribution modelling and sensor planning for large-scale environmental monitoring (Diadem project).
- Dexterous Manipulation and Motion Learning,
  concerning learning of skills and tasks for robotic manipulators from demonstrations given by a human teacher; in particular learning and development of grasping and manipulation skills for dexterous robotic hands (HANDLE project) and Programming-by-Demonstration of robot manipulators.
- Safe Operation in Dynamic Environments,
  concerning navigation of mobile robots in dynamic, structured and semi-structured environments. This includes in particular safe operation in semi-structured ambient environments such as pedestrian areas (addressed in the DustBot project); and autonomous transportation applications (MALTA project and ALL-4-eHAM project).
- 3D Perception,
  concerning efficient representations of 3D data, 6DOF scan registration, scanning-while moving, semantic mapping, and fusion of visual and range information in the context of different applications. Specific application domains considered are autonomous mining vehicles, forklift trucks (MALTA project) and wheel loaders (ALL-4-eHAM project).
- Robotic Map Learning and SLAM,
  concerning learning of spatial and appearance-based maps by mobile robots. A variety of aspects of robotic map learning are addressed: from indoor to outdoor, from static to dynamic environments, from 2D to 3D maps, from topological and geometric maps to hybrid and semantic maps.
- Robot Vision,
  concerning mapping of visual data (eventually fused with further sensor modalities) to consistent internal models for change detection, visual SLAM, appearance-based localization and mapping and people tracking.

Collaborative Projects

The research of the AASS Learning Systems lab that is related to unmanned systems concerns Safe Operation in Dynamic Environments, 3D Perception, Robotic Map Learning and SLAM, and Robot Vision. The general interest in these research directions is pursued in several ongoing collaborative projects, including:

(1) The EU project DustBot (FP6 STREP, November 2006 - January 2010)
in which we contributed to develop a system of autonomous service robots for garbage collection and pollution monitoring in populated, ambient urban environments. The key challenges in this project included safe operation in close vicinity to humans and modelling gas distribution in a natural environment.

(2) The MALTA project (KKS, April 2008 - March 2011)
in which we contribute to develop a demonstrator platform for a fully autonomous fork-lift truck that handles heavy paper reels in an industrial setting (= loading/unloading/stacking paper reels, and storing them in containers, trucks or train wagons) operating together with other autonomous and manually driven trucks. The key challenges in this project include safe operation at high speed and accurate localization in an environment that undergoes constant changes because the papers reels need to be stored temporarily and because of their size dominate the appearance of the scene.

(3) The ALL-4-eHAM project (KKS, April 2009 - March 2012)
in which we contribute to develop a generic, modularized system for autonomous wheel loaders that carry out all parts of the material handling cycle in the context of an asphalt production site. One key challenge is perception and navigation at high speeds in a dynamic, unstructured outdoor environment. Another main aspect of this project lies in the loading aspect. The task of the wheel loaders is to load heterogeneous materials from piles continuously heaped up by human operators. The shape of the piles is not known in advance and changes continuously. The materials differ substantially in their properties and accordingly the way they have to be handled. Given the material properties, the

optimal loading procedure has to be determined from a simulation of the material behaviour and the current state of the pile.

Good Use Declaration

Regarding the intended applications that we target, we feel indebted to the Uppsala Code of Ethics for Scientists. Our aim is ultimately to free humans from dull and dangerous tasks (as phrased by Norbert Wiener: "the human use of human beings") and to understand perceptual, biological and physical processes through the help of robots. We are aware that our results may have also other, less beneficial, applications and therefore declare that it is strictly prohibited to use or to develop, in a direct or indirect way, any of our scientific contributions by any army or armed group in the world, for military purposes and for any other use which is against human rights or the environment.