

A5.1 Mobile Systems – Navigation and Communication

Time: Monday, 13.09.2010

Location: Humboldt-Building, Lecture Room 201

Chairman: M. Lemmel (DE-Bremen)

1:30 p.m.	D. Jopp, M. Lemmel (DE-Bremen)
<p>Indoor Positioning on Industrial Facilities with an Accuracy of Measurement of $\pm 50\text{mm}$</p> <p>Within the joint project 'Indoor Positioning on industrial facilities with an accuracy of measurement of $\pm 50\text{mm}$', the partners BIMAQ and IAT on behalf of BCM and the engineering consultant Obergfell & Partner (IPO.Plan) developed an automatic and wireless acquisition of conveyor-technical factory layouts to be transferred into a CAD model of the facility. The project is funded by the German Federation of Industrial Research Associations (AiF) from the 01.07.2008 to the 31.12.2009. A system is developed to automatically capture the actual 3D-movements in conveyor-technical arrangements. An electronically or optically pursuable module, which follows the course of a conveyor, acquires defined parameters such as the conveyor height, role distances or inclinations using a new sensor system. The project aims at an exact and reliable detection within a covered facility. After studying the market of upcoming tracking solutions the 'Ubisense'-RTLS which uses ultra-wideband (UWB) radio was discovered as an appropriate solution and installed into a tentative production facility of about 900 m². This application is intrinsically more accurate than other radio technologies because of its resistance to signal distortions caused by the reflections that always occur in real-world deployments. The sensors use combined Angle-of-Arrival (AoA), Time-Difference-of-Arrival technology (TDoA). The associated software-package consists of two runtime environments and a development component. It is necessary to verify the included filter algorithms to respectively suit them to the according building. Though, accuracies of approximately 10 - 15 cm could be reached.</p>	

What is different? - Modeling the Changeability of the Environment

In mobile robotics the task of finding an appropriate way to drive to a goal, following a person, or even to localize itself within a dynamic environment are still challenging tasks. To enable a mobile robot to interact well within the environment, the robot needs an internal representation of the environment, usually called a map. The problems of interaction with the environment arise by using an outdated representation (map) of the environment and releasing actions to an actual environment, e.g. by trying to drive through a blocked floor, a closed door or by trying to drive through moved pieces of furniture. This paper presents a new method of adapting the internal map in a consistent way by including new states of the environment and also retaining the old states of the environment. The basic idea of our approach is the inclusion of all sensor information at different "forgetting levels". We do so by assembling a stack of topological maps where for each node of the map sensor information is collected with a different update rate per stack slice. This way, we can model maps with long-term memory characteristic as well as with short-term characteristic and all in between. Our method also presents an approach how to create consistent environment information when the impression of a certain place was only partially observable and collected at different points in time. The benefit of our approach is the representation of consistent expected observations at different levels of time-scale, so no mixtures of observations which are very unlikely to belong together are selected. All this information is represented in a consistent fashion to the mobile robot to improve self-localization and path planning in dynamic environments.

2:10 p.m.	Th. Glotzbach (PT-Lissabon), M. Schneider, P. Otto, Ch. Ament (DE-Ilmenau)
<p>Bio-Inspired Adaptive Autonomy for Mobile Vehicle Teams: Results of the Research Project 'GREX'</p> <p>The usage of the notation 'autonomy' in research on unmanned mobile systems often creates difficult situations. It is not intuitive to determine which abilities a vehicle must have to be called autonomous. The possibilities for the interaction of a human operator into the mission of an 'autonomous' vehicle is unclear. Especially for teams of unmanned systems, it is actually an antilogy to speak about 'cooperation' between 'single autonomous' systems. These problems can be solved by the interpretation of autonomy as a state in a spectrum which can be changed for each vehicle at all time. This concept is called Bio-Inspired Adaptive Autonomy. The nucleus of this paper is to give a concrete example of the usage of this principle during the research project 'GREX' which aimed to the development of a conceptual framework and middleware systems to coordinate a group of heterogeneous unmanned marine vehicles working in cooperation to achieve a well defined practical goal in an optimized manner. Within the GREX project, the participating researchers from eight institutions (both industry and universities) of five different countries with funding from the European Community were able to realize a group of unmanned marine vehicles, cooperating in different small scenarios. In this paper, we will describe the basic team abilities which were realized during this project. In doing so, it will get clear that these abilities required different control hierarchies, were different vehicles became the team leader for a certain period of time, while in other situations all vehicles operated on an equal level. These different architectures were necessary due to the special conditions in the maritime and under-water environment. The latter offers only limited communication and navigation abilities. We will show how the description and definitions of these architectures benefit from the Adaptive Autonomy concept which allows an evaluation and comparison between the different control structures and proof the importance of this concept. Finally, the paper will describe the practical results of the GREX project which were demonstrated during the Sea Trials at Sesimbra, Portugal, in the autumn of 2009.</p>	

2:30 p.m. | E. Einhorn, Ch. Schröter, H.-M. Groß (DE-Ilmenau)

Building 2D and 3D Adaptive-Resolution Occupancy Maps using Nd-Trees

In mobile robotics map building is an important basis for different navigational tasks. It provides a model of the environment that is essential for collision avoidance, path planning and localization. In the past, most approaches applied two dimensional occupancy grid maps which are built using sensors like laser range finders or sonar sensors that are able to obtain only two-dimensional information about the environment. Recently, different sensors like time-of-flight cameras or 3D lasers are evolving which are able to obtain three-dimensional information about the local surroundings. Consequently, three dimensional representations are necessary to take full advantage of these sensors. In previous works, regular voxel representations and octrees have been proposed as a three dimensional alternative to 2D grid maps. However, all of these existing approaches have in common that they partition the environment into regular cells with a fixed resolution. The choice of the cell resolution is crucial. An improperly chosen resolution may lead to inconsistent maps or to maps with insufficient precision. In this paper we present a novel mapping technique that chooses the resolution of each cell adaptively depending on the measurements. If an additional measurement becomes available that conflicts with the current map estimate, i.e. the states of the existing occupancy cells, the measurement is either an outlier or the inconsistency is caused by a too coarse resolution of the map. In the latter case the affected cells are subdivided to increase the resolution. Simultaneously, neighboring cells with similar occupancy values are merged to reduce the spatial and computational complexity of the approach. Both splitting and merging of the cells is based on an information theoretic measure that we derive in this paper. Additionally, we introduce the Nd-Tree, a generalization of quadtrees and octrees that allows to subdivide any d-dimensional volume recursively with N^d children per node. Using this data structure our approach can be implemented in a very generic way and allows the creation of 2D, 3D and even higher dimensional maps using the same algorithm. Finally, we show results of our proposed method for 2D and 3D mapping using different kinds of range sensors.

2:50 – 3:10 p.m. Coffee break

3:10 p.m.	M. Griegoleit, St. Kühne (DE-Zittau/Görlitz)
<p>Wireless Sensor Network based of IEEE802.15.4 with Real Time Capability</p> <p>Wireless Sensor Network based of IEEE802.15.4 with real time capability The scope of this project is the development of the hardware and software basis for a wireless network, based on the standard IEEE802.15.4 and built up in a star network topology, to transmit data from remote sensors (RF-End Device) to a central processing unit (RF-Net Coordinator). The main focuses are the real time capability of the system according to the timing requirements of the project, by using a Superframe structure with a so-called "contention-free period (CFP)" and „Guaranteed Time Slots (GTSs)" as described in IEEE802.15.4, the robustness against interferences within the harsh RF environment of the widely used 2.4-GHz-band, the battery-powered operation of the sensors (and hence the energy budget) and the coexistence of several similar networks, even within the radio transmission range of a neighbouring system. The primarily targeted sensor types are pressure and torque measuring devices, but the use of other sensors or different data sources may also be possible under consideration of the system's maximum transferable data rates.</p>	
3:30 p.m.	K. Lunde, L. Kieble (DE-Ulm)
<p>Simulating Communication within a Satellite-Based Automated Toll Collection System</p> <p>In several European countries, more or less automated toll collection systems are in use, which employ a great variety of technologies. The least invasive systems use satellite-based positioning systems like GPS to detect the position and the travelled distance of a vehicle on the highway network. While vehicles are moving, communication may be caused by a variety of reasons, including toll-charging processes, software updates, or updates of geographic map data. The corresponding messages are exchanged via a mobile communications network. A similar system structure can be observed in a variety of distributed systems with a large number of mobile agents and a single computing centre where messages or requests are processed, as is often the case in vehicle telematics applications. As an example application, we consider tolling commercial vehicles on the German highway network. We have developed a simulation framework using discrete-event system simulation (DES) to explore the dependency of the frequency and the volume of the communication within a satellite-based toll collection system on essential parameter values and the choice of different update strategies. The paper focuses on communication caused by the toll-collection process. It outlines the underlying traffic model, and describes the agent model and the communication protocol. One of the challenges we address is the large number of distributed agents, which can not be reduced materially without distorting essential system properties due to the single computing centre. A discussion of some simulation results, which were attained using the DES-tool OMNeT++ , concludes the paper.</p>	
<p>End of Lecture Session</p>	