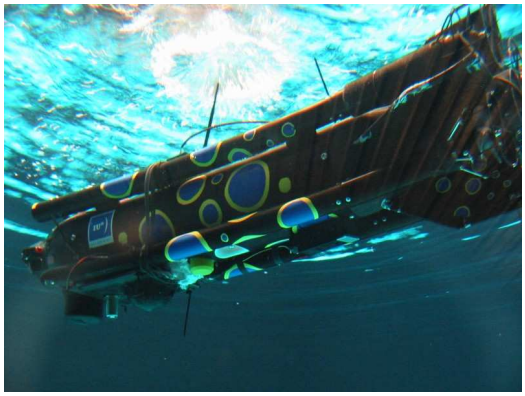
IEEE

Robotics
JACOBS UNIVERSITY

8th IEEE International Workshop on

Safety, Security, and Rescue Robotics
SSRR - 2010

Bremen, 26.-30. July 2010



SSRR-2010
Invited Talks

Tuesday, 27.07.2010, 14h00 – 15h00

Bernardo Wagner
Perception and Navigation with 3D Laser Range Data in Challenging Environments

Wednesday, 28.07.2010, 11h30 – 12h30

Andrea Caiti
Waterside Safety and Security in Coastal Areas: Underwater Robots Cooperation in a Communication-Constrained Medium

Thursday, 29.07.2010, 14h00 – 15h00

Davide Scaramuzza
Omnidirectional vision in robotics: from calibration to robot motion estimation and autonomous flight of micro helicopters

Bernardo Wagner
Perception and Navigation with 3D Laser Range Data in Challenging Environments

Abstract:

Robot navigation includes the tasks of localization, path planning, object recognition and avoidance as well as vehicle control. Under real-world conditions, these tasks face the challenge of unknown and typically complex obstacle configurations in time-variant environments.

The use of rich 3D sensor data provides a promising basis to solve these tasks. For use under real-time conditions, algorithms to extract the desired information from the huge amount of data are required. This data reduction is one main aspect of current systems.

In this talk an overview of recent work in the field of localization, object classification and long-term navigation based on 3D laser-based sensor data will be presented. The talk concludes with the exemplary appliance of the work to real-world problems. This includes an autonomous forklift truck for automated load handling in industrial environments and the autonomous operation of an unmanned vehicle at the European Land Robot Trials (ELROB).

Andrea Caiti

Waterside Safety and Security in Coastal Areas: Underwater Robots Cooperation in a Communication-Constrained Medium

Abstract:

Starting from a survey on the state of the art of underwater robotics in safety, security and search and rescue scenarios, the talk will focus on safety and security applications in coastal areas. Two main scenarios are considered: the patrolling activities in order to detect any anomalous event (monitor and detect), and the reaction to a detected anomaly (reacquisition, classification and deterrence). The use of a team of underwater autonomous robots in both scenarios potentially has a very high pay-off, in terms of area coverage and operational costs, however it still has to face a set of unsolved scientific and technical issues.

Most prominent among these is acoustic communication. Data and message exchange between the team members is severely limited both in range and bandwidth by the characteristics of acoustic propagation in ocean waters. The degrees of freedom of the autonomous robot team may be exploited in order to optimize the acoustic communication channel performance while at the same time preserving the mission objective. Current developments in this direction within the European Union project "UAN – Underwater Acoustic Network" will be reviewed.

Davide Scaramuzza

Omnidirectional vision in robotics: from calibration to robot motion estimation and autonomous flight of micro helicopters

Abstract:

Cameras are having a large impact on our society, every cell-phone is equipped with a camera and in the very near future all cars will feature cameras to improve traffic safety and even clothing will be equipped with integrated cameras. While cameras are continuing to pervade our daily lives, optics developers are working on increasing the field of view of the cameras. If the field of view of a camera exceeds 180 degrees, it is called an omnidirectional camera.

Up until three years ago, these cameras were too heavy, expensive, and bulky to be integrated in commercial products. However today, omnidirectional cameras have become sufficiently small to be installed in cars and even carried on small lightweight helicopters. The market of these cameras is increasing and accordingly, the demand for software that enables their use in the real world is rising.

In this talk, I will present how to combine omnidirectional vision and robotics in two applications: ground robots and micro aerial vehicles. After a brief overview on omnidirectional vision, I will show some result on vehicle motion estimation for ground vehicles and autonomous flight of micro helicopters by just using a single miniature omnidirectional camera as a sole input.

SSRR-2010
Program Overview

Monday, 26.07.2010

18h00 – Reception & Dinner

Tuesday, 27.07.2010

09h15 – 09h30 Welcome

09h30 – 11h00 ROBOT LOCOTMOTION AND MECHANISMS 1

Tetsuya Kinugasa, Tetsuya Akagi, Kuniaki Ishii, Takafumi Haji, Koji Yoshida, Yuta Otani, Hisanori Amano, Ryota Hayashi, Kenichi Tokuda and Koichi Osuka
Measurement of Flexed Posture for Flexible Mono-tread Mobile Track Using New Flexible Displacement Sensor

Jimmy Tran, Alexander Ferworn, Martin Gerdzhev and Devin Ostrom
Canine Assisted Robot Deployment for Urban Search and Rescue

Keiji Nagatani, Hiroaki Kinoshita, Kazuya Yoshida, Kenjiro Tadakuma and Eiji Koyanagi
Development of leg-track hybrid locomotion to traverse loose slopes and irregular terrain

11h00 – 11h30 Coffee Break

11h30 – 12h30 COOPERATIVE SYSTEMS 1

Donny Kurnia Sutantyo and Serge Kernbach
Multi-Robot Searching Algorithm Using Levy Flight and Artificial Potential Field

Julian de Hoog, Stephen Cameron and Arnoud Visser
Dynamic Team Hierarchies in Communication-Limited Multi-Robot Exploration

12h30 – 14h00 Lunch

14h00 – 15h00 INVITED TALK

Bernardo Wagner
Perception and Navigation with 3D Laser Range Data in Challenging Environments

15h00 – 15h30 Coffee Break

(Tuesday, 27.07.2010)

15h30 – 16h30 COOPERATIVE SYSTEMS 2

Alessandro Renzaglia and Agostino Martinelli
Potential Field based Approach for Coordinate Exploration with a Multi-Robot Team

Bin Li, Shugen Ma, Tonglin Liu and Mhwang Wang
Cooperative Reconfiguration between Two Specific Configurations for A Shape-shifting Robot

16h30 – 17h00 Coffee Break

17h00 – 18h00 MOTION CONTROL

Jorge Bruno Silva, Vitor Matos and Cristina Santos
Generating Trajectories With Temporal Constraints for an Autonomous Robot

Noritaka Sato, Takahiro Inagaki and Fumitoshi Matsuno
Teleoperation System Using Past Image Records Considering Moving Objects

Wednesday, 28.07.2010

09h15 – 09h30 Announcements

09h30 – 11h00 FIELD REPORTS AND APPLICATIONS 1

Johannes Pellenz, Dagmar Lang, Frank Neuhaus and Dietrich Paulus
Real-time 3D Mapping of Rough Terrain: A Field Report from Disaster City

Fernando J. Pereda, Hector Garcia de Marina, Juan Francisco Jiménez and Jose M. Girón-Sierra
Sea Demining with Autonomous Marine Surface Vehicles

Thorsten Linder, Viatcheslav Tretyakov, Sebastian Blumenthal, Peter Molitor, Hartmut Surmann, Dirk Holz, Robin Murphy and Satoshi Tadokoro
Rescue Robots at the Collapse of the Municipal Archive of Cologne City: a Field Report

11h00 – 11h30 Coffee Break

11h30 – 12h30 INVITED TALK

Andrea Caiti
Waterside Safety and Security in Coastal Areas: Underwater Robots Cooperation in a Communication-Constrained Medium

12h30 – 14h00 Lunch

(Wednesday, 28.07.2010)

14h00 – 18h00 ROBOT DEMONSTRATIONS

19h00 – Banquet

Thursday, 29.07.2010

09h15 – 09h30 Announcements

09h30 – 11h00 TERRAIN CLASSIFICATION

Tae-Yeon Kim, Gi-Yeul Sung and Joon Lyou
Robust Terrain Classification by Introducing Environmental Sensors

Wei Mou and Alexander Kleiner
Online Learning Terrain Classification for Adaptive Velocity Control

Piotr Skrzypczynski and Dominik Belter
Rough Terrain Mapping and Classification for Foothold Selection in a Walking Robot

11h00 – 11h30 Coffee Break

11h30 – 12h30 FIELD REPORTS AND APPLICATIONS 2

Ivan Maza, Fernando Caballero, Jesus Capitan, J.R. Martinez-de-Dios and Anibal Ollero
Firemen Monitoring with Multiple UAVs for Search and Rescue Missions

Robin Murphy
Findings from NSF-JST-NIST Workshop on Rescue Robotics

12h30 – 14h00 Lunch

14h00 – 15h00 INVITED TALK

Davide Scaramuzza
Omnidirectional vision in robotics: from calibration to robot motion estimation and autonomous flight of micro helicopters

15h00 – 15h30 Coffee Break

15h30 – 16h30 VICTIM AND OBJECT DETECTION

Andreas Laika, Johny Paul and Adam El Sayed Auf
FPGA-based Real-time Moving Object Detection for Walking Robots

M. Zaheer Aziz and Bärbel Mertsching
Survivor Search With Autonomous UGVs Using Multimodal Overt Attention

16h30 – 17h00 Coffee Break

17h00 – 18h00 MAPPING

Thomas Wiemann, Andreas Nuechter, Kai Lingemann, Stefan Stiene and Joachim Hertzberg
Automatic Construction of Polygonal Maps From Point Cloud Data

Qian Cheng, Tan YingZi, Shen Hui and Xu YingQiu
A Global Line Matching Algorithm for 2D Laser Scan Matching in Regular Environment

Friday, 30.07.2010

09h00 – 09h15 Announcements

09h15 – 10h45 ROBOT LOCOTMOTION AND MECHANISMS 2

Martin Gerdzhev, Jimmy Tran, Alexander Ferworn and Devin Ostrom
DEX – A Design for Canine-Delivered Marsupial Robot

Yuki Iwano, Koichi Osuka and Hisanori Amano
Development of Rescue Support Stretcher System

Haruo Maruyama and Kazuyuki Ito
Semi-autonomous snake-like robot for search and rescue

10h45 – 11h00 Coffee Break

11h00 – 12h30 SENSOR NETWORKS AND WIRELESS COMMUNICATIONS

Richard Voyles, Sam Povilus, Rahul Mangharam and Kang Li
RecoNode: A Reconfigurable Node for Heterogeneous Multi-Robot Search and Rescue

Hisayoshi Sugiyama, Tetsuo Tsujioka and Masashi Murata
Autonomous Chain Network Formation by Multi-Robot Rescue System with Ad Hoc Networking

Hai Dan, Zhang Hui, Xiao Junhao and Zheng Zhiqiang
Cooperate Localization of a Wireless Sensor Network (WSN) Aided by a Mobile Robot

12h30 – 14h00 Lunch

SSRR-2010
Abstracts

Tetsuya Kinugasa, Tetsuya Akagi, Kuniaki Ishii, Takafumi Haji, Koji Yoshida, Yuta Otani, Hisanori Amano, Ryota Hayashi, Kenichi Tokuda and Koichi Osuka

Measurement of Flexed Posture for Flexible Mono-tread Mobile Track Using New Flexible Displacement Sensor

Abstract. We have proposed Flexible Mono-tread mobile Track (FMT) as a mobile mechanism for hazardous environment such as disaster area. FMT has only one track which can flex in three dimension. Generally speaking, one has to teleoperate robots under invisible condition. In order to operate the robots skillfully, it is necessary to detect not only condition around the robots and its position but also posture of the robots at any time. Flexed posture of FMT decides turning radius and direction, it is very important to know its posture, accordingly. FMT has a vertebral structure composed of vertebrae as rigid body and intervertebral disks made by flexible devices such as rubber cylinder and spring. Since the intervertebral disks flex in three dimension, it is not easy for traditional sensors such as potentiometers, rotary encoders and range finders to measure its deformation. The purpose of the paper, therefore, is to measure flexed posture of FMT using a new flexible displacement sensor. We prove that the flexed posture of FMT with five intervertebral disks can be detected through experiment.

Martin Gerdzhev, Jimmy Tran, Alexander Ferworn and Devin Ostrom

DEX – A Design for Canine-Delivered Marsupial Robot

Abstract. This paper presents the work on Drop and EXplore (DEX), a small rescue robot to be used in Urban Search and Rescue (USAR) operations. Unlike other rescue robots, DEX was designed to be used in tandem with trained USAR canines. The development of DEX was part of a new concept called Canine Assisted Robot Deployment (CARD). CARD utilizes search canines to deliver robots close to the casualties trapped under rubble. A small robot is attached to a search dog. After the dog uses its agility and sense of smell to find a casualty, the robot is deployed when the dog gives its bark indication. This method circumvents the current problems of response robots, their inability to traverse rubble. As DEX was constructed in order to test the concept of CARD, its designs are described in this paper along with the experiments conducted.

Keiji Nagatani, Hiroaki Kinoshita, Kazuya Yoshida, Kenjiro Tadakuma and Eiji Koyanagi

Development of leg-track hybrid locomotion to traverse loose slopes and irregular terrain

Abstract. The track mechanism has high mobility on irregular terrain, and is typically used as a locomotion mechanism for all-terrain robots. However, the track mechanism sometimes slips while traversing slopes comprising loose soil. Therefore, we developed a new locomotion mechanism, referred to as surface-contact-type locomotion, which has high mobility on weak soil. It uses a simple legged mechanism that has a wide contact area with the ground so as not to corrupt the contact surface. However, it has the disadvantage of low mobility on irregular terrain. To solve the problem of the above trade-off, we developed the leg-track hybrid locomotion mechanism by fusing the two locomotion mechanisms. In this paper, we detail the developed locomotion mechanism and report some initial experiments.

Donny Kurnia Sutantyo and Serge Kernbach
Multi-Robot Searching Algorithm Using Levy Flight and Artificial Potential Field

Abstract. An efficient search algorithm is very crucial in robotic area, especially for exploration missions, where the target availability is unknown and the condition of the environment is highly unpredictable. In a very large environment, it is not sufficient to scan an area or volume by a single robot, multiple robots should be involved to perform the collective exploration. In this paper, we propose to combine bio-inspired search algorithm called Levy flight and artificial potential field method to perform an efficient searching algorithm for multi-robot applications. The main focus of this work is not only to prove the concept or to measure the efficiency of the algorithm by experiments, but also to develop an appropriate generic framework to be implemented both in simulation and on real robotic platforms. Several experiments, which compare different search algorithms, are also performed.

Julian de Hoog, Stephen Cameron and Arnoud Visser
Dynamic Team Hierarchies in Communication-Limited Multi-Robot Exploration

Abstract. In the near future, groups of autonomous robots using wireless communication will be used for a wide variety of tasks. In many such applications, communication may be unreliable and communication ranges difficult to predict. While most current approaches to this problem strive to keep team members within range of one another, we propose an approach in which navigation and exploration beyond range limits is explicitly planned for. Robots may either explore or relay known information, and the team hierarchy corresponds to a tree. As the exploration effort unfolds, robots swap roles within this tree to improve the efficiency of exploration. Since robots reactively adjust to communication availability, the resulting behaviour is robust to limited communication. This makes it particularly suitable for applications such as robotic search and rescue, where environments are likely to contain significant interference and unexpected communication ranges.

Alessandro Renzaglia and Agostino Martinelli
Potential Field based Approach for Coordinate Exploration with a Multi-Robot Team

Abstract. In this paper we introduce a new distributed algorithm for the exploration of an unknown environment with a team of mobile robots. The objective is to explore the whole environment as fastest as possible. The proposed approach is based on the potential field method. The advantages of using this method are several and well known, but the presence of many local minima does not assure the exploration of the entire environment. Our idea is to preserve these advantages but overcome the problem of local minima by introducing a leader in the team which has a different control law, unaffected by this problem. Furthermore, we consider also the case of several local leaders, dynamically selected on the basis of a hierarchy within the team. Extensive simulations are presented to evaluate the performance of the algorithm. In particular, the results are compared with the exploration obtained by a potential field approach without leaders.

Bin Li, Shugen Ma, Tonglin Liu and Mhwang Wang
Cooperative Reconfiguration between Two Specific Configurations for A Shape-shifting Robot

Abstract. A reconfigurable mobile robot called AMOEBA-I has diverse configurations. A cooperative reconfiguration is proposed to endow the robot with reconfigurable ability and reinforce the adaptability of robot in unstructured environment. A mathematical model is established correspondingly. Cooperative reconfiguration methods are analyzed theoretically. The kinematical relations of three modules under cooperative reconfiguration are determined. Transforms are actualized under two specific configurations. Then, an

evaluation is proposed for AMOEBA-I's cooperative reconfiguration performance. The feature of cooperative reconfiguration methods are compared through theoretical analysis and experiments. Experimental results prove the validity of the cooperative turning methods on various grounds.

Jorge Bruno Silva, Vitor Matos and Cristina Santos
Generating Trajectories With Temporal Constraints for an Autonomous Robot

Abstract. Trajectory modulation and generation are two fundamental issues in the path planning problem in autonomous robotics, specially considering temporal stabilization of the generated movements. This is a very critical issue in several robotic tasks including: catching; hitting; human-robot scenarios and generating sequentially structured actions. In this work we address these problems and focus on generating movement for a mobile robot, whose goal is to reach a target within a constant time. We use an Hopf oscillator whose solution controls velocity, adapted according to temporal feedback. We have also proposed an adaptive mechanism for frequency modulation of the velocity profile that enables setting different times for acceleration and deceleration. This approach is demonstrated on a DRK8000 mobile robot in order to confirm the system's reliability with low-level sensors.

Noritaka Sato, Takahiro Inagaki and Fumitoshi Matsuno
Teleoperation System Using Past Image Records Considering Moving Objects

Abstract. In this paper, teleoperation system using past image records (SPIR) considering moving objects is proposed. SPIR virtually generates the scene looked from backward-tracking viewpoint by overlaying the CG model of the robot at the corresponding position on the background image which is got from the camera mounted on the robot at past time. However, moving objects cannot display correct positions, because the existing SPIR uses past static images as a background. In this study, to reflect moving objects, we improve three methods in the system. The first method is detection of moving objects. We install the particle filter algorism in the system. The second method is elimination of moving objects on the background image. The third is overlaying moving objects at the correct position on the background image. Furthermore we have a verification experiment for the proposed system.

Johannes Pellenz, Dagmar Lang, Frank Neuhaus and Dietrich Paulus
Real-time 3D Mapping of Rough Terrain: A Field Report from Disaster City

Abstract. Mobile systems for mapping and terrain classification are often tested on datasets of intact environments only. The behavior of the algorithms in unstructured environments is mostly unknown. In safety, security and rescue environments, the robots have to handle much rougher terrain. Therefore, there is a need for 3D test data that also contains disaster scenarios. During the Response Robot Evaluation Exercise in March 2010 in Disaster City, College Station, Texas (USA), a comprehensive dataset was recorded containing the data of a 3D laser range finder, a GPS receiver, an IMU and a color camera. We tested our algorithms (for terrain classification and 3D mapping) with the dataset, and will make the data available to give other researchers the chance to do the same. We believe that this captured data of this well known location provides a valuable dataset for the USAR robotics community, increasing chances of getting more comparable results.

Fernando J. Pereda, Hector Garcia de Marina, Juan Francisco Jiménez and Jose M. Girón-Sierra
Sea Demining with Autonomous Marine Surface Vehicles

Abstract. A sea demining method using autonomous marine surface vehicles (AMSV) is introduced. The method involves the development of exemplars of these vehicles, and the procedures for area scanning and coverage. The demining is made by field influence, towing a submerged "fish". This study is made both with simulations and with scale experiments.

Thorsten Linder, Viatcheslav Tretyakov, Sebastian Blumenthal, Peter Molitor, Hartmut Surmann, Dirk Holz, Robin Murphy and Satoshi Tadokoro

Rescue Robots at the Collapse of the Municipal Archive of Cologne City: a Field Report

Abstract. This paper presents a field report and summarizes the problems of the appliance of rescue robots during the Collapse of the Historical Archive of the City of Cologne. Two robots where on the field, ready to be applied: A shoe-box size tracked mobile robot (VGTV Xtreme) and a caterpillar like system (Active Scope Camera). Due to the special type of collapse and design limitations of the robots, both robotic systems could not be applied. Either they could not reach voids or did not fit into, or could not be controlled from a safe distance. The faced problems were analyzed and described in this paper.

Tae-Yeon Kim, Gi-Yeul Sung and Joon Lyou

Robust Terrain Classification by Introducing Environmental Sensors

Abstract. This paper presents a vision-based off-road terrain classification method that is robust despite large environmental variations caused by seasonal or weather changes. In order to account for an overall image feature variation, we adopted environmental sensors, and to train a neural network based classifier, constructed a database according to environmental conditions. Robust classification could be achieved by selecting the training parameter set best suited for each environmental state. Also, we propose a hardware architecture that enables distributed parallel processing for real- time implementation of the present algorithm. Experimental results for real off-road images show that in spite of dissimilar conditions, degradation of classification performance could be minimized by replacing the nearest parameters.

Wei Mou and Alexander Kleiner

Online Learning Terrain Classification for Adaptive Velocity Control

Abstract. Safe teleoperation during critical missions, such as urban search and rescue, and bomb disposal, requires careful velocity control when different types of terrain are found in the scenario. This can particularly be challenging when mission time is limited and the operator's field of view affected.

This paper presents a method for online adapting robot velocities according to the terrain classification results combined from vision- and laser-based classifiers. The vision-based classifier is self-supervised and adapts itself according to the vibration sensing and the pose estimation of the robot. The image patches where the vibration data are gathered are used to train the vision-based classifier. The Support Vector Machine is used for the laser-based classifier to train and classify the data. The final prediction result is produced by using the Naive Bayes Classifier to fuse the vision- and laser-based classifiers. The system is robust to illumination variations, and can be improved online given feedback from the operator.

Piotr Skrzypczynski and Dominik Belter

Rough Terrain Mapping and Classification for Foothold Selection in a Walking Robot

Abstract. This paper presents an algorithm for real-time building of a local grid-based elevation map from noisy 2D range measurements of the Hokuyo URG-04LX miniature laser scanner. The terrain mapping module supports a foothold selection method, which employs a polynomial-based approximation method to create an adaptive decision surface. The robot learns from simple simulations, therefore no {\em a priori} expert-given rules or parameters are used. The acquired terrain map and planned footholds enable the robot to walk more stable, avoiding slippages and fall-downs.

Ivan Maza, Fernando Caballero, Jesus Capitan, J.R. Martinez-de-Dios and Anibal Ollero
Firemen Monitoring with Multiple UAVs for Search and Rescue Missions

Abstract. This paper describes a multi-UAV firemen monitoring mission carried out in the framework of the AWARE Project. Two firemen were located in an area in front of a simulated building assisting injured people and moving equipment. The objective of the user was to have an estimation of the location of the firemen on the map and also images of their operations. Two autonomous helicopters were available and ready in the landing pads for this mission.

The techniques adopted to compute the required waypoints for the observation of the firemen from the UAVs are described in the paper. The detailed description of a firemen monitoring mission used to validate the approach is also provided in the paper.

Robin Murphy
Findings from NSF-JST-NIST Workshop on Rescue Robotics

Abstract. This paper summarizes the findings and observations from the NSF-JST-NIST Workshop on Rescue Robotics held at Texas A&M, March 8-11, 2010. The 50 workshop participants represented sixteen universities in the USA, Japan, and China. Over a dozen land, marine, and aerial vehicles were tested using the Response Robot Evaluation Exercise #6 or in more scenario-oriented testing at Disaster City. The workshop produced nine recommendations for standards for unmanned vehicles as well as proposed four topics for human-robot interaction evaluation. While the workshop generated tangible contributions to the ASTM Standards meeting and individual research programs, the workshop illustrated the benefits of interacting with more responders, robots, and other researchers than has been previously available to the community.

Andreas Laika, Johny Paul and Adam El Sayed Auf
FPGA-based Real-time Moving Object Detection for Walking Robots

Abstract. In a rescue operation walking robots offer a great deal of flexibility in traversing uneven terrain in an uncontrolled environment. For such a rescue robot each motion is a potential vital sign but the existing techniques for motion detection have severe limitations in dealing with strong levels of ego-motion on walking robots. This paper proposes an optical flow based method for the detection of moving objects using a single camera mounted on a hexapod robot for an application in a rescue scenario. The proposed algorithm estimates and compensates ego-motion to allow for object detection while the robot is moving. Our algorithm can deal with strong rotation and translation in 3D, using a first-order-flow motion model, with four degrees of freedom. Two alternative object detection methods using a 2D-histogram based vector clustering and motion compensated frame differencing respectively are examined for the detection of slow and fast moving objects. In addition to a software implementation, the system was implemented on an FPGA, enabling processing in real-time at 31 fps.

M. Zaheer Aziz and Bärbel Mertsching
Survivor Search With Autonomous UGVs Using Multimodal Overt Attention

Abstract. Rescue robotics is gaining increasing attention as an application of human assistance machines. Robots (or unmanned ground vehicles) for searching victims in disaster sites require a high level of reliability and robustness. This paper proposes a mobile vision system able to search for victims using integration of video and thermal camera inputs. A time efficient scanning strategy is designed for the pan-tilt camera head with a biologically inspired robust search mechanism to improve the performance of the overall

system. Results show success of the proposed methodology in enhancing robustness in autonomous survivor detection.

Thomas Wiemann, Andreas Nuechter, Kai Lingemann, Stefan Stiene and Joachim Hertzberg
Automatic Construction of Polygonal Maps From Point Cloud Data

Abstract. This paper presents a novel approach to create polygonal maps from 3D point cloud data. The gained map is augmented with a interpretation of the scene. Our procedure shows to be fast and reliable and produces accurate maps in indoor environments. The created maps are used with different kinds of sensors for reliable self localization.

Qian Cheng, Tan YingZi, Shen Hui and Xu YingQiu
A Global Line Matching Algorithm for 2D Laser Scan Matching in Regular Environment

Abstract. Some line matching algorithms have been proposed for the laser scan matching problem. But lots of them do the matching between current scan frame and the last one, rather than current frame and the global map. This work proposes a real-time laser scan matching method named Global Line Matching, which matches between current scan frame and the global map, leading to a better result.

This paper presents the algorithm in detail and shows some applications to simultaneous localization and mapping (SLAM). Results on a simulated environment (USARSim) are demonstrated, showing that this algorithm is capable to map unmodified indoor environment reliably.

Jimmy Tran, Alexander Ferworn, Martin Gerdzhev and Devin Ostrom
Canine Assisted Robot Deployment for Urban Search and Rescue

Abstract. In Urban Search and Rescue (USAR) operations the search for survivors must occur before rescue operations can proceed. Two methods that can be used to search in rubble are trained search dogs and specialized response robots(sometimes called rescue robots). Rescue robots are used to collect information about trapped people within a disaster like a collapsed building. Information from them can help first responders plan and execute a rescue effort. The main challenge for these robots is the restrictions placed on their mobility by challenging rubble surfaces. While current research in this area attack this challenge through mechanical design, good solutions remain elusive. This paper presents a new method for dispensing response robots called Canine Assisted Robot Deployment (CARD). CARD's approach utilizes USAR dogs to deliver robots close to a trapped human detected by the dog. This method exploits the canine ability to find survivors using their olfactory sensors and agility. Once a dog carrying a small robot has found a casualty, the robot can be dropped and begin exploring. Initial experiments and results are described in this paper.

Yuki Iwano, Koichi Osuka and Hisanori Amano
Development of Rescue Support Stretcher System

Abstract. A sarin gas incident occurred in the Tokyo subway system on March 20, 1995. This fatal gas attack caused sicknesses to many passengers. Since the disaster broke out under the ground, the main job of rescue personnel was to transport victims on stretchers to a first-aid station on the ground.

So, we research and development the rescue support stretcher system (robot) for a heavy casualty disaster in underground areas or at stations can be handled in a quick, effective manner. The stretcher robot is expected to help firefighters achieve efficient rescue

operations. In this paper, we describe the produced stretcher robot. And, we evaluate that stretcher robot can transfer a victims by the experiment.

Haruo Maruyama and Kazuyuki Ito
Semi-autonomous snake-like robot for search and rescue

Abstract. Recently, applications of snake-like robots for search and rescue have attracted considerable attentions. However, they have a problem in operability, because many degrees of freedom of their bodies cause complexity of operation. In our previous works, we addressed this problem and developed a prototype snake-like robot that can be controlled easily by a user interface of usual automobile. In this paper, we improve our previous robot for searching in wide-range area like a whole building. To realize our goal, we consider 3 requirements which are Self-powered mechanism, High-mobility, and Semi-autonomy. To demonstrate effectiveness of our proposed mechanism, new snake-like robot is developed and experiments are conducted. As the results, we confirm that proposed robot realize the three requirements and has higher mobility than conventional robot.

Richard Voyles, Sam Povilus, Rahul Mangharam and Kang Li
RecoNode: A Reconfigurable Node for Heterogeneous Multi-Robot Search and Rescue

Abstract. Search and rescue robots can benefit from small size as it facilitates access to voids and movement in cramped quarters. Yet, small robots cannot be the entire answer for urban search and rescue because small size limits the size of actuators, sensor payloads, computational capacity and battery capacity. Nonetheless, we are attempting to alleviate these limitations by developing the hardware and software infrastructure for heterogeneous, wireless sensor/actuator/control networks that is well-suited to miniature search and rescue robots, as well as a host of other relevant applications. These networks of application specific sensors, actuators and intelligence will be assembled from a backbone that includes scalable computing, a flexible I/O bus, and multi-hop data networking. But two things will ultimately give our wireless infrastructure its novelty: a dual-baseband communications layer and the embedded virtual machine. The dual-baseband communications layer augments the standard data communication layer with a secondary, sub-millisecond synchronization layer to permit high-fidelity, deterministic, distributed control across the network. The determinism of this dualbaseband communications layer, in turn, enables the creation of the embedded virtual machine, which is a programming construct that abstracts away the physical sensor/actuator/control nodes. With this infrastructure, programming will not be done at the node level, as in conventional wireless sensor networks. Instead, programming will be done at the task level with portbased objects distributed across physical resources as necessary at either compile-time or run-time. At compile-time, the system can assist in the specification of the physical network, while at run-time the system can react to changes in configuration, such as nodes exhausting their batteries or losing connectivity. This paper describes progress to-date on developing this scalable infrastructure, specifically the RecoNode high-performance, dynamically-reconfigurable computational node for the Terminator Botcrawling robot and the FireFly mid-performance node, as well as their real-time software.

Hisayoshi Sugiyama, Tetsuo Tsujioka and Masashi Murata
Autonomous Chain Network Formation by Multi-Robot Rescue System with Ad Hoc Networking

Abstract. The autonomous chain network formation by multi-robot rescue system is investigated. Chain networks connecting a base station and rescue robots are essential to reconnoiter distant spaces in disaster areas. The chains must be formed to assure communications among them and must be transformed if the target of exploration changes. These formations must be executed by autonomous movements of robots from view points of reliability in rescue operations. As the basis of their movements, we adopt autonomous classification of robots into search robots and relay robots. They act according to the

behavior algorithms of each class of robot to form chain network threading the path to the distant spaces. The rule of the classification and the behavior algorithm refer forwarding table of each robot constructed for ad hoc networking. The results of simulations show that chain networks are formed and transformed by rescue robots appropriately for their reconnaissance to distant spaces even though three spaces exist beyond different corridors stemming from the safety zone where base station is established.

Hai Dan, Zhang Hui, Xiao Junhao and Zheng Zhiqiang

Cooperate Localization of a Wireless Sensor Network (WSN) Aided by a Mobile Robot

Abstract. Localization is an essential problem for application of Wireless Sensor Network (WSN). We introduce a mobile robot to localize the sensor nodes in cooperative way. Specifically, we consider sensors would provide range measurements between themselves. The localization strategy was set to be a mixed form of centralized and distributed manner considering the character of robot and WSN. The algorithm can efficiently fuse multiple measurements of the system to form conservative covariance estimates and avoid over-confident problem properly. The algorithm was described in a Bayes framework and proved to be efficient in simulation result.