Security Rescue Robots

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Abstract

Supporting human rescue teams in disaster scenarios with robots is a current research topic [1], [5]. This work deals with the subtopic of finding victims in such a scenario. A multi robotics approach is used in this work where small robots assist human rescue teams to find victims in a disaster area. We focused on the task of detecting humans for that we build a distributed classification via heterogenious sensor systems on multi robot systems.
The robot system BeBot [3], developed at Heinz-Nixdorf-Institute at Paderborn, served as basis for this task. To realize an intra and inter communication between the BeBots the middleware RSB [9] (Robotic-Service-Bus developed at CorLab Uni-Bielefeld) was introduced. Each robot can host different sensor systems like a microphone, camera or infrared sensor. Thus, every robot became an expert for one special sensor and use that sensor to classify objects. In regards to a distributed multi sensor system the results of each expert were combined on a remote BeBot.

Introduction

In a disaster area one main task of rescue teams is to recover and safe victims. This is a dangerous task due to the fact that rescue teams often have to deal with hazardous and unknown situations.

In this application area, robots can be used to support them. One challenge they could adopt is determining the position of victims. For this task the robot must be able to classify a human.
The advantages of using robots in rescue scenarios are threefold [5]. First, the robots could explore new areas and search for further victims while the rescuers safe current known victims. Second, robots are superior to humans in hazardous and long term situations. Finally, a robot is less valuable than a human and can be replaced more easily.

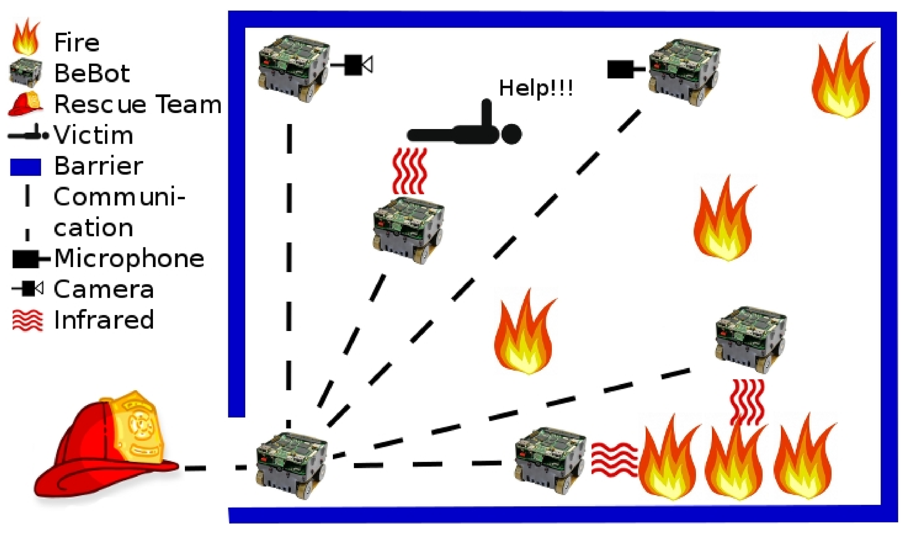

Figure 1: Schematic scene of a multi robot approach in rescue scenarios.

The multi robotic approach aims at the replacement of complex single solutions, like the GETBot [7], developed at the University of Paderborn, to reach a higher overall system robustness. This work focussed on the sub-task of classifiying humans in rescue scenarios by a distributed, heterogenious sensor system.

Main Objectives

1. Communication interface for intra and inter robot communication realized via RSB
2. Software for classifying via *Microphone-*, *Camera-* and *Infrared-Expert*
3. Fusion of all classified sensor data via *Fusion-Expert*

Materials, Methods and Architecture

To accomplish the goal of classifying a human or other valuable objects via a distributed multi sensor system with multiple small robots the project was devided into mutual exclusive tasks: The implementation of each single sensor expert, the use of a middleware and the design and implementation of the sensor fusion.

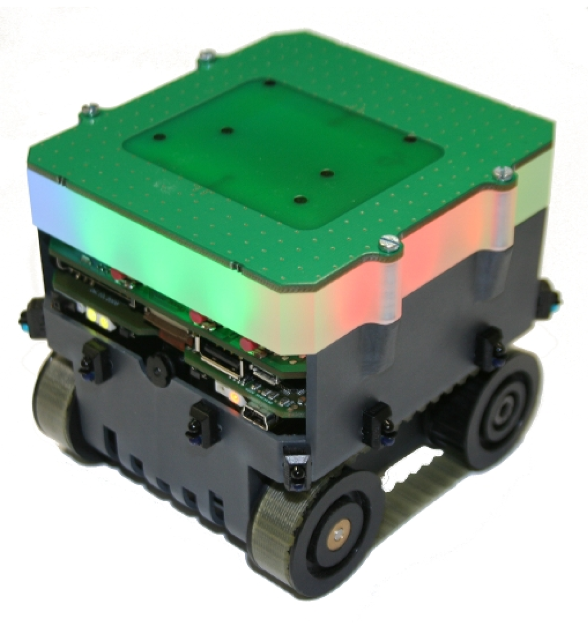

Figure 2: Front view of a BeBot.

For a classification, each sensor type uses different Methods:

- *Camera-Expert:* This expert uses *OpenCV* for the image processing. In the background, there is a database with example images of classifiable scopes.
- *Infrared-Expert:* The idea was to measure the intensity of incoming infrared light and classify them with respect to their intensity. The expert is trained supervised to build up probability densities for different classes.
- *Microphone-Expert:* To detect the presence of humans by their voice the common spectrum in voice signals was considered.

To get a modular project structure and inter program communication, each BeBot (figure 2) has its own local RSB socket transport communication between the programs for the sensor input and the classification. In order to put all results together in a sensor fusion RSB socket transport was used for inter robot communication.

This separates the hardware restricted tasks, like getting the data from a robots sensor or the motor control, from the task of estimation or classification, shown in figure 3. This makes it much easier and faster to transfer the project to develope, maintain and transfer of the project to new hardware.

Furthermore, there is a global RSB socket transport communication which is used by the BeBots sent their classification results to the sensor fusion. This allows heterogenious robot systems working together which leads to great flexibility.

The sensor fusion combines the classification values of all sensor experts and gives an assumption. It gets input from the experts about three different classes, which are *Human*, *Fire* and *Unknown*. The experts send a classification result for each class which is then fused to a final result by the *Fusion-Expert*. Thus, if one expert gives a bad classification, this can be invalidated and balanced out by good classifications by the other experts.

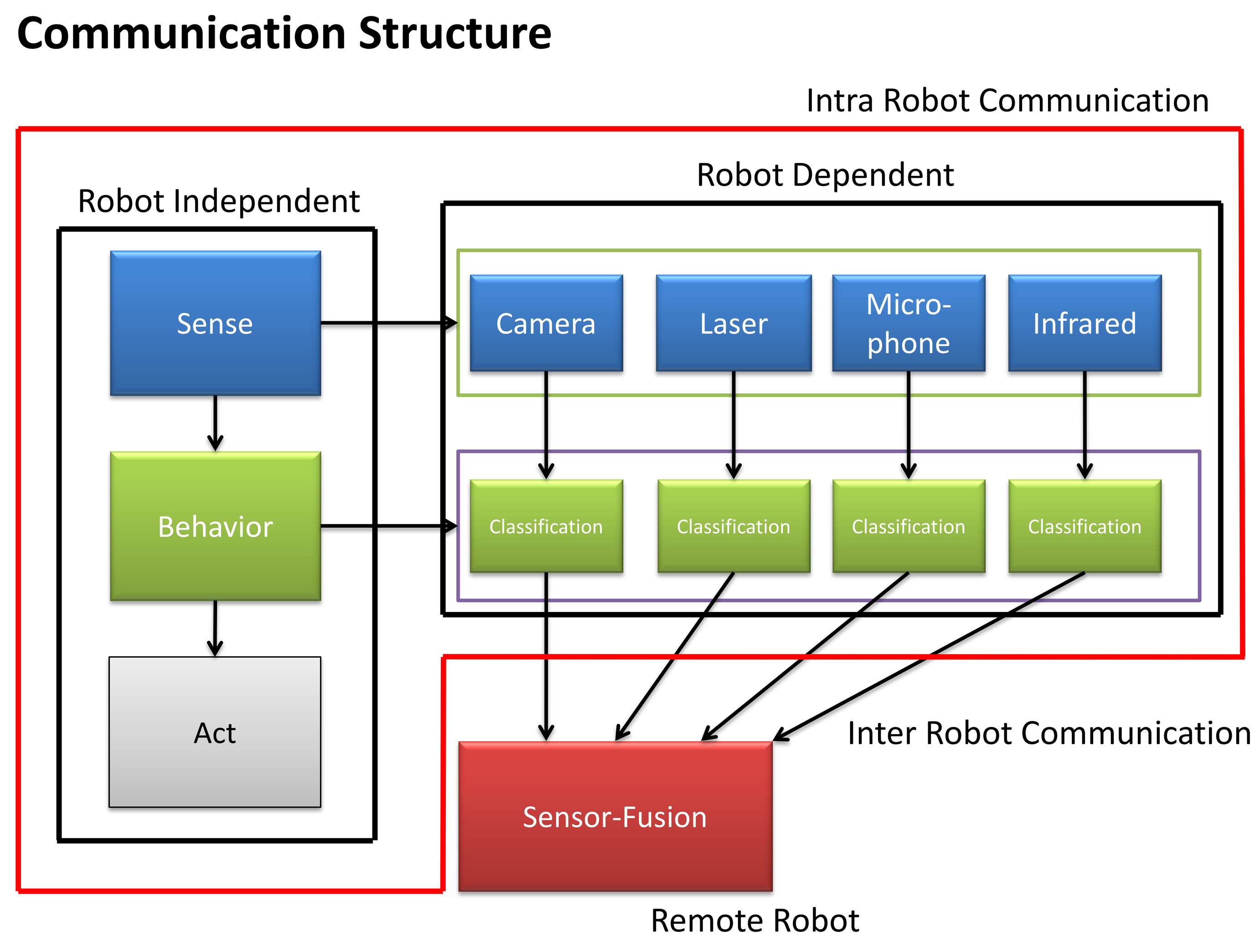

Figure 3: Overview of the communication structure

Results and Current State

At the current stage the *Camera-*, *Infrared-*, *Microphone-* and *Fusion-Expert* are largely implemented and give some first results in classifying their input between *Humans*, *Fire* and *Unknown*.

- *Camera-Expert:* Is currently able to classify human faces. For a classification of other objects, the database has to be extended by example images of this objects. The classification is currently done with *Local Binary Patterns Histograms* from *OpenCV*.
- *Infrared-Expert:* Is able to train its classifier on training data. Currently, it can just classify between different light sources. At this stage, a human can not be classified due to the problem of the restricted spectrum of the infrared sensor itself.
- *Microphone-Expert:* Is able to classify a human voice. First, the short-time fast Fourier transformation is computed to get the power spectral density (PSD). The PSD is then used to calculate the power of the bandwith where human voice is commonly present and the overall power of the sound signal. The ratio of these values is used as feature.
- *Fusion-Expert:* The results are sent via the global RSB socket transport using WLAN to another BeBot, which is an expert for sensor fusion. Currently, this is done by a MAP-classifier [4] with the input of the sensor experts to distinguish between the three scopes *Human*, *Fire* and *Unknown*.

Further Work

In the next stage one option is to extend the Sensor-Experts by a *Laser-Expert* to gather more information about the shape of an object. Additionally building up an thermometer is an option to focus on, due to the result that recognizing heat with the infrared sensors of the BeBot did not worked very well.

Furthermore, the sensor fusion can be substituted by different machine learning algorithms. For example self organized maps or a perceptron can be used to fuse the input data from the sensor experts. In a second step, an evaluation and comparison between these algorithms and their efficiency can be applied.

Another approach is to use the TeleWorkBench [8], a camera based system in the laboratory that provides information about the position of the robots. This can be used to work with navigation and positioning of the BeBots in a test scenario. Finally, there is the chance to use the new robot AMiRo [2] in this project.

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