Extended Abstract on Mobile Robotics

Constantin Schieber, 1228774, Technische Universitaet Wien

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1 Introduction and problem statement

Detecting and tracking people on a mobile robotic platform with real time requirements and hardware constraints is an upcoming issue. Knowing the positions of people over time is important for many applications that focus on human - robot interaction, e.g. autonomously following a person.

The following work summarizes five papers on this topic to introduce the available hardware / algorithms and its utilization for people tracking.

2 Short summary of the Papers to Investigate

OpenPTrack
The first paper [1] introduces OpenPTrack. OpenPTrack is a framework built with the Robotic Operating System (ROS) and enables the user to utilize and calibrate a network of multiple RGB-D cameras. Detection of people happens in a distributed fashion while the tracking is done in a single node that processes all detection from the network.
The relative position of the cameras to each other can be easily calibrated using a checkerboard and real-time visual feedback from the ROS application.
Real-time tracking perfomance of groups is achieved under most light conditions due to the usage of different sensor readings (depth, infrared, color).

Person Tracking and Following with 2D Laser Scanners
In this paper [2] an approach that utilizes depth sensors - such as laser or RGB-D - for sensing its surroundings is introduced. The implementation is provided as open source ROS package which can be used with any depth sensing based hardware on a height of 30cm. A retraining of the human-confidence learning algorithm may be necessary when different sensor resolutions are used.

Detection and tracking works with moving and non-moving persons in cluttered environments. It is independent of light conditions, works in close proximity to the tracked person and does not need an *a priori* occupancy grid map of the surroundings. Depending on the used laser noise from the sun can be a problem. A joint leg tracker is used instead of tracking individual legs.

Thermal vision based approach
This work [3] uses thermal vision and ultrasonic sensors. It uses the distinct thermal profile of people to detect and track them. This is independent of light conditions. Acquiring the position of a human in an thermal image is realized by segmenting the image in Regions Of Interests (ROIs). Data of the

thermal sensor represents differences in the thermal energy of objects in an environment. Thresholding this data then allows to extract segments of interest. As most thermal image segmentation algorithms fail to provide real time performance a new algorithm is introduced.
Utilizing fuzzy membership functions that determine how strongly a RGB color belongs to the fore- or background it is possible to have a fast and reliable segmentation algorithm. Applying such fuzzy logic on RGB color instead of greyscale images provides much better results. A disadvantage is that this method won't yield good results in situations where more precise tracking is required, e.g. for body joints.
A neuro-fuzzy classifier then determines if a segment is human or not.
This approach provides fast and reliable tracking of one person. It is able to detect and track multiple persons but - depending on the interactions between these people - loses track easily.

Ultrasonic Sensor based approach
The authors of this paper [4] propose an ultrasonic/RF sensor based approach for single person tracking scenarios. This system works well under any light conditions and provides good performance in scenarios with terrain variations. ROS nodes are used for measurement and control tasks. A drawback is that the tracked person needs to carry an active sonar emitter.
The sensor array on the robot is passive. A RF signal is sent to the robot, indicating the start of emitting ultrasonic pressure waves from the tracked person. The robot then measures the time of flight (ToF) and calculates the position of the person from this data. Due to high noise, non-linear behavior and the constant delay of the RF transmission triangulation based on this data is not sufficient for people tracking. A Gaussian Process Regression (GPR) model of the sensors is the novel approach of the authors to overcome this problem. This system is then trained in a controlled setup to determine the likelihood of measuring a given sonar signal at a certain location. A MATLAB-ROS Bridge is used for this training. Experiments show that this work is improving person tracking with ultrasonic/RF sensors in a significant way, making it usable for systematic person tracking in a outdoor setting with varying terrain.

Human robot spatial interaction
With the advance of robust people tracking implementations another aspect is becoming more important: Socially acceptable behavior of robot movement. That means to not only treat humans as dynamic obstacles but to navigate around them in a "natural" way.
This paper [5] attempts to model such interactions and provides a processing pipeline implemented with ROS. It uses a combination of upper body and leg detection. Tracking and predicting movement of people is achieved with a probabilistic real-time tracking framework. Qualitative Spatial Relations (QSR) are derived from the movement of tracked persons. This is done with Qualitative Trajectory Calculus (QTC). QTC state chains can be created and classified using a Hidden Markovchain Model (HMM) that was set up in advance. For a distinct behavior a distinct HMM is trained.
It is shown that various QTC-based scenarios (e.g. overtaking, pass by) are significantly different from each other.

References

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