Landmark detection by a rotary laser scanner for autonomous robot navigation in sewer pipes

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Extended Abstract

Introduction: Recent research in service robotics has focused on the development of autonomous sewer inspection robots [8, 5, 2] and automatic fault detection systems [7, 1]. Hertzberg et.al.[3] give an introduction into conventional inspection procedures. A successful approach to application of innovative sensors to multisensor fusion in order to detect artefacts in sewer pipes can be found in [6]. We consider landmark detection for navigation purposes as an important component of introduction of autonomous robotic systems for sewer pipe inspection.

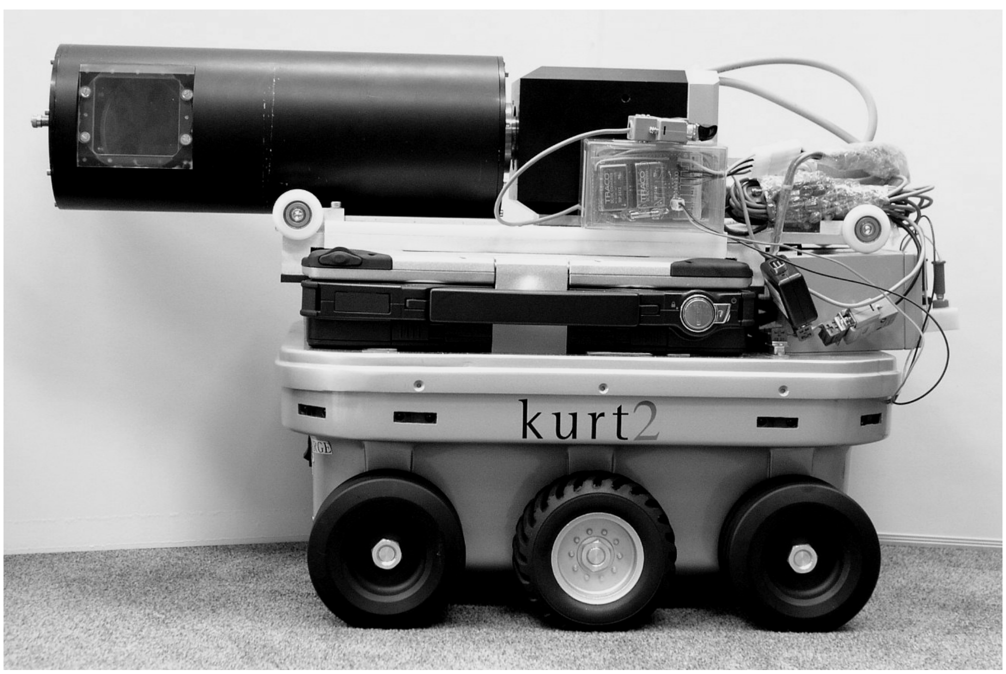
In this paper, we present unsupervised neural network based analysis for real time landmark detection on a mobile robot mounted rotary laser scanner. As opposed to other common sensors used in robot navigation e.g. infrared and ultrasound sensors, the rotary laser scanner combines several positive aspects: it is insensitive to common artefacts in data aquisition, optical shades and hues, and redundant signals due to reflection and limited range. Furthermore, the data can be used for multiple purposes: identification of artefacts in the pipe, damage identification, and deformation identification.

System hardware: The system is shown in Fig.[1]. It is based on the german Kurt2 autonomous robotic platform, [4]. which was developed by the Fraunhofer Institut Autonomous intelligent Systems, Germany, as a first study for autonomous sewer inspection platforms. The control unit is a Pentium III 600mhz processor, running under the linux operating system, which contains the navigation, data retrieval and processing software. Main sensor for the data retrieval task is a commercially available rotary laser scanner. All on board-sensors, motors of the robot, laser scanner and control unit are connected with via a CAN bus system.

Data analysis: In a learning phase, reference data is acquired in an test environment. The test environment consists of 5 environmental states: T-type intersection, manhole from top, inlet from top, inlet from side, normal pipe section. The goal of analysis is to process the approximately 600 laser samples, categorizing with regard to the presence of different environmental features. We take an unsupervised dimensionality reduction approach (such as e.g. [9]), applying firstly principle components analysis (PCA) to reduce the dimensionality, collapsing the signals onto the 10 largest axes of variance. Secondly, a clustering neural network using a 5 neuron competitive layer and a 'winner takes all' learning algorithm is used to discretize the 10-D space into local regions. The final system is implemented online efficiently as projection on a set of orthogonal basis vectors, followed by quantization with regard to the cluster centers.

Results: The cluster centers were found to correspond almost exactly to the environmental states; yielding a correct classification rate of 97%. As expected, errors in classification coincided when the robot was transitioning from one environmental state to the next. The results demonstrate that appropriate sensor hardware, combined with appropriate data-driven processing routines, results in effective real-time landmark detection in a realistic industrial setting.

Figure 1: Kurt2 with mounted Optimess laser scanner



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