MARTIN MAGNUSSON has been a graduate student at the Centre for Applied Autonomous Sensor Systems, Örebro University. His research interests include three-dimensional sensing and scan registration, localisation and mapping for mobile robots, and semantic analysis of three-dimensional scenes.

Three-dimensional records are important tools in several quite diverse disciplines, such as medical imaging, archaeology, and mobile robotics. In mobile robotics, three-dimensional scanning of the environment is useful for several subtasks, such as mapping, localisation, and extraction of semantic information from the robot's environment.

Three-dimensional models can be represented in a number of ways. The central theme of this dissertation is one such representation: the normal-distributions transform, or NDT. The normal-distributions transform provides an attractive representation of range-scan data, with applications in many tasks where three-dimensional scan data are used.

When performing three-dimensional imaging, it is often the case that the whole area of interest cannot be captured in a single scan. Therefore it is typically necessary to perform scan registration—fitting the pieces together—in order to produce a complete model. Scan registration is also useful for localisation in mobile robot applications. After registration, the precise position and orientation at which each scan was made are known, making it possible to recover the robot's trajectory. Using the NDT representation of the scan data, it is possible to use standard methods from the numerical-optimisation literature to perform scan registration, which is shown to quickly produce accurate results, compared to common registration algorithms.

Even when using accurate scan-registration techniques for mobile-robot localisation, errors will accumulate over distance. Once the robot closes a loop and returns to a previously visited location, however, it is possible to correct the estimate of its position. The problem is how to reliably detect loop closure. It may be necessary to detect loop closure only using the appearance of scans, which means to recognise a place just by comparing its appearance to that of previous scans. While it is relatively easy for a human observer to recognise two scans acquired at the same place, it is not at all trivial to do so automatically with a computer. This dissertation proposes a very fast NDT-based loop-detection method that is discriminative enough to successfully detect a large part of scans that have been acquired at the same place with a very low number of false detections.

In order to enable more high-level tasks, it is desirable to extract semantic information from the available models. Having a truthful model is one thing, but being able to automatically segment the model into meaningful components and "understand" what they represent will be necessary to further increase autonomy. This dissertation presents a method, also inspired by the NDT surface representation, that provides semantic surface information that can be used in a variety of applications, including mobile robots in unstructured terrain as well as mining and construction applications.

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