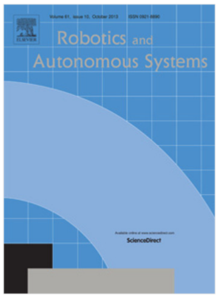
Accepted Manuscript



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PII: S0921-8890(17)30700-5
DOI: https://doi.org/10.1016/j.robot.2018.07.003
Reference: ROBOT 3057

To appear in: *Robotics and Autonomous Systems*

Received date : 5 October 2017
Revised date : 7 June 2018
Accepted date : 14 July 2018

CICP: Cluster Iterative Closest Point for Sparse-Dense Point Cloud Registration

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Abstract

Point cloud registration is an important and fundamental building block of mobile robotics. It forms an integral part of the processes of mapping, localization, object detection and recognition, loop closure and many other applications. Throughout the years, registration has been addressed in different ways, based on local features, global descriptor or object-based. However, all these techniques give meaningful results only if the input data are of the same type and density (resolution). Recently, with the technological revolution of 3D sensors, accurate ones producing dense clouds have appeared as well as others faster, more compatible with real-time applications, producing sparse clouds. Accuracy and speed are two sought-after concepts in every robotic application including those cited above, which involves the simultaneous use of both types of sensors, resulting in sparse-dense (or dense-sparse) point cloud registration. The difficulty of sparse to dense registration lies in the fact that there is no direct correspondence between each point in the two clouds, but rather a point equivalent to a set of points. In this paper, a novel approach that surpasses the notion of density is proposed. Its main idea consists in matching points representing each local surface of source cloud with the points representing the corresponding local surfaces in the target cloud. Experiments and comparisons with state-of-the-art methods show that our approach gives better performance. It handles registration of point clouds of different densities acquired by the same sensor with varied resolution or taken from different sensors.

Keywords: sparse to dense (dense to sparse) registration, density change, cluster, points selection, matching, ICP.

1. Introduction

The problem of dense-sparse registration has received less attention from the scientific community in the past [1]. The majority of research has been focused on dense registration [2, 3], or sparse registration [4, 5, 6, 7]. Recently, the need for sparse to dense registration has come to the limelight, and this is due to the emergence of sensors that produce sparse data like Velodyne [1] LiDAR (Light Detection And Ranging), which is widely used in autonomous vehicles (Google car [8], DARPA Grand Challenge [9]), because of its ability to provide 3D data at a high refresh rate and at a long range [7]. Accurate sensors producing dense clouds also achieved a technological leap with the appearance of 3D laser sensors like Leica P20[2], Riegl VZ400i[3] or Trimble TX8[4], etc. Furthermore, multiple sensors that allow the change of scanning resolution have recently appeared on the market. These sensors can produce point clouds of different densities depending on the chosen resolution. Nevertheless, the difference in cloud density is generally due to the change of the sensor. For example, two different sensors generate two clouds with different point densities, which requires a calibration step between the two sensors in order to exploit the resulting clouds. Calibration is necessary whenever the two sensors are moved, which is a hard and tedious task. On the other hand, the main shortcomings of available point cloud registration methods are their lack of speed due to the increase of input data or their lack of precision due to the decrease in density [7] whereas, for most robotic applications such as localization, these two attributes are highly desired. A recent trend is to use both kinds of sensors [10, 11, 12] to achieve these two sought-after concepts simultaneously, highlighting the importance of dense to sparse registration techniques.

As with all registration methods, an overlapping between the two clouds, usually called source cloud and target cloud, is necessary to determine the rigid transformation between these two clouds perceived from different viewpoints. With the conventional methods that use coherent data from the same sensor, what changes are the representation of points pertaining to the two views. For sensors that also provide intensity or color, these two attributes can be changed if the two clouds are acquired at two different times. Otherwise, except for the noise, nothing else

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[1]Velodyne LiDAR: http://velodynelidar.com/
[2]Leica P20: http://leica-geosystems.com/
[3]Riegl VZ400i: http://www.riegl.com/nc/products/terrestrial-scanning/produktdetail/product/scanner/48/
[4]Trimble TX8: http://www.trimble.com/3d-laser-scanning/tx8.aspx