Comments on :

"A Review of Point Cloud Registration Algorithms for Mobile Robotics"

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Abstract

The scope of this work is to present registration algorithms and their use in mobile robotics.

I. Introduction

Registration algorithms associate sets of data into a common coordinate system by minimizing the alignment error.

PB : Unless two identical shapes are registered together, outliers that are not present in both shapes need to be iden- tified.

primitives derived from points are too sensitive to noise and are not stable in moving systems with current (1994) sens- ing capabilities. => points were more reliable

need to handle dynamic elements.

difficulty to find a single versatile ICP version.

The aim of geometric registration is to be able to represent a shape, called reading, in the same coordinate frame as another, called reference. This is equivalent to finding the transformation of reading that best aligns it to reference.

Algorithm 1 Summary of ICP algorithm.

Require: ${}^{\mathbb{A}}\mathcal{P}$ ▷ `reading`
Require: ${}^{\mathbb{B}}\mathcal{Q}$ ▷ `reference`
Require: $\mathcal{T}_{init}$ ▷ initial transformation
  ${}^{\mathbb{A}}\mathcal{P}' \leftarrow \text{datafilter}({}^{\mathbb{A}}\mathcal{P})$ ▷ data filters
  ${}^{\mathbb{B}}\mathcal{Q}' \leftarrow \text{datafilter}({}^{\mathbb{B}}\mathcal{Q})$ ▷ data filters
  ${}^{i-1}_{v}\mathcal{T} \leftarrow \mathcal{T}_{init}$
  repeat
    ${}^{i}\mathcal{P}' \leftarrow {}^{i-1}_{i}\mathcal{T}({}^{i-1}\mathcal{P}')$ ▷ move `reading`
    $\mathcal{M}_i \leftarrow \text{match}({}^{i}\mathcal{P}', \mathcal{Q}')$ ▷ associate points
    $\mathcal{W}_i \leftarrow \text{outlier}(\mathcal{M}_i)$ ▷ filter outliers
    ${}^{i+1}_{i}\mathcal{T} \leftarrow \arg\min_{\mathcal{T}} \left(\text{error}\left(\mathcal{T}\left({}^{i}\mathcal{P}'\right), \mathcal{Q}'\right)\right)$
  until convergence
Ensure: ${}^{\mathbb{B}}_{\mathbb{A}}\hat{\mathcal{T}} = \left(\bigcirc_{i} {}^{i-1}_{i}\mathcal{T}\right) \circ \mathcal{T}_{init}$

Figure 1: *ICP algorithm*

*A thank you or further information

i. sensors

laser rangefinders (lidars)

cameras

Light field capture simultaneously multiple focus points and reconstruct images with different depth of fields out of the recorded data.

ii. transformations

Rigid transformation is a combination of translation and rotation. It is also known as a Euclidean transformation.

Similarity transform is a combination of rigid transformation and uniform scaling.

Affine transform is a combination of rigid transformation, nonuni- form scaling and shear.

Orthogonal projection is a group of transformation based on vector and planar projection.

The initial transformation is a sensitive part of registration al- gorithms when the data association is realized mainly based on geo- metric features.

iii. feature enhancement

most of the shapes encountered in the a real environ- ment are too complex to be completely synthesized with parameters

fives types of primitives :

- point,
- line,
- plane,
- curve and
- quadric

The ratio of noise to signal is often higher in robotics than in object modeling, thus rendering many complex mod- eling algorithms ineffective. This could explain why most registration algorithms applied to robotics tend to select a shape representation very close to the raw measurements (i.e., points) instead of relying on faulty surface reconstruction.

iv. Descriptor enhancement

using the intensity remission combined with cameras to add color information techniques are used to reduce the number of features: random sampling, grid projection, octree and bounding box.

v. data association

In laser rangefinder based matching, feature positions are quite accurate compared to descrip- tor uniqueness but the initial transformation needs to be within a maximum range to avoid local minima

When using descriptors, the matching becomes independent of the initial position, but may fail for repetitive elements

kD-tree is better in terms of accuracy, query time, build time, and memory usage

Outlier filter

outlier filters are used to reduce the impact of erroneous matches

Rejection based on features, a threshold on euclidian distance is used

Weighting weighting functions can consist of the ratio of mean distance over each paired distances and eventually multiplying by a reflectance value

vi. Error Minimization

shape morphing

Several ways to perform data association the naive one is to do point-to-point. When a primitive with higher dimensionality is matched with a lower one, it is morphed via projective geometry to adapt to its coun- terpart

optimization

- Singular Value Decomposition (SVD) [2]
- quaternions [3]
- orthonormal matrices [4]
- dual quaternions [5]

point-to-plane : linearization based on small angle approximation [6]

objective functions for point cloud alignment rely on histogram correlation [7], tensor voting [8], or Hough transform [9]

II. Use cases

i. search and rescue

the use of 3d maps is usefull for planning human intervention. Onboard localisation is essential to return the platform toa location were wireless communication can be reestablished. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

III. Results

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IV. Discussion

i. Current state

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ii. Possibles enhancements

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