# Simplification of objects for faster registration

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## Abstract

In this paper, we investigate the impact of an object simplification approach in registration using the Iterative Closest Point (ICP) algorithm. Though the simplification of the objects remarkably reduces the registration time, it also raises a critical issue, whether the simplified version of the object carries sufficient information to recover the proper geometric parameters of registration. Accordingly, we investigate both simulated and real data to test the geometric degradation caused by the simplification. As for computational times, we monitor how much time we can save during the ICP registration using simpler objects. Moreover, we check the times taken by the simplification process itself to see whether simplification can be considered online, as well.

## Introduction

Registration is a fundamental task in image processing to find the geometric relationship between image and/or geometric data. It has many possible applications in the fields of computer vision, remote sensing and medical image analysis [2, 7]. In the latter field the usual registration scenario is to match an image against another one, where the two images have been acquired using the same or different medical modalities (e.g. CT, PET, MRI, SPECT). Since the patient cannot be positioned exactly the same way at two occasions, the investigated geometry undergoes such simple geometric transformations as rotation and translation. The main task of the registration algorithm is to capture the parameters of these unknown geometric transformations.

From the original 3D medical data an interesting subset of voxels (volume elements) is extracted for registration purposes. Some registration methods consider the selection to be manual while others automatic. Especially in the latter case, the extracted data set may consist of a huge number of voxels. Naturally, the computational times of the registration algorithms highly depend on the number of object voxels. Thus, the simplification of the sets is a common approach, e.g. through reducing the resolution [6]. In this paper, we suggest a simplification approach, which is based on the Centroidal Voronoi Tessellation (CVT) framework [3, 4, 5]. It does not change the resolution, but performs a direct simplification of the objects instead. We present our first experimental results regarding the application of this method for speeding up registration. We also explain how we can take advantage of other properties of our approach. These are the applicability for data of arbitrary dimensions, the simplification of both surface and solid objects and the possibility of non-uniform simplification.

The aim of the paper is the investigation of this simplification step and the corresponding computational gain we can achieve in registration. The selection of the suitable registration algorithm is out of the scope of this study. To perform as objective tests as possible, we considered the Iterative Closest Point (ICP) algorithm [1, 8] as one of the most well-known registration methods; validated implementations of this algorithm can be found easily.

## Results and conclusion

To briefly summarize, we investigated the effect of object simplification in registration. We considered CVT based simplification approaches and the standard ICP registration method. The main focus of our experiments were to check how the level of the simplification affected the geometric accuracy of the ICP registration. We checked the substitution efficiency of our simplification approach in both simulated and real cases regarding different levels of geometric distortion. The outcome of this analysis was that the simplified versions represented the original objects well, down to a certain level of simplification.

Besides the geometric degradation caused by the simplification, another crucial issue is the computational performance we can gain using simplified objects. Since the acquisition of the sets to be registered takes place at different times, we can perform the simplification of the first test data in an offline way. Consequently, in this case we simply check the speed up within ICP using simplified objects. However, we may also investigate the following online problem: is it possible to apply simplification in an online way to the second data set, as well? This approach is reasonable, if we are able to perform the simplification very fast regarding the computational gain within ICP. We found that the time required by the ICP registration linearly droped with the level of simplification, and simplification seems to be a valid approach for online registration, as well.

# References


[1] P. Besl and N. McKay. A method for registration of 3d shapes. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 14:239–256, 1992.

[2] L. Brown. A survey of image registration techniques. *ACM Computing Surveys*, 24(4):325–376, 1992.

[3] Q. Du, V. Faber, and M. Gunzburger. Centroidal voronoi tessellations: Applications and algorithms. *SIAM Review*, 41:637–676, 1999.

[4] Q. Du, M. Gunzburger, and L. Ju. Constrained centroidal voronoi tessellations on general surfaces. *SIAM J. Scientific Comp.*, 24:1488–1506, 2003.

[5] A. Hajdu and I. Pitas. Optimal approach for fast object-template matching. *IEEE Trans. on Image Processing*, 16(8):2048–2057, 2007.

[6] T. Jost and H. Hugli. A multi-resolution scheme icp algorithm for fast shape registration. *3D Data Processing Visualization and Transmission, pp.*, pages 540–543, 2002.

[7] J. Maintz and M. Viergever. A survey of medical image registration. *Medical Image Analysis*, 2(1):1–36, 1998.

[8] Z. Zhang. Iterative point matching for registration of free-form curves and surfaces. *International Journal of Computer Vision*, 13(2):119–152, 1994.