

Chapter 8

Conclusion

An approach was developed for the automatic construction of computer models of 3D solid objects from a single range image. This approach was obtained through bottom-up processing methods that take a single range image as input and yield a computer model of the polyhedral objects as output. The developed approach was composed of several algorithms: edge detection, segmentation, initial vertex extraction, occlusion detection, faces grouping into objects, and object representation.

In the edge detection algorithm, noise reduction for range images was treated first. by implementing a robust technique based on the least-median-square method. The noise reduction algorithm was proven successful when tested by introducing different types of noise, additive impulsive salt and pepper, additive Gaussian, and multiplicative speckle noise, through the evaluation of the gain of the signal to noise ratios (SNR). Three approaches for edge detection were presented, one being a novel approach, implemented because of its superior performance, and the other two being extensions of work by other researchers. In general, the performance of these edge detection methods in handling noise was considerably better than many others in the domain of range image segmentation.

A robust solution for object extraction from a single range image was achieved by a hybrid segmentation approach. A quantitative evaluation of the construction algorithms was considered by comparing the results of the proposed segmentation technique and the ground truth database for these range images. In addition, a quantitative comparison between the segmentation results with the work of [43] was performed and better results has been obtained.

A novel approach to find the vertices of the polyhedral objects was presented. The 3D vertex locations for the objects were obtained through an analysis of two-dimensional (2D) region shape and corner proximity. The performance of this approach of corner isolation was tested and compared to the performance of the angle detection algorithm. The

performance criteria were false alarm, missed detection, and correct detection rates. The proposed algorithm provided better results in terms of correct detection rates and omitting false alarm.

Occlusion detection for the 3D overlapped objects is considered the main contribution of this work. Two novel approaches to solving the occlusion problem were presented. The first approach utilized the correspondence between the different modes in a histogram of the distance values from a given range image and the layers in a single range image to isolate occluded objects. Ideally, each mode of the histogram was associated with one or more surfaces having approximately the same distance from the sensor. However, because of thermal noise and other phenomena, a typical histogram exhibited many local extrema. The approach introduced a non-parametric estimation technique that can be used to smooth the histogram, thereby exhibiting improved performance in the presence of noise. Specifically, second order polynomials with adaptive window length were fit to the histogram using the robust estimators, L_1 -norm and Huber, and the conventional least squares. This approach had difficulty when two or more objects were overlapped and lying the same distance from the sensor.

To address the problem of equidistant overlapping, a second approach was developed based on detecting occlusion that may be present between each pair of adjacent faces associated with the initial vertices of the 3D object. The approach utilized the topology and geometrical information of the 3D objects via multiple evidence-based system. To evaluate this approach, the performance of the rules was tested in terms of false alarm, and missed and correct detection rates of occlusion. Also the performance of the combining methods, weighted average, voting, and certainty factor (MYCIN) for the measures of belief were evaluated. While these methods provided good results in terms of correct detection rate, the certainty factor method produced a high false alarm rate.

After occlusion detection, faces were grouped into objects according to the adjacent relations and the absence of occlusion between them. The initial vertex estimates were improved significantly through a global optimization procedure. Finally, the model of the

3D objects was represented using the boundary representation technique, which utilizes the region adjacency graph (RAG) paradigm.

Another researcher can reproduce the results of this work where all details of the data (Perceptron real range images), extraction and representation algorithms, and the parameters and thresholds values that are used are available in this dissertation.

One recommendation for future work is to extend this system to involve objects with curved surfaces. Preliminary results on curved surfaces seem promising for this extension. With some modifications to the multiple evidence-based approach of occlusion detection, the curved objects could be addressed. In addition, the model construction could include representation of the hidden surfaces for the 3D objects. This could be achieved by using multiple views for the same scene or through assumptions, which include but are not limited to: one plane can close the volume and the symmetry of the hidden part to the visible part of the objects.