NEW METHODS FOR SURFACE RECONSTRUCTION FROM RANGE IMAGES

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I certify that I have read this dissertation and that in my opinion it is fully adequate, in scope and in quality, as a dissertation for the degree of Doctor of Philosophy.

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To Jelena

Abstract

The digitization and reconstruction of 3D shapes has numerous applications in areas that include manufacturing, virtual simulation, science, medicine, and consumer marketing. In this thesis, we address the problem of acquiring accurate range data through optical triangulation, and we present a method for reconstructing surfaces from sets of data known as range images.

The standard methods for extracting range data from optical triangulation scanners are accurate only for planar objects of uniform reflectance. Using these methods, curved surfaces, discontinuous surfaces, and surfaces of varying reflectance cause systematic distortions of the range data. We present a new ranging method based on analysis of the time evolution of the structured light reflections. Using this spacetime analysis, we can correct for each of these artifacts, thereby attaining significantly higher accuracy using existing technology. When using coherent illumination such as lasers, however, we show that laser speckle places a fundamental limit on accuracy for both traditional and spacetime triangulation.

The range data acquired by 3D digitizers such as optical triangulation scanners commonly consists of depths sampled on a regular grid, a sample set known as a range image. A number of techniques have been developed for reconstructing surfaces by integrating groups of aligned range images. A desirable set of properties for such algorithms includes: incremental updating, representation of directional uncertainty, the ability to fill gaps in the reconstruction, and robustness in the presence of outliers and distortions. Prior algorithms possess subsets of these properties. In this thesis, we present an efficient volumetric method for merging range images that possesses all of these properties. Using this method, we are able to merge a large number of range images (as many as 70) yielding seamless, high-detail models of up to 2.6 million triangles.

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Contents

List of Tables

List of Figures