Preface

In recent years, superquadrics established themselves as a popular model for representation of objects and 3D scenes in computer vision, computer graphics, and robotics. Superquadrics are a family of parametric models that cover a wide variety of smoothly changing 3D shapes which are controlled with a small number of parameters. For greater versatility the superquadric shapes can be augmented with global and local deformations. Superellipsoids, a subset of superquadrics, are volumetric models particularly suited for part-level modeling of 3D scenes which directly supports reasoning and manipulation. Especially, interpretation of range images in computer vision has been influenced by various methods for recovery of superquadric models from image data.

Readers of this book can expect to find a thorough evolution and definition of superquadric models, as well as derivations of their various geometric properties. Advantages and disadvantages of superquadrics in comparison to other volumetric models used in computer vision are addressed. Applications of superquadrics in computer vision and robotics are thoroughly discussed and in particular, the use of superquadrics for range image registration is demonstrated.

The central theme of the whole book is our method of recovery and segmentation of superquadrics from range images. The method is in essence the result of doctoral dissertations of all three authors which span a nearly ten year period. It is described in detail and compared with other methods of superquadric recovery and segmentation. Numerous examples of recovery and segmentation from range images are given.

The intended audience for this book are researchers, developers, and students of computer vision and robotics. It is assumed that the readers have a general engineering/computer science background with some familiarity of computer vision issues.
Organization of the Book

The book consists of seven chapters. This first chapter introduces the concept of part-level models for description of three-dimensional shapes and superquadrics as a special case of such models. The second chapter covers geometric properties of superquadrics. Besides the definition of superquadrics, several other useful geometric properties of superquadrics are derived. The third chapter introduces different ways of extending the expressive power of superquadrics by addition of global and/or local deformations, as well in the form of a richer parameterization (hyperquadrics). Global deformations of tapering and bending are given in detail. The fourth chapter covers the recovery of individual superquadrics from pre-segmented images. We give a survey of different recovery methods while our method of superquadric recovery from pre-segmented range images based on least-squares minimization is covered in depth. The fifth chapter is on segmentation. We define our recover-and-select segmentation paradigm and show how the recovery of superquadrics can be tightly integrated with segmentation to achieve their recovery without any prior segmentation of range images. The sixth chapter gives extensive experimental results of the combined superquadric model recovery and segmentation on range images. The seventh chapter is a survey of various superquadric applications in computer vision, computer graphics and robotics. In particular, we show experimental results on how superquadrics can be used for range image registration. Appendices at the end of the book contain useful tools, such as the Mathematica Code for display of superquadrics, principles of structured light range image acquisition, and pointers to the software used for the experiments shown in this book.