

Preface

The computational modeling of deformations has been actively studied for the last 30 years. This is mainly due to its large range of applications that include computer animation, medical imaging, shape estimation, face deformation as well as other parts of the human body, and object tracking. In addition, these advances have been supported by the evolution of computer processing capabilities, enabling realism in a more sophisticated way.

This book encompasses relevant works of expert researchers in the field of deformation models and their applications. The primary audience for this work are researchers from different multidisciplinary fields, such as those related with Computer Graphics, Computer Vision, Computer Imaging, Biomedicine, Bioengineering, Mathematics, Physics, Medical Imaging, and Medicine.

This book is divided into two main parts. Part I presents recent object deformation techniques from the point of view of computer graphics and computer animation. First, Palmer et al. present a survey of all the most modern techniques in the representation of deformable objects such as NURBS representation, free form representation, level sets, mass-spring models, algebraic surfaces, modal decomposition, and so on. Next, in [Chap. 2](#), Raffin presents the free-form deformation techniques and its application to deform objects maintaining their topology and geometry.

[Chapter 3](#) introduces us to the cage deformation techniques. Nieto and Susin show how these techniques are useful in modeling, texturing, and animation. In addition, the advantages and drawbacks of these techniques are shown, as well as how they are used in order to deform more complex systems. In the following chapter, Xie shows how to deform an image gradient using level set. The 2D and 3D deformable model segmentation is used to capture complex geometries and to deal with difficult initializations, weak edges, and broken boundaries.

In [Chap. 5](#), Buades et al. present a new methodology to design shoes based on the biomechanical anatomical structure of the foot and of the deformable shape. The use of a deformable model is introduced in order to design shoes that are perfectly adapted to the foot's shape. The last chapter of this part introduces a deformable model, which allows the interactive simulation of objects with

heterogeneous material properties and complex geometries. The model presented by Gilles et al. combines the realism of physically based continuum mechanics models and the usability of frame-based skinning methods.

The work presented thus far covers the geometric- and physics-based deformation models. In computer vision, however, modeling deformations is necessary in order to study the variations of natural shapes so as to extract useful real information from image or video sequences. Thus, deformation models are important for the accurate localization of complex structures in applications ranging from facial feature detection to tracking of anatomical structures in medical images.

Part II of this book presents six works that study deformations from a computer vision point of view with a common characteristic: deformations are applied in real-world applications.

First, the work of Marques et al. presents four methods to initialize deformable models in order to properly extract 2D and 3D shape estimations. These algorithms show an improved performance when compared to the classical techniques. This is proved experimentally in the estimation of facial features in 2D face images and in the detection of deformations of the left ventricle in an ultrasound 3D volume. The following chapters are mainly devoted to these two fields of application of deformations models. Particularly, one of the most recent impressive advances in facial feature tracking is explained in [Chap. 8](#), where Saragih reviews the constrained local models (CLM). This approach for deformable face alignment leverages the generalization properties of local appearance representations of parts and the strong global constraints imposed by the geometrical relationships between part locations. Specifically, this work places CLM in the general context of deformable face alignment, highlighting its similarities and differences with other approaches and justifying its benefits.

In the field of medical imaging, the work of the Siemens research team has achieved a great interest from the scientific community by using a robust approach to deformation models in medical applications. [Chapter 9](#) presents their robust learning-based fusion framework, demonstrating it by means of various medical image analysis applications. The framework combines the prior information with traditional tracking approaches based on template matching and registration, in order to maintain an anatomically consistent representation of target appearance. This representation has proved it can cope with inherent changes due to target movement, imaging device movement, varying imaging conditions, and is consistent with the domain expert clinical knowledge. A different approach in medical imaging applications is presented in the next chapter, where Igual et al. describe an automatic segmentation method for brain medical images. Its approximation defines a deformable model by combining an atlas-based segmentation strategy with a well-known computer vision technique, the Graph-cut model, which is adapted to make it suitable for segmenting small and low contrast structures. The obtained results show improved performance in terms of segmentation accuracy compared to current approaches. The last two chapters present two particular applications of deformation models in medical applications. In [Chap. 11](#), Fürtinger et al. map a Purkinje fiber

network from a real heart. The elastic deformations guarantee that despite even large differences in the endocardial geometries of both models, the artificial Purkinje fiber network is mapped sufficiently close to the real endocardium. In the last chapter, Bilgen applies deformation models in order to obtain an accurate and precise motion estimate in elastography.

Finally, we want to thank the chapter authors for providing work of great quality and for their collaboration in all the book edition process. We believe that thanks to the achieved contributions, this book gives an excellent overview of the state of the art of the applications of deformation models in animation and computer vision.

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