8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

DETERMINATION OF OBJECTS CONTOURS USING PHYSICAL PRINCIPLES

***Patrícia C. T. Gonçalves[1], João Manuel R. S. Tavares[2] and R. M. Natal Jorge[3]**

Faculty of Engineering of the University of Porto
Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

[1]patricia.goncalves@fe.up.pt [2]tavares@fe.up.pt www.fe.up.pt/~tavares [3]rnatal@fe.up.pt

Key Words: *Segmentation, Physical Modelling, Deformable Models, Dynamic Equilibrium Equation.*

ABSTRACT

Segmentation, the identification of an object represented in a static image or along image sequences, is one of the most common and complex tasks in the domain of Computational Vision. Usually, whenever we intend to extract higher level information from images, we need to start by segmenting them.

The main goal of this work is to segment an object represented in an image by extracting its contour after defining an initial contour for it; this coarse contour will evolve along an iterative process until it reaches the frontier of the desired object, figure 1. For that purpose, a deformable model is used, whose behaviour is driven by physical principles.

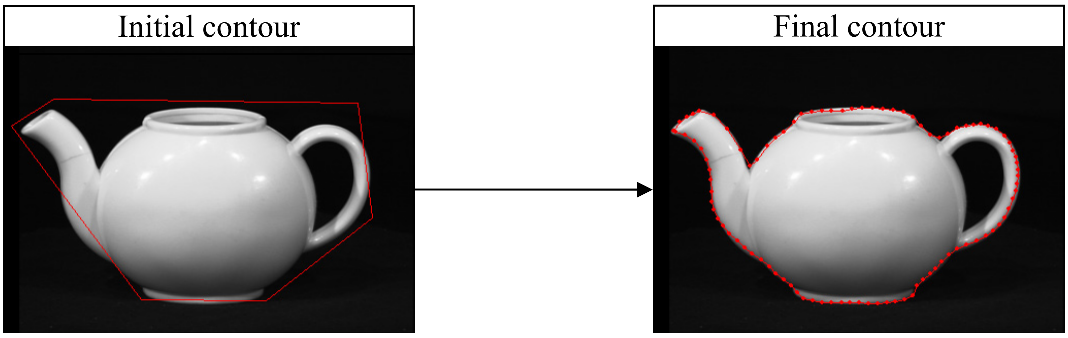

Figure 1. The main purpose of this work: starting from a coarse shape evolve to one that defines well the contour of the desired object.

More precisely, in our methodology, the initial contour is transformed into an elastic physical model – assigning mass, rigidity and damping to each of its points – that is gradually deformed in order to segment the desired object. This deformation is driven by the characteristics of the physical model built and by the object features. The physical model for the initial contour is determined by the virtual material adopted for it and by the use of the finite elements method. As for the object features, they are computed by enhancing particular characteristics of the object in the input image. In our work, the characteristics considered are intensity, edges and the distance from each pixel to the nearest edge.

To control the behaviour of the model built for the contour, we follow the methodology proposed by

Nastar [1] using the dynamic equilibrium equation, also known as equation of motion. To physically model the contour and to simulate its elastic behaviour, Nastar used affine interpolation functions together with finite differences. Instead, Gaussian interpolants and the finite elements method are used in this work for the same purpose. Namely, Sclaroff's [2] isoparametric finite element is considered, that uses a set of radial base functions as interpolants.

Then, the movement of the physical model of the contour towards the border of the object to be segmented is estimated by solving the second order differential equation, usually known as Lagrange's dynamic equilibrium equation,

$$\mathbf{M}\ddot{\mathbf{U}}^t + \mathbf{C}\dot{\mathbf{U}}^t + \mathbf{K}\mathbf{U}^t = \mathbf{F}^t,$$

for each time step *t*, where $\mathbf{U}$, $\dot{\mathbf{U}}$ and $\ddot{\mathbf{U}}$ are, respectively, the displacement, velocity and acceleration vectors, $\mathbf{F}$ represents the external forces, and $\mathbf{M}$, $\mathbf{C}$ and $\mathbf{K}$ are the mass, damping and stiffness matrices, respectively, [3; 4]. This equation describes the equilibrium between the internal and external forces involved. The internal forces are defined by the physical characteristics adopted for the model, determined by the adopted virtual material and the level chosen for the interaction between the nodes of the model (considered while building Sclaroff's isoparametric finite element); and the external forces are determined by the image features that best describe the object to segment. In particular, the intensity value of each pixel of the initial image, the value of the pixels of the edges image, and the distance from each pixel to the nearest edge.

The experimental results obtained using our physically driven segmentation methodology are quite satisfactory. However, our approach has two major problems:

1) it becomes slower as the number of nodes of the model used in the segmentation process increases; what can be very inconvenient when a detailed contour extraction is to be accomplished and the application demands very fast results;

2) the segmentation result can be compromised when the image in which the object is represented is complex, with noisy data or objects overlapped, for example.

Because of these two major problems, in the near future some changes to fasten and improve the segmentation process will be introduced, such as trying different approaches for the definition of the external forces, and the development of parallel implementations.

The use of finite elements more suitable for large and nonlinear deformations is also a subject to be addressed in the following stages of this work.

REFERENCES

[1] C. Nastar and N. Ayache, "Fast Segmentation, Tracking, and Analysis of Deformable Objects", *Proc. of the Fourth International Conference on Computer Vision*, Berlin, Germany, pp. 275-279, (1993).

[2] S. Sclaroff and A. Pentland, "Modal Matching for Correspondence and Recognition", *IEEE Trans. Pattern Anal. Mach. Intell.*, Vol. 17, pp. 545-561, (1995).

[3] P. C. T. Gonçalves, R. R. Pinho and J. M. R. S. Tavares, "Physical Simulation Using FEM, Modal Analysis and the Dynamic Equilibrium Equation", *Proc. of the CompIMAGE - Computational Modelling of Objects Represented in Images: Fundamentals, Methods and Applications*, Coimbra, Portugal, pp. 197-204, (2006).

[4] R. R. Pinho and J. M. R. S. Tavares, "Dynamic Pedobarography Transitional Objects by Lagrange's Equation with FEM, Modal Matching and Optimization Techniques", *Lect. Notes Comput. Sc.*, Vol. 3212, pp. 92-99, (2004).