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# Active Contours and their Utilization at Image Segmentation

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*Abstract: Image segmentation is one of the most important steps in the image analyses. Its main aim is to devide an image to some parts, which correlate strongly by objects of reality. Image segmentation is a difficult task mainly because of a big variability of object shapes, as well as different image quality. Images are often interfered by signals and artefacts which rose of during sampling, what may cause big problems at using of common techniques of segmentation. In image segmentation, deformable models which were studied at resolving of these problems, found wide use. Deformable models became popular since their publishing in work 'Snakes: Active contour models' which was published in 1987 and since then they have become active and successful research branche of image segmentation. In the literature we can meet different names of these models as for example snake, active contours, as well as surfaces or baloons. This article deals with principles of functioning of these segmentation methods, how they are devided and finaly, how they are used.*

*Keywords: active contours, snake, deformable models, image segmentation*

## 1 Active Contours Models

### 1.1 Background

The concept of active contours models was first introduced in 1987 [1] and has later been developed by different researchers. An active contour is an energy minimizing spline that detects specified features within an image. It is a flexibile curve (or surface) which can be dynamically adapted to required edges or objects in the image (it can be used to automatic objects segmentation). It consists of a set of control points connected by straight lines, as it is showed in Figure 1. The active contour is defined by the number of control points as well as sequence of each other. Fitting active contours to shapes in images is an interactive process. The user must suggest an initial contour, as it is showed in Figure 1, which is quite close to the intended shape. The contour will then be attracted to features in the image extracted by internal energy creating an attractor image.

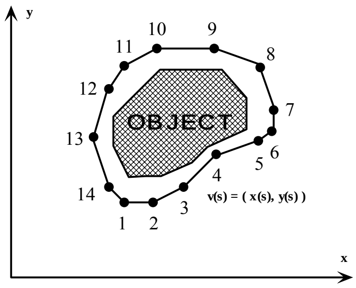



Figure 1
Basic form of active contour

### 1.1.1 Basic Types of Deformable Models

There are 2 basic types of deformable models [2, 3, 4]: parametric and geometric.

**The parametric deformable models** represent curves and surfaces during deformating explicitly in parametric form. The parametric models can be described with help of some of the following formulations, and so by formulation of energy minimizing or formulation of dynamic force.

***The formulation of minimizing energy*** - the base of deformable models on the basis of energy minimization is searching of parametric curve that minimizes weighted sum of internal energy and potential energy. Internal energy specifies tension or smoothness of contour. The potential energy is defined in the image domain and it usualy has minimal value at the point where it is high intensity gradient in the image what is shown on the object edge. Total energy minimization occures when internal and external energies are equal.

***The formulation of dynamic force*** - it is used in those cases in which it is more confortable to form deformable model straight from dynamic problem with help of force formulation. These formulations facilitate the use of common external forces, even those which are note potential, e.g. forces which can not be described as a negative gradient of potential energy function.

**The geometric deformable models** offer elegant solution of the most important limits of parametric deformable models. These models are based on the evolution curve theory and the level set method. At curves and surfaces evolution only geometric criteria are used that leads to the evolution independent from parametrization. As well as at the parametric deformable models, the evolution is connected to image data at objects edge finding. Forasmuch as the evolution is independent from parametrization, the curves and surfaces generating can be represented as the 'level set' of a multidimensional function. The result of this is that topological changes are easy to control.

The active contour can be either closed or open curve.

### 1.1.2 Basic Definition

Active contour (a set of the coordinates of control points on the contour) is defined parametrically as [1, 3, 5]:

$$\vec{v}(s) = \left(\vec{x}(s), \vec{y}(s)\right), \tag{1}$$

Where *x(s)* and *y(s)* are *x, y* coordinates past the contour and *s* is the normalized index of the control points.

The energy function that describes active contours is composed of two components, the internal energy and the external energy. Internal forces make the curve compact [elastic forces – 1st member of the equation no 2] and limit its very acuminous deflections [bending forces – 2nd member of the equation no 2]. External forces tend the curve towards the object's borders.

The internal energy - summation of an elastic energy and a bending energy - can be expressed as:

$$E_{int} = E_{elastic} + E_{bend} = \alpha\,(s)\left|\frac{dv}{ds}\right|^2 + \beta\,(s)\left|\frac{d^2v}{ds^2}\right|^2, \tag{2}$$

where α is an adjustable constant that specifies continuity and β is adjustable constant that specifies contour curving.

The elastic and bending energies are then defined followingly:

$$E_{elastic} = \int_s \alpha\,(\vec{v}(s) - \vec{v}(s-1))^2\,ds, \tag{3}$$

$$E_{bend} = \int_s \beta\,(\vec{v}(s-1) - \vec{v}(s) + \vec{v}(s+1))^2\,ds, \tag{4}$$

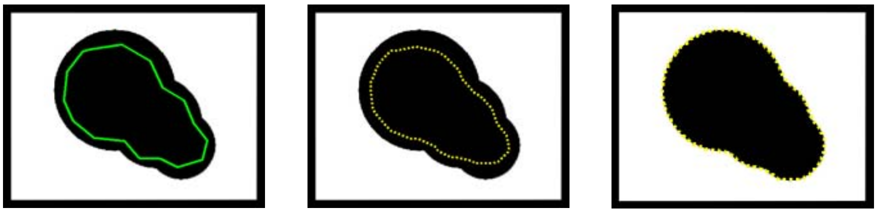
Energy of functional, which is minimized can be expressed as:

$$\begin{aligned} E^*_{snake} &= \int_0^1 E_{snake}\left(v(s)\right)ds = \\ &\int_0^1 \left\{E_{int}\left(v(s)\right) + E_{image}\left(v(s)\right) + E_{con}\left(v(s)\right)\right\}ds, \end{aligned} \tag{5}$$

where $E_{int}$ is the internal energy of the curve, $E_{image}$ is the energy of the picture and $E_{con}$ are the external limitations.

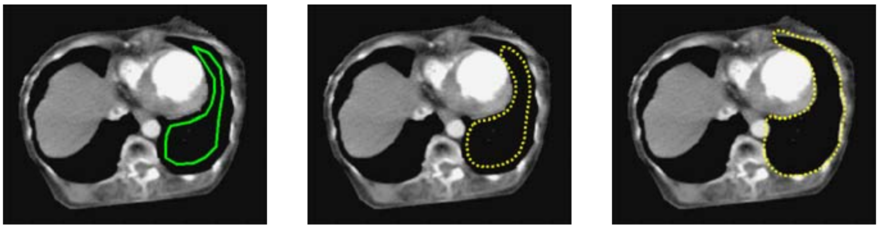
## 1.2 Experiments

In the following part we are about to show some possibilities of the use of the active contour methods on artificial and real picture. The experiment was realized in Matlab with help of existing and published method created according to [4] published on website http://www.cs.sfu.ca/~hamarneh/software/acm/index.html. The first set [Figure 2] of the pictures consists of some iterations of the method applied on the artificial picture and the second set [Figure 3], on the other hand, on the real one.



a) b) c)

Figure 2
Experiment on the artificial picture
a) initialization, b) after 5th iteration, c) after 12th iteration



a) b) c)

Figure 3
Experiment on the real picture
a) initialization, b) after 5th iteration, c) after 15th iteration

As it is possible to see, in both cases the initiation points were given in tight vicinity of the sought contour for the algorithm to find the sought contour in the shortest time that is possible. The number of iterations depends on the size of the scanned surroundings – the bigger the scanned surrounding, the smaller the number of iterations. In the first case, it means in the application of the active contour method on the artificial picture, which is apparently easier, the result of the contour seeking is better as in the second case where the real picture was used. The used artificial picture was made in the standard application of the operational system Windows, assigned for drawing – Paint, and the real picture was used from the pictures from the web site http://www.cs.cmu.edu/~cil/v-images.html.

## Conclusion

In the picture segmentation there is much to upgrade and there are many methods to find but the round of possibilities of the new, fast and efficient methods uprise is getting smaller and so there come out the methods with the bigger computing difficulty again. The active contour methods have many advantages and acquisitions to the picture segmentation but there are also some disadvantages to which we can count the fact of their dependency on the initial points of the contour, type of the picture and, the above mentioned, computing difficulty, as well. By the use of less accurate but satisfactory methods it is possible to low the computing difficulty, the choice of the initial points of the contour can be automatized but we can say that in the last years the trend is to use the interactivity with the user. It is well known that these methods have been more and more used in the recent time in the medicine which is also the branch in which we want to use them as well.

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