UTILIZATION OF ACTIVE CONTOUR METHODS

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Abstract: The main aim of image segmentation is to divide an image to some parts, which correlate strongly by objects of reality. At image segmentation, deformable models which were studied at resolving of these problems, found wide use. Deformable models became popular since 1987. In the literature we can meet different names for these models, for example snake, active contours, as well as surfaces or balloons. This article deals with principles of functioning of these segmentation methods, how they are divided and finally, how they are used.

Keywords: image segmentation, active contour, parametric and geometric deformable models

1. INTRODUCTION

Man has five senses for information processing at his surroundings, however majority of this information is executed by sight (approximately 90%), in which it is his intelligence that plays a big role at operating of this information, experience and skills about the world around him acquired throughout the life. Computing sight strives by the help of some technical resources to imitate human sight. At a computing sight we talk about a solution of some similar problems as are those, which are solved man, even though on account of complexity of the processing of this information actual methods are convenient only for simple problems solving.

One of the most difficult steps at image analysis is image segmentation. Its main aim is to divide 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 artifacts which rose of during sampling, what may cause big problems at using of common techniques of segmentation. And exactly one of the fields of the segmentation techniques, particularly so called deformable models – active contours, which found wide scope at image segmentation, is treated also by this article.

2. BASIC TYPES OF DEFORMABLE MODELS

There are 2 basic types of deformable models: parametric and geometric (Kass, Witkin, Terzopoulos, 1987).

The parametric deformable models represent curves and surfaces during deforming 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 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 parametric measurement. 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 parametric

measurement, the curves and surfaces generating can be represented as the "level set" of a multi-dimensional function. The result of this is that topological changes are easy to control.

3. BACKGROUND

Deformable models – active contours – were described for the first time in the work and since that time they have become active and successful research field at image segmentation used in various branches. An active contour is an energy minimizing spline that detects specified features within an image. It is a flexible curve (or surface) which can be dynamically (under influence of internal and external forces) adapted to required edges or objects in the image. It consists of a set of control points connected by straight lines. The active contour is defined by the number of control points as well as sequence of each other.

Their advantage is a resistance towards noise and discontinuities of the objects in the image, ability to find complex forms and possibility of integration of the components of the edges into a coherent and consistent mathematical description. Disadvantages are e.g. more parameters, which is needed to adjust (e.g. elasticity, toughness, voltage of the curve), eventually manual adjusting of initialization curve, which will be deformed. The most popular from methods of deformable models are 'snakes', which are actually curves minimizing the value of an internal and potential energy of the curve. Another representative can be 'balloons'. If there is set the initializing curve into the object, so in this case the deformed as well as inflated balloon and stops at as for a detected edge, which is then copied.

The basis of models on base of energy minimization is a research of the parameters of the curve, which minimize valued sum of the internal energy – specifies the tension (internal forces hold the curve compact – elastic (elastic) forces) or smoothness (internal forces defend also strict curves – bending forces lines and potential energy – external forces – to pull the curve towards the border (minimum is in the picture and usually at the point of big gradient intensity, consequently at the borders of the object) required object (Demjénová, Zolotová, Tomori, 2004). Active contours are defined parametrically followingly:

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

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

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

$$E^*_{snake} = \int_0^1 E_{snake}\left(v(s)\right) ds \qquad (2)$$
$$= \int_0^1 \left\{\left[E_{int}\left(v(s)\right)\right] + \left[E_{image}\left(v(s)\right)\right] + \left[E_{con}\left(v(s)\right)\right]\right\} ds,$$

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

The internal energy (3) – summation of an elastic energy (4) and a bending energy (5) – can be expressed as:

$$E_{int} = E_{elastic} + E_{bend} = \alpha(s)\left|\frac{dv}{ds}\right|^2 + \beta(s)\left|\frac{d^2v}{ds^2}\right|^2, \qquad (3)$$

$$E_{elastic} = \int_s \alpha\left(\vec{v}(s) - \vec{v}(s-1)\right)^2 ds, \qquad (4)$$

$$E_{bend} = \int_s \beta\left(\vec{v}(s-1) - \vec{v}(s) + \vec{v}(s+1)\right)^2 ds, \qquad (5)$$

where α is an adjustable constant that specifies continuity and β is adjustable constant that specifies contour curving. First derivation of the formula (3) avoids the expansion and causes that the model behave as an elastic string. The second derivation of the formula (3) defends the bending and causes, that the model behaves as inflexible rod. The member E_{image} of the relation (2) presents an image energy and it is derived from image data, through which the contour stretches. There are three essential image properties, which can tend the contour; they are the lines, edges and terminations. The total energy of the image can be represented as a balancing combination of these three properties. The member E_{con} within the relation (2) rise from the external limitations is concerns restrictions on multi global strategies as e.g. the relation to other objects in the image or compulsory powers forcing the contour to move towards the important lines in the image. Practically, there are these restrictions represented by e.g. rustled area of the image, etc.

The problem of the curve recovery, which minimizes the power functional, which is indicated in the relation (2), is known as a variation problem. It has been demonstrated, that the curve, which minimize has to fulfill following condition (Marek, Demjénová, Tomori, Janáček, Zolotová, Valle, Favre, Dietler, 2005):

$$-\frac{d^2}{ds^2}\left(\frac{\partial E}{\partial\left(\frac{d^2x}{ds^2}\right)} + \frac{\partial E}{\partial\left(\frac{d^2y}{ds^2}\right)}\right) + \frac{d}{ds}E_{v_s} - E_v = 0 \qquad (6)$$

4. POSSIBILITIES OF A PRACTICAL USE OF THE METHODS OF ACTIVE CONTOURS

In the following part we will summarize some possibilities of the use of the methods of active contours in technical or medical applications. The most essential division of the methods is division of these according to the type of the incoming image data, and this happens according to the fact whether it is a statical images or moving images. Practically we can meet segmentation of the static images most frequently at an extraction of the objects from the image, searching for ways in satellite snapshots and at medical images (Bakoš, 2007).

One of the possible applications is searching for ways and objects in satellite snapshots (Most frequently it concerns seeking and measuring of the way length in satellite snapshots, let us say analysis of the building location used e.g. at virtual places modeling.). At medical images, which are important source of anatomical and functional information and are extremely important at diagnosing and treatment of diseases, the main reason of the segmentation is that, the processing of the monumental data quantity, in the images with a big discernment, is not effectively operated by traditional techniques and just visual analysis of the images is for doctors insufficient. These methods are in this area used most frequently for diagnostic purposes, even though ceaseless improvement of the display methods makes it possible for us to investigate also different possibilities of their processing. Frequently it concerns methods of visualization of CT/MR data, 3D modeling of the fibers, scheduling and simulation of the operations, doctors' navigation at medical help and a lot of others. Eventual fields of application of active contours at medical images is e.g. segmentation of the parts of body, searching bone contours, bone fracture detection, measuring parameter and number of segments (Physicians need to find out cell measurements frequently, let us say their number at the displayed area, better to say at scanning by a confocal microscope it is possible by cutting the delaminated section to obtain also quantity of the cells in a given content. In case of the DNA strings we measure length but also another parameters.) and 3D fiber modeling (Image data are generated by a 3D screen. The merit of the three-dimensional data representation is com-pared to standard 2D cuttings bright. Segment Ted fiber can be investigated from any view. The scanning is then simpler and much more precise.).

The utilization of the moving images has wider usage. It is used e.g. for interaction of a man with a computer (By moving hands over the table we can give instructions to the computer, that it has to obey.), stirring the face the controlled animations (Stirring the face is here used as an example for computer designed face. The monitored look can be copied or systematically exaggerated.), lip reading , traffic situation control (Scanning and estimation of the information is used e.g. at statistical scoring of the driving velocity, distance between cars, overtaking of the cars, course holding of the cars in driving strips, etc.), biometrics or animating of the stirring on the basis of persons the move (It concerns detection of the movement of the persons, following which the system can detect his presence and identify this person. It concerns the analysis of the anatomical properties (lengths of the extremities sections), distance measurement and method of the movement. Of course the additional use of similar techniques finds its application in Computing graphic at animating the movement of the human body in games, etc. Problems occur e.g. at dancing, when there is the overlay of individual extremities, etc.), movement detection (Most frequently used at detection of the people in some monitored place, another possibility is utilization at taking photos of panoramic shots, where there is object movement unacceptable and different methods of the detection are (e.g. at distant objects) ineffective. It doesn't need to concern only people following, but it can be e.g. movement monitoring of the object and recording by a camera system behind the detected object.).

5. IMPLEMENTATION

The implementation of the active contours method can work in different ways. This is possible to do in 2D, or in 3D space. Fitting active contours to shapes in images can be an interactive process. The most important part is often the initialization, that may be realized either automatically and by the automatic match of appropriate initial points by the calculations, or semi automatically, when we lead the program by position appliance to the surroundings of the required points and that program in their surroundings finds the most appropriate solution or manually, or interactively with the user, when he elects either points, spheres, islands, etc., and he initiates a contour, from which he comes out and this is followed by the calculation by various active contours methods. In case of fully automatic initializations, when the initialization points (items) are determined automatically and the segmentation, in another words evaluating of its results following the comparison with the model are also realized automatically and these programs can guess the results without any assistances of the man, or relatively correctly take out from the quantity of incoming data those which are substantial.

Nowadays is best approved and preferred the interactive co-operation of an operator and a program especially concerning a setting the initial point of active line but also different valuating the importance of some points or a fixed location of some points on a contour, so as the program come to a required result faster and more correctly, eventually limits itself only

on strictly designed specific element of researched scene.

6. OUR SKILLS WITH ACTIVE CONTOURS

Our contemporary research, which concerns active contours and deformable models, aims to specify the external powers and limits. These influence running of line deformation and can be supplemented as a member, influencing the equation (2), even in case of influence made by a movement or its prediction and concerning acceleration of a further enumeration at non-static images in case of those the speed of the enumeration is very important. In addition, other important things, that are able to define the searched edges of objects in static and non-static images on the basis of the surroundings of the researched points, are various external and compressive powers. In the basic research we focus on searching more effective methods to simplify and accelerate the enumeration. The speed of the enumeration depends on the environment in which it is implemented. For the basic testing of the methods we usually use the development environment MATLAB where a relatively long duration of the enumeration and drawing substituted by a simple implementation. It facilitates an interactive Access with the researched source of the image, as well as the possibility to watch the enumeration and its running with the help of various statistical tools which do not need to be laboriously programmed (because they are the parts of this tool). It enables interactive communication with the examined picture as well as to check the calculation and its behaviour by means of various statistical tools that are not needed to be programmed as these are the part of the tool. For the testing of speed and running ability of the application in real conditions we use the programming environment Visual Studio .NET and the programming language C# eventually the environment Ellipse (http://www.ellipse.sk) by programming of dynamical libraries. We have tried the actual experiments at active contours on a quantity of the artificial, rippled and real images obtained from the praxis as well as from some various accessible image databases (to compare results with another published methods). We have also tried it on a quantity of well – known and modified methods (as an example we can mention the method published on the web site http://www.cs.sfu.ca/~hamarneh/software/acm/index.html) (Hamarneh, 2001) where we tried to test experimentally, compare the results and eventually improve mentioned method. To reach more effective results it is possible to combine some active contours with other segmentation methods. These influence very positively the results in case of some sorts of images (e.g. Watershed, mathematical morphology, artificial intelligence methods). For wide implementation of these methods in practice they are still popular.

7. CONCLUSION

From the mentioned possibilities of the application, which neither from a distant are covering all possibilities, which the methods of the active contours at image segmentation offer, as well as in the medicine it has its use. At image segmentation it is generally still enough to improve and finding new processes, fast and at the same time productive methods is being reduced and so there come back methods with bigger computing arduousness. By the use of less exact, though satisfactory modifications of these methods it makes it possible to reduce the computing arduousness and the option of the initialization points of the line is automatizable, even though in recent years it has been such trend, that the possibility of interactivity with the user is given preference to. Our interest is to make use of possibilities of these methods in co/operation with systems of the mobile robotics and in medical applications on the basis of existing necessities.

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REFERENCES

Bakoš, M. (2007). *Deformable models at digital image segmentation* (in Slovak). Essay to dissertation examination, Department of Cybernetics and Artificial Intelligence, Faculty of Electrical Engineering and Informatics, Technical university of Košice

Demjénová, E., Zolotová, I., Tomori, Z. (2004). Interactive Segmentation of Fibre-like Objects. In: *Proceedings of 2nd Slovakian-Hungarian Joint Symposium on Applied Machine Intelligence, SAMI 2004*, Herľany, Slovakia, pp. 259-268, ISBN 963 7154 23 X.

Hamarneh, G. (2001). *Towards Intelligent Deformable Models for Medical Image Analysis.* Ph.D. Thesis, Department of Signals and Systems, School of Electrical and Computer Engineering, Chalmers University of Technology. Technical report 415, ISBN 91-7291-082-8.

Kass, M, Witkin, A., Terzopoulos, D. (1987). Snakes: Active Contour Models. In: *Proceedings of 1st International Conference on Computer Vision*, London, pp. 259-267

Marek, J., Demjénová, E., Tomori, Z., Janáček, J., Zolotová, I., Valle, F., Favre, M., Dietler, G. (2005). *Interactive measurement and characterization of DNA molecules by analysis of AFM images*, Cytometry Part A, **Volume 63A**, Issue 2, Wiley-Liss, Inc., pp. 87-93