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Dual Pyramid of Agents for Image Segmentation

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***Abstract*—**An effective method for the early detection of breast cancer is the mammographic screening. One of the most important signs of early breast cancer is the presence of microcalcifications. For the detection of microcalcification in a mammography image, we propose to conceive a multiagent system based on a dual irregular pyramid.

An initial segmentation is obtained by an incremental approach; the result represents level zero of the pyramid. The edge information obtained by application of the Canny filter is taken into account to affine the segmentation. The edge-agents and region-agents cooper level by level of the pyramid by exploiting its various characteristics to provide the segmentation process convergence.

***Keywords*—**Dual Pyramid, Image Segmentation, Multi-agent System, Region/Edge Cooperation.

I. Introduction

IMAGE segmentation is one of the most widely used steps in the process of reducing images to get useful information. It allows the partitioning of image into several distinct regions. Various work was carried out in this field, many publications showed the advantage of combining region information and edge information. Currently these cooperative approaches offer a promising sight. To develop a cooperative approach multiagent systems are well adapted, to solve the problem of merging information resulted from the application of a various operators.

We propose for the detection of microcalcification in a mammography image, to cooperate region-agents obtained by an incremental approach and edge-agents obtained by a Canny filter in a pyramidal structure.

Initially, a short outline of the irregular pyramid is presented, then we expose in brief way some work carried out in image segmentation by multiagent approach, there after we present our approach while arguing the choice of the dual pyramid and the role of the agents. Finally we conclude this paper by some prospects for possible improvements.

II. Irregular Pyramid

The irregular pyramid according to [1] is a stack of graphs which describe an image. Each level of the pyramid represents an adjacency graph where the set of vertices correspond to regions of the level and the edges' set correspond to the adjacency relations between regions.

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- the bottom level of a pyramid (level 0) is created starting from the image to be treated by using the 4 or 8-connexity for the adjacency graph.

- the graph of the k level is obtained by processing decimation on the graph of k-1 level.

This decimation procedure is based on two rules [1]:

1. Two neighbors at a given level cannot both survive at the next level;

2. For each non-surviving cell, there is at least one surviving cell in its neighborhood.

The selection of the surviving vertices to represent the following level of the pyramid can be done randomly (Stochastic) [13] or according to an *interest operator* [10] based on the variance of the region associated to the vertex.

- each non survivor vertex is assigned to its survivor neighbor the most similar, to be represented by it at the next level.

The characteristic of the irregular pyramid is due to the fact that the cells composing the levels represent each one a region of which the form is not constrained by a geometrical pattern (square, triangle, polygon). The result obtained by the application of the irregular pyramid is independent of the course of image.

However these pyramidal structures can generate non-existent borders or forget existing discontinuities, the use of the cooperative approaches will palliate this type of disadvantages by furnishing to these structures other parameters like information edge. The use of the irregular pyramid to the image processing showed difficulties of processing the edge information. The dual pyramid [11], is introduced to code the borders between regions and thus, to facilitate a region/edge cooperation.

A. The Dual Pyramid

The use of simple graphs to the irregular pyramids forces to have only one edge between two vertices in the graph, thus, it is unable to distinguish from the graph an adjacency relation from inclusion relation between two regions. This limitation was raised by Kropatsch [11], Willersinn [16] and others who propose to build a dual irregular pyramid complementing each level of an irregular pyramid by its dual graph during construction.

The basic process for construction of the dual pyramid is the dual decimation. It combines the selection of decimation parameters and the dual contraction that proceeds in two basic steps dual edge contraction and dual face contraction:

1. *selection of the decimation parameters* (S_i, $N_{i,i+1}$)*:*

Identification of the survivors and non-survivors: $S_i \subset V_i$ a subset of surviving vertices and $N_{i,\,i+1} \subset E_i$ a subset of primary

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non-surviving edges.

2. *dual edge contraction* $N_{i,i+1}$*:*

The contraction of a primary non-surviving edge from $N_{i,i+1}$, consists in the identification of its endpoints (vertices) and the removal of both the contracted edge and its dual edge.

3. dual face contraction:

- selection of the decimation parameters (S^*_i,$N^*_{i,i+1}$)
- dually contract edge $N^*_{i,i+1}$

The relation (Fig. 1), between two pairs of dual graphs, (G_i, $\overline{G_i}$) and (G_{i+1}, $\overline{G_{i+1}}$) established by dual graph contraction with decimation parameters (S_i, $N_{i,i+1}$) is expressed by function C [,].

$$(G_{i+1}, \overline{G_{i+1}}) = C\,[(G_i, \overline{G_i}), (S_i, N_{i,i+1})] \quad (1)$$

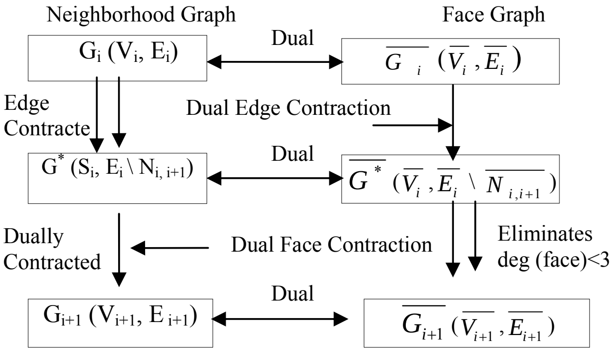


Fig.1 Dual Graph Contraction: (Extract from ([9])

To overcome the over-segmentation problem, generated by the use of Watershed. Selmaoui and Kropatsch [14] combine Dual Graph Contraction and the watershed method for the image segmentation. The use of the dual graph for finding connected components in an image [12] and, to build a hierarchy of partitions of an image [9], made it possible to preserve the topology of the image and to correctly code the relation of adjacency and inclusion between regions.

The dual irregular pyramid facilitates the use of edge information. The borders between the regions correspond to the edges connecting the faces of the dual graph [16]. Thus, there is a correspondence between the edges and the borders.

To have a natural aspect of cooperation between regions and edges which can take various forms [6], for the division or the fusion of regions, the multiagents systems seem well adapted to develop a cooperative approach and thus, to resolve the fusion information problem resulted from the application of a various operators.

III. Multiagent Approaches in Image Segmentation

According to the application developed in previous works, different kind of agents with a variety of characteristics, interaction and coordination concepts can be found.

One of the aspects of Boucher system [2] is the manner of launching agents in the next image of the sequence according to what is being held in current image. The agents thus launched start by segmenting their components and will meet progressively while growing. Two agents which meet and discover that work both on the same component of image can fuse their efforts in order to decrease the number of redundant agent.

In a context of MRI segmentation, Germond [8] cooper edge-agents based on (A*) algorithm and region-growing agents specialized for the detection of the white matter (WM) and the grey matter (GM) of the brain. The system comprises a deformable model that provides valuable information on the brain boundary, to position the GM-agents that allow eventually the localization of WM-agents. Edge-agents are used to refine brain boundary assessed by the deformable model.

Duchesnay [5] presents a society of agents (region-agent, edge-agent) organized in irregular pyramid while detailing the initialization process of the pyramid and the total control which intervenes in the passage of one level to another. An agent of the pyramid stands for a region primitive (obtained by the Quadtree method) or edge primitive, he will supplement this primitive while merging with others agents by running a sequence of seven behaviors:

1. *Territory marking and features extraction:* each agent marks a territory that corresponds to its primitive
2. *Exploration:* agents are exploring a shared environment around their territory to discover their neighbors.
3. *Merging planning:* each region agent tries to find out (similar) neighbors to merge with.
4. *Cooperation:* agents cooperate with each other to enhance the quality of their merging plan.
5. *Decimation:* the number of agents has to decrease level by level, then a distributed decimation protocol, performed by the agents, selects survivors.
6. *Reproduction:* each survivor agent creates a new agent in the next level of the pyramid.
7. *Attachment:* all agents should be represented in the next level, then each non-surviving agent looks for the best representative in its neighborhood.

Region-agents and edge-agents cooperate for the segmentation of MRI, in a multiagent plate forms proposed by Settache [15]. Two images are inputted to the multiagent system, region-chart (obtained by Quadtree algorithm) and edge-chart (obtained by a Deriche filter), from which region and edge agents are launched. Segmentation-agents, whose behaviors are defined by an automat related on the region-agents and the edge-agents, are responsible for the improvement of the initial pre-segmentation.

IV. Proposed Approach

We propose to conceive a multiagent system for image segmentation, which allows a cooperation region/edge, and it differs primarily from the work presented in Sect. 3 by the use of dual pyramid.

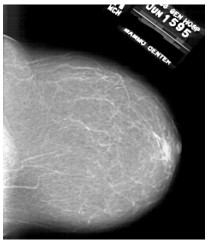
A Region Map

The growing region method (pixel aggregation process) is chosen for pre-segmenting the image into regions. This approach preserves the form of each region. To build a "region" primitive, first select a special set of pixels called *seeds*. Regions are grown by aggregating to the seeds pixels which verify a fixed criterion. Thus, a membership of a pixel into region taking into account: information of region and local information relating to the pixel.

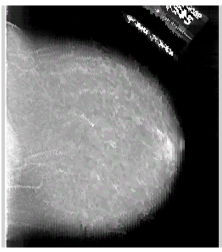
The seeds are pixels with a low ecart-type calculated in window 3x3. The evaluation of pixels to annex to region depends on two weighted homogeneity criteria: average of gray level (C_1) and the variance of region (C_2).

$$C = \alpha C_1 + \beta C_2 \qquad (2)$$
$$\alpha + \beta = 1$$

The image result is the base of our pyramid, where each region will be represented by an agent.



(a) Initial Image.



(b) Region map

(c) Edge map

Fig.2 Preprocessing of the image: (Extract from [4])

B. Edge Map

In order to refine our segmentation, we propose to hold account the edge information, obtained by application of the Canny filter [3]. Canny imposes three criteria to obtain an optimal filter, that of the good detection, the good localization and the low multiplicity of the answers for only one contour.

C. Dual Pyramid of Agents for the detection of microcalcification

An effective method for the early detection of breast cancer is the mammographic screening. One of the most important signs of early breast cancer is the presence of microcalcifications. A microcalcification is a tiny white speck seen on a mammogram. It represents flecks of calcium salts, and is often the only indicators of malignant tumors [7].

For the detection of microcalcification in a mammography image, we propose to conceive a multiagent system based on pyramidal structure.

The use of the agents instead of simple vertices enriches the decisional framework of the approach. Indeed the agents provide a concept particularly adapted for the expression of the cooperation and the negotiation between closed regions.

Different kinds of agent are proposed for our system:

- Agents allowing the control and the good functioning of the multiagents system: user interfaces-agents, monitor-agent, sequencer-agent and agent known as dual-agent to control the various steps of the dual decimation (§2.1).

- A region-agents and edge-agents: Each agent is related to a primitive region from region-map (Fig. 2b) or edge from edge-map (Fig.2c). It has all relevant information concerning it (examples: average and compactness of the region, length and continuity of edge).

Each agent is provided with some behaviors, each one can correspond to one step of the segmentation process. The behaviors developed in this section are related to the region /edge cooperation, where edge-agents intervene to help making the decision fusion between region-agents:

- A behavior allowing the agent **to mark a territory** corresponding to its primitives (region, edge).

- A behavior allowing the agent **to discover its neighbors** and thus to establish the acquaintance relations. The connection of region-agents is restricted to the 4-connexity, which makes it possible to have a planar graph at the base level of the pyramid. For the neighborhoods of the edge-agent we use the distance between the ends of edge.

- A behavior allowing agent **to interact**, **to decide** with which agent he wishes **to merge** by calculating a *fusion desire* for each one of its neighbors, expressed in function of the average of grey level, the variance of regions and the number of pixels borders of the two regions.

$$D_f = (\alpha_1 . diff_{moy} + \alpha_2 \; diff_{var}) / F_{pix} \qquad (3)$$
$$\alpha_1 + \alpha_2 = 1$$

A candidate regions list of a region-agent (*candlist*) gathers regions with a mutual *fusion desire* – lower than a fixed threshold-.

- a behavior allowing the agent to enhance or to cancel its fusion with other agents, by taking into account the opinion of fusion communicated by the dual agent. The regions of which fusion is cancelled are removed from the list *candlist*. -

- A behavior to select the survivor's agents by application of decimation's rules, adapted to an *interest operator* said *fusion plan* which is for an agent the sum of the *fusion desire* of regions from its *candlist*.

$$Plan_f = \sum_{i \in candlist} D_{f(i)} \qquad (4)$$

- A behavior allowing a surviving agent to **create a new agent** at the **next level** of the pyramid.

- A behavior allowing each **non-survivor** agent to be **represented** by his best neighbor **survivor** agent, at the next level of the pyramid

To control the process of the dual decimation a dual-agent executes two behaviors:

- A behavior allowing **to build a dual graph**, to extract faces, discover neighborhood of faces. The edges between faces represent the borders between regions (edge information).
- A behavior to **control the process**, relating to the **dual contraction** of edges and faces. This behavior can provide to region-agent an opinion about fusion. The dual agent informed by the agents that are candidate to merge, initiate edge-agents by information relating to the borders –edges- of regions candidates to the fusion.

An edge-agent starts by calculating its edge -contour-segments by application of the Canny filter. Once the calculation is finished, the dual agent examines the coherence between the edge obtained and the borders of the concerned regions, by evaluating a criterion (C_f) calculated according to the number of points of border of agent ag_i with agent ag_j ($R_{ag_i \ ag_j}$); and the number of points of border of agent ag_i with agent ag_j appertain to an edge ($R_{ag_i \ ag_j}$).

$$C_f = \alpha_1 (F_{ag_i \ ag_j}) + \alpha_2 (R_{ag_i \ ag_j}) \quad (5)$$

$$\alpha_1 + \alpha_2 = 1$$

Thus, an opinion (*avis*) of fusion can be an assent to a fusion between two regions if the criterion (C_f) is lower than a threshold adapted to the image.

$$avis = 1 \quad \text{if} \quad C_f < \text{threshold}$$

Therefore, the detection of a not significant edge separating two regions, lead to an authorization of fusion between two region-agent, that correspond to the annulment of the two faces and the edge that represents a border connecting them. In term of graph, this is equivalent to a dual contraction of edges and faces. The significant edges detected by edge-agent, represent the surviving edges which will be incorporated in the image regions of the level k+1.

The interaction between agents makes it possible to build the various levels of the pyramid. Each level of the pyramid represents an organization of agents. This organization [5], defines the respective role of the agents and the relations connecting them. Among the notions of the multiagents systems, which seemed essential to us, we find: distribution, adaptation and cooperation. In our case, the adaptation is reduced to problem of merging information resulted from the application of various operators (region /edge). The agents cooperate from level to another in order to segment an image, some agents integrate opinion of other agents in their decision-making processes and each agent of one level integrates the results of the agents of the previous level.

V. Conclusion

The image segmentation constitutes the base of the process image interpretation; it remains an active subject of research in artificial vision. Many techniques are available to deal with the image segmentation problems. In this article, we propose to cooperate region based-method and edge based-method by multiagent system in a dual pyramid for image segmentation.

This work is in progress, we envisage implementing various modes of cooperation: cooperation region/edge, region/region and edge/edge in order to ensure the convergence of the segmentation process.

VI. References

[1] P. Bertolino. "*Contributions des pyramides irrégulières en segmentation d'images multirésolution*". Ph.D. thesis, Institut National Polytechnique de Grenoble, 1995

[2] A. Boucher. "U*ne approche décentralisée et adaptative de la gestion d'informations en vision, Application à l'interprétation d'images de cellules en mouvement*". Ph.D. thesis, Université Joseph Fourier, Grenoble, 1999.

[3] J.F. Canny. "*A computational approach to edge detection*". *Patt Ana.Mach. Int*, 1986, pp. 8(6):679-698.

[4] *DDSM: Digital Database for Screening Mammography*. University of South Florida. http://marathon.csee.usf.edu/Mammography/Database.html00

[5] E. Duchesnay. "*Agents situés dans l'image et organisés en pyramide irrégulière. Contribution à la segmentation par une approche d'agrégation coopérative et adaptative*". Ph.D. Université de Rennes-1, 2001.

[6] J. Freixenet, X. Munoz, D. Raba, J. Mart and X. Cufi. *"Yet Another Survey on Image Segmentation: Region and Boundary Information Integration".* ECCV 2002, LNCS 2352, Springer- Berlin Heidelberg, 2002, pp. 408–422.

[7] F. Gaspoz. "*Mammographie digitale & Analyse d'images par ordinateur*". Laboratoire TIMC – IMAG. Faculté de Médecine Grenoble. Université Joseph Fourier Grenoble, France. 2003

[8] L. Germond, M.Dojat, C. Taylor, C. Garbay. "*A Cooperative Framework for Segmentation of MRI Brain Scans*". *Artif. Intell. in Med*. 20 (2000), pp. 277-94.

[9] Y. Haxhimusa, W.G. Kropatsch. "*Hierarchical Image Partitioning with Dual Graph Contraction*". Technical Report PRIP-TR-81, Institute of Computer Aided Automation 183/2, Patt. Recogn. Image. Proc Group, Austria, 2003.

[10] J.M. Jolion and A. Montanvert. "*The adapted pyramid: a framework for 2d image analysis*". Computer Vision Graphics and Image Processing, May 1992, pp. 55(3):339-348.

[11] W.G. Kropatsch. "*Building irregular pyramids by Dual Graph Contraction*". Technical Report PRIP-TR-35, Institute of Automation 183/2, Dept. for Patt. Rec. Image. Proc, TU Wien,Austria, 1994.

[12] H. Macho, W. Kropatsch. "*Finding connected components with dual irregular pyramids*". PRIP, Institute for Automation, AUSTRIA. *In Cinquième Colloque DGCI*, p.147-158. LLAIC1, Université d'Auvergne (1995).

[13] P. Meer. "*Stochastic image pyramids*". *Comp. Vision. Graph. Image Proc*, 1989, pp. 45 (3): 269-294.

[14] N. Selmaoui, W. Kropatsch. "*Watershed by Dual Graph Contraction.*" PRIP - Institute for Automation, 183/2. Vienna University of Technology, Austria (1997).

[15] H. Settache. "*Une plate-forme multi-agents pour la segmentation d'images: Application dans le domaine des IRM cérébrales 2D*". DEA Report, Université de Caen, 2002

[16] D. Willersinn. "*Parallel Graph Contraction for Dual Irregular Pyramids*". PRIP-TR 28, Institute for Automation, 183/2, Technical University of Vienna, Austria, 1994