EXTRACTION AND GROUPING OF THE VISUAL INFORMATION FROM ONE OR MULTIPLE IMAGES

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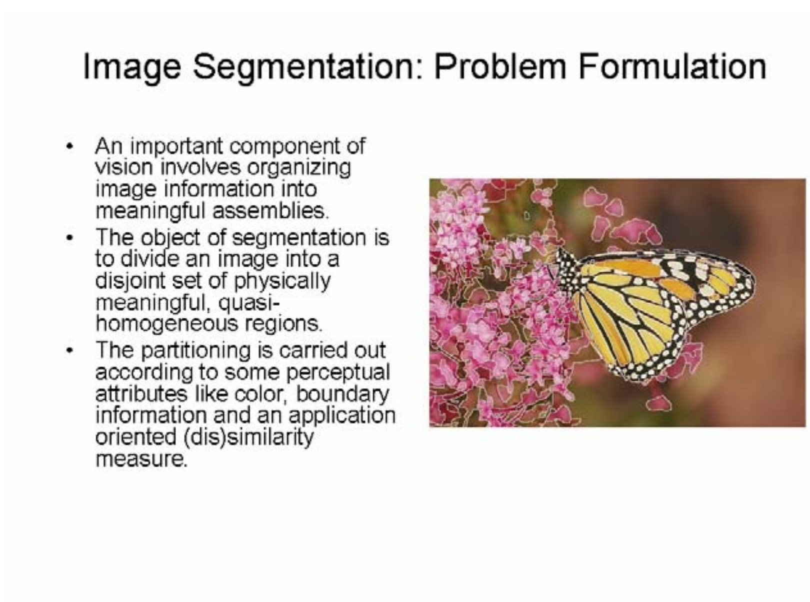
1. Introduction

A central issue in computer vision and image analysis areas is the grouping of visual content into meaningful assemblies, extracted from one (image segmentation) or multiple images (motion segmentation, image registration, image retrieval). Here are presented some considerations that arise in this context and the proposed solutions.

2. Multiresolution Clustering and Graph Partitioning for Perceptual Grouping

The Human Vision System includes a natural and almost unnoticed process that is performed in order to identify portions of the image scene as consistent objects. This is an adaptive operation, which takes into consideration several static and dynamic attributes.

The calculation and organization of some of these perceptual vision attributes is an essential task for the computer vision domain. Depending on the visual entities that

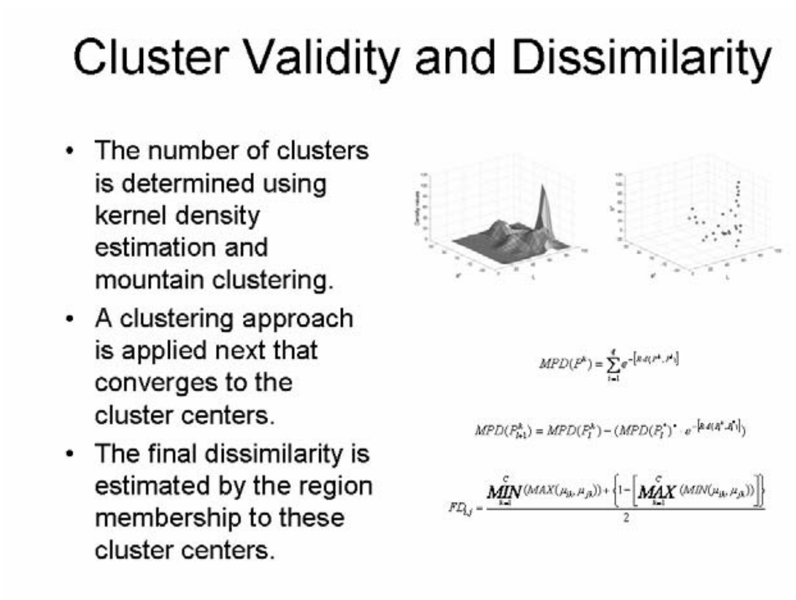


are being measured and processed, and the level of the visual processing information, we can distinguish these tasks into low (segmentation), medium (registration) and high level (content-based information representation and retrieval) approaches.

Mathematically speaking, image segmentation is the process of partitioning the image plane into a set of uniform and disjoint regions. This process is carried out on the basis that objects or substantial parts of them are represented by regions, which are homogeneous according to intensity, color and texture. The partitioning results may be used for other computer vision methods such as object recognition, motion segmentation, face detection, stereo imaging, multimedia analysis, biomedical imaging and cognitive science among others. It can also be stated that many other perceptual grouping or computer vision processes may be implicitly or explicitly related to the segmentation problem.

In this section are presented a dissimilarity measure that emulates the human perception of visual difference, a graph-based combinatorial optimization algorithm for grouping of region entities and a motion segmentation method that employs the principles of differential segmentation and spatial coherence to detect the moving objects.

2.1 Feature-Spatial Domain Cooperative Dissimilarity Measure

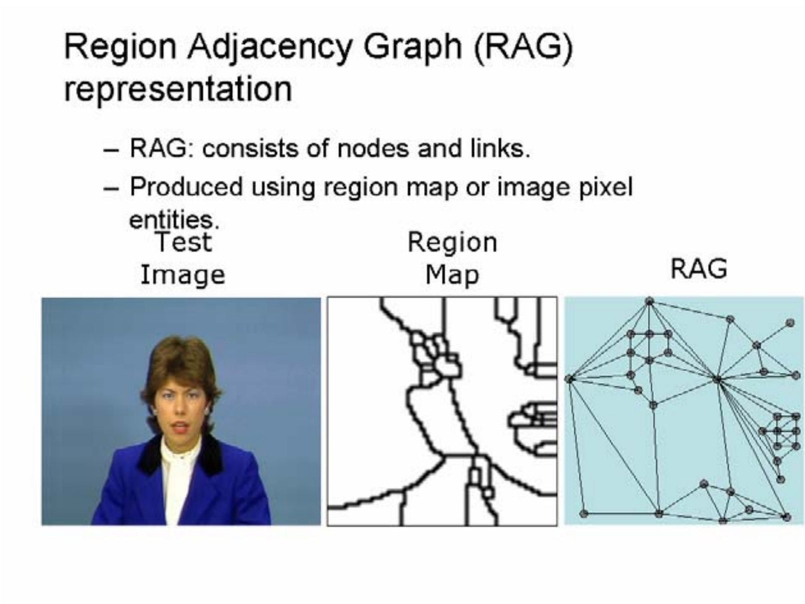


The concept of combining information from two complementary image domains, i.e. spatial and feature space has been recognized by several researchers. Nevertheless, there is still a need to develop a method that will directly incorporate the global feature information into the spatial dissimilarity relation for image segmentation applications.

A fuzzy inter-region dissimilarity relation has been proposed in order to determine the graph-based dissimilarity matrix of the initial partitioning provided by Watershed analysis [1]. More specifically, this inter-region dissimilarity relation may be regarded as a transformation from the employed feature space to the space of fuzzy membership vectors obtained by means of a clustering approach. The dissimilarity between spatial regions is expressed as the distance from the main clusters that are formed by the features of the processed image. This measure is dependent on the data of each image and is characterized as non-metric, since the triangle inequality is not always guaranteed. A fuzzy operator is also applied on these membership vectors to estimate the final dissimilarity values.

Moreover a graph representation is considered in which the nodes are the Watershed regions and the links convey the previously described data-dependent dissimilarity relations. In addition to that, the spatial information is used to set constraints to our optimization problem; the dissimilarity relations -represented by graph links- are defined only for adjacent regions. Two different grouping algorithms are applied next to partition the graph structure, which are based on agglomeration heuristics. The first one is the Shortest Spanning Tree (SST) and the second is a Minimax splitting approach applied on the SST.

2.2 Multiscale clustering and graph-theoretic grouping.



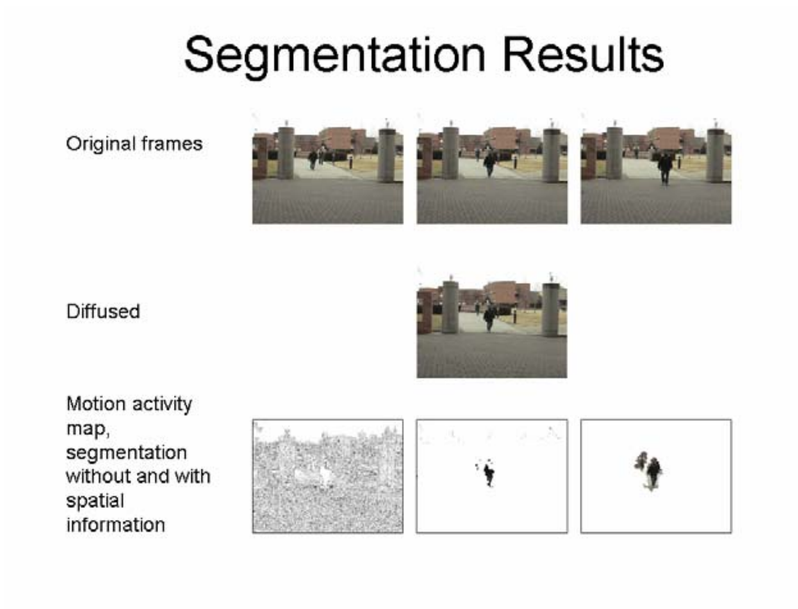
A multiresolution color image segmentation approach has been developed that incorporates the main principles of region-based segmentation and cluster analysis approaches [2].

The Watershed algorithm is routinely employed to produce the initial regions and the feature vectors are calculated over the Watershed regions that define the starting point of our method. The clusters formed by the initial region features are estimated via the Fuzzy C-Means (FCM) algorithm. The latter uses as initial conditions the cluster validity given by non-parametric cluster analysis, i.e. mountain clustering. The multiple resolutions are iteratively generated in the employed feature space by increasing the resolution parameter of the mountain clustering process. The multiscale membership vectors produced by the FCM method are assigned to each Watershed region next, and a multiresolution dissimilarity relation is also defined that will be used in the subsequent merging stage.

The topic of spatial grouping of the visual content is also handled here. It is indicated that region-based segmentation may be described using fuzzy similarity relations and graph theory. In this framework the main weaknesses of merging operations are explained and some existing graph theoretic segmentation approaches are interpreted according to our previous analysis and generalized for the case of region-based segmentation. A compact and generalized formulation of the segmentation process is also given using similarity relations theory. This analysis results in a new merging algorithm that develops a transitivity relation from tolerance relation using the spatial interconnection information. This may be regarded as a Minimax operation applied on the RAG structure. The RAG-Minimax algorithm represents a very efficient segmentation scheme.

This method is expected to operate as an autonomous application to segment and detect objects. An interesting perspective is to make use of the multiscale processing algorithm and the perceptual characteristics of the graph theoretic scheme for object synthesis, to emulate the human visual perception process.

2.3 Motion Analysis using Spatial Coherence



The domain of motion analysis is related to the estimation and recognition of the movement of scene objects and the ego-motion of the imaging sensor. Motion segmentation is the detection and partitioning of the moving objects derived from a sequence of images.

The analysis of image sequences is very popular with applications to multimedia coding and description, surveillance, target tracking and navigation systems. The motion analysis and segmentation approaches may be generally divided into the categories of image differencing, optical flow-based methods and spatio-temporal methods.

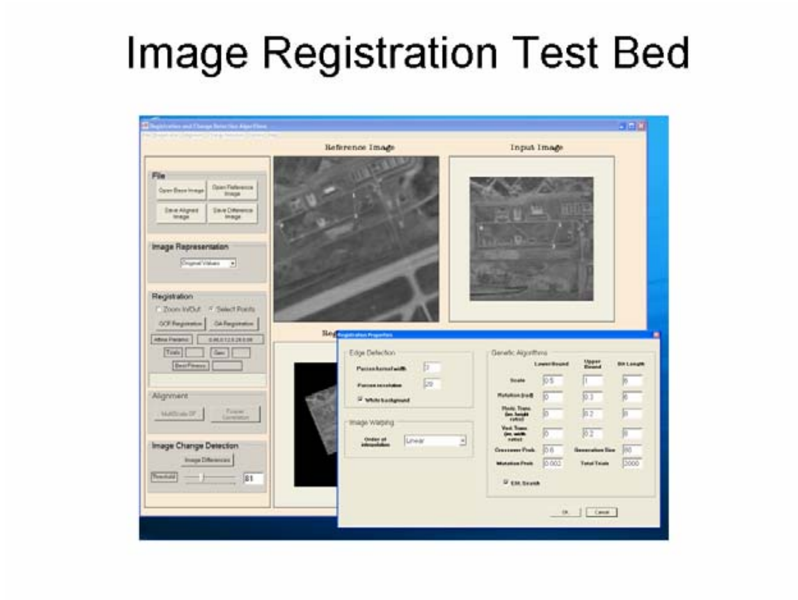
A motion analysis scheme has been developed to detect and segment moving areas for assistive vision technology. The main stages of this approach include the video stabilization approach, a spatio-temporal diffusion approach that produces a motion activity measure and a Parzen kernel-based method to create a probability map for moving objects. The final area is detected by means of watershed segmentation.

The proposed methodologies were developed to operate in an integrated environment as an assistive vision technology tool for motion segmentation, tracking and object recognition scheme. Our future objectives are to include an object recognition scheme to identify humans and to investigate the real-time implementation of the proposed scheme.

3. Image Registration using Stochastic Optimization

Image registration is the process of geometrically aligning two images of the same scene that have been taken under varying conditions. It is usually employed as the first stage of other computer vision schemes and the applications of image registration include medical imaging, remote sensing, robot vision, motion detection and guidance systems, stereo vision and pattern recognition. In the remote sensing field it is frequently being used for change detection, topographic mapping and urban planning among others. For the case of change detection, the objective is to find the differences between two images of the same scene that have been taken from variable viewpoints, at different times, using different cameras and sensors.

A registration method for aerial images that contain temporal and viewpoint variations has been developed. The misregistered images might also include variable terrain and the process is required to be automated. The main element of this scheme is a stochastic optimization scheme that uses Genetic Algorithms (GA’s) to reduce the search space that is defined by the Affine Transform parameters. The resampling operation is carried out using spline interpolation and several similarity measures have also been developed and compared w.r.t. the registration accuracy.



References

[1] S. Makrogiannis, G. Economou and S. Fotopoulos, “A Region Dissimilarity Relation that combines Feature-Space and Spatial Information for Color Image Segmentation”, IEEE Trans. on Systems, Man and Cybernetics: Part B, vol. 35, no 1, pp. 44-53, February 2005.

[2] S. Makrogiannis, G. Economou, S. Fotopoulos and N. G. Bourbakis, “Segmentation of Color Images Using Multiscale Clustering And Graph Theoretic Region Synthesis”, IEEE Trans. on Systems, Man and Cybernetics: Part A, vol. 35, no. 2, pp. 224-238, March 2005.

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