Available online at www.sciencedirect.com
SCIENCE DIRECT®
J. Vis. Commun. Image R. 16 (2005) 333–358
Journal of Visual Communication & Image Representation
www.elsevier.com/locate/jvci

A logic framework for active contours on multi-channel images ☆

Berta Sandberg, Tony F. Chan *

UCLA, Mathematics Departement, 405 Hilgard Avenue, Los Angeles, CA 90095-1555, United States

Received 19 February 2004; accepted 18 August 2004
Available online 11 November 2004

Abstract

We propose a mathematical framework for object detection using logic operations as a structure for defining multi-channel segmentation. The model combines object information from the different channels into *any* logic combination. We consider active contour methods which use one initial contour that would evolve from the information given in each channel simultaneously. Specific models are derived based on the single-channel region based "active contours without edges" [IEEE Trans. Image Process. 10 (2) (2001) 266] model. Numerical experiments show that the method is able to find general intersections, unions, and complements of the regions of objects of both synthetic and realistic images.

Keywords: Multi-channel; Segmentation; Logic operations; Active contours

1. Introduction

Much has been written on active contour segmentation of multi-channel images. There are papers that discuss methods for color images (Sapiro, 1997; Zhu and

☆ This work was supported in part by ONR Contract N00014-96-1-0277, NSF Contract DMS-9973341 and NIH P20 MH65166.
* Corresponding author. Fax: +1 310 206 6673.
E-mail addresses: bsand@math.ucla.edu (B. Sandberg), chan@math.ucla.edu (T.F. Chan).

1047-3203/$ - see front matter
doi:10.1016/j.jvcir.2004.08.005

Yuille, 1996; Dibos and Koepfler, 1997), texture images convolved with filters (Chan et al., 2002; Sapiro and Ringach, 1996; Paragios and Deriche, 1999), multispectral images with occlusion in some channels and noise in others (Chan et al., 1999), and image sequences (Guichard, 1998; Yezzi and Soatto, 2003). Many of these models attempt to extract parts of an object from each of the channels and to recombine this information in a logical fashion. In most of these cases, the segmentation is some combination of occluded objects, or a combination of noisy images.

An example of occluded channels is given in Fig. 1. Most models for multi-channel segmentation would find a triangle that is the union of both channels as the desired segmentation.

While taking the union is reasonable, our view is that this is too limiting. We want to define a general framework, which allows the user to choose any logical combination of object information from each channel depending on the specific application. These segmentations can be described using combinations of intersection, union, and negation of the objects in the images. The user decides which logic operator is appropriate for the segmentation. In Fig. 2, examples of logic segmentation are given using union, intersection, and negation.

In this paper, we would like to stress two areas of interest that we cover. We define a logic framework for multi-channel image segmentation, as a general idea, regardless of the segmentation model used. This opens up solutions that have not been given previously, and explains the segmentation solutions that have been solved by other models. We then apply the logic framework to a region based model, Active Contours without edges (Chan and Vese, 2001). For a region based model, we found that models which treat inside the region and outside the region in the same manner, will have these two sides competing. For example, if we want the union of the objects

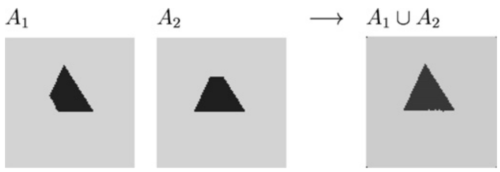

Fig. 1. A synthetic example of an object (a triangle) in two different channels. In A_1, the lower left corner is missing. In A_2 the upper corner is missing. Most multi-channel models converge to the union of the objects that are in the channels.

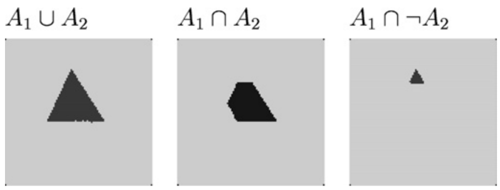

Fig. 2. Different logical combinations for the sample image, $A_1 \cup A_2$ is the union of the objects in each channel, $A_1 \cap A_2$ is the intersection, $A_1 \cap \neg A_2$ the object in A_1 that is not in A_2.