Chapter 7

A Robust Color Watershed Transformation and Image Segmentation Defined on RGB Spherical Coordinates

Ramón Moreno
Universidad del País Vasco, Spain

Manuel Graña
Universidad del País Vasco, Spain

Kurosh Madani
University PARIS-EST Creteil, Senart-FB Institute of Technology, France

ABSTRACT

The representation of the RGB color space points in spherical coordinates allows to retain the chromatic components of image pixel colors, pulling apart easily the intensity component. This representation allows the definition of a chromatic distance and a hybrid gradient with good properties of perceptual color constancy. In this chapter, the authors present a watershed based image segmentation method using this hybrid gradient. Oversegmentation is solved by applying a region merging strategy based on the chromatic distance defined on the spherical coordinate representation. The chapter shows the robustness and performance of the approach on well known test images and the Berkeley benchmarking image database and on images taken with a NAO robot.

INTRODUCTION

Image pre-processing and image segmentation are key steps on robotic vision. On the one hand, humanoid robots are in continuous movement, changing of sceneries, changing of point of view, and in all cases illumination conditions could be unstable and different, e.g. a robot can go by walk from a corridor with natural illumination to a room with tungsten illumination. In this case, a robust image pre-processing is key in order to normalize the image respect to the illumination. On the other
hand, when the image is already normalized, the
following step, is the information extraction. The
most used is the segmentation process. This step
divides the image in some regions such that these
regions can be identified as objects in the scene.
For this work, we have found robustness respect
to the illumination through spherical coordinates,
and for segmentation we will use a watershed
transform with a region merging directed by the
image chromaticity.

Color images have additional information over
gray scale images that may allow the development
of robust segmentation processes. There have been
works using alternative color spaces with better
separation of the chromatic components like HSI,
HSL, HSV, Lab (Angulo & Serra, 2007; Hanbury
& Serra, 2001) to obtain perceptually correct
image segmentation. However, chromaticity’s
illumination can blur and distort color patterns.
Color constancy is the perceptual mechanism
which provides humans with color vision which
is relatively independent of the spectral content
of the illumination of a scene. It is the ability of
a vision system to diminish or, in the ideal case,
remove the effect of the illumination, and therefore
“see” the true physical scene as the invariant to
illumination changes. To obtain color constancy,
one approach consists in the estimation of the il-
illumination source chromaticity followed by the
chromatic normalization of the image. There are
several approaches in the literature to achieve this
goal (Tan, 2003; Yoon, 2005; Toro, 2008) assum-
ing a uniform chromaticity of the illumination all
over the scene. Other approaches try to obtain
segmentation procedures which are inherently
robust to illumination effects (Mallick, 2005; Zick-
ler, 2006). The segmentation method proposed in
this paper has inherent color constancy due to the
color representation chosen and the definition of
the chromatic distance.

Color constancy is closely related to the re-
sponse of the gradient operators (Geusebroek,
2003). Regions of constant color must have low
gradient response, while color edges must have
a strong gradient response. Image segmentation
methods based on spatial gradients need a correct
definition of the spatial color gradient and unam-
biguous contour definition. In fact, formulation of
watershed segmentation methods in color images
is still an open research issue (Aptoula, 2007). A
straightforward but inexact approach is the inde-
pendent application of the watershed segmenta-
tion on image channel (Tarabalka, 2010). This
approach loses chromatic information, and has
difficulties merging the subsequent independent
segmentations into one.

In this work we will use the RGB spheri-
cal coordinates representation to achieve color
constancy properties of our image segmentation
approach (Moreno & Graña, 2010; Moreno &
d’Anjou, 2010; Moreno & Zulueta, 2010). We
define a chromatic distance on this representa-
tion. The robustness and color constancy of the
approach is grounded in the dichromatic reflec-
tion model (DRM) (Shafer, 1984). We propose
a chromatic gradient operator suitable for the
definition of a watershed transformation on color
images and a robust region merging for meaningful
color image segmentation. The baseline chromatic
gradient operator (R. Moreno & d’Anjou, 2010;
Moreno, 2010) suffers from noise in the dark areas
of the image. We propose in this work a hybrid
gradient operator overcoming this problem. We
use it to build a watershed transformation on
color images. To achieve a natural segmentation,
we perform region merging on the basis of our
proposed chromatic distance over the chromatic
characterization of the watershed regions. We
give a general schema that combines watershed
flooding with region merging in a single process.
Finally, we specify our proposal as an instance of
the aforementioned general schema.

This work is motivated for its application
on robotic context; therefore it needs of a good
speed-up (close to real time). The method is
implemented in C# and the results are shown
in the color image segmentation section where
we will give more details. We have used a NAO
robot. The images taken by the NAO robot are
noisy due to the movements of the robot and to