# Texture Segmentation by Minimizing Vector-Valued Energy Functionals: The Coupled-Membrane Model ⋆

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**Abstract.** This paper presents a computational model that segments images based on the textural properties of object surfaces. The proposed Coupled-Membrane model applies the weak membrane approach to an image $\mathcal{W}I(\sigma, \theta, x, y)$, derived from the power responses of a family of self-similar quadrature Gabor wavelets. While segmentation breaks are allowed in x and y only, coupling is introduced to in all 4 dimensions. The resulting spatial and spectral diffusion prevents minor variations in local textures from producing segmentation boundaries. Experiments showed that the model is adequate in segmenting a class of synthetic and natural texture images.

## 1 Introduction

This paper presents a computational model that segments images based on the textural properties of object surfaces. The proposed model distinguishes itself from the previous models in texture segmentation [Turner 1986, Voorhees and Poggio 1988, Malik and Perona 1989, Fogel and Sagi 1989, Bovik, Clark and Geisler 1990, Reed and Wechsler 1990, Geman et al 1990] in the following way.

Previous models have started with the extraction from the image $I(x, y)$ of some set of texture features which can be viewed as forming auxiliary texture images $I_\alpha(x, y)$. Then applying either region growing, boundary detection, or (in the single paper [Geman et al 1990]) a membrane-like method combining these two, a segmentation is derived. In our model, the texture features are the power responses of quadrature Gabor filters. These filters form a continuous family depending on two variables $\sigma, \theta$, and can be derived like wavelets from dilation and rotation of a single filter. Thus we think of the texture features as combining into a single image $\mathcal{W}I(\sigma, \theta, x, y)$ depending on *4 continuous variables.* We apply the weak membrane approach to segmenting this signal, in which coupling is introduced in all 4 dimensions, but breaks are allowed in x and y only. We call this the *Coupled- Membrane model.*

Why is this model useful? Previous methods generally deal only with textures that are statistically stationary (i.e. approximately translationally invariant) and not too granular (e.g. with widely spaced textons, or large local variations). But natural textures do not satisfy either: Firstly, they show considerable texture 'gradients', in which the power distribution of the texture among various channels changes slowly but systematically over

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