Image Segmentation using Markov Random Field Model

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Introduction

We are interested in the image segmentation problem from a pixel labelling approach: each pixel of an image is assigned to a label $z \in \mathcal{Z}$, where $\mathcal{Z}$ is the class of labels available. The label assignment is achieved by using a parametrized probablistic model.
The parameters are:

1. The mean of pixel values for each class $\mu(z)$
2. The variance of pixel values for each class $\sigma(z)$

Sometimes we also parametrize the prior assumption of the label assignment to enforce boundary smoothness condition

Framework

The prior assumption is modelled by:

$$P(I = x; \theta) = \frac{1}{\beta} e^{-U(x)}, \tag{1}$$

where β is the partition function and U is the energy function.
The conditional probability is modelled by:

$$P(Z_{ij} = z | I = x; \theta) = \frac{1}{(2\pi\sigma(z)^2)^{MN/2}} e^{\frac{-||x-\mu(z)||^2}{2\sigma(z)^2}}, \tag{2}$$

where σ and μ are the variance and mean dependent on the label z.
From (1) and (2), we can compute the objective function:

$$P(Z_{ij} = z | I = x; \theta) = P(I = x; \theta) P(Z_{ij} = z | I = x; \theta). \tag{3}$$

Methods

We use two different approaches to optimize the non-convex problem:

1. PHTS search
2. EM

PHTS search

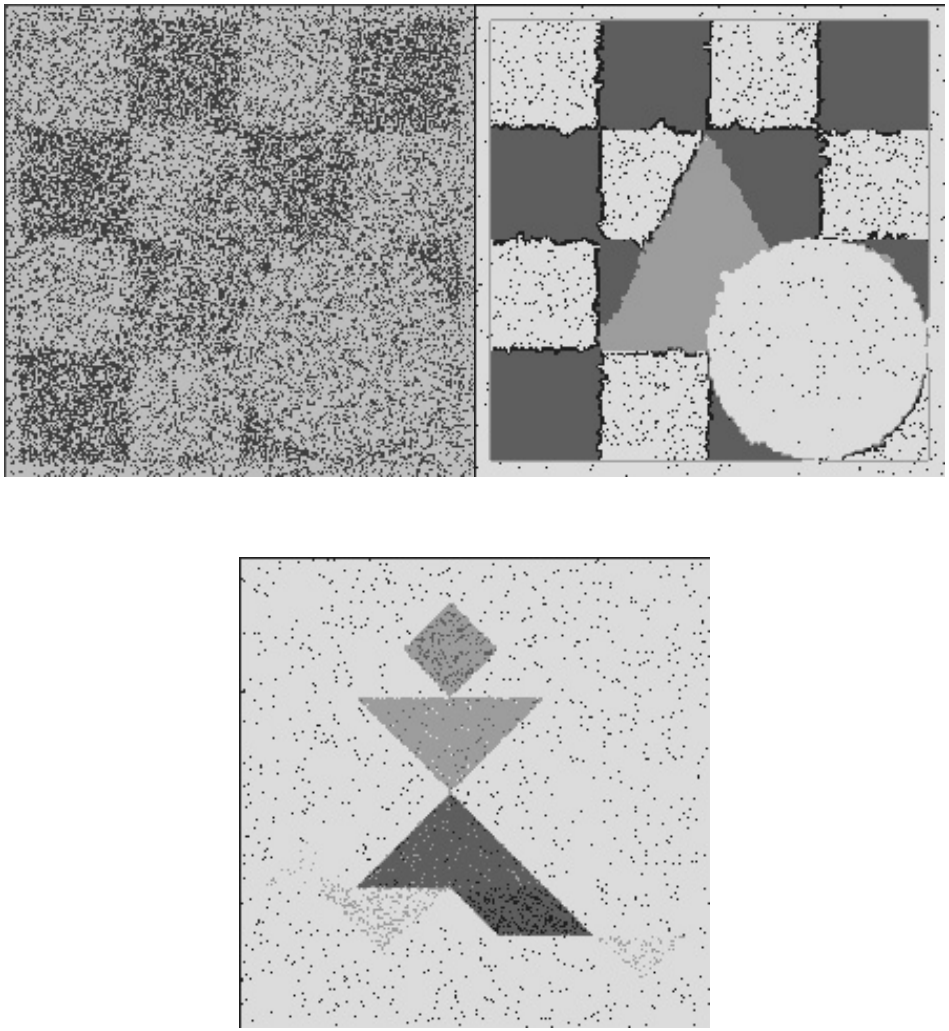

Figure: EM Segmentation with four/two classes of label

EM