Efficient MRF Deformation Model for Non-Rigid Image Matching

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Abstract

The motivation of this project comes from the registration of 3D faces. Using Discrete Ricci Flow and conformal mapping, we can map a 3D face onto a 2D image. Registration work is done on this 2D image. Our project focuses on the second step. We use MRF energy to represent the matching problem and minimize the energy to achieve our goal. This work has been specified in [1].

1 Introduction

Face registration is always widely used in many areas. In medical field, cosmetology demands accurate registration between face models of the same person to see the change as time. And this market worths billions of dollars in United States.
According Prof. Xianfeng David Gu's previous work, a face 3D model could be mapped onto a 2D image using conformal mapping. Based on this work, we focus on the image registration using Markov Random Field(MRF). We define a MRF energy function and try to minimize it to get the deformation, which transforms an image to another. As for the optimisation method, we use both Iterative Conditional Modes(ICM) and TRW-S, and compare the results of them.
We will introduce the algorithm in Section 2, and present the result in Section 3. Future work will be found in Section 4.

2 MRF Energy Function

2.1 Define Energy Functioin

Since we use MRF to register two images, we need to define the MRF energy function.
Let $L = \{1...K\}$ be a set of labels. Let $G = (V, E)$ be a graph with $E \subseteq V \times V$. Each graph node is assigned with a label $x_s \in L$ and a labeling or configuration is defined as $\mathbf{x} = \{x_s | s \in V\}$. So the energy of a configuration $\mathbf{x}$ is defined as

$$E(\mathbf{x}|\theta) = \sum_{s \in V} \theta_s(x_s) + \sum_{st \in E} \theta_{st}(x_s, x_t) \quad (1)$$

where $\{\theta_s(i) \in \mathbb{R} | i \in L, s \in V\}$ is unary potentials and $\theta_s(x_s)$ is referred as the unary term. $\{\theta_{st}(i,j) \in \mathbb{R} | i, j \in L, st \in E\}$ is pairwise potentials and $\theta_{st}(x_s, x_t)$ is the pairwise term. The probablity distribution defined as

$$p(\mathbf{x}|\theta) \propto \exp(-E(\mathbf{x}|\theta)) \quad (2)$$

is a Gibbs distribution corresponding to a certain Markov Random Field(MRF). Thus the problem of maximize a posteriori(MAP) configuration corresponds to the energy minimization $\min_{\mathbf{x}} E(\mathbf{x}|\theta)$.

2.2 Improvements

2.2.1 Block Model

2.2.2 Distance of Blocks

3 Minimize Energy Function

3.1 ICM

3.1.1 ICM Pipeline

3.1.2 Result

3.2 TRW-S

3.2.1 TRW-S Pipeline

3.2.2 Result

4 Summary and Future Work

References

[1] Alexander Shekhovtsov, Ivan Kovtun, and Václav Hlaváč. Efficient mrf deformation model for non-rigid image matching. *Computer Vision and Image Understanding*, 112(1):91–99, 2008.