1. Introduction

- Fibered confocal fluorescence microscopy (FCFM) has recently gained prominence in investigating the presence of bacteria in the distal lung [1].
- A bacterium’s diameter is usually smaller than the width of the fibre core as well as the gap between two consecutive fiber cores.
- A bacterium appears as a high intensity dot in the image frame and, tends to ‘blink’ on and off in consecutive image frames.

2. Problem Formulation

Observation model:

\[ y = x + r + e \]

- \( y \in \mathbb{R}^N \): observed samples.
- \( x \in \mathbb{R}^N \): actual intensity values.
- \( r \in \mathbb{R}^N \): outliers (\( r = z \odot t \)), where \( z \in \{0, 1\}^N \) is the label vector, and \( t \) is the outlier amplitude.
- \( e \in \mathbb{R}^N \): Gaussian noise \( N(\sigma_N, \sigma_e^2 I_N) \)

3. Proposed Bayesian Model

Likelihood:

- The function of the unknown parameters \((x, z, \sigma^2)\) given the observed data \(y\).

Parameter prior distributions:

- Intensity field \(x\): Gaussian Markov random fields prior.
- Noise variance \(\sigma^2\): Non-informative Jeffreys’ prior.
- Outlier amplitude \(t\): Conjugate Gaussian prior.
- Label vector \(z\): Bernoulli Markov random fields prior.
- Conjugate priors for the hyperparameters associated with the parameters mentioned above (regularization parameter \(\gamma^2\), outlier mean \(\mu\), and outlier variance \(\sigma^2\)).

Joint posterior distribution:

- Bayes’ theorem to compute the joint posterior distribution.

Bayesian inference:

- Gibbs sampler to generate random variables according to the conditional distributions of the parameters and their associated hyperparameters [2].
- Final label vector \(z\) is estimated by marginal maximum a posteriori (MAP) estimation.

4. Simulations Using Synthetic Data

- Denoising of a subsampled version of the standard image of Lena.
- A subsampled image is created by considering the sampling pattern of an actual FCFM.

Evaluation criterions:

- Denoising \(\rightarrow\) root mean square error (RMSE).
- Detection \(\rightarrow\) receiver operating characteristics (ROC) graph.

5. Simulations Using Real Data

- Images of ex vivo Sheep lungs instilled with bacteria.
- Eight videos with 130 total frames.
- A trained clinician marked the co-ordinates of phenomena in the images that he believes to be bacteria.

6. Conclusions and Future Work

Conclusions:

- A Bayesian approach for bacteria detection in FCFM lung tissue images was proposed.
- Good performance on synthetic and real datasets.

Ongoing and future work:

- Validation on an increasing bacteria concentration dataset.
- Bacteria tracking by taking advantage of the temporal information in the datasets.

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References