A CONNECTED-TUBE MPP MODEL FOR OBJECT DETECTION WITH APPLICATION TO MATERIALS AND REMOTELY-SENSED IMAGES

Tianyu Li, Mary Comer, Purdue University, USA
Josiane Zerubia, Université Côte d'Azur, Inria, France

Abstract

- A connected-tube model based on a Marked Point Process (MPP) for strip feature extraction in images is proposed
- A mixed MPP model can be formed by combining the proposed model with other geometric models
- The proposed model can be applied to complex detection tasks, such as short and long fiber detection in material images, road and roof detection in satellite images.

Introduction

- Traditional MPP model works well in figure 1, but may not work well with objects whose size varies over a wide range, as shown in figure 2.
- We propose a connected-tube model based on a MPP. Instead of modeling the long fiber by an ellipse object, we model it as a series of connected tubes.
- Advantages:
- The size of the tubes can be controlled in a smaller range
- The tube model can be combined easily with the ellipse or rectangle model to form a mixed MPP model.

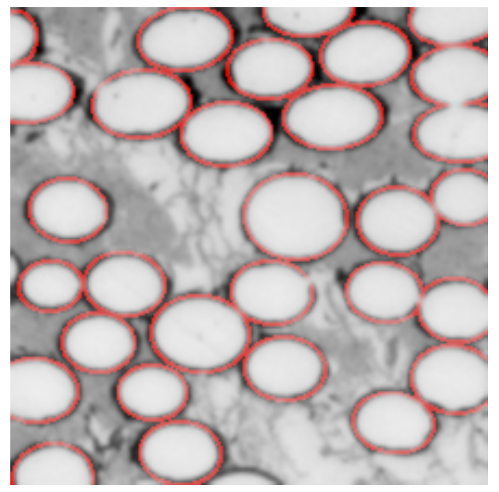

Figure 1. MPP result on ellipse fiber detection

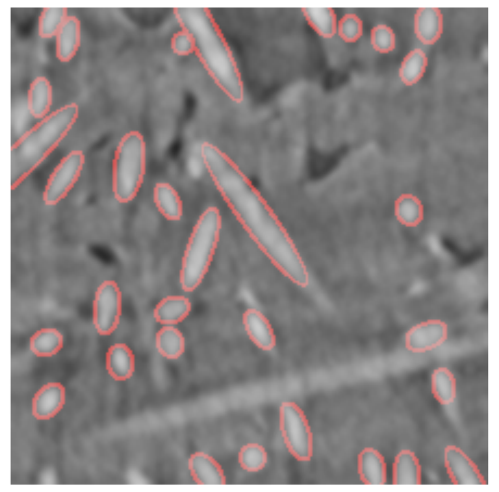

Figure 2. MPP result on long fiber detection

	MLR	MSR	OD
ellipse MPP	81.53%	4.22%	2.10%
mixed MPP	9.23%	1.40%	4.89%

Table 1. Fiber Detection Evaluation. (missed long fiber rate: MLR, missed short fiber rate: MSR, and over-detection rate: OD)

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Model and Algorithm

- The density of the mixed marked point process of ellipses and tubes is given by

$$f(w|y) = \frac{1}{Z} exp\{-V_d(y|w) - V_p(w)\} \quad (1)$$

where w is the object configuration, y is the observed image, Z is a normalizing constant, $V_d(y|w)$ is the data energy, which describes how well the objects fit the observed image. $V_p(w)$ is the prior energy introducing the prior knowledge on the object configuration.

$$V_d(y|w) = \sum_i V_d(y|w_i) \quad (2)$$

where $V_d(y|w_i)$ describes how well object w_i fits the observed image y. In our model, it is characterized by the contrast between the inner(white) area and outer(green) area in figure 3.

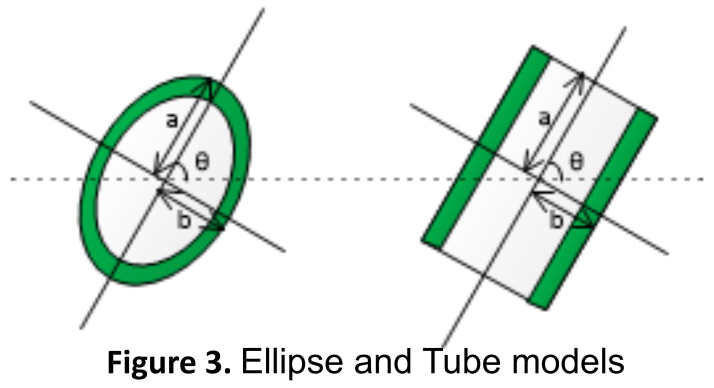

Figure 3. Ellipse and Tube models

$$V_p(w) = \alpha V_p^{ol}(w) + \beta V_p^{len}(w) + \gamma V_p^{con}(w) \quad (3)$$

where $V_p^{ol}(w)$ is the overlap prior, which penalizes the object overlap with other objects. $V_p^{len}(w)$ is the length prior, which penalizes the short tube objects. $V_p^{con}(w)$ is the connection prior, which encourages the tubes to be connected. α, β and γ are weights for each term, which are set by trial and error.

- We define the joint area of a tube object, as the two circle areas shown in figure 4.
- We suppose that the joint area of each tube object can overlap the joint area of any other tube object.

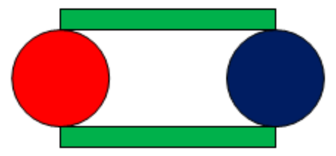

Figure 4. Joint area of a tube object

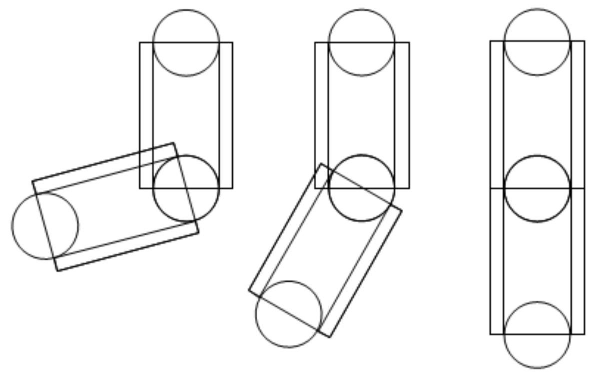

Figure 5. Illustration of connection relationship between tubes

- Optimization: RJMCMC (birth and death kernel, affine perturbation kernel and switch kernel).

Results

- We test the mixed-MPP model on 10 images of dimension 308×308.
- The missed long fiber rate(MLR), missed short fiber rate(MSR), and over-detection rate(OD) are listed in Table 1.

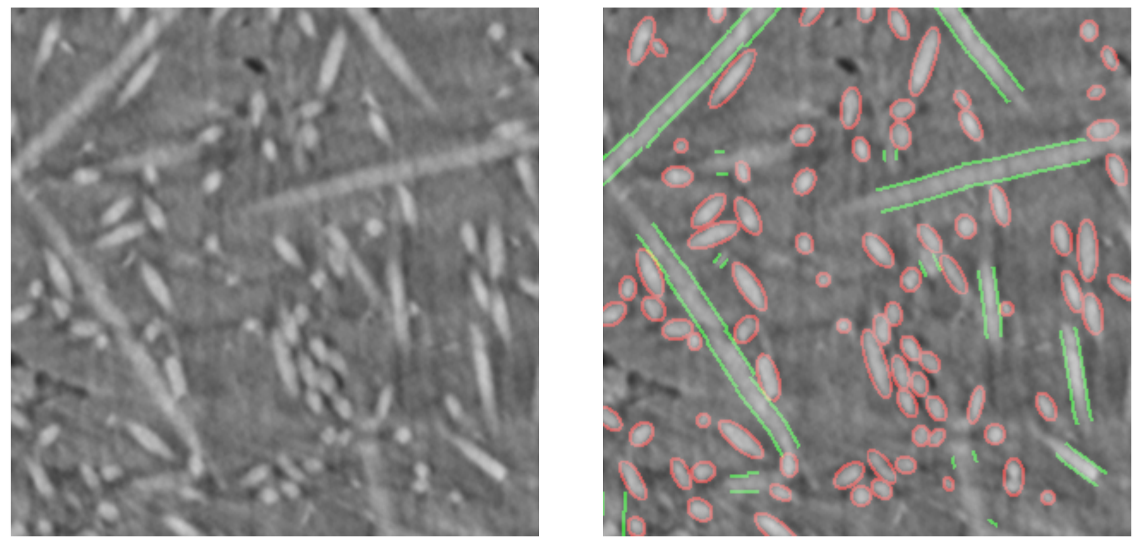

Figure 6. Fiber detection on Fiber-Reinforced Composite Material image (Courtesy of Prof. Mike Sangid, Purdue University)

- We also test the proposed model on remotely sensed images to show its potential for detecting roads and roofs.

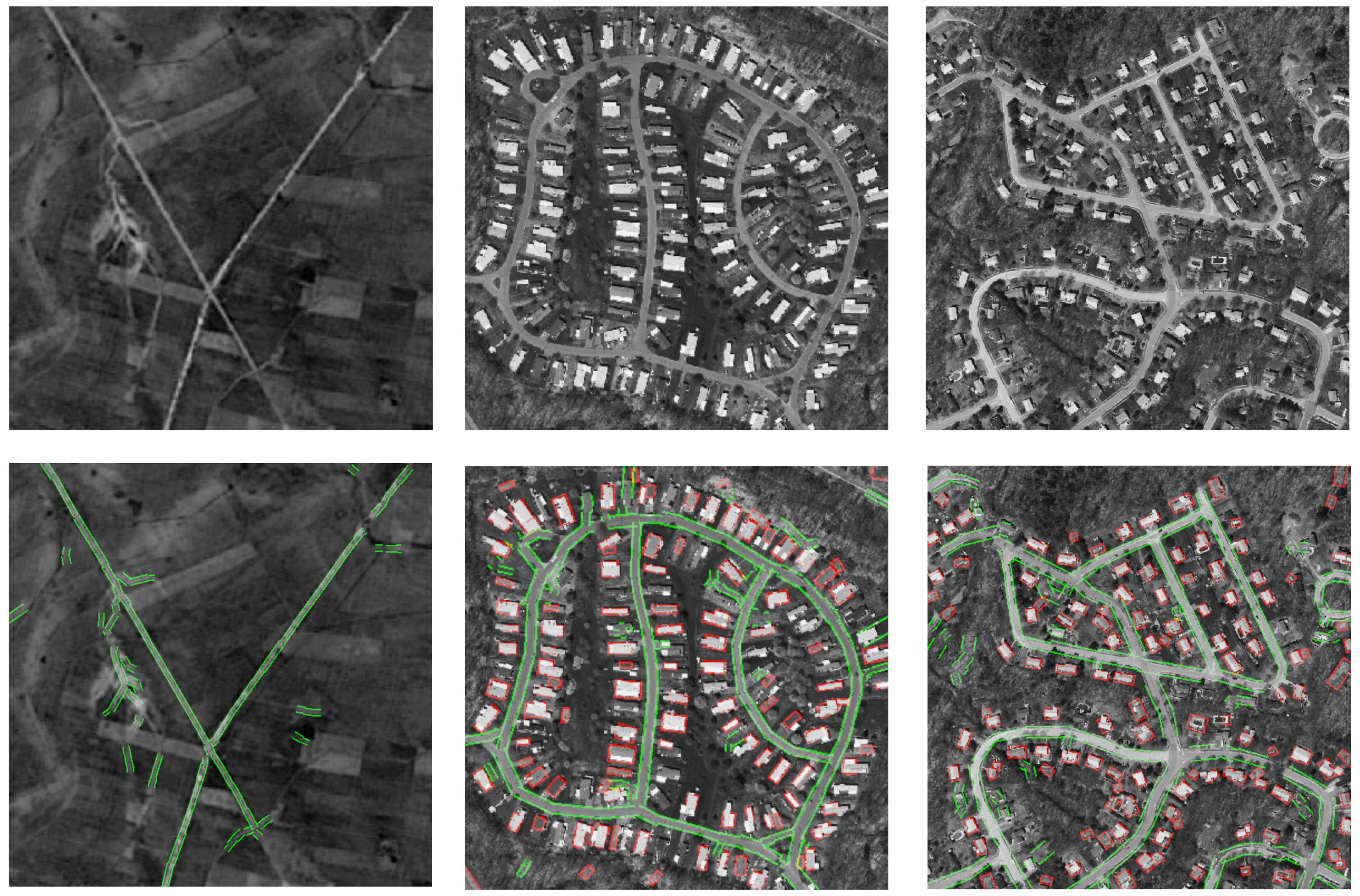

Figure 7. Road and roof detection. Upper row: original satellite images; Bottom row: results obtained with the proposed method.

Conclusions

- A connected-tube model based on marked point processes has been proposed.
- By combining it with an ellipse model, a mixed MPP model is built, which solves the problem of wide mark range in MPP model for detecting the fibers in material microscopy images.
- The tests of our model on remotely sensed images shows its potential for detecting roads and roofs.

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