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Usage of the Laplace Transform as a Basic Algorithm of Railroad Tracks Recognition

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Abstract

In this paper we consider an algorithm of railroad tracks recognition. Our approach is based on the usage of the Laplace transform as a basic algorithm.

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The edge of an image is one of the most basic features of the image. It contains a wealth of information of the image. Edge detection is one of the key research works in image recognition. Note that the current image edge detection methods are mainly differential operator technique and high-pass filtration. But, in recent years, researchers generally support the view that the most primitive of the differential and gradient edge detection methods are complex and the effects are not satisfactory (see e.g. [1]). The widely used operators such as Sobel, Prewitt, Roberts and Laplace are sensitive to noises and their anti-noise performances are poor. Nevertheless, in this paper we consider an algorithm of railroad tracks recognition which use the Laplace

Figure 1: The Laplace transform with $\sigma = 2$.

Figure 2: A threshold filter with $threshold = 100$.

transform as a basic algorithm. In particular, we use the Laplace transform in the form

$$\mathrm{Laplace}(f) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}.$$

For our implementation of the Laplace transform we use the Sobel transform

$$\nabla f(x,y) = \left(\frac{\partial f}{\partial x}\frac{\partial f}{\partial y}\right)^T = (G_x G_y)^T$$

where we define A as the source image,

$$G_x = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} * A,$$

$$G_y = \begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{pmatrix} * A,$$

and $*$ denotes the 2-dimensional convolution operation.

Obviously, usage of the Laplace transform can give us only some image edge detection (see e.g. figure 1). So, for railroad tracks recognition we need some additional transformations.

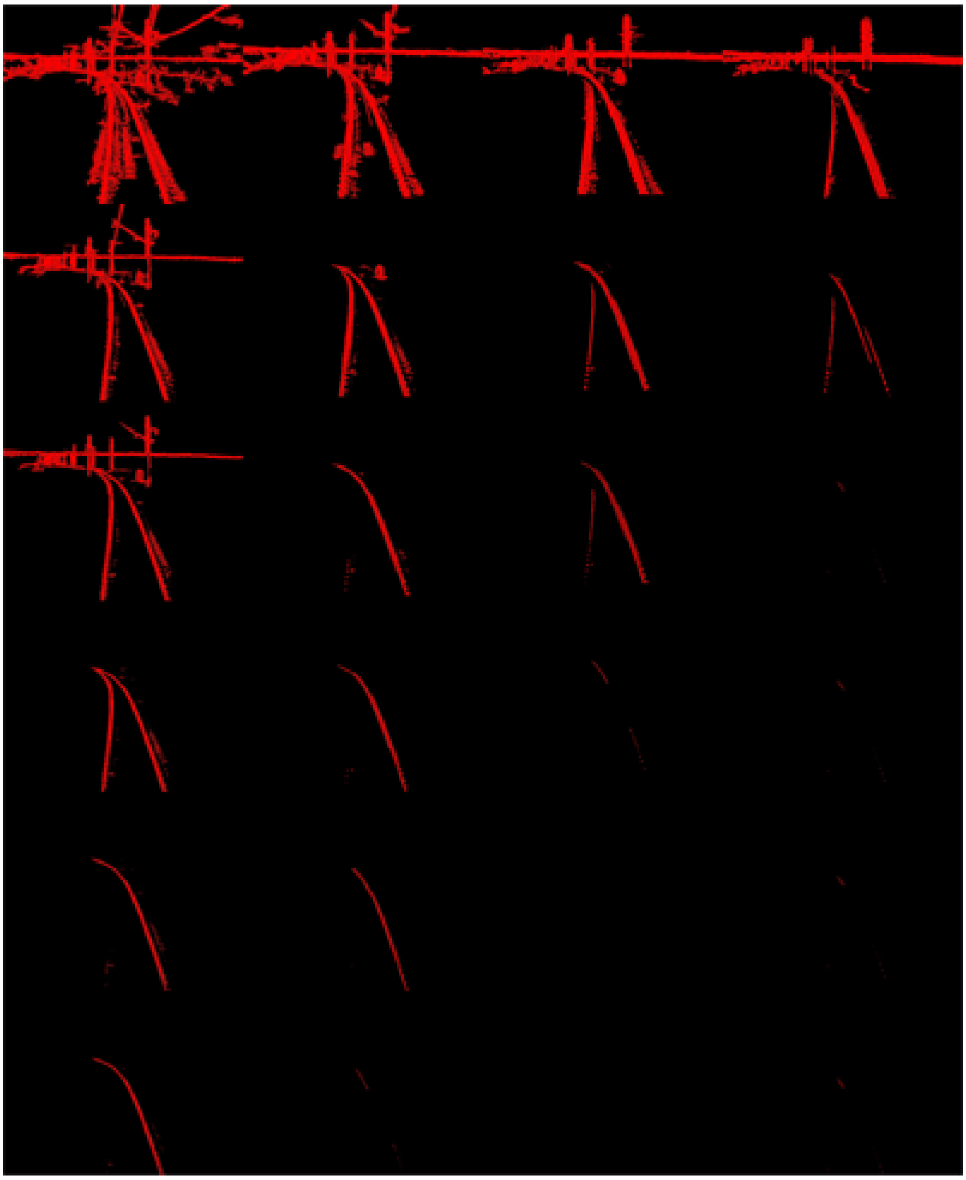

Figure 3: Results of intelligent algorithm for different values of σ and *threshold*. $\sigma \in \{1, 2, 3, 4\}, threshold \in \{30, 70, 110, 150, 190, 230\}$.

First of all, we convert the image to grayscale. After that, we use a threshold filter (see e.g. figure 2).

We apply an intelligent algorithm of edge selection to the resulting image. This algorithm is based on the predefined knowledge about railroad tracks (see figure 3).

Also this algorithm need a system of self-awareness (see e.g. [2, 3, 4, 5]) for correct detection of proper railroad tracks (see figure 4) and prediction

Figure 4: Multiple railroad tracks.

Figure 5: Railway embranchment.

Figure 6: Results of intelligent algorithm for $\sigma = 2$ and $threshold = 100$.

of rotations (see figure 5). However, the main part of this algorithm is an intelligent module of prediction of values of σ and *threshold*. Note that there are no unique values of σ and *threshold* that can provide a high level of railroad tracks recognition. In particular, in case of figure 3 we have $\sigma = 1$ and $threshold = 110$. But, in case of figure 6 we have $\sigma = 2$ and $threshold = 100$.

Although the Laplace transform requires a significant post-processing, it gives us a very important advantage. We do not need to modify edges. We can use entire edges.

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