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Amplitude-only log Radon transform for geometric invariant shape descriptor

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ABSTRACT

A shape descriptor combining the Radon transform, the amplitude extraction, and the log-mapping is proposed in this paper. It is invariant to shape rotation, scaling, and translation. Invariance to translation is achieved by amplitude extraction on the radial coordinate. Rotation and scaling are log-mapped into two-dimensional translations and recovered with the phase-only correlation function. In addition, all transformation parameters (rotating angle, scaling factor, and position shift) can be determined also. The efficiency of the proposed descriptor compared to existing methods is shown experimentally on different kind of datasets.

1. Introduction

Shape representation and matching are very important techniques for object recognition. In document analysis, they are used in character, symbol, or logo recognition [1]. In computer vision, shape recognition is a task of finding a given object in an image. It is a common requirement that, in applications that involve shape recognition, the recognition performance is invariant to shape transformations (rotation, scaling, and translation) and noise. In the literature, various methods have been proposed and applied to many systems, each has its own pros and cons.

Fourier transform has been used as the starting point for the proposal of many shape descriptors. The generic Fourier descriptor (GFD) proposed by Zhang and Lu [2] is a typical one, and it is invariant to rotation. However, in the case of translation and scaling, GFD needs normalizations. The phase-only correlation function (POC) proposed by Kuglin [3] has been shown to be effective for shape matching. The correlation between two images is calculated using their Fourier transform's phase spectra and this makes the computed results invariant to translation. However, when the shape is rotated and scaled, the matching precision decreases remarkably. For this reason, POC needs normalizations to be invariant to rotation and scaling.

Sheng and Duvernoy have proposed a method called the Fourier–Mellin transform (FMT) [4]. First, the authors map the input image into the polar coordinate system; then, the one-dimensional Mellin transform and the one-dimensional Fourier transform are performed on the radial and angular coordinates of the polar image respectively. Their method is robust to rotation and scaling but it needs a translation normalization. Generally

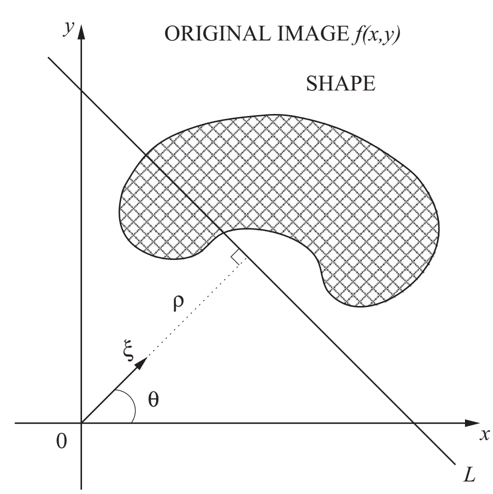

Fig. 1. Graphical illustration of the Radon transform.

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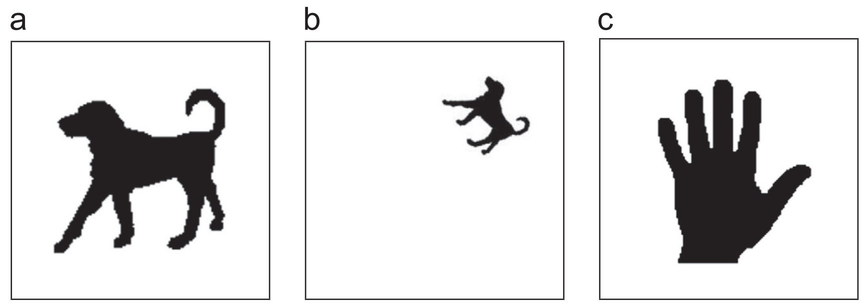

Fig. 2. Examples of original images. (a) and (b) respectively The "Dog" image and its RST version, (c) the "Hand" image.

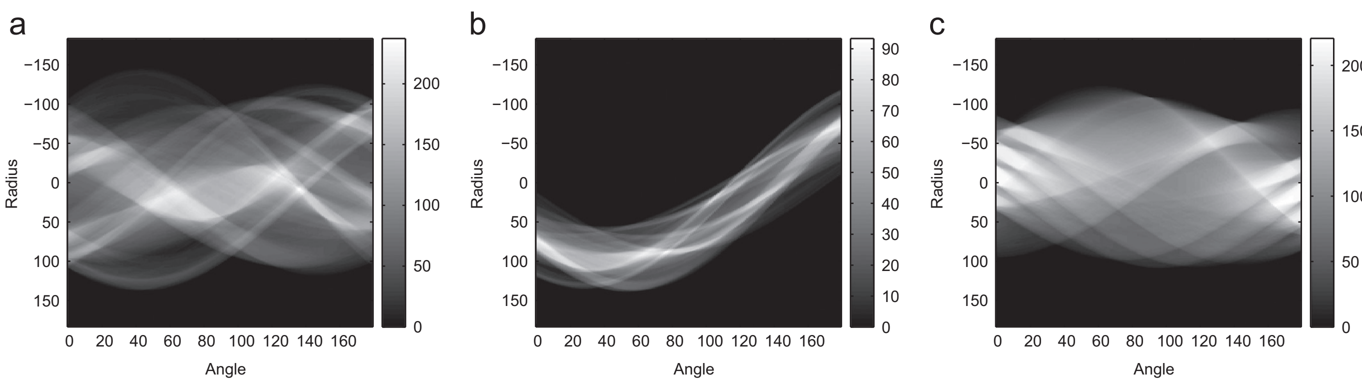

Fig. 3. The Radon transform: (a), (b), and (c) are the results using the original image of Fig. 2(a), (b), and (c) respectively.

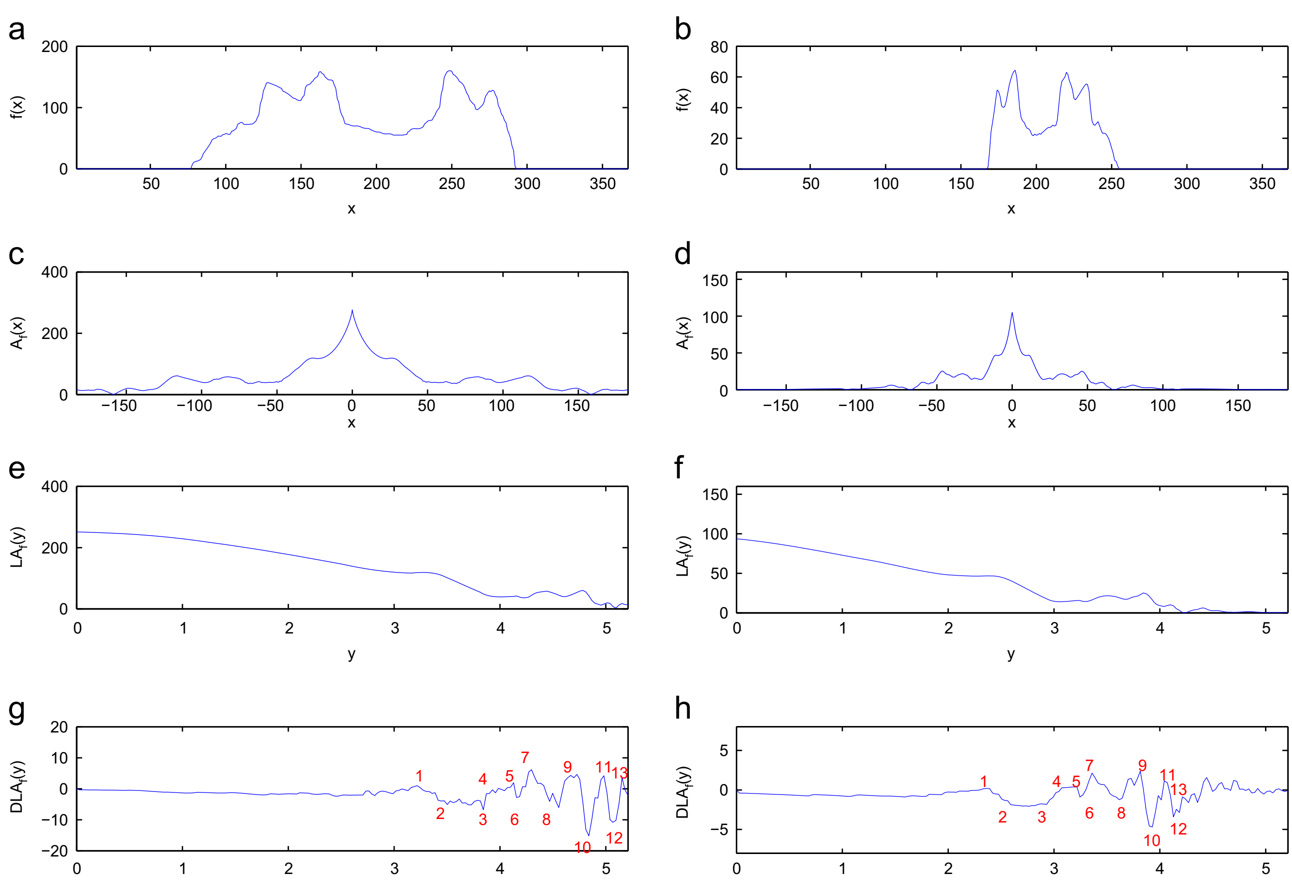

Fig. 4. (a) and (b) respectively original 1d signals from the Radon domain (a column of Fig. 3(a)) for $\theta = 0$, and $\theta = 120$. (c) and (d) Amplitude-extracted signals $\mathcal{A}_f(y)$ and $\mathcal{A}_g(y)$ respectively. (e) and (f) Results of the log-mapping $\mathcal{LA}_f(y)$ and $\mathcal{LA}_g(y)$ respectively from the half domain (c) and (d) ($x \geq 1$). (g) and (h) Results of the differentiation $\mathcal{DLA}_f(y)$ and $\mathcal{DLA}_g(y)$ respectively.