11. INTRODUCTION

Some interest regions of an image can be parameterized with descriptors. Local image descriptor are used for solving different image processing tasks like stereo matching [1], object recognition [2], video indexing [3], panorama building and others. The image points matching is the basic task that can be considered as a subproblem in more comprehensive problems mentioned above.

The procedure of points matching using local image descriptors consists of three steps. The first step is keypoints detection. The second step is to construct feature vector of a support region surrounding each keypoint. This feature vector is called keypoint descriptor or local image descriptor. The third step is to measure the similarity between keypoints descriptors of the first image and keypoints descriptors of the second image. Using the constructed descriptors the points of the images can be matched. In this paper we focus on the first and the second step of the points matching process.

There are many approaches to the keypoints detection problem such as Harris corner detector [4], DoG approach presented by Lowe [5], the approach based on circular harmonic functions theory [6, 7], etc. The problem of keypoints descriptor construction is also widely presented in literature [5, 6, 8]. The invariance of descriptors to rotation and scaling is the goal properties of local image descriptors. Satisfying these properties one can achieve the stability of matching across multiple views. As the majority of keypoints descriptors construction algorithms are computationally expensive, development of efficient computation algorithms becomes actual.

In this paper the keypoints detection and local descriptor construction multiscale approach based on Gauss—Laguerre circular harmonic functions [6] is considered. The main drawback of this technique is its high computational complexity. To resolve this drawback the efficient computational algorithm based on Hermite projection method is proposed.

The structure of the paper is the following: in the Section 2 the Gauss—Laguerre keypoints detection algorithm is considered, Section 3 is devoted to Gauss—Laguerre local keypoints descriptors construction, the acceleration algorithm is presented in the Section 4 and test results are described in the Section 5.

2. KEYPOINTS DETECTION

Let us consider a family of complex orthonormal and polar separable functions:

$$\Psi_n^{\alpha}(r, \gamma; \sigma) = \psi_n^{kl}(r^2/\sigma)e^{i\alpha \gamma}, \quad n = 0, 1, \ldots; \alpha = 0, \pm 1, \pm 2 \ldots.$$
Their radial profiles are Laguerre functions:

$$\psi_n^\alpha(x) = \frac{1}{\sqrt{n!\Gamma(n+\alpha+1)}}x^{\alpha/2}e^{-x/2}L_n^\alpha(x),$$

where $L_n^\alpha(x) = (-1)^n x^{-\alpha}e^x (x^\alpha x^{-\alpha})^{(n)}$ are Laguerre polynomials.

The Laguerre functions $\psi_n^\alpha(x)$ can be calculated using the following recurrence relations:

$$\psi_{n+1}^\alpha(x) = \frac{(x-\alpha-2n-1)}{\sqrt{(n+1)(n+\alpha+1)}}\psi_n^\alpha(x)$$

$$-\frac{n(n+\alpha)}{(n+1)(n+\alpha+1)}\psi_{n-1}^\alpha(x), \quad n = 0, 1, \ldots,$$

$$\psi_0^\alpha(x) = \frac{1}{\sqrt{\Gamma(\alpha+1)}}x^{\alpha/2}e^{-x/2}, \quad \psi_{-1}^\alpha(x) = 0.$$

The functions $\Psi_n^\alpha$ are called Gauss–Laguerre circular harmonic functions (CHF) and they are referenced by integers $n$ (radial order) and $\alpha$ (angular order). The real and imaginary parts of $\Psi_n^\alpha$ for $n = 0, 1, \ldots, 4; \alpha = 1, 2, \ldots, 5$ are illustrated in Fig. 1. In each cell of Fig. 1 the real part of $\Psi_n^\alpha$ is depicted on the left and the imaginary part is on the right.

Let $I(x, y)$ denote the observed image defined in Cartesian coordinates. As $\Psi_n^\alpha$ functions form the complete orthonormal system in $L_2(-\infty, +\infty) \times L_2(-\infty, +\infty)$ this image can be expanded in the neighborhood of the analysis point $x_0, y_0$ for fixed $\sigma$ as:

$$I(x, y; \sigma) = \sum_{\alpha=-\infty}^{\infty} \sum_{n=0}^{\infty} g_{n, \alpha}(x_0, y_0; \sigma)\Psi_n^\alpha(\rho, \omega; \sigma),$$

where

$$g_{n, \alpha}(x_0, y_0; \sigma) = \int \int I(x, x_0, y, y_0)\Psi_n^\alpha(\rho, \omega; \sigma)dx dy,$$

$$\rho = \sqrt{x^2 + y^2}, \quad \omega = \arctan \frac{y}{x}.$$