Fast Eigen Matching

Accelerating Matching and Learning of Eigenspace method

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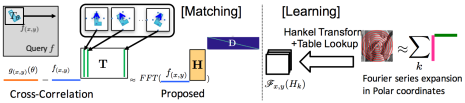

Fig. 1: Overview of the proposed method

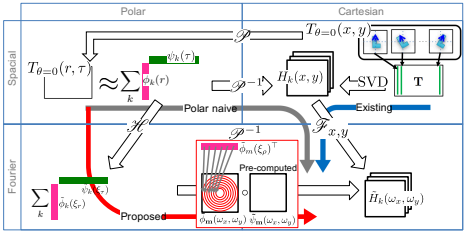

Fig. 2: The learning algorithm.

We propose *Fast Eigen Matching*, a method for accelerating the matching and learning processes of the eigenspace method for rotation invariant template matching (RITM).

Correlation-based template matching is one of the basic techniques used in computer vision. Among them, rotation invariant template matching (RITM), which locates a known template in a query irrespective of the template's translation and orientation, has been widely put to use in many industrial applications. A naive implementation of RITM requires intensive computation since one needs to correlate query f with N rotated templates $\boldsymbol{T}$ (Fig.1 left). Eigenspace methods takes advantage of the fact that a set of correlated images $\boldsymbol{T}$ can be approximately represented by a small set of *eigenimages*. Once *eigenimages* and it's 2D-Fourier transform are computed in learning process, matching process of RITM can be performed very efficiently using these 2D-Fourier transform*ed eigenimages*[1].

It is also important to speedup the learning process, especially for applications such as global robot localization, where a template changes frame by frame and efficient online learning is required. The existing eigenspace methods are not feasible for problem settings of this kind, because it requires a lot of time for generation of rotated templates, SVD and 2D-FFT.

To speed up the matching and the learning process of existing Eigenspace methods, we propose *Fast Eigen Matching* by exploiting FFT and Hankel Transform. Our contributions are as follows:

Speedup the Matching process By focusing on the circularity of in-plane rotation and concentration of power spectrums to low frequency, we compute *fast-eigenimages* $\boldsymbol{H}$ by expanding a templates using Fourier basis, which leads to the use of FFT in a matching process (Fig.1 left).

Speedup the Learning process By utilizing the fact that Fourier expansion in polar coordinates is efficiently transformed to frequency domain using Hankel transform[2], our method computes 2D-Fourier transform of each *fast-eigenimages* $\tilde{\boldsymbol{H}}$ in polar coordinate (Fig.1 right Fig.2). This computation is equivalent to existing learning method, i.e., time-consuming rotated template generation, numerical SVD and 2D-FFTs in Cartesian Coordinates, but substantially boosts the learning process by avoiding these time-consuming computation.

Our experiments revealed that the learning, matching, and total processes respectively becomes 120, 3, and 36 times faster, while keeping comparable matching performance compared to previous method. As a representative example, we show an application to global localization with a Particle Filter.

[1] Gou Koutaki and Keiichi Uchimura. Occlusion Robust Pattern Matching Using Shape Based Eigen Templates. *IEEJ Transactions on Electronics, Information and Systems*, 133(1):134–141, 2013.

[2] Robert Piessens. The hankel transform. 2000.