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SIFER: Scale-Invariant Feature Detector with Error Resilience

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Abstract We present a new method to extract scale-invariant features from an image by using a Cosine Modulated Gaussian (CM-Gaussian) filter. Its balanced scale--space atom with minimal spread in scale and space leads to an outstanding scale-invariant feature detection quality, albeit at reduced planar rotational invariance. Both sharp and distributed features like corners and blobs are reliably detected, irrespective of various image artifacts and camera parameter variations, except for planar rotation. The CM-Gaussian filters are approximated with the sum of exponentials as a single, fixed-length filter and equal approximation error over all scales, providing constant-time, low-cost image filtering implementations. The approximation error of the corresponding digital signal processing is below the noise threshold. It is scalable with the filter order, providing many quality-complexity trade-off working points. We validate the efficiency of the proposed feature detection algorithm on image registration applications over a wide range of testbench conditions.

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1 Introduction

Feature point detection and matching are preliminary stages in the image processing of many computer vision applications such as image registration, panorama creation, 3D reconstruction, object recognition, camera calibration, robot navigation, etc. Corners (Mikolajczyk and Schmid 2004) and blobs (Lowe 2004; Bay et al. 2008) of various sizes are typical local image features that are detected by filtering the image in a multi-scale filterbank. The first and second order Gaussian derivative filters are widely used emphasizing the planar rotational invariance (Lowe 2004; Bay et al. 2008; Mikolajczyk and Schmid 2004).

In this paper, we present a novel algorithm to detect scale invariant features by using the Cosine Modulated Gaussian (CM-Gaussian) filter. This filter has a balanced scale-space atom and minimal Heisenberg's uncertainty spread in both scale and space simultaneously. This paper's contribution is the detection of image feature points that are more strongly resistant to variation of scale, resolution, zoom, blur, motion--blur, illumination, image compression and noise, at the expense of giving up on planar rotational invariance compared to state-of-the-art methods (Lowe 2004; Bay et al. 2008). The detected local image features are described with location, orientation, scale or size and a feature descriptor. We denote our approach by "SIFER", because it sieves image features of different granularities, while being strongly resistant to image artifacts. The scale-invariant feature detection algorithm follows a system design paradigm where the quality of features detected is dependent on the scale-space filter specifications, as well as their integration into a non-linear