Optik 124 (2013) 4685–4692

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Efficient numerical analysis of optical imaging data: A comparative study

David Duarte-Correa [a], Alberto Pastrana-Palma [a], Carlos A. Olvera-Olvera [a], Sergio R. Ramírez-Rodríguez [c], Daniel Alaniz-Lumbreras [b], Domingo Gómez-Meléndez [d], Ismael de la Rosa [b], Salvador Noriega [e], Vianey Torres [e], Victor M. Castaño [a,*]

[a] Universidad Autónoma de Querétaro, Cerro de las Campanas s/n, 76010 Querétaro, Mexico
[b] Unidad Académica de Ingeniería Eléctrica, Doctorado en Ingeniería Universidad Autónoma de Zacatecas, Jardín Juárez 146, Centro Histórico, Zacatecas, Mexico
[c] Tlachia Systems S.A. de C.V., Calle 13 de septiembre No.1, Niños Héroes, C.P. 76010 Querétaro, Mexico
[d] Universidad Politécnica de Querétaro, Carretera Estatal 420 S/N, El Rosario, C.P. 76240 El Marqués, Querétaro, Mexico
[e] Departamento de Ingeniería Industrial y Manufactura, IIT, Universidad Autónoma de Ciudad Juárez, Av. P.E. Calles 1210, Fovissste Chamizal, C.P. 32310 Juárez, Chihuahua, Mexico

ARTICLE INFO

Article history:
Received 5 September 2012
Accepted 20 January 2013

Keywords:
Interest points
Detector
Computing time

ABSTRACT

The computational efficiency of 14 optical detectors over six types of transformations, namely: blur, illumination, rotation, viewpoint, zoom, and zoom-rotation changes, was analyzed. Images with the same resolution (750 × 500 pixels) were studied, in terms of correspondences, repeatability and computing time, and the correspondence was measured by using homographies *i.e.* projective transformations, to obtain the best efficiency for imaging applications. Results show that the multi-scale Harris Hessian detector is the most efficient for blur, illumination, and zoom-rotation changes. Meanwhile, multi-scale Hessian and Hessian Laplace are the best methods for rotation, viewpoint, and zoom changes.

1. Introduction

A fundamental issue in computer vision is image matching of optical data. The main problem in object recognition is finding correspondences between two optical images of the same scene, taken from arbitrary viewpoints, with different cameras, scaling, rotation, and illumination conditions. Different solutions have been developed over the past few years by using interest points detectors. These approaches first detect characteristic features and then compute a set of descriptors for these features [1–5].

Among the different types of transformations for image recognition, feature detection has become the most widely used. In this method, at least few features must be present in both images in order to allow correspondences. Features shown to be particularly appropriate are called keypoints [5]. These features have also been referred as salient points or interest points in the literature [1]. These interest points are typically blobs, corners and junctions. Additionally, there is no universal detector or descriptor, but a combination of complementary operators seems to be a reasonable solution [9]. If the change of scale between images is unknown, a simple way to deal with this change is to extract points at several scales and use them to represent the image, *i.e.* a multi-scale approach. In this approach, generally a local image is presented in a defined scale range. The points are then detected at each scale within this range. As a consequence, there are many points that represent the same structure, however the location and scale of points is slightly different. The unnecessary high number of points increases the probability of mismatches and the complexity of the matching algorithms. In this case, efficient methods for rejecting the false matches and for verifying the results are required [6].

On the other hand, optical detectors and descriptors are relevant methods to extract meaningful features for image recognition. Studies that measure correspondence, occurrence, and accuracy within images have been recently reported [6–10]. However, just a limited number of works actually compare the efficiency of these methods. Generally speaking, the main goal of the detection methods is to recognize image regions with covariant transformations, which are used as support regions to compute invariant descriptors. In this work we present evaluations of detection methods in different contexts. The same scene or object is observed under different viewing conditions: blur, illumination, viewpoint, rotation, zoom, and zoom-rotation changes.

Accordingly, this paper compares the efficiency and repeatability of the leading detector algorithms reported in the literature. The evaluation was carried out by using the following detectors [6]:

* Corresponding author at: On sabbatical leave at CIATEQ , Centro de Tecnologia Avanzada, Queretaro, Mexico.
E-mail address: meneses@unam.mx (V.M. Castaño).

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http://dx.doi.org/10.1016/j.ijleo.2013.01.116