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Fast similarity metric for real-time template-matching applications

Fernando E. Correa-Tome · Raul E. Sanchez-Yanez

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Abstract In this study, a visual similarity metric based on precision–recall graphs is presented as an alternative to the widely used Hausdorff distance (HD). Such metric, called maximum cardinality similarity metric, is computed between a reference shape and a test template, each one represented by a set of edge points. We address this problem using a bipartite graph representation of the relationship between the sets. The matching problem is solved using the Hopcroft–Karp algorithm, taking advantage of its low computational complexity. We present a comparison between our results and those obtained from applying the partial Hausdorff distance (PHD) to the same test sets. Similar results were found using both approaches for standard template-matching applications. Nevertheless, the proposed methodology is more accurate at determining the completeness of partial shapes under noise conditions. Furthermore, the processing time required by our methodology is lower than that required to compute the PHD, for a large set of points.

keywords Maximum cardinality similarity metric · Template matching · Hausdorff distance · Hopcroft–Karp algorithm

1 Introduction

Computer vision plays an important role in many applications nowadays. It is used to extract meaningful information from digital images and video, aiming to reproduce the human visual abilities. The extraction of such information normally requires the identification of objects in a scene and, before this information can be extracted, the presence of the object itself needs to be ascertained. The object is then located in the scene by obtaining different spatial features, such as translation, scale and orientation. For some video applications, the extraction of information needs to be performed in real-time, meaning that the processing time for a single frame (i.e. an image) is required to be below the frame rate of the video. Owing to this restriction, the video application requires to be optimized in time, and arises the need for fast algorithms.

To achieve real-time object detection, the volume of data and the complexity of the algorithms involved need to be reduced to fit the time requirements. In their article, Hossain et al. [11] point out that edge information offers more robustness than intensity information. Moreover, using edge information significantly reduces the amount of information to be processed. Nevertheless, object detection in edge images is affected by noise, changes in illumination, occlusions and small differences in edge locations for video sequences. Rucklidge [27] proposes a method based on the Hausdorff distance (HD) to identify objects under affine transformations in edge images, and Knauer et al. [17] propose a methodology also based on the HD that handles imprecision of the data. In both articles, the HD provides the robustness required to overcome the aforementioned problems found in edge images. Nevertheless, obtaining the HD is computationally expensive, having a $O(n^2)$ complexity.

A number of approaches aim to use the HD in a more efficient way, to reduce the computing time required. Rucklidge [26] proposes a set of methods to efficiently

F. E. Correa-Tome · R. E. Sanchez-Yanez (✉)
Universidad de Guanajuato DICIS, Comunidad de Palo Blanco, 36885 Salamanca, Guanajuato, Mexico
e-mail: sanchezy@ugto.mx

F. E. Correa-Tome
e-mail: fe.correatome@ugto.mx

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