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Original

Real time non-rigid surface detection based on binary robust independent elementary features

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Abstract

The surface deformation detection of an object has been a very popular research project in recent years; in human vision, we can easily detect the location of the target and that scale of the surface rotation, and change of the viewpoint makes the surface deformation, but in a vision of the computer is a challenge. In those backgrounds of questions, we can propose a framework that is the surface deformation, which is based on the detection method of BRIEF to calculate object surface deformation. But BRIEF calculation has some problem that can't rotate and change character; we also propose a useful calculation method to solve the problem, and the method proved by experiment can overcome the problem, by the way, it's very useful. The average operation time every picture in continuous image is 50~80 ms in 2.5 GHz computer, let us look back for some related estimation technology of surface deformation, and there are still a few successful project that is surface deformation detection in the document.

Keywords: BRIEF descriptor; Binary descriptor; Non-rigid surface; Deformation detection

1. Introduction

Object surface deformation detection has been a rather popular research topic in recent years and subsequent applications have also been extensive. Augmented reality (AR) is an interesting man-machine interaction technology in which a filming camera is used in combination with an effective algorithm for image calculation to enable interaction between people and virtual images, making hardware equipment become more than just computation tools but also allowing lively and fun man-machine interaction. The incessant quest of humans for novelty, speed, and innovation has provided the drive behind advancements in information technology and prices have also become more affordable, unlike the high costs that limited the availability of hardware equipment in the past. Kinect, that Microsoft released for Xbox 360 in 2010, for instance, was a breakthrough both in hardware performance and price wise. Previously, hardware equipment of such specifications could easily cost hundreds of thousands of New Taiwan (NT) dollars, but today people are able to acquire such equipment by spending a few thousand dollars.

Due to the affordability of hardware prices and upgrades in computation speeds, the growth of AR application and services has been amazing. The market value increase from 2010 to 2013 has been rather considerable. This means that object surface deformation estimation will remain a worthwhile topic and objective of studies for quite some time.

Feature descriptors, sometimes called descriptors, have always been a popular research topic and a tough challenge. They are commonly used in algorithms for target detection and further applications such as automatic control, product inspection, face identification, and object tracking, etc. Such subsequent applications have resulted in problems that need solving, including detection of change of angle of view, scale and rotation of objects and multi-targets. Therefore, an effective algorithm is required to solve these problems. A detector is used to locate in an image the keypoints which can be edges or corners. The keypoints are then filtered to keep only the ones that meet the established conditions. The purpose is to facilitate detection and reduce the quantity of keypoints to be processed. The descriptors are applied to describe the features, such as the size and shape of an eye, to make the keypoints more distinguishable. In the end, matching between the template and the target is conducted and match results are generated. (Baker & Matthews, 2004) proposed a theory called image alignment to depict other algorithms and framework extension.

Scale-Invariant Feature Transform (SIFT) is a feature description method proposed by Lowe (2004). It is a pioneer in the feature description. When the SIFT algorithm is applied,

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the difference of Gaussians (DoG) is used first to figure out the gradient changes because distinct features like edges and corners are needed to calculate gradient directions in order to establish a pyramidal image to indicate the different scales, in other words different scaling ratios. In subsequence, feature description is conducted. The feature description in this paper is conducted from block to block to calculate the different gradient directions around a feature to identify the primary and secondary gradient directions, equip them with rotational invariance, and establish the descriptors (Yasmin et al., 2014; Yasmin et al., 2013).

H. Bay put forth Speeded Up Robust Features (SURF) (Bay et al., 2006), and proposed to apply the Hessian matrix to locate changeable keypoints and consolidate integral images to achieve scale invariance, same as the steps to establish the pyramidal image. The method greatly improved the bottleneck in SIFT computation speed because, after obtaining the overall integer value, it only requires the Hessian matrix of different sizes to indicate the image ratio changes resulted from different scales. Then, the keypoints around each keypoint are calculated and the direction with the most keypoints is regarded the direction of the said keypoint to achieve rotational invariance. Finally, the features around the keypoint are divided into feature descriptors carrying a symbol and not carrying a symbol.

M. Calonder came up with the Binary Robust Independent Elementary Features (BRIEF) (Calonder et al., 2010) algorithm. Since detectors used in algorithms developed in the past, such as SURF, could be used in search of initial keypoints and scales, Edward Rosten proposed in 2010 the FAST corner detector, while Elmar Mair also put forward the AGAST corner detector. Both algorithms were not only able to search initial keypoints quickly, but also reliable and capable of effectively reducing the cost of initial computation; they were therefore suitable to provide a good foundation for establishment of subsequent descriptors, while different image scale changes could also be identified by using integral images. They proposed the use of binary descriptors to break through the bottleneck encountered in studies on subsequent descriptor computation so that the cost of matching and descriptor computation could be reduced.

ORB (Rublee et al., 2006) is an algorithm proposed by Microsoft researcher E. Rublee in 2010. The paper was primarily to suggest ways to improve the defect of lack of rotational invariance of BRIEF, its initial keypoint filtering mechanism, and calculation of different keypoint directions. The keypoint search and scale changes could still be conducted in reference to detection methods adopted in algorithms developed in the past. In the beginning, the FAST method was applied to locate the keypoints in an image. The keypoints located were filtered to select the most reliable keypoints. Then, future directions are calculated in accordance with the intensity centroid of each of the selected keypoint to establish binary descriptors.

S. Leutenegger presented Binary Robust Invariant Scalable Keypoints (BRISK) (Leutenegger et al., 2011) in 2012. The main contribution of the paper was the approach of incorporation of AGAST detectors to locate keypoints with scale invariance and improve descriptors effectiveness. In the paper, it was described how AGAST detectors were able to locate keypoints effectively and reliably and the outcome and speed were at least as outstanding as those of FAST detectors. Also mentioned in the paper was a way to find reliable keypoints under different scales and an approach different from the methods adopted in past literature to establish DAISY descriptors to make the descriptors more robust.

In 2012, A. Alahi proposed FAST Retina Keypoint (FREAK) (Alahi et al., 2012) to establish descriptors based on the concept behind the human retina and claimed that the approach could lead to better results than BRISK, SURF and SIFT. Before performing the two descriptor matching, stages, the first section was first examined to see if it met the threshold and, if so, the matching for the second section was then conducted; thus, the cost of computation could be reduced.

Other papers released, including those by Ke and Sukthankar (2004), Dalal and Triggs (2005), and Mikolajczyk and Schmid (2005), were all related to feature descriptor algorithms. K. Mikolajczyk also published another paper in 2008 to discuss the comments about descriptors (Rosten, Porter & Drummond, 2010).

The framework of the algorithm put forward in this paper. First, the template and the target image are imported for detection and matching to obtain match results. Then, mismatches are rejected. The keypoint initially acquired is incorporated in the tracking algorithm to be the initial point and complementation is performed through detection and tracking. In the end, a deformation function is obtained according to the matching relationship between the template and the target. The objective of this algorithm is to find out how to conduct real-time non-rigid surface deformation detection by using feature descriptors.

2. The proposed method

The objective of this study is to identify with effectiveness the relationship between the matches of the template and target keypoints and then, according to the relationship, to establish a warp function that represents the coordinate conversion relationship between corresponding template target keypoints.

2.1. FAST detector

The purpose of detection is to locate the keypoints such as corners or edges in the image, and they would be described into the descriptors. How to effectually locate the keypoints, filtering and descriptors generation is main issue in this chapter (Yasmin et al., 2014; Yasmin et al., 2013).

The description of keypoint detection will be divided in two parts FAST (Features from Accelerated Segment Test) corner detection and FAST corner filtering.

In 2006, E. Rosten proposed the FAST (Rosten & Drummond, 2006; Tuytelaars & Mikolajczyk, 2008), a quick corner detection algorithm based on the idea of scanning one by one all the pixels in an image, and using each pixel as the center to detect whether the grayscale difference of the pixel on a radius point meets the grayscale difference threshold as well as calculate the number of pixels that meet the said threshold. If the cumulative number of pixels meets the quantity thresh-