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主　論　文　の　要　旨

論文題目　Pairing Approaches in Object Identification

(物体識別におけるペアリングアプローチ)

氏　　名　NIK MOHD ZARIFIE BIN HASHIM

論 文 内 容 の 要 旨

Object identification has become one of the focussed areas in computer vision. It is widely utilized in various computer vision applications, e.g., robotics, security, mobile apps, transportation, and many more. A conventional definition of object identification is deciding whether two observations are the same object or not. This thesis redefines this definition by giving a broader alternative context to the existing computer vision applications that could be slotted in such a way to describe the conventional definition more clearly.

Chapter 1 introduces a new definition of image matching for an identity as ″object identification″ to systematically generalize two, or even more scenarios. To identify objects in a computer vision application, input images are generally matched to another set of output images. These two image sets are generally identified by inferring from both input and output sides as an image pair. Based on this idea, the ″pairing concept″ is introduced here. To discuss this new concept, existing computer vision, especially object identification tasks are carefully analysed and redefined. To start with, object identification is categorized into three categories, such as Instance-to-Class, Instance-to-Value, and Instance-to-Instance. The first category, Instance-to-Class object identification, is familiar and straightforward as in traditional image recognition tasks, e.g. face classification. Next, the second category, Instance-to-Value object identification, provides solutions for different image recognition problem settings, e.g. regression and key-point matching. For these two categories of object identification, since the instances are not paired, but rather straightforwardly identified as one class or value, they are not the main

interest of this thesis. Meanwhile, the third category, Instance-to-Instance object identification, is discussed in this thesis through the newly proposed pairing concept between input and output instances. In order to explain the pairing concept, the thesis will focus on Research topic 1: Object pose estimation with incremental viewpoints and Research topic 2: Set-to-set Person re-identification. The former is an example of pairing images from different viewpoints for optimal multi-view object pose estimation, while the latter is an example of pairing images of people for wide area surveillance, respectively.

Chapter 2 reviews the current work in the discussed fields and comprehensively analyses the state-of-the-art in this field. Existing works related to object identification for pose estimation and person re-identification, together with object identification applications are introduced.

Chapter 3 introduces an example of the Instance-to-Instance object identification as pairing images from different viewpoints; Research topic 1: object pose estimation with incremental viewpoint. Generally, the aim of the task is estimating an object's pose from a single observation. Traditionally, the estimated pose is a value that is yielded as a result of Instance-to-Value object identification. However, most existing works on single-viewpoint pose estimation face the ambiguity problem, which occurs when an object cannot be fully captured from one viewpoint or occluded. To solve this ambiguity problem, it is essential to select an alternative viewpoint. Averaging the original and current viewpoints with a careful arrangement and decision could infer the best viewpoint among all viewpoints. For this, this thesis introduces an entropy-based score of the object pose ambiguity, by selecting a viewpoint that minimizes this score, the best next-viewpoint is recommended. Evaluation is performed with synthetic object images of several indoor object categories. It demonstrates that the proposed method can properly estimate a pose when facing an ambiguous angular pose for a given object category, which is very important when considering the pose estimation in a categorical level, e.g., comparing mug images from many mug types.

Chapter 4 introduces an example of the Instance-to-Instance object identification as pairing images of people; Research topic 2: simultaneous person re-identification. Generally, the aim of this task is identifying all persons in scenes captured from different cameras which could be considered as paring persons between query and gallery sets from the pairing perspective. Traditionally, the single query pairing setting in Instance-to-Instance object identification is applied, whereas similarity of persons that appear in two different cameras is compared individually. However, in such a naïve approach, redundant matching or pairing occurs, where one of the persons could be paired

with multiple persons, leading to degraded performance. This occurs when the pairing is performed without considering the successfully paired persons. In addition, until recently, a small number of works focussed on non-similar image numbers in the person re-identification task, where the number of images in query and gallery sets are unbalanced. Therefore, this thesis proposes a person re-identification method that challenges two issues; redundant pairing and multiple query pairing for person identification based on object selection and arrangement during the image pairing process. Concretely, the Stable Marriage Algorithm (SMA) is introduced to solve the problem. Evaluation is performed with publicly existing dataset images of pedestrians in a two-camera condition setting. It demonstrates that the proposed method can successfully pair the persons between query and gallery cameras individually or simultaneously, which is essential when facing similar and non-similar image numbers in query and gallery sets.

Chapter 5 summarizes the thesis and discusses object identification based on Research topics 1 and 2, where their solutions can be considered under one framework. Likewise, other applications in computer vision could also be categorized under the framework for future research exploration.