EVALUATING THE TRADE-OFF BETWEEN ACCURACY AND REAL-TIME TRACKING PERFORMANCE OF DISCRIMINATIVE CORRELATION FILTER (DCF) BASED SHORT-TERM VISUAL TRACKER

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Supervisor Name : DR. LIM KHA CHUAN

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DEDICATION

Special dedication to my beloved parents, Tung Kam Wah and Tang Zoo Heok, my kind supervisor, Associate Professor Dr. Lim Kim Chuan and my friends. Thank you for all your care, support and believe in me.

ABSTRACT

Object tracking is an important component of many computer vision systems. In recent years, Discriminative Correlation Filter (DCF) based methods have significantly advanced in tracking. DCF have demonstrated excellent tracking accuracy, measured in Expected Average Overlap (EAO), for visual object tracking. Three methods that have been applied on selected DCF based tracker (Channel and Spatial Reliability DCF, CSR-DCF) to evaluate the trade-off between accuracy and real-time tracking performance. The first proposed speed-accuracy trade-off method is to reduce the tracker computation by disable the update of the channel reliability weights. The second proposed method is to further reduce the tracker computation by disable the update of spatial reliability map but still performing filter learning for each frame. Then, the third method is to even further reduce the computation by skipping the learning of the filter in every alternative frames. The performance of CSR-DCF based tracker is tweak-off by increasing the number of histogram oriented gradients (HoGs) features channel from 18 to 27 channels to increase the tracking accuracy with a bit reduce of speed reduced. Result of benchmarking shows that the third method, disable both channel and spatial reliability with alternative frame filter learning, is able to meet the 10.8FPS real-time requirement with EAO of 0.615.

ABSTRAK

Penjejakan objek adalah komponen penting dalam banyak sistem penglihatan komputer. Pada tahun kebelakangan ini, kaedah berasaskan Penapis Korelasi Diskriminatif (DCF) telah maju dalam pengesanan. DCF telah menunjukkan ketepatan pengesanan yang baik, diukur dalam Tinjauan Purata Yang Diharapkan (EAO), untuk pengesanan objek visual. Tiga kaedah yang telah digunakan pada tracker berdasarkan DCF terpilih (Saluran dan Kebolehpercayaan Spatial DCF, CSR-DCF) untuk menilai pertukaran antara ketepatan dan prestasi penjejakan masa nyata. Kaedah pertama adalah mengurangkan pengiraan tracker dengan menyahdayakan pembaharuan berat kebolehpercayaan saluran manakala kaedah kedua pula mengurangkan pengiraan tracker dengan melumpuhkan kemas kini peta kebolehpercayaan ruang. Seterusnya, kaedah ketiga adalah mengurangkan pengiraan dengan melangkau pembelajaran penapis dalam setiap bingkai alternatif. Prestasi tracker berdasarkan CSR-DCF adalah tweak-off dengan meningkatkan bilangan kecerunan berorientasi histogram (HoGs) yang menampilkan saluran dari 18 hingga 27 saluran. Hasil penandaarasan menunjukkan bahawa kaedah ketiga, melumpuhkan kedua saluran dan kebolehpercayaan ruang dengan pembelajaran penapis bingkai alternatif, dapat memenuhi keperluan masa nyata 10.8FPS dengan EAO 0.615.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The field of artificial intelligence (AI) has been booming thanks to the technology advancement in recent years. Applications of AI in the field of medicine, education, data analysis, engineering and more has enhanced the quality of life and enables people to be more productive. For example, by applying Unmanned Aerial Vehicle (UAV) to assist security guard in their daily duty for user object verification and recording purpose in real-time with camera on drone. It will act as a patrol buddy in strengthening the security in Universiti Teknikal Malaysia Melaka (UTeM). Every day from 7am – 9pm, public can make use of the road within the compound of UTeM to save their traveling time. This is because UTeM has a path that act as a shortcut that allows public to travel from Ayer Keroh to Jasin and east coast highway as shown in the map in Figure 1.1.

Figure 1.1: Map of route from Ayer Keroh to Jasin and North-South Expressway pass through UTeM.

Instead of solely relying on security guards to guide and monitor both the UTeM students/staffs and publics/visitors, the drone will track and lead the publics/visitor according to their planned routes. If the visitor is suspicious, the security guard will use the drone to select and track the target vehicle and make sure the target does not deviate from the route and immediately alert the security control central if deviation is detected.

Figure 1.2: A drone tracking a vehicle.

Figure 1.3: Drone tracking a cyclist.

Visual tracking is a classical computer vision problem with many applications. Tracking is a task to estimate the trajectory of a target in an image sequence. The

tracker must generalize the target appearance from a very limited set of training samples to achieve robustness against, camera motion, illumination, size change, occlusions, fast motion and deformations. Discriminative Correlation Filter (DCF) has successfully been applied to the tracking challenge. DCF learns a correlation filter from a set of training samples. The correlation filter is trained to perform a circular sliding window operation on the training samples.

In this research, a Discriminative Correlation Filter with Channel and Spatial Reliability (CSR-DCF) based tracker will be used to analyse the performance of short term visual tracking for drone application. CSR-DCF tracker is a very smart tracker. It has a very high accuracy and robust performance.

1.2 Problem Statement

Discriminative correlation filter (DCF) based tracker requires huge computational resources and hence the real-time frame per second (FPS) performance dropped significantly despite of high accuracy and robustness. Filters need to be learnt by DCF to represent the target object to be tracked required significant amount of computing resources. However, the limited computational power on embedded computing platform is not able to provide real-time tracking (low frame per second) of the DCF. Thus, study on suitable performance accuracy trade-off is to implement the DCF object tracking for embedded system.

1.3 Objective

The aim of this research is to identify the speed and accuracy trade-off the discriminative correlation filter (DCF) based short term visual tracker in real-time are:

1. To analyse and identified the tracking performance for discriminative correlation filter based channel and spatial reliability (CSR-DCF) based tracker and efficient convolution operators (ECO) based tracker.
2. To evaluate the trade-off between accuracy and real-time tracking performance of Discriminative Correlation Filter (DCF).
3. To analyse and identified optimal tracking parameters which can increase the accuracy of tracking with real-time tracking performance.

1.4 Scope of Project

This project is to evaluate the trade-off between accuracy and real-time tracking performance of Discriminative Correlation Filter (DCF) based short term visual tracker. The software, method, type of tracking images, performance measurement, sources of data samples and data samples size are shown in Table 1.1:

Table 1.1: Scope of project.

Software	MATLAB R2016b
Method	Discriminative Correlation Filter (DCF) with channel and spatial reliability
Type of Tracking Images	• Car • Human • Ball • Wakeboard • Truck • Others
Performance Measurement	• Speed (fps) • Expected Average Overlap (EAO)
Sources of Data Samples	• VOT 2017 datasets • UAV123 datasets • Real-time drone takes off datasets
Data Samples Sizes	• 1280 x 720 • 720 x 480

1.5 Chapter Review

Chapter 1 describes the general overview of this project. The background of the project, problem statement, objectives and project scope will be firstly discussed in the chapter. Chapter 2 will discuss the previous work of established image object trackers and the challenge video used to benchmark the accuracy of the tracker. The method of discriminative correlation filter, Unmanned Aerial Vehicle (UAV) video tracking challenges, datasets and performance measurement of the tracker also discussed in this chapter.

The drone scenarios, UAV123 datasets, tracker code preparation and MATLAB equation implementation for CSR-DCF and ECO based tracker are firstly discussed in Chapter 3. Three proposed speed-accuracy trade-off methods applied to the selected CSR-DCF based tracker is subsequently discussed. The last part of Chapter 3 proposed the method to tweak off the performance for CSR-DCF based tracker.

Chapter 4 describes the comparison performance between CSR-DCF and ECO based tracker, the performance of three proposed method applied to the CSR-DCF based tracker and increasing number of tracking features to improve the accuracy of CSR-DCF tracker.

The findings of this project are concluded in Chapter 5.