UNIVERSITY OF TECHNOLOGY SYDNEY
Faculty of Engineering and Information Technology

Research on Object Tracking Technology for Orderless and Blurred Movement under Complex Scenes

by

Manna Dai

A Thesis Submitted
in Fulfillment of the
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Certificate of Original Authorship

I, Manna Dai declare that this thesis, is submitted in fulfilment of the requirements for the award of PhD, in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This thesis is the result of a research candidature conducted with another University as part of a collaborative Doctoral degree.

This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

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ABSTRACT

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Visual tracking is widely found in anomaly behaviour detection, self-driving, virtual reality. Recent researches reported that classic methods, including the Tracking-Learning-Detection method, the Particle Filter and the mean shift, were surpassed by deep learning in accuracy and correlation filtering in speed. However, correlation filtering can be affected by boundary effects. The conventional correlation filtering fixes the size of its detection window. When its detection window only captures partial target images due to large and sudden scale variations, the correlation filtering fails to locate the tracked target. When the target is undergoing violent shaking, motion blurs and orderless movements appear along with it. The conventional correlation filtering locks itself in the previous position of the target, and hence, the target is out of the sight of the correlation filtering. In this case, the correlation filtering drifts or fails to track. Therefore, this thesis topic is to track single-objects under complex scenes with attributes of motion blurs, orderless motions and scale variations. The main research innovation is listed as follows.

(1) An approach for searching orderless movements is designed in a generative-discriminative tracking model. To address the uncertain orderless movements, a coarse-to-fine tracking framework is adopted. A spatio-temporal correlation is learned for the detection in the subsequent frames. Experiments are conducted on public databases with orderless motion attributes to validate the robustness of the proposed approach.

(2) A template matching method is proposed for tracking objects with motion

blurs. An effective target motion model is designed to provide supplementary appearance features. A robust similarity measure is proposed to address the outliers caused by motion blurs. Our approach outperforms other approaches in a public benchmark database with motion blurs.

(3) An ensemble framework is designed to tackle scale variations. The scale of a target is estimated based on the Gaussian Particle Filtering. A high-confidence strategy is used to validate the reliability of tracking results. Our approach with hand-crafted or CNN features outperforms the methods based on correlation filtering and deep learning in databases with scale variations.

To sum up, this thesis addresses boundary effects, model drifts, fixed search windows and easily interfered hand-crafted features of objects. Different trackers are proposed for tracking single-objects with orderless movements, motion blurs and scale variations. As future work, our methods can be extended to using a neural network to further improve single-object tracking models.

Dissertation directed by Professors Xiangjian He, Dadong Wang and Shuying Cheng

Statement Indicating the Format of Thesis

The format of this thesis is Conventional thesis.

Dedication

I would like to dedicate this thesis to my husband, Gao Xiao. I want to thank him for being so patient with me and supportive through the these years of my study for the PhD degree. His love and wisdom have enabled me to face up to any difficulties and make me be the person who I am today. I would also like to thank my parents, Jingjuan Kang and Dexing Dai, for all of the financial support and encouragement throughout these years of my study abroad. All great wishes to you.

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Thank my parents and my husband for supporting and encouraging me to pursue my PhD degree and keeping me going in the academic career.

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Manna Dai

Sydney, Australia, July 2019.

List of Publications

Journal Papers

J-1. Manna Dai, Shuying Cheng*, Xiangjian He*. "Hybrid generative-discriminative hash tracking with spatio-temporal contextual cues", Neural Computing and Applications, vol. 29, no. 2, pp. 389-399, 2018. (SCI, ERA B, JCR IF 4.664)

J-2. Manna Dai, Shuying Cheng*, Xiangjian He*, Dadong Wang. "Object tracking in the presence of shaking motions", Neural Computing and Applications, pp.1-18, 2018. (SCI, ERA B, JCR IF 4.664)

J-3. Manna Dai, Gao Xiao, Shuying Cheng*, Dadong Wang*, Xiangjian He*. "Structural Correlation Filters Combined with A Gaussian Pa rticleFilter for Hierarchical Visual Tracking", Neurocomputing. (Under Review, SCI, ERA B, JCR IF 4.072)

Conference Papers

C-1. Manna Dai, Peijie Lin, Lijun Wu, Zhicong Chen, Songlin Lai, Jie Zhang, Shuying Cheng*, Xiangjian He. "Orderless and Blurred Visual Tracking via Spatio-temporal Context". International Conference on Multimedia Modeling, MMM 2015, pp. 25-36, 2015. (EI)

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Abbreviation

BC - Background Clutters

CLE - Center Location Error

DEF - Deformation

DP - Distance Precision

FFT - Fast Fourier Transformation

FM - Fast Motion

FPS - Frames Per Second

HOG - Histograms of Oriented Gradient

IPR - In-Plane Rotation

ISM - Incremental Similarity Matrices

IV - Illumination Variation

LBP - Local Binary Patterns

LR - Low Resolution

MIL - Multiple Instance Learning

MAP - Maximum a Posteriori

MB - Motion Blur

OCC - Occlusion

OP - Overlap Precision

OPE - One Pass Evaluation

OPR - Out-of-Plane Rotation

OV - Out-of-View

PCA - Principal Components Analysis

PF - Particle Filter

RBF - Radial Basis Function

SSD - Sum of Squared Differences

SV - Scale Variation

SVM - Support Vector Machine

SVT - Support Vector Tracking

Nomenclature and Notation

Capital letters denote matrices.

Lower-case alphabets denote column vectors.

$(.)^T$ denotes the transpose operation.

$\mathrm{G} = [\mathrm{G_{ij}}]_{\mathrm{m \times n}}$ is the identity matrix of dimension $m \times n$.

$\sum$ represents the summation notation.

$\sqrt{}$ denotes the cube root notation.

$\bigcup$ represents the intersection operation.

$\bigcap$ is the union operation.