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Automated detection and tracking of slalom paddlers from broadcast image sequences using cascade classifiers and discriminative correlation filters

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ABSTRACT

This paper addresses the problem of automatic detection and tracking of slalom paddlers through a long sequence of sports broadcast images comprised of persistent view changes. In this context, the task of visual object tracking is particularly challenging due to frequent shot transitions (i.e. camera switches), which violate the fundamental spatial continuity assumption used by most of the state-of-the-art object tracking algorithms. The problem is further compounded by significant variations in object location, shape and appearance in typical sports scenarios where the athletes often move rapidly. To overcome these challenges, we propose a *Periodically Prior Regularised Discriminative Correlation Filters* (PPRDCF) framework, which exploits recent successful Discriminative Correlation Filters (DCF) with a periodic regularisation by a prior that constitutes a rich discriminative cascade classifier. The PPRDCF framework reduces the corruption of positive samples during online learning of the correlation filters by negative training samples. Our framework detects rapid shot transitions to reinitialise the tracker. It successfully recovers the tracker when the location, view or scale of the object changes or the tracker drifts from the object. The PPRDCF also provides the race context by detection of the ordered course obstacles and their spatial relations to the paddler. Our framework robustly outputs the evidence base pre-requisite to derived race kinematics for analysis of performance. Experiments are performed on task-specific dataset containing Canoe/Kayak Slalom race image sequences with successful results obtained.

1. Introduction

In competitive Canoe/Kayak Slalom (CK Slalom), negotiation of obstacles through gates is the fundamental skill and key determinant of overall performance. In race context where the winner is commonly decided by fractions of a second, minimising task time-to-completion is paramount. Thus, developing an optimal strategy and techniques for negotiation of gates that minimises overall course time-to-completion is critical. However, there is currently little quantitative data that characterises the trajectory of gate negotiation in Slalom (Fig 1).

Through extensive literature survey, we have found but only one paper that attempted to characterize the strategy employed by slalom paddlers in negotiation of upstream gates (Hunter, 2009). It analyzed upstream gate negotiation strategies of 17 elite Slalom paddlers using manual extraction of spatial kinematic data of the boat and athletes' head from image sequences obtained by overhead camera. The utility of the methodology used by Hunter (2009) is, however, limited by the use of a custom calibration rig when there is no water on the course, obtrusive attachment of markers to the boat and athlete, and laborious object labelling for extraction of trajectory kinematic information. In order to be relevant in elite sport training environment or competition and improve the likelihood of feedback driven technical or tactical amendments, an analysis method must provide near real-time results.

In this work, we investigate the challenging problem of simultaneous human detection and long-term tracking from readily available image sequences comprised of persistent view changes obtained from multiple uncalibrated cameras typical of broadcast image sequences. This task serves as a crucial evidence base, a prerequisite to kinematic motion analysis of athletes aimed to optimise technique and performance in sport (see Fig. 2). We aim to tackle the limitations of existing visual object detection and

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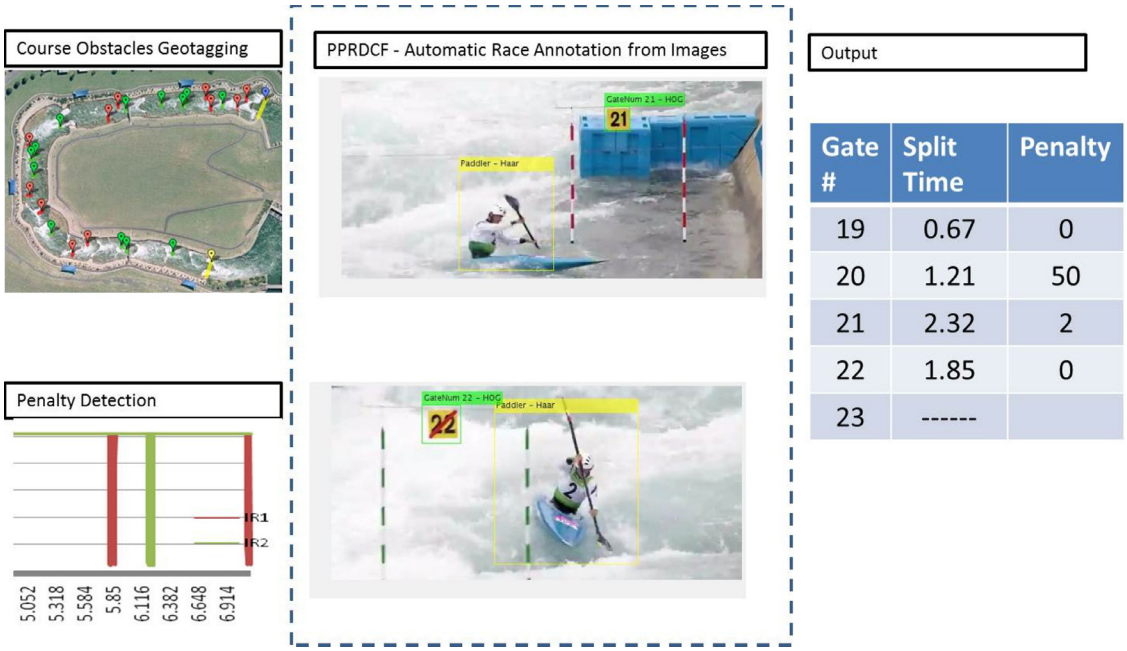
Fig. 1. Our PPRDCF framework outputs location and scale of the slalom paddler, and the location and order of the gates.



Gate #	Split Time	Penalty
19	0.67	0
20	1.21	50
21	2.32	2
22	1.85	0
23	------	

Fig. 2. An illustrative schematic overview of a CK Slalom annotation system for the daily training environment and competition. The system includes global race course and obstacles geotagging, penalty detection and race annotations from image sequences, and outputs a detailed comprehensive race annotations including split times and penalties. This paper focuses on the race annotations from image sequences (encompassed by the dashed line).

object tracking algorithms especially for long term sequence with frequent view changes. We develop a new and unified framework for object detection and tracking from disparate multi-view image sequences that couples the advantages of each approach to overcome the limitations of the other. The method is applied to detection and tracking of CK Slalom paddlers through gate negotiation of a race course, which enables near real-time performance analysis.

Contributions. A Periodically Prior Regularised Discriminative Correlation Filters (PPRDCF) framework is proposed for tracking fast moving objects in sport event using broadcast image sequences with possibly frequent shot transitions. Our framework exploits recent successfully applied Spatially Regularised Discriminative Correlation Filters (SRDCF) (Danelljan et al., 2015) with a periodic regularisation by a prior discriminative cascade classifier that is learnt offline. To overcome tracking failure associated with rapid shot transition, we introduce a robust adaptive shot transition detection algorithm that allows soft initialisation of the tracker. Finally, our framework provides race context through the detection of course obstacles and their spatial relations to the paddler. We perform experiments on task-specific dataset containing CK Slalom race image sequences and compare our results to state-of-the-art trackers. Our framework robustly outputs the evidence base pre-requisite to derived race kinematics for analysis of performance.

2. Related work

A comprehensive survey of visual object tracking is outside of the scope of this paper. Instead, this section presents a brief survey of recent techniques relevant to our task, to provide the context for our new method.

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