Autonomous Real-time Vehicle Detection from a Medium-Level UAV

Toby P. Breckon, Stuart E. Barnes, Marcin L. Eichner and Ken Wahren

***Abstract*— A generic and robust approach for the detection of road vehicles from an Unmanned Aerial Vehicle (UAV) is an important goal within the framework of fully autonomous UAV deployment for aerial reconnaissance and surveillance. Here we present a novel approach to the automatic detection of vehicles based on using multiple trained cascaded Haar classifiers (a disjunctive set of cascades). Our approach facilitates the real-time detection of both static and moving vehicles invariant to orientation, colour, type and configuration. The results presented show the successful detection of differing vehicle types under varying conditions in both isolated rural and cluttered urban environments with minimal false positive detection. The technique is realised on aerial imagery obtained at 1Hz from an optical camera on the medium UAV B-MAV platform with results presented to include those from the MoD Grand Challenge 2008.**

***Index Terms*— vehicle detection, UAV image analysis, threat detection, cascaded Haar classifier.**

I. Introduction

Within the common deployment roles of Unmanned Aerial Vehicles (UAV) the detection and location reporting of key ground assets such as vehicles and people are found to be common to both military and civil scenarios. Whilst the detection of people has received considerable attention within the literature [8], [13], [10], work on the detection of vehicles has until recently been dependent on movement of the vehicles in the scene [6], [8], [13].

Here we consider the detection of vehicles from a mid-range aerial platform that provides a perspective aerial view downward from an acute camera angle on the platform (e.g. Figure 4). Compared to a top-down planar view, such a camera view is better suited towards the detection of people for dual role detection strategies [13] but poses additional challenges for vehicle detection. From a perspective viewpoint the shape and size of a vehicle is less invariant to changes in camera position and orientation which vary considerably with UAV approach angle. A planar viewpoint reduces the vehicle detection problem somewhat to the detection of a simplified rectangular object at an angular offset to the horizontal. By contrast, from a perspective viewpoint the available vehicle view is one that includes both side-on and top-down vehicle detail. The result is a complex representation of a vehicle that is highly variant to approach angle of the camera to the target in the *x/y* plane and to minor changes in the angle of horizontal view in *z*. Such a perspective view, however, facilitates both a significant improvement in situational awareness for human operators/users and aids greatly in the automated or manual identification of human assets within the same imagery. Unlike the vehicle case, the aerial detection of people benefits from the consistent projection of the upright human form to a vertical trace within a perspective view image - an assumption notable even in the state of the art approaches within this domain [1]. As can be seen from our examples (Figures 4 - 8) no such assumption is applicable within the domain of aerial vehicle detection from a perspective viewpoint. The general problem of aerial vehicle detection is also made significantly more challenging by the non-uniformity of vehicle colour, localised shape characteristics and overall dimension. Thermal/IR vehicle detection is similarly limited by the variance in thermal signature in relation to time of day (sunlight to vehicle heat transfer) and operation (engine to vehicle heat transfer) meaning that additional scene information is often required to detect vehicles in addition to thermal signature based approaches [4].

The key challenge is a robust approach for the orientation invarient detection of both moving and static vehicles in both cluttered and uncluttered aerial views. We propose the use of a novel adaptation to the established real-time detection approach of [11], already investigated for ground based vehicle detection by [9], to this problem.

II. Prior Work

Recent work on UAV based vehicle detection appears to largely focus on the detection of moving vehicles [5], [6], [13] or the specific tracking of identified ground objects [3]. The work of [5] uses an approach based on identifying consistently moving subsets of edges within an overall flight sequence as a moving vehicle using a graph cuts driven technique. Previously [6] followed a similar methodology through the use of camera motion estimation and Kalman filter based tracking of a moving object within the scene but extended over optical/IR sensing. In [13] the authors present an approach based on layered segmentation and background stabilization combined with real-time tracking which then leads to the classification of identified moving objects as {people | vehicle} based on [1]. The more general work of [3] makes use of the classical mean-shift tracking approach to track generic ground object descriptors, including but not limited to vehicles, from a UAV image sequence but does not explicitly tackle the initial object detection problem. In all of these cases [5], [6], [13]

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