# Development of Unmanned Aerial Vehicle for Intelligent Transportation

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**Abstract**

*An unmanned aerial vehicle (UAV) has many applications including implementation in intelligent transportation. The UAVs can be used in detection and tracking of a specific road which play an important role in transportation including traffic monitoring, and ground–vehicle tracking. It can also be implemented in constructing road networks for modeling and simulation. Various algorithms can be used for detection of the road networks. In this paper, two main approaches have been proposed including, graph-cut–based road detection during the initialization stage and a homography-based road-tracking scheme is developed to automatically track road areas. The proposed system works more efficiently as the road detection is performed only when it is necessary. Thus implementation of UAVs in intelligent transportation provides a more efficient of tracking and detection of road conditions and traffic situations.*

***Index Terms:*** *GraphCut algorithm, homography algorithm, unmanned aerial vehicle (UAV).*

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## 1. INTRODUCTION

Unmanned aerial vehicles (UAVs) have been widely used in many fields such as traffic monitoring, inspection of road construction, and survey of traffic, river, coastline, pipeline in transportation system. Generally UAVs used to follow roads/rivers, oil-gas pipeline inspection, and traffic parameters measurements. UAVs equipped with cameras are viewed as a kind of low-cost platform that can provide efficient data acquisition mechanisms for intelligent transport systems. With the increasing use of vehicles and their demands on traffic management, this kind of platform becomes more and more popular. UAV has following advantages: (1) It is a low cost to monitor over long distances; (2) it is flexible for flying; and (3) it is capable of carrying various types of sensors to collect abundant data. To collect information for the transportation system, it is important to know where the roads are in UAV videos. Knowledge of road areas can provide users the regions of interest for further navigation, detection and data collection. For road detection and tracking most approaches uses color and structure property of the road, the combination of road color and boundary information have achieved accurate results than using only one of them in road detection. Therefore, we are using both types of information.

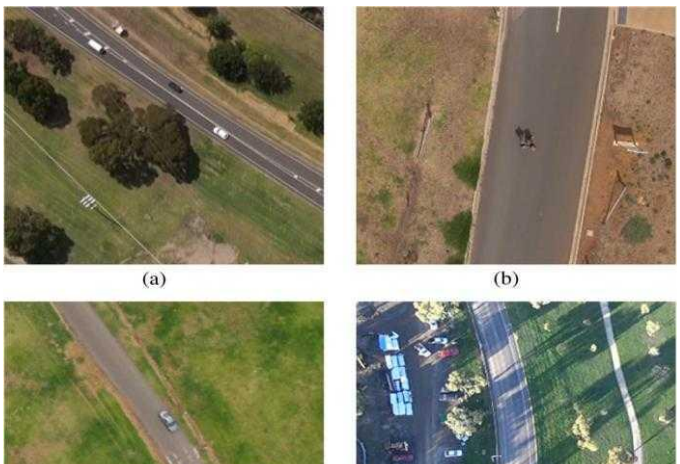
In this paper, we propose to utilize Graphcut algorithm for road detection and homography for road tracking approach. In road tracking, we aim to track the road border structure between two consecutive frames. Some earlier methods are largely depend on the extracted road border and vanishing points of the road , it might not be easily adaptable to UAV because the road boundary or markings are usually not enough to be detected due to the altitude of UAV. Therefore we are adapting homoghraphy algorithm to develop tracking scheme over existent tracking technique. Homography is a transformation that can be used to align one image plane to another when the moving camera capturing the planer scene. As our aim to make framework efficient, where the efficiency in homography attributed mainly three factors: (1) the corner detector is used to find key points in each road frame. (2) The Kanade–Lucas–Tomasi (KLT) tracker is applied to establish a correspondence between the two sets of corners in two consecutive frames. (3) A context-aware homography estimation approach is given where only the corresponding corners in the road neighbors are used with random sample consensus (RANSAC) estimator.

An online Graphcut scheme is used to detect road area in initially and in middle of tracking and drift error correction are illustrate detailed in further section. However, the tracking strategy based on the homography alignment is not complete because the road region mapped from previous frame to current one does not cover the whole road area but only a large portion of it, this is due to the fact that only the road area in the overlapping part can be tracked where the road area in nonoverlapping part still need to be detected. To solve this problem we propose an online Graphcut scheme to detect nonoverlapping part in road areas.

The contribution of this paper is to introduce a tracking technique and make real time framework for the detection and tracking of a specific road in low and mid altitude UAV videos. It should be noted that our proposed technique is not just limited to road detection and tracking. It can be also applicable to river, pipeline, or coastline detection and tracking in UAV videos.

## 2. RELATED WORK

There are various algorithm used to track and detect the road areas but in this paper our focus is to design such a algorithm for low and mid altitude UAVs. There are also other research in UAV based road detection uses satellite or high altitude UAVs, which aims to identify road network, including many junctions and roundabouts from an image frame. Generally high resolution camera is used for such a UAV application. Since the focus of this paper is on road detection and tracking using low-/mid-altitude UAVs.



In general, region colour distributions or boundary structures are probably the most important information utilized for road detection. In [2], they proposed to learn road colour distributions using Gaussian mixture models (GMMs) from given sample images, and then determine road pixels in each frame by checking the probabilities of pixels that fit the GMMs. Gaussian and gamma distributions are used to represent colour and gradient models. In [10], they learn how vanishing points are calculated by detecting pairs of line segments, and used to rectify the image in order to obtain rectified horizontal scans. Road boundaries are then identified by finding large intensity changes in the cross-section profile of each horizontal scan. Our objective is to survey the different technology used for road detection and tracking in UAV videos for intelligent transportation.

## 3. PROPOSED ARCHITECTURE

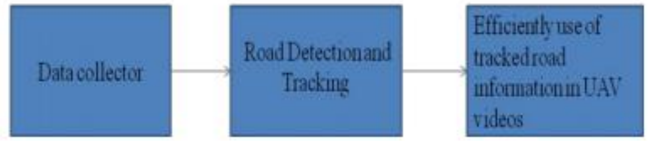



Fig1: system architecture

In our proposed architecture there are three different part can be explain as follows, the Data collector is the part of unmanned aerial vehicle (UAV). The UAV includes several basic components such as camera equipped with bottom of the UAV for road detection and monitoring purpose, it is capable to take the images at different places with varying altitudes. Basically the camera used here will be input device for various type of data collection for road tracking and detection which helps in intelligent transportation system.
Initially the Graphcut algorithm is used to detect the road area explain detailed in section IV and Homography algorithm is used to track the road area also explain detailed in section V. It is most important to know where the road area in UAV videos. The last block is for in future how efficiently use of tracked road information in UAV videos.

### 3.1. ROAD DETECTION USING GRAPHCUT

In GraphCut-based road detection method, where the GMMs are used to model image color distributions, and structure tensors are employed to capture image edge features. Two Gaussian mixture models (GMMs) GMM0 with K0 components and GMM1 with K1 components are used to represent the nonroad and road color distributions. In this paper, we choose K0 as 3 and K1 as 5. The next is to create K0 components for GMM0 and K1 components for GMM1. This requires to partition nonroad pixels into K0 clusters, and road pixels into K1 ones. We need the online GraphCut detection in two aspects: the first one is to detect road area in the nonoverlapping region of the two aligned frames and the second one is that we need to switch from road tracking to road detection when the accumulated drift error in the homography-alignment-based road tracking is too large. Therefore, we propose to update GMMs online. New road and nonroad pixels are automatically collected at intervals (40 frames) based on successful road tracking results. The successful results can differentiate road from nonroad areas. After that we use the selected road and nonroad pixels to update GMM0and GMM1to make GMMs adaptive to the evolution of image frames.

### 3.2. HOMOGRAPHY ALIGNMENT BASED ROAD TRACKING

In this section, we give the details on how to achieve a fast road tracking based on homography alignment. We also propose a solution to correct the drift problem caused by accumulation error in homography estimation, and give criteria on assessing tracking results.

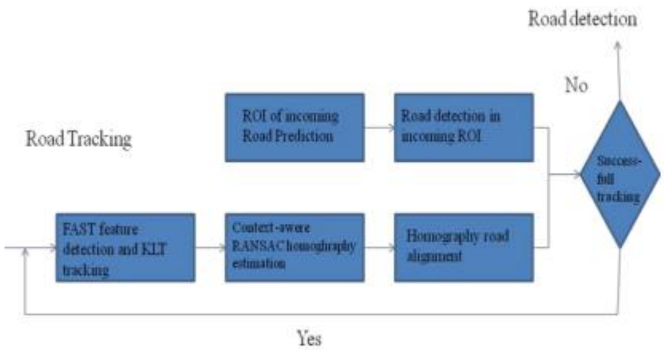


Fig2: flowchart of road tracking

FAST can achieve the best balance between accuracy and efficiency for our purpose. Next, the KLT tracker is applied to the set of detected FAST corners in each frame so that we can get the predicted FAST corners in the following frame. In other words, the KLT tracker establishes correspondence between the detected FAST corners in current frame and the predicted ones in the following frame through optical flow technique. Note that the procedure of establishing corner correspondence here is different from the conventional way in establishing the correspondence of corners. In the conventional (most common) way, the corners are detected in each frame and correlation is used to establish the matching between the two sets of corners of two frames. It might work in more general cases, where the two frames are perhaps not close to each other, but the correlation is time consuming due to its high computational complexity. In contrast, our application is a special case, where the two frames to be aligned is consecutive, and the motions of corners are small, which can just satisfy the condition of the KLT tracker.

Once we find the corresponding FAST corners of two consecutive frames through KLT, next, we use them to estimate the homography between current frame and the following one. Specifically, we propose a fast homography alignment process. Since our purpose of using homography is to align the road region in two consecutive frames as accurately as possible, we propose a context-aware homography estimation approach, where only the corresponding FAST corners in the local neigh-borhood of road are used within the RANSAC process. This is motivated by the observation that the homography that is estimated by RANSAC based on a local sampling of FAST-corner pairs can more accurately align the two images at this local region than the homography that is estimated by the common RANSAC

## 4. EXPERIMENTAL RESULTS

Proposed system consist of both hardware and software implementation. Hardware part consist development of quad copter which includes several basic components: ground monitors and controllers, batteries and chargers, a camera and camera stabilization support is shown in bellow.

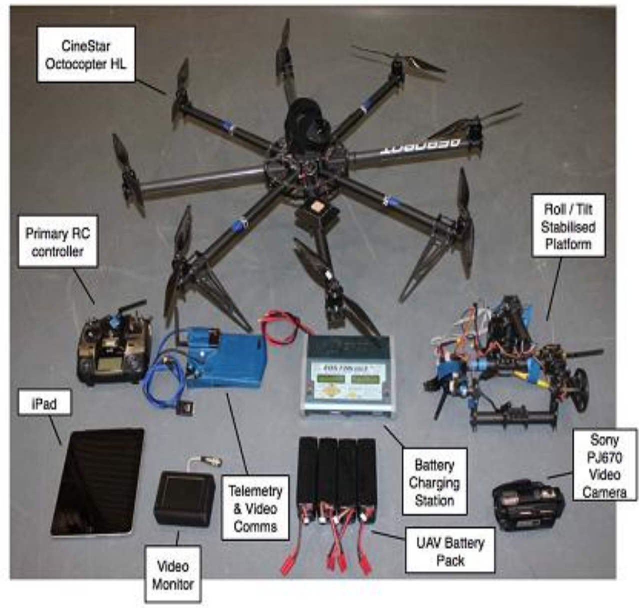



**Fig 3: HARDWARE CONFIGURATION**

The software part consists of graph-cut–based road detection during the initialization stage and a homography-based road-tracking scheme is developed to automatically track road areas. Road and nonroad pixels are first collected from s ample images for l earning road/nonroad color distributions. We select dozens of frames from UAV videos as the sample images, and scratch several strokes in each frame using green and red colors to specify road and nonroad pixels, respectively, as shown in Fig. 4(a). Two Gaussian mixture models (GMMs) GMM with K0 components and GMM1 with K1 components are used to represent the nonroad and road color distributions. Sample image with strokes examples for collecting road (green) and nonroad (red) pixels and video frame shown in bellow.

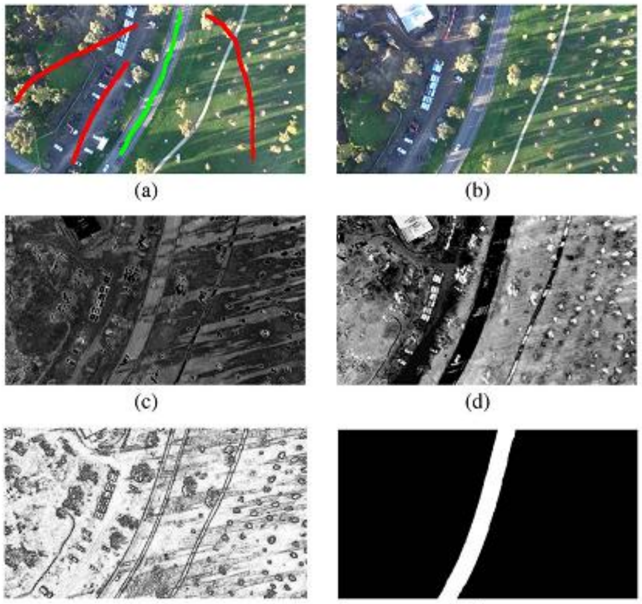



Fig 4: ROAD DETECTION

TABLE 1
PERFORMANCE EVALUATION OF THE PROPOSED DETECTION ALGORITHM

| | GMM based | GraphCut | GraphCut with structure tensor |
|---|---|---|---|
| $Q$ | 94.80% | 98.93% | 99.45% |
| $ER$ | 5.78% | 3.95% | 3.77% |
| $T$ | 0.142s | 0.271s | 0.283s |

Experiments are mainly conducted on image sequences acquired using our UAV and some other image sequences downloaded from the Internet are also used for more evaluation on different scenarios.

We compare their performances to road detection in terms of average error rates ER, precision Q and times T. Table I show the comparison results.

## ACKNOWLEDGEMENT

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