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A Review of Unmanned Aerial Vehicle (UAV) Applications In The Road Surveying

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Abstract: Road transport is a must as it provides ample facilities benefits to a country and to individuals, especially in improving access to places jobs, economic resources, educational facilities, health centers and more. Behind the importance of transportation to the population, there is also a negative effect, namely, road accidents. The cause of an accident can be done by various factors. One of those factors is road design. This paper presents a review of recent developments in relation to the application of UAVs in three major domains of transportation, namely; road safety, traffic monitoring and highway infrastructure inspection. This study, includes data collection, data analysis, and results. Advance application of UAVs in extracting key information which will be utilized in accident investigation and assessment, traffic flow analysis and damage assessment roads. To further enhance the knowledge of the advantages of this UAV. From reading all the journals, it can be concluded that all the use of UAVs can help us to facilitate surveying. Present methods of investigation (tape calculation and complete station survey) often require the closing of highways, and their operating procedure takes time. Unmanned aerial vehicles (UAV) can track the accident site from various angles or at different altitudes without interrupting the traffic flow, so UAV is used for reconstruction of the accident scene.

Keywords: Unmanned Aerial Vehicle (UAV), Drone, Unmanned Aerial System

1. Introduction

Road transport is a must as it provides ample facilities benefits to a country and to individuals especially in improving access to places jobs, economic resources, educational facilities, health centers and more. Behind the importance of transportation to the population, there is also a negative effect, namely, road accidents. Injuries resulting from road accidents are among the leading killers in the world after Chronic diseases such as heart disease, stroke, lung infections and respiratory problems. In addition, the report on the Global Burden of Disease Project in 2004 states that this fatal accident contributes to 1.27 million deaths each year and that together with the number of deaths caused by a combination of other factors [1].

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Driving all through Malaysia is troublesome and has a genuine well-being concern. Motor vehicle accidents (MVA) both genuine and lethal are a typical issue. High speeds, poor street conditions, general negligence by different drivers and walkers for right of ways, just as uncontrolled animals meandering into the roadway are contributing foundations for MVA. Little over-burden trucks having a place with free vehicle administrators are engaged with or cause various mishaps because of their fast and driver weariness. High traffic force builds the event of mishaps on the investigation site and on the nation in general.

The use of small Unmanned Aerial Vehicles (UAV), commonly known as 'drones', is increasing in all sectors. UAVs can perform air operations that manned aviation struggle with, and their use results in evident economic savings and environmental benefits whilst reducing the risk to human life. Within, transportation field, there are a wide variety of ways this technology is being used and progress is being made to explore ways to benefit from the technology. Majority of the efforts are based on collecting traffic and driving behaviour data captured via cameras mounted on UAVs. This data is then used for a variety of purposes such as surveillance and monitoring, recognizing traffic violations, aid in managing traffic congestion, signal optimization and extracting vehicle trajectories to answer research questions in relation to accident risk assessment etc [2]. The goal of this paper is to systematically review peer-reviewed academic studies on UAVs to identify trends in their application and technological components. The articles were searched for the publication year range from 2000 to 2020 in the SCOPUS and Google Scholar databases.

The focus of this paper is to review the research efforts that utilized UAVs in relation to three different domains of transportation such as road safety, traffic monitoring and highway infrastructure inspection management. A systematic effort was made to gather and compile all the relevant materials available online. The reviewed documents include journal papers, conference papers, technical reports.

1.1 Objectives of The Study

The Objectives of the Study are:

i. To review the UAV study method in each road surveying.

ii. To investigate the use of the UAV in road surveying in 2016-2020.

2. Literature Review

Road accidents could happen anytime, anywhere on road to anyone. A complete definition of a road traffic accident by Transport Research Laboratory (TRL) is "a rare, random, multi-factor event always preceded by a situation in which one or more road users have failed to cope with their environment, resulting in a collision on the public highway which should be recorded by the police.

2.1 Road accident factor

There is rarely an accident situation in which only one "thing" or person is truly the sole cause of the accident; hence accidents are multi-factor events, basically grouped into 3 categories of factors:

a) Human factors;

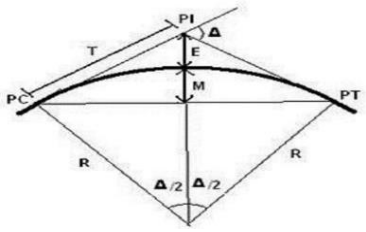
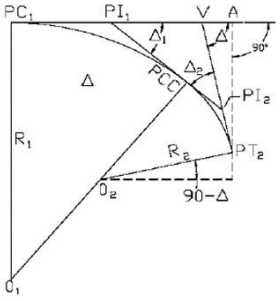
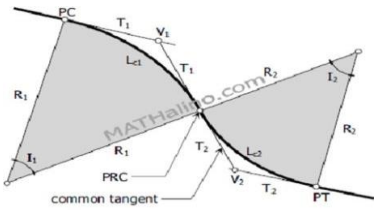
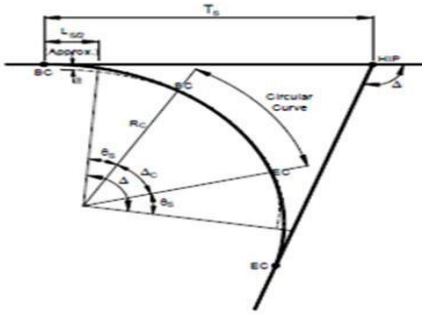
b) Road and environment factors;

c) Vehicle factors

In this study, the study focused on the issues of road and surrounding factors

2.2 Geometric design of road

The geometry of a road influences its safety performance. While studies of contributing factors to road accidents show that human factors predominate, roadway factors are the second most common category, with vehicle factors last.

Type	Explaination	Figure
Simple curves	The curve is a segment of a circle with radius, R. The minimum radius is a limiting value of curvature for a given speed arid is determined from the maximum rate of super elevation and the maximum allowable side friction factor	 (Garber & Hoel, 2009).
Compound curves	Compound curves consist of two or more simple curves in succession, turning in the same direction, with any two successive curves having a common tangent point. To avoid abrupt changes in the alignment, the radii of any two consecutive simple curves should not be widely different	 Garber& Hoel, 2009
Reverse curve	Reverse curves usually consists of two simple curves with equal radii turning in opposite directions with a common tangent. They are usually used to change the alignment of a highway.	 (www.mathalino.com)
Spiral curves	Spiral curves are placed between tangents and circular curves or between two adjacent circular curves having substantially different radii. Spiral curves provide a vehicle path that gradually increases or decreases the radial force as the vehicle enters or leaves a circular curve	 (www.expertsmind.com)

2.3 Type of UAVs

Three UAV types of rotary-wing, fixed wing, and blimps were reported. Fixed wing vehicles are aerial platforms that resemble to traditional aircrafts and are known in their ability to perform continuous flight demanding tasks, but they require runways to take off or land and cannot hover. Rotary-wing UAVs can hover, take off and land vertically, and can be helicopters or multi copters depending on the number of propellers mounted on the drone [3]. Blimps, or aerostats, are lighter-than-air vehicles that gain their lift through indoor gas pressure available in the unit, allowing longer flying time when compared to other UAV platforms [4].

The most popular UAV manufacturers were;

• DJI®, Ascending Technologies (Asctec), Parrot, and Microdrones,

The mostly used models were

• Asctec Falcon 8, Microdrones MD4-200, DJI Phantom 2 Vision+, DJI Phantom 3 Pro, Parrot A.R Drone 2.0

2.3 Review paper on application of UAVs (Transportation)

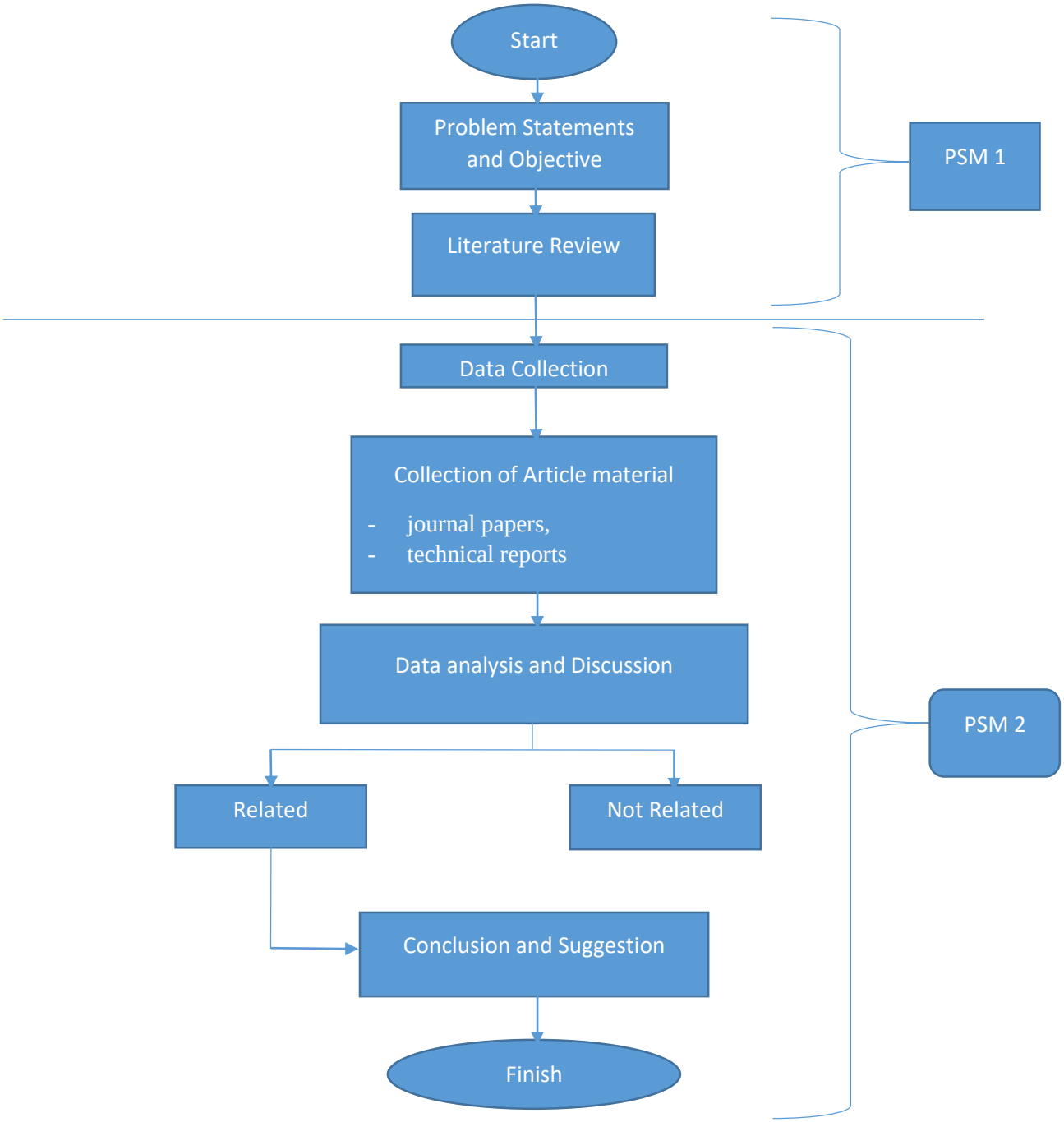
Multiple authors have investigated UAVs performing structural and infrastructure inspections during the last decade. The assessments covered buildings, bridges, as well as several other structures (e.g., retaining walls, roads, windmill and dams). The articles are:

Bridge inspection	Duque et al., 2018b; Khan et al., 2015; Khaloo et al., 2018; Ellenberg et al., 2016; Hallermann and Morgenthal, 2014; Gillins et al., 2016; Ellenberg et al., 2015; Kim et al., 2015; Brooks et al., 2017; Xu and Turkan, 2018; Kasireddy et al., 2018; Seo et al., 2018; Zekkos et al., 2018
Roads	Liu et al., 2019; Ardestani et al., 2016; Raj et al., 2020; Barmpounakis et al., 2019; Zhang et al., 2019
Dams	Hallermann et al., 2015; Henriques and Roque, 2015; Zekkos et al., 2018

3. Methodology

The research methodology in this section describes the methods, methods, and approaches used for information collection. This study, includes data collection, data analysis, and results. With the methodology of this study, the research can be further completed in a more structured study and follow the procedures that have been set in achieving the objectives. This section will also discuss the information obtained from previous research papers. Besides, there are various review papers related to the use of UAVs in other fields, but to achieve the objectives of this study, only one method has been focused on. Therefore, in this chapter, it will explain the process used along with an overview so that it is more detailed.

3.1 Methodology Flow Chart



3.2 Data Collection

To get the data in this study, first step is operationalizing the research questions into search terms and syntax that will identify as many potentially relevant publications as possible. For this study, the research questions were broken down to individual concepts, and related keywords, which were then arranged into the following search syntax for study retrieval: (“Unmanned Aerial Vehicles” OR “Unmanned Aerial System” OR “UAV” OR “Drone”) AND (“Road Surveying” OR “Road

Inspection"). A review is using the search syntax, was performed in the Google Scholar database. freely accessible web-based search engine capable of identifying full text and multi-disciplinary publications. It offers the advantage of entering a specific syntax query, which instantly generates an exhaustive list of papers unique to a specific topic and may be indexed in other alternative databases.

4. Results and Discussions

This chapter will discuss past research findings data taken from two sources namely journals and thesis. Discussion of this result will focus on the objective of this research, specifically, to answer the following research objective a) To review the UAV study method in each road surveying. b) To investigate the current use of the UAV in road surveying. Majority of the research efforts come under this theme of road safety are proposals, systems, software tools and image processing methodological advancements that help reconstruct the accurate accident scene and therefore assist in accident investigation.

3.1 Results

Author	Journal Tittle	Hardware	Finding
Liu et al., (2019)	An approach of traffic accident scene reconstruction using unmanned aerial vehicle photogrammetry	Using; DJI Inspire 1 UAV, Others hardware; FC350 Camera with GPS functionality	Reconstruction Value For measurement, peak signal-to-noise ratio (PSNR) and structural similarity SSIM are used. 41.62.—41.62. PSNR = SSIM = 0.9475 (Indicate) (Indicate) Successful quality)
Ardestani et al., (2016).	3D Accident Site Reconstruction Using Unmanned Aerial Vehicles (UAV)	Using; UAV with GPS sensor Others hardware; high resolution camera, HD transmitter, Ground station for communication	Shooting height, angle, smooth surface glares, geotagging and GPS signals have an effect on the accuracy of the results of scanning.
Raj et al. (2020)	Vision based accident vehicle identification and scene investigation	Using; Parrot AR Drone 2.0, Others hardware; Two cameras for front, downward facings, PC is used to control takeoffs, landings	For the proposed LabVIEW based vehicle detection, 95.81 percent precision is obtained
Barmpounakis et al. (2019)	Extracting kinematic characteristics from unmanned aerial vehicles	Using; DJI 7 Spreading Wings S900 hexacopter, Other hardware Onboard Camera offers 4 K 30 quality	It extracts car and pedestrian trajectories. It is also calculated that OD
Zhang et al. (2019)	Real-time traffic analysis using deep learning techniques and UAV based video	Using; Mavic Pro Platinum Model, Dji Company Other hardware; onboard camera with 24 fps.	Due to the existence of motorcycles and algorithms, difficulty added can be identified, but errors in vehicle counts are high.
Skorput et al. (2020)	Applying Unmanned Aerial Vehicles (UAV)	DJI Phantom 4 UAV	Error reported under − 5% to +2% in several

	in traffic investigation process.	3D model measurements from with real data.

4.2 Discussions

4.1.1 Raj et al. (2020)

4.2.1.1 Method

The purpose of this work is to create and introduce a UAV monocular camera approach to identify an accident vehicle in order to assess its position with respect to the location of the accident victim. To interact with the drone, the algorithm is run over LabVIEW using the AR Drone LabVIEW kit, as shown in Figure 1 below.

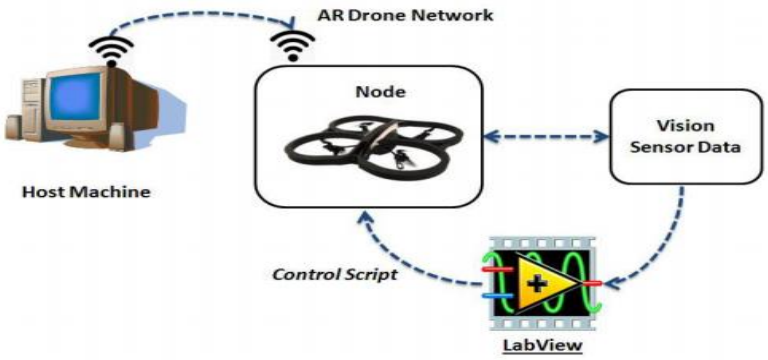


Figure 1: System Architecture for the proposed victim vehicle detection system that demonstrates algorithm implementation in LabVIEW

4.2.1.2 Result

Figure 2: The 3-D model for point cloud research (Left-hand site) and photo stitching process (Right-hand side)

In order to create a 3-D model of an accident site, the photographs and videos taken from the AR Drone were used. A point-cloud model of the accident scene that seems to have failed to maintain the details of the accident is seen in the picture on the left-hand side of Figure 2. The right-hand side image shows the effects of the method of image stitching, which was able to retain essential data such as the car's location and the details of the number plate. The Haar cascade algorithm takes more time to process the input image in LabVIEW, causing a delay during the testing stage of more than 1 second. This delay can become a major factor in vehicle detection's poor real-time efficiency. If an external camera is used along with an AR Drone monocular camera, LabVIEW assistance can be called to perform image processing and AR Drone Control VI can access the resulting image output without any delay in

processing. If the AR Drone front camera is used, it is necessary to convert the image format of the AR Drone to a pixmap, followed by a conversion of the RGB array, and then the conversion of the RGB to the 2D array. An external camera for the AR Drone is highly recommended for overcoming these obstacles, both for image processing and for controlling the AR Drone using LabVIEW.

4.2.2 Zhang et al. (2019)

4.2.2.1 Method

A established system of traffic monitoring is the proposed approach. The proposed solution consists of a developed traffic monitoring and congestion analysis platform consisting of a UAV-based video collection system, a vehicle tracking system and a traffic analysis system. Figure 3 illustrates the main blocks of our plan.

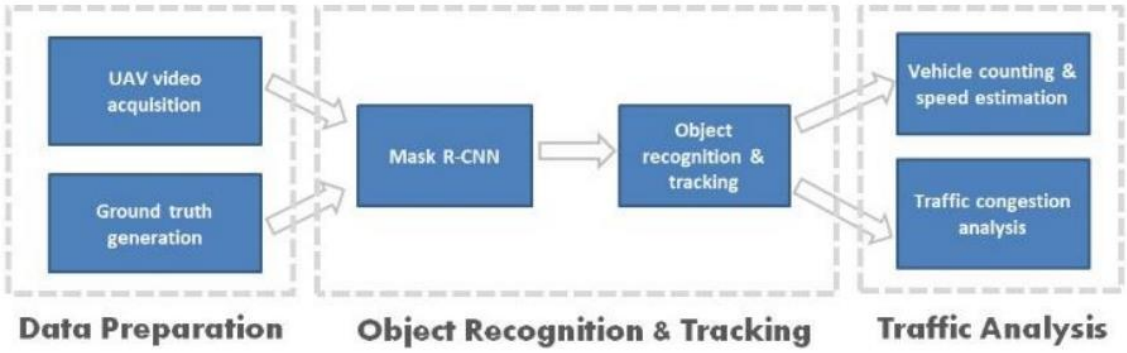


Figure 3: Block diagram of solution proposed

4.2.2.2 Result

Figure 4: Example of the product of instance segmentation

In this analysis, to collect video data, the UAV is fixed so that its function is similar to a camera. To estimate the spatial length paired to a pixel in the image, we apply the geometric configuration and UAV's position. In a future report, we will explore traffic congestion with a mobile UAV in a wide area. Using orthorectification with an effective mathematical model and image georeferencing, the pixel measurement could be measured more accurately.

4.2.3 Skorput et al. (2020)

4.2.3.1 Method

For the purposes of this scientific paper, a simulation of a traffic accident on a polygon was performed. Sets of geo-referential images were taken at heights of 30 m and 50 m and were used to make a 3D test model of the site of the traffic accident. For the purpose of the experiment, the UAV DJI Phantom 4 was used. It was supported with adequate mobile application and took about 30 angled photos at a height of 30 m in the circular trajectory around the accident site. A second set of straight-lined flights combination was provided at an altitude of 50 m to achieve more visibility and surface of

the 3D model, where UAV also took angled photographs of the site of the experimental accident. The flight planning period was approximately ten minutes in total. The UAV Phantom 4 weighs around 1.5 kg, which means that it is light enough for one person to plan and monitor the flight. It took less than 10 minutes to complete the UAV flight following the flight plan, and a total of 61 geo-referential photographs were taken during the flight. The 3D dot cloud machine can be created and visualized from these photographs. Based on known locations of UAVs, it calculates the location of each dot in the 3D dot cloud during the shooting. The following machine actions enable this provided cloud of dots to be filled with texture. It is possible to make measurements on generated 3D and orthophoto computer models of traffic accident vision, as shown in Figure 5.

Figure 5: 3D computer model calculation and orthophoto model of accident position measurement

4.2.3.2 Result

For the purposes of this paper, classical field measurements, along with measurements on 3D and orthophoto computer models, were made at the site of the simulated traffic accident. Using UAVs and 3D tools for traffic accident reconstruction saves time and costs while delivering satisfying performance. The results generated are permanently available in the form of a file, with the possibility of measurements being carried out at any time. True events are saved as 3D objects with precise data accurate to a centimetre. It also requires less preparation to work with the details, and in order to recreate accident scene of court expert demands, they are permanently preserved

5. Conclusion and Recommendation

From reading all the above journals, it can be concluded that all the use of UAVs can help us to facilitate surveying. Present methods of investigation (tape calculation and complete station survey) often require the closing of highways, and their operating procedure takes time. Unmanned aerial vehicles (UAV) can track the accident site from various angles or at different altitudes without interrupting the traffic flow, so UAV is used for reconstruction of the accident scene. Firstly, the accident scene reconstruction process framework was suggested in which UAV was used to take pictures of the accident site and the 2D and 3D accident scene reconstruction imaging system was implemented. Then, 3D reconstruction, generation of point clouds and optimization of the model were presented. Next, a UAV flight experiment was carried out for the reconstruction of the traffic accident scene and two measurement indexes, signal-to-noise ratio and structural similarity, were implemented to test the picture quality of the reconstruction of the accident scene (Liu et al., 2019).

Construct a prototype UAV system that can be produce improvements for video-based site survey and 3D accident site reconstruction in the field. UAVs fitted with a high-frequency global positioning system (GPS) sensor, a high-resolution camera, an HD transmitter, and a contact and data collection ground station are built into the hardware system. The application programs include 3D mission control, planning software, and photogrammetry reconstruction tools for. At a structured accident site, the prototype system has been tested and the current 3D models have been constructed that produce promising potential for further development. The test results show variables such as altitude and angle shooting, smooth surface glare, geo-tagging photo snapshot, and GPS signals have major impacts on

the scanning results. These effects need to be managed efficiently to ensure the integrity of the designed model (Ardestani et al., 2016).

GCS (Ground Control Service) is used for navigation where the waypoints are set by the authorities concerned to guide the UAV to the accident position using GPS coordinates. It locates the victim's car before the drone reaches the target position and takes photos/recordings of the accident zone. The solution proposed should locate the vehicle of the victim; identify its location and shift the UAV to the vehicle while maintaining a minimum safety distance from it. The algorithm for detection is implemented and executed via LabVIEW (Raj et al. 2020) to communicate with the drone. It presents a low-cost semi-automatic way to extract detailed vehicle trajectory data through UAV video footage. Also listed are steps to minimize errors due to camera instability and to achieve adequate calibration. Two studies are presented; the first relates to four-legged intersection vehicle tracking and the second to pedestrian flow tracking (Barmpounakis et al. 2019).

Traffic flow analysis using videos focused on UAV and deep learning techniques. By using a position-fixed UAV, the road traffic video is obtained. To classify the moving objects in videos, the new deep learning methods are applied. To perform traffic analysis and assess the effects of traffic congestion, the related mobility metrics are measured. The method proposed is checked with the results of manual research and the results of visualization (Zhang et al. 2019). The digitalization and three-dimensional (3D) simulation of traffic accident sight possibilities were demonstrated in this paper. Innovative technologies such as the development of three-dimensional (3D) models of the actual location of traffic incidents using unmanned aerial vehicles (UAV) and photogrammetric procedures have been identified (Skorput et al. 2020).

In conclusion, recent UAV applications in the transport sector have been critically reviewed and graded, especially in the areas of road safety, traffic monitoring and inspection of highway infrastructure. Advanced use of UAVs in the extraction of key information for use in the investigation and evaluation of collisions, traffic flow analysis and assessment of road damage.

To further enhance the knowledge of the advantages of this UAV. Universities in Malaysia especially need to highlight the use of this UAV to students by holding a Co-curriculum subject or holding an industry week that can attract students about this UAV. In addition, the private sector especially needs to apply the use of this UAV for their company to increase the skilled manpower for the use of this UAV while accelerating all the processes that will be carried out especially in the surveying sector.

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