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Driver Assistant Systems Applied by Deep Learning Technology : A survey

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***Abstract*-Increasing the number of vehicles and the tremendous development in the used techniques in the vehicles. In addition to, the increase in traffic accidents, which led to the rising of systems' invention ofDriver Assistance Systems (DAS)that assist the driver in driving safely and discovery the ways by warning the driver about the dangerous situation in real time.This paper presents a study that highlighted the main approaches, methods, algorithms used to make smart assistant systems in the vehicles which used different architectures, tools, and sensors: GPS, Camera, Stereo camera, LIDAR, and Radar, Based on Deep learning algorithms, Computer vision, combined with deep learning and sensor fusion for years from (2011-2020).**

***Key words*-Driver Assistance System, sensors, vehicle technology, Deep Learning, data sensor fusion.**

I.INTRODUCTION

This Driver assistance system (DAS) is an intelligent system. It's a variety of different development techniques start from alerting the driver to events in the external environment and monitoring the reaction of the driver, till the system reaches the maximum degree of development as taking decision instead of a driver [1].

DA task is to detect and process objects such as pedestrians, cars, bikes, buses, trucks in either a highway or countryside and urban areas, and make real-time decisions by warning the driver. The recognition of road or pathway is a fatal enabler for driver assistance systems DAS. For the past decade, it was an effective field of research. Under diverse scenarios, the problem was challenged with various task definitions; result in usage of varied modalities and approaches for sensing [2].

Driver Assistance categorized into different systems including: navigation system, collision avoidance system, lane keeping assist, blind spot detection, adaptive cruise control, and other safety luxuries. These systems can provide the basics of an autonomous vehicles' framework. However, many challenges remain with the current state of the art in DAS technologies that hinders safe and robust implementation vehicles for consumers. One of the key challenges is real-time detection and identification of moving object of various shapes and speeds under all possible environments and backgrounds.
The paper aims to study the used systems, methods, and algorithms, identify the used devices and sensors in such systems.

II. SYSTEMS TOOLS

The types of used sensors as shown in fig.1, which used in Driver Assistance Systems and their attributes are described as follows; table I. shows the advantage and disadvantage of DAS's Tools:

1. GPS- Global-positioning system (GPS) is a system of satellites and receivers used for global navigation of Earth. It is useful for finding the exact coordinates of a vehicle when it is in the line of sight of multiple satellites orbiting the Earth, shown in fig.1 (a) [1].

2. Camera: A camera is an optical tool that utilizes for capturing images or recording video. It is useful for acquiring images or video sequences of object pixels in the lens view in order to help detect, segment, and classify objects based on a recognizable object property like location, color, shape, edges and corners, shown in fig.1 (b) [3].

3. LIDAR- Light Detection and Ranging (LIDAR) is a procedure of remote sensing that uses light in shape of a pulsed laser to compute the distance to an object based on signal time of light. The LIDAR is good for perceiving environment when 3-dimensional, high-resolution, light-independent images, shown in fig.1 (c) [4].

4. Stereo camera- It's the same work of LIDAR but it cheaper to perform than it and can't extend the same range of accuracy and reliability of LIDAR. The challenge of depending the effective depth measurement on the composition with highly uniform surfaces. A function of the stereo baseline is the range precision (the space between the two cameras). A major baseline stereo system will supply superior ambit accuracy, but often at the cost of reliability' reducing and increase computational, shown in fig.1 (d) [5].

5. Radar- Radio Detection And Ranging (radar) is a remote sensing device that uses an antenna to scatter radio signals across a region in the direction it is pointing and listens for response signals that are reflected by objects in that area. It's useful for detecting obstacles, vehicles and pedestrians around a vehicle, shown in fig.1 (e) [6].

Fig. 1 tools which used in DAS

In fact there are different types for each tool, there is no specific type, as for example type of camera used in the vehicle (pi camera, web camera, and etc.) and the same for other tools.

Table I. Advantage and Disadvantage of DAS's Tools

Sensor	Advantage	Disadvantage
GPS	Specific coordinate measurements, fast, reliable in the line of sight	Expensive, liable to failure in bad weather conditions, liable to failure in distant locations where satellite coverage is blocked or Unavailable, dependent on an external data source.
Camera	Perceives high-level object characteristics like color, shape, and edges and easy to visualize data.	Potential slow frame-rate update, image quality dependent on light, weather and various other factors, data-intensive processing, has a restricted range of perception compared to other sensors, expensive some type of it.
LIDAR	Independent of light, weather and external data sources, fast, accurate, 3-D, high-resolution.	Expensive, matter to interference by reflection or loss therefrom, conflicting with transparent surfaces, data-intensive processing, less strong than other sensors.
Stereo camera	Like LIDAR can be applied to the same principal tasks, containing obstacle detection, add up to road pitch angle assessment, and 3D road geometry.	increased probability of errors, lack of accuracy
Radar	High-bandwidth signals, wide-spread area coverage, independent from external systems, works in multiple weather conditions	Expensive, matter to interference, easy to corrupt signal with electromagnetic interference, harder to manage signals, algorithms for tracking are still deficient.

III. DRIVER ASSISTANT SYSTEMS CATEGORIES

Fig. 2 shows the simple components for Driver Assistant System, the driver assistant system divided into subsystems, these subsystems affect different aspects include:

1. Navigation system

The type of this system receives the information regularly from external sources to observe the vehicle's location and advise the optimum route of destination. The definition of Satellite-based location (by means of GPS) depending on the utilization of sensors set up in an onboard computer or either through a device connected externally (e.g., smartphone). The bulky, heavy paper maps have been replaced effectively by GPS navigation systems. Frequently these systems are qualified for providing acoustic directions furthermore; the driver has been saved from the constraints of keeping track of the screen. There are several navigation systems which helpful for traffic jam avoidance by supplying live traffic data [7, 8].

2. Collision avoidance system

These types of system are linked to driving safety directly, for that has received a wide range of style. The aim of the system is to enhance the driving safety which is known as «pre-crash system» [9] utilize a vast range of means (radar, laser lights, and cameras, etc.) for reveal pressing collisions. There is an assortment of sensors utilizing by collision avoidance systems to detect if the vehicle is in a dangerous situation or near to shock with other objects. These systems sense the vicinity of other vehicles, animals, pedestrians, and various roadway handicaps. The system notifies the driver when the vehicle is in danger of interfering with another object [10, 11].

3. The adaptive cruise control system

This system controlled automatically the motor vehicle's speed by adjusting the speed of the vehicle to preserve a secure distance from the vehicle at the head. The process is depending on the sensors utilization that is installed on the vehicle. These sensors can be categorized into two types [12-14]:

- Laser lights (inaccurate, due to the trigged by conditions of weather and dirt).
- Indicators using infrared radar (used as a part of the collision avoidance system mostly).

This technology of driver assistance is mainly helpful on highways, where drivers otherwise have to monitor their cruise control systems for safety reasons permanently.

4. Traffic sign detection and recognition (TSD) and Traffic Sign Recognition (TSR) an important part of ADAS [15].

This system transacts to recognize the concerns regions and the outline of the traffic signs in a specific image. Supposed the perfect algorithm is to detect all pertinent traffic signs in an image with potentially slight false detections.Traditionally the detection of the sign in digital images is split into two methods:

4.1. Color-based detection methods intent to segment an input color image in order to supply traffic signs' regions and the outline for extra processing. The obstacle of this method is difficult to estimate the correct color information in an image due to the variations of light intensity and illumination variations in order to day-night variations and weather situations (rainy, foggy, snow, etc.).

4.2. Shape-based detection methods:

- Although the methods that using (Hough Transform) may extend satisfying performance. The main drawback of these methods they are high complexity of computational and large requirements of storage.
- Some shape-based methods using the corners in the image. In this method the corners are computed at first and then compute the distance of each pixel that nearest for the corner.

Traffic Sign Recognition methods traditionally divided into two categories: template techniques and classifier techniques.

4.3. Template technique includes the pixel-correlation template; it is easy and good when the aligned very well between the examined image and the template images.

4.4. Classifier- based approaches depend on machine learning techniques; it's extracted a feature vector from the image at first to decrease the computational complexity. After that, the class label of the feature vector is gained by using the classification methods.

5. Driver monitoring system

Comparatively, it is a new category of systems pursues supervision the behavior of the driver. The system should have several cameras built in the car [16,17]. A prominent model of the system is subsequent to the driver's fatigue, drowsiness or awareness of that not using a mobile phone while driving, by using the sensors of the headrest and look for the driver's head to wobble or nod in an indicator motion that mark dowse [18], the warning happened when the observing of driver's face is not forward for more than three seconds while the vehicle continues moving forward [19-22].

6. Adaptive high beam

These systems These systems are intended for helping the drivers for best moreover sight in the dark.

This technology allows to rotate and orbit the headlights to perfect the roadways' illumination out of corners and in other circumstances and spontaneous settlement of brightness shaft rely on the exterior environment. It provides supreme visibility range for the driver (in the status of nighttime driving or bad weather) without shining the other drivers. Usually, the resource of information is a camera seated on the rearview mirror [1].

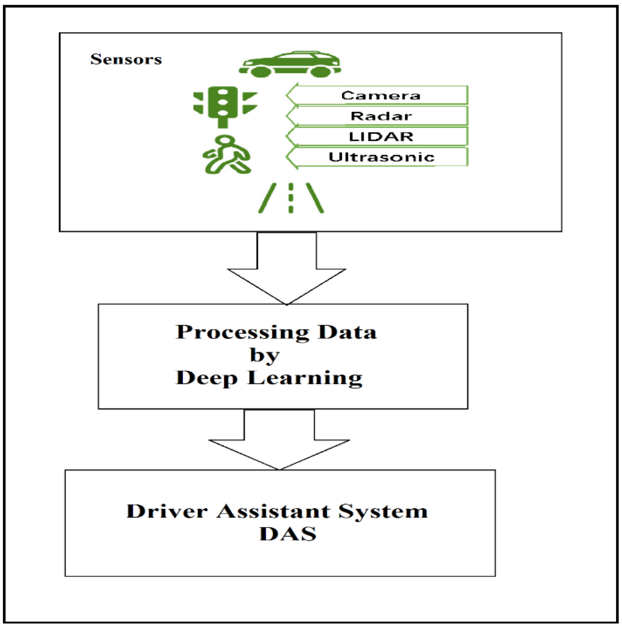

Fig. 2components of Driver Assistant System

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IV. DEEP LEARNING

This section highlights Deep Learning (DL) algorithms, their purpose and differences in their works:
Deep neural networks are tools working powerfully for visible analytics, improved supreme performance in varied tasks. In contrast with the classical models of cursory computational constructions, the representations of data are the major features of deep nets are constructed automatically in the learning process. For that, deep neural networks are considered to be predominantly end-to-end learning, assert that the construction of manual feature is substituted by automatic impersonation learning. The increase in using DL methods which used for object detection [3][16-20] have exceeded numerous classic methods to gain speed and accuracy. Depending on the DL methods for detection, there are systems evolved the results of detection in an intelligent way of computational [24].

1.Convolutional Neural Networks (CNNs) algorithms are able to produce a perfect achievement in highway lane and vehicle detection, CNN had held the major success in image recognition during the past 3 years [18,25] Deep CNN reveals marked lane boundaries simultaneously and elicits the geometry feature of the boundary for detections positively. The output of CNN consists of a classifier to expose the existence of lane signs to classification the location and orientation of it.

2. RNN had able to dealing with areas of a sequence image to detect lane boundaries, implicitly learns structures from the local labels in the training data without needing for heuristic knowledge about the structures [6, 19].In the practical lane detection, CNN and RNN outperformed on conventional detectors [26], they are both discovered to be efficient in detecting lanes with workable traffic scenes, out precede conventional detectors.

3. Bayesian methods utilize probabilities to uncertainty represent; it can be applied for all singular components to representation in subjective confidence as output.

4. Faster R-CNN [3] this technique at first runs the full input image to gain a feature map through some convolutional layers. After that suggesting the secluded region network has utilized these convolutional features to submit probable detection of regions.

5. A multi-sensor detection system [23] used by merging the camera and LiDAR revelation for the precise and robust highlight invention system. A real-time system has been designed as for collision avoidance and examined with initial in various scenarios.

6. Support vector machines (SVMs) are commonly used with conventional features. It is a supervised algorithm for machine learning which can be applied for either classification or regression provocation. It is mostly applied to problems of classification [27].

7.Fully convolutional network (FCN) is used vastly in applications that work for face detection; the in-vehicle driver face detection is considered essential status recognition, like drowsiness detection.
(FCN) for LIDAR–camera fusion is prompted.
In the last years the deep learning algorithms have obtained impressive success in the fields of computer vision and pattern recognition [28].

8. You Only Look Once yolo is a real-time object detection algorithm, foresees offsets off the true location a dependability score and classification it when it thinks that is an object there in the same location as a grid.
YOLO is fast but defeats to reveal a small object sometimes in the image; it obtains speed by combine class and region prediction into one network [23].
There is a similarity between YOLO and R-CNN algorithms.

Table 2 comparison between systems

Method	Tools	Result	Reference
Faster R-CNN	Camera images	Object detection in real time	[3]
deep neural network within a Bayesian framework	LIDAR and camera	appraisal the road surface and boundaries of it	[4]
CNN	Camera	Driver drowsiness detection	[18]
RNN	Mobile camera	Driver face detection	[19]
YOLO	LIDAR–camera Fusion	Collision avoidance	[23]
Sensor fusion based deep learning (CNN)	LiDAR and a single RGB camera	gain more accurately placement and tag information for each detection	[25]
recurrent neural network (RNN)	Sequence image	lane boundary detector	[26]
support vector machine (SVM)	camera images, novel 3D sensors	Road detection traversable in urban and extra-urban screenplays	[27]

fully convolutional neural network (FCN).	Lidar and camera fusion	detect the road in point cloud of top-view images	[28]
CNN	monocular camera images	Resolve the missions of road segmentation and vehicle detection	[29]
conditional random fields (CRFs)	LIDAR–camera fusion	outline road detection	[30]

V. CONCLUSION

Due to the differences in Driver Assistant systems and their purposes and various techniques, methods and tools, it is complicated to make a comparison with them, but there is something almost systems are based on the visual data and the applications that used for object detection based on deep learning techniques in common.

This paper makes a survey of the diversity of application and tools used in vehicle technology and driver assistant system.

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