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AUTOMOTIVE DIGITAL PERCEPTION

Abstract. In this paper the automotive digital perception of self-driving robotic cars is considered. Self-driving robotics vehicles are cars or trucks in which human drivers are never required to take control of the vehicle safely operating. The challenges for this technology are planning and navigation of the vehicle in dynamic environments, ensuring the safety of its passengers and pedestrians, offering high rode efficiency. The development of sensors, algorithms and actuators have made it possible to generate advances in self-driving robotic cars. Impressive progress has been achieved in the last decade, yet recent works on self-driving cars still present limitations in the complexity of the environment and/or the speed of movement.

Keywords. Automotive digital perception, self-driving robotic cars, dynamic environments, sensors, algorithms, actuators.

1. Introduction

Self-driving robotics vehicles are cars or trucks in which human drivers are never required to take control of the vehicle safely operating. The challenges for this technology are planning and navigation of the vehicle in dynamic environments, ensuring the safety of its passengers and pedestrians, offering high rode efficiency [1-2].

The development of sensors, algorithms and actuators have made it possible to generate advances in Self-driving cars. Impressive progress has been achieved in the last decade, yet recent works on self-driving cars still present limitations in the complexity of the environment and/or the speed of movement [3-4].

The paper is organized as follows:
section 1 Introduction,
in section 2 Self-Driving Cars Structure is illustrated,
in section 3 Perception System is presented,
in section 4 Perception System – Gestalt Principles is presented,
in section 5 Perception System – Subsystems is presented,
in section 6 Perception System – Control is presented
in section 7 Perception System – Vulnerabilities is presented,
in section 8 Perception System – Limitations is presented.
Conclusions are given in section 9.

2. Self-Driving Cars Structure

Self-Driving cars can be structured and organized with the perception and decision-making systems, in a sequential way and orderly.

The Perception system is responsible for digitally representing the environment in which the vehicle operates, taking into account the state of the vehicle, using data from sensors inside the vehicle [5-6].

The Decision-Making System is in charge of tracing the most appropriate route for the vehicle, from its initial position to the previously established final objective (Figure 1).

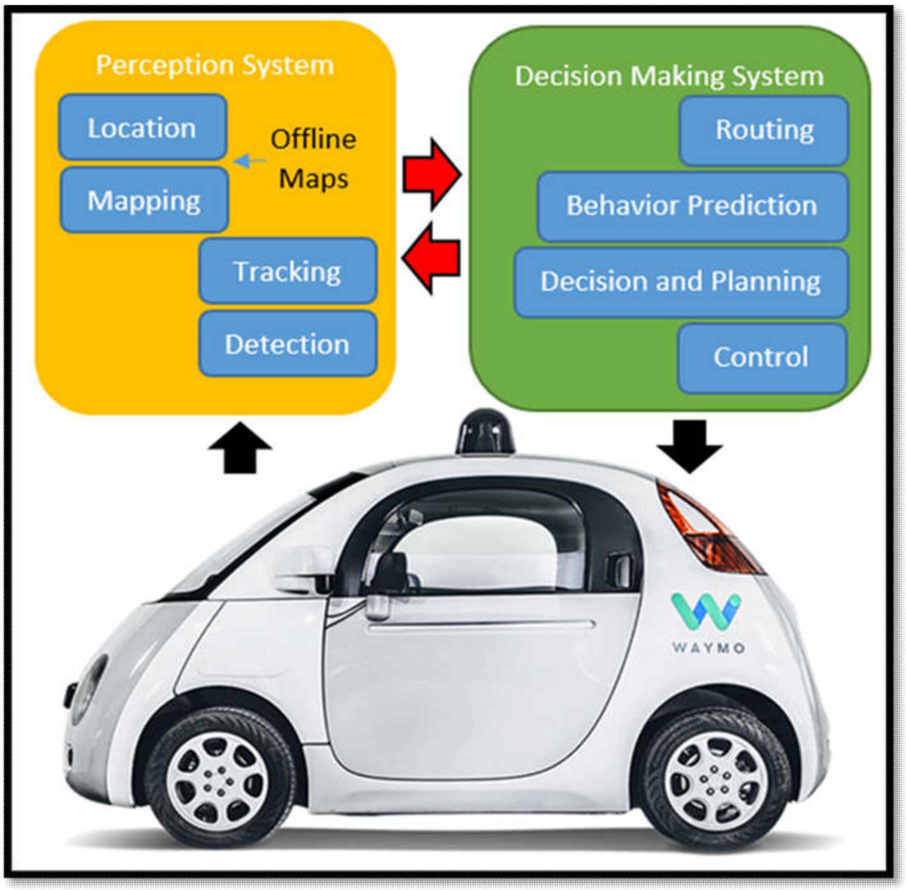

Figure 1. Self-Driving cars structure

The information obtained in the perception system together with historical information collected from the road network, the rules of the road, the vehicle dynamics and the sensors models, all help in the automatic generation of values for control and execution variables of autonomous vehicle.

Autonomous vehicles, which operate in complex dynamic environments, require methods that generalize to unpredictable situations and reason in a timely manner in order to reach human-level reliability and react safely even in complex urban situations. Informed decisions require accurate perception.

3. Perception System

Perception is the process by which human beings receive, interpret, and understand the signals from the environment in which they interact, this information is encoded with sensitive activity [7-9].

It is a series of data that are captured by the human senses as raw information, which then go through an active-constructive process, which involves processing new information by comparing it with previously obtained data (experiences).

In psychology, perception has two components to analyze:

The external environment, refers to the general environment that will be captured (images, sounds, etc.)

The internal environment refers to the way in which the human body interprets these external stimuli (it depends on the individual experiences). For this reason, it is said that perception is subjective. It is selective, based on the decisions of each person and the way of perceiving stimuli, and it is temporary, in an environment of permanent change.

4. Perception System – Gestalt Principles

The Gestalt psychological School, delimited the principles of grouping stimuli that are perceived by human, assigning a specific meaning to what is perceived. The premise "The whole is greater than the sum of its parts" is the logical base of this school. The principles in a general way can be summarized as organization of stimuli by background and form, elements that are at a close distance are usually perceived as a group or as the same object (proximity), linking to things that are continuous and complete. These principles can be applied in algorithm generation for self-driving cars, which means that give the vehicle the ability to discretize the information and choose just the important it, gain process time, and storage space (Figure 2.) [10-12].

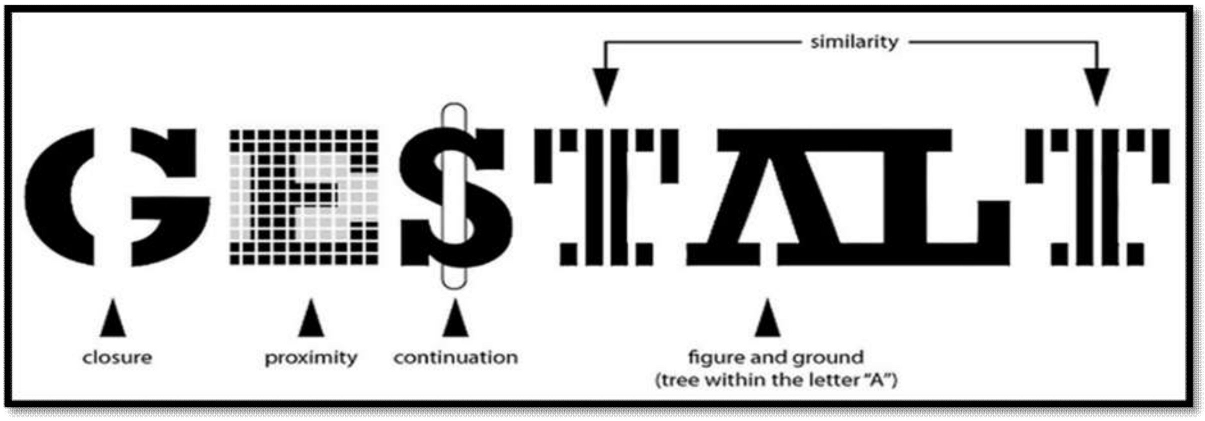

Figure 2. Perception System – Gestalt Principles

5. Perception System – Subsystems.

The perception system is made up of multiple subsystems that include location, tracking, mapping and detection. Modeling of an autonomous system begins with the notion of the configuration of the vehicle, which represents its position and location in the world with reference to a coordinate system. These subsystems joint with offline maps, transform the sensors data input into useful information for the decision-making system and allow vehicle to navigate.

Location: The localizer subsystem is in charge of detecting the current state of the car (cardinal position, angular and linear speed, etc.) relative to a reference frame in a map, which can be either a raw point cloud map or an annotated semantic map, depending on intelligent technology and sophisticated algorithm. This reference map

(Offline map) is given by the information obtained from the sensors of the autonomous vehicle and is automatically calculated before the autonomous operation.

Mapping: The mapping subsystem is in charge of creating online maps, using the information about the state of the car (Location Subsystem) and the offline maps, for decision-making in an autonomous vehicle. The online map provides a static representation of the environment in which it navigates, in addition to information on the position and speed of moving obstacles. This process allows greater autonomy to avoid collisions with moving obstacles and eliminate them from the online map.

Tracking: The tracking subsystem is in charge of determining and estimating the position of the obstacles that appear during the navigation of an autonomous vehicle. This information is used for the algorithms development that allow the vehicle to avoid obstacles in motion. The phases of tracking system are the Segmentation, where the obstacles are divided into smaller segments that have different needs, characteristics and behaviors; the Association, where it connects objects with similar characteristics (depending on the criteria of an intelligent algorithm); and the Filtering, where Kalman filters and particulate filters are used to smooth the vehicle's dynamics.

Detection: The detection subsystem is responsible for the recognition and estimation of vehicles that circulate in the environment, it is based on characteristics such as their position, direction in which they are moving and their sizes. The steps for obtained necessary information through cameras and sensors are: The first step is to take a picture, the second step is to assign labels to each pixel of the image (an object can have several pixels with the same label), and the third step is to create a 3D image to determine the position of the vehicles [13-15].

6. Perception System – Control

In traditional automotive control, at relatively low speeds, a kinematic model of the car could be employed for control. Given a reference path, proportional–integral–derivative (PID) control, feedback linearization, or simple model predictive control can then be used to track it. Currently, operating at high speeds or performing aggressive maneuvers requires employing the full dynamic model of the vehicle, including tire forces. Nonlinear control, model predictive control, or feedback–feedforward control stabilizes the behavior of the vehicle while tracking the specified path. Good tracking performance has been achieved with these vehicle models and controllers, even for autonomous racing. The algorithms and software that interpret sensor inputs and control the vehicle outputs are, of course, a critical part of the technology. A vehicle needs machine learning algorithms to have the capability of identifying and reacting to objects autonomously. To train a driving system use these algorithms requires large sets of annotated images. The chosen technique will depend on the amount and type of data available, the knowledge about the system dynamics, and the control method to be employed. Since the conditions of the road and the vehicle will vary with time, online model identification and lifelong system identification will improve the performance of autonomous vehicles. Tools from machine learning show great potential to create models from the large amounts of data collected [16-17].

7. Perception System – Vulnerabilities

With the growth of smart devices capable of storing information on the cloud, generate an enormous amount of data will become available for alternative usage, which is likely to present challenges and opportunities about data security, privacy concerns, and data analytics and aggregation. In a personal mobility based on autonomous vehicles, threats will undoubtedly arise. Unauthorized parties, hackers, or even terrorists could capture data, alter records, instigate attacks on systems, compromise driver´s privacy by tracking individual vehicles, or identifying their residences [18-19].

8. Perception System – Limitations

The artificial driving intelligence is still incapable to annotate and categorize driving environment on its own, without need for human assistance. Also, much of the earlier tests conducted on autonomous driving were predominantly on open roads and good weather. The technology to obtain data (sensors) as fast as necessary and to vehicle reaction (actuators) to unexpected events. The ability to store (networking) and process a very large amount of data with adequate speed.

9. Conclusions

In this paper the automotive digital perception of self-driving robotic cars is considered. Self-driving robotics vehicles are cars or trucks in which human drivers are never required to take control of the vehicle safely operating. The challenges for this technology are planning and navigation of the vehicle in dynamic environments, ensuring the safety of its passengers and pedestrians, offering high rode efficiency. The development of sensors, algorithms and actuators have made it possible to generate advances in Self-driving robotic cars. Impressive progress has been achieved in the last decade, yet recent works on self-driving cars still present limitations in the complexity of the environment and/or the speed of movement.

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