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Autonomous Car without Using GPS

[1]DR.S.Anita, [2]A.Chandrasekar, [3]K.Hitesh, [4]V.Mohanakrishnan
[1]Asst.Professor, EEE dept, RMK Engineering college
[2,3,4] Students , EEE dept, RMK Engineering college

Abstract:

The main idea of this paper is to deduce a systematic and cost effective method by which we can implement a system in order to effectively navigate an autonomous vehicle without the usage of any GPS systems for a predefined locality. This can be achieved by our idea where we replace the usage of the GPS system by using predefined maps of the locality and the programming the system to work out the best route possible by out Adaptive Mapping Algorithm. The various advantageous of this system include a cheaper implementation and a much higher degree of accuracy in comparison to the existing ideas.

Keywords — **CAV (Connected autonomous vehicles), GPS (Global positioning system), AMA (Adaptive Mapping Algorithm).**

I. INTRODUCTION

An autonomous car (also known as a driverless car, self-driving car, robotic car) is a vehicle that is capable of sensing its environment and navigating without human input. It is an entirely self-sufficient system that can operate without constant guidance or any human interactions. It can be designed to operate on predefined pathways or to chart out its own course based on the local environment.Autonomous cars use a variety of techniques to detect their surroundings, such as radar, laser light, GPS, odometry and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage Autonomous cars must have control systems that are capable of analyzing sensory data to distinguish between different cars on the road.

A. Levels of driving automation

In SAE's autonomy level definitions, "driving mode" means "a type of driving scenario with characteristic dynamic driving task requirements (e.g., expressway merging, high speed cruising, low speed traffic jam, closed-campus operations, etc.)".

- Level 0: Automated system issues warnings and may momentarily intervene but has no sustained vehicle control.
- Level 1 (”hands on”): Driver and automated system shares control over the vehicle. An example would be Adaptive Cruise Control (ACC) where the driver controls steering and the automated system controls speed. Using Parking Assistance, steering is automated while speed is manual. The driver must be ready to retake full control at any time**. Lane Keeping Assistance (LKA)** Type II is a further example of level 1 self-driving.
- Level 2 (”hands off”): The automated system takes full control of the vehicle (accelerating, braking, and steering). The driver must monitor the driving and be prepared to immediately intervene at any time if the automated system fails to respond properly. The shorthand “hands off” is not meant to be taken literally. In fact, contact between hand and wheel is often mandatory during SAE 2 driving, to confirm that the driver is ready to intervene.
- Level 3 (”eyes off”): The driver can safely turn their attention away from the driving tasks, e.g. the driver can text or watch a movie. The vehicle will handle situations that call for an immediate response, like emergency braking. The driver must still be prepared to intervene within some limited time, specified by the manufacturer, when called upon by the vehicle to do so. In 2017 the Audi A8 Luxury Sedan was the firstcommercial car to claim to be able to do level 3 self-driving. The car has a so-called Traffic Jam Pilot. When activated by the human driver, the car

takes full control of all aspects of driving in slow-moving traffic at up to 60 kilometers per hour. The function works only on highways with a physical barrier separating oncoming traffic.

- Level 4 (”mind off”): As level 3, but no driver attention is ever required for safety, i.e. the driver may safely go to sleep or leavethe driver's seat.Self-driving is supported only in limited areas (geofenced) or under special circumstances, like traffic jams. Outside of these areas or circumstances, the vehicle must be able to safely abort the trip, i.e. park the car, if the driver does not retake control.
- Level 5 (”steering wheel optional”): No human intervention is required. An example would be a robotic taxi.

B. *Google self driving car*

In August 2012, Google announced that their vehicles had completed over 300,000 autonomous-driving miles (500,000 km) accident-free, typically involving about a dozen cars on the road at any given time, and that they were starting to test with single drivers instead of in pairs. In late-May 2014, Google revealed a new prototype that had no steering wheel, gas pedal, or brake pedal, and was fully autonomous. As of March 2016, Alphabet had test-driven their fleet in autonomous mode a total of 1,500,000 mi (2,400,000 km).In December 2016, Google Corporation announced that its technology would be spun-off to a new subsidiary called Waymo.

Based on Google's accident reports, their test cars have been involved in 14 collisions, of which other drivers were at fault 13 times, although in 2016 the car's software caused a crash.

In June 2015, Brin confirmed that 12 vehicles had suffered collisions as of that date. Eight involved rear-end collisions at a stop sign or traffic light, two in which the vehicle was side-swiped by another driver, one in which another driver rolled through a stop sign, and one where a Google employee was controlling the car manually. In July 2015, three Google employees suffered minor injuries when their vehicle was rear-ended by a car whose driver failed to brake at a traffic light. This was the first time that a collision resulted in injuries. On 14 February 2016 a Waymo vehicle attempted to avoid sandbags blocking its path. During the manoeuvre it struck a bus. Google stated, "In this case, we clearly bear some responsibility, because if our car hadn’t moved there wouldn’t have been a collision". Google characterized the crash as a misunderstanding and a learning experience.

II. THE GPS MODEL

GPS actually refers to a space based radio navigation system that is owned by the US Air Force. The more generic term is “**SATELLITE NAVIAGTION**”.A satellite navigation system with global coverage may be termed a **global navigation satellite system** (**GNSS**).Global coverage for each system is generally achieved by a satellite constellation of 18–30 medium Earth orbit (MEO) satellites spread between several orbital planes. The actual systems vary, but use orbital inclinations of >50° and orbital periods of roughly twelve hours (at an altitude of about 20,000 kilometers or 12,000 miles).

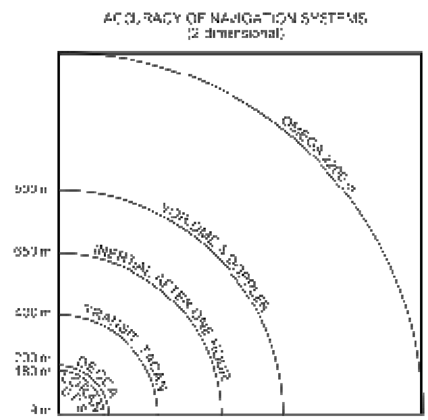

Fig. 1. Accuracy of navigation system

The United States' **Global Positioning System (GPS)** consists of up to 32 medium Earth orbit satellites in six different orbital planes, with the exact number of satellites varying as older satellites are retired and replaced. Operational since 1978 and globally available since 1994, GPS is currently the world's most utilized satellite navigation system.

The Indian government has developed its own system called **GPS-aided GEO augmented navigation** (**GAGAN**). It is used by the AAI and was developed by ISRO.

A. *Drawbacks of the GPS model*

There are several problems that have been encountered in the implementation of the GPS model with the most notable examples being high implementation costs and lower accuracy for more inexpensive models. This can have severe drawbacks and cause impaired functioning. Hence in order to better improve the device and get more reliability we propose the removal of the GPS and installation of a more accurate and sturdy system. This is the main driving idea for the AMA model. By using our AMA model we can overcome all the major drawbacks that are present in the traditional system.

III. PROPOSED SYSTEM: THE AMA MODEL

Here we use our algorithm in order to plot the suitable path that is required for the navigation of the vehicle. Here we have proposed the model only for usage in a small scale representation. However we believe that this same system can be sufficiently extended to include more larger and complicated systems by applying the same logic. This system can be automatically extended to accommodate more complicated and real time applications.Navigation maps provide critical information for 'Advanced Driving Assistance Systems and Autonomous Vehicles'. When these maps are refined to lane-level, ambiguities may occur during the map-matching process, particularly when positioning estimates are inaccurate. Our method uses lane-level maps that feature dedicated attributes such as connectedness and adjacency. The vehicle position is essentially estimated by dead-reckoning sensors and lane detection using an intelligent camera.

The position the vehicle can be monitored in real time by using optic sensors and hence we can map out the vicinity of the vehicle. The initial position of the vehicle can be given by the user which is defined as point 0 or the starting point. With reference to this point the rest of the pathway is defined. Hence with only the initial position we can plot out the future course of the vehicle. This gives us the required data for the entire navigation system.

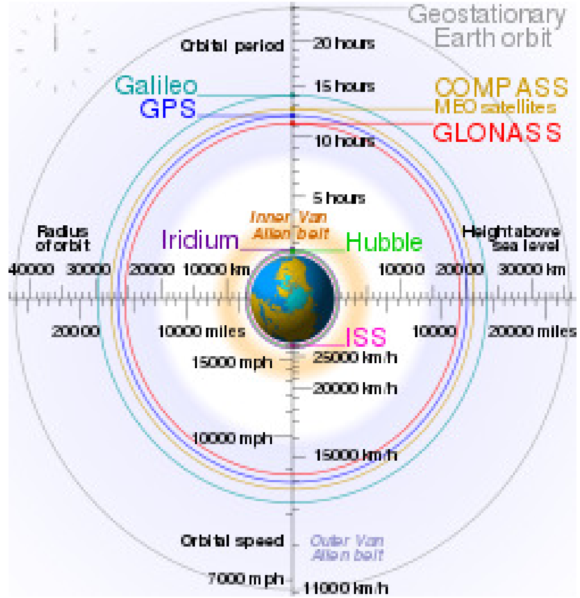

Fig. 2.Geostationary Earth Orbit

Comparison of geostationary, **GPS**, **GLONASS**, **Galileo**, **Compass (MEO)**, International Space Station, Hubble Space Telescope and Iridium constellation orbits, with the Van Allen radiation belts and the Earth to scale. The Moon's orbit is around 9 times larger than geostationary orbit.

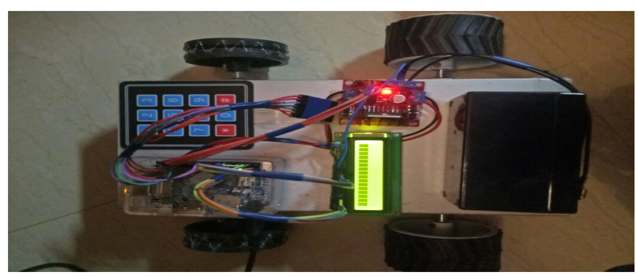

Fig. 3. Working model

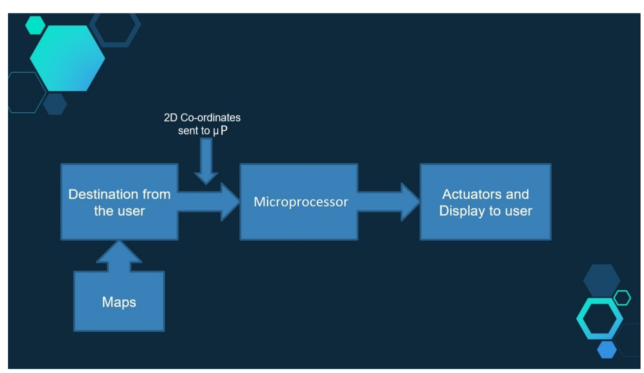

Fig. 4. Block diagram

The image shows the system that we had constructed in order for the trial run. Here we have stripped it down to its bare essentials and working parts. The vehicle has is pending actual field tests but is functional on a theoretical scale. The working of the coordinate system which is the backbone of the entire project is explained below.

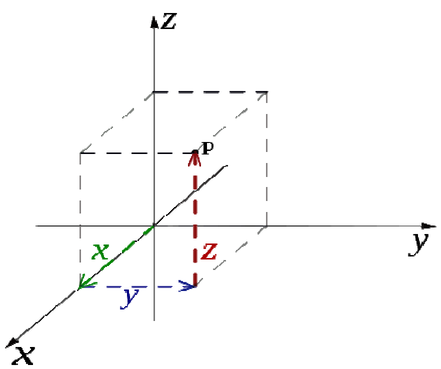

Fig. 4. Coordinate system

A **Cartesian coordinate system** is a coordinate system that specifies each point uniquely in a plane by a pair of numericalcoordinates, which are the signed distances to the point from two fixed perpendicular directed lines, measured in the same unit of length. Each reference line is called a *coordinate axis* or just *axis* (plural *axes*) of the system, and the point where they meet is its *origin*, at ordered pair (0, 0). The coordinates can also be defined as the positions of the perpendicular projections of the point onto the two axes, expressed as signed distances from the origin.One can use the same principle to specify the position of any point in three-dimensionalspace by three Cartesian coordinates, its signed distances to three mutually perpendicular planes (or, equivalently, by its perpendicular projection onto three mutually perpendicular lines). In general, *n* Cartesian coordinates (an element of real *n*-space) specify the point in an *n*-dimensional Euclidean space for any dimension*n*. These coordinates are equal, up to sign, to distances from the point to *n* mutually perpendicular hyperplanes.

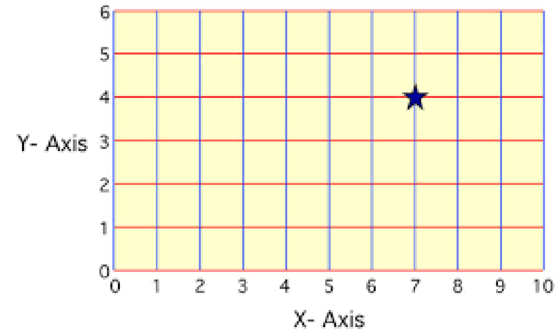

Fig. 5. The graph using which the car locates

Here we can see the real life application of using the coordinate system to map a real time location. The equations are given below.

$$m = \frac{y - y_1}{x - x_1}$$

$$(x - x_1)m = \frac{(y - y_1)}{(x - x_1)}(x - x_1)$$

$$(x - x_1)m = (y - y_1)$$

$$(y - y_1) = m(x - x_1)$$

Here we can calculate the slope m from the equations.

From the equations we can calculate the locations for any point and get the best pathway for the vehicle to go through. Hence by this system we can solve for any random point. This system can then be extended to include all otherapplications.

Linear equations can be written in different forms, depending upon what we either know or want to know about a line. The point slope form,

$$(y - y_1) - m(x - x_1),$$

is useful in situations involving slope and the location of one or more points. The standard form, Ax + By = C, is usually easier to use when we need to make algebraic calculations. When needs or knowledge change, we can convert an equation from one form into another.

IV. NAVIGATION EQUATION

The receiver uses messages received from satellites to determine the satellite positions and time sent. The *x, y,* and *z* components of satellite position and the time sent are designated as $[x_i, y_i, z_i, s_i]$ where the subscript *i* denotes the satellite and has the value 1, 2... *n*, where $n \geq 4$. When the time of message reception indicated by the on-board receiver clock is $\tilde{t}_i$, the true reception time is $t_i = \tilde{t}_i - b$, where *b* is the receiver's clock bias from the much more accurate GPS clocks employed by the satellites.The amount of error in the results varies with the received satellites' locations in the sky, since certain configurations (when the received satellites are close together in the sky) cause large errors. Receivers usually calculate a running estimate of the error in the calculated position. This is done by multiplying the basic resolution of the receiver by quantities called the **Geometric Dilution Of Position (GDOP)** factors, calculated from the relative sky directions of the satellites used. The receiver location is expressed in a specific coordinate system, such as latitude and longitude using the WGS 84geodetic datum or a country-specific system

V. CONCLUSION

The present autonomous system uses GPS system to track the location and to reach the destination. This has a major disadvantages in many places as the GPS is not always not accurate and also in uncertain conditions like places where there is no GPS signal facility available mainly in military purpose. So this system can be used in any places where the GPS signal is not available.

VI. ADVANTAGES

- ***Better accuracy***:In this method we getmuch higher accuracy than using GPS system. Thisis due to the fact that we us local systems that give better results.
- ***Lower costs:*** This is due to the fact that we use much cheaper hardware in comparison to GPS.
- ***Easier access:*** This is due to the easier implementation of this system.

VII. DISADVANTAGES

- ***Manual updates needed:***In this system we need to manually update the maps in the car.

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