Self Driving Car: Artificial Intelligence Approach

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Abstract - Artificial Intelligence also known as (AI) is the capability of a machine to function as if the machine has the capability to think like a human. In automotive industry, AI plays an important role in developing vehicle technology. Vehicular automation involves the use of mechatronics and in particular, AI to assist in the control of the vehicle, thereby relieving responsibilities from the driver or making a responsibility more manageable. Autonomous vehicles sense the world with such techniques as laser, radar, lidar, Global Positioning System (GPS) and computer vision. In this paper, there are several methodologies of AI techniques such as: fuzzy logic, neural network and swam intelligence which often used by autonomous car. On the other hand, self driving cars are not in widespread use, but their introduction could produce several direct advantages: fewer crashes, reduce oil consumption and air pollution, elimination of redundant passengers, etc. So that, in future where everyone can use a car and change the way we use our highways.

Key Words - artificial intelligence, self driving, vehicular automation, fuzzy logic, neural network, swam intelligence.

I. INTRODUCTION

AI brings a new paradigm in the automotive world. Manufacturers of the world's vehicles face a revolutionary moment as vehicles acquire advanced onboard computer systems, Internet access, and advanced display/interaction hardware. In general, automotive manufacturers have little or no experience in software development, and especially UI development [1].

Meanwhile, mechatronics is an engineering discipline integrating the fields of mechanical engineering, electrical engineering and computer science [2]. While the word "mechatronics" already has a long history, it is only the last ten years that we see their application all around us. Cars, CD players, washing machines, railways are all examples of mechatronic systems. The main characteristic (and driving force) of recent advances is the progressively tighter coupling of mechanic and electronic components with software.

An autonomous car, also known as robotic or informally as driverless or self-driving car, is an autonomous vehicle capable of fulfilling the human transportation capabilities of a traditional car [3]. As an autonomous vehicle, it is capable of sensing its environment and navigating on its own. A human may choose a destination, but is not required to perform any mechanical operation of the vehicle. Advanced control systems interpret the information to identify appropriate navigation paths, as well as obstacles and relevant signage. Autonomous vehicles typically update their maps based on sensory input, such that they can navigate through uncharted environments.

Modern cars are equipped with a variety of sensors, advanced driver assistance systems and user interfaces nowadays. To benefit from these systems and to optimally support the driver in his monitoring and decision making process, efficient human-machine interfaces play an important part. These systems give the driver new possibilities to control or to interact with the car and to assist the driver.

From a Computer Science perspective unmanned vehicles serve as a research platform for progress in a variety of fields as machine learning, computer vision, fusion of sensor data, path planning, decision making, control architectures and intelligent autonomous behavior.

II. METHODOLOGY

Based on several literature papers/journals which we read with related to self driving or vehicular automation, there are several approaches to artificial intelligence methodology like some of the things below are summarized from the literature:

- Autonomous navigation of robotic vehicles is achieved via continuous interaction between perception, intelligence and action [4]. Navigation of autonomous robotic vehicles in obstacle filled dynamic environments requires derivation and implementation of efficient real-time sensor based controllers. Effective control algorithms for autonomous navigation, should imitate the way humans are operating manned or similar vehicles.

  Fuzzy logic is a form of many-valued logic or probabilistic logic; it deals with reasoning that is approximate rather than fixed and exact [5]. In contrast with traditional logic theory, where binary sets have two-valued logic: true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false.

The system can change and affect its environment instantaneously by reacting through the effectors. Theoretical analysis of the fuzzy control algorithms of mobile robot control will be performed. The requirements for a suitable rule base selection in the proposed fuzzy controller will be provided, which can guarantee the asymptotical stability of the system. These rules may include:

- The vehicle must maintain its alignment within established boundaries to define the environment
- The direction of travel of the vehicle is usually fixed
- The speed of the vehicle is restricted to an upper limit
- The vehicle must not collide with other vehicle or the environment boundaries

Modular approach helps to distribute the processing power amongst its sensor, motor driver and supervisor modules and also, easy future enhancements in robot design.

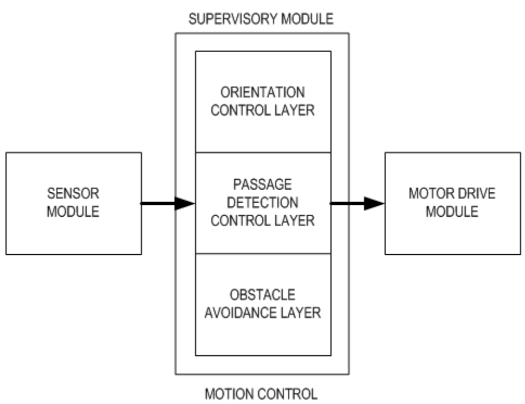
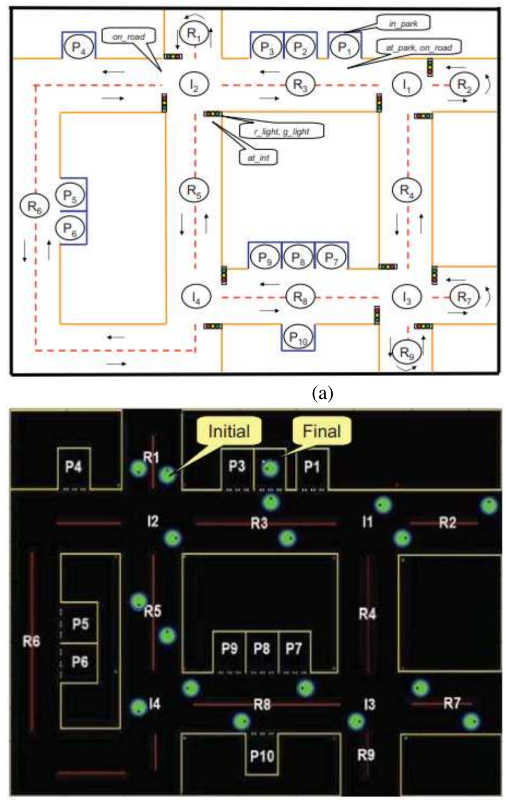


Fig 1. Block Diagram of System

The sensor module will sense all the obstacles in the path of the robot and if find any obstruction, it will compute the distance between them i.e. the obstacles and the robot; and notifies it to the motion controller to manage. The motor driver module maintains all the information needed to travel from source to destination distance traveled and also take care of movement of robot in a specific direction. The decision making part of the robot is handled by the supervisor module, which instructs the sensor module regarding the sensor sequence to be fired and commands the motor driver module to move in a particular direction along with the direction to turn if there is an obstacle. It also sets the speed with which the robot should move. These navigational decisions are made utilizing a control algorithm of the supervisor module.

- A computational framework and an experimental setup for deployment of autonomous cars in a miniature Robotic Urban-Like Environment (RULE) [6]. There are several aspect proposed to implement framework, as follows:
  - ✓ Robot Transition System



(a)

(b)

Fig 2. (a) A schematic representation of the city environment; (b) Snapshots from a movie produced with our simulator showing a robot executing the motion

Each state models a behavior or a collection of related robot behaviors where each is implemented as a low-level feedback controller. There is a transition from a robot state to another once an event (input) is triggered by the environment or the robot itself. For instance, in state Drive, the robot moves at constant speed in a lane while looking for intersections and parking spaces. When an intersection or a parking space is found, the event at_int at_park is generated, and the robot transits to the next state. The robot is initiated either in parking wait or drive. If the robot is driving on a street and reaches an intersection, the event at_int is triggered, which forces the robot to transfer to the Intersection wait state.

✓ Environment Transition System

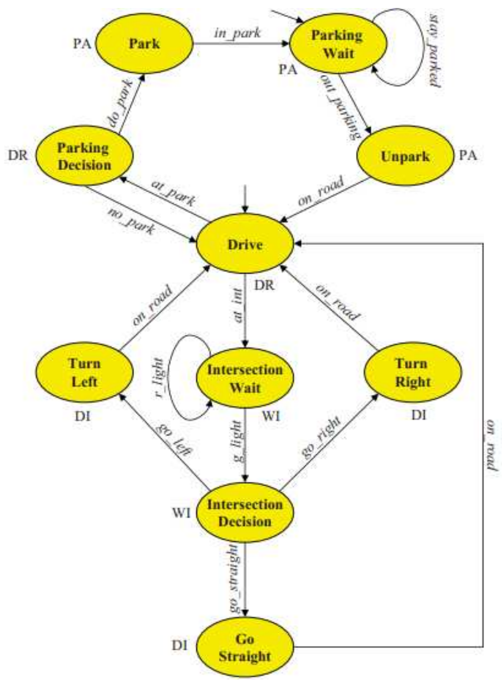


Fig 3. The robot transition system (TR). The states label robot behaviors (e.g., Drive, Park). The transitions are enabled by inputs that can be robot decisions (e.g., go_left) or environmental events (e.g., at_int). The observations (e.g., DR = "Drive on a road", DI = "Drive through an intersection") are high-level descriptions of the robot behavior.

Based on the picture number 2, the environment comes with a label or mark that can be read by an infrared sensor which is owned by the robot. Based on these signs will identify the robot or the obstacles in front of robot. For example I_i, the robot will recognize that there is an intersection ahead. And if the robot is in the parking area, if the sensor captures R_n word, it means no parking area.

Based on the picture number 3, we can see the transfer status of the algorithm moves the robot to follow the infrared sensor.

The transition systems to model the motion and sensing capabilities of the robots and the topology of the environment, formulas of Linear Temporal Logic (LTL) to allow for rich specifications, and tools resembling model checking to generate robot control strategies and to verify the correctness of the solution.

- Road junctions are important objects for all traffic related task, and are essential e.g. for vehicle navigation system [7]. They also play a major role in topographic mapping. For automatically capturing road junction from images models are needed, which describe the main aspect. The whole feature serves as input an artificial neural network. The neural classifier decides for a search window, whether it's central pixel is a part of road junction or not.

Edge detection is a fundamental tool in image processing, machine vision and computer vision, particularly in the areas of feature detection and feature extraction, which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities [8].

The development of the junction operator started with a model-building step. In this phase image samples of different type of road junctions were collected. The obtained data set contained crossings with different road widths and or intentions. In order so me what simplify the task the type of the junctions was limited on several arm junctions.

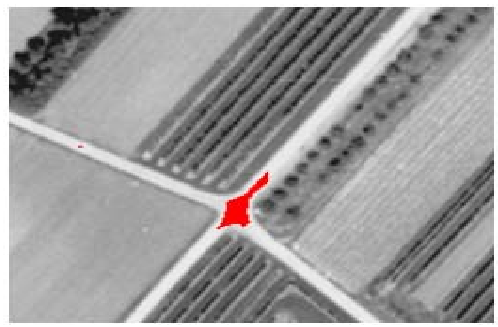


Fig 4. Recognition accuracy of the junction operator on known sample

The trained junction operator was first tested on known images, i.e. with images from the training set. Fig. 4 shows the correct identification of a 4-arm junction.

Fig 5. Detected junctions in the other part of the study area.

Fig. 5. All junctions were detected, except one in the left bottom corner. The shadows have the effect that no straight edge vector was detected, thus the crossing was not found.

The used vectors are derived by edge detection techniques. Obviously, these techniques do not only find road edges, but also all similar gray level edges all over the image. In order to reduce this ambiguity that has focused on the evaluation of the extracted edges by introducing the central circle criterion. The selected edge vectors were used to derive features, which in conjunction with raster features were the inputs for the artificial neural network.

- Swarm intelligence (SI) is the collective behavior of decentralized, self-organized systems, natural or artificial. The concept is employed in work on artificial intelligence. The expression was introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems [9].
  Unmanned vehicles are used to explore physical areas where humans are unable to go due to different constraints [10]. There have been various algorithms that have been used to perform this task. Swarm intelligence for searching a given problem space for a particular target(s). The work in this paper has two parts. In the first part, a set of randomized unmanned vehicles are deployed to locate a single target. In the second part, the randomized unmanned vehicles are deployed to locate various targets and are then converged at one of targets of a particular interest. Each of the targets carries transmits some information which draws the attention of the randomized unmanned vehicles to the target of interest. The Particle Swarm Optimization (PSO) has been applied for solving this problem. Results have shown that the PSO algorithm converges the unmanned vehicles to the target of particular interact success and quickly.
  The following is the quality factor.
  $V_{new} = w_i * V_{old} + c_1 * rand() * (P_{best} - P_{old}) + c_2 * rand() * (G_{best} - P_{old})$……………………(1)
  $P_{new} = P_{old} + V_{new}$…………………………………(2)

  Where,
  - ✓ V_{new} = New velocity calculated for each particle;
  - ✓ V_{old} = Velocity of the particle from the previous iteration;
  - ✓ P_{new} = New position calculated for each particle;
  - ✓ P_{old} = Position of the particle from the previous iteration;
  - ✓ P_{best} = Particle' best position;
  - ✓ G_{best} = The best position a particle attained in the whole population swarm
  - ✓ w_i = Inertial weight constant
  - ✓ c_1 & c_2 = Weights for the terms dependent on the particles' position (acceleration constants)

  The procedure for the implementation of PSO involves the following basic steps as follows:
  1. Define the problem space with its boundaries.
  2. Initialize an array of particles with random positions and velocities. These random positions are initially assigned to be the P_{best} of the particles. Also initialize the target(s) position(s).
  3. Evaluate the desired fitness function of the particles in step (ii). In this case, the Euclidean distance from the target. Select the G_{best} from the P_{best} of the particles.
  4. Compute the particles' new velocities and positions using (i) and (ii) respectively.
  5. Check if the particles are within the problem space. If the particles are not within the problem space, then the velocity is set to the maximum velocity (re-defined) and the particle's new position is set to its previous best position.
  6. Calculate the new fitness function for all the particles' new positions. Determine the particles' new P_{best}. compare with the particles' previous P_{best} and update the value with the new one if necessary.
  7. Calculate the new global best position G_{best} among all the particles' new P_{best}. Compare with the previous best and update the global best before the next iteration.
  8. The steps (iv) to (vii) are repeated until all the particles have attained their desired fitness.

  The differences between particles positions with respect to the global best (G_{best}) and the respective particle's best (P_{best}) are weighted by the constants cl and c2 and a random number between 0 and 1.

III. RESULT AND DISCUSSION

Having reviewed various papers as mentioned above, here is the result as follows:

- Since 2010, developments in information technology associated with the automotive industry can be said to be one entity, this can be seen from the self-driving car developed by Google [11]. AI techniques approach the autonomous car is an important part in the study. Autonomous car with fuzzy logic approach to engineering, computer vision, neural networks, swarm intelligence and the most frequently used. The whole AI techniques that have been mentioned above, facilitates the selection of the industry in technological approaches that may be developed.

- Based on the above four techniques, it is difficult if the use of AI techniques done partially on the autonomous car. This is due to each technique has its own advantages and disadvantages. The incorporation of several techniques in developing the autonomous car needs to be done further research to get the best results. So that the resulting product or a car could answer the needs of the market at the time.
- Self-driving cars are no longer just the stuff of science fiction. Increasingly, they're becoming a reality.

IV. CONCLUSIONS

AI is now applied in various fields such as education, industry, health, banking, entertainment, research and so forth. [12] In automotive industry, AI approaches in the smarter vehicles could help make transportation safer and more efficient: Cars would drive closer to each other, making better use of the 80 percent to 90 percent of empty space on roads, and also form speedy convoys on freeways. They would react faster than humans to avoid accidents, potentially saving thousands of lives. Vehicles would become a shared resource, a service that people would use when needed. You'd just tap on your smart phone, and an autonomous car would show up where you are, ready to drive you anywhere. You'd just sit and relax or do work. This is one way we see in the future this technology can actually make transportation better, make it more efficient.

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