

# Ethics of Artificial Intelligence in Autonomous Vehicles

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**Abstract**—There have been remarkable advancements in the automobile industry the last century. Along with the progress in computation and communication development, Real Time Operation Systems (RTOS) allows implementation of a vast set of technologies. RADAR, LIDAR, GPS and AI are some of them. Also, autonomous vehicles (AV) are becoming a reality. Safety, optimal trafficflow and ease of travel are among some of the aspects AV's are foreseen to cover. With the development of AV's comes ethical challenges and questions which are unavoidable. We propose that such matters should be integrated in the development rather than impeding it. United Nations Economic Commission for Europe (UNECE) has, as of this year (2020), made regulations that will allow for safer introduction for AV's in certain traffic situations. They have made a regulation where strict requirements are given for Automated Lane Keeping Systems (ALKS) and the current level for AV's is now at three. This leads us to think that AV's and similar types of landbased vehicles are not far fetched in the near future.

## I. INTRODUCTION

The technology in automobile industry has made some remarkable progress the last century. They have managed to make safe, reliable and affordable vehicles. The last couple of decades have seen significant advancements in computation and communication technologies, and consequentially autonomous vehicles (AV) are now becoming a reality [1]. Several prototypes exist today. Among others, Volvo have started implementing autonomous trucks that deliver goods [2].

### A. Autonomous vehicles

1) *What is it?*: A definition of autonomous vehicle (AV) can be a vehicle which senses its environment with little or no human input or interaction. This means that the vehicle is capable of gathering information about the environment around it such as objects, temperature, position, velocity etc. And execute tasks or functions according to certain directives.

2) *Why?*: Humans are biological lifeforms which depend and react on, among other things but not limited to, sleep, food, stress, isolation, social interactions and other similar processes. Besides being complex lifeforms humans react differently to these processes choices taken, in certain situations, differ greatly.

Machines today are not dependent on such stimuli and therefore they can, theoretically, continue with tasks to an

infinite amount of time. At mundane and repeated tasks such as arithmetic calculations or retaining huge amounts of data, machines and computers excel with unrivalled precision and accuracy. This makes them good candidates for making pure rational and logical decisions based on optimal outcomes of certain criteria.

Based on this assessment machines would take more optimal choices over time in comparison with the average human. And their choices would be easier to determine based on simulations and testing scenarios. This would make outcomes and outputs deterministic and easy to predict and consequentially present a good basis for development and optimization.

## II. THEORY

### A. Technology

A brief presentation on certain technologies implemented in today's land based vehicles. Both autonomous and nonautonomous.

1) *Real Time Operating System*: Cars today rely on numbers of sensors to acquire information about their surroundings. The velocity, GPS, proximity to obstacles, temperature etc. These sensors communicate to certain modules that are connected to an operating system (OS). This is often a specialized form of OS. A so called Real Time Operating System (RTOS) makes up the central core and processor of the car. Within, all decisions based on data from the sensors are made and functions executed. Some aspects of RTOS are presented here. [3]

a) *Hard time RTOS*: A deterministic RTOS. Meaning that the output of the RTOS should happen within a certain time or deadline. Used in mission critical systems like medical devices, flight control space shuttles etcetera.

b) *Soft time RTOS*: Not as deterministic as Hard Time, but deadline of tasks and processes should be met within certain limits. The RTOS performance will degrade if tasks are never done within deadline and would be useless. Examples here can be audio-visual-systems for entertainment, games and general purpose OS's like Windows, Ubuntu and iOS.

2) *Camera*: Cameras are indispensable for providing visual information and feedback to any system, in regards to its environment. In comparison to radar, LIDAR or similar sensors, cameras are affected by weather, dust and pollution.

3) *RADAR*: Radio Detection and Ranging (RADAR) can complement the camera and is resistant to both pollution, weather and similar. It emits electromagnetic waves which reflect on obstacles and back to the RADAR. Distance, velocity and position (relative to the RADAR) can then be calculated with great accuracy. There are different types of RADAR and the most used is Frequency-modulated continuous Wave (FMCW). [4]

a) *FMWC*: Allows the detection of small objects with the use of the Doppler effect. Since the known transmitted frequency is known, stable and slow-moving objects can be filtered out of the receiving signal. This reduces interference and increases the signal to noise ratio.

4) *LIDAR*: Goes under many names. One of them is "Laser Imaging and Ranging". This method utilizes laser beams and their reflection of objects to measure distance. Also called ranging. The lidar's output would be point cloud data, which provides all the necessary information, to a software for detecting and determining where potential obstacles and objects are located in the environment. [5]

5) *GPS*: A property of the United States Government. GPS is acronym for "Global Positioning System". It utilizes satellites for positioning. The system is freely available for anyone with a GPS receiver and has global coverage. Several other systems from other countries exist. As long as a GPS receiver has line of sight to four or more satellites, a pinpoint of position can happen with an accuracy of two meters or less.

## B. Autonomy

The definition for autonomy would be the capacity to make informed and uncoerced decisions, based on some set of information. From a more metaphoric perspective, this would be that an entity, person or organization would be given self-governing capacity. This to make decisions not forced on it by a higher ranking entity, regime, person etc.

## C. Machine learning

Machine learning (ML) is a subset of artificial intelligence (AI) and by definition is "the study of computer algorithms that improves automatically through experience" [6]. Said in simpler terms it makes the machine/system learn from experience without being explicitly programmed, but to do so it needs a lot of data. This data set is divided into "training data" and "testing data", where the "training data" obviously is used to train the model and the "testing data" is used to check the accuracy of the model.

ML is often divided into three categories:

1) *Supervised learning*:: This type of algorithms is designed to learn by example, and the idea behind is that training this type of algorithms is like having a "supervisor" watching over the whole process. The training data consists of input that is paired with the correct output and during training the algorithm will search for patterns that correlates to the desired output. After training you get a model that takes new unseen input data (of the same kind) and determine which label this new inputs classifies as based on the training data. The whole

essence of this kind of algorithms is to predict the correct label for newly presented inputs based on past data. On its simplest form it can be written as

$$Y = f(x)$$

where  $Y$  is the desired output from the mapping function  $f$  with value  $x$  [7]. Supervised learning can be divided into two categories

a) *Classification*: This algorithm is typically used to put the new data into a category or a class based on its training data. Under training this algorithm will be given data points with an assigned category. The most common example is filtering out spam emails.

b) *Regression*: This algorithm is a predictive statistical process where the model tries to find relationship between dependent and independent variables in the data set. The goal of a regression algorithm is to predict a continuous number such as sales, income, and test scores.

2) *Unsupervised learning*:: In contrary to supervised learning that needs to train its algorithms to recognize patterns in dataset with known labels, unsupervised learning is used on big dataset to recognize patterns in unlabeled dataset. In simpler terms this type of algorithm learns useful patterns and properties in the data structure in big datasets with no labels. The most used algorithm used in unsupervised learning is cluster analysis [8] [9].

a) *Cluster analysis*: Cluster analysis, also called clustering, is used to group datasets with shared properties in order to find algorithmic relationships. Each group made is called a cluster hence the name cluster analysis or clustering, but the name "cluster" can not be precisely defined. Since the notion cluster isn't well defined there are many different clustering algorithms out there, but they all have one thing in common they group data [10].

3) *Reinforcement learning*:: Reinforcement learning (RL) agent is learning by interacting with an environment, in other words it learns from the consequences of its actions. The RL agent can do this because of a numerical reward system that encodes the success of an action's outcome. The RL agent seeks to learn how to find the actions that accumulate the most reward over time. The RL agent learns from exploring its environment and making decision upon how to act in every single scenario, instead of explicitly getting taught how to respond in advance. Thus this kind of algorithms is very complicated compared to the other two other ML categories algorithms [11].

## D. Artificial neural network

Artificial neural networks (NN) are interconnected sets of model neurons that simulate the function of biological neural networks. The neurons in a neural network is a mathematic function that collects and classifies information. The network is much like the statistical methods such as curve fitting and regression analysis. NN contains layers of interconnected nodes and each node is a binary linear classifier called perceptron and is similar to multiple linear regressions. [12]

### E. Semantic image segmentation

Partitioning a digital image into multiple segments (sets of pixels) based on some characteristics is image segmentation. Semantic image segmentation is when we assign a class to each pixel in the image [13]. This technique uses the unsupervised learning category in ML along with NN (this is also called deep learning) to partitioning the image and classifying the pixels.

## III. IMPLEMENTATION OF AI IN AV'S AND IT'S CONSEQUENCES

RTOS are essential software's used in our daily lives. They are implemented in between the hardware abstraction layer and the user application interfaces. They handle all the tasks, semaphores and how these are prioritised. This is why they are implemented in AV's, and every other system which needs handling of time- and safetycritical objectives.

### A. Why do we use AI in vehicles?

We need to go 30-40 years back to find a vehicle that did not use any kind of AI, we can say that the vehicle was without a "brain". The vehicles were purely mechanic and the human behind the "steering wheel" was the one in control, the "brain" of the vehicle. Take cars as an example, there were no anti-lock braking system (ABS), electronic stability control (ESC), cruise control, detection for tire pressure the list goes on. The reason we use AI in vehicles is to make the vehicle safer, not only for the driver but for everybody.

As a thought experiment, AI could be implemented with the intention of detecting all possible obstacles and objects in an environment. Ranging from traffic lights and road signs, to humans, houses, animals and so on. The incentive would be the safety aspect of a traffic environment. When it comes to simple arithmetic operations, computers are far superior than humans when it comes to calculation and the precisions of these calculations. With clear directives, protocols and instructions AI, would react and take action much faster than a human being ever could. This would make AV's far more optimal for collective transport, and also a tremendous supplement when it comes to assistive functions in human operated vehicles.

If we take a look at modern cars, this kind of AI is already in use. There is for example a city safe systems that helps the driver avoid collision in small velocities. This system uses lidar and cameras along with object detection technology to detect if there is a pedestrian or even an animal entering it's lane, or just to avoid collision in slow going queues. We are actually not so far away from being able to have vehicles that can be fully autonomous as explained in the thought experiment.

Already this year (2020) 60 countries, including Norway, have reached a milestone in mobility with the adoption of a United Nations Economic Commission for Europe (UNECE) regulation that will allow for safer introduction for AV's in certain traffic situations. In this regulation there is given strict requirements for Automated Lane Keeping Systems (ALKS). This new regulation therefore marks an important step towards

the further deployment of AV's in the future, and helps realize the vision in the thought experiment for safer, more sustainable mobility for everyone. [14]

### B. Implementation

1) *Which algorithms are used?*: What kind of algorithm used is dependent on computational ability and determined on what kind of technology implemented within the AV. Be it GPS, LIDAR or similar. There is no problem implementing all sorts of algorithms, but a factor that limits range of viable candidates are, the beforementioned demands and also demands in regards to safety and security.

2) *Semantic image segmentation*: An essential part of a modern AV's driving system, for navigating through it's surroundings and action handling, is semantic image segmentation. Their excellent performance in recognition makes this technique optimal for various AV implementations [15]. Unfortunately the technique per now, is computationally quite costly and therefore not implemented in practice. [16]

Instead predefined features from images are used in simple driver-assisted functions like recognition of road signs, road markings and traffic lights. So there is no real-time training happening in the vehicles system as it drives.

### C. Ethics

1) *Evaluation*: We will briefly discuss how semantic image segmentation is implemented in AV's and some of it's effects and consequences. Certain thought experiments and future conjectures will be utilized to reveal certain ethical and safety aspects which must be critically evaluated when considering deploying AI into daily life AV.

2) *Decisions*: How would AI decide which action to take when it comes to a life and death situation. Certain cornerstone examples could be to hit a child or an elderly person. Or the vehicle has 5 people in it and is on the collision course with one person, should it hit and kill the one person or drive off the road potentially killing every one in the vehicle? This kind of extremal problem all though important to think about is from an engineering point of view unnecessary. Why not try avoid a situation like this all together? These kind of dilemmas maintain the assumption that the car only have two options when in reality it would have infinite. That the vehicle has such a high velocity it couldn't brake down to a speed that wouldn't kill anyone is also improbable in this scenario [17]. The easy solution to this problem is to have the vehicle have a safe velocity in areas that these scenarios are probable, and therefore a city safe system that is in modern vehicles today would take care of that problem.

We should not discard these kinds of problems all together. It is very important to have them in mind when developing AV technology. Vehicles should not be limited to binary choices, but rather multiple decisions based on optimal solutions from statistics. With these kinds of decisions and choices, we as a society have to consider how we want to distribute them.

#### IV. CONCLUSION

The end goal of implementing AV's should always be to minimize the risk and fatalities of travel along the roads or streets in the cities. That is also why edge problem, trolley dilemmas is important to consider and should be discussed in public. It should not impede the progress regarding development of AI for AV's. City safe system currently in use in vehicles today, along with cutting edge break technology is already generating safer environments for pedestrians than ever before. Even though we are at level 3 AV's with the UNECE regulations for ALKS, the pilot of the vehicle still needs to supervise the driving.

Our thoughts of the matter is that ethical challenges should be discussed alongside, and integrated into the development of future AV's. Not impede it. If all sorts of ethical dilemmas should be considered and evaluated equally, both in time and risk factor, it is in our opinion that development will stagnate and be set back. The technologies in use in today's vehicles, both autonomous and non autonomous is still, in relative terms, new. And have not seen their full potential.

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