Volvo's Automatic Brake System

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***Abstract*—To be written.**

I. Introduction

Autonomous vehicles (i.e. self-driving cars) are right around the corner with Volvo Cars aiming for a 2021 release to market. [1] Will it revolutionize the world or not? Who knows, what we do know is that the development had to start somewhere. One piece of the puzzle is to make the car have an automatic brake system to assist the driver to avoid/mitigate hazardous situations.

For example, imagine a car driving in the suburbs when suddenly a child accidentally kicks a ball onto the streets. The child makes a run for the ball, not aware of it's surroundings. The driver brakes, but it's due to reaction time of the driver the kid gets heavily injured. Now picture the same scenario with a automatic brake system. The car would be able to stop, by itself, in time and the accident would be avoided considering the car has (close to) no reaction time.

Another possible scenario is that the driver crashes into the rear-end of the car in front due to inattention.

An automatic brake system

With the driver being responsible for approximately 94% of all car crashes, Volvo Cars with it's three key values, Environment, Quality and Safety, see great value in reducing those types of accidents. [2], [3]

A. Volvo Cars

Volvo Cars has had a strong history of leading the market when it comes to safety innovations with the three-point safety belt in 1959 and side impact protection, whiplash protection and roll-over protection in 1991, 1998 and 2002 respectively. While most of the innovation in the safety field up to the early -00 where protective features newer innovations focus on proactive safety such as the blind spot information system which was introduced in 2003. [4]

Volvo Cars has been offering an automatic brake system for rear-end collisions in it's cars since 2008 and added a similar system for pedestrians in 2010. [4] These functions has since their introduction been standard in all models and was in 2015, soon after the release of the second generation of "City Safety", rebranded so that all their different versions of automatic braking where included in their trademark "City Safety". [5]

With the announcement of the rebranding statistics proving the positive effect it has had on safety where provided and presented as a stepping stone towards autonomous vehicles. [5]

B. Zenuity

In April 2017 a joint venture between Volvo Cars and Autoliv started its operations with the purpose to develop autonomous driving and advanced driver assist systems (ADAS). [6] With both Autoliv and Volvo Cars licensing and transferring relevant intellectual property and moving personnel over to Zenuity the development of ADAS functions moved from in-house development to a separate unit. Since automatic brake systems are classified as ADAS these where most likely included in the transfer from Volvo Cars to Zenuity.

C. OSS

Open source software (OSS) is a software open for anyone to read, modify and distribute. However depending on the licence of the OSS, tit might be more or less permissive. [7]

D. Competition

E. Customer Segment and Market

- Who is typical customer?
- How many are there?
- Where are they?
- What are they prepared to pay for?
- Why do they buy?
- How to reach customers?
- How pay?
- How are you going to make a profit?

F. Software Patents

1) General Information: Software patents are hard to grasp. From the beginning, patents were meant as a legal protection for inventors. Patents could be viewed as a reward and acknowledgement of a scientist's success, dedication and time spent on an invention. The patent itself gave the inventor monopoly of the invention and therefore protects from potential thieves who steal the idea and use it for their own purpose. [11] At that time, the kind of inventions would typically be a physical product such as post-office drawer lock. [12]

A software program usually imply a computer program. The definition of a computer program is several lines of instruction

given to a computer which will execute them sequentially. One may not patent the lines of instructions, however, in conjunction with an executing computer it can be patentable. The reasoning is that a software program needs to be part of a process and in this case an executing computer is considered a process. In Europe, The European Patent Convention (EPC) has taken the "process" definition a step further. [11]

> A computer program claimed by itself is not excluded from patentability if the program, when running on a computer or loaded into a computer, brings about, or is capable of bringing about, a technical effect which goes beyond the (normal' (sic) physical interactions between the program (software) and the computer (hardware) on which it is run. [11, p. 36]

To summarize, one can not patent the software program code itself, but with some kind of hardware it is possible.

2) Volvo's Patents:

G. Big Data

Nowadays a company's big struggle is not to store all collected data, it is how to use it. The data is called "Big Data". [8]

Depending on the software, the collected data could be commute patterns, phone usage or as simple as the amount of user. With this kind of information the company can make smart decisions. The downside is, the more data one got, the harder it is to process. To take fully advantage of the stored information the processing velocity is key. Another problem is the variety of data a company got. What information is in reality useful? [9]

II. Description of the system

- Mobileye http://www.mobileye.com/about/industry-firsts/
- Delphi https://www.delphi.com/media-old/pressreleases-old/2014/10/02/delphi-first-to-market-with-integrated-radar-and-camera-system-on-volvo-cars
- No open source components
- Ground truth, inhouse data, move to neural networks -> user data (big data).
- 2017 moved ADAS to new joint venture Zenuity w/ autoliv. https://www.media.volvocars.com/global/en-gb/media/pressreleases/202044/volvo-cars-and-autoliv-announce-the-launch-of-zenuity

III. Business aspects

1) Volvo's Business Plan:

2) Business Idea:

- Problem
- Solution
- Benefit / Value
- Competition

3) Customer Segment and Market:

- Who is typical customer?
- How many are there?
- Where are they?
- What are they prepared to pay for?
- Why do they buy?
- How to reach customers?
- How pay?

4) Business Model:

- How are you going to make a profit?
- Value proposition, as a differentiation <2014, now commodity.
- Lines up with business strategy to provide the most reliable and best safety features, part of intellisafe.
- Strengthens brand
- Zenuity (see article p. 47)
- Lines up with goal to be seen as part of the premium segment.
- Open Source Software

IV. Ethical aspects

- Data collection.
- incorrect brake.
- missed brake.

> City Safety should not be used to alter the way in which the driver operates the vehicle. The driver should never rely solely on this system to safely stop the vehicle.

V. Legal aspects

- Data collection.
- incorrect brake.
- missed brake.
- Open Source Software

VI. Summary

A. Peer-reviewed references

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APPENDIX

CONTRIBUTION STATEMENT