

The Active Pedal Project

Keywords: Smart mobility; Active Accelerator Pedal; Safety; Driving Simulator

The Active Pedal is an innovative accelerator pedal developed by Robert Bosch GmbH which applies haptic stimuli (vibration, counterforce or knocking) under certain situations; the commercial target of the pedal is the automotive market, aiming to reduce the fuel consumption and to improve the safety during driving.

The objective of this Alta Scuola Politecnica multidisciplinary project is to identify new possible pedal uses, mainly dealing with the connectivity, to prove the pedal effectiveness and to evaluate new business opportunities in the global mobility environment.

Team Members and Skills

Bombardi Giulia: Electronics Engineering Student specialised in ASIC design. Giulia mainly worked on state of the art and market analysis and installation of the Pedal in the I.Drive simulation laboratory. In particular, she developed from scratches the communications protocols needed to connect the pedal to the already existing systems. Giulia also helped in the organization and implementation of the testing activities.

Bonomi Mattia: Electronics Engineering Student specialized on analog design and silicon photonic integration. Mattia focused on the state of the art and patent analysis and on elaboration and interpretation of the big amount of data coming from the eye tracking systems. Mattia worked to provide useful insights on the benefits in terms of decrease of distraction in the driver coming from the use of the pedal.

Fontana Francesco: Project Team Leader, Automotive Engineering Student specialized in technology and innovation management. Francesco mainly worked on state of the art analysis and competitor landscape and market analysis. He then focused on the interpretation of the data regarding speed limits and driver reaction times and on the design and interpretation of the survey aimed at the evaluation of the pedal User Experience.

Lucarelli Daniele: Automation Engineering Student specialized in control of multiagent and networked control systems. Daniele initially focused on state of the art analysis and patent search and interpretation. Later on, he worked on the elaboration of new use cases and business opportunities and on the interpretation of data and results coming from the Eye Tracker.

Terzo Leandro Corrado: Team Financial Controller, Automotive Engineering Student specialised in hybrid powertrains. Leandro initially worked researching and understanding Bosch competitor's patents. Then, he focused on the elaboration of new business opportunities especially related to light and heavy commercial vehicles. Eventually, he focused on the elaboration of data coming from the simulation environment.

Tordini Pietro: Design and Engineering Student. Pietro worked on market and competitor analysis. Then, he focused on the installation of the pedal and on the construction of the simulation environment in the PoliMi I.Drive Laboratory, enabling the realization of the testing activities. He eventually contributed to the whole set-up of the laboratory and to the organization of the tests.

ABSTRACT

Safety, connectivity and user experience are increasingly assuming a central role in today transportation and mobility environment. From this point of view, the Robert Bosch active accelerator pedal, on which the entire work is based on, could represent a break-through for the entire accessories and optional market.

Indeed, the aim of this work is to explore and understand the market potential and the effectiveness of a new technology developed by Robert Bosch GmbH in the field of the smart mobility: the active accelerator pedal.

The work starts with a deep analysis of the current market situation, patent analysis and state of the art relative to the active accelerator pedal.

Then, new possible use cases and business opportunities have been investigated and presented to Bosch. Among the proposals, following Robert Bosch' business interests, an analysis on the benefits coming from the use of the pedal to improve vehicle's safety and reduce cognitive and visual distraction in the driver has been carried out. In particular, the benefits in the fields of reducing distraction in the driver, improving the human machine interface between cars' smart systems and drivers and consistently brushing up driver's response in emergency situations have been analyzed.

A simulation environment has been created ad hoc in the Polytechnic of Milan driving simulation laboratory (I.Drive Lab) and the gathered data regarding safety and user experience have been analyzed and presented. As it will be seen, the active accelerator pedal by Bosch strongly emerges as an effective tool to improve driver attention (up to 14% increased time of attention at the road of the driver) and to dramatically decrease the reaction time (more than 50% reduction).

Eventually, all those considerations are presented in a brief summary consisting of the assessed benefits coming from the use of the pedal and the suggestions to further proceed with the project and to confirm the results achieved.

Exploring the opportunities

The first task the Team worked on has been the identification of the state of the art and the understanding of the current market situation and competitor strategic positioning. In particular, an accurate patent search analysis and a deep web investigation have lead the team to gain awareness on the extreme competitiveness of the sector and on the global market situation related to the Active Accelerator Pedal. The results have been presented in October 2016 to Bosch Management in the Company's Headquarter based in Stuttgart, generating an increasing interest in the project from the Company itself. Thanks to the aforementioned work, indeed, it has been possible to understand and highlight Bosch's pedal unique features and strengths as well as possible weak points to be improved. During this preliminary phase, and having the market and patent research as input for the work, new possible uses and business opportunities have been presented in December to Bosch.

The presented new possible use cases, which are summarized below, tried to exploit in the best way Bosch pedal unique technical feature, considering the potential fertile markets segments:

- Charging Station Optimal Speed Advisory (CSOSA):
- Green Light Optimal Speed Advisory (GSOSA):

- Light and Heavy Commercial Vehicles safety and fuel consumption reduction;
- Cognitive distraction reduction;

Following Bosch' business interests and needs, the Team then focused on the implementation and study of the applications of the pedal in the field of cognitive distraction reduction in the driver.

Generating the Solution

In order to investigate the real benefits coming from the use of the pedal, the Team decided to perform a set of virtual driving simulation tests. From this perspective, a prototype of the pedal made available by Robert Bosch GmbH has been installed in the I.Drive simulation laboratory of the Polytechnic of Milan. In particular, to accomplish to this task, three parallel activities have been planned and carried out. The first activity regarded the study and implementation of the communication protocols between the pedal and the other simulation systems to ensure the correct control of the pedal. The second task concerned the physical preparation of the mechanical and electronic environments to host the active accelerator pedal and the third the designing and building of a simulation environment to host the simulation.

After several months of work, the simulation environment has been tested and marked as ready to host the tests. In order to gather a significant amount of data, twenty male students, aged from 21 to 26, have been recruited to take part to three simulation tests to assess and isolate in an objective way the benefits coming from the pedal use as alerting tool. Indeed, the participants were asked to drive in a highway scenario in three different conditions: without any assisting driving system, with an acoustic and visual signal on the dashboard and with the active accelerator pedal functioning. The alerting tools, when present and functioning, were meant to advise the driver both in case of emergency conditions and in case of infringement of the normal driving rules (i.e. safety distance or maximum speed limit not respected). The tests provided useful insights from two different perspectives: from one side thanks to the I.Drive infrastructure and technology was possible to gather eye tracking, bio metric and general data which have been later analyzed and interpreted. From the other side, the participants' answers to the two surveys presented before and after the tests gave extremely useful information on potential customer perception of the pedal, both from the user experience and from the market potential.

Conclusions

After the completion and elaboration of the data, the team was able to finally assess the benefits coming from the use of the pedal and to evaluate the customer user experience. The results achieved, from one side confirmed a consistent possible improvement in vehicles' safety and from the other side helped in understanding the user experience and market attractiveness of the pedal. Going into the details, from the data gathered during the simulations it was possible to assess a consistent reduction in the cognitive and visual distraction of the driver. It is interesting to point out that the distraction using the pedal was significantly less with respect to both the simulation using visual and acoustic alerting tools (7% reduction) and to the simulation in which no alerting tools were implemented (11% reduction). Out of one hour of driving in a highway scenario, this means the driver would look at the road up to six minutes more. This result is even magnified underlining that six minutes at a speed of 120 km/h means 12 kilometers more of attention. To further strengthen the

innovativeness and great potential of the pedal, it has been recorded an impressive reduction in the reaction times of the drivers during emergency situations, with reaction times cut up to 50%. Always assuming a cruise speed of 120 km/h, this would lead the driver to stop the car more than 33 meters in advance than usual in an emergency braking situation.

Starting from the aforementioned qualities and performances of the pedal the team has started to evaluate the market and business potential of the pedal, trying to understand the perceived value from the customers. However, the relative price estimate coming from the analysis of the surveys resulted to be lower than the final proposed price by the OEMs and car manufacturers. This important consideration should drive a discussion on possible strategies to either augment the perceived value of the pedal or to sensibly reduce the final price seen by the potential customers.

However, it is opinion of the team that the pedal could represent a real break-through in the vehicles' safety, helping in the achievement of the ambitious European targets on road safety.