FFI

Stereo-vision for Active Safety

Project within Vehicle and Traffic Safety, 2009-00078

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Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

In 2004, the US police reported 6 million light vehicle crashes that resulted in an estimated loss of 2.8 million functional years at a cost of 120 billion $. Each year around 9,000 pedestrians and cyclists are killed and about 300,000 are injured on European roads.

The StereoVision for Active Safety (SVAS) project studied the possibilities to use a "low-cost" stereo camera as a sole pre-crash mitigation sensor for rear-end vehicles to vehicles and vehicles to pedestrians crashes.

The work was divided into 3 Work Packages:

- WP 1: Sensor development which consists in designing vision algorithm and porting them into a production-like Electronic Central Unit
- WP2: Specifications system architecture & demo car which is about integrating the sensing system with the braking system so that the overall vehicle can decelerate upon a command sent by the stereo-vision system
- WP3: Testing which is the evaluation of the system

Achieving a Collision Mitigation by Braking implies:

A. A Detection Rate that is sufficiently high.

B. A False Positive rate that is low-enough

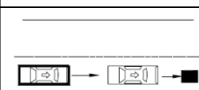
C. A level of functional safety, i.e. the software architecture, hardware architecture and the development processes, that does not invoke non-desirable behaviour.

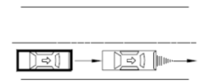
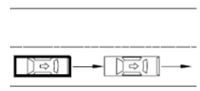
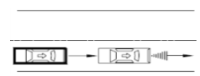
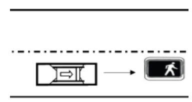
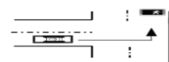
Focus has been set on part A and C, the two most important part for a feasibility study.

Given the current performances of the system, the robustness of the decisions and our overall technical judgment, the development team thinks that the project goal is achieved:

A stereo-vision camera can be used as a sole pre-crash mitigation sensor.

The table below gives a estimation of the stereo-vision system effectiveness.

	description	% of "37 NHTSA crashes"		
A	Following vehicle approaching a stopped vehicle	16,4		Effective

B	Following vehicle approaching an decelerating lead vehicle	7,2		Effective
C	Following vehicle approaching lead vehicle moving at lower constant speed	3,5		Effective
D	Following vehicle approaching an accelerating lead vehicle	0,3		Effective
E	Pedestrian crash without prior vehicle maneuver	0,7		Effective
F	Pedestrian crash with prior vehicle maneuver	0,3		Not effective

Regarding case F, even if the occurrence is rather high, 30% of all pedestrian cases, the associated fatality rate is low.
The stereo-vision based algorithm has been implemented in an automotive ECU and thereby it is demonstrated that such algorithms are compatible with automotive ECUs making a program application possible.

This project is the results of the fruitful collaboration between:

- Saab Automotive (Trollhättan)
- Autoliv Electronics AB (Linköping)
- Autoliv Development (Vårgårda)
- Totalförsvaret forskningsinstitut, FOI (Linköping)

2. Background

Purpose of the Project

As stated into the project application, the purpose of this development is to "explore the possibilities of a low-cost stereo camera as a sole pre-crash mitigation sensor".
Collision Mitigation by Braking, CMbB, is an highly demanded function. Nonetheless, so far, this function is made by a set of sensors which increases costs.
From the supplier side, it forces to bear several developments and production investment programs as well as maintenance and quality insurance structures.
In the meantime, for the car maker, several sensors implies higher cabling, integration, purchasing and project management expenses.
Thus, a single sensor, that gives satisfactory performances, is necessarily a competitive solution.

Technology

Stereo-vision technology is about using a pair of images taken at exactly the same time which describes the same scene from 2 different angles of view. This slight difference in the angle of view enables the system to compute a direct distance measurement.

This is done by computing a disparity image, i.e. the difference, expressed in pixel coordinates, of the corresponding point in the left and the right image. The depth, i.e. the distance between the camera and a given point in the world, is then deduced by a trigonometric relation.

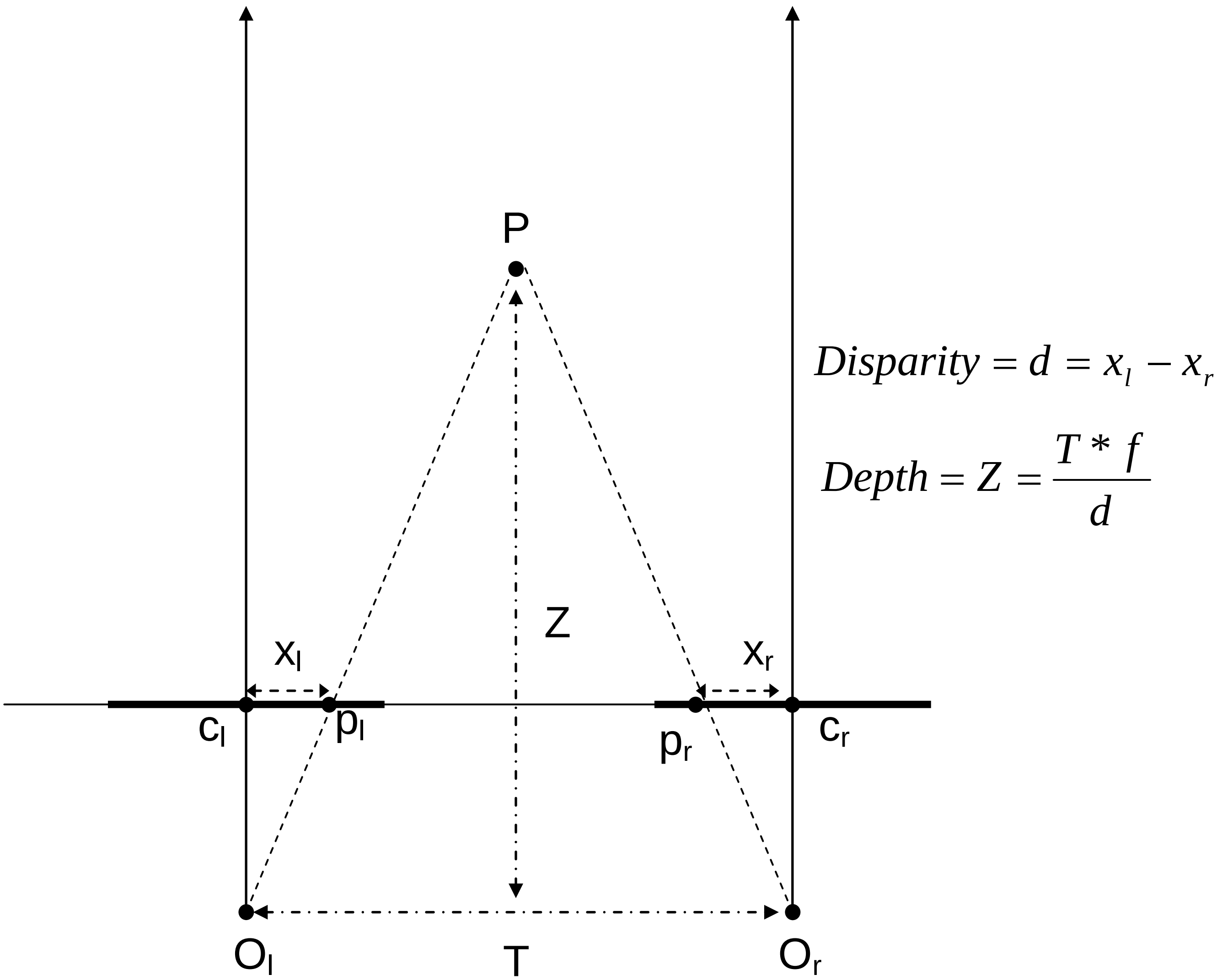


Figure 1 : stereo Vision: Theory

Equivalent computation are made for all the pixel which results into a depth image which associates a distance to each pixel.

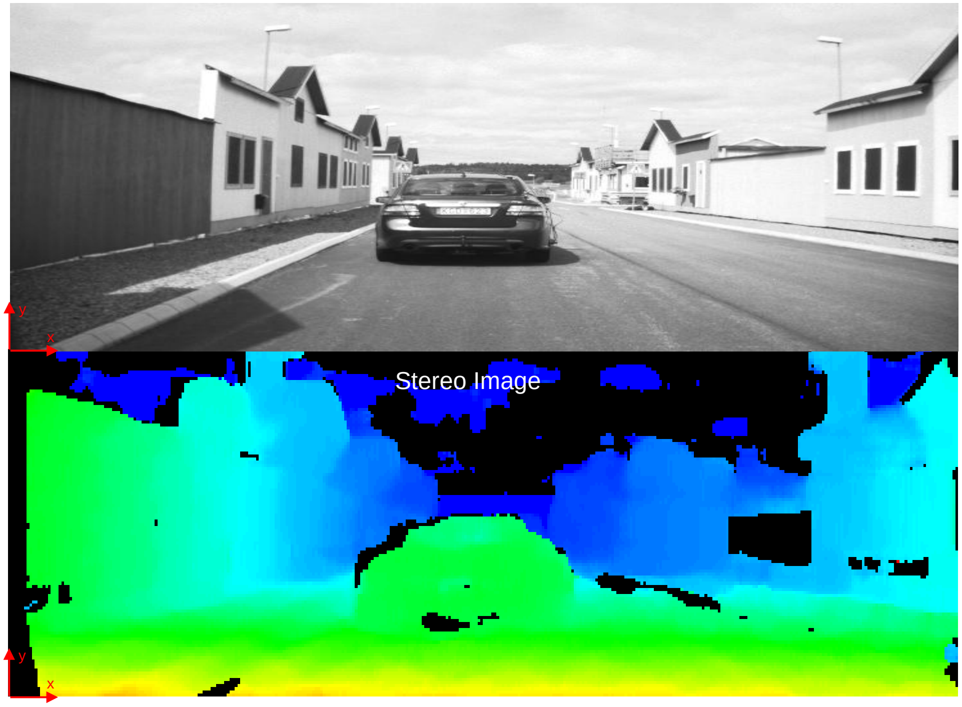


Figure 2: depth image

3. Objective

The project team decided to "explore the possibilities of a low-cost stereo camera as a sole pre-crash mitigation sensor" by making a nearly complete application of a stereo-vision sensor which means:

- Designing an stereo-vision algorithm (image processing) and a pre-crash mitigation function (high-level application)
- Making a production-like implementation of the stereo-vision algorithm
- Making a vehicle implementation and the connection with the brake system
- Testing the system in real-time.

Thus the overall objective is that the Saab vehicle equipped with the stereo-vision automatically brakes on selected scenarios.

4. Project realization

The work is split into 3 main work packages.

Work Package 1:
This work package is about algorithm and sensor development.

It is made of two sub-parts:

- Part A: Vision Algorithm Development
- Part B: Sensor Development

Autoliv Electronics AB is the main responsible of this work package. FOI acted as an expert for given parts of the algorithm.

Work Package 2:
This work package covers the integration in vehicles (specifications, FMEA, packaging study) and project management.
Saab Automobiles is the main responsible for this work package.

Work Package 3:
This work package includes the test scenarios definition and the system testing.
Autoliv Development and Saab was the main responsible of this work package

5. Results and deliverables

5.1 Delivery to FFI-goals

An Automated Emergency Braking is recognized as system with a very high efficiency and certainly contribute to a reduce fatalities and injuries.

It implies that cameras systems are now close to become a standard equipment in vehicles which positively influence the grow in sectors as chips and optical systems suppliers.
This high-growth and technology-intensive field is made of few players which means that technological leadership in such a sector leads to significant exportation possibilities for Sweden.

6. Dissemination and publications

6.1 Knowledge and results dissemination

Automated Emergency Braking is recognized as such an highly efficient system that the EuroNcap organization decided to introduce AEB tests for both vehicles (2014) and pedestrians (2016). It is a strong confirmation of the interest for these systems.

6.2 Publications

No publications were made in the project.

7. Conclusions and future research

The StereoVision for Active Safety (SVAS) project studied the possibilities to use a "low-cost" stereo camera as a sole pre-crash mitigation sensor for rear-end vehicles to vehicles and vehicles to pedestrians crashes.

Given the current performances of the system, the robustness of the decisions and our overall technical judgment, the development team thinks that the project goal is achieved:

A stereo-vision camera can be used as a sole pre-crash mitigation sensor.

Nevertheless, the current project handles only about rear-end collisions and pedestrians collisions.

Automated Braking efficiency can certainly be improved by the use of Automated Steering.

8. Participating parties and contact person

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