FAST VISION ALGORITHMS FOR ADVANCED DRIVER ASSISTANCE SYSTEMS

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Motivation of the work:

In 2010 more than 1.25 million people were killed in motor vehicle collisions and more than 50 million were injured in 2004 [1]. As these casualties are declining in developed countries, it is expected an increase in developing countries as the number of vehicles in circulation grow every year.

ADAS (Advanced Driver Assistance Systems) are systems developed to help the driver, both to increase safety and to ease the driving process. Safety features are developed to avoid collisions, sometimes only alerting the driver of the danger and even taken the control of the car. With the increase popularity and development of autonomous cars, the **ADAS** move its attention to this area.

The autonomous vehicle (according to SEA) are classified in the 6 categories from level 0 to 5. Today self driving systems are between level 2 and 3. Only can be used in limited scenarios and the user must be attentive to events and system fails.

The systems used so far include radar, LIDAR, GPS, ultrasound, car2car networking, car2infraestructure communications and computer vision. Many of these systems are too expensive to be required in all cars. As an example, the LIDAR used on Google´s self-driving cars cost more than 50.000$ and the differential GPS is around 6.000$ [3]. On the other side, cameras used in the automotive industry are around 50-150$.

The drivers use vision as their principal sense in the driving process, so **computer vision** is the natural way to perceive the environment as a human can do.

But many state of the art computer vision algorithms used for ADAS are not capable of **real time processing** (the algorithm in [4] runs at around 2.5 Hz on an Intel Core i7 870 with a Nvidia GeForce GTX 470 GPU) or can´t be implement in car computers (CPUs, DSPs, FPGAs or the new systems based on GPUs [5]). Moreover, many of these systems don't work in real driving conditions as rain, strong shadows, fog, road degradation or partially occluded objects.

So there is an inherent need in developing **computer vision algorithms** that can work in real driving conditions and in real time.

Thesis Objectives

Adapt state of the art algorithms to ADAS working in real time.

There are algorithms with a good performance but they can´t work in real time or embedded in a car because of high computation cost or power requirements. Sometimes they can be implemented in cars with performance loss.

Develop new algorithms for ADAS that work in real time.

There are ADAS systems based in computer vision that detect lines, traffic signals, pedestrian, vehicles or another kind of objects. Some of them are implemented in commercial vehicles today, but there are a lot of room to improve their performance. New algorithms to help the autonomous driving in urban scenarios will be needed in the future. I have developed a first implementation of a surround view system that will help drivers in parking manoeuvers and driving at low speed. Future implementations will improve the presentation to the driver and add other points of view. Also, I will consider SFM (Structure From Motion) algorithms in urban scenes to determine paths where the car can move and real distances to objects. The point clouds that we can obtain from a SFM can also help other ADAS to achieve real time speed and better performance.

Compare the performance with other ADAS non based on computer vision.

There are ADAS that can also use technologies not based in computer vision. For example, line keeping assistant system can rely in LIDAR or computer vision or obstacle detection systems can be laser, radar, ultrasound or camera based . As mentioned in the motivation work, some technologies are more expensive than computer vision, but a comparative of the performance of the systems is necessary to adopt one or another.

Study of new hardware parallel architectures (GPUs and FPGAs). Study the adaptation of algorithms

New computer systems to be implemented in cars are emerging today. GPUs are a hot topic today and their manufacturers are paying great attention to the automotive market. So, algorithms that today may not work in real time will achieve real time performance with the use of GPUs.

Research Plan

All algorithms developed for this thesis will be implemented and tested in a common platform for better evaluating the results. This platform has been almost developed this first year. The GPU part will be developed in the third year of the planning. The platform is also used to present information to the driver. The algorithms in research stage will be tested in the platform as soon as they are optimised to work in real time.

Ground truth data for computer vision algorithms will be obtained using other technologies or hand labelled scenes. These data will allow to compare the performance of computer vision based ADAS with other technologies.

The table at right shows the detailed research plan.

Research Plan	NMonths	Year1		Year2		Year3	
		S1	S2	S1	S2	S1	S2
Literature Review	3	2		1			
Analisys state of the art	4	2		1		1	
Development of a global platform to test algorithms	5	2	2		1		
Adapt state of the art algorithms	7		3	1	1	1	1
Develop new algorithms	8		1	1	2	2	2
Compare to other technologies	5			2	2	1	
Study of GPUs and adaptation of algorithms	4					1	3

Results & Discussions

Development of a surround view system to help drivers in parking manoeuvres.

Implementation of an architecture to use one camera with different computer vision ADAS in parallel.

In this year I´ve developed an architecture where different ADAS can run in parallel using only one camera. The first systems implemented in this platform is a surround view system and the detector of a TSR system (see below)

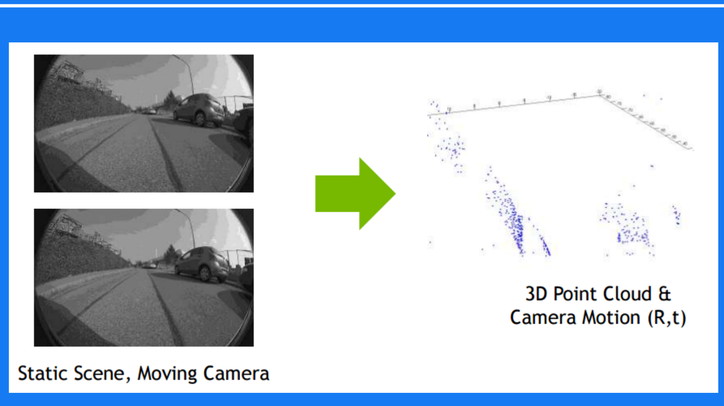
Implementation of a pre-processing stage in CTAG TSR system

This stage improves the detection of traffic signs, gaining 0.5 sec. The algorithms developed in [6] are near state of the art in detection rates and works in real time, improving the detection speed of the old system.

Next Year Planning

Analysis and development of a SFM module.

SFM (structure from motion) is the process of estimating 3D scenes from 2D images obtained at different positions (moving camera).
Usually they involve sequences of a great number of images to obtain precise 3D structures after high computational cost.
In an automotive application, they can only use 2-3 images to obtain the 3D points (see figure), so a great precision can't be achieved.
But a cloud of points will be sufficient to help another systems and to determine where there is an object.
The first step is to develop a SFM system that can be used in ADAS.
The second step is to adapt it to work in real time (not easy to achieve)



Compare the performance of ADAS based in computer vision with other systems

As we mentioned before, ADAS can be based in different technologies, so it is necessary to compare their performance in terms of real time processing and detection precision.
A starting point will be compare laser based systems to computer vision based systems, since they are in opposite related to their cost.

Study of a traffic sign recognizer based in deep learning architectures.

I´ve developed a Traffic sign detector using the LCP and kercenters techniques described in [6]. Next year a recognizer will be developed to improve recognition rates. Deep Learning is a hot topic nowadays, but it is necessary to compare its performance with other techniques and compare its speed when running in non-GPUs and GPUs embedded in car equipment.

References

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