FAST VISION ALGORITHMS FOR ADVANCED DRIVER ASSISTANCE SYSTEMS

Multimedia Technology Group (GTM)

PhD: FRANCISCO PARADA LOIRA

Advisor: JOSE LUIS ALBA CASTRO

Laboratorio de VISION Universida de Vigo

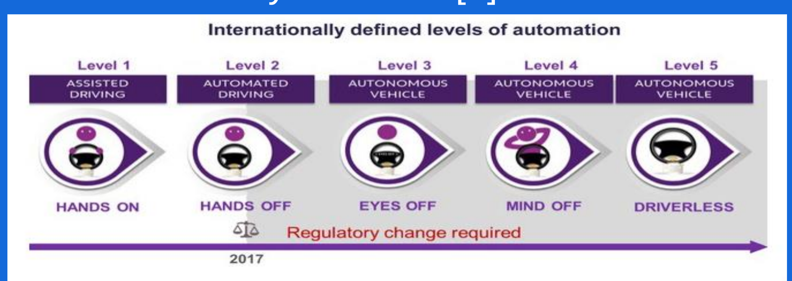
2018 WORKSHOP ON MONITORING PHD STUDENT PROGRESS (DOC_TIC)

Motivation of the work:

Safety: 90 % of car accidents are motivated by human factors [1]. ADAS and autonomous cars can reduce the number of car accidents and so the number of deaths, but even autonomous cars have been involved in traffic accidents (sensor errors, failure in algorithms, interaction with car with drivers)

Autonomy : ADAS are essential to achieve autonomous cars. The autonomous vehicle (according to SEA) are classified in the 6 categories from level 0 to 5. Today, commercial self driving systems are between level 2 and 3.

Commercial cars in level 4 will be available starting 2020 and level 5 cars around 5 years later [2].



Cost: Computer vision is cheaper than other technologies used in ADAS like Radar, laser (LIDAR) [3] [4] or has better performance than others like ultrasound. A camera cost around 150-200 $ and LIDAR from 4000 (16 layers) to 60000 (64 layers).

Cars in test by different companies use 1 to 20 cameras and 1-12 LIDAR[5] (Uber uses 7 LIDAR [7])

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

Computational : ADAS must run in **real time** and must be integrated in cars with limited resourced computers (CPUs, DSPs, FPGAs or the new systems based on GPUs [6]). So there is still an inherent need for 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 are implemented in cars but with performance loss.

Develop new algorithms for ADAS that work in real time.

There are ADAS based in computer vision that detect lines, traffic signs, 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 interface with 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 not 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 technology 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.

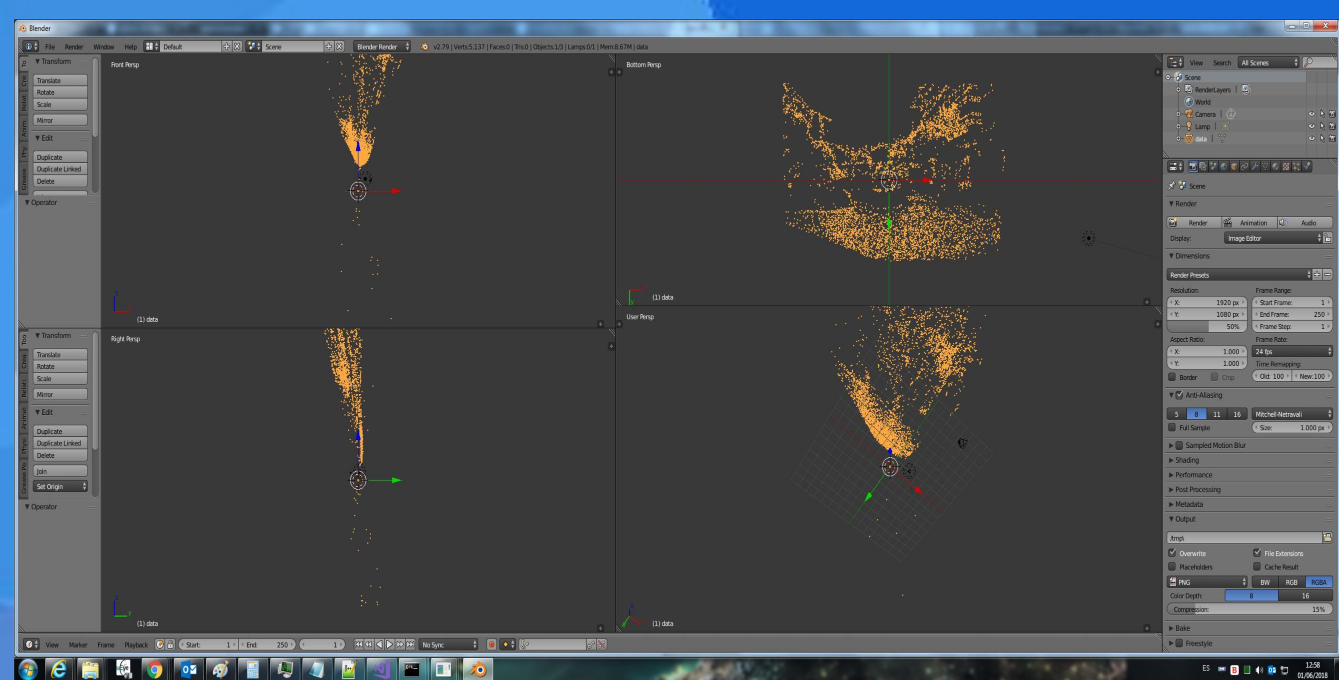
Research Plan

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 the 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 labeled 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 (F.T.)		Year2 (F.T.)		Year3 (F.T.)	
		Y1	Y2	Y1	Y2	Y1	Y2
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

1) Improvements in the TSR module

2) Design of a module to detect and map bus stops.

A new traffic sign was designed to not only determine when the bus is approaching the stop, the position of the bus stop in the map (through a QR code) and also the distance to the stop (SLAM).

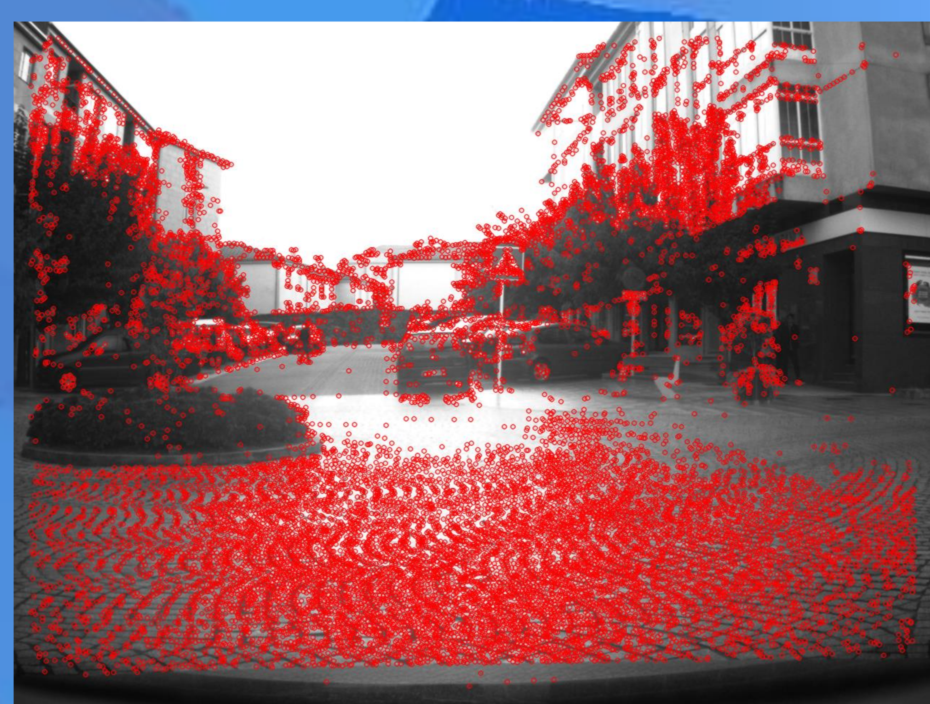
3) Development of a Structure From Motion (SFM) module

Exhaustive analysis of all available keypoint detectors, descriptors and matcher to determine if they can be used in a real time application, the computation requirements and the performance to obtain a valid 3d point cloud.

Implementation of different triangulation methods (Hartley and Sturm, optimal, etc.) and compare with existing implementations in OpenCV to analyze its performance and computation times.

Develop of a complete SFM module capable of running in real time. The module execution time can be as small as 47 ms for a highway scene obtaining only 500 3D points to 5200 ms for a very complex urban scene with about 20000 3D points without matching optimization (see figure).

Determination of the free space zone using the 3D point cloud. This area is been used for planning the motion of car in scenes where the road doesn't have lane marks.



Next Year Planning

Continue improvement of the SFM module.

Continue to improve the module porting some of the algorithms to CUDA or embedded devices.

Improve the free space determination algorithms to achieve more precision and better performance.

Use parts of the SFM module to implement SLAM algorithms, the car will not only know where to move but also where it is in the map

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

I´m involved in the development of a new low cost LIDAR system. When the system is finished I will be able to compare the performance of both systems.

Current LIDAR systems are more precise, but they are much expensive that computer vision systems.

Prepare an article comparing our real-time TSR system (both detector and classifier) with state of the art algorithms and systems.

Last year planning, but not finished due to restrictions from the CTAG.

Prepare an article with the improvements and results from SFM module

References

[1] https://www.sciencealert.com/driverless-cars-could-reduce-traffic-fatalities-by-up-to-90-says-report

[2] https://www.greentechmedia.com/articles/read/fully-autonomous-vehicles-decade-away-experts#gs.XnzQ_jc

[3] https://www.wired.com/2015/04/cost-of-sensors-autonomous-cars/

[4] https://www.spar3d.com/news/lidar/velodyne-cuts-vlp-16-lidar-price-4k/

[5] https://www.macrumors.com/2018/05/29/apple-self-driving-car-fleet-62/

[6] http://www.nvidia.com/object/drive-px.html

[7] http://www.cos-mag.com/article/36413-ubers-use-of-fewer-safety-sensors-prompts-questions-after-arizona-crash/