DeMS White Paper

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Abstract

Privacy concerns and the high demand of GPU capabilities are some of the main problems when dealing with real time video processing, security and safety in the industry and growing cities are some of areas of great demand for such techniques. The rising power of small computers and the increasing availability and effectivity in machine learning techniques allow to design devices capable of detecting events in real time without the need of internet connectivity and a cloud computing service, saving money and solving the increasing privacy problem for business and government. In Deep Micro Systems we achieved to combine several techniques to detect events in real time video and combine the information of several cameras connected to a single device to achieve a good frame rate and a good resolution to capture enough detail in the pictures.

Keywords

Computer Vision — Smart Cities — Offline computing — Artificial Intelligence

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Introduction

Privacy concerns, low internet conectivity and low computational power are some of the main reasons to improve real time video analisys to work in local devices. The need of internet connectivity or a GPU service are some huge problems that industries and developing countries have to face, increasing costs and not been accesible all the time.

Computer vision has proved to be of great help for industries and governments aimed to increase security and safety at competitive prices, embedded systems have limited power, thus, the need of new computer vision techniques and new hardware for them to handle complex tasks.

Some specific tasks can offer some facilities to real time video monitoring. That is the case of fixed cameras, surveillance cameras and security cameras that can handle only the changind pixels of video to reduce complexity or can make use of computer vision techniques to stabilice the frames in case of a sudden shake of the camera.

Simple computer vision techniques require low computational power and allow the devide to focus machine learning techniques, more heavy, on the main core of the problem to be solved. New, more powerful, small computers are also rising such as Orange Pi, Raspberry Pi 3 B + and even neural sticks like Intel movidius, capable of handling new machine learning techniques.

1. Deep Micro Systems

Deep Micro Systems is a Bolivian Start up in the field of Computer Vision and Smart cities with the mission to expand the awareness and knowledge industry and governments to smart cities, providing security, efficiency and generating solutions to critical problems in a measurable and sustainable way.

Road Insecurity The high numbers in roads accidents is currenlty a great concern for Bolivian government with 1300 deaths every year, new technologies are needed in order to reduce this huge numbers and help solve the main problem. As Internet connectivity in Bolivia is expensive and low efficient compared to our neighbor countries, the need of offline processing is a major concern. In order to achieve this Deep Micro Systems designed an All-In-One Device capable of detecting traffic Infringements, generate a visual proof of them and generate valuable real time data for city planning.

In order to generate security in roads and streets, our camera is capable of detecting events in real time video, measure and identify if necessary the vehicle violating law.

Applications of computer vision Besides road infringement detection, Deep Micro Systems works with computer vision, and it's variety of applications in industry and government. Some of other projects for Deep Micro Systems in the short term are:

- Optimal city design, parking, roads and flows
- Traffic accidents forecast
- Smart traffic light managing

Figure 1. All-In-One computer vision device

Industry Boliviann local business such as Enalbo and IBCO SRL, let us know their interest in detecting real time events such as security infringements of their personal, abnormal functioning of equipment and other failures.

1.1 All-In-One devices

The lowering costs of pocket computers and the increasing power and efficiency of machine learning techniques allow to build small devices capable of solve huge problems in cities and in the industry without the need of internet connectivity, guaranteeing privacy and cheaper uninterrupted work.

Computer processors such as Cortex-A53 (ARMv8) 64-bit SoC with 1.4GHz and ARM H3 Quad-core Cortex-A7 with 1.6GHz are capable to handle complex tasks and can make use of the new neural chips to get even faster results in real time.

All this components allow to build custom devices for solving specific problems, providing ethernet connectivity, GPS, GSM/GPRS, Bluetooth, WiFi and any kind of sensors to be required.

Currently Lu-Cam, our smart traffic enforcement camera is a 8x9x16 cm device capable, as seen in figure 1, and it is capable of detecting events in real time video. Rather than getting frame features with convolutional neural networks, that would take several seconds to complete, we make use of some advantages of their main purpose, extracting only relevant features and making an improvement to less of a tenth of the time it would require. Other techniques continue to appear such as [1], in order to improve efficiency without missing the main objectives of a project.

1.2 Real time monitoring and data analysis

Such All-In-One Devices holds a huge advantage, allowing to pre process data. For example for real time road monitoring we could get real time histograms of infringements and label them according to our needs as shown in figure 2. Then a central computer can handle data from several devices to make desitions, improving efficiency or automating complex process.

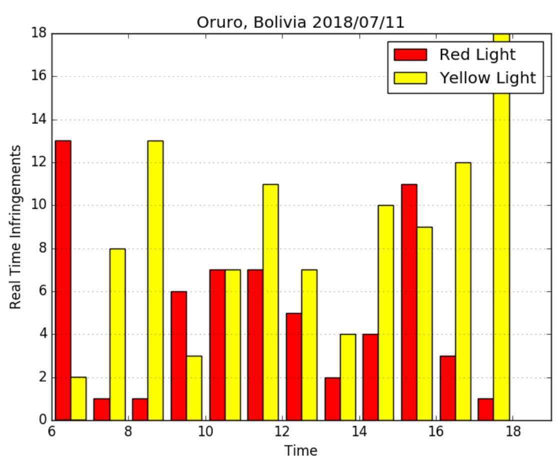

Figure 2. Real time histogram

2. On the Edge Computing

As opposed to conventional visual monitoring systems (CCTVs, IP cameras), that send the video data to a data center to be stored and processed, embedded smart cameras process the image data directly on board. In this proposal we present:

- *Our aproach* to on-board smart camera computing.
- *Hardware and Software description*.
- *Actual real Use Case implementation* of our product.

Nevertheless, there is strong demand for mobile vision solutions ranging from object recoginiotn to advanced human-machine interfaces.

2.1 Our Aproach

The problem of on-board computing and further analysis of live video feed is an ongoing research. We follow the next procedure which is focused on 3 main cicles which are:

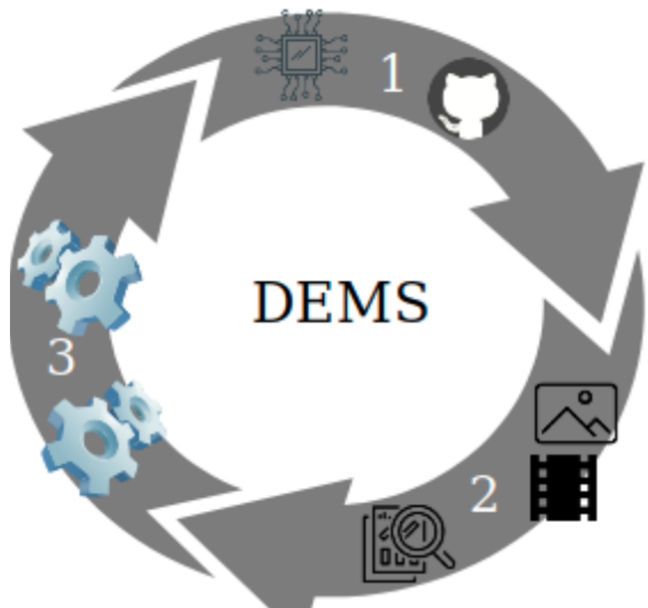

Figure 4. Cicle of work

1 *Algorithm Design*. If the client requirement does not have precedents, we partially hand craft a Computer Vision Algorithm applied to client use case for further data recolection, analysis and improves.

2 Data Analysis for client use cases and presentation of results according to initial requierements.

3 *Improvement*. Improve original algorithm using the propietary collected data with the use of Machine Learning techniques (if is requiered also with hardware udgrade).

We dedicate a specialized team to solve the problems in each cycle. The case study that we present in the whole proposal, complete 2 of the

Figure 3. Time synchronization between cameras

3 states of our cicle of work, and we are currently working on an improvement of our main hardware and algorithm to provide greater security to our clients and at the same time increase our technology. Also be in an advantageous position above the competition thanks to the collected propietary data in order to create new products and improve existing ones.

2.2 Hardware and Software description

Below is a description of the hardware and software we use.

2.2.1 Software Description

If the requirements are very specific and no historic data is aviable, we design a algorithm with tradicional computer vision techniques according to the use case with focus on the embedding side; we maintain a constant monitoring of the program for the event that client is looking for and at the same time we collect data for three main purposes, improve the current algorithm with Machine Learning techniques, bring data for further applications by the side of client and by own, be propietary of labeled data in the target area of work.

Our main tools for the creation of custom algorithms are Python and C++ as main languages. OpenCV is our compendium of multiple purpose Computer Vision techniques which are used to hand craft the desired behavior of the program and data recollection.

2.2.2 Hardware Description

The figure 5 shows the main aspects of our smart-camera, this contains:

- A Low resolution camera which is used for detection of flow in the video
- A HD 8MP camera is used for capture the main aspects of interest when the Low resolution camera trigers the signal of capture.
- We also develop a optional pripietary Integrated Circuit with the main idea of triger the infra-red filter for the HD camera. Also this can be used for further sensor integrations, by now we are using it also as a GPS tracker for the device.

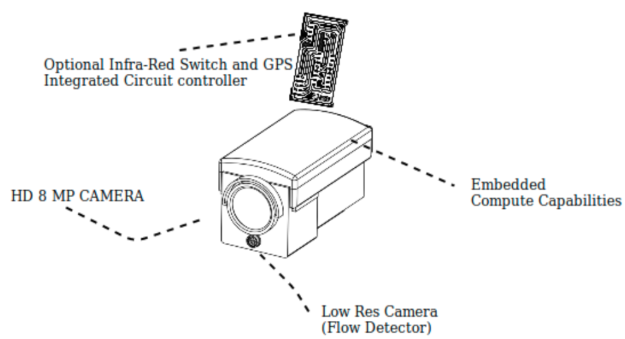

Figure 5. Schematics of our hardware

The compute capabilities of our enveded device are descrived below:

- SoC: Broadcom BCM2837B0 quad-core A53 (ARMv8) 64-bit @ 1.4GHz
- GPU: Broadcom Videocore-IV 256 MB VRAM
- RAM: 1GB LPDDR2 SDRAM
- Networking: Gigabit Ethernet (via USB channel), 2.4GHz and 5GHz
- 802.11b/g/n/ac Wi-Fi

- Bluetooth: Bluetooth 4.2, Bluetooth Low Energy (BLE)
- Storage: Micro-SD
- GPIO: 40-pin GPIO header, populated
- Ports: HDMI, 3.5mm analogue audio-video jack, 4x USB 2.0, Ethernet
- Camera Serial Interface (CSI), Display Serial Interface (DSI)
- Dimensions: 82mm x 56mm x 19.5mm, 50g
- Optional - Neural Network Compute Capabilities according to use case.

2.3 Actual real Use Case implementation

Below is a schematics of our embedded device working in the wild.

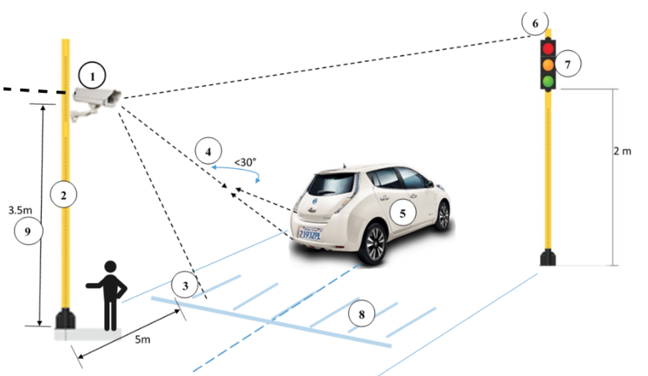

Figure 6. Actual use case of our embedded camera

1 - On Board Computation according client requirement,this communicates his events to private cloud if internet access is aviable.
2 - Mounting pole. The height to our device from ground, influence the algorithm behavior.
3-8 - Pedestrian crossing limit right/left side way.
4 - Optimal vision angle for plate detection.
5 - Target object, in this case cars
6 - Traffic Light mounting pole,
7 - Actual Traffic Light, the camera color sensor implemented by software sees the color transitions and control the algorithm behavior and cameras syncronization, as Figure 3 shows, Figure 3 shows the extract of 5 seconds video from Low resolution camera and a picture of High Resolution for target object with region of interest, this two assets, video and picture is the output of our custom algorithm.

As mentioned before, if you have an Internet connection, we can, in real time, make a wingspan of the information of video/picture and serve it to different users as required, or save it in a bucket for further analysis, the next diagram shows what it follows if we are online.

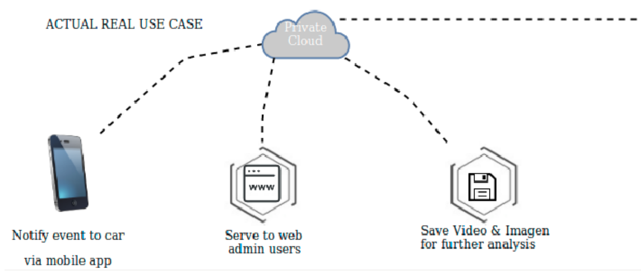

Figure 7. Online process for the information detected in the road.

At the time of writing this, we are training a NN Algorithm to support the Hand Crafted algorithm with the information of video and image generated from the beginning of this year 2018. Following our cicle of work of Figure 4, we generate enought labeled data for our use case and we are ready to start a new cicle of production.

You can see the partial results of this project in our test page www.demsbo.com and our github project https://github.com/alvarohurtadobo/prototipo.

3. Further applications

3.1 Forecasting

3.2 Real time simulation

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