System to Monitor Vehicles in Apartment's Garage by Small Autonomous Car using Deep Learning and Beacons

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1 Introduction

Currently, there is an increase in the number of Peruvian families living in apartments for lots of advantage; however, in some cases there are troubles such as robberies of goods that are usually left at the parking lots or due of entrance of strangers that use the tenants parking lots. Due to these problems, the use of a self-driving mini-car is proposed to implement a monitoring system of license plates in an underground garage inside a building using a deep learning model with the aim of recording the vehicles and identifying their owners if they were tenants or not. In addition, the small robot has its own location system using beacons that allow us to identify the position of the parking lot corresponding to each tenant of the building while the mini-car is on its way. Other objective is to build a low cost mini-robot that would replace expensive cameras or work together in order to keep safe goods of tenants. Finally, vehicles in the future will be strongly dependent on the development of the software algorithms controlling the autonomous navigation and how they can process the massive amount of data generated, so the motivation is to build a prototype of a self-driving vehicle and it is able to process data at the same time.

2 Structure of the System

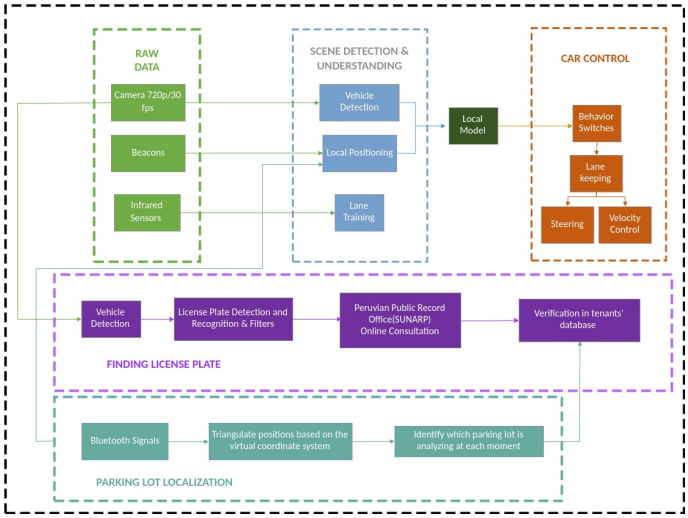
Implementation of a mini-robot (see Fig. 1(b)) that runs through an underground garage and verify that tenants' cars are in their respective parking lots by car and license plate detection to localize vehicle and get information of the owner of each car. The holistic system is made up of the following main parts: The computer vision system that allows the self-driving and the license plate recognition; the location system that allows us to know the mini-car location and which parking lots are near at the same time; and the system that describes how the mechanic and electronic mini-car components are integrated.

Firstly, to build a system that verifies if a vehicle is parked on its respective parking lot we need owner information. This data is collected from tenants of the building such as apartment number, name, parking lot ID, license plate, objects left, etc. The owners name and their license plates will be compared with the data obtained by the mini-car license plate recognition and shown to the doorman of the apartment.

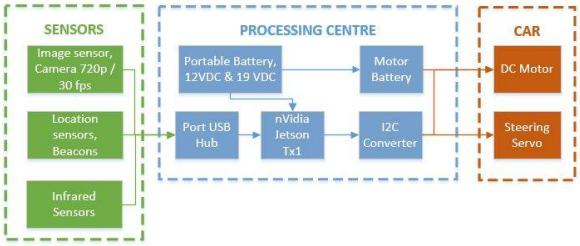
Self-driving is faced imitating Behavioral Cloning method. A CNN (Convolutional Neural Network) based on the NVIDIA model[1] for regression is used to predict angle of rotation of wheels of robot only obtaining images of paths of three front cameras (1 physical camera and 2 virtual cameras) separated each other by few centimeters. The Neural Network implemented is similar to NVIDIA model adding some regularization layers. Testing of the CNN is proved on Udacity simulator, obtaining a clear outstanding performance when driving autonomously as can be seen in [3] and later applied to Jetson in garage.

The first attempt was cars detection. A CNN is in charge of this task using Tiny YOLO model[2]. It has the best performance between accuracy and inference time in object detection on real time such as cars (see Fig. 1(c)). Once the car is detected, relative position brought by the beacons is saved in Jetson's memory.

We use OpenALPR [7] to detect plate licenses of each car and later compare with SUNARP dataset. The robot records videos on its way in a garage so that the license plate recognition could be done. After obtaining candidates, we choose license plates that have six digits (Peruvian's rule) and the most confident. Later, the system must access the Peruvian public records office (SUNARP) online query[6] to get information related to the owner of the vehicle. Once important information such as name and license plate is obtained, it will be compared with the database that the mini robot stored from collecting data of the building tenants.



(a) Structure of the system joining each task



(b) Hardware Communication

Mini-robot's current position in real time is possible because we have been distributed Beacons (a Bluetooth devices) efficiently in a garage that has 8 meters between walls and from 2.45 to 7.35 meters between vehicles. Beacons are useful for indoor location in places where the Internet is not enough to make a connection [4], even allowing tracking in real-time applications [5].

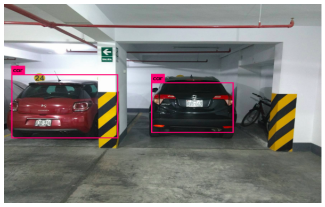
3 Results

To determine position we use the triangulation method. It forms imaginary circles around each beacon and then calculate with simple equations like this: $E_i : (x - x_i)^2 + (y - y_i)^2 = d_1^2$ for i=1,2,3. Using Methods like Gauss Elimination (Sequential), Jacobi and Gauss-Seidel with OpenMP and CUDA, and using Montercalo techniques we get an execution average time.

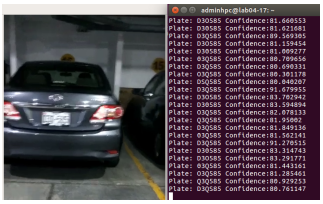
Method	Serial time	Parallel time (n=2)	Parallel time (n=4)	Parallel time (n=8)	Parallel time CUDA
Gauss-Seidel	0.0729176	0.0670215	0.0362759	0.0152195	0.0000512
Jacobi	0.366089	0.358308	0.370612	0.0151156	0.0000586
Gauss	68.8792	34.4715	17.9784	17.0431	2.321465

Table 1: Execution average time for 40000 times

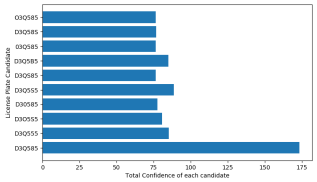
In fig. 1(d) we can see that license plate was recognized with a high confidence. It turns out that input is a video file that was recorded by the mini-robot and its outputs in the console are lots of candidates to be considered as the real license plate. After it, three candidates with the most high confidence are chosen.



(c) Detection of cars



(d) License plate recognition



(e) License Plates vs Confidence

References

1. M. Bojarski, D. Del Testa, D. Dworakowski, B. Firner, B. Flepp, P. Goyal, L. Jackel, M. Monfort, U. Muller, J. Zhang, X. Zhang, J. Zhao, K. Zieba, End to End Learning for Self-Driving Cars, arXiv preprint arXiv:1604.07316, 2016.
2. J. Redmon, A. Farhadi. YOLO9000: Better, Faster, Stronger, CoRR, arXiv preprint arXiv:1612.08242. 2016.
3. CarND Self-Driving Nanodegree Udacity. 'Behavioral-Cloning simulation'. [Online]. Available: https://youtu.be/e7D23Kdy72Q. [Accessed: 7- Jun- 2018]
4. Jinglong Li, Meifeng Guo, Siwei Li. An indoor localization system by fusing smartphone inertial sensors and bluetooth low energy beacons.Frontiers of Sensors Technologies (ICFST), 2017. Shenzhen, China.
5. Ievgen Gorovyi, Alexey Roenko, Alexander Pitertsev, Ievgen Chervonyak, Vitalii Vovk. Real-time system for indoor user localization and navigation using bluetooth beacons. Electrical and Computer Engineering (UKRCON), 2017 IEEE First Ukraine Conference.
6. SUNARP, Servicio Gratuito de Consulta Vehicular con datos relacionados a las caractersticas de los vehculos registrados a nivel nacional. Available: https//:www.sunarp.gob.pe/ConsultaVehicular. Last accessed 7 Jun 2018.
7. C. T. Hsieh, Liang-Chun Chang, K. M. Hung, Hsieh-Chang Huang. A real-time mobile vehicle license plate detection and recognition for vehicle monitoring and management. Joint Conferences on Pervasive Computing (JCPC), 2009.