BIOLOGICALLY INSPIRED DEEP LEARNING SYSTEM APPLIED TO EGYPTION MULTI-STYLE LICENSE PLATE DETECTION

By

Amr Abd El-Latief Abd El-Aal

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
Computer Engineering

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Under the Supervision of

Prof. Dr. ELSAYED E. HEMAYED

Professor
Computer Engineering Department
Faculty of Engineering, Cairo University

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Approved by the
Examining Committee

_____
Prof. Dr. Elsayed E. Hemayed Thesis Main Advisor

_____
Prof. Dr. Magda B. Fayek Internal Examiner

_____
Prof. Dr. Reda A. Ahmed External Examiner
Vice Dean for Educational and Student Affairs,
Faculty of Computers and Information, Cairo University

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
2018

Engineer's Name: Amr Abd El-Latief Abd El-Aal Hassan
Date of Birth: 7 / 8 /1987
Nationality: Egyptian
E-mail: amr.a.ellatief@gmail.com
Phone: 01060555693
Address: 9-taha st. – taqseem el mesaha – Faisel - giza

Registration Date: 1/3 /2013
Awarding Date: / / 2018
Degree: Master of Science
Department: Computer Engineering

Supervisors:
Prof. Dr. Elsayed E. Hemayed

Examiners:

Prof. Dr. Elsayed E. Hemayed (Thesis main advisor)
Prof. Dr. Magda B. Fayek (Internal examiner)
Prof. Dr. Reda A. Ahmed (External examiner)
-Vice Dean for Educational and Student Affairs, Faculty of Computers and Information, Cairo University

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Biologically Inspired Deep Learning System Applied to Egyptian Multi-Style License Plate Detection

Key Words:
Artificial intelligence; Computational Neuroscience; Machine Learning; Deep Learning; computer vision

Summary:

This thesis presents a proposed biologically inspired deep learning system and performance on two tasks: first task is detection of Egyptian Car license plates. The second task is general object detection task in which we used the System to detect different objects in the Graz-02 object detection Dataset. the system consists of two main parts or stages: the first stage role is finding candidate object areas in the image. The second stage is mainly responsible for detecting precisely the objects among the candidate areas which are output from the previous stage. The system achieved detection percentage of 95% in detection of car plates task.

In addition to this task we applied our proposed system to general object detection from the Graz-02 data set. It has different types of categories (Car, Bike and people). We achieved average percent of 75% on all those categories.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Date:

Signature:

Dedication

In the Name of the Unique God “Allah”, the Beneficent, the Merciful, dedicates this work for my parents and for the youth, who wants to bring back the community to the real historical challenges.

Acknowledgments

In the name of Allah, the Most Gracious and the Most Merciful, all praises to Him for the strengths and His blessing in completing this thesis.

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Nomenclature

ALPR	Automatic License Plate Recognition
ANPR	Automatic Number Plate Recognition
AVI	Automatic Vehicle Identification
C1	Locale Invariance Layer
CPR	Car Plate Reader/ Recognition
DM	Dorsomedial Area
DP	Dorsal Prelate
FN	False Negative
FP	False Positive
HOV	High-Occupancy Vehicle
IP	Inferior Temporal
IT	Infratemporal
LBP	Local Binary Pattern
LP	License Plate
LPD	License Plate Detection
LPR	License Plate Recognition
OCR	Optical Character Recognition
PFC	Prefrontal Cortex
ROI	Region of Interest
S1	Gabor Filters Layer
S2	Intermediate Layer
TN	True Negative
TP	True Positive
V1	Primary Visual Cortex

Abstract

This research proposes a biologically inspired deep learning system for object detection. We applied the proposed algorithm to the detection of Egyptian car license plates and to the general object detection task from Graz-02 object detection dataset. The motivation for using biologically inspired approaches was that, those approaches usually gives good results even if a scarce amount of training data. When we tried to make a system to detect the Egyptian car license plates we faced the problem of low number of training images. So, we decided to go to the biologically inspired approaches. We proposed an end-to-end biologically inspired license plate (LB) detection system, and it could be used for general object detection task too. This proposed detection system consists of two main stages; candidate detection stage and classification stage.

The first stage role is to highlight the candidate regions (regions which are more likely to be the target object), and it consists of two parts. The first one is a sliding window which scans all the images and gets parts of it to send it to the next stage which is a biologically inspired deep learning classifier. The classifier is trained to classify the object from non-object/background parts of the image for candidate regions. The classification is performed in two steps using the same classifier but with more features. The first classifier uses 1500 features while the second one uses 4096 features. The first classifier is a weak classifier that takes less time than the second one but applied to all candidate plates. The second classifier has more features so it takes longer time but applied to a subset of the candidates. The first classifier groups small plate regions to form a bigger region that could be a plate candidate that is classified as plate or background using the second classifier.

There are two main parameters that affect the system. The first parameter is the window size of the sliding window. We test our system with different window sizes; 100x50, 200x100 and 300x200. Plate size of 200x100 achieved the best results. Another parameter is the number of features of the classifiers. We tried three numbers 1500 features, 4096 features, and 10000 features. Best performance is achieved using 4096 features. The performance of 4096 features is slightly higher than the performance of 1500 features despite the huge difference in computation cost. Using 10000 features did not improve the system accuracy. Thus we used the 1500 features classifier in the first stage and the 4096 features classifier in the second stage.

The biologically inspired classifier emulates the vision system in the human brain. It consists of five layers; image layer, Gabor filters layer (S1), locale invariance layer (C1), intermediate layer (S2), global invariance layer, and finally the SVM classifier. Generally, and based on Hubel and Wiesel there are two basic types of neurons in the human brain simple layers which apply local

filters, complex layers which increase invariance by pooling units of the same orientation but differ slightly in scale and size. The classifier transforms the image to grayscale first. It uses Gabor filter features to extract features from the input image, and then iterations of pooling and template matching are used to get the final bag of features. We differentiate one class from other classes through training a SVM linear classifier by such bag of features captured from the training images. Using this bag of features and through training a SVM classifier candidate plates are classified.

We tested our system on the detection of the Egyptian license plates. The Egyptian plates can be classified into two main plate categories; standard and non-standard or customs plates. The standard plates are the new plates adopted in Egypt late 2008. It constitutes the majority of the Egyptian plates. Non-standard Egyptian license plates have different combination such as straight and curved lines style, different font types, and different colors, two-line license plates, two-language license plates (Arabic and English characters), curved-text license plates. In this work, we considered only non-standard styles; two-line, two-language, and curved-text license plates. In this task, we reached 95% detection rate.

In addition to this task, we applied our proposed system to general object detection from the Graz-02 data set. It has three categories (car, bike, and people). We applied our system to detect individual object vs background. In this task, we achieved an average of 83% detection rate. In simultaneous object detection, we achieved 75% detection rate.

Chapter 1 : Introduction

The license plate detection system is a tool that reads license plates on vehicles using a system of algorithms. Despite it is being mainly regarded as a solved problem, most of the proposed techniques have been mainly developed for a specific country or special formats which can strictly limit their applicability. However, there have been extensive studies of license plate detection since the 70s, the suggested approaches have difficulties in processing high-resolution imagery in real-time. This thesis presents a novel algorithm for automatic multi-style license plate detection in high-resolution videos. License plate detection consists of two parts: software and hardware. This thesis focuses on the software part. The software parts of each license plate recognition system are composed of three stages, namely, license plate detection (LPD) or localization, character segmentation and character recognition.

The deployment of an ALPR system for identifying, reading and comparing to relevant vehicles offers promising efficiencies and effectiveness for law enforcement and also outside law enforcement applications. The development of image processing tools and algorithms for recognizing and reading license plates has been critical for the improvement of ALPR systems. In broad terms, there are three essential steps in the process of identifying a specific license plate sequence: 1) Identifying the license plate (as opposed to other parts of the vehicle or road signs), 2) Identifying and separating license plate characters, and 3) Recognizing each character.

There are three key factors of an ALPR's ability to accurately read a license plate; capture-distance, ambient light, and feature extraction. Data were collected using videos of moving vehicles with various viewing angles and lighting. A variety of uses of ALPR system data exist outside of law enforcement applications, license plate identification through automated means can provide transportation agencies and highway users with valuable information about travel times along a route. Matched license plate data can also supply necessary information for transportation planning processes, including origin-destination studies. Many methods have been proposed for license plate detection, some give the most accurate results in critical situations like lighting distance effects etc. Some methods work for fixed images, some for videos and some for sequence images, etc.

License plate detection systems utilize algorithms in order to identify a license plate, take a clear image and identify its state. It is used primarily in traffic monitoring in parking lots and gated security entrances, this allows the camera to capture a license plate number. License plate detection works when the camera captures video of a vehicle's license plate and then runs the image through video analytics algorithm to read its content. Many researches have been