



AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
MECHATRONICS ENGINEERING DEPARTMENT

Sensor-based Localization and Control of Autonomous Vehicles in Unstructured Environments for Autotronics Applications

A thesis submitted in partial fulfillment of the requirements for the degree
of Philosophy of Doctoral degree (PhD) in Mechatronics Engineering

By

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M.Sc. Mechatronics Engineering
Ain Shams University, 2014

Supervised by

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EXAMINERS COMMITTEE

Name	Signature
Prof. Farid Abdelaziz Tolba
Prof. Sherif Ali Mohamed Hammad
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Date: 25 / 6 / 2018

Statement

This is to certify that:

- (i) This thesis comprises only my original work toward the Philosophy of Doctoral (PhD) Degree in Mechatronics Engineering department at the Faculty of Engineering - Ain Shams University (ASU),
- (ii) due acknowledgment has been made in the text to all other material used.

Omar Mahmoud Mohamed Shehata
25 June, 2018

Researcher Data

Name : Omar Mahmoud Mohamed Shehata
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Thesis Achievements

The following two international publications have been published during the interval of this study:

- Magdy, Y., Shehata, O. M., AbdelAziz, M., Ghoneima, M., & Tolbah, F. (2017, June). **Metaheuristic optimization in path planning of autonomous vehicles under the ATOM framework**. In Vehicular Electronics and Safety (ICVES), 2017 IEEE International Conference on (pp. 32-37). IEEE.
- Radwan, A., Shehata, O. M., AbdelAziz, M., & Tolbah, F. (2017, October). **X-by-Wire ROS-enabled System Development based on ATOM Framework**. In the 15th European Automotive Congress (EAEC) in Madrid, Spain from the 3rd to 5th October, 2017.

Also, the following funded project was attained based on the methodology and results achieved in this study:

- **ESITIP2017.R2.1:** (PEAV) Personal Electric Autonomous Vehicle, in the Egyptian-Spanish Joint Co-operation Program in Information and Communication Technologies. Funded by 2.25 Million EGP (110K euros). Project Starts in July, 2018.

Thesis Summary

Development and Control of Autonomous Vehicles (AVs) is the scope of this study. This thesis presents the researcher's view about the development of a unified framework for the development of these vehicles, which facilitates the utilization of different theories and research efforts of various researchers in this field.

The first chapter presents the evolution of the industrial revolution up to Industry 4.0 and its relation with AVs' development, highlighting the main challenges that faces their development. Chapter two covers an overview about relevant research efforts in the same field, concluding with the research gap addressed by the study; developing a unified framework for AVs to facilitate utilizing these efforts.

In chapter three the main contribution of the study is presented; development of the ATOM framework. It enables the development of several add-on modules to the vehicle to communicate and exchange information. The main controller takes the most suitable decision in light of the vehicle's surrounding environment.

Chapter four handles the different details of upgrading the manual vehicle to become by-wire enabled, using three modules (steer, brake and drive). In chapter five, the different sensors that are used to acquire information about the internal states of the vehicle and the external environment components are presented.

Chapter six presents the different control approaches used for each component in the vehicle. The details of the low-level PID controller are discussed such as steering control, as well as the high-level controller (FLC) used for vehicle's trajectory tracking. Chapter seven presents how to interconnect these different presented and developed components.

The eighth chapter presents the different validation experiments. The chapter starts with the sensors model results, then the importance of utilizing Kalman Filter (KF) and Extended KF for filtration and fusion. The different tracking results are highlighted, as well as the results of the camera's results for obstacle detection and classification, and finalizing with the conclusions of these results.

Finally, chapter nine presents the summary and conclusion of this study, as well as its contribution to this field. It also presents the recommendations for future work. In this study, a unified framework for AVs development is developed to facilitate the utilization of other researchers' theories and algorithms easily.

“If the journey wasn’t challenging, the destination wouldn’t be rewarding.”

Anonymous

“If you get to the top of the mountain, find a bigger mountain.”

Anonymous

*“Life is not about how hard you hit,
It’s about how hard you can get hit and keep moving forward.”*

Sylvester Stalone (Rocky Balboa)

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First and for most, I thank God for giving me the strength required to make this journey, and I pray that I have enough courage to make use of what I learn, and furthermore learn what I can make use of.

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To my Mother, the woman behind my successes, with her never ending river of love, care and support. Your prayers always guided me along the way. I hope that I make you happy and proud of me. Thank Mom.

To my beloved son Youssef, my ongoing goal towards success. I hope that one day, you understand and be proud of your old man. To my lovely sister for all she does for me directly and indirectly. Last but not least, thanks to my wife, for tolerating me and my many working late hours.

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