PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student:

Cycle: XXXVI

Training and Research Activities Report

Academic year: 2021-22 - PhD Year: Second

Martina Guerritore

Tutor: Prof.

Date: October 29, 2022

1. Information:

- **PhD student: Martina Guerritore**
- **PhD Cycle: XXXVI**
- **DR number: : DR9954**
- **Date of birth: 15th August 1995**
- **Master Science degree: Biomedical Engineering**
- **University: Federico II University of Naples**
- **Scholarship type: INPS - Dottorati INNOVATIVI – Intersettoriali, vertenti sulle tematiche dell'iniziativa "Industria 4.0"**
- **Tutor: Prof. Mauro D'Arco**
- **Co-tutor: Ing. Luigi Fratelli PhD and Ing. Giuseppe Graber PhD**

2. Study and training activities:

Activity	Type[1]	Hours	Credits	Dates	Organizer/ Lecturer	Certificate[2]
Connecting the dots: Investigating an APT campaign using Splunk	Seminar	2	0.4	26/11/2021	Dr. Antonio Forzieri	N
Threat Hunting Essentials	Seminar	2	0.4	03/12/2021	Group-IB	N
Designing Quantum Algorithms	Seminar	1.5	0.3	16/12/2021	Prof. Michele Amoretti	N
All roads lead to WebRTC: an introduction to Janus	Seminar	2	0.4	16/12/2021	Dr. Lorenzo Miniero	N
Computational analysis of cancer genomes (CQB)	Seminar	1.5	0.3	February 16, 2022	Nùria Lòpez-Bigas	Y
RAILS MID-TERM WORKSHOP	Seminar	-	0.8	February 25, 2022	(see the poster)	N
PICARIELLO LECTURE: Project Vāc: can a Text-to-Speech Engine Generate Human Sentiments?	Seminar	1	0.2	February 28, 2022	Vijay K. Gurbani	Y
The search for Earth-like exoplanets in the Galaxy	Seminar	1.5	0.3	24 March 2022	Giovanni Covone	Y
From basic principles in Spintronics to some recent developments toward spin-orbitronics	Seminar	1.5	0.3	31 March 2022	Vincent Cros	Y

Capillary surfaces and a model of nanowire growth	Seminar	1	0.2	07 April 2022	Massimiliano Morini	Y
Likelihood-weighted active learning with application to Bayesian optimization, uncertainty quantification, and decision making in high dimensions	Seminar	1	0.2	21 April 2022	Themistoklis Sapsis	Y
Observing the VHE gamma ray sky with Cherenkov Telescopes in the XXI century	Seminar	1.5	0.3	28 April 2022	Lucio Angelo Antonelli	Y
Bench to Bytes to Bedside: Converting genomic data into healthcare tools	Seminar	1	0.2	4th March 2022	Serena Nik-Zainal	N
Computational single-cell biology: from one to many cells	Seminar	1	0.2	23rd March 2022	Oliver Stegle	N
Cellular strategies to overcome stimuli that arrest proliferation	Seminar	1	0.2	13 April 2022	-	N
Towards a political philosophy of AI (PICARIELLO)	Seminar	2	0.4	11rd April 2022	Mark Coekelbergh	Y
An Introduction to Deep Learning for Natural Language Processing	Seminar	1	0.2	13 April 2022	Dr. Marco Valentino	N
Potential and challenges of next generation railway signaling systems: Moving Block and Virtual Coupling"	Seminar	1	0.2	Bm3	Prof. Valeria Vittorini	N
XR Spring School 2022 - eXtended Reality Spring School 2022	PhD schools	-	5	02-07/05/2022	-	Y
Sensori per applicazioni biomediche	MSc course	-	9	II semester	Prof. Egidio De Benedetto	Y
Discovery using Systems Biology approaches	Seminar	1	0.2	18/05/2022	Mukesh Bansal	N
Accelerating target identification and drug discovery through the power of high scale human genetics	Seminar	1.5	0.3	20/06/2022	Giusy Della Gatta	N
PICARIELLO LECTURE: A day in the life of a Chief Data Officer models - 09/05/2022- Lecturer: Roberto Maranca	Seminar	2	0.4	09/05/2022	Roberto Maranca	Y
Probing and infusing biomedical knowledge for pre-trained language models	Seminar	2	0.4	07/06/2022	Dr. Zaiqiao Meng	N
An introduction to quantum machine learning for engineers - I & II session	Seminar	4	0.8	17/05/2022	A. Delugan, M. Fazzari, L. Mazza	N
Augmented reality for remote use of measurement instrumentation	Seminar	2	0.4	24/05/2022	Prof. Annalisa Liccardo	N
QoE management in 5G networks	Seminar	2	0.4	08/06/2022	Luigi Atzori	N

Risk-modeling Complex Engineering Systems	Seminar	1.5	0.3	16/06/22	Enrico Zio	N
Introduction to Intellectual Property Management	Seminar	2	0.4	19.07.22	Alessandro Marroni	N
FROM RESILIENCE ASSESSMENT TO DESIGN FOR RESILIENCE: WHAT IS MISSING?	Seminar	1.5	0.3	14.07.22	Paolo Franchi	N
PhD Excellence School "I. Gorini" 2022	PhD schools	-	3	5-9/09/22	-	N

1) Courses, Seminar , Doctoral School, Research, Tutorship
2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	-	1.5	7	0.16*	8.66
Bimonth 2	-	1.3	7	-	8.2
Bimonth 3	-	2.7	10	-	12.7
Bimonth 4	14	3.2	10	-	29.2
Bimonth 5	-	0.7	10	-	10.7
Bimonth 6	3	-	10	-	13
Total	17	9.4	54	0.16	-
Expected	30 - 70	10 - 30	80 - 140	0 – 4.8	

*please refer to section 7

3. Research activity:

Introduction

Mobility in smart cities is receiving much attention, promoting transport modes based on zero emission electrical technologies and low financial investment. In the next decades, passenger global mobility demand will grow mainly in urban areas where, in 2050 will live 68% of the world population, 95% more than 2015 [1,2]. The main demand is expected from emerging countries, such as China, India and in regions such as Africa and South America, causing a high impact both in terms of pollution.

The attention is shifting to increasingly intense use of public transport with zero emissions, such as that offered by trams. Large investments in infrastructure are not required for the use of trams, which unlike the other rail transport systems use the same road infrastructure as cars, motorbikes, bikes, and pedestrians. Integration of trams into the environment in which the tram will soon find themselves

interacting, must be safe for themselves and other road users. It is clear, therefore, that the time is ripe for the adoption of driver support systems for trams to improve road safety.
The PhD program aims to develop an *advanced driver assistance systems* (ADAS) for trams, which are crucial for safety and reduction of accidents.
The automotive sector can lead this process of technological innovation for the tramway: assisted driving systems have already been developed and are based on the use of traditional cameras and deep-learning approaches. Existing camera-based solutions provide a 2D view of the scene and, above all, are dependent on the illumination of the scene. More details on the LiDAR sensor and its advantages over traditional cameras can be found in the literature reviews [3-6].

Following this summary, an assisted guidance system based on the fusion of traditional cameras and LiDAR sensor is proposed and will perform:
-Detection of moving objects in 3D
-Tracking of moving objects
-Warning the driver of possible dangers/obstacles.

Methodology
The development of an *advanced driver assistance system* aims to detect moving objects and estimate their size, direction, position, speed, and acceleration. Some important challenges are 1) how to reduce the computational load to make the algorithm in real time and 2) how to produce accurate estimates on kinematics.
The system can be implemented through specific operations, like inter-frame comparisons for background filtering, clustering for object recognition, 3D bounding box fitting for object orientation estimation, and Kalman filtering reinforced by feedback for object tracking.

The first step focused on developing techniques of background subtraction i.e., filtering out points of non-interest describing static objects, such as trees, buildings, and many others. The filtering techniques must show the performance of ability to adapt to any scene and above all to execute in real time. Filtering the background, therefore, allows to reduce the number of points describing a scene to only those points representing moving objects. As a second step, clustering techniques must be applied to group points with the same characteristics and recognize individual moving objects in the scene.
Subsequently, the orientation and kinematic parameters of the moving objects must be estimated, and the tracking process to update in the frame sequence the pose, direction, velocity, and acceleration of each of them.

Discussion and results
Initially, the proposed methodology is applied to data collected with a static LiDAR. The data are acquired on an urban road near the metropolitan city of Naples, Italy. The road is a main artery

connecting the city, characterized by high traffic density during office hours. The LiDAR is mounted on a tripod at a height of 1.5 m positioned on the roadside in a parking area.

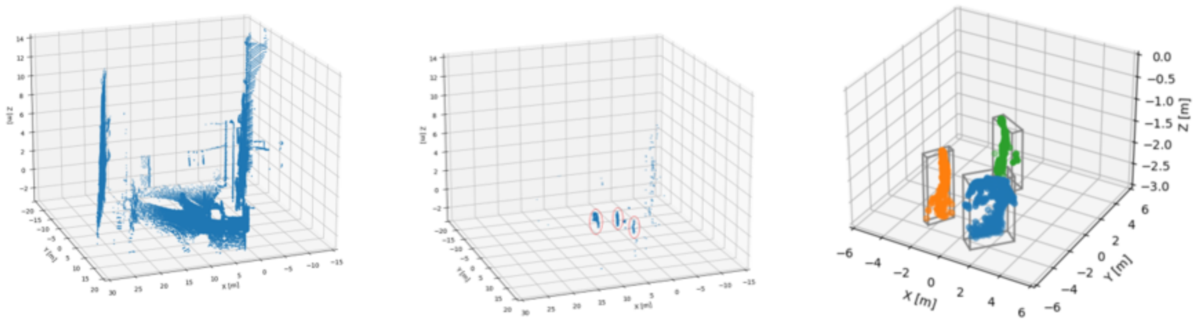

Figure 1: (a) Scene returned by the LiDAR sensor: cloud of points describing a urban scene in Cartesian coordinates. (b) Scene resulting after background filtering: the moving objects recognized by the algorithm are highlighted with red circles and correspond to a pedestrian, a motorbike and a car; the remaining points represent noise points. (c) Urban scene with three moving objects after applying clustering and estimation of their size. The 3D bounding box is marked by using the gray cube.

The results, in the Figures (1-2), find application in Intelligent Transport Systems where the monitoring of vehicles and pedestrians moving on a road is a critical task, essential for improving the safety of people and optimizing the maintenance and use of roads. Monitoring encompasses a range of tasks, such as detecting and classifying vehicles, estimating traffic density, detecting, and counting pedestrians walking along the roadside or at crossroads, measuring vehicle and pedestrian speeds, and so on.
Indeed, reliable and accurate monitoring results are invaluable in mitigating risks through early warnings to drivers and pedestrians and/or by invoking the direct intervention of traffic wardens. In addition, traffic data collected over long periods allows quantification of the cumulative stress and obsolescence of infrastructure and its subsystems. However, appropriate road monitoring systems can be an aid to assisted driving systems by exchanging information with each other.

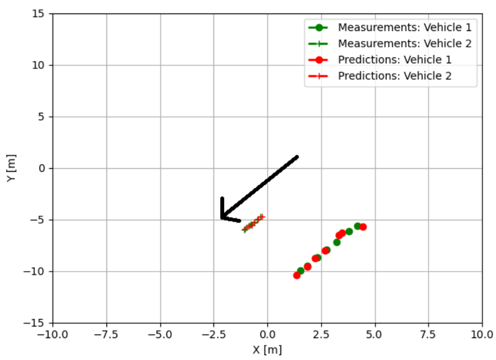

Figure 2: Two track position signals relating to two vehicles with different speeds. the direction of the two vehicles is indicated with the black arrow

In addition, one would like to apply the proposed methodology to data collected by LiDAR mounted on trams. In cooperation with researchers from Hitachi Rail S.P.A, LiDAR sensors and traditional cameras are mounted on trams working on the urban lines of Naples.
An initial processing shows that vibrations can vary the position of the LiDAR with respect to the initial position. So, a calibration process is required to take account of these aberrations.

Reviewer for the scientific journal Scientific Reports

[1]. United Nations - Department of Economics and Social Affairs, "World Population Prospects 2019", New York, 2019, available at URL: https://population.un.org/wpp/Publications/
[2]. OECD/ITF, ITF Transport Outlook 2017, OECD Publishing, Paris, 2017.
[3]. Campbell, Sean, et al. "Sensor technology in autonomous vehicles: A review." 2018 29th Irish Signals and Systems Conference (ISSC). IEEE, 2018.
[4]. Zhao, Xiangmo, et al. "Fusion of 3D LIDAR and camera data for object detection in autonomous vehicle applications." IEEE Sensors Journal 20.9 (2020): 4901-4913.
[5]. Kumar, G. Ajay, et al. "LiDAR and camera fusion approach for object distance estimation in self-driving vehicles." Symmetry 12.2 (2020): 324.
[6]. Li, You, and Javier Ibanez-Guzman. "Lidar for autonomous driving: The principles, challenges, and trends for automotive lidar and perception systems." IEEE Signal Processing Magazine 37.4 (2020): 50-61.

4. Research products:

[-1]	Estimation of Euler angles via gyroscope and point cloud for self-alignment of moving and/or static LiDAR sensor. Word in progress - in validation
[j2]	Real-Time Detection and Tracking of Moving Objects using Roadside LiDAR Sensors. M. D'Arco , L. Fratelli, G. Graber and M. Guerritore Submitted to Sensor MDPI
[c3]	Application Scenarios for Gait Analysis with Wearable Sensors and Machine Learning. Mauro D'Arco, Martina Guerritore, Annarita Tedesco. Accepted by IMEKO TC4 International Symposium

[j4]	D'Arco, M.; Guerritore, M. Multi-Sensor Data Fusion Approach for Kinematic Quantities. Energies 2022, 15, 2916. https://doi.org/10.3390/en15082916 Published

5. Conferences and seminars attended

PhD Excellence School "I. Gorini" 2022 - winner of BEST PROJECT AWARD
XR Spring School 2022 - eXtended Reality Spring School 2022

6. Periods abroad and/or in international research institutions

The training period abroad is started on October 24th, 2022, at the European R&D centre (ERD) of HITACHI EUROPE SAS, R&D in Sophia Antipolis, 955 B2, Route des Lucioles, 06560 Valbonne Sophia Antipolis, France. The research will focus on the development of technologies to provide an assisted guidance system in tramway based on fusion of LiDAR sensors and camera.

7. Tutorship

- *Misure elettriche ed elettroniche per la Bioingegneria, AA 2021/22*
  2h, on 2th December 2021
  2h, on 9th December 2021
- *Bachelor's degree supervision:*
  SISTEMI LiDAR PER LA GUIDA AUTONOMA
  Candidate: Barbara Vanacore, Matr. N36/002706
- *Master's degree supervision:*
  Candidate: Fernando Nicolini

8. Plan for year three

The activities planned for the third PhD year include applying the above proposed methodology to the data collected by LiDAR mounted on trams, as referred to above. Before of applying the proposed methodology to the data obtained from the second experimental set-up, is important to solve the self-alignment problem of moving LiDAR sensor. For LiDARs are mounted on a self-driving vehicle or are used for road monitoring, there may be deviation angles between the main and Sensor reference systems due to errors in installation, vibration, and others.

In the literature, there are approaches based on the use of IMU sensors, in particular gyroscope and accelerometer sensor fusion by applying Kalman Filter. The accelerometer measures gravity acceleration in static or quasi-static conditions and measures external acceleration in dynamic conditions.

Thus, in dynamic conditions, it is necessary to estimate the external acceleration due to movement and subtract its contribution to obtain the effect of gravity. The sensor calibration method, one wants to propose, aims to estimate the angular deviations by avoiding use of the accelerometer, and compensate them for more accurate measurements.