Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.y. 2014/2015

Michele Cucuzzella

XXX Cycle

Tutor: Prof. Antonella Ferrara
Scientific activity

1. Higher Order Sliding Mode Control for Microgrids

The main purpose of this activity is the modelling and the design of a control scheme for distributed generation units which supply local composite loads in both grid-connected operation mode (GCOM) and islanded operation mode (IOM), i.e., when the distributed generation unit operates disconnected from the main grid. In particular the objective of this work is the performance analysis of the proposed control strategies in terms of robustness in presence of modelling uncertainties and disturbances, and in terms of tracking error of the controlled variables.

The considered control problem has been solved by designing advanced control strategies of sliding mode type, particularly appreciated for its robustness properties. However, sliding mode control requires the use of discontinuous control laws, which can enforce the chattering effect, i.e., high frequency oscillations of the controlled variable due to the discontinuities of the control law. An effective way to alleviate the chattering problem, maintaining the robustness properties typical of sliding mode control, is to increase the order of the sliding mode: Higher Order Sliding Mode.

In particular, during this activity, a master-slave scheme with the Suboptimal Second Order Sliding Mode (SSOSM) algorithm and the min-max time-optimal third order sliding mode (3-SM) algorithm, has been proposed. First, the use of SSOSM control has been investigated, observing how this approach can provide satisfactory chattering alleviation only in case of GCOM, since in that case the controlled system relative degree is unitary, while in IOM it is equal to 2. Then, to attain a chattering attenuation effect also in IOM, a 3-SM control law has been designed for that case. So, on the whole, it is possible to devise a control policy which switches from a SSOSM control law to a 3-SM control law, i.e., changes the order of the sliding modes which are generated, whenever a transition from GCOM to IOM occurs. Moreover, in order to face some undesired overshoot on the currents fed into the load and injected into the grid, due to the reconnection to the main grid, as well as to step variations of current references, a constrained SOSM control has been designed.

The microgrid system controlled via the proposed sliding mode control laws exhibits appreciable stability and robustness properties, which have been formally analyzed. Moreover, simulation results confirm that the obtained closed-loop performances comply with the IEEE recommendations for power systems.

However, the presence of interconnected voltage source converters, which are not taken into account in our models, can be viewed as a source of modelling uncertainty and disturbances. Moreover, another source of uncertainty in microgrids is the fact that only the nominal values
of the parameters of the grid and of the loads are typically perfectly known, and their variation could be unpredictable, making the definition of the bounds on the uncertain terms impracticable.

Having in mind the microgrids application, during my activity, four adaptive control strategies of sliding mode type have been designed and theoretically analyzed. The first two techniques are adaptive versions of the SSOSM control, in which during the reaching phase, the control amplitude is continuously adjusted, so as to arrive at dominating the effect of the uncertainty on the controlled system. When a suitable control amplitude is attained, the origin of the state-space of the auxiliary system (i.e., the second order system with states coinciding with the sliding variable and its first time derivative) becomes finite time attractive. The other two control strategies are oriented to reduce the control amplitude in steady-state by applying an additional component to the discontinuous adaptive law, based on the “average control”, obtained at the output of a first order low pass filter.

Two adaptive strategies are finally applied to the microgrid system, which exhibits satisfactory performance even in realistic scenarios, characterized by disturbances and critical parameters variations.

2. Event-Triggered Sliding Mode Control

In particular, during this activity, I have designed a novel Sliding Mode control algorithm of event-triggered type, capable of dealing with a class of nonlinear uncertain systems. The design objective is indeed to reduce the number of transmissions over the network, while guaranteeing that the proposed Event-Triggered Sliding Mode (ET-SM) control, is a stabilizing control law with appropriate robustness in front of matched uncertainties. The kernel of the proposal is a triggering rule depending on a suitably defined sliding variable and on a pre-specified boundary layer of the sliding manifold. Then, the proposed control algorithm has been theoretically analyzed, proving that the sliding variable associated with the controlled system results in being ultimately bounded, with the amplitude of the convergence boundary layer which can be arbitrarily set.

In the second part of this activity, I have designed a novel Event-Triggered Second Order Sliding Mode (ET-SOSM) control algorithm for double integrators subject to model uncertainties and external disturbances. The proposal is based on a triggering condition, which depends on the state of the controlled system, and on a pre-specified ultimate state convergence set. The proposed control strategy has been theoretically analyzed. Specifically, it has been proved that the state of the controlled system is ultimately bounded and, at most, switches along the bounds, with the bounds of the convergence set which can be arbitrarily set.
Moreover, according to SOSM control theory, the control problem of a n-dimensional system can be reduced to the design of controllers stabilizing a suitable auxiliary system, that is a perturbed chain of two integrators, obtained by using as state variables the so-called sliding variable and its first time derivative. Indeed, by applying the proposed ET-SOSM control algorithm, it has been proved that the sliding variable is ultimately bounded and its first time derivative is ultimately bounded as well or, at most, switches along its bounds.
**Education activities**

I attended the course on “Industrial Control”, by Prof. L. Magni, but I have to do the exam, (6 CFU).

I also attended the course organized by the SAFD “Imparare a progettare in Europa” by Dr. Baggini and Dr. Carini, Servizio Ricerca e Terza missione, Università degli Studi di Pavia, (2 CFU).

I also attended the course organized by the SAFD “Linguaggi, problemi e metodi della comunicazione della ricerca scientifica” by Prof. Bacchetta, Prof. Mainino and Dr. Cagnotti, (8 CFU).

I also attended the course “Python programming for machine learning” by Blaz Zupan and Marinka Zitnik from the University of Ljubljana, (2 CFU).

I also attended the course “The LMI/BMI Approach to Optimal Control” by Prof. Richard D. Braatz from MIT, (2.4 CFU).

I also attended the course “Electrical machines for advanced applications” by Prof. Lorand Szabo from Technical University of Cluj, Romania, (1.6 CFU).

In the a.y. 2014/2015 I worked as teaching assistant for the courses “Fondamenti di Informatica” and “Fisica Tecnica”.

**Attendance to seminars, congresses and schools**

I attended the seminar “Learning Personalized Models: Application to Electric Load Forecasting”, by PhD Francesco Dinuzzo, organized by Prof. Giuseppe De Nicolao, (0.2 CFU).

I also attended the Spring School “Sliding Mode Control: Theory and Applications”, by Professors Ferrara, Spurgeon, Orlov, Plestan, Perruquetti, De Jong, Brogliato, Fridman at Aussois, (5.2 CFU).

**Seminars and presentations held**

I have presented the paper “Third Order Sliding Mode Voltage Control in Microgrids” by M. Cucuzzella, G. P. Incremona and A. Ferrara at the IEEE European Control Conference 2015, held from 15th to 17th July in Linz, Austria, (1 CFU).

I have obtained an overall number of **22.4 CFU**.
Stay abroad

None.

List of publications

Journals


Referred Conferences


Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.a. 2014/2015

Daniele De Martini

XXX Cycle

Tutor: Tullio Facchinetti
1 Scientific Activities

1.1 Mobile Robotics

The main research field I work on is mobile robotics, in particular on SLAM and vision, both in simulations and on a physical robot.

First of all we worked on a robot that could autonomously explore air conditioning pipes of buildings and make a map out of its sensing. This robot is made in collaboration with a company named Alisea. I had a part in the preliminary design of the robot and in the electrical and electronic design.

Then my work moved to inspect the localisation and mapping task, although at this moment we rely on the ROS environment and its mapping stack that uses a laser scanner to sense the environment. Our task is to get rid of the laser sensor and start to use the camera more effectively: I wrote a library that can make the robot detect QR codes and decipher them, so it can apply SLAM algorithms to understand where it is.

Afterwards, my work concentrated on the study of the SLAM algorithms and I proposed one to use with the QR code finder algorithm. Now I’m studying a way to get rid of the laser scan due to its cost and processor consumption: my solution is to use a laser diode to project a line and detect its deflection with the camera, so that we can detect holes and obstacles, and sense the environment. Next I will integrate this with a full monocular SLAM.

Lastly, I’ve written drivers to connect a Wii controller to the computer and use it to control a robot that uses the ROS navigation stack.

From this work, I derived a simulation environment for students attending the course on Robotics to practise in motion planning. The simulator is built on top of the Morse platform, an open-source implementation of Blender for robotics applications, which implements many built-in sensors and actuators. I had to create an environment and a robot from scratch and then write bindings for the sensors and actuators signals in the C and Java languages. This platform is in use from the current year in the Robotics class.

A last mention is for a project in which we are developing a flying drone for off-shore rescue: at the moment we have done a preliminary design that led to a thesis on the topic.

1.2 Sensors

In this second field, my research activity focused on gaining experience with inertial sensors (or IMU).
First of all my goal was to develop a tracking system based on IMUs, starting from a previous project and implementing online calibration algorithms for IMUs, using accelerometer and magnetometer sensing to get a correction of the gyroscope drift.

During this studies, we realized we needed a tool able to quickly estimate the coefficients of the ellipsoid of the acceleration measurements of a IMU: for this reason we developed a prototype for a calibration tool that helped us when we decided to put a IMU on the mobile robot described in the first section. We gained more accurate measurements from the sensors, but some additional work is required to complete the project, in particular regarding the mechanical aspects.

Last but not least, I worked on a new type of liquid flux sensor, that could be accurate, reliable and cheap. To achieve that we decided to convert an old project of a wind sensor and reshape it to be used in pipes: I optimized the shape of the sensor and made CFD simulations to estimate how it could effect the fluid it is immersed in and if it could be effective. The next step is to build a first prototype, and we decided to 3D print it and validate the simulations.

1.3 Other
Beside the fields of study described above, I work on two other minor projects: I wrote a genetic algorithm library that can be used for the optimization of electric loads starting from previous research in the laboratory I work in.

The second one is about a regenerative clutch able to smooth the loss of velocity when a driver changes gear, both in acceleration and in deceleration, by means of an electric motor on both side of the clutch.

Last, I am part of the team who is writing a book of exercises of the C programming language, which will be released in the next months.

2 Education activities

- Imparare a progettare in Europa, Università degli Studi di Pavia, 2CFU
- Soft computing theory, techniques and applications, Politecnico di Milano, 6 CFU (waiting for the related documentation)
- Parallel computing using MPI and OpenMP, Politecnico di Milano, 5.6 CFU
• Teoria dei giochi, Università degli Studi di Pavia, 5.83 CFU (inserted later for possible relations to cooperative planning)

3 Attendance to seminars, congresses ad schools

• UAV-Based remote sensing, Università degli Studi di Pavia (9 June 2015)

4 Seminars and presentations held

None.

5 Stay abroad

None.

6 List of publications

None
Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.a. 2014/2015

Samuele Davide Di Dio Cafiso

XVIII Cycle

Tutor: Prof. Antoniangelo Agnesi
Scientific activity

1. Generation and amplifications of ultrashort pulses with Yb-doped materials

My research activity is based on the generation and amplification of ultrashort pulses in the spectral region of 1030 – 1080 nm, with Yb-doped materials, for industrial applications. I spent part of my research activity in the laser company Spectra-Physics in Rankweil (Austria). This company produces lasers for biomedical applications such as surgery, ophthalmology and cardiovascular medicine and for industrial applications such as industrial cutting and soldering. Yb-doped crystals are interesting materials for generations and amplifications of ultrashort pulses thanks to their flat and broad emission bandwidth that allowing sub-100-fs pulse generation and their good thermo-mechanical properties.

During my second year of PhD, I was involved in two activities: (1) an oscillator in low and medium power pure SESAM (Semiconductor Saturable Absorber Mirror) Mode-locked (ML) with a Yb:CaF$_2$ as gain medium and (2) a MOPA (Master oscillator power amplifier) based in Yb:Lu$_2$O$_3$.

(1) 65-fs Yb:CaF$_2$ laser mode-locked by SESAM

Yb:CaF$_2$ is an interesting materials for his really broad emission spectrum (~ 70 nm) and for its relatively high thermal conductivity (5 Wm$^{-1}$K$^{-1}$ for a 2.5% doping concentration) along with a weakly negative thermos-optic coefficient, result in a significant reduction in thermal lensing. The material has a long fluorescence lifetime ($\tau_f$ = 2.4 ms) and relatively low peak emission cross section ($\sigma_e = 0.17 \times 10^{-20}$ cm$^2$). Large $\tau_f$ value can be exploited for high-energy amplification of short pulses, reducing the complexity of the pump system for such applications. Although the product $\sigma_e \tau_f$ is still favorable for low threshold laser operation, the high value of $\tau_f$ yielding high energy storage capability can easily responsible of SESAM optical damage in presence of Q-switched mode-locking (QML) instabilities. Here It is presented a CW and ML operation and results in pure SESAM ML with Yb:CaF$_2$, and the guidelines that allowed to get the stable ML. We start with a low-power setup, pumping with a pair of single-mode fiber-coupled laser diodes, both emitting about 400 mW maximum power at 976 nm. Owing to the excellent beam quality, this pump system yields the highest gain per Watt of absorbed power, and the lowest thermal stress in the crystal. This allows optimizing the oscillator for short pulses with greater ease than with respect to multiwatt multimode pumping, requiring more careful thermal management of the crystal and proper thermal lensing consideration in the laser design. The oscillator for the low-power experiments was a X-folded resonator with a 3-mm long, 5%-doped Yb:CaF$_2$, sample with both facets anti-reflection (AR) coated for the pump and laser wavelengths respectively. Through ABCD modeling of the resonator we could estimate a fundamental cavity mode radius in the active medium ranging from 11 to 13 $\mu$m within the stability region, well matched to the pump radius. The characterization of the laser in CW regime, it was performed for a set of different output couplers (OCs) with different transmission values T. With the optimum T = 5% it was obtained up to 240 mW with an absorbed pump power of 435 mW (55% internal optical-to-optical efficiency). A maximum slope efficiency of 67.5% was obtained with T = 10%. In order to determine the total losses $\delta$ (cavity + crystal) and the intrinsic slope efficiency $\eta_0$, it was performed the Caird analysis. It was obtained an intrinsic slope efficiency $\eta_0$ ~ 83% (accounting the mode matching efficiency and quantum efficiency) and a total resonator losses, excluding the reabsorption losses in the Yb-doped crystal, of $\delta = 1.5\%$ (mostly due to AR
losses from the crystal facets). For ML experiments we replaced the end mirror of the cavity with a SESAM having 3% modulation loss and a saturation fluence of ~ 140 µJ/cm² (a set of such SESAMs with similar parameters was available). In order to polarize the laser output it was inserted a 2-mm thick fused silica plate at Brewster angle close to the output coupler. For intracavity group delay dispersion (GDD) compensation, a pairs of GTI mirrors providing -55 fs² negative dispersion per bounce were chosen. Stable and self-starting soliton ML regime was obtained with a minimum number of 5 bounces per mirror, corresponding to a total negative dispersion per round trip of about -1100 fs². Pulses as short as 65 fs with an optical spectrum of 20 nm (FWHM) centered at 1050 nm were obtained with T = 0.8% at an average output power of 35 mW, close to the Fourier-transform limit for sech² shaped pulses. No variation in beam profile were observed when switching between CW and ML, for example during adjustment of the dispersion. This makes contributions from KLM unlike in our setup. In order to assess the stability of the ML operation, it was measured the radio frequency (RF) spectra in different span ranges, with a fundamental beat note at 139 MHz with an high extinction ratio of 50 dB, indicating the absence QML instabilities. As a further step confirming the validity of our design guidelines, and to investigate the potential power scaling of the laser, we designed and built a second resonator pumped by a 12-W, 100-µm fiber-coupled single-emitter pump laser diode at 976 nm. The pump beam was imaged in the active medium by means of an achromatic lenses telescope with a magnification factor of 1.2. Because of different power module it was necessary redesign the x-folded resonator with respect to the low power experiment in order to maintain the same value of saturation fluence in the gain medium and on SESAM. For intracavity GDD compensation it was employed a pairs of fused silica prisms separated by a distance of about 500 mm, yielding a maximum negative GDD of about -1100 fs². In this resonator configuration ABCD modeling yielding a cavity mode waist in the active medium and on the SESAM of about 60 and 80 µm respectively. Stable and self-starting ML pulse trains at 80 MHz repetition rate were obtained with a maximum output power of 1.4 W at an incident pump power of 11 W with T = 5% and pulse as short as 65 fs with an optical spectrum of 14 nm centered at 1050 nm close to the Fourier-transform limit.

(2) **MOPA based in Yb:Lu₂O₃**

With a market strongly pushing towards shorter pulse duration and higher average power, a crucial point of laser materials research is the identification of the best candidates offering both good thermos-mechanical properties and wide, and possibly flat, emission bandwidth, allowing sub 400-fs pulses amplification. Yb:Lu₂O₃ is an interesting material thanks to his really good thermo-mechanical properties, especially for its relatively high thermal conductivity (11 W m⁻¹ K⁻¹) that allowing high intensity pumping, and thanks to its still favorable emission bandwidth (~ 13 nm) allowing sub 400-fs pulse amplification, favor this material as gain medium in high power MOPA amplifiers in place of the well know Yb:YAG and Yb:CALGO in thin-disk and regenerative amplifier technologies or as post/pre-amplifier. Furthermore MOPA architecture is relatively easy to implements, cost-effective and all-optics technology. In this work the target is build a booster amplifier at 1 µm, that give an output power greater than 100 W and allowing sub 400-fs pulse amplification.

The first step was to compare four different Yb-doped materials in term of spectral gain, in order to understand witch was the peak gain, at with wavelength and in order to evaluate the gain narrowing due to the non-flat spectral shape. The measurements, were performed in four different Yb-doped crystals: a 10-mm long 1.9%-doped
Yb:CaF$_2$, a 8-mm long 2%-doped Yb:CALGO, a 10-mm long 2%-doped Yb:KYW and a 8-mm long 1.5%-doped Yb:Lu$_2$O$_3$.

As a seeder, it was built a continuous wave (CW) oscillator with Yb:KLuW, easily tunable in the window of 1030 - 1040 nm that give a constant output power of 1 W. The seeder, after a careful signal conditioning, was sent in the amplifier in a double pass configuration. The beam quality was good ($M^2$ ~ 1 for both axes), even if with little astigmatism, that didn’t affect the gain of the amplifier. The pump module was a 100 W, 100 µm fiber-coupled diode at 976 - 980 nm. In order to manage the thermal loading, it was used sink-copper water cooled for the crystals and water cooling for the high power pump diode module. A lot of efforts are involved in order to stabilize and compensate the thermal effects, which play a crucial role in the final performances of the amplification in term of beam quality and gain.

From this set of measurements it was evident that the gain in the Yb:Lu$_2$O$_3$ was higher with respect to the others materials with a maximum peak gain of 6.55 at 1033 nm, while the others Yb-doped materials has shown a gain smaller than 3.5. Indeed, in term of band-flatness, the Yb:Lu$_2$O$_3$ shown a Lorentian-shape-gain with a bandwidth of ~ 10 nm that could affect the seeder to amplifier in term of gain narrowing, even if theoretically still enough to amplifier pulse as short as 400 fs.

The second step was a CW amplification of a high power seeder in two stage of amplification. In this case it was used as seeder a CW oscillator with Yb:Lu$_2$O$_3$ with an excellent beam quality ($M^2$ ~ 1 for both axes) and with a maximum output power of 30 W. In the first stage of amplification, Yb:Lu$_2$O$_3$ shown an maximum output power of 62 W and 80 W in single and double pass configuration with an input signal of 30 W, respectively. It is evident the drop of the gain in high power regime, due to the saturation of the gain, but still improvable. In a further stage of amplification in double pass configuration, it was demonstrate the possibility to boost an input signal of 20 W up to 105 W with a good beam quality.

Finally an estimation of gain narrowing it was performed by using as a seeder, a low power oscillator (360 mW) with a pulse bandwidth of about 6.5 nm. This was sending in the first stage of Yb:Lu$_2$O$_3$ amplifier in double pass configuration. The output signal was slightly affected by the gain narrowing with a bandwidth of about 5.5 nm but still good amplification (~ 5.2). Further experiments will be performed in order to amplifier high power seed with pulse as short as 400 fs in order to obtain an output power of 100 W.
**Education**

1. “Industrial laser design” run by Prof. Antoniangelo Agnesi
2. “Optoelettronica biomedica” run by Prof.ssa Sabina Merlo

**Attendance to seminars, congresses and schools**

1. Renewable energies development centre Algeria, 21 October 2014
2. Sensor sensor-networks, sensor information processing (I part), 21 October 2014
3. Sensor sensor-networks, sensor information processing (II part), 6 November 2014
4. Perception, navigation and target localization for autonomous robots, 27 October 2014
5. Ant algorithm for image edge detection, 26 November 2014
6. Ground stations design analysis and test – the practical case of IXV project, 11 December 2014
7. Antennas for space applications - technologies and challenges, 19 January 2015
8. A 2-16 GHz stepped frequency integrated radar for breast cancer diagnostic imaging in 65 nm CMOS, 14 January 2015
9. Imparare a progettare in Europa, course, 10 - 11 and 18 February 2015
10. Python programming for machine learning, 24 February 2015
11. Metrology with/for MEMS/WEMS devices, 20 April 2015
13. Cryogenic low noise amplifier for satellite communication and radio astronomy applications, 6 May 2015
15. Metodi e strumentazioni per analisi mixed domain e misure ad alta sensibilitá, 28 May 2015
16. IEEE STARCAS courses, 3 - 5 June 2015

**Seminars and presentations held**


**Stay abroad**

1 July – 31 December 2015, Spectra-Physics High Q Laser GmbH · Feldgut 9 6830 - Rankweil Österreich

**List of publications**

*Secon Year*

1. “Sub-50-fs widely tunable Yb:CaYAlO$_4$ laser pumped by 400-mW single-mode fiber-
2. “65-fs Yb:CaF$_2$ laser mode-locked by SESAM”, JOSA B
Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.a. 2014/2015

LIU KAIXU

2014/2015 Cycle

Tutor: Gianmario Motta
1. **Tema 1: Indoor Navigation**

With the popularity of smartphones and the rapid development of positioning service requirements, navigation service for mobile devices is getting more and more attention. Map applications of smartphones have been widely applied to people's lives of travelling, dinner and shopping, but most applications can only provide users with outdoor service and be powerless for indoor navigation. GPS can supply a high-precision location service in the open environment, where the signal of satellite loss very small. But since the loss of the signal, GPS cannot be used in indoor. Geomagnetic with its advantages of low-cost and high accuracy becomes currently one of the most popular new technology to be applied in indoor positioning and navigation.

I design and implement a geomagnetic positioning indoor navigation system based on Android platform, using geomagnetic sensors of Android phones to achieve positioning and providing the user with navigation service. The biggest feature of the system is easy to deploy, requiring no additional deployment equipment, using a mobile terminal can provide positioning and navigation services for users.

System uses geomagnetic technology for indoor positioning, Dijkstra’s algorithm for navigation functions, Hibernate and CXF frameworks for design and SURF algorithm for floor detecting. After testing, the precision of the system is approximate to 1 meter, which meets the requirements.

**Indoor Navigation System Information Services:**

![Diagram of Information Services]

**Conversion services:**
- Choose SVG as the standard format for indoor maps and convert the interior CAD drawings or indoor architecture images into 2D.SVG and 3D indoor map as the underlying data of Web and mobility.
• JOSM as a critical tool for converting target building’s framework to OSM file and 2D or 3D SVG indoor map.

**Image gathering services:**
• Indoor and outdoor images are to be collected either by a massive or selective procedure.
• Selective procedure is to be used for detailed information on POI.
• Massive procedure is used for creating maps and is based on Panoramic Camera, and a subsequent treatment of images, that are mapped on the map and simplified to foster positioning.

**POI information services:**
• Thanks to public service information, users’ preferences are addressed to generate pro-active and personalized service applications as discount information in a shopping mall.
• Time waste of disabled people in airports is avoided thanks to the published information on flights and boarding gates.

**Path planning services:**
• Various path planning methods proposed for each class of users
  ▪ Short path planning strategy of multi-destination path for citizens
  ▪ Barrier free path for wheelchair users and VIPs.
• Warning mode during navigation of blind people.

**Positioning services:**
• Geomagnetic field offline positioning based on indoor spatial difference with an error less than 1 meter.
• Positioning combined with flexible path planning (multi-destination path algorithm).
• Images stitching for floor identification:
  ▪ Input of a current image,
  ▪ Stitching of other scenes
  ▪ Recognition of the current floor
  ▪ Recognition of the position in the floor.

**Communication/action for the user:**
• Capture of the disabled user’s characteristics and his/her preferences.
• Tuning of services for the different user classes:
  ▪ alert mode for blind people,
  ▪ path priority mode for wheelchair users and stick users,
  ▪ normal mode for citizens.
• Various backgrounds and services e.g.
  ▪ advertising services in malls,
  ▪ flight check-in services at airports,
  ▪ room services in hotels
  ▪ etc.

**Data management:**
• Data management for input data, storing data, filtering fake events, event de-duplicating, face recognition and data encryption.
• Face hiding in images and sensitive information encryption.

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2. **Tema 2: Image Stitching**

Until now, In Indoor Atlas, Magnetic Field technology only detects the latitude and longitude information, but not altitude information. For altitude of user’s location, for example, the number of the floor, our Indoor Mobility matches the POI around current location with stored POI information. Image stitching technique stitches the given POI with stored POI to detect indoor floor information.

(1) **Feature Extraction**
• Features are detected on the captured image by using the Speeded Up Robust Feature (SURF) (a robust detector of local feature that can fits tasks as object recognition).
• SURF features are detected on the image.
• The strongest Features (blob) are extracted from the image and stored in a variable.
• The image and extracted features are stored in a database.

(2) SURF features extraction from two potential images.
(3) Removal of Outliers to improve the accuracy of the matched features.
(4) The features obtained are stitched with features obtained from a second image belonging to a similar object.

Attendance to seminars, congresses and schools
1. 2014 Nov 26th Attended a seminar “Ant Algorithm For Image Edge Detection”.
2. 2015 May 20th Attended a seminar “Asian Century: Reality Or Holy Grail?”.

Seminars and presentations held
2. 2015 Aug, 20th Give lectures “CITY FEED” in Northeastern University (NEU)
3. 2015 Sept. 22nd Give lectures “Indoor Navigation” in “Flexible City for Smart Community” summer school.

List of publications
2. 2015. “A threefold similarity analysis of crowdsourcing feeds” ----ICSS 2015 conference
Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.a. 2014/2015

Tianyi Ma

XXX Cycle

Tutor: Gianmario Motta
**Scientific activity**

In second year I continued my research on Mobility Data Integration, which integrates following mobility related data:

- Open data & Sensor data
- Crowd & Social data

This year I mainly focus on two topics in Mobility Data Integration:

1. **MOBANA: A Public Transit Data Integration Framework**

   The public transit data integration framework: MOBANA is designed for open & sensor data integration. It covers the whole lifecycle of public transit data which include data gathering, data processing, data integration, data analysis and visualization. The framework uses GTFS (General Transit Feed Specification) as the standard data format and provides a tool chain to help transit providers generate their GTFS data easily. It also integrates high amount of real-time sensor data using a distributed streaming processing approach. The real-time sensor data are sent to a message queue, and data producers emit data from message queue (FIFO). The emitted real-time data are consumed by distributed consumers in different virtual / physical machines. Each consumer processes data for different functions. For the functions that requires intensive data processing, multiple consumers that have the same functionalities are assigned by broker. The consumers can be implemented for following functions:

   - Real-time vehicle position map: because of the constraints of transit providers, system cannot directly get the real-time vehicle positions. In order to visualize the real-time position of vehicles, a simulation function to estimate the real-time position by GTFS and real-time delay is implemented.
   - KPI dashboard: a KPI dashboard for monitoring status of transit network. The updating and data aggregating cost a lot of CPU time, therefore, for each KPI one designated consumer should be assigned.

   Mobility Analyzer for Pavia was implemented as proof of concept. Public transit data from LINE S.p.A are gathered and converted to GTFS format. A real-time data producer is implemented to receive the sensor data coming from server of LINE and send them to the message queue. 4 consumers are implemented and deployed in 3 different physical machines. The testing result proves that it can handle the data volume in Pavia area well (average 1.2 million real-time feeds per work day, from 5:00 AM to 10:00 PM). Mobility Analyzer is reusable and easy to customize and configure thanks to the GTFS format and distributed processing. For larger city, e.g. Milano, we can simply replace the GTFS files and increase number of consumers to adopt the larger data volume.

   In the third year, more features will be added in the framework, e.g. Replay and Rewind from specific timestamp. They will provide managers and planners a more precise view on performance of transit network.

2. **Crowd & Social Data Integration: Credibility Assessment on Crowdsourcing and Social Network Feeds**

   Mobility feeds from crowdsourcing platform and social networks (e.g. Twitter, Instagram) are good complementary sources for city officials to identify and fix the mobility issues quickly. However, the trustworthiness of these data sources is not guaranteed comparing to the feeds
In order to integrate crowdsourcing feed and social network feed, an automated credibility assessment on these feeds are needed.

In the second year, I designed data integration processes that automatically detect mobility feeds from social network (Weibo and Twitter). Firstly, a multi-class feed detector is trained to detect feeds in a certain area (center of Beijing). When a feed is detected, its trustworthiness will be evaluated by a comprehensive credibility assessment approach. The approach is the core of the integration processes. It contains following steps:

- **Step 1 - Spam & Bot Detection:** it detects patterns of tweets uploaded by the user and determines the tweet is published by a human or a spam bot in three aspects:
  - Behaviour patterns. E.g. time intervals of recent tweets. Spam bot may publish tweet regularly, e.g. it publishes tweets every hour after 0 AM.
  - Content patterns. Spam bots always publish Ads, links, etc. A content detector is trained by a pre-defined spam dataset.

- **Step 2.1 - User Score:** the user profile and his / her recent tweets will be evaluated by number of followers, number of mutual friends, number of reply, retweets, favourites, etc. A User Score will be calculated.

- **Step 2.2 - Network Score:** in this step, an analysis on nearby tweets based on graph theory can detect similar tweets. If similar tweets are detected nearby it means higher credibility.

- **Step 2.3 - Sentiment Score:** the sentiment of the tweet will be analyzed by a pre-trained sentiment detector. The tweets with positive and confirmative sentiment will get a higher score.

- **Step 3 - Recursive Credit Updating:** the tweet that finishes step 2 will be monitored. The scores in step 2 will be recursively updated until the feed is confirmed, closed or deleted.

Please note that 2.1, 2.2, 2.3 can be processed in parallel. Therefore, these three steps can be processes in distributed consumers that has been introduced previously.

As the proof of concept, a mobility feed detector for Twitter and Weibo is implemented. The detector uses KLD (Kullback-Leibler Distance), a multi-class online machine learning algorithm, to detect and update detector model online. The detector was trained by a pre-defined dataset that contains more than 900 mobility feeds. The testing result from cross-validation shows that the accuracy is higher than other online machine algorithms, e.g. PA (Passive Aggressive Algorithm). Furthermore, the training model can be updated online without re-train from all datasets. The crowdsourcing feeds that are confirmed in CITY FEED (a city issue management system based on crowdsourcing, developed by Service Engineering Lab) can be another training datasets for the model. The KLD is also used in step 2.3: sentiment analysis, by training from a dataset that contains 2,000 tweets.

In the third year, I will finish the model and implementation of credibility assessment. The model will be tested in true scenario (CITY FEED).
**Education activities**

**Course attended:**
1. Multimedia databases, 12 CFU

**Teaching activities:**
3. 05/2015: Gave lectures “Big Data Technologies” in course Enterprise System. Harbin Institute of Technology, P.R.China.
4. 08/2015: Gave lectures “Trip Planner Case Study” in course Enterprise System. Northeast University, P.R.China.

**Attendance to seminars, congresses and schools**

**Schools:**
1. 15/12/2014 – 16/12/2014: Tools and techniques for massive data analysis, CINECA, BOLOGNA
2. 18/02/2015 – 20/12/2015: Python programming for machine learning, BIOLAB, University of Pavia

**Seminars:**
1. 21/10/2014: Sensors, Sensor networks, Sensor Information Processing, Prof. Kiril Alexiev
2. 21/11/2014: Ant Algorithm for Image Edge Detection, Prof. Stefka Fidanova

**Conferences:**
3. 30/03/2015 – 03/04/2015: 9th International IEEE Symposium on Service-Oriented System Engineering, San Francisco Bay, USA.

**Seminars and presentations held**

**Paper presented:**
Stay abroad

List of publications

Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.a. 2014/2015

Riccardo Marchetti

XXX Cycle

Tutor: Paolo Minzioni
Research Activity

My research has been focused on the study and characterization of passive and active optical devices integrated on silicon-based chips. In particular my work has been carried out in the frame of the “FABULOUS” (FDMA Access By Using Low-cost Optical network Units in Silicon photonics) European project. The target of the FABULOUS project is to design, develop and characterize new Silicon Photonics components for application in next-generation passive optical networks (NG-PON2), particularly in a WDM/FDM architecture based on a reflective optical network unit (ONU); these components will be integrated onto a multi-functional optoelectronic chip that will then be the core of a fully-functional system demonstrator. The ONU at the user side will not only receive the downstream modulated signal from the central office, but also a bunch of CW optical beams at different wavelengths, in order to use one of them to generate the upstream traffic. A schematic of the ONU architecture for the upstream signal generation is shown in Figure 1.

As it’s shown in Figure 1, the CW light beam is injected into the ONU through a polarization beam splitter, implemented as a two dimensional grating coupler (2D-GC) which enables to separate the two orthogonal light polarizations into two different single mode waveguide. After that, light is amplified with two semiconductor optical amplifier (SOA) integrated on the silicon substrate, then filtered using WDM ring resonators, and finally modulated using a bidirectional Mach-Zehnder modulator.

My work has been centred on the study and experimental characterization of:

- WDM filters
- Integrated SOA
- Two dimensional grating couplers

The WDM filters are based on micro-resonators structures, and exploit different topologies:

- Racetrack: an elliptical ring with two opposite straight couplings waveguides; waveguides are 220 nm high and 500 nm wide.
- Ring with straight coupling: a circular ring with two opposite straight coupling waveguides; waveguides are 100 nm high and 525 nm wide.
- Ring with curved coupling: a circular ring with two opposite curved coupling waveguides; waveguides are 100 nm high and 825 nm wide.

All the filter different topologies were implemented as single, double and triple resonators configurations. The filters are also endowed with metallization layers, in order to finely tune the filters resonance wavelength through the thermo-optical effect.
The WDM filters characterized were fabricated by CEA-Leti, and belong to the first fabrication run of the FABULOUS project; my work aimed to investigate the impact of optical nonlinear effects like two-photon-absorption (TPA), free-carriers-absorption (FCA) and free-carrier-dispersion (FCD) on the filters behavior. Measurements were done using both continuous-wave and 10 Gbit/s modulated signals. Results showed that, at high value of injected power (> 2 mW), the free carriers generated by TPA produce a refractive index change (because of FCD), thus causing an undesired shift of the resonance wavelength of the resonators and a consequent distortion of the transmission spectrum of the filter. When a laser signal at the resonance wavelength is injected, even at moderate power (e.g. 0 - 3 dBm), TPA affects the device insertion losses: the output power grows linearly with the input power until a certain “threshold-power”; after the threshold no significant increase of the output power is obtained by increasing the input power. Interestingly, reduced-height waveguides (100 nm) show a higher threshold-power with respect to the standard waveguides (500 × 220 nm). This behavior can be related to the reduced height of the waveguide: as recombination centers are mainly located on the waveguide surfaces, the use of a reduced-height structure allows for a faster free-carrier recombination. Measurements with modulated signals showed that TPA and FCA don’t affect the BER of the transmitted signal, even with different modulation patterns.

Beside the experimental characterization, I also took part in the simulation and the design activity for the second fabrication run of the WDM filters. As most of the issues related with the first generation of the filters were due to fabrication constraints, we decided to change some geometrical parameters, like the distance between the resonators and the input/output waveguides (increased from 200 nm to 250 nm) in the racetrack configuration, in order to relax the fabrication tolerances. I also focused on the design of new geometries for the wavelength-tuning metal heaters, in order to make them more robust at high value of injected current.

Regarding the SOA characterization, I evaluated the gain properties of a multi-quantum well amplifier made of III-V semiconductor, hybridly integrated trough wafer-bonding, onto a silicon-on-insulator waveguide, where the optical mode transfer between silicon and III-V waveguides takes place by means of waveguide tapers. The SOA was fabricated by III-V Labs and then packaged as a stand-alone device by Tyndall. Measurements were carried out in order to evaluate the SOA gain as a function of injected current, of the input optical power and of the operation wavelength, using an external cavity semiconductor laser to provide the optical input signal and stabilizing the device-under-test temperature. The SOA showed a fiber-to-fiber gain of about 10 dB at the wavelength of 1550 nm, for a feeding current of 120 mA; this value is considerably high for an integrated amplifier, but the gain exhibited a high ripple as a function of wavelength, due to spurious reflectivity, which affects strongly the device performance. Finally other measurements were made to assess the fiber-to-fiber and internal noise factor (NF) of the device as a function of the input optical power, for different value of the feeding current.

The last activity I did in the context of the FABULOUS project was the experimental characterization of the two dimensional grating couplers fabricated by CEA Leti in the second fabrication process of the project. The couplers are implemented as photonic crystal structures, where the geometrical parameters, like the etch-depth, the hole-radius and the grating-pitch, were optimized in order to achieve a coupling efficiency better than 4 dB at the wavelength of 1550 nm.

The main goal of my work was to evaluate the actual coupling efficiency and compare it with the values obtained from FDTD numerical simulations and with the values measured from the first fabrication process. The samples were composed by different test structure, including: 2D-GC connected to another 2D-GC by a multimode waveguide (width = 10µm) or by a standard SOI single mode waveguide (500x220nm) with a tapered section, 2D-GC connected to two 2D-GC using two multimode waveguides (for extinction ratio measurement), and 2D-GC connected to two 1D-GC by two standard SOI waveguides with tapered sections. Measurements were carried out using a tunable laser source operating in the extended telecom bandwidth (λ = 1500-1580 nm) and a polarization controlling scheme at the input of device-under-test.
The maximum measured efficiency (measured in the 2D-GC to two 2D-GC structure) is equal to -7.47 dB (at the peak wavelength of 1564 nm). Neglecting the waveguide losses, the coupling efficiency of the single 2D grating coupler results to be equal to -3.74 dB. The measured 3-dB band is equal to 43 nm, and the minimum extinction ratio between the two orthogonal polarizations is found to be 25.39 dB, at the wavelength of 1554 nm; both values are in good agreement with numerical simulations.

Besides the activities related with the FABULOUS project, I also a started a study about dispersion in silicon-on-insulator strip waveguide. I did some simulations using Lumerical MODE Solutions software in order to evaluate the dispersion constant in strip waveguides with different aspect-ratio, having both standard height (220 nm) and lowered height (100 nm). To confirm the simulation data and carry out the dispersion measurements, I designed some unbalanced Mach-Zehnder interferometers integrated on a silicon-on-insulator substrate, which will be fabricated by CEA Leti. By measuring the transmission function of the devices, which will be a cosine-like interferometric pattern, it is possible to assess the waveguide dispersion over the wavelength band of interest.

On the same chip that will be fabricated by CEA Leti, I also designed some ring based resonators (with lowered height waveguides) and racetrack based resonators (with standard height waveguides), for non-linear application, such as four-wave-mixing (FWM). In order to obtain efficient non-linear effects, it is necessary to reach a condition of so called “critical coupling”, in which the field coupling coefficient between the input bus waveguide and the resonators, equals the propagation loss coefficient. To do that I did some simulations using Lumerical FDTD Solutions software, in order to find the optimum gap between the bus waveguide and the resonators (as it affects the coupling coefficients), and designed different device configuration having different gap values (from 350 nm to 650 nm with 50 nm step for the racetrack resonator, and from 300 nm to 600 nm with 50 nm step for the ring resonator). All the resonators are also endowed with thermal heaters, in order to finely tune the coupling coefficient.
Attended seminars, congresses and schools

Seminars:
3. “Corso pratico introduttivo su LabVIEW con PXI” 8 July 2015

Schools and congress:
1. PhD School "Imparare a progettare in Europa" - 10-11 e 18 February 2015
2. CLEO/Europe-EQEC Conference 2015, 21-25 June 2015, Munich, Germany

Given seminars

Seminars and presentations held:
1. Contribution to CLEO-Europe & EQEC Conference “Impact of waveguide cross section on nonlinear impairments in integrated optical filters for WDM communication systems”, 21-25 June 2015, Munich, Germany
2. Presentation of the exhibit and of the research activities at “Notte del ricercatore” – 25 September 2015, Pavia

Total # of CFUs obtained as of October 14: 8.6
Ph.D. in Electronics, Computer Science
and Electrical Engineering

Activities report a.a. 2014/2015

Andrea Martellosio

XXX Cycle

Tutor: Marco Pasian
Scientific activity (2-3 pagine max)

My scientific activities were focused on three research topics, all related to the development of state-of-the-art antenna systems for space and biological applications. The first regards the study of the biological tissues under microwave and millimeter wave illumination. An extensive experimental campaign was conducted in cooperation with the European Institute of Oncology (IEO), which represents a fundamental step for the development of a new generation of imaging systems for early breast cancer detection. The second research topic regards the study of radome systems. A first section of this topic regards the evaluation of the framework in order to find out a strategy to minimize the impact of the radome on the antenna performance. The analysis, design, and experimental verification are the objects of the study, which is in cooperation with FDS ITALY, the only Italian company with experience in the design and production of radomes. A second section regards the feasibility study of high frequency radomes, intended to be installed in harsh environment, in particular polar regions, to protect small-to-medium (2 to 6 meter) ground stations. In cooperation with FDS ITALY, the study is also joined by the European Space Operations Centre (ESOC) of the European Space Agency (ESA). Finally, the third research topic about the analysis of a wideband cryogenic feed receiver for VLBI is conducted. The VLBI (Very Long Baseline Interferometry), allow to achieve interferometric observation of a celestial source using radio telescopes arranged on the Earth’s surface then the signals received are correlated in order to extract the interferometric information. The study is in cooperation with Callisto Space, which has over 20 years experience producing cryogenic Low Noise Amplifiers for satellite ground stations. It has produced more than 50 cryogenic receivers for worldwide renowned customers such as the European Space Agency (ESA), the Indian Space Agency (ISRO), the French Space Agency (CNES), the BKG (Wettzell Observatory) and several other institutional or private operators.

Topic 1
Breast cancer is a leading cause of disease worldwide and represents the most diagnosed cancer type among women. Even though a decrease of the mortality rate has been registered in the years, the incidence rate of the breast cancer is in increase. A unique reason that explains the onset of the cancer does not exist, instead different factors like the age, hereditary factors, environmental factors and lifestyles, are identified as principals causes of the breast cancer. However, an enhancement of the knowledge about the problem has increased significantly the success rate of medical treatments. This is due to improvements in the treatment itself and to the use of early detection techniques. Besides well-established methods for breast cancer detection (e.g., ultra-sound and X-rays techniques), an interesting approach, which is receiving a lot of interest by the scientific community, is based on imaging at microwave frequencies. By means of this methodology, the main advantages are the use of non-ionizing radiation, the lack of any compression, and the availability of low-cost transmitters and receivers. Moreover, the use of millimeter wave frequencies has been investigated as a possible solution. With a central operating frequency around 30 GHz, it is possible to provide a sharper resolution than microwave systems, even if a shorter penetration depth is expected. The microwave and millimeter wave detection is based on the transmission of a signal by an antenna; a fraction of the electromagnetic field is scattered by dielectric discontinuities of the biological tissues and collected by the antenna. For this reason, the contrast in the dielectric properties between normal and malignant tissues is fundamental for diagnostic applications. While at microwave frequencies until 20 GHz, the dielectric properties of biological tissues have been investigated for a long time, including malignant and benign breast tissues obtained from breast reduction and cancer surgeries, demonstrating a significant contrast, there is no reliable data in the
frequency range above 20 GHz. Therefore, the dielectric characterization of biological tissues over the 0.5–50 GHz frequency range was performed. As a preliminary validation and reference, fat and lean animal tissues have been characterized, which are expected to exhibit features analogous to normal and malignant breast cancer human tissues. The experimental results in the case of breast tissues show that malignant and normal tissues exhibit a significantly different complex dielectric permittivity up to 50 GHz, due to their high and low water content. Therefore, both animal and human tissues were characterized, showing a significant difference up to 50 GHz between the dielectric permittivity of low water content tissues (e.g., healthy adipose breast tissues) and high water content tissues (e.g., a wide class of tumors).

On the basis of the experience and knowledge acquired during the characterization campaign described above, next year this topic will continue with the analysis and design of a prototype aimed to demonstrate the imaging possibilities at mm-waves for biological targets. Both experimental and numerical activities are expected, still in cooperation with IEO. In addition, a side task is related to the evaluation of the mmWave energy deposition in biological tissues at microwave and mmWave frequencies, with the aim of evaluating the exposure thresholds to different radiating devices.

**Topic 2**

A radome is a structure designed to protect radar and communication antennas from harsh environmental conditions such as wind, rain, snow, ice, blowing sand, fungus, corrosion, ultraviolet rays, and wide temperature fluctuations. The radome has to be designed to have a minimum impact on the electromagnetic performance of the enclosed antenna but must also have high mechanical strength properties. Unfortunately, these properties are often mutually exclusive and the best solution has to be a clever compromise between mechanical and electrical performance.

- **Section 1**
  A radome is composed of a series of dielectric panels which are interconnected together in order to realize the dome. These interconnections, which are called seams, are characterized by joints and bolts. The frequency bandwidth of the radome, in terms of transmission losses and side lobe perturbation performance, is determined by the combined effect of the panels and the seams. The panels, ordinarily do not limit the overall radome performance. Therefore, they can be easily carried out as a suitable choice of materials and thicknesses of various dielectric layers in order to maximize the transmission coefficient in the operative frequency band. On the contrary, the seams may degrade the total system performance by introducing high scattering levels and limiting the operational frequency bandwidth. Practically, the incident filed produce an induced currents in the joints which become the sources of the scattered field. Therefore, the seams have to be compensated in order to equalize the electromagnetic behavior with respect to the panels. The compensation may be achieved through the joint tuning, which consists in the insertion of metal wires or grids in the seam itself. The geometry of these compensation devices is generally determined on the basis of full-wave parametric analyses.

While this first year has been mainly devoted to the study of the current state-of-the-art, to the realization of a suitable modelling environment, and to an experimental campaign aimed to characterize the dielectric properties of typical materials used for radome applications, next year will be mainly aimed to the analysis and design of the compensation structures at different operation frequencies.
Section 2
The feasibility study for high-frequency and harsh-environment radomes was evaluated considering different topology of radome from the electromagnetic point of view. It is possible to distinguish two main contributes about the electromagnetic performance of a radome: the transmission loss of signal passing through the radome walls and the scattering loss of the radome framework. In order to find the better solution, two different category of radome were analyzed: the multi-layer radomes and the space frame radomes. The multi-layer radomes are achieved by different layers of dielectric panels which are typically joined together through little mechanicals flanges. They perform well over relatively narrow frequency bands or potentially at multiple discrete frequencies. The parameters of the structure, like number of layers, thicknesses, etc., are optimized to provide the required performance. The space frame radomes consist of a triangular panels that are bolted together to form a geodesic dome. These panels are characterized by hubs, beams and windows. The hubs and the beams, scatter the electromagnetic field coming from the antenna. Given that the scattered field of the hubs are much less than that of the beams, thus can be ignored. Conversely, the windows are formed by single-layered or multi-layered skin through which electromagnetic field can be transmitted. Therefore, a space frame radome is characterized by two elements: the flange framework (hubs and beams) and the membranes (skin/wall). Depending on the material used to realize the flange framework, it is possible to distinguish: the metal space frame radome and the dielectric space frame radome. In the metal space frame the flange framework is realized by metallic materials (typically aluminum), whereas in the dielectric space frame the flange framework is realized by dielectric materials (typically fiberglass).

While this first year has been mainly devoted to the study of the current state-of-the-art, to the realization of a suitable modelling environment, and to an experimental campaign aimed to characterize the dielectric properties of typical materials used for radome applications, next year will be mainly aimed to the analysis and design of the radome considering both the details of the single panel (by means of full-wave solvers) as well as the entire radome geometry (by means of asymptotic techniques, e.g., physical optics).

Topic 3
The research activity was characterized by several simulations of a Quad-Ridged-Flared-Horn antenna implemented in a Dewar. The Dewar is an insulating storage vessel which maintains the inner content isolated from the outside, and it will be used as a cryogenic cooling structure. Different kind of Dewars were evaluated in order to find out the better solution from the electromagnetic point of view. In particular the radiation pattern of the system (QRFH + Dewar) was evaluated in order to find out the impact of the Dewar on the QRFH antenna performance. Afterwards, the simulations of the entire 12-m antenna system were performed. A GRASP model was implemented to evaluate the performance impact at antenna level. The models were obtained considering the different models of Dewar simulated previously by the HFSS simulator. Finally, different kind of probes antennas used to find out the coupling factor with the QRFH antenna were implemented. In addition, the optimum position where the probe has to be placed was studied and defined.

The simulation activities have been subsequently verified against measurements of the entire system, including both the QRFH and the probe antenna, showing a very good agreement.
**Education activities** (specificare/giustificare anche eventuali discrepanze rispetto al piano formativo approvato dal Collegio Docenti)

*Linguaggi, problemi e metodi della comunicazione della ricerca scientifica*
(Corso accreditato per gli Studenti Scuola di Alta Formazione Dottorale)

**Imparare a progettare in Europa**
(Corso accreditato per gli Studenti Scuola di Alta Formazione Dottorale)

Assistant supervisor of two bachelor degree students. Their activities were related to the first research topic.

**Attendance to seminars, congresses and schools**

- EuMW 2015 – European Microwave Week 2015 *(conference)*
- EuMW 2014 – European Microwave Week 2014 *(conference)*
- Cryogenic LNA for satellite communication and radio astronomy *(seminar)*

**Seminars and presentations held**

**Stay abroad**

**List of publications**

Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.a. 2014/2015

Diego Orlando Martinez Hernández

POWER ELECTRONICS LABORATORY

XXX Cycle

Tutor: Prof. Enrico Dallago
Scientific activity

1. POWER MANAGEMENT SYSTEM TO PARALLEL MICROBILA FUEL CELLS WITH DIFFERENT ELECTRICAL CHARACTERISTICS

During the first year of the PhD, the field of my research has been Energy Harvesting from Microbial Fuel Cell (MFC); in the Power Electronics Laboratory (PEL) was developed a power management system (PMS) for the parallel connection of MFCs that work in unbalanced conditions in terms of internal resistance, output voltage or performance.

The Fig. 1 shows the proposed PMS. It comprises a set of Boost converters working in discontinuous current mode and driven by the same signal switch. Each MFC is connected to its own DC/DC converter, but the output storage element is common for all the cells. The converter output diode makes that each cell work independent from all the others. Even if one or more cells would not work correctly, the remaining ones would still be able to charge the capacitor, and their operation would not be affected by the not-working MFCs. This PMS configuration allows every cell to charge the output capacitor in a way proportional to its electric performance and characteristics.

The system was designed with the aid of PSpice simulator. Values of inductances, frequency and duty cycle of the driving signal of the boost converters were chosen to make the cells work with a limited voltage ripple. An experimental set-up was afterwards developed in order to test the PMS behavior. This research was presented and evaluated in the Sixth European Fuel Cell Technology & Applications Conference, Naples 2015.
2. **Maximum Power Point Tracking system for simultaneous, real-time control of multiple Microbial Fuel Cells**

The second research activity has been developed as an initial collaboration with Helmholtz Centre for Environmental Research – UFZ (Leipzig- Germany). The aim of the activity is the realization of a maximum power point tracking system (MPPTS) able to work with multiple MFCs for the simultaneous and real-time control of the applied load resistance. The control algorithm is similar to the one previously developed at Power Electronics Laboratory (PEL), but some novel strategies have been implemented to ensure more stability in tracking the maximum power point (MPP).

The implementation of MPPTS applied to MFCs is adopted to improve the electrical performances and power output, through the resistance load control. The external load should be adjusted in order to make it equal to the internal resistance of the MFC; the aim is to follow the MPP. In this work an enhanced P&O method is used, since it is the best compromise between precision, robustness and implementation.

The improvement of the algorithm consists in the addition of MFC voltage measurement to the power comparison, to determine the direction of resistance variation. A voltage gradient (voltage/time) is calculated and compared to a threshold value (tolerance), to determine if the MFC has reached a steady-state condition and send the instruction to the output hardware. The next step will be the parallel connection of a group of MFC that work in their MPP.
Education activities

- **SUMMER COURSE ON POWER ELECTRONICS AND APPLICATIONS**: ROMA, Università Roma TRE, June 30th – July 16th 2015.

- **IEEE - START CASS: ADVANCE RESEARCH ON CIRCUITS AND SYSTEMS**: PAVIA, Università degli Studi di Pavia, June 3rd – June 5th 2015.

- **SHORT COURSE ON ELECTRICAL MACHINES FOR ADVANCE APLICATIONS**: PAVIA, Università degli Studi di Pavia, September 29th – September 30th 2015.

- **INSTRUMENTATION AND METHODS FOR MIXED DOMANIN ANALYSIS AND HIGH SENSITIVITY MEASUREMENTS**: PAVIA, Università degli Studi di Pavia, May 28th 2015.

Attendance to seminars

- **DESIGN OF ELECTRICAL MACHINES AND COMPUTATIONAL TOOLS FOR VIRTUAL PROTOTYPING**: Pavia, Università degli Studi di Pavia, May 14th 2015.

- **OPTOFLUIDIC LAB-ON CHIP FOR CELL MANIPULATION FABRICATED BY FEMTOSECOND LASERS**: Pavia, Università degli Studi di Pavia, May 27th 2015.

- **DESIGN CRITERIA FOR HIGH POWER SALIENT-POLE GENERATORS: SIZING AND ELECTROMAGNETIC CALCULATION**: Pavia, Università degli Studi di Pavia, May 28th 2015.

- **THE UNIFIED DIGITAL PLATFORM AND EXAMPLE OF MIXED SIGNAL ELECTRONIC DESIGN**: Pavia, Università degli Studi di Pavia, June 4th 2015.

- **IL MERCATO ELETTRICO ITALIANO: STATO DELL’ARTE E PROSPETTIVE**: Pavia, Università degli Studi di Pavia, June 8th 2015.

- **COHERENT SYSTEMS AND WAVELENGTH SWITCHING TECHNOLOGIES IN NEST GENERATION PHOTONIC BACKBONES**: Pavia, Università degli Studi di Pavia, June 9th 2015.

- **UAV- BASED REMOTE SENSING**: Pavia, Università degli Studi di Pavia, June 9th 2015.

- **APPLICATION OF ANTS IDEAS ON IMAGE EDGE DETECTION**: Pavia, Università degli Studi di Pavia, October 13th 2015.
Ph.D. in Electronics, Computer Science
and Electrical Engineering

Activities report a.a. 2014/2015

Gianluca Roveda

XXX Cycle

Tutor: Tullio Facchinetti
**Scientific activity**

The first year of my PhD has been focused on developing tools to gather real-life data, which I will use to implement mining techniques and analysis for the upcoming years.

My work can be split in the following categories:

- Comfort sensor’s improvements
- MYagonism Coach Agenda: an Android app for coaches
- Data gathering from “Croce Verde” ambulances

During this year I also tutored three bachelor candidates in their thesis projects.

**Comfort sensor**

My first research activity has been focused on improving some aspects of my master thesis project, a comfort sensor for vehicles’ passengers. During my master degree I have developed, together with Alessandro Tramonte, the comfort sensor application for Android, an application that uses several sensors (accelerometers, gyroscopes, magnetometers) to gather data while driving, and uses fuzzy logic and previously gathered data to compute an index that reflects the driving quality.

I also developed a Java framework to perform simple data analysis, and test the effects of filters and the resulting scores on logged data.

In the first months of my PhD I defined a more flexible and simple protocol for file logging, and implemented it in both the Android application and Java framework. This was done to achieve better results when logging in unknown circumstances (e.g. when data from other sensors is needed, when user surveys must be recorded, when some sensor is missing etc.).

The Java framework was also refactored to achieve modularity, which will come handy to perform data mining on data, and enhances code reusability between the Android application and the Java framework itself.

I enhanced the Android application performances by integrating the C-language version of the filtering and scoring algorithm, provided by Alessandro Tramonte, using the Android NDK. To gather better data I worked on the Android app compatibility with some more boards, including a software-rewritten MultiWii that avoids the need to poll data from the device.

I also greatly reduced the time required to compute the scores, pre-generating models with fuzzy logic and using multilinear interpolation (with Rick Wagner approach) during the driving for much faster calculations.
MYagonism Coach Agenda

Coach Agenda is an Android application written to help coaches administer their sport teams. I developed the Android app from April to July, and it is currently available to download in Google’s Play Store, with both a paid and a free version (the latter has some limitations). This work has been done in collaboration with the startup MYagonism, which provided graphics elements and a workflow, as well as server-side development (with a Drupal server, and custom-made php API’s for app interaction).

The gathered data is currently used to provide several statistics about the games and the players to coaches. The statistic data to be shown is decided from both MYagonism team and some professional team coaches, and involves a lot of performance indicators. In the future, I plan to analyze data in an anonymous form to suggest improvements to MYagonism team, which could involve their use of data as well as user experience.

A submission of a paper derived from this work is under evaluation to one of the following journals:
- Sport Management Review
- Journal of Science and Medicine in Sport
- Journal of Sport and Health Science
- Science & Sports
- Sports Medicine
- Sports Engineering

Ambulances comfort sensor’s data gathering

In the end of July I started working for a cooperation with “Croce Verde” in Pavia to gather comfort data from ambulances. Gathering data requires both an acquisition device to be attached to the ambulance and a human operator that fills in the required surveys about the comfort; the latter, however, is not a problem since there’s always one non driving staff member on the ambulance that can fill the required data.

This cooperation required the development of an Android app that logs the data and sends it to our server. User interface considerations was particularly important during the design phase: the app has to be simple to use (operator must not need training), effective and efficient (must require as few efforts as possible) and must not provoke motion sickness to the user in order to not alter the comfort data.

After the drive has ended, the app uploads the data automatically when the phone connects to internet via WiFi. The operator can choose to manually upload data using 3G/4G mobile connections, in case he..
has not access to WiFi connections, but he is prompted with a message that previews the upload size in order to prevent over consumption of personal data plan.

**Bachelor candidates’ thesis**

During the first year of my PhD I supervised the following students in their bachelor thesis developed on Android platform:

- Di Gioacchino Alberto: “CoachAgenda: sviluppo, testing e documentazione di un'applicazione Android”
  where Alberto worked on a part of CoachAgenda’s Android version, and wrote documentations and a test suite for both client and server APIs;
- Bardini Alessandro: “Interfaccia utente per il tracciamento di statistiche sportive in ambiente Android”
  where Alessandro worked on a ported and improved version of a MYagonism basketball app for iOS platform;
- Andronio Francesco: “Progettazione e sviluppo di una applicazione Android per lo studio della fruibilità di edifici: A4A fill & go”
  where Francesco worked on an app to evaluate buildings accessibility.
Education activities

“Teoria dei giochi” presso il Collegio Borromeo (5.83 CFU)
“Python programming for machine learning” (2 CFU)
“Imparare a progettare in Europa” (2 CFU)
“Linguaggi, problemi e metodi della comunicazione scientifica” (2 CFU)

I decided to follow “Linguaggi, problemi e metodi della comunicazione scientifica” instead of “Soft computing techniques and applications” because I thought it would have been more useful for writing papers. I also decided to follow “Teoria dei giochi” instead of “Game theoretical models in engineering” because it was held in Pavia instead of Milan.

Although not rewarded with CFU, I also attended the extreme programming course “ScuolaXP”, held at 7Pixel, from March 9th to March 13th 9:00-18:00.

Attendance to seminars, congresses and schools

Seminars and presentations held

Stay abroad

List of publications
Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.a. 2014/2015

Edwin Javier Sánchez Uriza

XXX Cycle

Tutor:  Prof. Norma Anglani
Scientific activity

Overview

The first year of my research started in February 2015 and it was framed around the design of the most suitable hybrid micro-grid to supply the electrical power needs of the Juan de Castellanos University Child Care Hospital (JDCH), in the rural area of the city of Tunja (Colombia).

The first stage of this research was to estimate the future electrical load for the hospital, in order to design a micro-grid based on renewable energy sources which could support part of the demand of energy needs. The load planning is very important due to the fact that hospitals are high power energy consumers.

A lot of energy challenges remains in the world and mankind nowadays still depends greatly fossil fuels, decreasing the environmental resources. I have found that this is more critical in developing countries (like Colombia) because the use of coal and fuelwood is needed in rural areas due to the impossibility or nonexistence of an electrical grid connection, rapid demand growth and low penetration of alternative and renewable energy sources implies a major difficulties to develop social and industrial projects in these areas.

In Colombia, there are some barriers that do not allow to improve the energy production like appropriate policies that encourage the noncommercial energy production and the most significant is the lack of knowledge about the potential of the renewable energy sources in the local region in an economic and environmental way.

The papers' review: during this process the great diversity of strategies and methods to determine the energy consumption have been collected, it must be mentioned that the vast majority of information was related to existing hospitals and sometimes it was quite old.

The consulted literature was classified in three groups: related to 1) the development of models 2) proposed methodologies and 3) development of simulation programs.

The studies related to (1) reports the energy consumption in 10 hospitals where various parameters such as volume and/or area of the building, the year that it was built and others. An interesting result of these review was that to determine the electric charge, thermal and HVAC systems, different simulation programs were used. Most of models correctly reproduce the behavior of energy consumption in
existing or constructed buildings but those have poor prediction in cases, such as new hospitals. Other models showed that climate issues are extremely important in the forecasting of energy consumption in hospitals. This drastically affect the calculation of the loads such as air conditioning systems. Different aspects are also taken into account in the design of models such as building orientation, the regime of operation and size of doors and windows and others.

The methodologies related to (2): this method of calculating the energy consumption in hospitals is mainly focused on implementing energy efficiency strategies and costs reduction. Interesting is the reference to indexes to audit the energy consumption of the building and to obtain high-quality/green certifications.

The use of simulation programs (3) to define the energy consumption is largely based on models of buildings of the tertiary sector and are supported by the most significant parameters that affect the energy load. DOE-2, EnergyPlus and Matlab are widely used. These tools are the most viable option when a project is in its initial stage and when there is limited availability of data for the calculation of energy demand.

After the literature review, I proceeded to design a model of energy forecast for the hospital and I initially take into account the real basic information such as the geographic location, seasons during the year and the construction characteristics of the building. But before of that I needed to clearly understand which patterns involved a hospital building which has a wide variety of uses and energy services.

The activities carried out during the first year have been instrumental to understand how to conceive and complete the database with all the useful information for a correct plant design to the service of the electric micro-grid.

The highlights of this year research are described in the following sections.

I. HEALTH CARE FACILITIES
Hospital facilities have their own particular characteristics in relation to other facilities of the tertiary sector, whose final purpose is the preservation of human life. During the investigation it was found that the levels of electrical and thermal load are quite high for the size of the spaces, the diversity of rooms and additional factors such as the widespread use of HVAC (Heating, Ventilation and Air-Conditioning).

It was observed that it is essential to accurately estimate the energy demand because
it is necessary to supply the needs required by patients and other people who inhabit
the hospitals. The literature studied shows that in the last years different control
strategies have been implemented to control and reduce energy demand. On the other
hand it was evident the high impact (from energy, economic and environmental
standpoint) that the HVAC systems have worldwide hospitals covering about 30% to
50% of the energy demand. These outcomes must be taken into account in the final
design.
Information regarding models to design and calculate the necessary infrastructure to
supply the energy required by a new hospital is very hard to find and to scientifically
analyze, because most of documents refers to strategies to reduce energy
consumption in already existing hospital buildings. These studies are mainly based
on development models and simulations using a variety of control strategies.

II. ELECTRICAL DEMAND JDCH PROFILE
It has been possible to define the profile of consumption (load) representative in
different hospitals worldwide through indexes such as energy consumption per
square meter (kWh/m²), number of beds among others. An important result of this
work was to determine the high influence of the geographical and technological
context of hospitals. Part of the results of the investigation show that hospital
buildings geographically located in tropical areas of the world have a high level of
energy consumption due to the climate and moisture compared with tropical northern
countries like Italy.
The cumulative effect of groups of individual loads is one of the determinants of
distribution system design. Facility loads can be understood in a number of ways.
First, the loads can be seen as calculated loads or as measured loads. They can be
understood as load density (i.e. W/ft²) or in terms of circuits required. They can be
viewed in terms of the one-time peak or in terms of the profile of the loads from hour
to hour, from day to day, and from month to month. Each perspective has a different
dynamic, and each perspective is important for a different reason.
Analyzing or predicting or attempting to understand load profiles for medical centers
should understand the occupancies within the medical center, their hours of
operation, and their probable electrical load profiles. Every Hospital building in the
world may house many different occupancies over its lifetime. The nature of a
modern health care facility is that it should respond to changes in ownership, in
reimbursement policies, and in changes to its patient population.
It was found that different weather aspects significantly influence the forecast of
energy consumption in buildings of the tertiary sector, especially hospitals. On the other hand to use a typical day of a month rather than annual climate data causes erroneous energy estimation or underestimation or overestimation of the energy consumption of the hospital. It was concluded that some external environmental conditions should be taken into account for designing the hybrid micro grid.

III. DATA BASE BUILT UP

After the information about the indexes in hospital the next step was the building up of a data base to inventory the electric power used by the health care sector in some countries and to define the most appropriated performance indicators of electricity energy use, in relation to a specific area or hospital size and so on. The thermal power is not studied in this part of the research.

The data base has been built to show all the different kind of contexts from the hospitals group studied and it is a suitable way to express the relationship between Electrical load and JDCH. Comparing electrical energy load among health care buildings is not a simple task because there are several factors and activities in the making difficult to get an accurate electrical load values only by comparing some indexes (i.e. indexes referring to specific area). The data collection have been organized in ten groups of loads to understand and to predict the electrical load. The main aim of this is to size the energy of the hospital and consequently support the design and implementation of renewables energies integrated to the cogeneration system. Perhaps the most difficult part of making this database was the selection of appropriate indexes to identify the energy levels and their variation in different periods. Thus, to compare the electrical load of different hospitals as Italy and Colombia, the same energy indexes were used despite meteorological, architectonics and economic differences because the pattern that determines the electrical demand in a building of the tertiary sector is very similar.

The load indexes obtained have been statistically processed in order to identify typical load patterns that can be used as benchmark daily/week/month load diagrams for the hospital and also analysis with weather dependent variables such as daily temperature and degree day values has been evaluated.

Indexes were categorized in ten main aspects with respect to size of building, Electrical consumption and degree day. All these provide a useful pillar but there are substantial number of potential indicators to be included or maybe some important factors could be missed out.
**Education activities**

- Automazione e comunicazione nei sistemi industriali (6 credits acknowledged)
- Gestione dei sistemi fotovoltaici (3 credits acknowledged)

**Attendance to seminars, congresses and schools**

9 seminars (1.8 credits acknowledged)
- *The hidden topology of a noisy point cloud part I and II* held by Prof. Andrea Pedrini on March 20 2015 in the University of Pavia.
- *The data transmission network of the University of Pavia: structure and management* held by Claudia venturini and Mariagrazia Tambani on March 25 2015 in the University of Pavia.
- *The hidden topology of a noisy point cloud part III* held by Prof. Andrea Pedrini on March 27 2015 in the University of Pavia.
- *Metrology with/for MEMS/NEMS devices* held by Prof. Teodor Gotszalk on April 20 2015 in the University of Pavia.
- *Cryogenic Low Noise Amplifier for Satellite Communication and Radio Astronomy Application* held by Thomas Bonhoure on May 6 2015 in the University of Pavia.
- *Design of Electrical Machines and Computational Tools for Virtual Prototyping* held by Luca Gregorio Frigoli on May 14 2015 in the University of Pavia.
- *Il mercato elettrico italiano: stato dell’arte e prospettive* held by Virginia Canazza on June 8 2015 in the University of Pavia.
- *Coherent Systems And Wavelength Switching Technologies In Next Generation: Photonic Backbones* held by Marco Schiano on June 9 2015 in the University of Pavia.
- *UAV- based Remote Sensing* held by Paolo Marras on June 9 2015 in the University of Pavia.

3 courses:
- “*Cloud computing*” held by Prof. Dana Petcu on 28 and 29 april 2015 in the University of Pavia. (2.5 credits acknowledged)
• “Linguaggi, problemi e metodi della comunicazione della ricerca scientifica” held by Marco Cagnotti on May 4, 5, 11 and 13 2015 in Collegio Nuovo – Fondazione Sandra e Enea Mattei (2 credits acknowledged)
• “IEEE STAR-CAS: selected topics on advanced research on circuit systems” on June 3, 4 and 5 2015(3.6 credits acknowledged)

1 Workshop: PLECS, advanced modeling and simulation of power electronic systems at Politecnico di Milano on April 17 2015. (1 credit acknowledged)

1 PhD School: 16th edition of the european PhD school, 2015, organized by the University of Cassino, in Gaeta, Italy on May 25-29. (5.6 credits acknowledged)

1 International congress (without acknowledgement of credits): II Scientific technological and innovation parks International Congress. The Scientific and technological parks for the regional development through research, innovation and entrepreneurship. 19 – 21 August 2015, Tunja, Colombia.

2 Seminars (without acknowledgement of credits)
• Standard IEC ed Europei di prodotto per gli Azionamenti Elettrici a velocità Variabile [PDS] held by Marco Franchi on March 23 2015 in the University of Pavia.
• Automotive Research and Innovation in E/E Architectures held by Stefano Spizzi on June 8 2015 in the University of Pavia.

Seminars and presentations to be held

“Energy consumptions in hospitals: a review functional to the sustainable design of a new child care hospital in Colombia” in the International Seminar in application of new technologies for the sustainable development of the region. At Juan de Castellanos University. Date: October 21 and 22, 2015 in Tunja, Colombia.

Stay abroad

I started my PhD in Pavia as of February, 1st 2015.
As of July 2015 I have been at the Juan de Castellanos University (Tunja, Colombia) as part of a research period abroad and in order to retrieve all the useful information right on
the field. In this period I have been defining the electrical load design, through a checklist of all the design stages that have to be considered including access to the site, renewable energy potential in the region and studying the situation of the existing rural electrical grid structure in Tunja. Cooperative work has been carried out with different professionals involved in the hospital building like architects, civil and environmental engineers and technicians.
DOTTORATO DI RICERCA IN INGEGNERIA ELETTRONICA, INFORMATICA ED ELETTRICA

RELAZIONE CONSUNTIVA DELLE ATTIVITÀ SVOLTE NELL’ANNO ACCADEMICO 2014/2015

Mo’min I.M. Tabash

XXX CICLO

Tutor: Prof. Maria Carla Calzarossa
Research activities

The scientific activity carried out during the academic year 2014/2015 can be summarized in two main areas: the first one deals with a detailed analysis of the literature on cloud computing and simulation technologies, the second one focuses on the study of the behavioral characteristics of the workloads in the clouds. Cloud technologies provide on demand services and are characterized by elasticity and flexibility in resources provisioning. Cloud applications can be found in many business and scientific domains, such as e-commerce, e-government, engineering design and analysis, finance, healthcare, web hosting and online social networks. Service providers must ensure a certain service level that satisfies the user requirements. Thus, to cope with the characteristics of cloud workloads, effective scheduling policies need to be considered to enhance the resources provisioning and improve performance and utilization of cloud resources.

Cloud computing

During the first months, my work focused on a literature review of cloud computing. Cloud computing enables users to access distributed, scalable, virtualized hardware and software resources over the Internet. Since virtualization is an essential requirement to build cloud infrastructures, resources are dynamically shared, among requests and diversified clients. Therefore, resource management mechanisms are required to allocate tasks to processing units. Task scheduling is one of the most important components of resource management. Because of the diversity and the complexity of the cloud infrastructures and workloads, there is the need to devise effective scheduling policies. Thus, simulations are necessary for testing the new implemented policies and to check their performance and behavior. For this purpose, I studied the CloudSim toolkit, a popular open-source simulation framework that enables modeling, simulation and experimentation of cloud infrastructures and application services. It allows the investigation of specific design issues by modeling the cloud components, such as data centers and virtual machines (VMs), and resources provisioning policies. CloudSim is implemented in Java. It contains classes which are the building blocks of the simulator and represent the cloud components. The architecture is composed of two main parts. The first part is the simulated environment of the cloud, while the second part is an extension that includes additional simulation features, such as the MapReduce programming model. Examples of basic classes are the Datacenter, VM and Host. Workload modeling is essential in a cloud simulation tool. The design and development of a workload generator to be integrated in the CloudSim
toolkit were part of the research activities of this year. The generated outcomes are a set of jobs/tasks that represent the input to the scheduling policies. The workload generator allows varying workload intensity, the mix of operations and the data access patterns and frequency.

**Workloads in the clouds**

A parallel activity carried out during this first year focused on the analysis of the workloads in the clouds. Cloud workloads consist of a collection of many diverse applications and services, each characterized by its own performance and resource requirements and constraints specified in the form of Service Level Agreements (SLAs). The issues related to the entire lifecycle of the workloads in the clouds, refer to their characterization at the design time (i.e., workload categories, structures and patterns), their matching at the deployment phase (i.e., resource requirements and scheduling) and the conditions in the execution phase (i.e., failure analysis and prediction). This study has shown that a large variety of factors affects cloud performance, including, among the others, the variability in the resource and network conditions and the highly dynamic nature of these workloads, whose intensity can suddenly grow or shrink as a consequence of the user interactions. More specifically, the use of virtualized time-shared resources could lead to performance degradation. This degradation is due to interference and resource contention arising from the co-location of heterogeneous workloads on the same physical infrastructure and overheads caused by the resource management policies being adopted. Non-functional requirements related to SLA constraints (e.g., performance, dependability, security) has been studied. More specifically, the presence of failures decreases the reliability of the cloud infrastructure and increases the utilization of the computational resources. Therefore, I studied the various failures types to identify their causes and the approaches to failure analysis to investigate the behavior of failures. This study shows that in general the workload failure rates significantly increase and depend on the priority associated with the individual tasks, thus reflecting the diversity in the workloads characteristics. Moreover, to cope with failures, machine learning techniques have been studied for prediction.
Attended courses:

- "Applied statistics" - Università di Pavia (Instructor: Professor Paola Cerchietti)
- "Cloud Computing" - Università di Pavia (Instructor: Professor Dana Petcu, University of Timisoara, Romania)
- "Presentation making" - Università di Pavia, Scuola di Alta Formazione Dottorale (Dr. Alessandro Bacchetta)
- "I fondamenti della comunicazione" - Università di Pavia, Scuola di Alta Formazione Dottorale (Dr. Marco Cagnotti)
- "Scrittura (Dottorati di area tecnico-scientifica)" - Università di Pavia, Scuola di Alta Formazione Dottorale (Dr. Marco Cagnotti)

Attended seminars:

- "Information Hiding and Medical Application" Dr. Hedieh Sajedi, University of Tehran, Iran, 08/04/2015
- "The data transmission network of the university of Pavia: Structure and Management" Dr. Claudia Venturini - Dr. Mariagrazia Tambani, University of Pavia, 25/03/2015.
- "The Hidden Topology of a Noisy Point Cloud (Part I & II)" Dr. Andrea Pedrini, Università degli Studi di Milano, 20/02/2015
- "Protecting Web Servers from Web Robot Traffic" Professor Derek Doran, Wright State University, USA, 14/11/2014

Publication

Book chapter
Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.a. 2014/2015

Alessandro Tramonte
XXX Cycle

Tutor: Tullio Facchinetti
Scientific activity (2-3 pagine max)

1. Topic 1

My first research activity has been focused on the development of an embedded device capable of detecting the comfort level of the passengers in a vehicle. Since in my thesis “Sistema per la determinazione del comfort dei passeggeri di un autoveicolo” I had already presented an algorithm to perform this task, the main problem was to develop an implementation of this algorithm capable of operate in a constrained environment. Therefore, a light version of each component has been developed in C language by following the guidelines:

- minimal data history;
- free RAM as soon as possible;
- minimal use of floating point numbers;
- minimal use of the division operator.

2. Topic 2

My second research activity has been focused on the enhancement of the embedded device described by Topic 1. This device represents a lightweight implementation of the algorithm presented in my thesis. The implementation had some limitations:

- it works only under some initial conditions;
- it require 2sec to estimate every event score;
- it is based on a small data collection;
- it does not consider the Z axis in the evaluation of the comfort.

My activity was dedicated to overcome some of the above limitations. In particular, the main problem was to understand which one of the limitations were addressable and how. The outcome of my research has led to the following enhancements:

- the time to estimate an event score is now a hundred times lower;
- there are no more initial conditions to impose on the system functioning.

The submission of a paper related to the above topic to IEEE Transactions on Instrumentation and Measurement is under evaluation.

3. Topic 3

My third research activity has been focused on the development of an iOS application to assist sport coaches in their training tasks. This research established a collaboration with the company MYagonism® srl. First, it has been necessary to understand the critical issues related to the training process. Next, we have designed and implemented an App to speed-up and optimize the collection and the analysis of training data.

The results obtained from this research will be submitted for publication to one of this journals: Sport Management Review, Journal of Science and Medicine in Sport, Journal of Sport and Health Science or Science & Sports.
4. Topic 4

This activity has been focused on writing some parts of the book “Esercizi di programmazione in linguaggio C”. This book has been written together with Prof. Tullio Facchinetti, Prof. Cristiana Larizza, Prof. Claudio Cusano, Dott. Daniele De Martini and Dott. Eleonora Losiouk. It is a workbook for the course “Fondamenti di Informatica”. In particular my job was to identify and implement the most important code snippets presented in the course.

5. Topic 5

This research activity has been focused on a further enhancement of the embedded device. As previously stated, one of the problem of this device is to be based on a limited data collection. To overcome this problem we started a collaboration with the “Croce verde pavese P. A. ONLUS”. Thanks to this cooperation we are now authorized to equip some ambulances with the embedded device. The Android smartphone, developed by Gianluca Roveda, allows the continuously collection of the opinions of a dedicated operator. The embedded device, developed by me, is a simple box made by an embedded board and suitable sensors. This device takes care of the continuously collection of sensory data. Thanks to such devices, we expect to obtain an acceptable number of data in less than two month to suitably calibrate the measuring device.
Education activities

“Teoria dei giochi” presso il Collegio Borromeo (5.83 CFU)
“Imparare a progettare in Europa” (2 CFU)
“Linguaggi, problemi e metodi della comunicazione scientifica” (2 CFU)

Attendance to seminars, congresses and schools

Seminars and presentations held

Stay abroad

List of publications
Ph.D. in Electronics, Computer Science and Electrical Engineering

Activities report a.a. 2014/2015

Haochen Wang

XXX Cycle

Tutor: Prof. Virginio Cantoni
Scientific activity (2-3 pagine max)

Tema 1: Biometrics based on Eye Tracking

In my first year of Ph.D. I have carried out research on biometrics based on Eye Tracking technology. Hereby I need to explain that, because of visa issues, I arrived in Pavia on the second half of January 2015. So my scientific activities were started at the end of January 2015.

Biometrics is the science of establishing the identity of a person based on physical or behavioral attributes such as fingerprint, face, iris, and voice. It can be viewed as a pattern recognition problem, where the machine learns the salient features (patterns) in the biometric attributes of an individual and robustly matches such patterns efficiently and effectively. The most typical applications of biometrics are recognition and authentication. Recognition is to find whether the person belongs to a specific group, and authentication is to judge whether the person is the individual who he or she claimed to be.

Eye tracking technology is the process of measuring either the point of gaze or the motion of eyes relative to the head. The device for measuring eye positions and movements is the **eye tracker**. Eye trackers are used in research on vision, in psychology, marketing, or used as input devices for human computer interaction. The most widely used current devices are video-based eye trackers, in which a camera focuses on the eyes of the user and records eye movements as the user looks at some stimuli. Due to the increasing availability of cheap eye trackers, eye-based biometrics has received growing attention in the last few years. The eye features and behaviors are more and more regarded as potentially safer authentication methods.

The eye tracker which I selected to support my research is the “Eye Tribe” eye tracker. The “Eye Tribe” eye tracker has the following positive features. Firstly, it occupies a small volume: it is probably smallest eye tracker device in the world, measuring 20×1.9×1.9 cm. Secondly, it does not require a separate power source, which makes it portable. The device uses a USB 3.0 connection, allowing it to run with most computers. Besides, developers can use simple software development kits based on C++, C# and Java programming platforms to develop applications for the device. In the end, the cost of an Eye Tribe eye tracker is low (99 USD). Here are the major parameters of the “Eye Tribe” eye tracker.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling rate</td>
<td>30 Hz and 60 Hz mode</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.5°(average)</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>0.1°(RMS)</td>
</tr>
<tr>
<td>Latency</td>
<td>&lt;20 ms at 60 Hz</td>
</tr>
<tr>
<td>Calibration</td>
<td>5, 9, 12 points</td>
</tr>
<tr>
<td>Operating range</td>
<td>45 cm – 75 cm</td>
</tr>
<tr>
<td>Tracking area</td>
<td>40 cm × 30 cm at 65 cm distance</td>
</tr>
<tr>
<td>Screen sizes</td>
<td>Up to 24 inches</td>
</tr>
<tr>
<td>API/ SDK</td>
<td>C++, C# and Java included</td>
</tr>
<tr>
<td>Data output</td>
<td>Binocular gaze data</td>
</tr>
<tr>
<td>Dimensions</td>
<td>(W/H/D)20 × 1.9 × 1.9 cm</td>
</tr>
<tr>
<td>Weight</td>
<td>70g</td>
</tr>
<tr>
<td>Connection</td>
<td>USB 3.0 Superspeed</td>
</tr>
</tbody>
</table>
Tema 2: Description of current works and plans for the next step

In my first year of Ph.D., I have been getting preparations of my research on biometrics and eye tracking. Besides, I did some teaching assistance works for my tutor, Prof. Virginio Cantoni. As already explained, these works were started at the end of January 2015. Here are the specific works that I carried out:

- Study of literature on biometrics and eye tracking technology.
- Study of Machine Learning approaches.
- Read papers by my tutor and my colleagues of my laboratory, getting awareness of the current progress of the research of my topic.
- Study of C# and the “Eye Tribe” eye tracker SDK.
- Performing some practical trials on the “Eye Tribe” eye tracker.
- Teaching assistance work for the course “Computer Vision”.
- Contribution to a paper which was published in a conference.

According to the works carried out to date, the plans for my next research activities are:

- Study of eye tracking based biometrics through experiments.
- Define the structure of tests.
- Experiments will be carried out with different image subjects (faces, landscapes, ambiguous figures, known and unknown environments, etc.).
- Through the experiments, find whether there are subjects that are more suitable for eye tracking based biometrics.
- Select the suitable data analysis approaches.

To better support my research, I am going to take the following courses:

- Computer Vision by Prof. Virginio Cantoni.
- Multimedia Systems and Technologies by Prof. Marco Porta.
- Human-Computer Interaction by Prof. Mauro Mosconi.
**Education activities**

Italian language course (level A1, Centro Linguistico Università di Pavia).

**Attendance to seminars, congresses and schools**

-  

**Seminars and presentations held**

-  

**Stay abroad**

**List of publications**