ISSUE - 3 | Spring 2018

LUCA

LASER AND ULTRASOUND CO-ANALYZER FOR THYROID NODULES

NEWSLETTER

This Issue's CONTENT

An Update on LUCA

The project carries out the successful completion of the first phase.

The LUCA project received positive feedback from the European Commission on the achievements during its first 18-month reporting period. A Review Meeting took place in Brussels on September 27, 2017, where the LUCA Project Officer and two independent reviewers evaluated the project and found that LUCA shows excellent progress and has fully achieved its objectives and milestones for the first period.

During this period, LUCA partners developed novel components for both DCS and TRS modalities that now offer drastic reduction in production costs, charted out and tested inter-operability and compatibility of DCS, TRS and US. In addition, work focused on performing extensive laboratory tests, the preparation of the clinical protocols, and the dissemination and communication of the project aims and progress while keeping in mind the ultimate goal of clinical and market translation. LUCA has now entered its crucial second phase in which the multi-modal demonstrator will be built and tested in a laboratory setting while activities concerning future commercial exploitation will be strengthened.

By the end of the second period in January 2019, the optical and ultrasound subsystems, the multi-modal probe and the corresponding software will be integrated into the fully functional LUCA demonstrator, which will be utilised in the validation of the device in real settings.

4th LUCA Consortium Meeting

Birmingham, UK - November 30-December 1, 2017

The 4th Consortium Meeting of the LUCA project took place from November 30th to December 1st in Birmingham, UK. **T. Durduran** gave the introduction talk and explained the overall progress of the project. He emphasised that the first version of the device would be ready by the summer of 2018. Subsequently, all Work Package leaders gave an overview of their current development within the project.

For the development of components and sub-systems package, **L. Cortese** presented the next deliverables due in the following months and for the end of the year, in particular those involving the upgrade of the software, hardware components and the DCS components and subsystems. Subsequently, **M. Renna**, together with **D. Contini** and **A. Tosi** gave a presentation on the TRS components and subsystems, while **S. de Fraguier** provided an update of the communication protocol and summarised the next steps for completing the communication protocol, with a fully functional software processing real data ready by June 2018.

On the other hand, **B. Rosinski** provided an overview of the Optical-Ultrasound multi-modal probe. Regarding the LUCA software server, **S. Wojtkiewicz** reported that all objectives have been accomplished in due time. As for the development of the demonstrator, **U. Weigel** reported on the advancement of the DCS and TRS modules and **A. Dalla Mora** provided an update on ex vivo phantom validation and standardisation. With respect to the validation in real-settings and the writing of a clinical protocol, **M. Mora** explained that the protocol was based on versions already submitted to the ethical committee and presented the protocols for a control group (10 patients) and a case group (35 patients, 15 benign, 10 malignant, 10 multinodular goiter).

As for the project management, **K. Krischak** summarized all internal deadlines for the upcoming deliverables and **P. Zolda** presented all dissemination activities from the last meeting, highlighting that LUCA was chosen to participate in the "Common Dissemination Booster" programme of the European Commission to boost dissemination capabilities and outreach.

Finally, regarding the exploitation phase of the project, **E. Garcia** gave an overview of the preliminary product/service profile and reviewed the potential markets and exploitation avenues for the LUCA device.■

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688303.
www.luca-project.eu www.photonics21.org

Interview with Antonio Suárez

THYROID CANCER PATIENT

What clinical analysis did the doctors use to determine you had a tumour in the thyroid?

The doctors did not carry out any analysis. Instead, they performed a palpation and found a lump in my neck.

What kind of tests did you go through in order to have this kind of tumour diagnosed correctly?

I had a sonography with a tap and a posterior study of the biopsied tissue. The cytology's result indentified psanoma bodies and the suspicion of the presence of neoplasia follicular, which was enough to consider surgery.

How was the surgery and the post-operation?

They were two operations. The first one was a thyroidectomy, since the nodule was small (15x8 mm) and located in the isthmus. This meant the probability of saving a great part of the gland. Once removed and biopsied, the result gave a pathologic anatomy of papillar carcinoma, which meant a complete removal of the entire thyroid gland.

The second surgery was conducted a month and a half after the first one. In both cases, the post-operation period was normal, considering that at the beginning, the analgesics that they gave me helped make the pain bearable. The worst moments could be graded with a 6 out of 10.

I passed the first night in the Intensive Care Unit for any possible complications that could happen. During my stay at the hospital (three days) I carried a drainage with two tubes emerging from the neck through two lateral openings, which ended up being pretty uncomfortable. What amazed me the most and caught me off guard, was the aphonia I acquired. I could talk, but my voice suffered considerably everytime I had to talk for long periods of time.

How was the recovery process?

My recovery at home was pretty comfortable and not very painful. The aphonia heals slowly but even now sometimes it reappears. The healing is good but it requires a lot of care. I had nuisances, which continue until today: sometimes I have problems swallowing, or weird sensations in the neck or low sensitivity in the operated zone.

What kind of medication are you taking? Do you know what the effect would be in the case of not taking any medication?

The basic medication is Eurtirox. The doctors have been playing with the dosis to find the right amount that I should take. This still has not been adjusted properly. The dose is daily, and it is a lifelong medication.

The doctors mentioned the possibility of taking thyroxine since they said my body would suffer otherwise. I have also been taking calcium (unprescribed two months ago), vitamin D and phosphate. Since the operation, I have had three blood tests, which have helped the doctors adjust my medication. Sometimes I have weird sensations in the body, like tingling or very subtle muscular vibrations in any part of the body, although they keep diminishing.

After the surgery, has your everyday life changed? Have your habits changed? Food, sleep?

I have not noticed major changes. I still have a tired sensation in the throat when I do need to talk for long periods of time. I do not have mood swings as I was told, but it is true that sometimes, at the beginning, I felt more euphoric or the opposite, but they were isolated moments and of short periods of time. I cannot complain because I sleep well, like always. In terms of food habits, the doctor told me I could loose weight, but it has been quite the opposite, although I control it with exercise and a more controlled diet, without being too strict. The habit that has changed the most involves having to wake up 15 minutes early to take the pill. In a few months, I have a test to rule out if there are traces of thyroid cells in my system. I am very optimistic. ■

European Congress of Radiology 2018

This year, the European Congress of Radiology 2018 (ECR) took place from February 27 - March 3 in Vienna, Austria. ECR is an international meeting and one of the leading events in radiology. It is one of the largest medical meetings in Europe and the second-largest radiological meeting in the world.

As part of the program, U. Weigel, partner from HemoPhotonics, presented the latest results of the LUCA project in the EIBIR Research Session "European imaging researchers united in diversity".

The complete presentation is now available online on the ECR website. (link)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688303.
www.luca-project.eu www.photonics21.org

Dr. Davide Contini
ELECTRONIC ENGINEERING

Did you ever expect to be working in the biomedical field? What expertise you are bringing into the initiative?

I started to work in the Biomedical Optics field fifteen years ago during my MSc. thesis in Electronic Engineering. I was so fascinated by the field that I decided to focus my PhD in Physics towards this topic. My main expertise is in time-resolved near-infrared spectroscopy (TR-NIRS) and in the development of optoelectronic systems to perform in vivo tissue characterization. As project manager of the PoliMi unit, my main goal is to follow the development of the TR-NIRS system from the single component up to its final application in the clinic.

How did you become involved in this project?

I met Turgut (PI of the LUCA project) the first time in 2005 and when he moved to the United States, all of the biomedical optics group of PoliMi started a close collaboration with him. When Turgut came to me with the idea of the LUCA project, I found it extremely interesting and considered it a wonderful opportunity to exploit the technology for TR-NIRS developed by my group together with my colleague Alberto Tosi and his group.

You have developed non-invasive measurement systems. For this project, are the techniques used completely different from the ones you had implemented before? What are the pros of this new approach?

The physical background is the same. The use of a time-resolved technique improves accuracy in tissue characterization and depth resolution. The difference between LUCA and the previous systems I have developed resides in the technology that is being employed. In fact, all the key components employed were tailor made at PoliMi to reduce dimensions, costs, complexity and improve reliability and robustness without sacrificing performance.

Have you had any relative suffer this illness? What you do think is the most innovative aspect of this technique that will help patients overcome the illness?

In fact, two close relatives of mine have thyroid problems, so I've been in touch, first hand, with these health issues that we would like to solve with the LUCA project.

The benefits of this new technique would include:

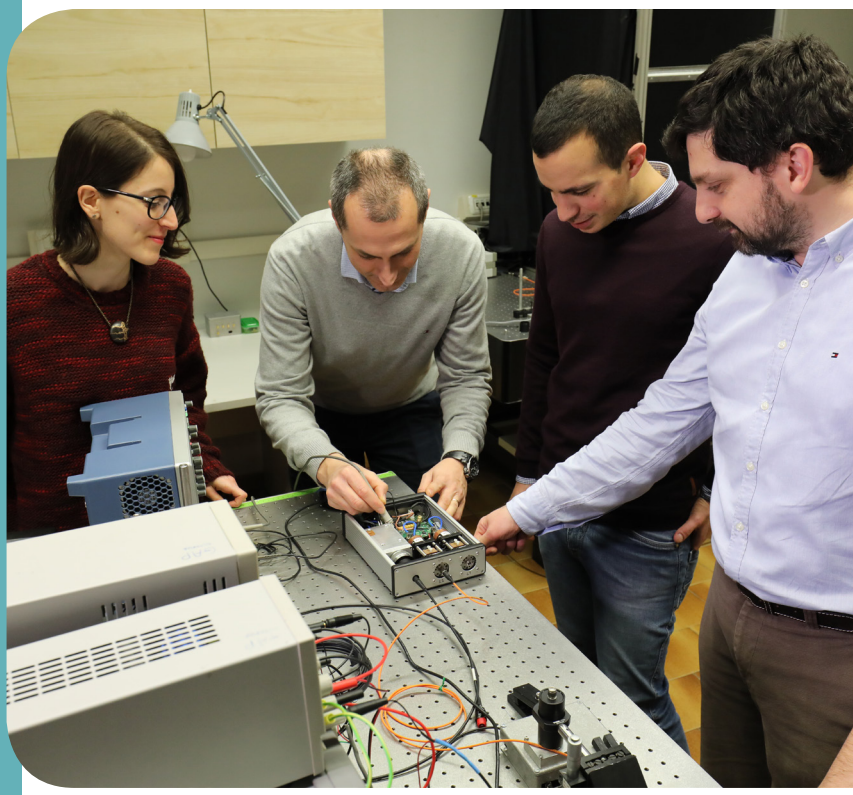
i) the possibility to better characterize tissue (structure, metabolism, composition etc.) improving accuracy and sensitivity of diagnosis;

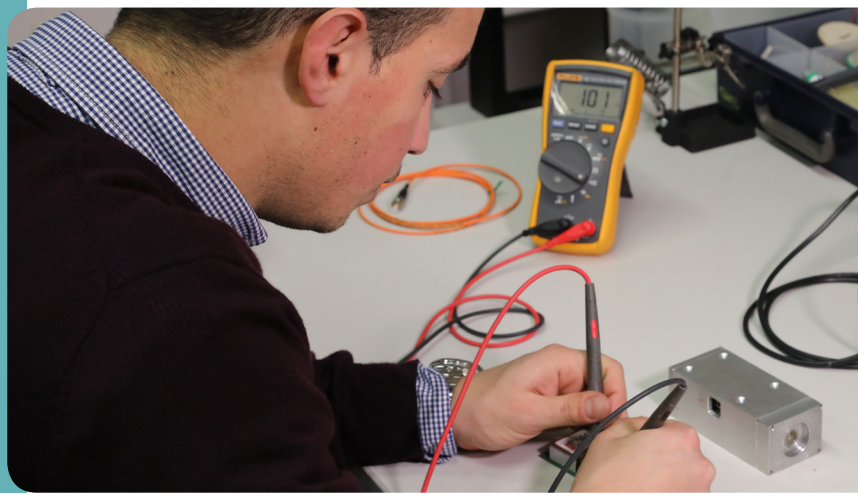
ii) the complete non-invasiveness, which can reduce the discomfort of the patient during the examination.

What makes this project different from others?

I believe that Optics and Optoelectronics can really make a difference in the biomedical world. Physics teaches us that it is possible to investigate inside our bodies by using light and today's technology has reached so far that it can transform these theories into real clinical instruments. I'm certain that LUCA's consortium has all the necessary expertise to reach this goal. ■

Davide Contini received the master's degree in electronics engineering and the Ph.D. degree in Physics from Politecnico di Milano, Milan, Italy, in 2003 and 2007, respectively. He was an Assistant Professor from 2008 to 2014. He has been an Associate Professor of Physics with Politecnico di Milano since 2014. His research activity is focused on the study of the interaction of laser light with matter. In this framework, his main topic of interest is time-resolved spectroscopy of highly diffusive media for applications in biology and medicine.





This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688303.
www.luca-project.eu www.photonics21.org

Dr. Alberto Tosi
ELECTRONIC ENGINEERING

How did you become involved in the project?

I have been collaborating with the group of Davide Contini (PoliMi, Dept. Physics) for over 10 years now and throughout these years, I've had the chance to collaborate with Turgut Durduran (ICFO) on smaller projects. When Turgut explained the LUCA project to our group, I thought that it was (and it is!) a great opportunity for developing a new biomedical instrument that could improve the quality of life of many people.

Why did you decide to focus your research in biomedicine / secure communications?

Optical techniques will play a major role in biomedical detection applications in the future. In particular, I believe that single-photon detectors and related electronics can give a strong contribution thanks to their extreme sensitivity and great scalability (SPAD detectors can be miniaturized). Besides biomedicine, secure communications and automotive safety are two fields in which single-photon detectors will also be a key ingredient technology in the future.

What challenges have you had to overcome so far in the development of the device?

In the LUCA project, our group designed and developed novel small sized picosecond pulsed lasers with high performance and at a low cost. The challenge was not in achieving the best performance, but in making high-level laser systems small enough and inexpensive, a solution that is not available on the market today.

You develop single-photon counting devices, based on silicon and other material technologies. What are the advantages and disadvantages of using these materials?

Silicon is the best semiconductor for detecting photons up to 1 µm, while InGaAs is the most suitable one for the 1 - 1.7 µm wavelength range. Recently, I started to explore new materials: germanium can be used up to 1.6 µm and can be integrated with silicon for developing complex smart systems, that is using germanium for the photon detection and silicon for the processing.

Have you ever met patients that have suffered this illness?

My mother-in-law had suspicious nodules in her thyroid and she underwent a surgical operation to remove the entire thyroid. Histological examinations proved that the nodules were benign. This is the typical clinical example that we try to solve by introducing the new LUCA instrument, which will give more specificity. ■

Alberto Tosi received the master's degree in electronics engineering and the Ph.D. degree in information technology engineering from Politecnico di Milano, Milan, Italy, in 2001 and 2005, respectively. He was an Assistant Professor from 2006 to 2014. He has been an Associate Professor of Electronics with Politecnico di Milano since 2014. In 2004, he was a Student with the IBM T. J. Watson Research Center, Yorktown Heights, NY, working on optical testing of CMOS circuits. He currently works on silicon and InGaAs/InP single-photon avalanche diodes (SPADs). His research activity includes arrays of silicon SPADs for 2-D and 3-D applications and time-correlated single-photon counting electronics.

Dr. Marco Renna
ELECTRONIC ENGINEERING

You are pursuing your PhD degree. How did you enter this project?

During my master's program, I started working with Prof. Alberto Tosi's research group in the development of fast laser diode pulsers and ancillary electronics for an instrument based on non-invasive spectroscopy for biological tissues. Upon receiving my degree, Prof. Tosi offered me the opportunity to join the LUCA project due to my thorough knowledge on the subject.

Why did you decide to work in the field of biomedicine?

Working in the biomedical field is an honour for me, mainly because I believe it is a great opportunity to contribute in the development of new instruments and techniques, which may be useful to improve our quality of life. For me, this is a key aspect with respect to other projects that are currently being carried out in our research group here at Politecnico di Milano.

What challenges do you face in your daily activities?

Because we are constructing a brand new instrument, every day we face issues that nobody has ever encountered before, forcing us to find new solutions on every occasion. Surely enough, I blieve the most difficult thing I had to overcome during the development of the TRS module. The interference emitted by the pulsed laser sources, coupled to the single-photon detector and thus degraded the system performance. Thus, I had to study the nature of the problem carefully to find a way to reduce interference while maintaining an optimal performance.

What are you in charge of developing within the project? What is your field of expertise?

My task within the LUCA project consists in developing the Time-Resolved Spectroscopy instrument sub-system, which is part of the integrated LUCA system. I designed and developed the pulsed laser sources module and the TRS control unit in addition to all the ancillary electronics required for an instrument that needs to operate in a clinical environment.

Marco Renna received his Master's degree in Electronics Engineering from Politecnico di Milano, Milan, Italy in 2016, which was focused on the development of a compact instrument for time-resolved near-infrared spectroscopy. The same year he enrolled in the Ph.d. in information technology in Politecnico di Milano. His main research activities are based on the development of pulsed laser sources and fast acquisition electronics for advanced multichannel TCSPC systems.