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*Željka Lučev Vasić<sup>1</sup>, Yueming Gao<sup>2</sup>, Min Du<sup>1</sup>, Mario Cifrek<sup>1</sup>*

### TEN YEARS OF COLLABORATION BETWEEN UNIVERSITY OF ZAGREB, FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING AND FUZHOU UNIVERSITY

<sup>1</sup> University of Zagreb, Faculty of Electrical Engineering and Computing

<sup>2</sup> Fuzhou University, College of Physics and Information Engineering

Back in February 2011, a young assistant professor Yueming Gao from Fuzhou University, College of Physics and Information Engineering contacted a Ph.D. student Željka Lučev Vasić from University of Zagreb, Faculty of Electrical Engineering and Computing with a suggestion to prepare a common project proposal for the Croatian-Chinese Scientific and Technological Cooperation call. At the time, both groups were working on different aspects of intrabody communication (IBC) topic, exploring how the human body could become a part of communication channel between electrical devices in its vicinity. The project proposal „Research of Intrabody Communication for Body Area Networks“ was prepared and submitted in April, and funding was approved in October 2011. Principal investigators on this project were Prof. Mario Cifrek from the University of Zagreb (FER) and Prof. Mang I Vai from Fuzhou University, College of Physics and Information Engineering (FZU) and University of Macau, Faculty of Science and Technology (UMAC). Researchers from all three institutions were involved in the project, Fig. 1.

The collaboration between Croatian and Chinese researchers has been going on ever since, in the field of intrabody communication and wireless devices and networks for health and rehabilitation monitoring. Main research topics were galvanic and capacitive IBC system modeling, IBC channel measurements and IBC hardware design, which were recently expanded with electrical impedance myography and monitoring of physiological parameters.

Croatian and Chinese researchers have similar academic backgrounds and research fields, but are focused on different aspects of similar research questions. The Croatian side (FER) has a rich experience in the field of capacitive intrabody communication, muscle fatigue evaluation in biomechanics, biomedical sensors (electromyography, EMG; electrocardiography, ECG; electroencephalography, EEG), ultra-wideband (UWB) and biomedical signal processing. The Chinese side (FZU and UMAC) is good at galvanic intrabody communication, electromagnetic modeling of biomedical systems, real-time detection of diverse biochemical parameters, and the design of medical devices. They also have experience in the industrialization and certification of developed medical devices.

Until now, the collaboration with Prof. Gao and his team resulted in four bilateral projects and two projects funded by Fujian province:

- 2011 – 2013 “Research of Intrabody Communication for Body Area Networks,” bilateral project, PI Prof. Mario Cifrek and Prof. Mang I Vai;



**Figure 1.** Collaborative universities: Fuzhou University, University of Zagreb, University of Macau.

- 2013 – 2015 “Cooperative Study of the Multi-Coupling Type Intra-body Communication for Body Area Networks,” International cooperation project of MOST of China, PI Prof. Mang I Vai and Prof. Mario Cifrek;
- 2015 – 2017 “Intrabody Communication as a Key Technology for Internet of Things in Health Applications,” bilateral project, PI Prof. Mario Cifrek and Prof. Yueming Gao;
- 2018 – 2020 “Body area networks for health applications based on intrabody communication,” bilateral project, PI Assis. Prof. Željka Lučev Vasić and Prof. Yueming Gao;
- 2018 – 2021 “Evaluation of the Local Muscle Fatigue with the EIM Method for Wearable Applications,” project of S&T Department of Fujian Province, China, PI Assis. Prof. Željka Lučev Vasić and Prof. Yueming Gao;
- 2020 – 2022 “Body Area Network for Athlete Fatigue Monitoring,” bilateral project, PI Prof. Mario Cifrek and Prof. Yueming Gao;
- 2021 – 2024 “Real-Time Impedance Spectroscopy of Low Back Muscles Based on Multi-Frequency Excitation,” project of S&T Department of Fujian Province, China, PI Assoc. Prof. Željka Lučev Vasić and Prof. Yueming Gao.

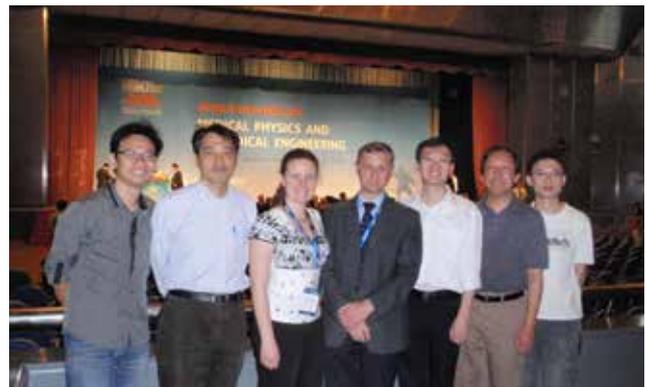
The Croatian researchers involved in these projects were Assist. Prof. Željka Lučev Vasić, Prof. Mario Cifrek, Prof. Igor Krois, Prof. Silvio Hrabar, Assist. Prof. Josip Lončar, Ivana Čuljak, M.Sc., and Krešimir Friganović, Ph.D. The Chinese researchers working on the projects were Prof. Yueming Gao, Prof. Min Du, Prof. Mang I Vai, Prof. Peng Un Mak, Prof. Sio Hang Pun; Figs. 2 to 7. The group jointly trained 4 Ph.D. students (1 in Croatia, 2 in Macau, 1 in China), and 37 Master students (16 in Croatia, 4 in Macau, and 17 in China).



**Figure 2.** The first meeting: Hangzhou, China at I2MTC 2011; Željka Lučev Vasić (FER) and Yueming Gao (FZU).

Less than two weeks after submitting their first project proposal, Yueming Gao from Fuzhou University and Željka Lučev Vasić from University of Zagreb met for the first time in person, on the outskirts of IEEE International Instrumentation & Measurement Technology Conference (I2MTC 2011) held in Hangzhou, China in May 2011, Fig. 2.

The first work meeting of the newly established collaboration group took place during the IFMBE World Congress on Medical Physics and Biomedical Engineering, held in Beijing, China in May 2012, Fig. 3.



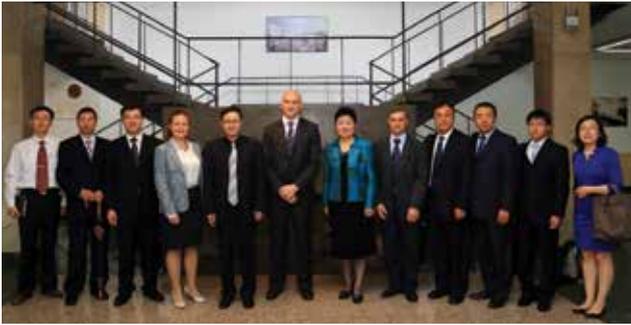
**Figure 3.** WC 2012, May 2012: Sio Hang Pun (UMAC), Peng Un Mak (UMAC), Željka Lučev Vasić (FER), Mario Cifrek (FER), Yueming Gao (FZU), Mang I Vai (UMAC), Pedro Antonio Mou (UMAC).

Further on, the researchers visited each other’s labs on multiple occasions, where they gave lectures and conducted experiments together. In May 2013, an International workshop on intrabody communication was organized in Zagreb, endorsed by IFMBE (International Federation for Medical and Biological Engineering) and IEEE (Institute of Electrical and Electronics Engineers). Members of the research groups from Croatia and China, as well as researchers from FER, presented their work on intrabody communication and signal transmission on/through the human body.



**Figure 4.** Measurements at FER, Zagreb, May 2013; Sio Hang Pun (UMAC), Peng Un Mak (UMAC), Yueming Gao (FZU), Mang I Vai (UMAC), Željka Lučev Vasić (FER)

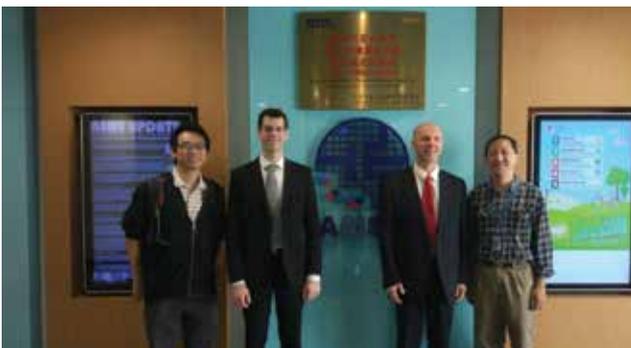
In June 2015, a delegation of the Chinese Ministry of Science and Technology, led by Deputy Minister Mr. Li Meng, and accompanied by representatives of the Embassy of the People's Republic of China in Croatia led by Ambassador Ms. Deng Ying, visited FER. After the presentation of completed and active bilateral projects between researchers from FER and China, the delegation visited the Department of Electronic Systems and Information Processing and the intrabody communication research facilities, Fig. 5.



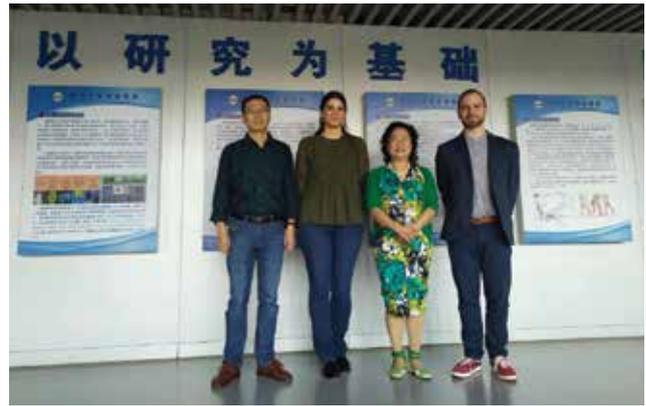
**Figure 5.** June 2015, FER: Yueming Gao (1st), Željka Lučev Vasić (4th), deputy minister Meng Li (5th), vice-dean for science Gordan Gledec (6th), ambassador Ying Deng (7th), Mario Cifrek (8th) with delegation of the Chinese Ministry of Science and Technology and the Embassy of the People's Republic of China in Croatia.

As a consequence of continuous collaboration and common interests in academic, scientific and cultural affairs, in 2018 the International Memorandum of Agreement was signed between the College of Physics and Information Engineering, Fuzhou University and University of Zagreb, Faculty of Electrical Engineering and Computing, with the objective of promoting academic cooperation in education and research.

The collaboration between the Universities of Zagreb, Fuzhou, and Macau was chosen as one of three collaborations between Croatian and Chinese educational institutions to be presented to the prime ministers at the “Exhibition on Cooperation in the Field of Education of Central and Eastern European Countries and China” during the 8th Summit of Central and Eastern European Countries & China in Dubrovnik, Croatia in April 2019.



**Figure 6.** December 2017, Macau: Sio Hang Pun (UMAC), Josip Lončar (FER), Silvio Hrabar (FER), Mang I Vai (UMAC).



**Figure 7.** October 2019, Fuzhou: Yueming Gao (FZU), Ivana Čuljak (FER), Min Du (FZU), Krešimir Friganović (FER).

At the 2020 IEEE International Instrumentation & Measurement Technology Conference (I2MTC 2020) in May 2020, a special session “Intrabody communication for body area networks” in which 5 papers were presented was organized and co-chaired by Yueming Gao and Željka Lučev Vasić.

As of today, the Croatian and Chinese groups are still working closely together in the biomedical engineering field and several new projects and papers are under the review process.

## Bibliography

Since 2013, when the first common papers were published, in addition to papers published by each group independently, Croatian and Chinese groups have co-authored 11 journal papers. Nine of these papers were published in journals indexed in Web of Science database (1 Q1, 3 Q2, 3 Q3, and 2 Q4 papers). The remaining two papers were published in a new journal not yet included in WoS but already in Q2 quartile in Scimago database. The researchers also participated in 11 conferences with 16 common papers. The common conference paper “An Investigation of the FEM Simulation for the Galvanic Coupling IBC Based on Visible Human Data” received the best paper award at the international conference 2015 IEEE International Conference on Consumer Electronics - China, held in April 2015 in Shenzhen, PR China

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