UCG
University of Montenegro

BIOIT

CENTRE OF EXCELLENCE IN BIOINFORMATICS

Faculty of Electrical Engineering

"Green house - Jovović"

IBM

cogimar

SRCES RAS
Saint-Petersburg, Russia

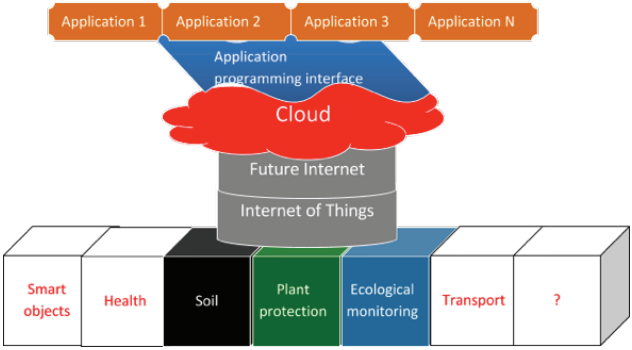
CTiF
Center for Telematics

Biotehnički fakultet
Biotechnical faculty

World Bank loan

BIO-ICT Centre of Excellence is the first Centre of Excellence in Montenegro, implemented as a three-year research programme at the University of Montenegro led by the Faculty of Electrical Engineering, financed by the Ministry of Science of Montenegro through a World Bank loan from June 2014. Besides the Faculty of Electrical Engineering, partners on the project are three leading Montenegrin research institutions: Biotechnical Faculty, Institute for Marine Biology, Institute of Public Health; two international universities: St. Petersburg Scientific Research Centre for Ecological Safety and Centre for TeleInFrastruktur (CTIF); and two successful Montenegrin SMEs companies: COGI doo and Green House Jovović doo.

BIO-ICT aim is the development of modular and state-of-the-art **BIO-ICT R&D platform** in the areas of sustainable agriculture, monitoring of the crops, forest and water/sea ecosystem, development of techniques for controlling and reducing air pollution, analysis and standardization of food products, control of land quality, and improvement in the public health area. A new pilot system is currently under development. It is service oriented with the aim to boost the application and use of the latest ICT technologies in the areas of agriculture, marine biology, environmental monitoring as well as health, smart object, transportation, energy, etc.



BIO-ICT R&D Platform

Pilot BIO-ICT system will be validated through three research facilities. One research facility is on the sea (COGIMAR), while the other two are farms (Biotechnical Faculty and Green House Jovović). These three research facilities are established with project partners with the aim to serve as the basis for future start-up/spin off companies. Wireless sensor nodes will be deployed on the research facilities. They will collect meteorological, soil and water data, as well as information about the development of vegetables and mussels. From there, the information will be transferred over state-of-the-art communications technologies to the cloud part of the system. Data mining approach will be used to extract information from the stored data and transform it into an un-

derstandable structure for further use. Presentation of these data will be done through a web interface. Based on the collected data and our competencies, recommendations for users will be created by preparing instruction according to standards and user expectations. Instruction for users will be transferred via Internet and accessed by user through user-friendly web interface. Finally, based on the previous activities, farmer or expert system will take action (spraying, irrigation or alarming) and give feedback about action effectiveness through social networks.

Biotechnical Faculty Research Facility

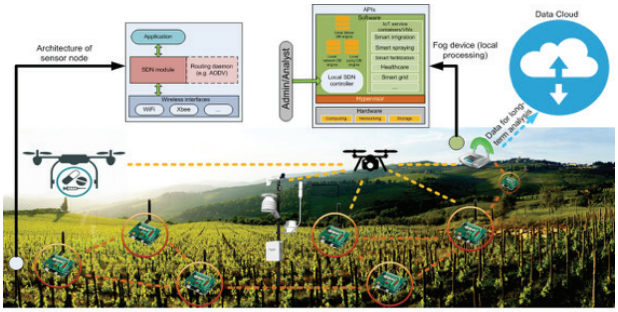
COGIMAR Research Facility

Our work involves **R&D&I activities in following research areas:**

- High-dimensional data collected in sensor networks could be represented in the form of graphs. Collecting, analysing and processing such data is an important and essential task which requires innovative approaches in order to extract valuable information to be used in decision making processes. Therefore we are developing **new graph based processing methods** based on the analyses of the fundamental concepts of graph data processing techniques, including graph signals and graph filters, graph Fourier transform, and graph spectral transformation.
- Investigation of **precision agriculture** potential for taking advantage of advanced ICT solutions to address today's agricultural issues such as the need to balance productivity with environmental concerns is the subject of our activities. We are working on the implementation of ad-hoc wireless sensors and actuator networks (WSANs), deployed to measure/monitor specific parameters of the environment and enforce control decisions. The data we obtain from sensor nodes will be used by cloud applications in order to make intelligent control decisions that should yield better and more crops through optimal application of water, pesticides and fertilizers.
- Within the BIO-ICT centre, data will be acquired from field trials and gathered from various sources (sensors, experts, laboratory testing, remote sensing, drones, etc.) and processed in order to make proper decisions regarding agricultural production, diseases and bio-monitoring. Two approaches are

primarily followed: **pattern recognition and data mining**. Image processing and pattern recognition tools will be adopted for the classification of grapevine diseases and automated pest monitoring. Techniques based on data mining will be developed for soil classification and data visualisation.

- Energy efficient cooperative relaying in wireless sensor networks, Software Defined Wireless Sensor Networks, Virtual MIMO for performance enhancement of wireless sensor networks and Mobile wireless sensor networks are examined as **advanced communications technologies** with particular emphasis on their implementation in BIO-ICT pilot system.
- Development of a **new IoT (Internet of Things) architecture** and its elements that combine benefits of two emerging technologies: Software Defined Networking (SDN) and Fog computing. SDN logically centralizes the network intelligence, which allows the implementation of sophisticated mechanisms for traffic control and resource management. On the other hand, Fog computing enables data to be analysed and managed at network edge, thus providing support for applications that require very low and predictable latency.



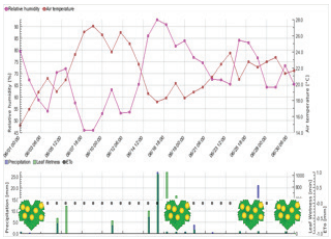
New IoT (Internet of Things) architecture

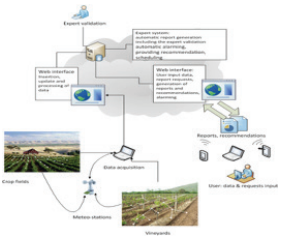
In the first year of the project, we achieved several significant R&D&I results as follows:

- **Comprehensive analysis of irrigation and fertilization influence on quality and quantity of the yield** shows that the fertilization at 50% of the recommended level reduced the yield and had positive effect on antioxidant activity, while fertilization at 150% of recommended level had negative effect. It is discovered that the fertilized plants were more active against colorectal carcinoma cells in comparison with non-fertilized plants.
- We created **new algorithm for software solution** in smart Irrigation and Soil Fertilization system. Web based **expert system for advising the amount of fertilizer** that should be applied on a certain crop is developed. Recommendations are

taking into account the interaction factors related to the types of land (provided by a **modern national agriculture data-base**, which we made based on available soil analysis data) and planted crops. Also, **an efficient irrigation system** that is controlled by our microprocessor based solution for automate irrigation process is under development.

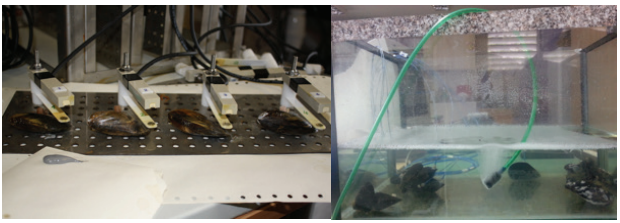
- Based on comparison of data collected by monitoring of occurrence of downy mildew (*Plasmopara viticola*) symptoms on grapevine and data obtained from weather stations, **an algorithm for disease forecasting** has been designed. It has been shown that temperature, humidity, precipitation and leaf wetness are crucial for the infection and can indicate the appropriate time for vineyard treatment which can lead to reduction of number of treatments. We are in the phase of designing a web oriented, user friendly, automatic expert system for predicting downy mildew disease of grapevine and providing recommendation for spraying.





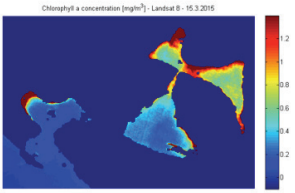
- **Our first prototype of micro meteorological station** for measuring and presenting of meteorological data on web was developed. We are working on its further improvements.

- We have tested state-of-the-art equipment for **monitoring of shellfish heart activities using biosensors**. Currently we are working on several innovations for improving its flexibility, usability and efficiency.



- We have worked on **sampling and analysing of physical and chemical characteristics of seawater, sediment and mussels**. We have examined the content of nutrients in seawater, heavy metals in sediment and mussel, and total organic carbon and nitrogen in the sediment and water.

- We have collected data about **quality and quantity composition of phytoplankton, as well as toxic and potentially toxic phytoplankton species**. We obtained results about biomass of phytoplankton based on concentrations of Chlorophyll a pigment. We collected almost annual microbiological data from mussels farms from water and mussel which shows trophic conditions and microbiological state of these organisms.
- Based on data about condition index of mussels, g**rowth and survival of mussels** and oysters we have preliminary data about influence of fish farming on growth, survival and condition index of shells. We obtained relevant results on length-weight relationship and condition factor of Gilthead sea bream (*Sparus aurata, Linnaeus 1758*) and European sea bass (*Dicentrarchus labrax, Linnaeus 1758*).
- **Satellite monitoring of Chlorophyll** a is performed and we found high correlation between Landsat 8 satellite acquiring data and laboratory analysis of Chlorophyll a concentration by spectrophotometry method.



BIO-ICT Goals and Next Steps are oriented on R&D&I in ICT for reduction or environment friendly fertilization, spraying and irrigation, increase of farm productivity, reducing human involvement for laborious tasks, helping to make precision farms more sustainable and efficient ecological monitoring. We will realize IoT/Cloud/Big Data open platform for precision agriculture and ecology monitoring application with potential for extending on different social contexts. Specific requirements that will be addressed include multiple sensors and devices linked with big data analytics and cloud data management. The research will address technological issues in big data application scenario such as wireless sensor networks with combined three emerging technologies IoT, SDN and Fog computing. This implies ease of deployment, cost and energy efficiency, "five 9" reliability, flexibility and perceived "zero latency" when it is needed. We intend to make available collected scientific data and data-analysis services for research community through our research infrastructure and cloud.

We gave you a partial overview of all our activities, for more information on BIO-ICT Centre of Excellence, please find us on Web - www.bio-ict.ac.me, Facebook, Twitter, LinkedIn.