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RESEARCH—TECHNOLOGY— INNOVATION

FOR SUSTAINABLE GROWTH

Automation of road transportation in Europe

Technical solutions, development tools and pilot applications in real conditions, that will be a game changer in the field of shared Cooperative, connected and automated mobility

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MyPal

MyPal: Palliative Care of Adults and Children with Cancer through Advanced Patient Reported Outcome Systems

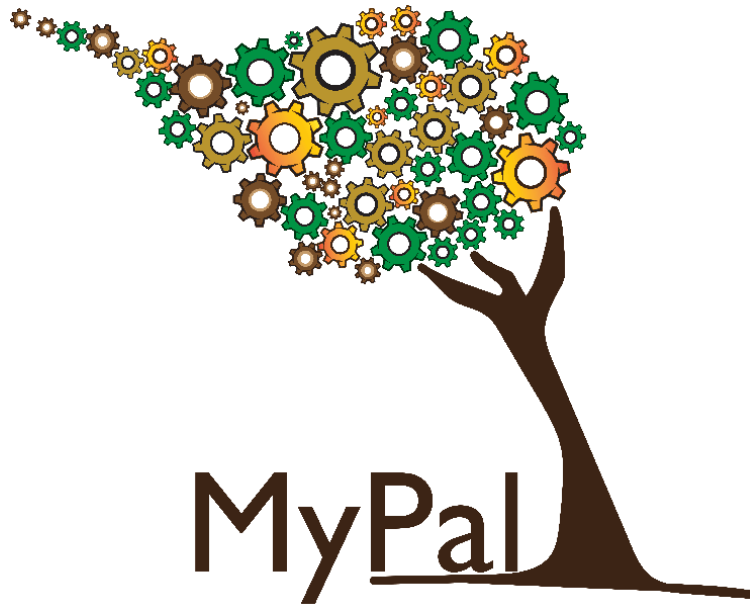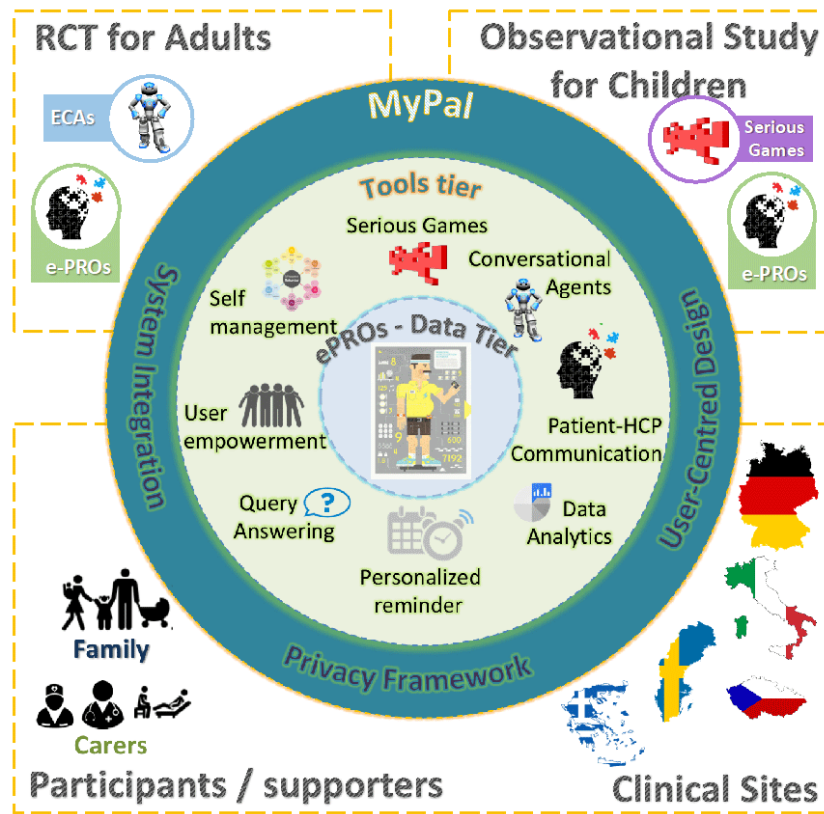**Empowering people with cancer** and their caregivers in capturing more accurately their conditions, **communicate** them in a seamless and effective way to their healthcare providers, is the aspiration of the European Project **MyPal**, coordinated by the Institute of Applied Biosciences of CERTH.

TEXT: **PANTELIS NATSIAVAS, CHRISTINA KARAMANIDOU**
EDITING: **AMALIA DROSOU**

According to World Health Organization, (WHO), Cancer is the second leading cause of death globally. During the course of cancer, face a various number of challenges related to the choice of the right treatment but also the management of negative emotions, such as fear and anxiety. At the same time, their caregivers face challenges in announcing them the diagnosis, the type and stages their patient should follow as well as recurrences of the disease.

The building blocks of the MyPal intervention

Responding to the challenge: The contribution of the European "MyPal" project

MyPal develops an innovative framework aiming to foster palliative cancer care, relying on the deployment of advanced ePRO systems that will enable timely reporting and monitoring of: symptoms; adverse events related to both the underlying disease but also the treatment; Quality of Life, (QoL), and general wellbeing of people with cancer and their caregivers. MyPal aspires to empower people with cancer and their caregivers in capturing more accurately their symptoms/conditions, communicate them in a seamless and effective way to their healthcare providers and, ultimately, foster the time for action through the prompt identification of important deviations in the patient's state and Quality of Life (QoL). To this end, MyPal will provide a comprehensive intervention for relieving symptom burden and distress in people with cancer as well as preventing disease- and/or treatment-related adverse events (both early and late-onset), that entails the deployment of user-friendly digital health tools for effective reporting by the patients and/or their caregivers.

More specifically, MyPal addresses the following objectives:

-Design a comprehensive, patient-centred intervention for palliative care in cancer by adapting and advancing patient reported outcome (PRO) systems

-Reduce symptom burden for people with cancer in need of palliative care

-Reinforce patient participation and empowerment in palliative care

-Provide novel tools for exploiting PROs and advancing electronic patient reported outcome (ePRO) systems

-Reinforce the evidence-base of the effectiveness and cost-effectiveness of ePRO for palliative care for people with cancer

-Prove the feasibility of integrating the proposed intervention in palliative care regimes and healthcare systems across Europe

In this context, the MyPal project includes two clinical studies, one targeting children (100 participants) and the other one targeting adults (300 participants). These clinical studies focus on the use of technical means for the practical application of the ePRO paradigm among patients and healthcare professionals. More specifically, the project has developed: (a) mobile applications that support the reporting of potential symptoms, as well as the overall condition of patients via well-structured questionnaires, (b) an interactive serious game aimed at facilitating the recording of childrens' condition, and (c) an integrated management platform that provides access to the patient reports for the healthcare professionals. At the present stage (February 2021), the development of the respective software applications (mobile application, game, management platform)

has been completed and the two clinical studies have started, including both adult patients and children in various clinics both in Greece and in the rest of Europe.

Contribution of INAB I CERTH

The project is coordinated, both scientifically and technically, by INAB|CERTH. More specifically, the INEB | CERTH team has coordinated the authoring of the respective studies' protocol, has handled the issues of privacy and data security of the project and has undertaken the technical coordination of the software development, aiming at the practical interconnection of the research results with the real world and ultimately improving patient care.

Consortium

The Project Consortium consists of 16 partners from 7 European countries, including organizations, that represent patients Private Sector bodies, as well as organizations, that play a leading role in the European research arena.

European project "SHOW" could have a catalytic impact on the **automation of road transportation in Europe**

The public health crisis tends to **accelerate the implementation of autonomous systems in the transport sector**, with the use of fully autonomous vehicles as well as remote control of vehicle fleets, including autonomous cars, buses, trucks, trains, ships and aircrafts.

The stepping stones of this new reality, are shaped by the European project show, with the Heelenic Institute of Transport as the Technical coordinator of the consortium and a pilot application in Trikala, Greece.

Dr. Evangelos Bekiaris, the Director of the Hellenic Institute of transport of CERTH and recently elected chairman of the Hellenic Institute of Electric Vehicles shares with us **his goals of promoting electromobility in Greece and tells us about the European project SHOW.**

INTERVIEW: **AMALIA DROSOU**

Dr. Bekiaris, you have recently been elected as the Chairman of Board of Directors of the Hellenic Institute of Electric Vehicles (HELIEV). What do you prioritize for the promotion of Electromobility in Greece?

Our immediate plans include the development of a network of chargers and electric vehicles, circulating in our country within the framework of e-mobility observatory in Greece, which will be managed by HELIEV, as well as the development of a nationwide charging network on highways, cities and countryside / provincial network.

At the same time, it is equally important for us to promote the development of fleets of electric vehicles by Public Bodies, especially Municipalities and Regions, as well as the promotion of e-mobility (electric bicycles, scooters, etc.), but also the common use of electric fleets, following the Mobility as a Service (MaaS) model.

Dr. **Evangelos Bekiaris** Director of CERTH I HIT, President HELIEV

Furthermore, we prioritize the development of appropriate business models for the promotion of e-mobility, adapted to the circumstances of our country, the training of professionals for the entire E-mobility chain, as well as the informing and raising awareness of citizens and politicians (Central Administration and Authorities of all levels), for the correct application and use of e-mobility technologies.

How difficult is it to face the challenges of creating autonomous vehicle fleet, as well as sufficient charging infrastructure?

Through planning, proper coordination and preparation of an integrated National Architecture based on specifications, financial tools and business models, we will gradually develop a charging network all over Greece.

" Through planning, proper coordination and preparation of an integrated **National Architecture** based on specifications, financial tools and business models, we will gradually develop a **charging network all over Greece.**

Dr. Bekiaris, the Hellenic Institute of Transport (HIT/CERTH) is the coordinator of the European project SHOW, which aims to deploy connected and electrified fleets of automated vehicles in coordinated Public Transport. What innovation does the project carry and at what stage is it today?

SHOW constitutes the biggest initiative so far of its kind in Europe and beyond. It brings together 69 partners from 13 European countries, and 10 third parties including vehicle and equipment manufacturers, authorities and Public Transport operators, users of transport means, small and medium enterprises, research and academic institutions as well as industrial partners.

It plans to transport more than 1,5 million travelers and 350000 containers of goods, targeting a seamless real life operation of 12 months, through a combined AV fleet of over 70 vehicles of various types (bus, shuttle, pod, car) in mixed traffic and dedicated lanes with and speeds from18 to over 50km/h in 20 cities across Europe, combining PT, DRT, MaaS and LaaS services.

As such, it is self-evident it will be a game changer in the field of shared CCAM.

What is the role of the Hellenic Institute of transport in the Project SHOW?

I have obtained the role of the Technical and Innovation Manager of SHOW. I am responsible for overseeing the technical progress of the project on a daily basis, applying proactive measures and mitigation actions, when required, and identifying innovative ways for the project to move beyond State of the Art. Minding, also, to ensure a constant compliance with industrial and research roadmaps as well as liaise with twinning and clustering initiatives on European and International level.

HIT I CERTH team participates also in the organization, technical support and conduct of the Pilot of Trikala Satellite and Thessaloniki Follower sites in Greece, for which, among other, it builds a TMC and prepares two automated passenger vehicles to operate in their context.

Furthermore, HIT leads the Subproject responsible for organizing the work around stakeholder needs, use cases, business and operational models as well as ethics, regulatory and legal aspects. It also leads the development of AI novel services and cooperative solutions for the interaction with other road users (i.e. VRUs). Finally, our team closely monitors and contributes to the iterative planning and execution of technical and field trials evaluation phases, supported and complemented by the simulation and impact assessment studies of the project.

What contribution will SHOW bring to autonomous urban mobility after the successful completion of the project?

I estimate that after the end of the project business and further research opportunities will flourish, not only in Trikala and Thessaloniki, where our pilot sites are located, but through replication actions in other regions of Greece, like for example our islands, where OEM's have already started to invest on automation.

The Greek Pilot site in SHOW, has already influenced the beneficial revision of the legislation regarding AV pilot operation in Greece,

which is a benefit for our country but also for the project as a whole, as it will allow flexibility in trying project solutions in real life and providing actual evidence on what is the readiness of a strategic South European country.

HIT, being the institute mandated on national level in Greece for conducting research and bringing innovation in transport, can be seen as the best ambassador of SHOW outcomes, with the collaboration with all the key players in Greece, both in terms of research and development and politics.

" SHOW integrates **automation of road transportation in Europe,** providing technical solutions, development tools and pilot applications in real conditions.

Dr. Bekiaris, how would you describe European project SHOW?

SHOW integrates automation of road transportation in Europe, providing technical solutions, development tools and pilot applications in real conditions. Through this project, the

current "caterpillar" of autonomous transportation (with vehicles that "crawl" at up to 20 km/h in special lanes) will be transformed into the "butterfly" of free autonomous transportation everywhere in the city of our future.

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FORTIKA

Vulnerable to Cybercrime no more: Helping small and medium-sized enterprises to tackle the threat of cyber-attacks

The FORTIKA project was launched with the specific aim of helping small and medium-sized enterprises (SMEs) to tackle the threat of cyber-attacks. After its successful implementation, the development of an innovative platform, the FORTIKA marketplace, as it is called is not just a means of eventually promoting the cybersecurity tools. It is much more an open platform, where a range of cybersecurity services can be marketed to SMEs worldwide. **FORTIKA has been recently identified as a success story by the European Commission.**

TEXT: **ANASTASIOS DROSOU, EVANGELOS KOPSACHEILIS**
EDITING: **AMALIA DROSOU**

Cybersecurity challenges

Cyber – attacks are the most growing type of criminal activity. Cybersecurity incidents cause financial damage to European companies and the economy as a whole, undermining this way the much sought trust of citizens and businesses in the digital society. Therefore, in addition to the business security, cyber threats affect the proper functioning of the state, the economy and the society, while at the same time, they have a profound impact on the daily lives of citizens. In this regard, it is significant to be mentioned, that in December 2020 the estimated cost of cybercrime to the global economy was reported to be more than EUR 775 billion a year.

Impact of COVID-19 on Cybersecurity

At the same time, the drastic change in living conditions and new retail practices due to COVID-19 pandemic, has significant implications for cybersecurity issues. Mandatory teleworking, means, that larger groups of non – skilled users, are exposed to cyber threats. Moreover, small traditional retail companies, have to be digitally present and trade daily over the Internet. This increased Internet activity means, that more opportunities and more potential targets that could cause cyber-attacks, are being created. Subsequently, cybersecurity challenges, even more crucial.

The FORTIKA solution is built upon Artificial Intelligence (AI) algorithms, which **monitor** on a continuous basis the protected corporate network and identify conditions that **are classified as "anomalies",** select the **optimal mitigation strategy**, generate in real-time notifications sent to the corporate network operator and **collect security-related data,** which generated in the network during the threat detection and mitigation process

The FORTIKA solution in brief

Due to the diversity and sophistication of nowadays cyber-attacks and the fact that they emerge in ever-changing and novel ways, the FORTIKA solution is built upon Artificial Intelligence (AI) algorithms which perform the following operations:

Monitor on a continuous basis the protected corporate network and identify conditions that are classified as "anomalies" implying the presences of an active threat.

For any detected threat, the system selects the optimal mitigation strategy and executes it instantly to eliminate the threat. The mitigation actions vary according to the type of the detected threat.

The system generates in real-time notifications sent to the corporate network operator, if the company employs such an employee, or directly to the end users.

Collection of security-related data that generated in the network during the threat detection and mitigation process, which then feed the Artificial Intelligence algorithms to train them further, so the system increases its effectiveness on an ongoing basis.

All this functionality represents very heavy computational tasks that need to be executed fast, close to real time. FORTIKA's approach towards this aim is to adopt a new hardware-based technology known as "Edge Acceleration". Edge Acceleration is Edge Computing (i.e. computing done at or near the source of the data) utilising hardware acceleration. All computational tasks are performed by the FORTIKA Gateway, a special-purpose routing device installed at the corporate network. The device includes a hardware accelerator which increases the speed of computations up to 20 times.

Help businesses respond to cyber security incidents, while relieving them from unnecessary costs

How small and medium enterprises can use FORTIKA technology

The typical scenario of using FORTIKA technology includes the procurement of FORTIKA Gateway and its installation in the corporate network. The FORTIKA Gateway is a small-sized device, available at affordable price. It features low energy consumption and includes the embedded hardware accelerator.

The device comes with a pre-installed set of basic FORTIKA cyber-security services. In addition, it provides routing services, so it can replace the corporate router. Alternatively, it may operate in parallel with the existing router and perform only the functions related to cybersecurity, i.e. the identification and elimination of cyber-threats.

Businesses that need additional FORTIKA services, in addition to the basic pre-installed ones, can obtain them through the FORTIKA Marketplace. The FORTIKA Marketplace is a specialized online store that allows the users to search for FORTIKA cybersecurity products select the ones they are interested in pay them and download at the FORTIKA Gateway. There the products are installed on the FORTIKA Gateway, and then they automatically deployed in the corporate network and provide the corresponding services.

An interesting fact is that the FORTIKA Marketplace is able to provide also third-party products from vendors other than FORTIKA. The only prerequisites for this is that these third-party products should be certified and compatible with the computing environment of FORTIKA Gateway.

Other FORTIKA info

While drawing up the specifications and the designing of all services and tools, produced by the project, all relevant legal requirements (especially GDPR requirements) as well as the ethical ones, were taken into account.

FORTIKA Project has received funding from the European Union's Horizon 2020 Frame-

work Programme for Research and Innovation. It lasted 3 years, was completed in May 2020 and was implemented by a consortium of 16 partners from 9 EU countries. CERTH was the Project Coordinator.

FORTIKA has been recently identified as a success story by the European Commission and also as a Project of the Week - 8-12 June 2020, by cyberwatching.eu

Supporting First Responders in hazardous environments

The challenges associated with the **protection of First Responders** in hazardous environments, while at the same time enhancing their capabilities in terms of **situational awareness and communication**, is the aim of FASTER European project, coordinate by CERTH.

TEXT: **ANASTASIOS DIMOU, KONSTANTINOS KONSTANTOUDAKIS, PETROS DARAS**
EDITING: **AMALIA DROSOU**

The challenge of natural disasters

Europe is experiencing an increasing number of disasters, caused by natural phenomena, technological accidents, or human actions. First Responders (FRs) are the people who are among the first to arrive at the disaster scene and provide assistance. They are often operating in risky and hazardous conditions disaster sites like demolished, burnt, or flooded districts, and exposed to non-visible threats such as very high temperatures and dangerous gases

Furthermore, FRs may experience incidents during operations that put their own health at risk, and which can prevent them from completing their mission. FRs' capabilities can be limited by chaotic environments: overwhelming amounts of information may reduce their situational awareness; multiple displays and gadgets are adding clutter to their equipment; autonomous vehicles can be useful in disaster scenes but have limited operational autonomy; communication between FRs and central command is often obstructed; cooperation amongst FRs and community members is often ad-hoc and lacks coordination.

Protection of First Responders while enhancing their capabilities

FASTER is a 3-year H2020 project that aims to address the challenges associated with the protection of FRs in hazardous environments, while at the same time enhancing their capabilities in terms of situational awareness and communication. FASTER is developing a suite of innovative, efficient and user-friendly tools covering: (1) Data collection, providing a secure IoT platform for distributed, real-time gathering and processing of heterogeneous physiological and critical environmental data from smart textiles, wearables, sensors and Social Media, (2) Operational capabilities, providing flexible, multifunctional autonomous vehicles, including swarms of them, for extended inspection capabilities and physical mitigation, (3) Risk assessment, providing tools for individual health assessment and disaster scene analysis for early warning and risk mitigation, (4) Improved ergonomics providing augmented reality tools for enhanced information streaming, as well as body

and gesture-based interfaces for vehicle navigation and communication, (5) Resilient communication, at the field level providing haptic communication capabilities, emergency communication devices, communication with K9s; and at the infrastructure level through 5G technologies and UAVs, (6) Tactical situational awareness, providing innovative visualisation services for a portable Common Operational Picture for both indoor and outdoor scenarios representation. (7) Efficient Cooperation and Interoperability amongst first responders, LEA, community members and other resource providers to request and deliver assistance where and when it is most needed using blockchain technology to give everyone involved the ability to exchange data on a trusted open-source platform to speed up disaster relief.

Reviewing inaccessible points using the camera of autonomous vehicles

More specifically, a technology developed by the Visual Computing Lab of CERTH/ITI is a system for reviewing inaccessible points using the camera of autonomous vehicles (UAV). "*Live footage is presented on augmented reality devices, taking into account the relative pose of the vehicle and the user, giving the illusion that the user can see through obstacles. The control of autonomous vehicles is done with gestures, without the need for additional equipment*", points out Dr Konstantinos Konstantoudakis, Post Doctoral Researcher at the Institute of Information and Communication Technologies (ITI) of CERTH.

The user (bottom right) can steer the drone (upper right) using hand gestures while watching both the drone and its camera feed (left)

" The control of autonomous vehicles is done with **gestures,** without the need for additional equipment, Dr Konstantinos Konstantoudakis, Post Doctoral Researcher at CERTH I ITI

Current phase of FASTER

FASTER is currently finishing its second year and, despite the significant challenges posed by the Covid-19 pandemic, has been achieving its milestones timings true to its original plan. A first version of the tools developed within the project has been produced and integrated. Furthermore, 4 pilot demonstrations have been completed, testing FASTER's tools in realistically simulated conditions with the participation of front-line FRs: in Athens, working in an abandoned mine with no infrastructure or communication means available; in Madrid, simulating an international operation according to the UN INSARAG guidelines after a major earthquake; in Turin, simulating a flooding event with multiple First Responders organizations and volunteers; and in Kajaani, simulating a terrorist attack and fire incident inside a building. FASTER is currently assessing the results of the pilots to produce the final specifications, system architecture and updated tools that will be demonstrated during a second round of piloting activities in the next 12 months.

Benefits

Benefits, that come along with the implementation of FASTER are of a great importance, as gesture control can reduce equipment clutter and free the one pilot's hands for other tasks.

> **"** Contextualized **AR visualization** can increase **situational awareness** by providing vision behind **obstacles or hazards** Dr Anastasios Dimou, Post Doctoral Researcher at CERTH I ITI - Deputy Project Coordinator

"Controlling a UxV with gestures is a much more intuitive process compared to the traditional remote controller and can reduce the learning curve associated with handling an autonomous vehicle. Contextualized AR visualization can increase situational awareness by providing vision behind obstacles or hazards and can lead to both improved victim detection and rescue, and increased risk awareness and FR safety", points out Dr. Anastasios Dimou, Post Doctoral Researcher - Deputy Project Coordinator.

CERTH is the Project Coordinator of FASTER, orchestrating the consortium that comprises 23 partners, including one from Japan. Moreover, CERTH's main technical contribution includes mapping functionalities using autonomous vehicles, Augmented Reality solutions for improving the inspection capabilities of First Responders, Gesture-based control of autonomous vehicles, and risk analysis of the disaster scene.
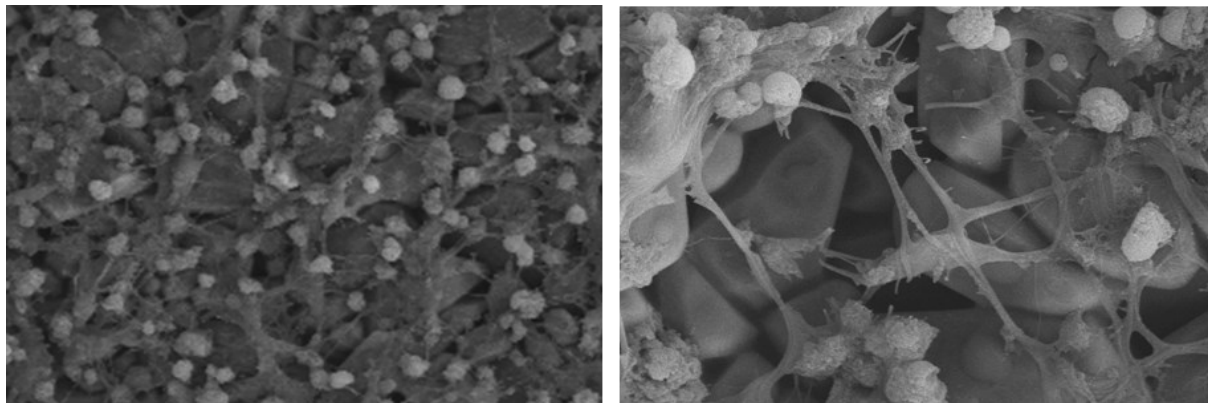
Networks of human neurons formed on ceramic scaffolds (magnification: left image 500x, right image 2.500x)

Construction of 3D structures of neural tissue modeling human neurodegenerative diseases

The brain is an organ with complex organization which degenerates in diseases, such as Alzheimer's disease. Construction of organoids, namely small-scale organs, would facilitate the **development of novel drugs.** Research teams at the Chemical Process Engineering Research Institute (CPERI) and the Institute of Applied Biosciences (INAB) of the Centre for Research and Technology Hellas (CERTH) are constructing **three-dimensional (3D) structures resembling human neural tissue,** using biocompatible materials and neurobiological techniques.

TEXT: **SPIROS PETRAKIS, AKRIVI ASIMAKOPOULOU**

The brain is an organ with complex organization which regulates and coordinates the function of the human body. It slowly degenerates in neurodegenerative diseases, such as Alzheimer's disease, due to the gradual loss of cells called neurons. Therapeutic strategies are aiming either at the replacement of damaged neurons or the prevention of their loss using chemical compounds. However, the development of efficient therapies is hampered by the lack of appropriate 3D models. Construction of brain-like organoids, namely small-scale organs resembling the human brain would facilitate the development of regenerative approaches using stem cells and the discovery of novel drugs.
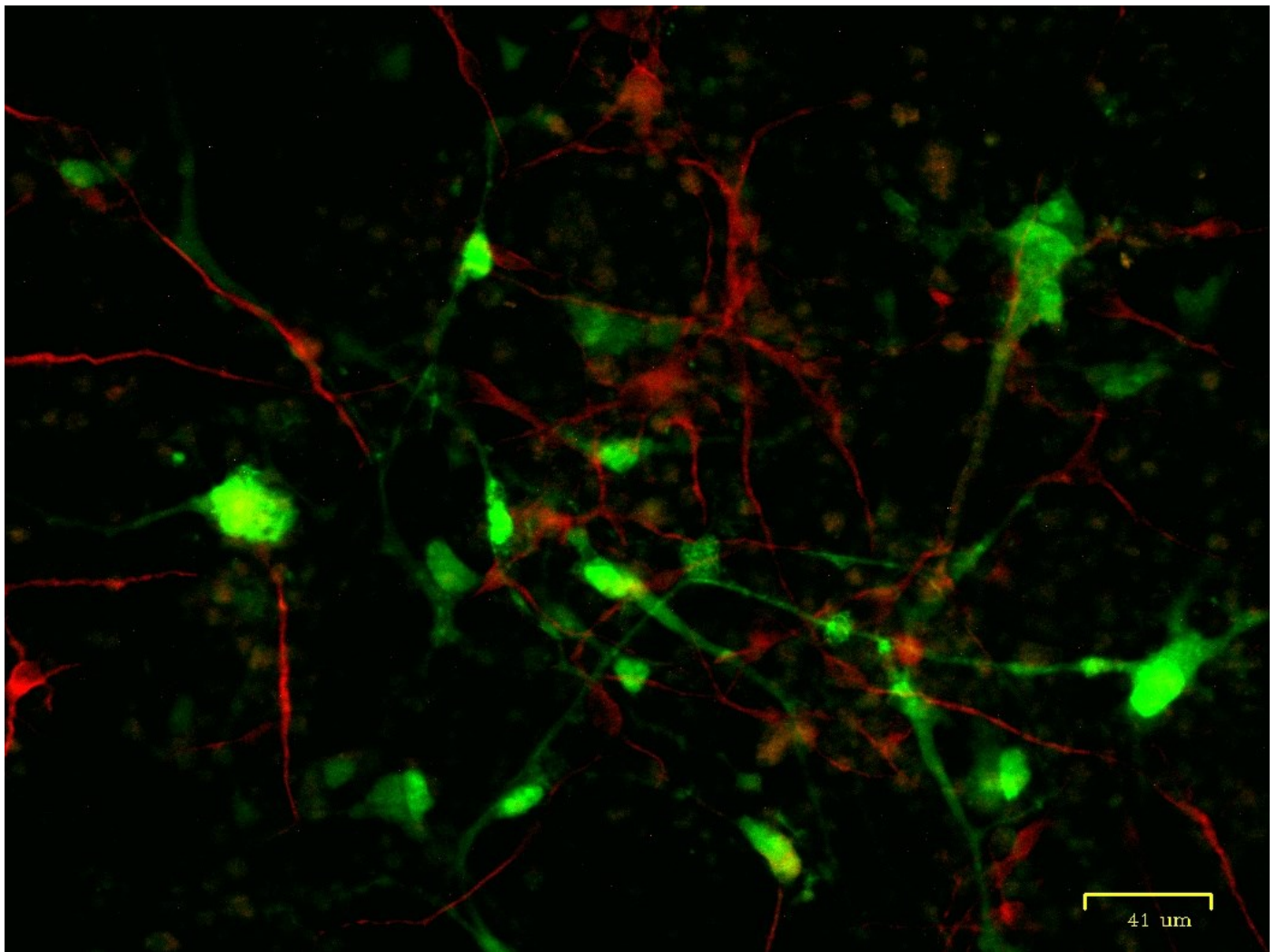
Co-cultures of human neurons (green color) and astrocytes (red color)

The brain consists of billions of cells that form networks with specific function. Therefore, the potential beneficial effect of drugs would be more reliably assessed in organoids allowing the 3D interconnection and interaction of neurons. Research teams at the Chemical Process Engineering Research Institute (CPERI) and the Institute of Applied Biosciences (INAB) of the Centre for Research and Technology Hellas (CERTH) are constructing three-dimensional (3D) structures resembling human neural tissue using biocompatible materials and neurobiological techniques.

More specifically, researchers construct ceramic scaffolds on which they culture human neurons that form functional networks (Asimakopoulou et al., J Funct Biomater. 2020. doi: 10.3390/jfb11030065). Next, they plan to generate scaffolds resembling the morphology of the human brain. In collaboration with researchers at the Information Technologies Institute (ITI), their work will be further optimized by 3D bioprinting of human neurons on engineered scaffolds. Construction of functional neural organoids will be a major breakthrough in neurobiology; such biosystems would allow the unraveling of the pathogenic mechanisms and the development of personalized therapies for neurodegenerative diseases.

Innovative membrane systems for post-combustion **CO₂ capture** in maritime

Developing **hyper-compact membrane systems** for post-**combustion CO₂ capture** in maritime and off-shore applications, that is the aim of the research program MemCCSea, coordinated by CERTH

TEXT: **GIORGOS SKEVIS, DIMITRIS KOUTSONIKOLAS, AKRIVI ASIMAKOPOULOU**

EDITING: **AMALIA DROSOU**

The maritime transport sector contributes significantly to the global anthropogenic release of gaseous and particulate pollutants. According to recent studies, exhaust emissions from ships contribute to 15% of global nitrogen oxide (NO_x) emissions and 3-7% of the corresponding sulfur oxide (SO_x) emissions. The shipping industry also contributes significantly to greenhouse gas (GHG) emissions.

" The innovative aspects of membrane technology lie in its **high efficiency**, **reduced volume**, large and well-defined **specific surface area**, in the easy and linear **scale -up** and in its potential for simultaneous capture and **utilization of carbon dioxide** and other pollutants Dr Akrivi Asimakopoulou and Dimitris Koutsonikolas, Post Doctoral Researchers at the Chemical Process Engineering Institute of CERTH

Currently 3% of the total global GHG emissions are attributed to the shipping industry and this share is expected to increase by 20 - 50% by 2050. As the shipping sector is growing rapidly - with Greek shipping playing a leading role – there is a tantamount need for strict measures to contain the environmental impact. In this context, both the European Union (EU) and the International Maritime Organization (IMO), through the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), have introduced stringent emission regulations.

The MemCCSea research project aims at developing hyper-compact membrane systems for post-combustion CO_2 capture in maritime and off-shore applications. The proposed membrane technology developed in the context of the project display significant advantages over conventional scubber technologies, such as substantially higher efficiency and reduced volume, issues that are crucial in the shipping industry.

Regarding the innovative aspects of membrane technology, these lie, according to Post Doctoral Researchers at the Chemical Process Engineering Institute of CERTH, Dr Akrivi Asimakopoulou and Dimitris Koutsonikolas *"in its high efficiency, reduced volume, large and well-defined specific surface area, in the easy and linear scale-up and in its potential for simultaneous capture and utilization of carbon dioxide (e.g. CO_2 conversion to solid carbonates) and other pollutants. In addition, in liquid-gas contact membrane devices, as the two phases do not mix, no flooding or foaming is observed, which is a common problem affecting the operation of conventional absorption columns and limiting their applicability"*
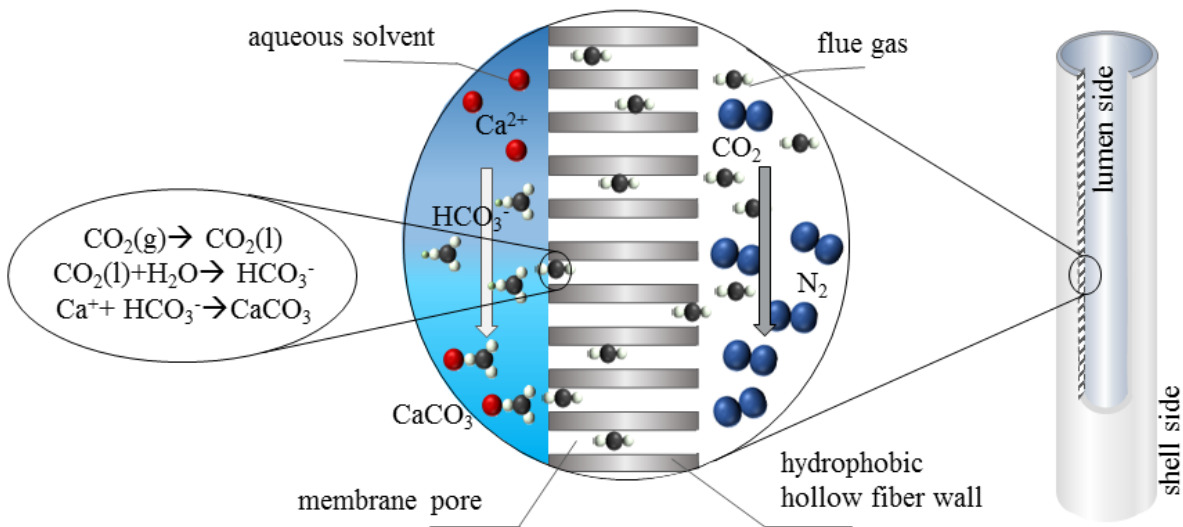
Cross section of hollow fiber porous membrane where gas-liquid interface is immobilized and CO_2 capture reactions are taking place.

The impact of the project after its implementation is expected to strong, since the reduction of emissions of carbon dioxide, as well as of other pollutants, from international shipping is a priority for the EU and is reflected in the gradual tightening of relevant binding regulations

"Carbon capture and utilization will continue to make significant contributions to the decarbonization of the shipping industry even during its transition to low- and/or zero-carbon fuels. Given the dominant position of Greek shipping, the developing technology will contribute in the medium term to maintain its competitiveness and will have a positive impact on the Greek economy in general.

The successful completion of the project will pave the way for further application of membrane technology for combined capture of critical pollutants (nitrogen oxides, sulfur dioxide) from shipping as well as the transfer of relevant know-how to critical energy intensive industrial sectors (e.g. cement industry).

Finally, the above research activity is part of a comprehensive research and development strategy of CPERI/CERTH that aims to the development of technologies and the provision of services to the Greek and international shipping industry (development of emission control technologies, alternative fuels, alternative propulsion, energy efficiency, etc.), underlines Project Coordinator, Dr. George Skevis.

" **Carbon capture and utilization** will continue to make significant contributions to the decarbonization of the shipping industry even during its transition to low- and/or zero-carbon fuels Given the dominant position of Greek shipping, the developing technology will contribute in the medium term to **maintain its competitiveness** and will have **a positive impact on the Greek economy** in general, Dr Giorgos Skevis, Researcher B at CERTH I CPERI - Project Coordinator

The project is funded by the EU through the ACT (Accelerating CCS Technologies) ERANET program and is a consortium of leading universities, research centers and industrial partners from Europe and the USA under the coordination of CPERI/CERTH (Project Coordinator: Dr George Skevis (Researcher B), Research team members: Dr Akrivi Asimakopoulou, Dr Dimitris Koutsonikolas and Mr. Michalis Mouratidis). Consortium members include Fraunhofer-IKTS (Germany), NTNU (Norway), NETL/DoE (USA), DNV (Greece/Norway) and DBI-GUT (Germany). The leading shipping company EURONAV also participates as an associate consortium member. CERTH's contribution in the MemCCSea project relates to the development of a pilot unit for the experimental evaluation of novel membrane-based carbon capture systems, the modification of commercial and experimental membranes for efficient carbon capture under ship operating conditions, and the development of numerical models for the simulation of membrane systems operation.

The project commenced in November 2019 and has a duration of 30 months. During the first year of the project the following activities have been carried out i) preliminary energy, environmental and techno-economic assessment of membrane-base systems integration in selected ships, ii) synthesis of advanced polymeric/graphene mixed matrix membranes and extremely hydrophobic coatings to optimize membrane and (iii) a preliminary experimental assessment of novel membrane systems for carbon capture performance under typical ship operating conditions in the CERTH pilot unit..

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The **Centre for Research and Technology-Hellas (CERTH)** founded in 2000 is one of the leading research centres in Greece and listed among the TOP-20 E.U. institutions with the highest participation in competitive research grants.

Today CERTH includes the following five institutes with indicated major fields of research:

- **Chemical Process and Energy Resources Institute (CPERI)** Sustainable & Clean Energy, Environmental Technologies, Chemical & Biochemical Processes, New Functional Materials

- **Information Technologies Institute (ITI)** Informatics, Telematics and Telecommunication Technologies, Safety and Security

- **Hellenic Institute of Transport (HIT)** Smart Sustainable Mobility, Transport Safety

- **Institute of Applied Biosciences (INAB)** Agri-biotechnology, Health Translational Research, Informatics for big bio-data

- **Institute for Bio-Economy and Agri-Technology (IBO)** Bio-economy, Agri-technology

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