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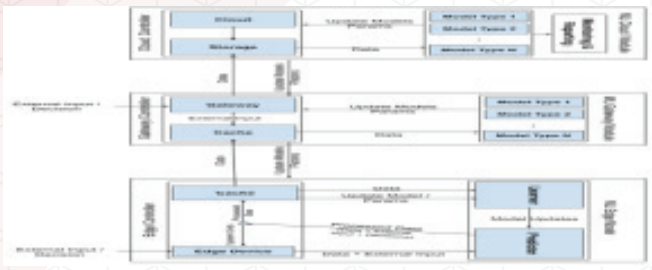
eCervello: A Prototype for Scalable IoT Systems based on Joint Edge, Fog and Cloud Intelligence

American University in Cairo and IoTBlue

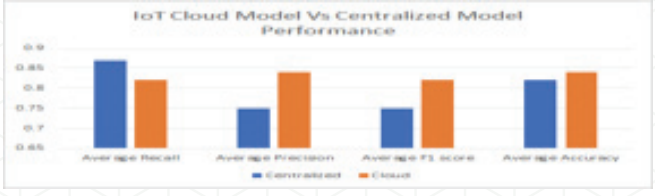
Teams from the American University in Cairo and IoT Blue have collaborated to design and demonstrate a prototype for a novel multi-tier machine-learning model for IoT that spans the edge, fog, and cloud. The developed technology is a key enabler for scalable IoT systems in diverse verticals in Egypt and worldwide, e.g., smart cities, ITS, Industry 4.0, and healthcare. State-of-the-art computing architectures are predominantly single-tier where intensive data processing tasks take place only in the cloud. The eCervello technology hinges on i) a multi-tier system with a joint edge, fog and cloud machine learning (ML) model, ii) Distributed ML model hosting lightweight Logistic Regression at the edge working in concert with more sophisticated Neural Network models at the fog and cloud tiers and iii) a data alignment mechanism to handle asymmetric data from multiple sensors (cameras) for a multi-vehicle tracking use case. "eCervello, supporting edge intelligence, addresses keys problems in state-of-the-art cloud-based IoT ML systems, namely limited scalability, large round-trip delays from pushing raw data to the cloud to feeding the decisions back to edge devices, imminent network congestion attributed to IoT big "raw' data, lack of data privacy and costly cloud investments/maintenance, to name a few' Says Prof. Tamer ElBatt, Professor at AUC in Dept. of Computer Science and Engineering and the principal investigator of the project.

As shown, we demo a prototype for a three-tier IoT system using actual hardware and networking technologies. Using the AI City Challenge 2020 public dataset, eCervello demonstrates comparable performance to the centralized ML baseline, yet, with a significant reduction in the training data up to 80% of the whole data set used to train the centralized model



Distributed Machine Learning Model

eCervello Prototype



eCervello's Distributed ML Model Performance

(Cloud) vs. the Centralized ML Model (Baseline)

Soft Exoskeleton Glove for hand rehabilitation and assistance with automated assessment features

Ain shams University

Researchers from Ain Shams University introduce an instrumented wearable glove, which is actuated using soft robotics. This glove helps patients with impaired hand motion secondary to weakness as seen in patients with stroke. This glove is designed to enable patients to move their hands and regain control through rehabilitation exercises. In other words, this glove can assist both the patient and the therapist to have more effective rehabilitation sessions. The actuators in this glove are modeled and fabricated based on using silicon rubber to develop mechanically programmable fiber-reinforced actuators. Finite element modeling software and sensitivity analysis of the actuator parameters were used during the design and modeling process to develop an actuator capable to achieve the desired movement and performance. "This developed instrumented system provides force and finger range of motion feedback using force, bending, and pressure sensors. This system can perform set of exercises for rehabilitation like finger bending and pinching and monitor the bending angle and force acting on the finger, which are shown on an LCD display to provide feedback for the therapist and patient' stated Dr. Mohamed Awad — associate professor at Ain Shams University and project principal investigator. In addition, smart objective assessment methods have been developed to assess and evaluate patient performance based on Gradient Boosting, Self-Organizing Maps, and XGBoost. A Supervisory machine-learning algorithm using XGBoost was developed to automatically assess the patients based on Fugl-Meyer's assessment of motor recovery. This automated assessment system can help in automated in-home rehabilitation and assessment especially during COVID-19 as this automated assessment system can be utilized to reduce the number of visits to a physician for assessment.

Figure 1: A soft robotic actuated glove

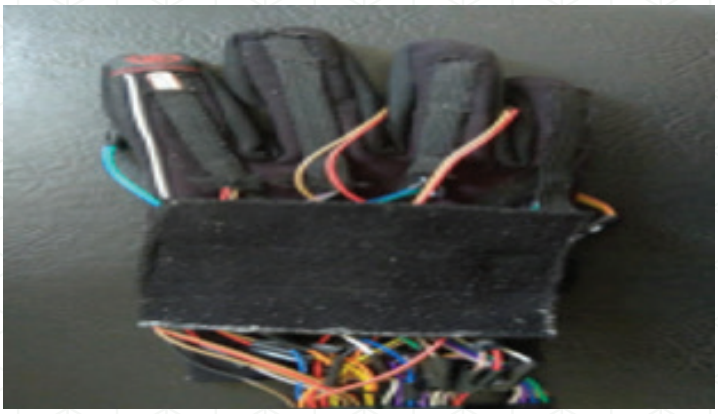


Figure 2: An instrumented passive glove

Lumiere(c) Integrating EEG and Facial Expressions for the Automatic Detection of Cognitive Skills

Zewail City, Cairo University and SMACRS

In Lumiere project, SMACRS, with the help of researchers from Zewail city and Cairo University, have developed an LMS to achieve a robust cognitive skills identification that is used to provide students with a customized adaptive learning scheme. Recently, a new trend to create a more adaptive LMS has been emerged by invoking either EEG or facial expression analysis for cognitive skills identification.

"Several machine learning algorithms were used to identify different student cognitive skills (such as: focus attention, memory, perception, etc.) using EEG signals and recorded videos to determine the best learning path and learning objects that is suitable for each student based on IEEE Learning Object Ontology and Bloom Taxonomy' says Dr. Hatem Adel Fayed – Professor at Zewail City and the project principal investigator.

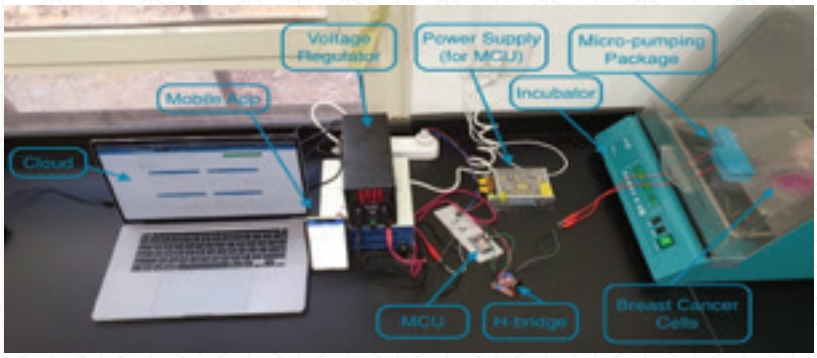
The main advantage of Lumiere project is that it can determine the best learning methodology for each student and even identify the skills that need improvement and guide teachers with instructions and advice to help students who need attention, all these features in a Web platform built with the cutting-edge technologies and user experience.

The deliverable of the system is a Web portal that can be customized and used in schools, universities, companies and in any educational platform to provide a Smart Adaptive Learning Management System alongside.

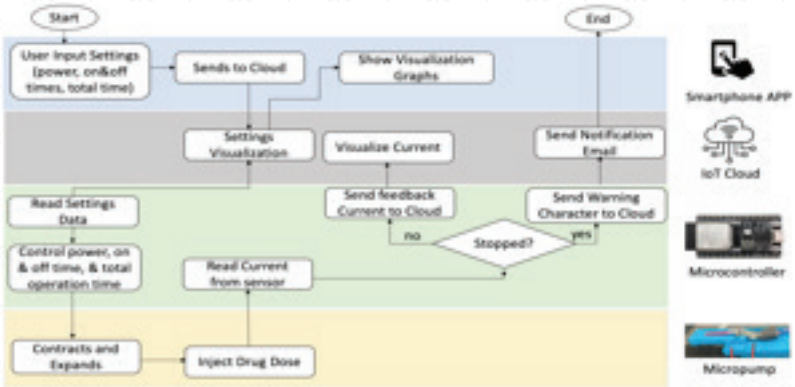
Wirelessly-Controlled Fully Implantable Smart Micropumping System for Local Anti-Cancer Drug Delivery in Pediatric Patients

American University in Cairo

Researchers from the American University in Cairo introduce an Internet-of-Things (IoT) based, wirelessly reconfigurable, sufficiently miniaturized micropumping device more suitable for personalized cancer therapy. The final product is intended to be locally implanted in tumor tissue, with the anticancer drug stored in refillable reservoirs. The wireless system facilitates the analysis of the transmitted data instantly, thus enabling control and reconfiguration of the drug administration regimen. Dr. Mohamed Serry – Associate Professor at the American University in Cairo and the project principal investigator stated, "The system is intended to improve the therapeutic performance of cancer drugs by reversing their resistance.' A new custom-made capsule micropump was designed and fabricated at the American University in Cairo. The system was successfully implemented, tested in vitro, and proven to deliver a model anticancer drug accurately and achieve a cytotoxic effect on breast cancer cells (>71%) with an optimized remotely controlled bolus dosing regimen. The proposed pumping solution is intended to improve the therapeutic performance of cancer drugs by reversing their resistance.



In vitro testing setup showing the micropumping package delivering the drug to cancer cells.



Flowchart of the IoT System