Innovation Project 5A EIS 2017-2018

Contents

(A) SKYDRUM INTERFACE

Supervisors: Jean-François MOUNET

Emails: contact@jfmounet.com

Keywords : micro controller - arduino – Raspberry PI3 - Script software – dmx512 – MIDI - MAX – Pure Data – Optical sensors – PCB – Kicad – Hardware Schematics -

Skills: Hardware schematics design (arduino – Raspberry PI interfacing), Kicad PCB design, software design under script objects IDE, embedded code for arduino and Raspberry PI (C language, Python ?...)

Project Context:

The project concerns the evolution of a current sound & light musical instrument called SKYDRUM (patent deposited by JF MOUNET).

This musical instrument works with 2 light beams held in the hands of the musician. The musician plays with the light beams on several (4) columns. The beams cross optical sensors horizontally placed on the columns. That triggers sounds, and colored lights into each played column according to the triggered sound volume shape and frequency.

Currently, this system works perfect using a hardware interface on which are input the electric signals coming from the captors, and outputting MIDI and DMX 512 signals to trigger sound generators and light projectors.

Project description and deliverables:

The purpose is to realize a new hardware interface for the Skydrum instrument in order to adapt the signals provided by the light captors of the columns, to a PC via some USB port (using a commercial USB -MIDI interface). Also, a virtual man machine interface (MMI) running on the PC will be developed, in order to generate MIDI and DMX512 signals via USB (using commercial interfaces).

For the hardware interface, an investigation of some new processing devices will be made, like for example Arduino mini and Raspberry PI mini.

The software part developed on the PC (MMI) will use either Max or Pure Data (open source) script objects IDEs. This software part will output DMX512 and MIDI signal via some commercial USB hardware modules.

Deliverables:

Hardware column interface, software MMI, hard and soft parts documentation.

(B) High Fidelity Wireless Multi Diffusion Sound System

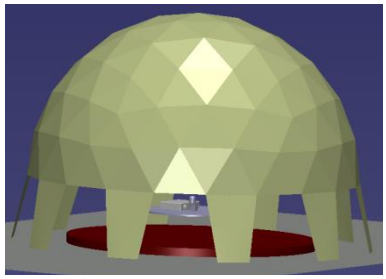
Supervisors: Hubert Jégat – Directeur Artistique, CréatureS Compagnie

Paul Foresto – Régisseur, CréatureS Compagnie

Emails: creatures.hj@gmail.com ; paul.foresto@gmail.com

Keywords: Sound, Wireless, Bluetooth, Space, Dome

Skills: Autonomy, Rigorous, Art interested



Maquette numérique du dispositif

Project Context:

This project is proposed by *CréatureS Compagnie* which creates and performs puppets shows, exhibitions ... [1]. For the moment the company is working on its next show called *Projet Z.E.R.O*. This is an immersive cardboard geodesic dome, 4m diameter and 2.5m height, where apprentice astronauts (4 – 5 persons of the audience) are invited to take place to travel in space on a turntable (3m diameter). Space images are created by apprentice scientists (5 persons of the audience) who perform live experimentations. Experimentations are filmed by webcams. Images are processed by a dedicated software created for the show (Max Software Tool) and then projected into the dome with a fish eye lens. One of the scientists is in charge of sound ambiance creation playing live music. This music is streamed inside the dome with multiple speakers or headphones. The main difficulty is that the dome is spinning so that no cable can go inside the dome. The idea of the company would be use a wireless sound system of high fidelity to stream music on 4 to 6 speakers. Nowadays Bluetooth technology would not allow to stream music on more than 2 speakers.

Project description and deliverables

The objective would be to develop a wireless system able to stream music with high fidelity on 4 to 6 speakers. The preferred technology is Bluetooth. In details, students would be in charge of:

- Understand the limitation of Bluetooth and how to overcome it.
- Develop a modular software able to stream music on 4 to 6 receivers. Different functions could be streaming the music all together or one after the other to simulate sound displacement.
- Share the development with the company and explain how it works. The company should be able to use the software for its show after the project.

Deliverables would be a demonstration of the sound diffusion. Moreover the show will be presented in December during a festival, *Métacorpus*. This could be the first full scale test for the system.

CréatureS Compagnie would prefer the development of the software to be made on Mac OS to ease the integration of it in the existing show material.
Next residency of the company is planned from August 18th till August 29th at Le Prieuré de Vivoin (72). The company would be happy to welcome students interested by the project to show them the dome and the installation.
Such development seems to exist and was led by ACROE – ICA laboratory [2]. The company is trying to be in touch with it. Then collaboration could be made with this laboratory.

[1] CréatureS Compagnie web site: creatures.free.fr
[2] http://www.acroe-ica.org/fr/produits/logiciels-applicatifs/genesis

(C) Smart Turntable

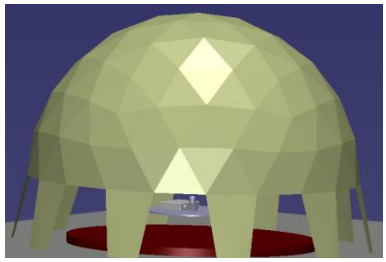
Supervisors: Hubert Jégat – Directeur Artistique, CréatureS Compagnie

Paul Foresto – Régisseur, CréatureS Compagnie

Emails: creatures.hj@gmail.com ; paul.foresto@gmail.com

Keywords: Sensors, Software development, Space, Dome

Skills: Autonomy, Rigorous, Art interested



Maquette numérique du dispositif

Project Context:

This project is proposed by *CréatureS Compagnie* which creates and performs puppets shows, exhibitions ... [1]. For the moment the company is working on its next show called *Projet Z.E.R.O*. This is an immersive cardboard geodesic dome, 4m diameter and 2.5m height, where apprentice astronauts (4 – 5 persons of the audience) are invited to take place to travel in space on a turntable (3m diameter – red part in the figure). Space images are created by apprentice scientists (5 persons of the audience) who perform live experimentations. Experimentations are filmed by webcams. Images are processed by a dedicated software created for the show (Max Software Tool) and then projected into the dome with a fish eye lens. Astronauts laid on a turntable (3.5m diameter). It is interesting for the show to give a motion to the audience. Their body can experience centrifugal force. *Créatures Compagny* believes that during the travel the turntable could trigger actions such as: motion changes, light changes, sound changes.

Project description and deliverables

The objective would be to prototype the smart turntable. A scaled-down model of the turntable should be built using an electrical motor (e.g. disco ball motor) and a circular plate. The students would be in charge of getting this plate smarter by equipping it with sensors.

- Design the mock-up
- Choose the best tools to develop a modular software able to control lights (DELs), sound and motor speed.
- Install sensor on the turntable to interact with the software

Deliverables would be a demonstration of the capability of the turntable mock-up. *CréatureS Compagnie* would help students by giving them specifications for the software and detailing actions needed from the software.

Next residency of the company is planned from August 18th till August 29th at Le Prieuré de Vivoin (72). The company would be happy to welcome students interested by the project to show them the dome and the installation.

Such development seems to exist and was led by ACROE – ICA laboratory [2]. The company is trying to be in touch with it. Then collaboration could be made with this laboratory.

[1] CréatureS Compagnie web site: creatures.free.fr

(D) Live Informer

Contact: Sébastien Bourguet

Keywords: Live software, development, wireless communications, hardware conception, embedded.

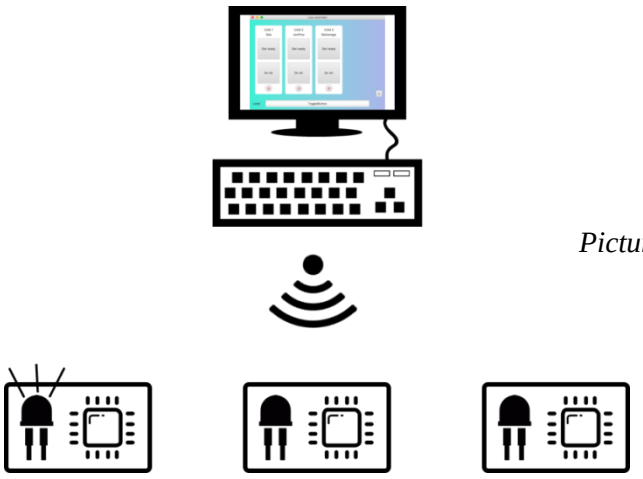
Skills: programming, wireless connection creation, hardware board conception.

Context

I want to develop a simple solution to inform camera operator during a live stream. In fact, I frequently work in video production and particularly in live streaming of events (like you can see on Facebook or YouTube). Generally for this case of event you need multiple camera operators, and one editor at the console to select to video stream that will be streamed. When operators are filming they don't know if they are online, or not, so they need to be always at 100%.
The idea of this product is to allow operators if they are on live with a simple and small case.

Project description

To sum up, the goals of this project is to help camera operators in live streaming.
I have made some searches and the main idea for the first prototype was to use a an embedded



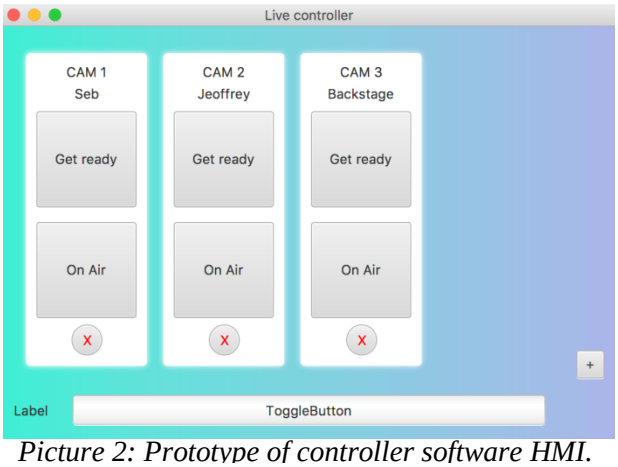
Picture 1: Project schematic

computer with a controller software (like Raspberry pi) as master controller and small embedded card as terminal for operator (like Arduino). See exemple illustration:

I have thought of 433MHz wireless unidirectional connection between controller and terminals.

A lots of functionalities could be added to this project like :

- Bidirectional connection (to allow communication between operator and editor.
- Bluetooth connection to controller, to allow controlling from mobile devices like smartphone or tablet
- Serial communication to the controller allow interfacing with video consoles.
- Create full terminal board.



Picture 2: Prototype of controller software HMI.

to

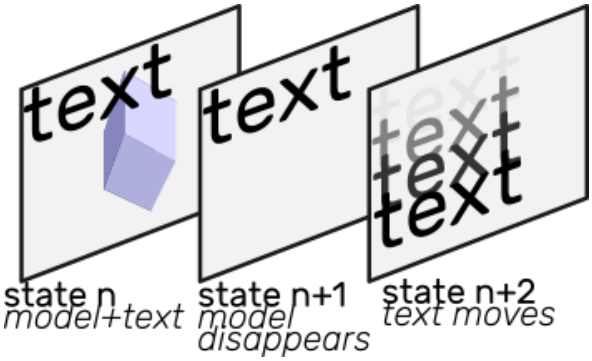
(E) Toboggan: an advanced presentation system

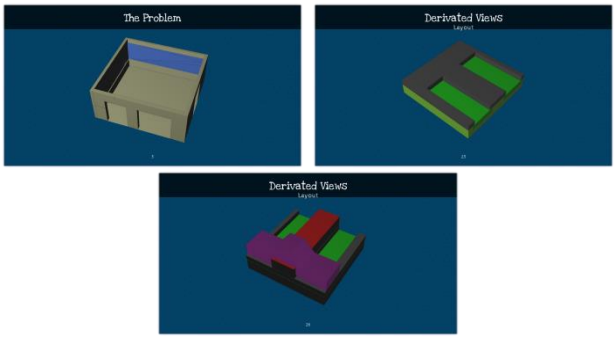
Contact: Simon Larguier

Keywords: presentation software, wiimote, states machines, development.
Skills: programming (Python, GLSL, XML), basic graphics design, good understanding of finite states machines.

Context

Toboggan is an advanced presentation system which aims to give a different approach from conventional tools found in office suites, or PDF. Toboggan aims to be a viable alternative to these tools. It will allow the user to use 3D models alongside his presentation, and various graphical effects usually found in games or movies (lights, fog and dust, etc.); and to use LATEX for advanced text rendering like formulas, or even drawings, schematics, diagrams. Toboggan core features will be: (1) dynamic presentations, and conditional transitions; (2) advanced 3D rendering alongside traditional content (text, images); (3) support for Wiimote and game controllers as input methods, for both controlling the presentation (go back and fourth, quit) and the render by selecting or moving 3D objects or lights. For Toboggan to be something else than yet another presentation program, slides will not be part of it. Instead, the presentation will behave like a finite state machine with which the user interacts, states transitions being light effects, animations, objects creation or destruction. Also, the Wiimote support is something really important, that can change the way a presentation is seen, and that can really make the presentation more dynamic. An experimental prototype has been developed for the REX presentation, which already features some elements like a basic state transition, some light effects and the inclusion of 3D models. It is developed as an open source project, but source code is not truly opened yet as I have been working alone on it.





Project description

The goal of the project is to implement most features of Toboggan, to create a technical demo of its capacities (i.e. a demo presentation); and to develop a basic graphical presentation editor. The save format will need to be redefined (current format is based on XML), better shaders will have to be written (using GLSL shading language), as with scriptable transition effects (for the moment, only a few hard coded transitions are available). Also, some custom file loaders for most of the usual 3D formats (obj, blend, etc.) will have to be developed, as the engine only support two of them (which can be easily exported, but requires a bit of knowledge of 3D editors like Blender).

The software uses Python as a programming language, and the 3D-engine used is Panda3D, a full featured and powerful game engine (free and open-source, well documented and easy to use).

For the Wiimote support, a bit of electronics might be required (infrared LED) and some lower level bluetooth interface.

(F) Home automation

Supervisors: Nicolas Barbot, Erwan Le-Saint (ST Microelectronics)

Emails: nicolas.barbot@esisar.grenoble-inp.fr, erwan.le-saint@st.com

Keywords: Home automation, Internet of Things, BLE, 802.11, STM32, CubeMX, HAL.

Skills: C programming**,** embedded systems, Web,

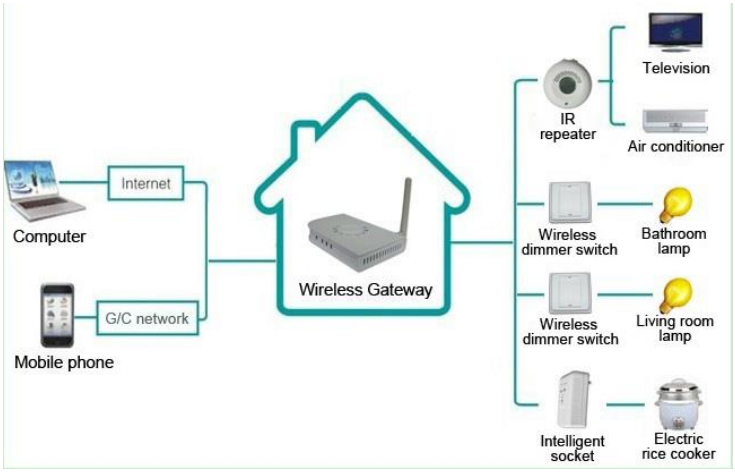
Project Context:

Home automation enables the monitoring and control of systems placed inside a building or a house. For example, it can permit to not only measure the temperature of a room or detect a human presence, but also to control the access to a room or switch the lights…

Project description and deliverables

The objective of this project is to develop a model and a complete solution for home automation.

The architecture of the solution is based on the use of node insides the environment. Nodes are connected to a gateway for sending or receiving messages. Protocol used for transmitting data can be 802.11 or Bluetooth LE depending of power consumption constraints. Moreover, monitoring and control of the house is done via web interface. Complete architecture is presented on the following figure:



Each node is built from a Nucleo 64 evaluation board which integrates a STM32 microcontroller (with or without low power profile) and different sensors and actuators (for example, fingerprint for access control, thermistor for temperature, servomotor for doors). Nodes also include Bluetooth (SPBTLE-RF) or wifi transceiver. Gateway ensures two different functions, collect and transmit messages to nodes and provide a web interface for the users (which imply the use of an application server).

Students have to develop a fully functional model of home automation that can permit to evaluate the potential of ST products for domotic application.

(G) Test of Mobile Apps using Crowdsourcing

Supervisors: Oum-El-Kheir Aktouf

Emails: Oum-El-Kheir.Aktouf@grenoble-inp.fr

Keywords: mobile apps, crowdsourcing testing, cloud-based mobile apps testing

Skills: software development (Java, Eclipse IDE). Other skills will be acquired (Spring platform, CloudFoundry, Hibernate, …)

Project Context:

In recent years, more and more mobile applications (mobile apps) have been developed to support different applications in social, news, tourism, health, business, and other domains. Hundreds of new apps are released and downloaded daily. By the end of year 2020, it is expected that the global revenue form the mobile app market will be 79 Billion USD whereas almost 378 Billion downloads of mobile apps will be performed (M. Neeraj. *Global Mobile App Revenue To Grow 2.2X by 2020*. https://dazeinfo.com/2016/04/20/global-mobile-app-download-revenue-market-2016-2020-report/) Consequently, testing mobile apps is a hot engineering topic and a challenging one as testing a mobile app induces to validate it on different hardware platforms, OS, Web browsers, many geographical locations for location-dependent apps, etc. Testing mobile apps requires new testing methods and tools (A. Méheust. *5 idées reçues sur le test d'applications mobiles à oublier absolument*. http://www.frenchweb.fr/5-idees-recues-sur-le-test-dapplication-mobile-a-oublier-absolument/221380#iWiokSo35Sbykoz2.99

The TMACS project (Testing of Mobile Apps using Crowdsourcing) at the LCIS lab. aims at developing a web or a cloud-based testing platform for mobile apps. This platform is based on crowdsourcing for allowing test coverage of both runtime platforms (OS, hardware device, Web-browser) and geographical locations. Crowdsourcing testing is the basic idea of the project.

Project description and deliverables

A web-based application is under development at the LCIS laboratory. This application, called TMACS provides important features for crowdsourcing testing of mobile apps by means of the following functionalities:

- It allows mobile app providers to register and upload mobile apps for testing;
- It allows volunteering Internet users to register and test uploaded mobile apps. Expected behabior is that uploaded mobile apps are tested by many different Internet users in order to cover different runtime platforms and meaningful geographical locations.

The above main functionalities of the platform have been developed.

The main objective of this innovation project is twofold:

- Validation of the TMACS application (testing plan, enforcing unit testing, integration testing, …). This aspect may require the development of new functionalities.
- Performance evaluation of the TMACS application in order to determine the critical load of testing requests, the mean testing time and the quality of testing results provided by the crowd-testers.

(H) SecureLOC : UWB based Secure ranging and LOCalization

Supervisors: B. Pestourie, N. Fourty, V. Beroulle

Emails: nicolas.fourty@iut-valence.fr; Vincent.Beroulle@lcis.grenoble-inp.fr

Keywords: UWB, localization, Raspberry PI, Arduino, security

Skills: embedded programming, wireless network communication, hardware security

Project Context:

The main objective of this project is to **secure an IR-UWB (Impulse Radio UltraWide Band) indoor localization system**. This localization system can be used for **security- and safety-critical applications**. These applications can be, for example, location based access control, automated safety checklist, emergency and rescue applications, and location based routing. These critical applications must be secure against attacks. In addition, the confidentiality of the distance measurements is also an issue in term of privacy. In fact, the location of people or things must be hidden to preserve the privacy of users. This work is related to a **hot topic which is the security of Internet of Things (IoT)**. Nowadays security and privacy of IoT applications are key issues for the development of this technology in our current life.

Project description and deliverables:

We want to develop a localization system based on IR-UWB chips. This development will be done into the Esynov platform. Then this localization system will be used as a demonstrator to emulate attacks and propose countermeasures. Indeed, current UWB ranging and localization protocols face the limitations of wireless communication standards and the limitations of chips. One of the main important limitation is the “non instantaneous delay computation” necessary for the chip to reply to a challenge in distance bounding protocols. These protocols are typical solutions against distance hijacking and frauds. As distance bounding are impossible in the context of 802.15.4a communication, then alternative countermeasures using multiple ranging will have to be tested and implemented.

So, this project **aims at developing a secure ranging and localization solution based on system-level countermeasures rather than physical solutions.** The proposed solution will have to be compliant with 802.15.4a communication standard (and its limitations). Moreover, this solution will also **consider (natural) transmission errors which cannot be neglected in indoor environments**. Finally this solution will also have to be **low cost and low energy**. Even if the developed countermeasures will use system level solutions, **a physical attack** (already identified and developed) **will be used to evaluate the system level solution efficiency**.

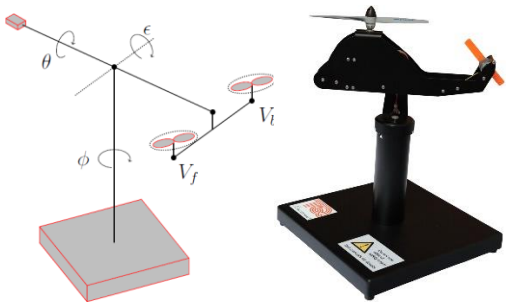
(I) Simulation, control design and experimental testing on a laboratory helicopter system

Supervisor: Ionela Prodan, ionela.prodan@lcis.grenoble-inp.fr

Skills: Modeling and System Identification, Control Theory, Informatics, Electronics

Context

The project will focus on modeling and closed-loop control of a laboratory helicopter using conventional control methods. The system consists of a body, carrying two propellers driven by DC motors, and a massive support. The body has two degrees of freedom. Both body position angles (elevation and azimuth) are influenced by rotation of propellers. Center of gravity is changed by moving small weight along the main horizontal axis of helicopter by a servomotor. The mathematical model of the helicopter system is a typical MIMO 2x2 system with significant cross-couplings. The electromechanical system can be linearized to a linear sixth-order model when operating near the steady state. A multifunctional card MF624 is used as interface module between PC based controller and helicopter system. It is designed for data acquisition and transmission. The card can be optimized for use with MATLAB/Simulink Real Time Toolbox. It also provides implementation of the control algorithms from the PC to the helicopter system. The user communicates with the system via Real Time Toolbox interface, all input/output signals are dimensionless and scaled into the MU (Machine Unit). The MATLAB/Simulink xPC Target Toolbox can be used to perform the experiments in real time applications.



An extensive range of experiments can be carried out with this apparatus. An example of experimental workflow is provided in the following:

- direct derivation of a general mathematical model using Lagrange equations, linearization and simplification;
- on-line identification of linear model parameters;
- system decoupling techniques, diagonalization of system transfer matrix and state space methods;
- the PC based controllers of the elevation and azimuth angle can be designed in MATLAB/Simulink;

At the start of their project activities the students have to:

- familiarize with existing nonlinear Helicopter dynamics,
- provide trajectory generation mechanisms and optimization-based control strategies;
- apply them in simulations over SISO/MIMO systems (nonlinear and linear systems).

Expected results

At the end of the project the students are expected to:

- be proficient with the Matlab/ Simulink environment and various toolboxes (Yalmip, MPT, Cplex for Matlab toolboxes);
- have tested the theoretical notions over experimental platforms provided by LCIS laboratory and to have obtained results validating them.

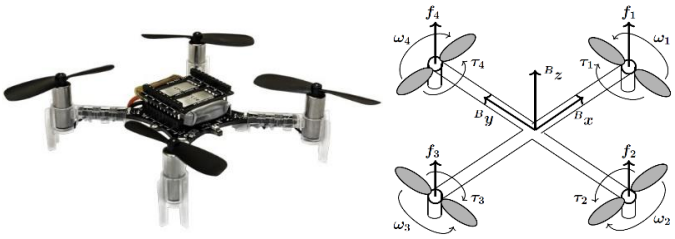
(J) Localization and hovering of a quadcopter platform (1 or 2 groups)

Supervisor: Ionela Prodan, ionela.prodan@lcis.grenoble-inp.fr, Ngoc Thinh Nguyen, ngoc-thinh.nguyen@lcis.grenoble-inp.fr

Skills: Informatics (Python, C, Matlab/Simulink), Modeling and System Identification (Newton-Euler formalism), Control Theory (PID, Nonlinear Control), Electronics

Context

The project will focus on localization and hovering implementation of a Crazyflie micro drone using an external positioning system interfaced with ROS (Robotic Operating System). The platform is composed from an aerial unit (the Crazyflie) and a host which sends/receives data through a dedicated USB radio dongle (the Crazyradio PA). The host platform can be either a Linux or Windows PC or an embedded system like Raspberry Pi or smartphone (in which case the communication is done via Bluetooth LE protocol). The Crazyflie quadcopter weighs 27 grams and the size is 92x92x29 mm. This quadcopter is equipped with an STM32 microcontroller, a 9-axis IMU sensor and a pressure sensor with a small Li-Po battery. This quadcopter is controlled either by the joystick/PC client or by the smartphone via wireless connection with 2.4 GHz Crazyradio PA and Bluetooth Low Energy module. The Crazyflie receives references from the ground and follows them in low-lovel control loops which are implemented on the embedded CPU installed on it. These references can be provided either manually (via joystick controllers) or as the result of computations on the host platform.



The project will concentrate on the following issues (any other ideas and innovative directions are strongly encouraged):

- understand the platform and its capabilities (Crazyflie http://www.bitcraze.se/crazyflie/);
- use the Loco Positioning system (a miniature GPS system) to find the absolute 3D position of object in space;
- solve and implement the hovering problem for the Crazyflie using an open-source platform for writing robotic software called ROS (Robotic Operating System) http://wiki.ros.org/;
- compare the results on ROS with the experimental results on the real platform;

At the start of their project activities the students have to:

- familiarize with existing nonlinear quadcopter dynamics,
- familiarize with the Crazyflie virtual machine and Loco positioning system
- familiarize with the ROS operating system.

Expected results

At the end of the project the students are expected to:

- be proficient with Python, C and Matlab/ Simulink environment and ROS;
- have tested the theoretical notions over experimental platforms provided by LCIS laboratory and to have obtained results validating them.

(K) BlockChainDemo

Supervisors: Stéphanie Chollet & David Hely & Laurent Pion

Emails: prenom.nom@esisar.grenoble-inp.fr

Keywords: block chain, embedded system design, web services

Skills: microcontroller programming, object programming, versioning, algo

Project Context:

The work will be carried out in the contexts of both smart grids and healthcare applications. The project involves LCIS team, the chair Trust, a G2Elab team, Orange and STMicroelectronics. Both smartgrids and healthcare applications would benefit of the blockchain technology. The main purpose of this work is then to investigate and develop a blockchain demonstrator which could suit these applications needs exploring issues at both server and embedded systems levels. During the projects the students will closely collaborate with industrial and academic partners.

Project description and deliverables

The main purpose of the project is to develop a block chain demonstrator gathering data from several connected embedded systems.

The students will first have to review existing platforms focusing on Ethereum. Then, the students will have to set up the blockchain infrastructure. Finally, simple embedded systems will be integrated in order to securely interact with the blockchain.

The deliverables are:

- State of the arts review of blockchain technologies
- The blockchain architecture
- The blockchain infrastructure
- STM32 based embedded systems (ES)
- Secure connection between ES and the blockchain
- A demonstrator with several connected ES

(L) Embedded Security Challenge

Supervisors: David Hely & Cyril Bresch

Emails: prenom.nom@lcis.grenoble-inp.fr

Keywords: Hardware Security, PLC, Fault attack, process control, PLC

Skills: microcontroller programming, automation control, PLC

Project Context:

The objective of this project is to participate the Embedded Security Challenge of CSAW.

Project description and deliverables

The theme of this year's competition is *cyberattack detection, isolation, and mitigation* for Programmable Logic Controllers (PLCs). PLCs are embedded systems deployed in cyber-physical environments, oftentimes controlling critical infrastructure. These systems are currently undergoing a modernization transformation, through the convergence of Operation Technology (OT) and Information Technology (IT), and the increasing use of Commercial-Off-The-Shelf (COTS) hardware and software commonly found in embedded devices. An unwanted side effect of this modernization trend is the increased exposure of the underlying physical systems to cyberattacks. Several real examples of cyberattacks against industrial settings have been reported over the past years, with the most prominent being Stuxnet, which targeted a uranium enrichment plant. ESC 2017 invites contestants to develop solutions for securing PLCs, and by extension critical infrastructure, from the far-reaching effects of cyberattacks. More specifically, the challenge focuses on the development of cyberattack-induced **error detection, isolation, and mitigation** strategies that can be **retrofitted to legacy PLCs** making them more resilient to contemporary cyberattacks. More information regarding the challenge is given through the following motivational scenario:

You have just been hired as a Chief Security Officer (CSO) at *CannotPwn Factory*. The previous CSO resigned after a sustained cybersecurity breach caused huge financial losses to the factory through injection of malicious logic on PLCs, which caused the industrial process to run suboptimally. To expedite incident response for future cyberattacks, before leaving the company, your predecessor procured several PLCs from different vendors and preprogrammed them as backup. You, as the new CSO, must come up with a solution that makes use of these redundant, diverse PLCs and would avoid future compromise. The assumptions and high-level requirements you pass along to your team of engineers for the new *intrusion detection and prevention system* you want to roll out are:

- You need an **error detection, isolation, and mitigation** system that can detect cyberattacks against vulnerable PLCs, isolate/filter the malicious inputs, and recover/mitigate their effects, providing resiliency and fault tolerance to the process. The cyberattacks you want to protect against may (a) introduce malicious inputs to PLCs, which will in turn manifest as errors in the PLCs outputs, or (b) subvert the control flow of the controller and generate malicious outputs irrespective of the inputs.
- You can make use of the **redundant** PLCs which have been programmed to have the same blackbox functionality, but achieve it through different implementations. Effectively, this means that when a cyberattack occurs it can affect **all PLCs**, but the attack **will not manifest in the same way in all PLCs**, or **an unknown subset of the PLCs may remain unaffected**. Moreover, redundant PLCs may be used as hot-backups that remain on stand-by until needed.
- Your new security system must be able to be **retrofitted to the field-deployed legacy PLCs**, without the need to make any modifications to the legacy controller (i.e., the PLC program source may not be available, and cannot be updated).
- The physical process in CannotPwn Factory has **inertia** meaning that it can sustain minor fluctuations, without rendering the entire system unusable.

(M) HackMyMCU

Supervisors: David Hely & Athanasios Papadimitriou

Emails: david.hely@lcis.grenoble-inp.fr

Keywords: side channel attacks, embedded SW, fault attack, hardware security, crypto

Skills: microcontroller programming, HW security

Project Context:

The work will be carried out in the context of the European project research Serene-IoT. The main purpose of this project is to develop safe and secure IoT systems for medical applications. The project involves several major companies such as STMicroelectronics, Orange… The LCIS will contribute to SERENE_IoT by developing low cost hardware based security countermeasures to provide a secure execution of the IoT node. Alongside, LCIS will develop tools to emulate the HW & SW under development within the system by modeling the various threats for security evaluation. This will allow to validate and to optimize the robustness and security of the IoT node taking into account all the system elements of an IoT environment. During the projects the students will closely collaborate with ST and LCIS teams.

Project description and deliverables

The main purpose of the project is to develop an evaluation platform of STM32 mcu aiming at evaluating the hardware vulnerabilities of software based cryptographic functions.

The students will first have to review existing hardware vulnerabilities against cryptographic services. These vulnerabilities are mainly side channel attacks and fault tacks. The main cipher function which will be studied here is the AES.

Then, the students will have to develop (or adapt existing ones) to perform side channel attack against STM32 mcu embedding a software based AES function (using both EM and power canals).

Fault attacks evaluation will also been developed using voltage glitch principles. A demonstrator will be designed in order to be capable of injecting errors through power glitch to perturbate the system.

Finally, simple software based countermeasures will be developed and tested to secure the crypto system.

The deliverables are:

- STM32 based platform for side chanel attack
- STM32 based platform for voltage glitch attack
- A demonstrator using both platform on naïve AES software design to demonstrate side chanel and fault attacks
- SW based countermeasures to protect the ciphering functions against hardware vulnerabilities

(N) URSUL: Usefull Ranging System Using Lora

Supervisors: André LAGREZE, Youness LAMI

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Keywords: embedded systems, network of wireless sensors

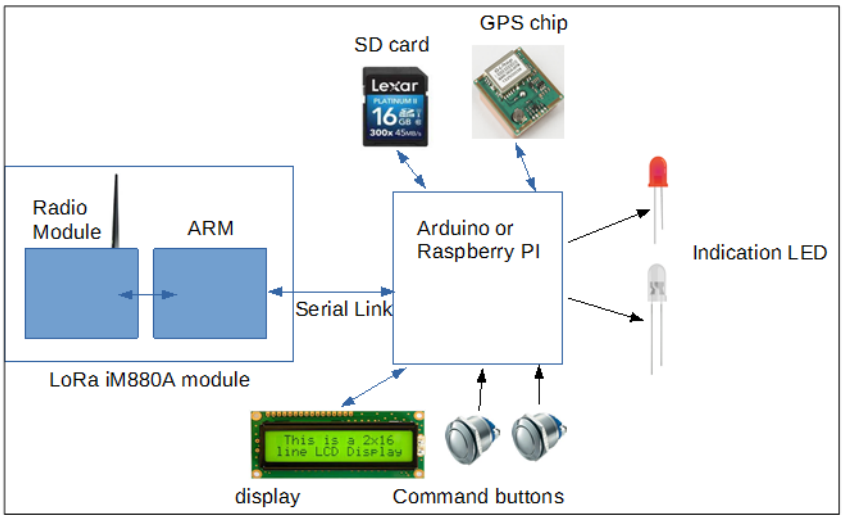
Skills: C and C++ programming, embedded programming, ARM architecture, Arduino, Raspberry Pi, LoRa technology

Project Context:

This project purpose is the conception and realization of a device to study the maximum reach of a LoRa communication between two systems. This project takes place in an other project aiming at the instrumentation and supervision of the irrigation channel of Bourne. This will be done by wireless sensors network with LoRa technology. To settle each node of this network, we have to estimate the range of the communication between the node and its neighbor nodes.

Project description and deliverables

The whole system will consist of two rough boxes (we want to evaluate performance in real environment). Each box will contain an electronic board, the architecture of which is shown below:



The expected features are :

"ping-pong" LoRa link between two boxes.
indication by LED of frame reception and frame emission.
estimation of distance beetween the two boxes based on GPS data (if they are received)
estimation of distance beetween the two boxes by the measure of RSSI (Received Signal Strength Indicator)
recording and time stamping on SD card of all frames and estimated distances.
local display of usefull data.

(O) Smart Contenant : Contenant connecté communiquant avec une passerelle cloud

Supervisors: Gérard Pospischek

Emails: gerard.pospischek@gmail.com

Keywords: *Smart BLE, IoT, Lora, Zigbee, Wifi, Wisp, Rfid, cloud, basse consommation, Sécurité, Mesh*

Skills: *Communication sans fil, Programmation Java, Python, C,C#, Php, électronique embarquée, antennes, système de communication, électromagnétisme*

Les besoins de la Supply Chain sont importants dans des domaines comme :
Gestion de parc, Inventaires automatiques, Localisation Indoor, Géolocalisation Outdoor, Sûreté, Surveillance d'actifs, Optimisation des chargements, des livraisons, …

D'une manière générale partout où l'intervention humaine est aujourd'hui nécessaire, il faut rechercher une automatisation visant à supprimer l'erreur humaine, et diminuer les risques physiques (manutention, TMS, ..), faciliter la remontée d'informations vers des systèmes de plus en plus complexes via des API, ou des Webservices.

Le développement des technologies de communication sans fils et basse consommation (Smart BLE, Wifi, Zigbee, NBIot, Lora, Sigfox, …) ainsi que les technologies de radio identification (RFID Uhf, Nfc, Wisp, …) peuvent être combinées avec des capteurs, et différents objets connectés dans des réseaux hétérogènes.

Ainsi apparaissent sur le marché : des palettes géolocalisables, de la géolocalisation d'entrepôt, des plateformes de suivi et d'optimisations des transports, …

L'objectif de ce projet est de développer un système pouvant s'intégrer à des contenants palettisables, ou à des palettes, qui, grâce aux combinaisons technologiques, permettra de pouvoir assurer des contrôles automatiques, et permanent, en temps réel, de présence d'objets, ou de marchandises, dans un champ restreint à l'espace du contenant (exemple des boites de formats différents jusqu'à la palette 80x120x200 cm).
Les contraintes d'environnement sont variées et nombreuses (proximité de différents contenants, différentes palettes, container métallique, mouvement, chocs, …)
Les contraintes énergétiques sont fortes, les éléments composants l'infrastructure du système (équipement des contenants notamment) doivent avoir une durée de vie longue (> 48 mois) sans recharge.
Il faudra privilégier pour les marchandises et objets un système d'étiquetage ou de marquage passif car ils ne pourront pas « embarquer » des tags onéreux qui seront « perdus » dans le transport.
La contrainte économique est également forte sur le matériel à mettre en œuvre ainsi que sur les équipements, ils devront donc être à faible coût.
Les contenants pourront être actifs car consignés et, seront, à ce titre, réutilisables (durée de vie > 48 mois).

Il faudra que chaque Contenant puisse être reconnu et identifié au sein d'un réseau basse consommation de type Mesh.

Le but de ce réseau vise à pouvoir, cycliquement, détecter, enregistrer et transmettre vers une passerelle connectée à un serveur cloud, des informations concernant le contenu de chacun des contenants détecté dans le champ de la passerelle.

Ce type d'approche a pour but de diminuer drastiquement les contrôles humains, assurer le maintien d'une permanence d'informations et garantir une intégrité maximale des contenants en historisant en temps réel les événements durant toutes les phases de la Supply Chain.

Les données devront être sécurisées de bout en bout.

(P) Développement de fonctionnalités RF avancées à partir d'un smartphone

Encadrant : E. Perret
Mots-clés : Smartphone, Applications Android, mesure de puissance RF. .
Compétences : Programmation (Android), électronique analogique et RF.

Aujourd'hui des technologies de pointes sont intégrées dans les smartphones. Ces objets du quotidien sont quasiment omniprésents autour de nous et les dévoilements des nouvelles technologies passent le plus souvent à travers ces objets-là. Ceci permet de donner accès à chaque utilisateur un très grand nombre de fonctionnalité, sans pour autant nécessiter d'acheter un équipement spécifique pour le service fourni.
L'objectif de ce projet est d'utiliser au mieux des performances de ces smartphones pour réaliser des fonctions originales, c'est-à-dire détournée de l'utilisation. Ces fonctions consistent à chercher à mesurer des paramètres physiques au moyen de ces appareils, paramètres physiques qui d'ordinaire nécessitent un appareil de mesure spécifiques c'est-à-dire ici un analyseur de spectre ou de puissance. On cherchera ainsi à mesurer des puissances de signaux RF, comme ceux à 2.45 GHz utilisés pour le Wifi. A partir de là, l'idée des d'utiliser deux smartphones de manière à pouvoir réaliser des mesure de transmission de puissance, voire de réflexion suivant le positionnement physique des appareils.
Les étapes du projet sont décrites par la suite :

- Réaliser un état de l'art sur les smartphones les plus courant, rechercher les bandes de fréquences émissent par ces appareils et les fonctions Android permettant de récupérer des informations des signaux RF émis ou reçus. Beaucoup de fonctionnalités sont bridées (par exemple autour des signaux GSM), c'est-à-dire non accessible à l'utilisateur, aussi il convient d'identifier celles utilisables. Cette recherche consiste également à regarder les applications Android déjà présentes (open source ?) et permettant par exemple de caractériser les réseaux wifi.
- Une fois réalisé le choix des fréquences, un premier programme Android consistera à d'implémenter les fonctionnes de base pour émettre des signaux et mesurer la puissance de signaux reçu. Des équipements de laboratoire (oscilloscope 10GHz, analyseur de spectre 26 GHz) seront accessibles aux étudiants pour réaliser des mesures qui permettront de valider cette première étape.
- L'idée est d'arriver à réaliser une mesure de transmission de puissance (idéalement de phase également… en fonction des possibilités des appareils) entre deux smartphones. Pour ce faire un premier smartphone (N°1) doit être capable de déclencher l'envoi d'une trame depuis le second appareil (N°2) et de mesurer la puissance de cette trame (au niveau du N°1). A partir de là, si on considère que l'on connait la puissance émisse par le 2nd appareil ainsi que celle mesurée par le 1er on peut en déduire la puissance transmisse (ou encore l'atténuation du canal par exemple). Une phase de calibration sera réalisée avec les appareils de laboratoire. De même, un banc de mesure garantissant une distance constante entre les deux appareils pourra être réalisé avec une imprimante 3D.
- Pour caractériser les nouvelles fonctions réalisées, des motifs RF de type Frequency Selectif Surface (FSS) seront conçus et réalisés en technologie planaire. Ces motifs devront résonner à la même fréquence que celle où la mesure de transmission est possible. Ces motifs seront placés entre les deux smartphones et la mesure de transmission sera effectuée. Là encore une comparaison avec la même mesure réalisée avec des appareils de laboratoire sera effectuée.

(Q) Développement d'une application Web pour lecteur d'identifiant RF

Encadrants : S. Chollet, N. Barbot, E. Perret
Mots-clés : UWB, RFID Chipless, Capteurs, Matlab, Java EE, Red Hat WildFly, HTML5/CSS3, Bootstrap, WebSocket.
Compétences : Programmation Java et Matlab, Applications/Programmation réparties, Antennes, Electromagnétisme.

La technologie RFID chipless est une solution d'avenir permettant d'identifier un objet par ondes radio fréquences. Ce système se compose d'un tag sans puce (placé sur l'objet à identifier) ainsi que d'un lecteur permettant d'interroger et de récupérer l'identifiant du tag totalement passif.

Dans le cas de la technologie RFID sans puce (chipless), le lecteur reprend les fonctionnalités d'un radar UWB à savoir l'émission d'un pulse très court et l'échantillonnage du signal rétrodiffusé par le tag. Le LCIS a développé sa propre solution chipless, à savoir un lecteur dédié ainsi que des tags réalisés par impression jet d'encre conductrice. Une démonstration de cette toute nouvelle technologie à mi-chemin entre le code à barres et la RFID avec puce a été faite dernièrement lors du salon international *la Drupa* à Düsseldorf.

Aujourd'hui la récupération des données d'identification RF est faite avec l'outil Matlab. Cet outil permet de s'interfacer avec le lecteur ainsi que de traiter et d'afficher les résultats localement. L'objectif du projet est de développer une application répartie qui permette de consulter ces mêmes résultats via une interface Web et de garder un historique des valeurs d'identification lues. L'interface Web doit être responsive ; c'est-à-dire s'adapter aux écrans des smartphones, tablettes et PC. En parallèle, il est demandé de modifier l'algorithme de traitement Matlab pour augmenter la performance ainsi que de déterminer d'autres informations comme la distance ou encore l'orientation du tag.

A terme, la fonction d'identification et de récupération des informations venant des capteurs devra se rapprocher des solutions de mesures autoalimentées, comme le WISP, mais ici uniquement à partir d'un objet totalement passif que l'on déplacerait dans la zone de lecture du radar. De plus, l'interface Web devra se mettre à jour dynamiquement en fonction des mesures faites avec la technologie des WebSockets.

Un premier projet sur ce sujet a été proposé en 2016-2017. Un travail de fond a été réalisé par le groupe d'étudiants, et une solution plus ou moins fonctionnelle a été obtenue. Ceci a permis de démontrer la preuve de concept, toutefois la solution développée reste lourde à mettre en place, nécessitant l'installation d'un grand nombre de drivers, ce qui la rend incompatible avec l'utilisation visée. De même le temps de lecture est trop grand (de lors de plusieurs secondes) ce qui ne répond pas à la problématique posée.
C'est pourquoi l'objectif de ce projet consiste à repartir de l'existant, à le comprendre puis à le faire évoluer de manière à répondre aux principaux problèmes observés en pratique. Il sera également attendu d'intégrer une fonction capteur de déplacement, fonction qui n'avait pas été implémentée l'année dernière faute de temps.

Vidéo du WISP contrôlant par sa position, son orientation :
https://youtu.be/SKQ3wkAqA_8
Informations sur les WISP :
http://sensor.cs.washington.edu/WISP.html

(R) BUILDING A CYBER-PHYSICAL SYSTEM SIMULATOR

Supervisors: Eduardo Mendes and Ioannis Parissis

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Keywords: Synchronous programming, testing, Java programming, physical system modelling

Skills: Java programming, synchronous programming (CS442) is a plus

Project Context:

Synchronous programming of safety-critical reactive systems requires intensive testing and simulation. Manually generating test input sequences can be extremely hard as well as observing the behaviour of the system under test. An example of such a situation has been provided in the CS442 class (Synchronous programming with Lustre/SCADE) where a Steam-Boiler control software application has been implemented by students. To test this application before its effective deployment, it is necessary to simulate the steam-boiler behaviour in a realistic way. This can be done manually, but in that case the simulation is hard and not reliable. Automating this simulation requires the definition of adequate mathematical models of the steam-boiler and their implementation as simulators. Such simulators must be able to reproduce several execution scenarios including failure and failure-free situations. In fact, implementing such a digital representation of a hardware device is a frequently used approach to test cyber-physical systems.

The objective of this project is to build such simulators, based on various models, providing a graphical representation of the steam-boiler giving easy to understand feedback of the system evolution as well as an easy way to introduce user-defined inputs to the software application.

Project description and deliverables

The full specification of the steam-boiler must be studied in order to define all the possible states, inputs and outputs that must be represented. This can be based on several models (proposed, for instance, in the scientific literature. The expected deliverables are:

- The documented models of the steam-boiler that will be implemented
- A Java application and associated documentation (Javadoc, used guide) that interacts with the control application:
  (1) Providing a graphical representation of the steam boiler and all its devices (valves, pumps…)
  (2) Updating the state of the boiler according to the commands sent by the software application.
  (3) Giving the user the possibility to change the boiler state (for example by introducing a device failure).
  (4) Optionally, connecting this tool to the luciole and sim2chro utilities.

(S) AutoGarden : the farming robot

Contact : Gaëtan Kussler (gaetan.kussler@etu.esisar.grenoble-inp.fr) & Loïc Philippot (loic.philippot@etu.esisar.grenoble-inp.fr)

Keyword : automation, robot, microcontroller, hardware bot creation, web development, application development

Context : We want to develop an automated planting which could be able to realize farming action, such as plantation, control of humidity, control the maturation of fruits/vegetables etc. Such a project already exist and it's called FarmBot. We don't want to reproduce exactly the same structure but it could be close to that final result (see Picture under).

Project description : The base system could be similar to a 3D printer. The idea is to develop a solution with several pots which can contain different kind of plants (fruits, vegetable, …) and create a system which is built around 2 axes. An instrumented head could advance in order to execute several operations defined by us, as planting, watering, control of parameters (luminosity, humidity) with the help of many sensors. That head could move on a slide horizontally and also up and down on it. If the time permit it, we can also add a 3rd axe to cover a more important zone.

To control it, we thought of a microcontroller as a Arduino or even a more complex system with a Raspberry Pi. A HMI should be developed in order to inform the user or even to program the system automatically.

This system is innovative and modular. We also thought about Bluetooth connection, more features about farming or adding more sensors to the "instrumented head".

The final aim of the project is to have a physical structure which can automatically realize several farming functions and to have a HMI to inform the user of the good process of it.

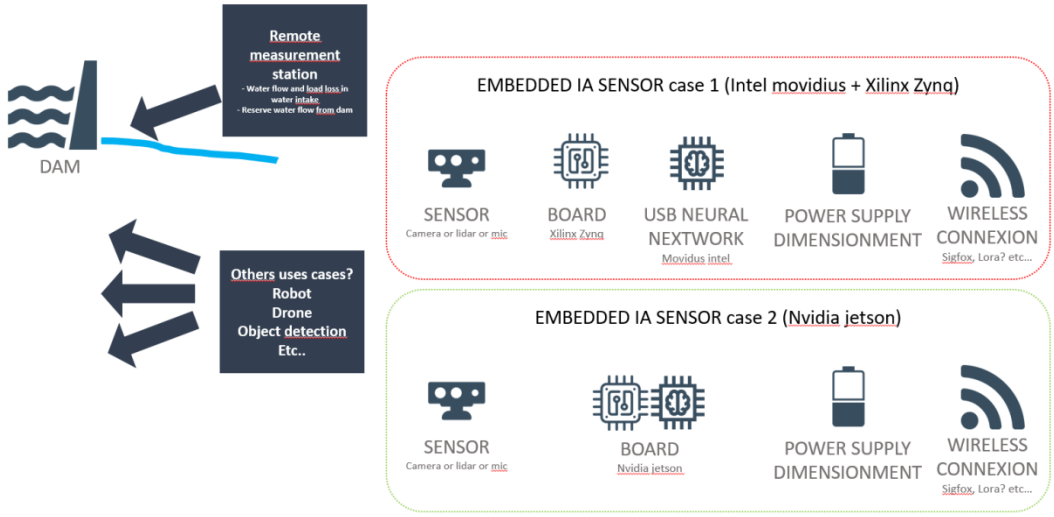
(T) Edge computing, Embedded Artificial intelligence

Supervisors: Yoann Biliato - 5APP - EDF
Emails: yoann.biliato@gmail.com
Keywords: edge computing, neural network, embedded Artificial Intelligence, Xilinx zynq
Skills: autonomy and team working, artificial Intelligence, software development, hardware integration

Project Context:
Who never heard about big data, artificial intelligence, machine learning, data science? We are surrounded by these technologies and it will continue growing exponentially. But companies are currently making their analysis in centralized datacenter. How can i do if i need privacy or have no network?. As system chip become more performant and tiny, we see a growing field that is call **edge computing**. The aim is to put the compute power and intelligence next to the sensor where network latency and bandwidth are issue. We have a system that analyze and predict in live, we obtain an **embedded AI system**. Big company such as the GAFAM ones (Google, Apple, Facebook, Amazon, Microsoft) are developing their own neural network chip to develop new application on their products. (ex: new iphone with a A11 bionic neural engine). Market examples are large such as autonomous vehicle, smart camera, smart drone, smart robot, augmented reality etc…

Project description:
The aim of this project is to have an operational embedded IA system. We will determine how to integrate it on a embedded system, interface it with the sensor and a wireless connexion, and code the algorithm.
We will use an existing dedicated neural network chip that we will integrate in a embedded system (Intel movidius + Xilinx Zynq or Nvidia Jetson) with an sensor for our application (camera or lidar or mic) and will have to define how to communicate to send the results.

As a use case, i propose to take a real one. One need in my company is to determine data from images for a remote measurement station. Data needs are the water flow and load loss of an intake water (prise d'eau) and reserve water flow (débit réservé) of the dam.
(But students are free to make others use cases propositions. Anomaly detection from sound, analysis of people's skin, smart drone, object classification, augmented reality etc…)



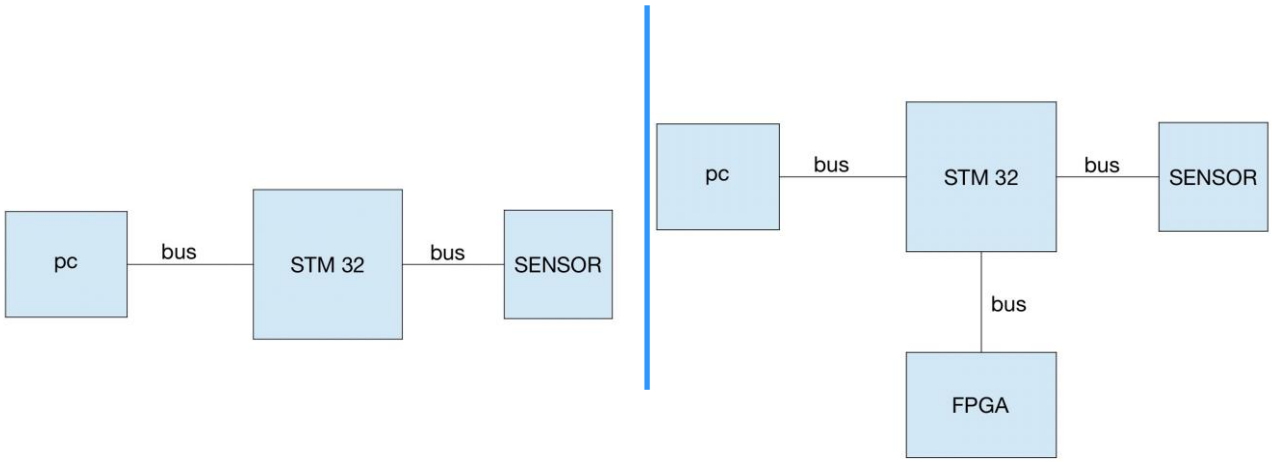
Deliverable:
Lot1: Functional embedded IA system with a simple algorithm (ex: fruit reconnition)
Lot2: Documentation to be easily implemented on others uses cases at ESISAR (like robotics club)
Lot3: Power consumption specifications
Lot4: Algorithm for hydraulic use case (or an other one?)
Lot5 (with time): Full embedded IA with communication remote

(U) Hardware acceleration of artificial intelligence algorithms on embedded systems with FPGA

Romain LE DONGE : romain.le-donge@etu.esisar.grenoble-inp.fr
Louka BARRIERE : louka.barriere@etu.esisar.grenoble-inp.fr

Introduction: Neural networks are today the key of data computation, classification… This has spread all around us, from the simple temperature control to autonomous cars. To achieve all that there are a lot of matrix operations, loops… It requires lots of computing power and can be problematic to do with a microcontroller. We plan to use a FPGA to perform and increase the speed of all heavy tasks such as matrix computation to improve the speed of the algorithm.

Description: Neural networks can be used in pattern recognition with data that can come from sensors. The main goal of this project is to compare performances between an embedded system with a microcontroller and the same system with a FPGA as the hardware accelerator for artificial intelligence computation. Execution times of each algorithms are sent back to the computer for comparison.



Deliverable: The group will have to develop a system that demonstrates the speed improvement of an embedded system doing artifical intelligence tasks with an FPGA. The STM32 can have an accelerometer to be able to get a concrete case of data source and the goal will be the detection of the movements of the STM32 (vertical/horizontal movements, shapes ...). Calculation time data will be sent back to the PC (UART ...). Students will have to choose the most appropriate protocol of communication between the different components of the system.

Skills: C/C++, VHDL/Verilog, Python, embedded systems

Keywords: Artificial Intelligence, Neural Network, Hardware acceleration, FPGA, STM32, Signal processing, Sensor

(V) Club Robot Automation

Contact: Quentin Le Gallic

Team: Quentin Le Gallic, Romain Forestier, Mathias Epstein Later, Felipe Sousa

Keywords: Raspberry PI, Arduino, sensors, wireless communication, power electronics

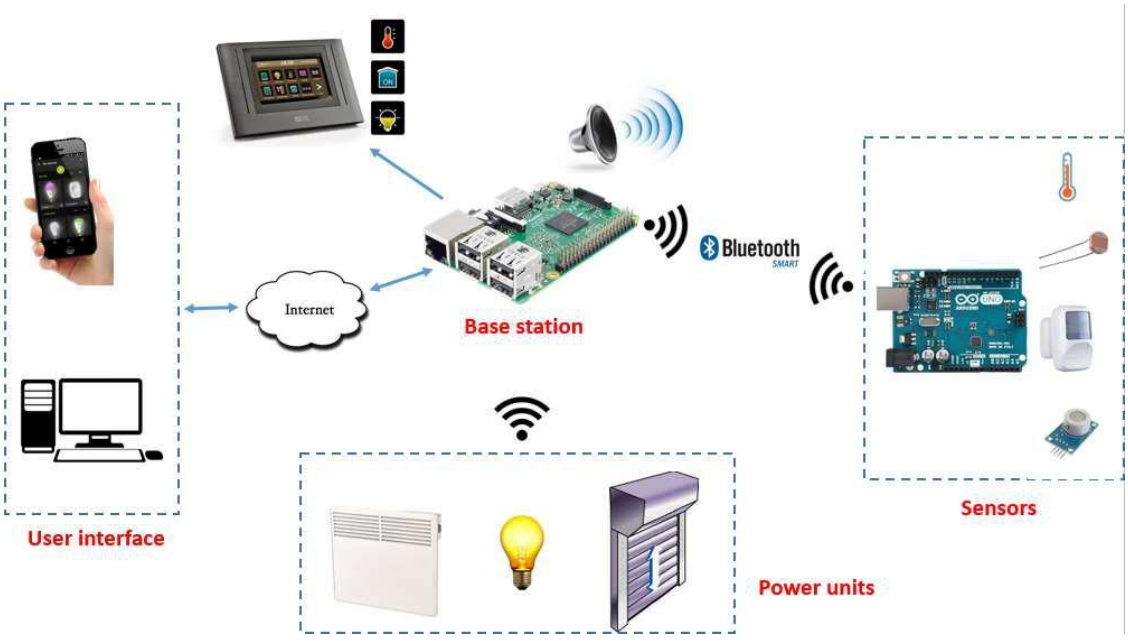
Skills: microcontroller programming, PCB, embedded system, web, integration

Project Context:

The robotic club wants to automate one of its rooms to increase the security and comfort.
The user will be able to control the room characteristics (temperature and brightness) and to visualize some security data from the room (intrusion or high level of gas) on a mobile device.
The control and visualization will be possible from outside and from inside the room.

Project description and deliverables:

The goal of the project is to automate the entire room. Thus, the system shall have to measure the temperature, humidity and brightness of the room and to regulate and maintain specifications given by the user.An HMI will be developed to simplify the utilization of the domotic system.



The system will be composed by a main base (Raspberry PI) which receives orders from the mobile device and sends information to it. This base will be connected to another microcontroller (Arduino) which will receive data from all the sensors. These data will then be used to control the power modules.
Visual information will be displayed on a screen placed on the main base to show critical data directly to the user.
In order to have low consumption, a BLE device will be used in the communication between the Arduino and the Raspberry PI. On the contrary, a simple BT device will be used to control the power units.
The information between the mobile device and the main base will be sent through a website.

(W) HOME AUTOMATION 2

Contacts:
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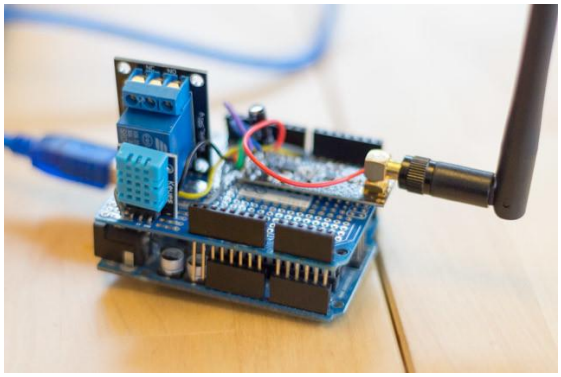


Keywords:
Home automation, Raspberry Pi, Arduinos, Sensors, Mesh Network, My Sensors, Electronic design, Battery

Project context:
Home automation enables the monitoring and control of systems placed inside a building or a house. For example, it can permit to not only measure the temperature of a room or detect a human presence, but also to control the access to a room or switch the lights…

Scenarios can be programmed to improve user's experience.

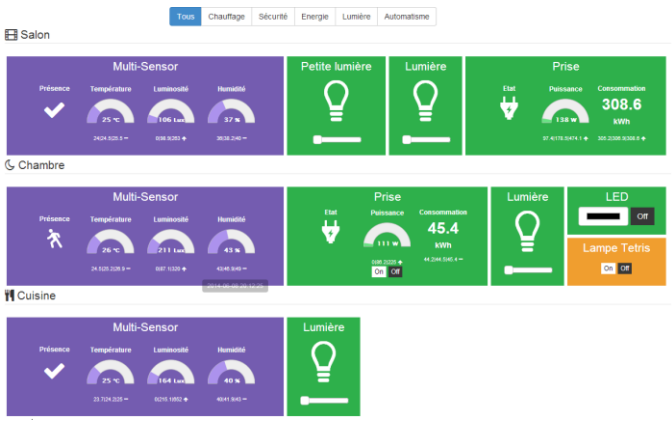
Project description:
The system is composed by a Raspberry pi and a node network. The network is a mesh network. Each node is driven by an arduino (nano or pro mini). Each node can embed multiple sensors.

The controller (Raspberry pi) runs on Jeedom (https://www.jeedom.com). Jeedom is an open source software that is developed for home automation. The jeedom team sells boxes with pre-installed jeedom. They also allow users to create a do it yourself installation with a raspberry pi image based on raspbian (debian adapted for raspberry pi).

Deliverables:
The goal is to provide nodes with multiple sensors. A single node needs to implement temperature sensor, lumen sensor, movement, …

It can also activate relays, lights, leds, or even power sockets.

The mesh network needs to be implemented: each node repeats a message if it is not aimed to itself.



Possible improvements:

- Designing a pcb to reduce power consumption.
- Running nodes on batteries to simplify installation.
- Creating the case for nodes and controller.

(X) Projection keyboard

Keywords : Micro controller - RaspberryPI3 - Script software - Video stream - Infrared sensor - Projector -.

Skills : Embedded code for Raspberry PI (C langage, Python), Interface programming, Video processing.

Project Context :

A projection keyboard is a form of computer input device whereby the image of a virtual keyboard is projected onto a surface: when a user touches the surface covered by an image of a key, the device records the corresponding keystroke.

Project Description :

The project consists of an embeded system of 3 modules (connected to a RaspberryPI3) : a projection module, a sensor module and a illumination module.

The projection module is used to display a keyboard on a flat surface when *the sensor module* will detect the coordinates of the user fingers when he touches any button on the keyboard.

The illumination module aims at diffusing an infrared laser layer upon the keyboard surface in order to help detecting the coordinates of the finger touching the surface: the infrared laser will be reflected by the finger to the sensor module.Then, by filtering the infrared vidéo stream and with the correct mapping, the software application will execute the desired fonction of the corresponding keystroke.

Deliverables : The keyboard laser, The softwar

(Y) Vocal Controlling Connected Lamps

Supervisor:

Contact: Samy Loulichki, Alexia Peiro, Valentin Bizeray, Arthur Landon

Keywords: Wi-Fi, Bluetooth, Android, Voice Control, Lamp, Raspberry, STM32, HMI, Arduino

Skills: C/C++ Programming, Java, Web languages, Web Protocols, Embedded System Programming

Context

Home automation enables the monitoring and control of systems placed inside a building or a house. For example, it can permit to not only measure the temperature of a room or detect a human presence, but also to control the access to a room or switch the lights...

Objectives

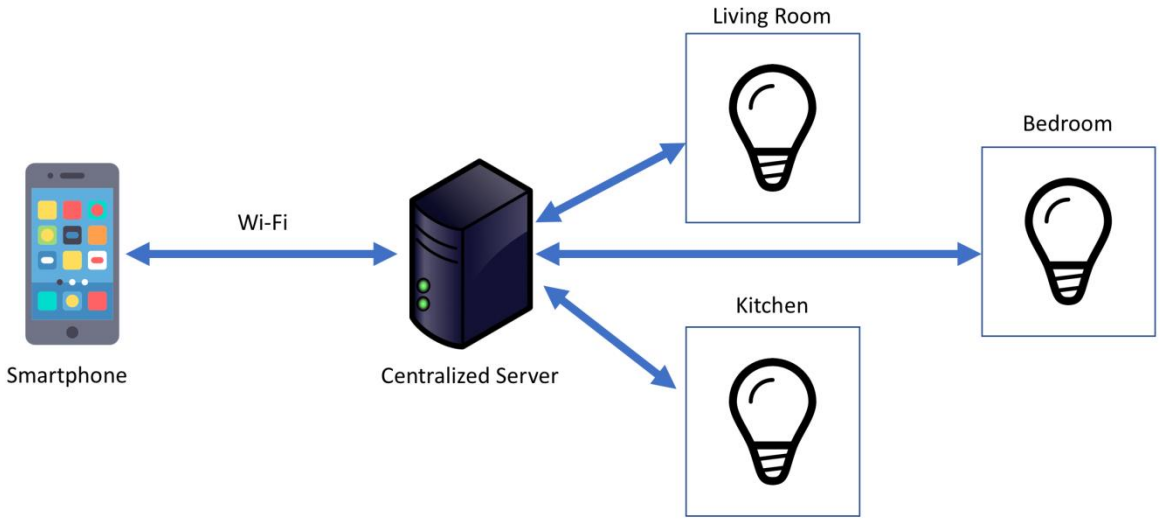
The idea of this project is to manage and control the state, the brightness and the color of all thelamps located in your house with an Android application.

Control and identification of the lamps will be done by voice control. A HMI will enable the user to choose the brightness level and the color.

Example: “Switch on the kitchen” will be turn on the light in the kitchen with the brightness and the color chosen in the app.

Information about consumption of energy will be monitored on the app.

The application will be connected to a centralized server which will communicate with every lamp.



(Z) Smart'AQ »:Android application for surveillance and control of an aquarium

keywords: sensors, automation, Internet of Things, android, matlab , kicad, software development

Required skills: graphic interface development, PCB, Bluetooth data transfer, control.

Context:

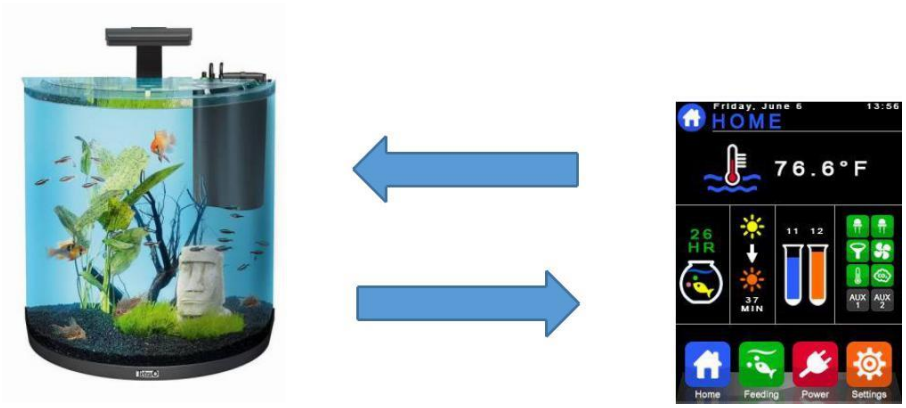
Within the context of developing innovative solutions for smart homes, this project aims to create a prototype for a connected aquarium that enables its user to monitor different local parameters in real time, view them via smartphones and implement some simple commands.

Project description and deliverables:

Sensors installed in the aquarium measure parameters such as temperature, luminosity, water level …

Design for a stm32 based electronic card to process incoming data from the sensors in the aquarium, analyze it and make a comprehensive feedback on the measured parameters.

Then, the data is sent through Bluetooth or IEEE 802.11 protocol to a smartphone application that allows one or multiple users to oversee it. When necessary, the user can send commands to actuators to engage the water filtration system, turn the lights on or off and feed the fish.



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