Politecnico di Bari Laboratories involved in Embedded Systems Design

Daniela De Venuto, Giovanni Mezzina, Michele Ruta, Eugenio Di Sciascio

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Laboratories Presentation

Led by **Daniela De Venuto**

- People:
  - ✓ **Giovanni Mezzina (research assistant)**
  - ✓ **Lucrezia Rutigliano (research assistant)**
  - ✓ **Valerio F. Annese (PhD student @Glasgow University UK)**
  - ✓ **Vincenzo Scarola (Technician)**
  - ✓ **3 Master thesis students**

Most Recent Research Projects:

- ✓ **AMICO: PON** ARS01_00900 2018-2020 – (Assistenza Medicale In COntextual awareness)
- ✓ **DIABESITY**: Regional Cluster 2016-2018 - Diabetes Integrated Monitoring System for self-care empowering promoted
- ✓ **PERSON:** FSC 2007-2013 Regional Cluster - PERvasive game for perSOnalized treatment of cognitive and functional deficits associated with chronic and Neurodegenerative diseases
- ✓ **INNOVAALAB** Regional Living Laboratory now promoted to **ENoLL**: European Network of Living Labs
- ✓ **CESAR RIDITT:** PON R&C 2007 -2013 – MISE D.M. 22 July 2009 – "Food safety and certification using RFID technology"
- ✓ **RES NOVAE:** PON R&C 2007 -2013 – "SUPPORTING INNOVATION" - operational objective: "integrated actions for sustainable development and for information society development"

Led by **Eugenio Di Sciascio**

Collaborations:

International Events:

IWASI 2007 · IWASI 2013 · IWASI 2015 · IEEE IWASI 2017

Laboratories Presentation

Led by Daniela De Venuto

Collaborations:

FINCONS GROUP

CONFINDUSTRIA

AUTORITÀ PORTUALE DEL LEVANTE

INFN Istituto Nazionale di Fisica Nucleare

AZIENDA OSPEDALIERA POLICLINICO BARI

exprivia

International Events:

2017 I-CiTies

TETHYS 2015 Toward Emerging Technology for Harbour sYstems and Services

ARGES

TETHYS 2014 Toward EmergingTechnology for Harbour sYstems and Services

gaia

Most Recent Research Projects:

- ✓ **ARGES:** "pAssengeRs and loGistics information Exchange System" E.T.C.P Greece Italy 2007-2013
- ✓ **ASMARA** "Applicazioni pilota post Direttiva 2010/65 in realtà portuali italiane della Suite MIELE a supporto delle Authority per ottimizzazione della inteRoperabili-tà nell'intermodalitA' dei flussi città-porto ASMARA PON
- ✓ **PERSON:** FSC 2007-2013 Regional Cluster - PERvasive game for perSOnalized treatment of cognitive and functional deficits associated with chronic and Neurodegenerative diseases
- ✓ **Ubicare:** "UBIquitous knowledge-oriented healthCARE" POR FESR 2007-2013
- ✓ **ERHA:** RADIOTERAPIA AVANZATA CON ADRONI/ ENHANCED RADIOTERAPHY WITH HADRONS - " 2014-2020 FESR Bando "HORIZON 2020"
- ✓ **RES NOVAE -** Reti, Edifici, Strade: Nuovi Obiettivi Virtuosi per l'Ambiente e l'Energia : PON R&C 2007 -2013
- ✓ **Puglia@Service** - Internet-based Service Engineering enabling Smart Territory structural development. PON-REC 2007-2013

SISINF LAB

Led by **Eugenio Di Sciascio**

- People:
  - ✓ **Michele Ruta (Associate Professor)**
  - ✓ **Floriano Scioscia (Post doc)**
  - ✓ **Agnese Pinto (Post Doc)**
  - ✓ **Giuseppe Loseto (Post Doc)**
  - ✓ **Giovanna Capurso (PhD Student)**
  - ✓ **Filippo Gramegna (PhD Student)**
  - ✓ **Saverio Ieva (research assistant**
  - ✓ **Ivano Bilenchi (research assistant)**
  - ✓ **Serena De Siati (Technician)**

Laboratories Presentation

Current Main Research Topics

Led by **Daniela De Venuto**

Brain Computer Interfaces
- Simulink-Matlab Signal Processing
- Time-frequency Analysis
- Remote Brain-driven Mechatonic Devices
- Improved Classification Algorithms

FPGA based sensor interfaces for Biomedicine
- Wearable Devices
- EEG/EMG-FPGA Interface
- Fall-prevention System
- Diabetes Monitoring
- Parkinson's Disease Stage Recognition
- Neuro-cognitive Assessment

Electronic Systems and Applications
- Integrated Circuit Design
- Design tool for Class-E Amplifier
- Pro-active WSNs for food safety and certification
- Power System for Wireless Neural Recording
- Biodegradable Endoradiosonde

Led by **Eugenio Di Sciascio**

Artificial Intelligence
- Knowledge Representation
- Knowledge discovery
- Skill and competence management
- Semantic Web and technologies

Distributed Information Systems
- Big Data
- Linked Open Data
- Model Checking
- E-Commerce and Automated Negotiation
- Decision Support Systems
- Service Oriented Architectures

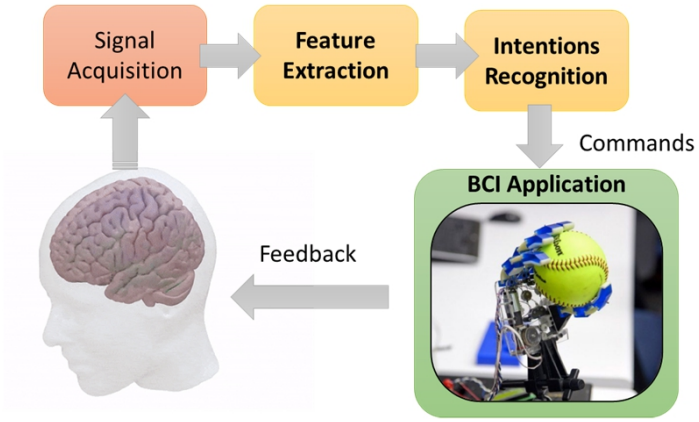
Pervasive Computing and Ubiquitous Web
- Domotics and Smart Cities
- Data/Text mining for Information Retrieval
- Internet of things
- Vehicular Networks
- Mobile Apps

DEISLab: Research Interests

Activity: P300-based Brain Computer Interface for Mechatronic Device Driving
Collaboration with: University of Glasgow (UK)

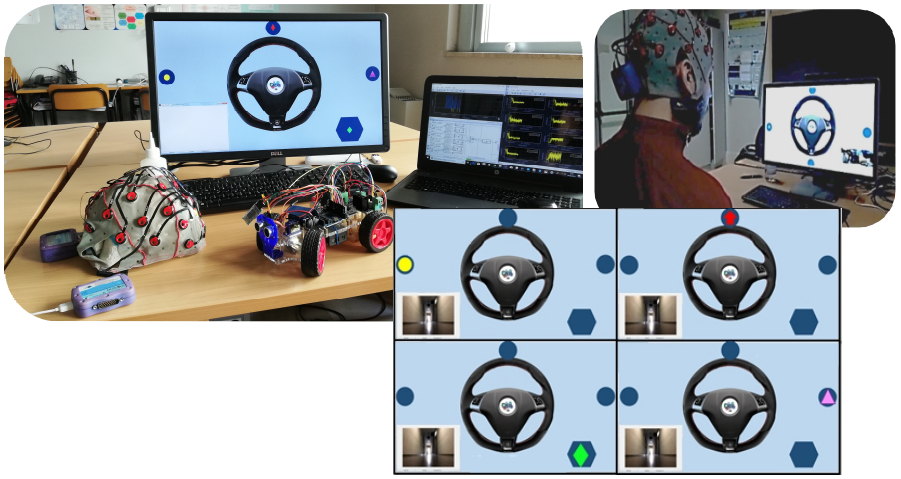
The Brain Computer Interface

A "Brain-Computer Interface" (BCI) is a direct communication channel between human brain and external devices by using a computer. The BCI is based on the recognition of a particular Brain Activity Pattern (BAP). In our case, the BAP is the event related potential (ERP) : P300.



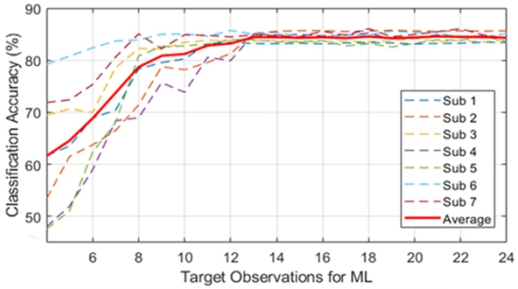
The Proposed BCI Architecture

EEG data are acquired by 6 smart wireless electrodes from the parietal-cortex area. The processing unit is hosted on a µPC performing stimuli delivery, data gathering, Machine Learning (ML) and real-time classification leading to the user intention recognition. The ML stage is based on a custom algorithm (t-RIDE) which trains the classifier on the user-tuned P300 reference features. The Raspberry-based navigation unit actuates the received commands and supports the mechatronic devices.



Key Results

The P300-based BCI has been tested on a prototype car based on Rapberry Pi. The ML stage uses an innovative algorithm, which guarantees implementation of a subjectivity-based feature selection, allowing a classification rate: 84.28 ± 1.24 %.



Accuracy by Subject (%)

	T1	T2	T3	T4
Sub1	83.42	83.68	89.8	84.9
Sub2	87.82	85.05	88.01	85.32
Sub3	86.78	80.78	85.78	83.69
Sub4	84.75	84.81	84.82	81.59
Sub5	85.39	80.63	83.46	80.87
Sub6	85.44	84.5	85	85.06
Sub7	84.34	85.03	74.37	84.68

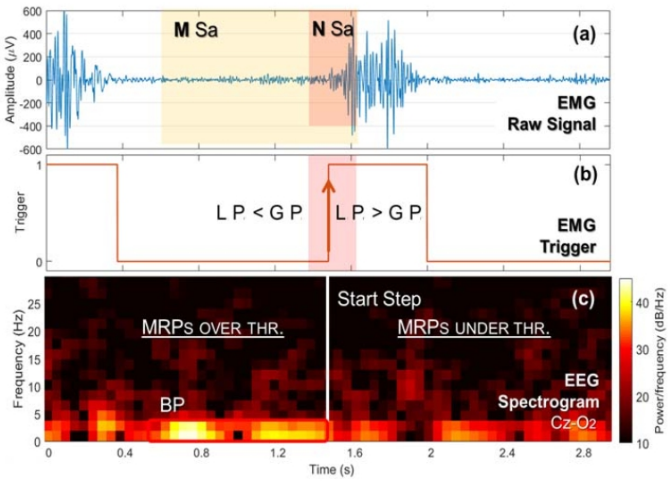
DEISLab: Research Interests

Activity: A Cyber-Physical System for Fall Prevention by Cortico-muscular Coupling Detection

Collaboration with: University of California at Berkeley (US), University of Bari (Neuroscience Dept.)

Motivations: EEG and EMG

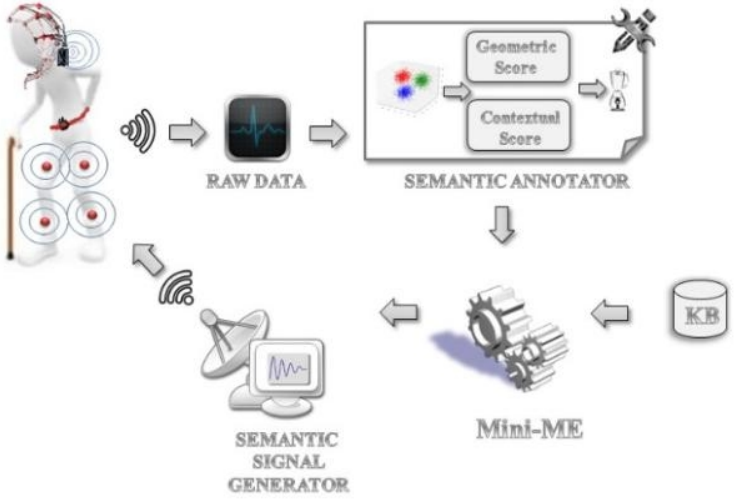
Voluntary movements are preceded Movement Related Potentials (MRP) in the motor area of the brain, i.e. Bereitschaftspotential-BP-(2-5 Hz), μ-rhythm (7.5-12.5 Hz) and β-rhythm (13-30 Hz).



The Cyber-Physical System

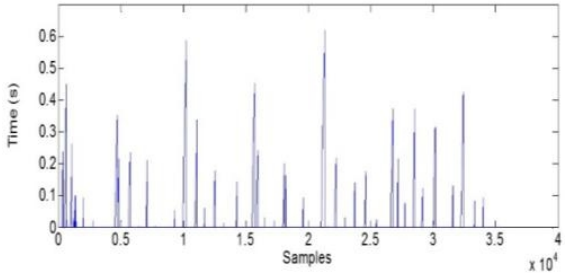
Real time acquisitions and elaborations of synchronized EEG/EMG data for involuntary and dangerous movements detections.

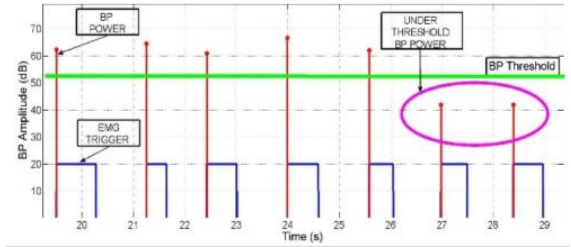
Applications : Medical diagnostic in neurodegenerative diseases and health-care systems for home assistance. Falls preventions by detection of involuntary movements and bio-feedback to control them



Key Results

When a EMG contraction a time-frequency analysis on EEG signal is performed. The goal is the detection of MRPs: if MRPs are detected, the movement is considered intentional. Otherwise a critical situation is detected



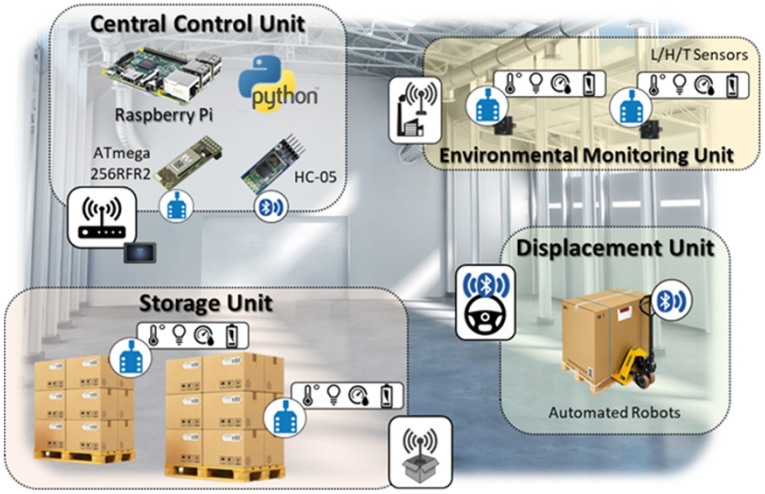


DEISLab: Research Interests

Activity: Spatio-Temporal Optimization of Perishable Goods' Shelf Life by a Pro-Active WSN-Based Architecture

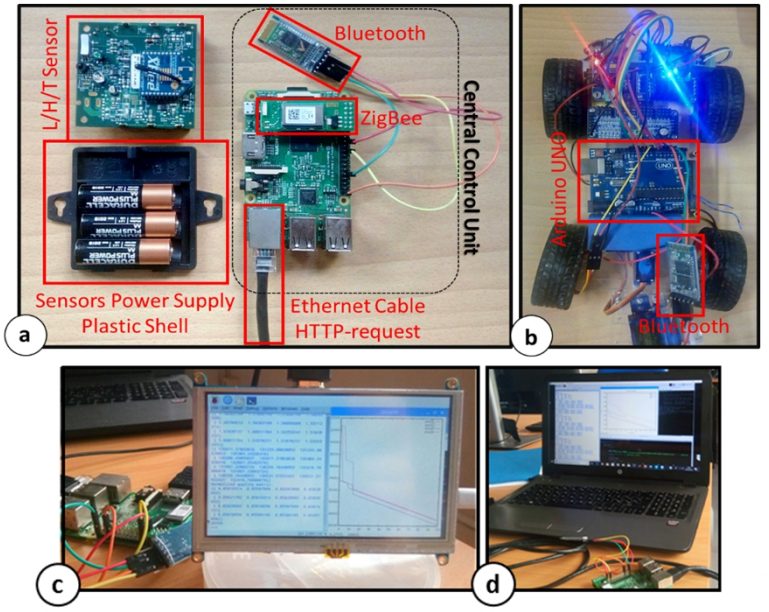
Wireless Sensor Network

A complete infrastructure for the monitoring of perishable goods supply chain, based on the combination of the wireless sensor network technology and a further data processing for shelf life prediction, has been developed.



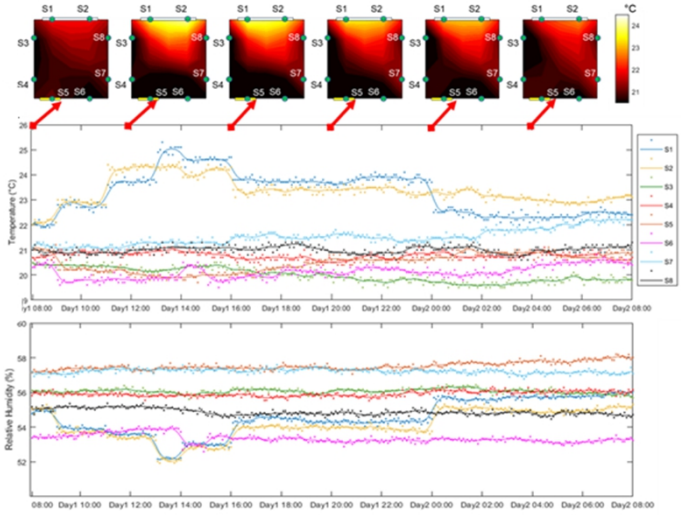
Adaptive Shelf Life Prediction

Architecture components: (a) L/H/T sensor and Raspberry Pi 2 Model B+ equipped with ZigBee and Bluetooth modules (b) prototype car driven by Arduino UNO core and Bluetooth. (c-d) Snapshots of Central Control Units



Key Results

The shelf-life prediction is based on an algorithm exploiting a first-order kinetic model in which the degradation rate follows the Arrhenius Law. The system has been tested on 4 pallets.



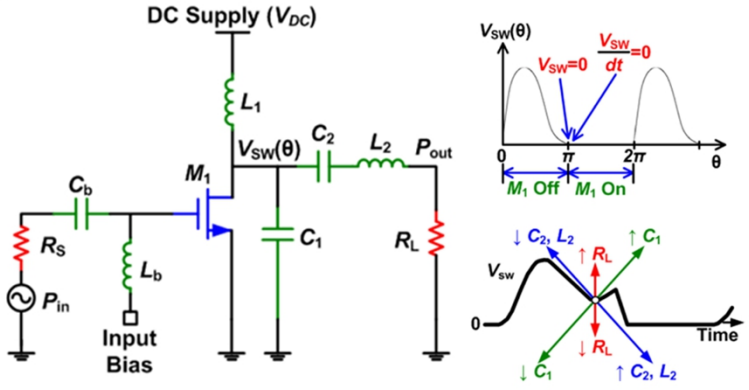
DEISLab: Research Interests

Activity: State Space Model-Oriented Design for Efficiency Improvement of Class E PA

Collaboration with: University of California at Berkeley (US)

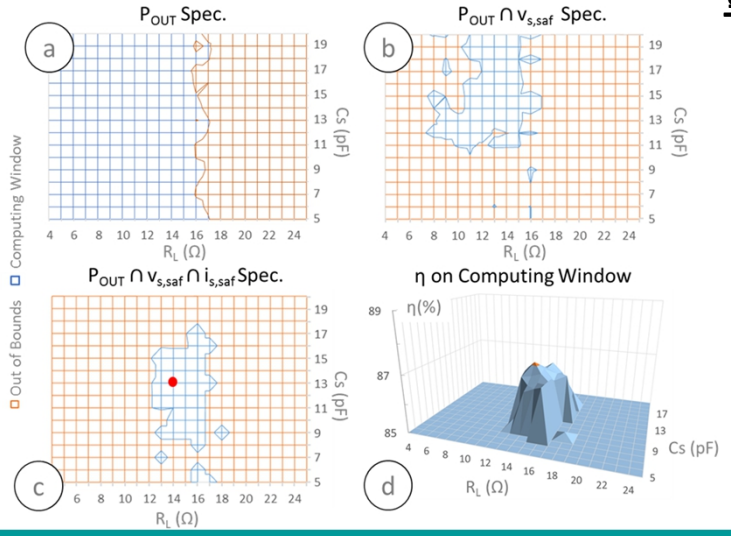
The Class E PA

A basic schematic for the Class E PA is shown in figure. The circuit consists of a MOS device (M1), which works as a switch at the frequency f0. The C1 shunt capacitor includes the output capacitance of the switch. L1 is the choke, while L2 and C2 are the band-pass filter, RL The suitable choice of the circuit components imposes that: (i) Zero slope Voltage Switching, ZsVS and (ii) Zero Voltage Switching, ZVS.



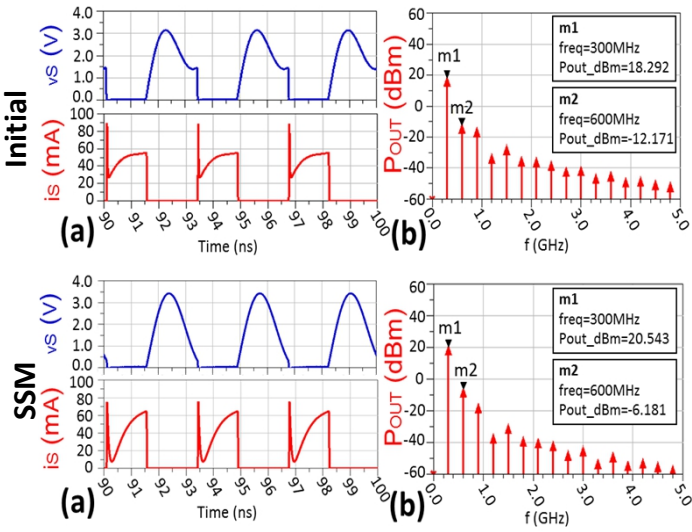
The 3D Specifications Check

The tool provides an automatic optimization of the Class E components, just by inserting the design specifications and the starting values. The second step of the automatic iterative tuning allows preserving the highest value of power efficiency. All specifications realize a three-dimensional matrix, which allows converging to an optimal solution by using the crosscheck of the specifications.



Key Results

As case study, an η-optimal design has been implemented by using the proposed tool. We compare the analytical design of the Class E PA implemented in TSMC 65nm CMOS technology, with the State Space Model.



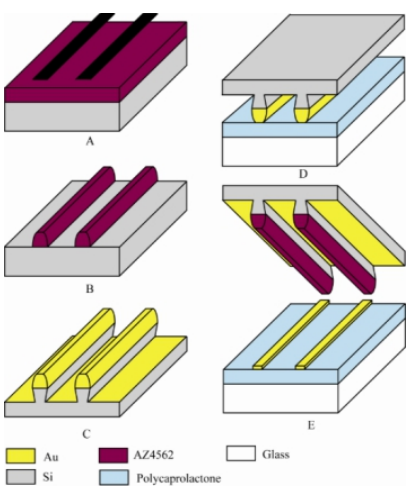
(a) **Simulated** Time domain waveforms: on the left, at the top the switch voltage, v_S, below, the current, i_S. (b) On the right the FFT of the P_{OUT}.

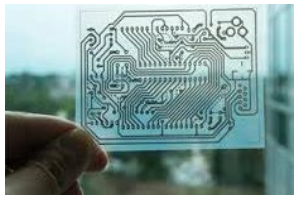
DEISLab: Research Interests

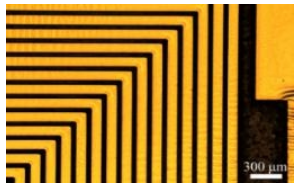
Activity: **Swallowable Biodegradable Endoradiosonde Printed in Gold on PCL**
Collaboration with: University of Glasgow (UK)

The Printing Technique

The printing technique allows to deposit very thin film of gold (30 um) on a flexible, biodegradable and biocompatible substrate called Polycaprolactone (PCL)

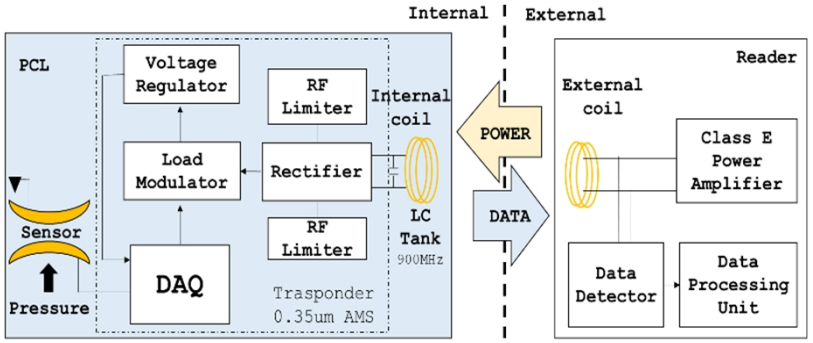






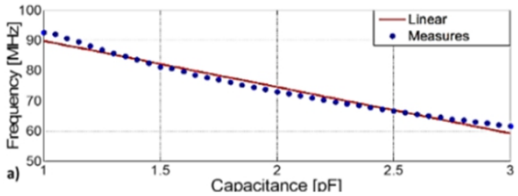
Endoradiosonde Architecture

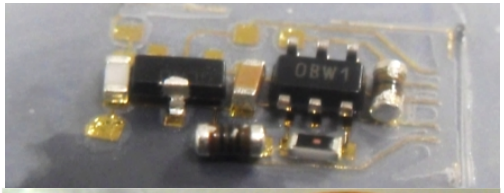
The ERS (pressure sensor to be swallowed or implanted) is made up by the pressure sensor, the transponder (data acquisition unit - DAQ - and RF front end) and a LC tank tuned at 900MHz. The transponder has been designed in 0.35um AMS technology. The pressure sensitive device is a tunable capacitor which performs a linear variation depending on the pressure with a sensitivity (ΔC/ΔP) of 0.4 pF/KPa

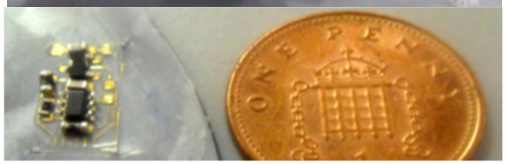


Key Results

The ERS can measure the sensor output frequency with an INL error of 0.4%, a sensitivity Δf/ΔP = -6.12MHz/kPa, occupies a volume of 1mm3 and consumes, respectively, 400uW and 360uW for dynamic and static power.



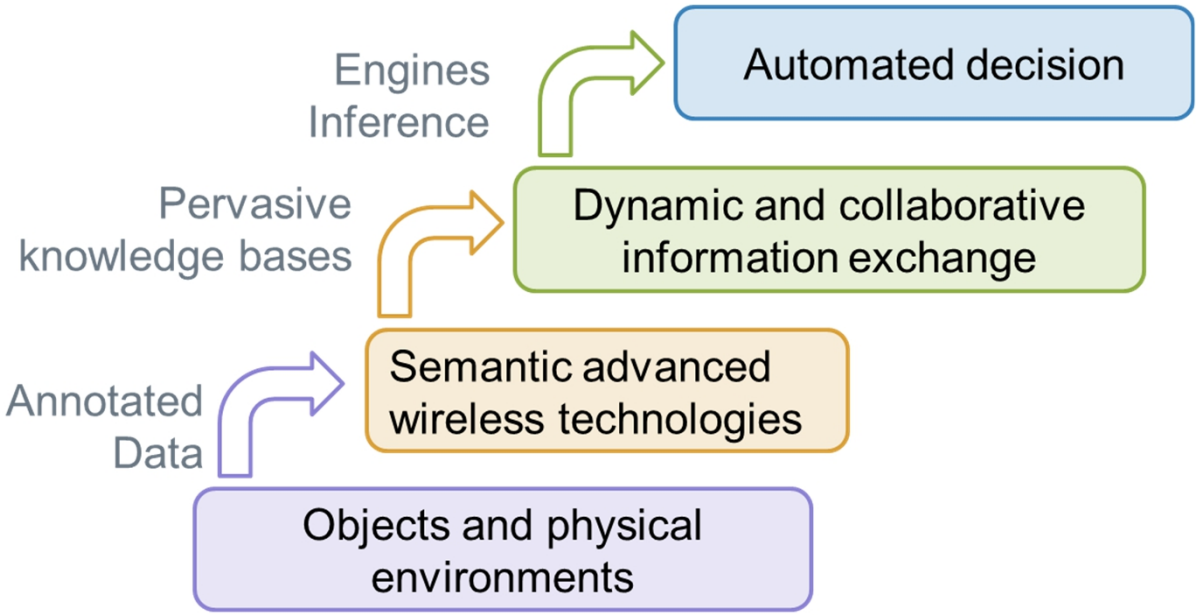




SisInf Lab: Research Interests

Activity: Semantic Web of Things

Knowledge representation technologies for the evolution of the capabilities of pervasive systems



Key Results →u-KB

A ubiquitous Knowledge Base (u-KB) is a distributed and decentralized knowledge base where the factual knowledge (i.e. individuals) is scattered among objects disseminated within a given environment with no centralized coordination

SisInf Lab: Research Interests

Activity: From IoT to SWoT- Technologies

A. Integration of knowledge representation into standard wireless communication protocols

- Bluetooth
- Identificazione a radiofrequenza (RFID)
- ZigBee
- Wi-Fi (IEEE 802.11)
- EIB/KNX (Konnex)
- CoAP
- OBD-II (On-Board Diagnostics)
- Physical Web

B. Automated inference engines highly optimized for systems with low computing resources

- Mobile systems : Android, iOS
- Embedded systems: Raspberry Pi, Intel Edison, Arduino, UDOO

Key Results →Mini-ME - the Mini Matchmaking Engine - http://sisinflab.poliba.it/swottools/minime/

SWoT Research Experience

 Supply Chain DSS	Resource optimization directly in the production phase
 Home and Building Automation	MAS for automated negotiation of home energy resources and services
 Healthcare DSS	Indentify user diseases and suggest most suitable therapies; verify drug interactions
 Car and Driving assistance	Real-time car diagnostics to suggest driver actions and behaviors and minimize risks
 Augmented Reality and Indoor Navigation	AR discovery tool matching the user profile with resources extracted from OSM
 Cyber-Physical Systems	Knowledge-based robotic systems for search and rescue scenarios
 Physical Semantic Web	Enhancement of ***Google*** *Physical Web* project to embed annotations into beacons

Key Results → Google Internet of Things (IoT) Technology Research Award, Best Paper awards, finalist at the konnex competition