Center of Technology and Systems

Intelligent Systems Associate Laboratory

Cyber-Physical Systems for Healthcare Monitoring

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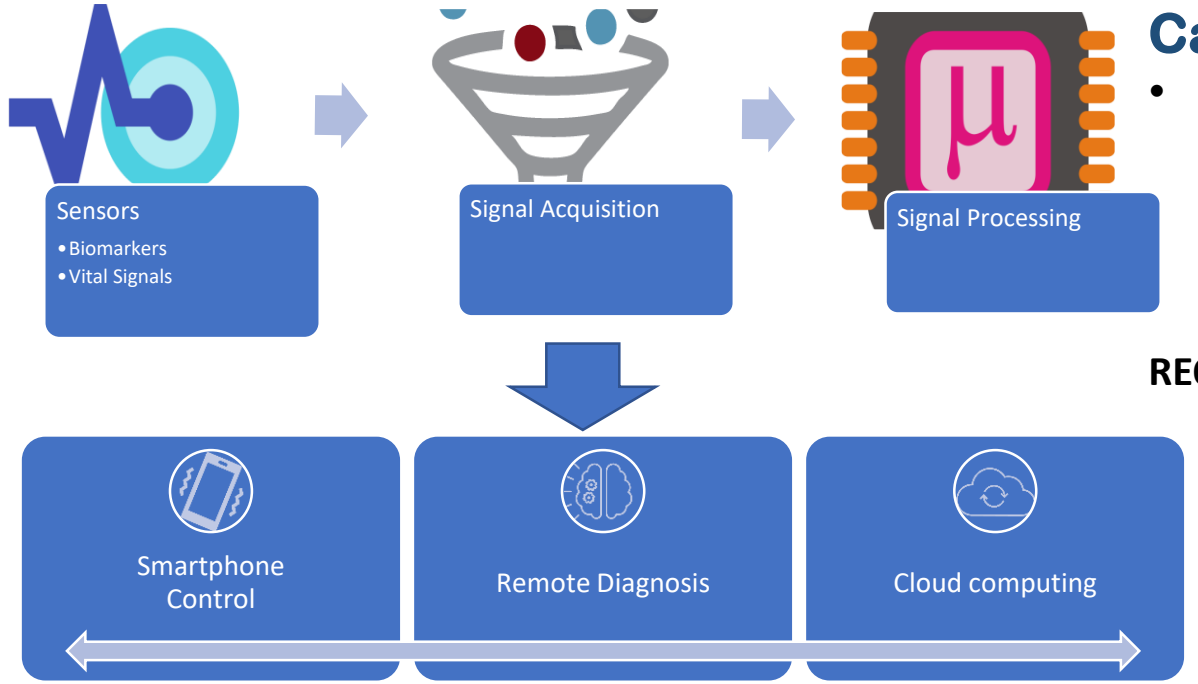
Cyber-Physical Systems for Healthcare Monitoring supporting personalized medicine and early diagnostics



Case Study 1: Acute Kidney Injury (AKI)

- AKI is an **abrupt loss of kidney function,** strongly related with the development of chronic kidney disease

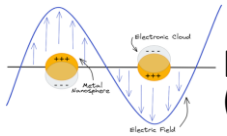
REQUIREMENTS:

- Need for a **multiplexed** parallel biosensor for the detection of a set of 5 AKI biomarkers
- Need for a **Point-of-Care** system, to bring the biomarker analysis outside the clinical laboratory
- Need for a low **Level Of Detection**

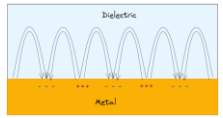
Case Study 2 : Pregnancy Monitoring

From the electrical signal from the Uterus is possible to investigate pregnancy monitoring methods. This electrical signal is ideal for telemedicine and Cyber-Physical Systems development

PROPOSED SOLUTION: Plasmonic Biosensors:

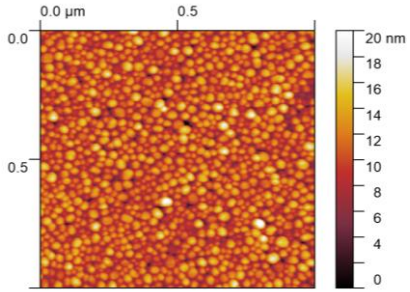


BIOCOLOR: Localized surface plasmons (LSPs) in metal nanoparticles

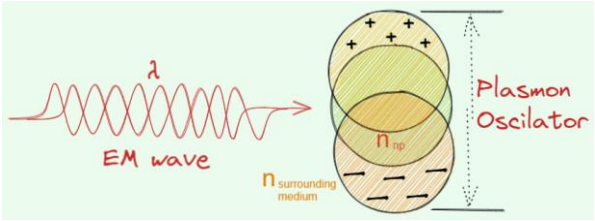


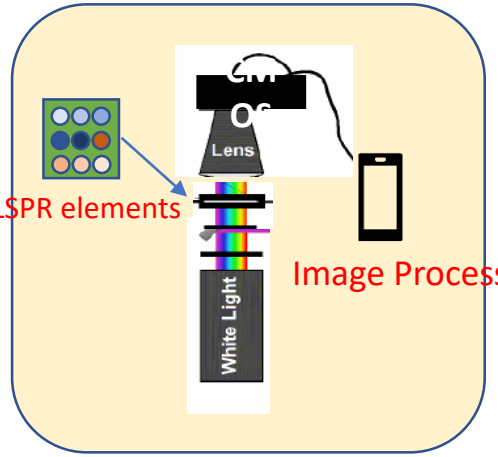
PIC4PHOTOAKI; Surface plasmon polaritons (SPPs): propagating along a planar dielectric–metal interface

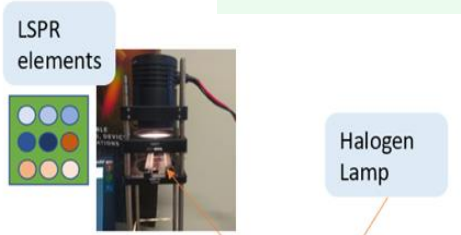
The BIOCOLOR platform: LSPR Sensing

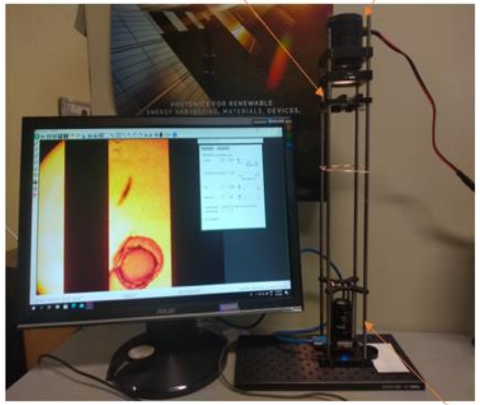


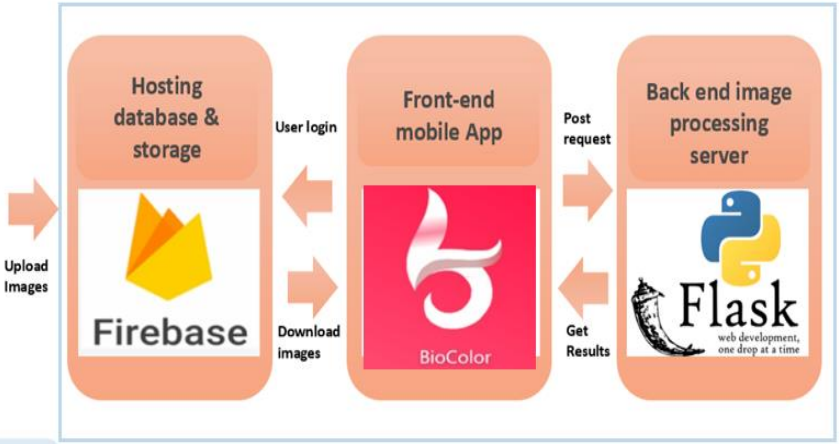
Coupling of light with Metal Nanoarticle surface produce a Localized Surface Plasmon Resonance

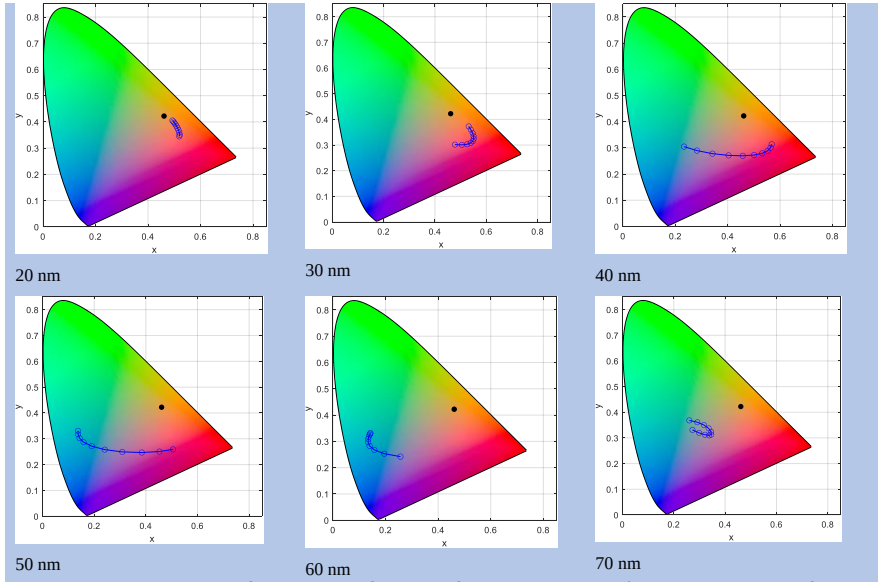








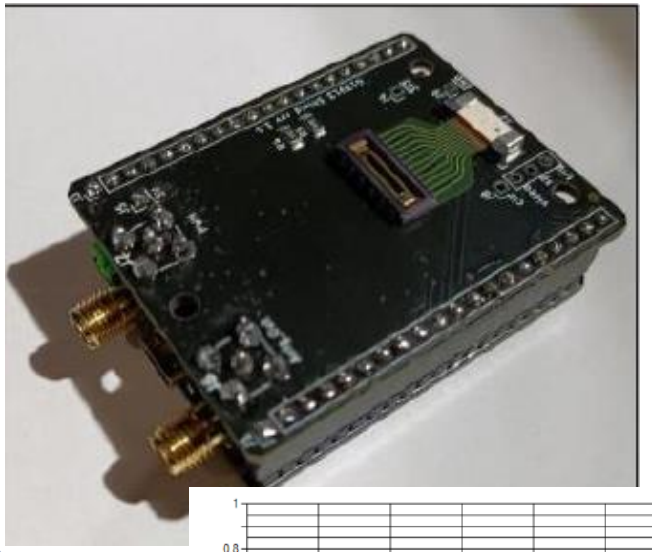




Color variation as a function of the refractive index *(1.3<n_{med}<1.5* of the surrounding medium for different dimension of the nanoparticle radius.

1. **Experimental Setup:**
   - LSPR elements: layer of gold nanoparticles;
   - CMOS camera;
   - Halogen Lamp.
2. **Hosting database:**
   - Stores captured images in the cloud.
3. **Mobile app:**
   - Displays images and obtained results.
4. **Image processing server:**
   - Runs the techniques used to implement the image processing interrogation scheme.

The Pic4PhotoAKI system: an SPR Interferometer Array



Analyte

ACTPHAST4R support

Laser

Light Emitter

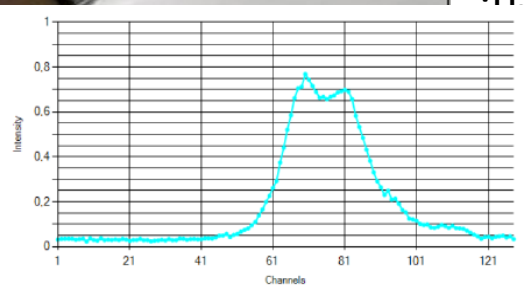
Light waveguide Coupling

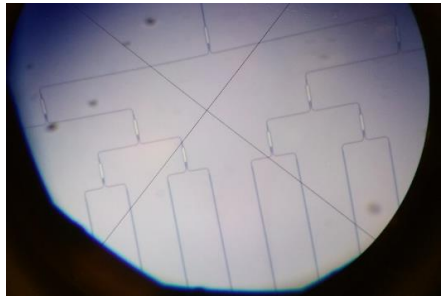
MMI splitter

Interferometers

Light Detectors

Signal Processing





Optical Fiber

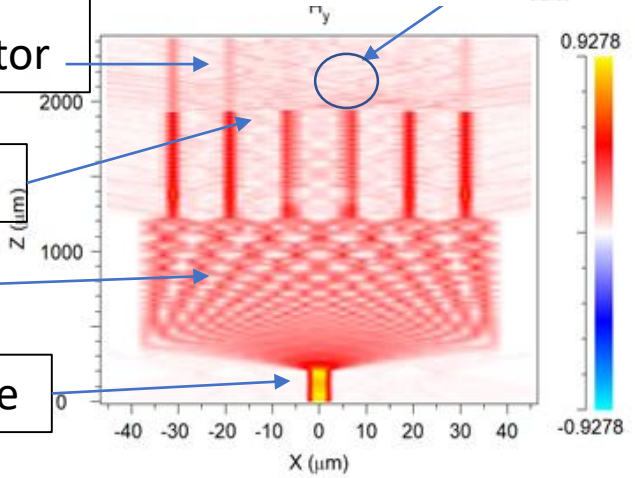
Computer

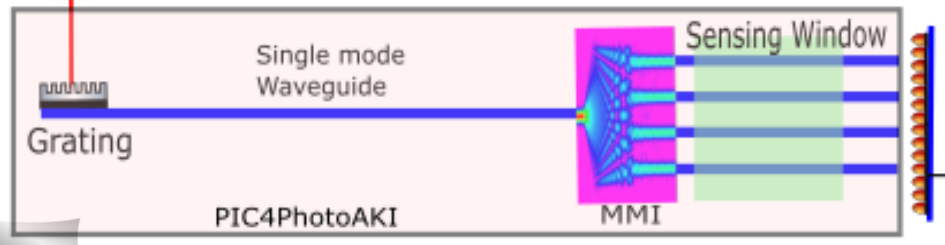
Output signals to the photodetector

Interferometers

MMI

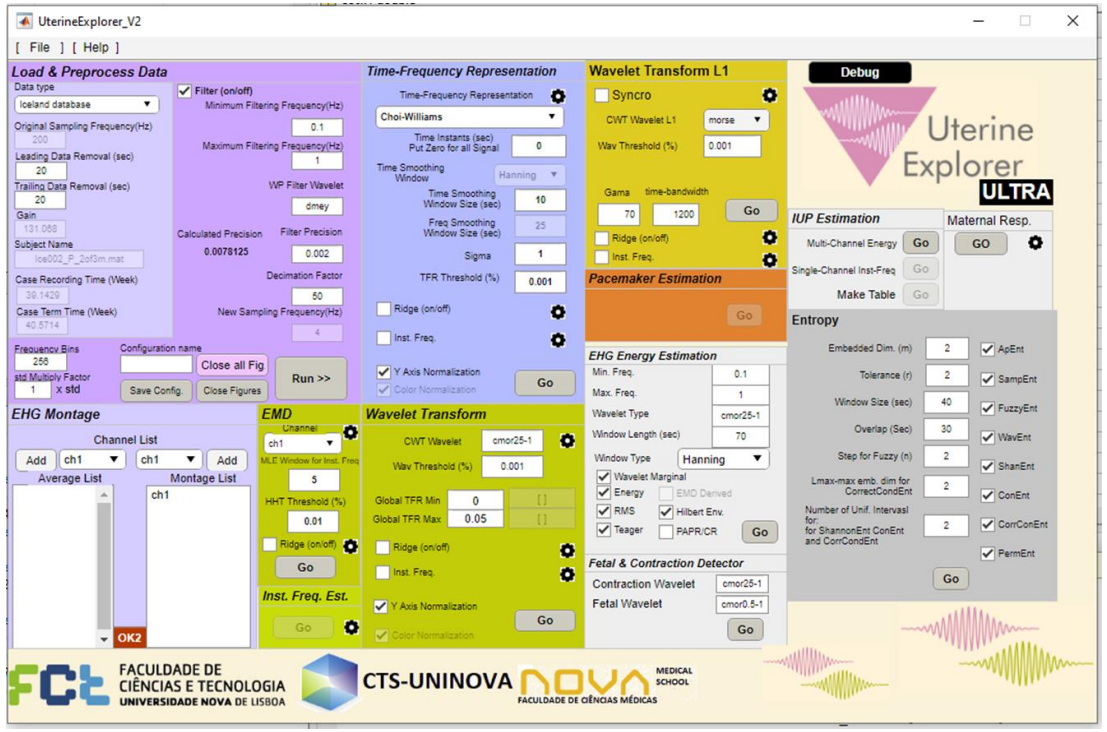
Input Waveguide

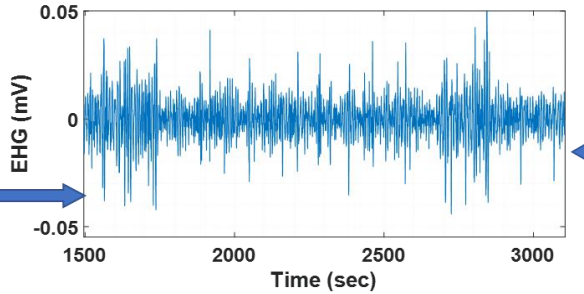


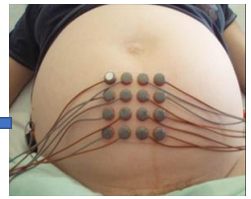


To each waveguide corresponds an interferometer with a different length

An Application for the processing of the uterine electrical signal (EHG) for pregnancy monitoring



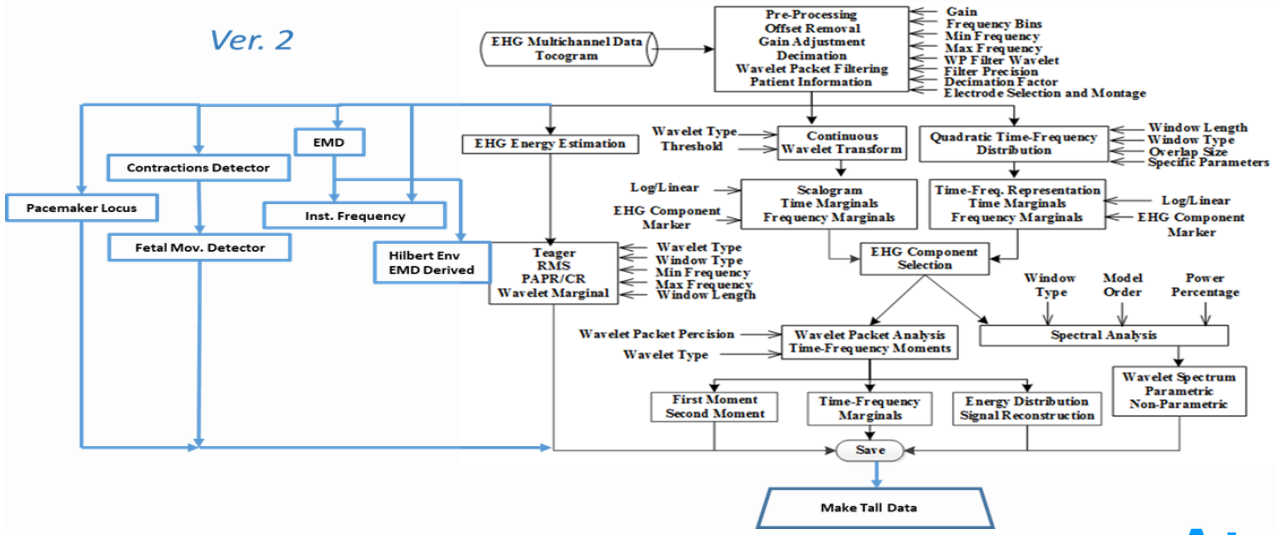




- The **Uterine Explorer** is a software application for the processing of the uterine electrical signal (EHG) for pregnancy monitoring.
- From the electrical signal from the Uterus is possible to investigate pregnancy monitoring methods. This electrical signal is ideal for telemedicine and Cyber-Physical Systems development.
- Algorithm development was based on Maternidade Alfredo da Costa-FCT-NOVA Database and Icelandic Database of Uterine Electrical Signals

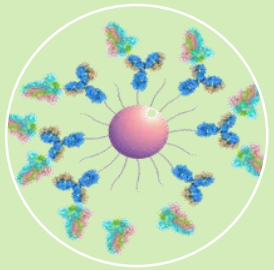
Ver. 1

Ver. 2



Conclusions

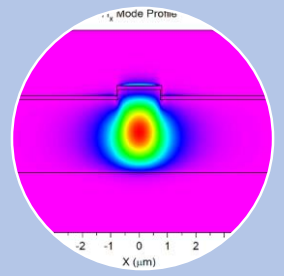
- A correct use of **Cyber-Physical Systems** may help to overcome the physical limitations to access health services, allowing health monitoring independently on geographic location and economical condition.
- CTS contributes to this goal within the context of two cases of major importance: **Acute Kidney Injury** and **Pregnancy Monitoring**
- The proposed approach include the development of sensing devices and a signal processing platform and improvements on this path are planned for the next future
- Similar approaches will be proposed for other health cases



BIOCHEMISTRY

Improve functionalization with antibodies and test the sensors against biomarkers

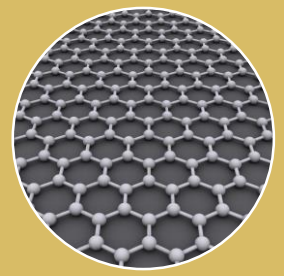
ELISA tests of selected biomarkers



PHOTONICS

Use visible light with SiNx waveguides

Application of Multimicron Rib-Waveguides



MATERIAL SCIENCE

Improve the sensors sensitivity with 2D materials

INFORMATICS

Exploit the Mobile Phone Application

Machine Learning approach

Future work

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