LAAS Days
Research & Technology

An embedded instrumentation approach for detecting the fragility of complex systems

TICS/ S4M « Smart Sensing and SystemS Monitoring »

Smart sensing methodology

> A Need for « Complex system smart monitoring » in spite of global modeling because systems are

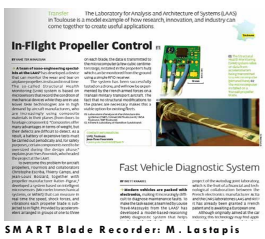
- heterogeneous
- strong and robust enough to support damages so that defects take time to appear
- their environment and use conditions are not deterministic

> One way is « SMART instrumentation »

- Design / assembly a node architecture capable of detection / analysis / information transmission
  - Using/adapting of sensors on shelves but using them in a different context
  - Manufacturing elements / layers / sensors based on micro/nano technologies
  - Developing a patch approach to place on / in the structure to be observed
- Search for "signatures" of behavioral evolutions by combining signals (accelerometer, piezo, magnetometer) resulting from the propagation of mechanical waves for « immobile systems » or displacement for « mobile » systems
- Implement algorithms to reduce power consumption using versatile architecture

→ to detect fragility or more precisely the level / risk of fragility

Smart sensing applications

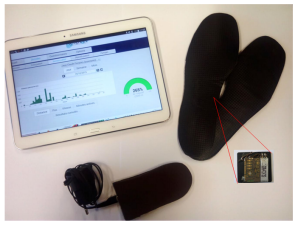


SMART Blade Recorder: M. Lastapis 2012 Thesis

Smart Patch : B. Hajjine 2016 Thesis

Method for detecting the fall of a human subject and corresponding actimetric device
WO 2016075013 A1

SMART SOIL MOISTURE: J. Roux Thesis 2017



SMART SOLE : Y. Charlon Thesis 2014

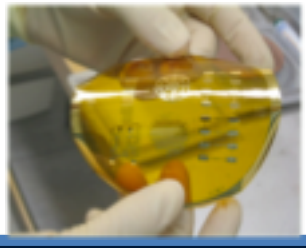
SMART Cycling: A. Bouillod Thesis 2017

surface measurement

Smart sensing: above or inside?

> Technological constraints

- Smart node take the measurement closer to the structure
- Smart node do not modify structure behavior
- Smart node could be above or inside the structure

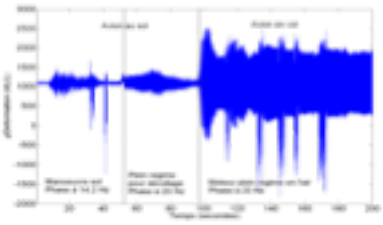


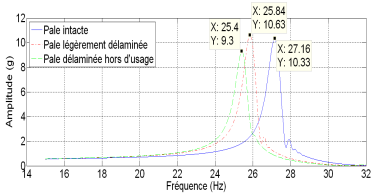
surface measurement

Smart sensing: looking for signature

> Methodology approach

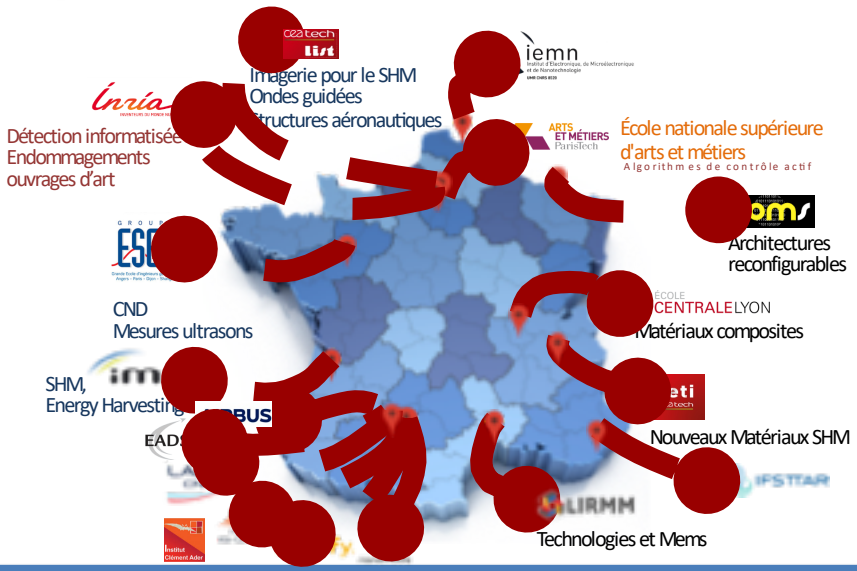
- Observation of the self intrinsic activity generated by the system (movement, vibrations, displacements...). Note that for static system (air plane, soil...) the piezo car generate stimuli)
- Computing of signature (based on spatio temporal behavior and/or statistical approach)
- Tracking temporal signature evolution (quick and/or slow drift)





eigen frequencies displacement

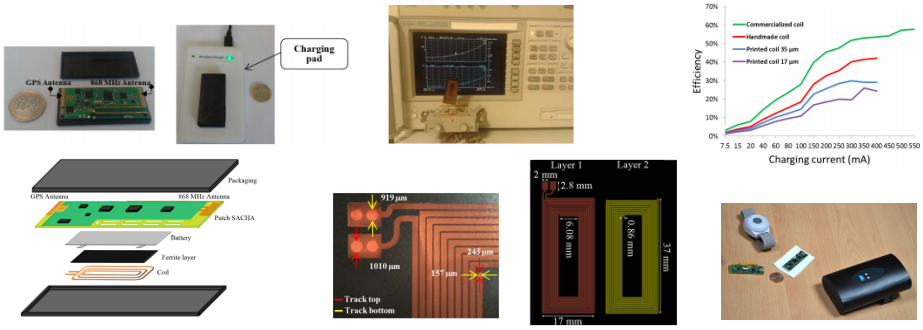
Our partners



Focus on human direct sensing

AIM: Mobility & gait sensing and analysis with a wearable patch

METHODS: Printed coil for wirelessly charging and integrated sensors



Compromise between reduced size and operational autonomy.

APPLICATIONS: Fall detection and localisation for frail people

Collaboration Industrial

B.Hajjine et al. "Development of an electronic patch for falls detection and elderly tracking", International Conference on Biomedical and Health Informatics, Haikou (Chine), 2015

Focus on human indirect sensing

INDIRECT sensing:

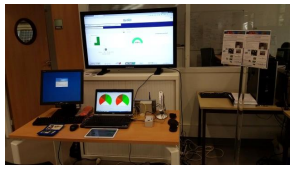
> Detection of critical human postures based on multi-cameras

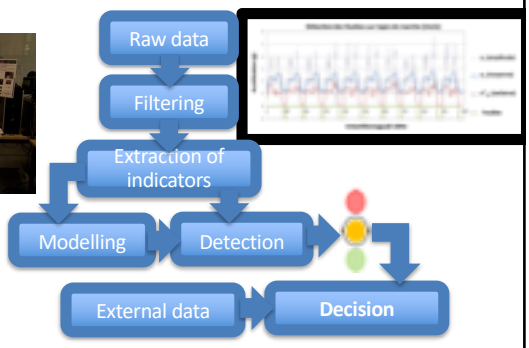
> Algorithmic Integration on FPGA-based platforms for real time applications

Focus on human indirect sensing

AIM: Continuous measurement of stride & speed walking with accuracy

METHODS: Sensors integration in a 3mm thickness shoe insole and embedded algorithm development





APPLICATIONS: Frailty monitoring of the old people

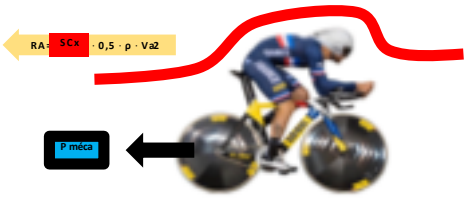
Collaboration CHU and Industrials

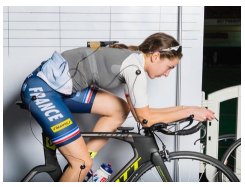
A. Piau et al. "A smart insole to promote healthy aging for frail elderly individuals: specifications, design, and preliminary results", JMIR Rehabilitation and Assistive Technologies, Jan-Jun, 2 (1), 2015
Y. Charlon et al. "Smart insole for measuring actimetry of trail peopleMed-e-Tel 2015

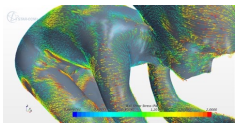
Focus on human direct sensing

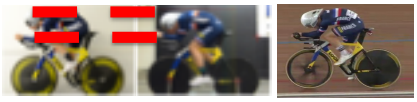
AIM: Biomech, physio & aéro sensing and analysis for performance monitoring

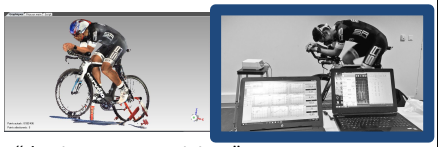
METHODS: Smart integration on both wearables and bike components











Compromise between reduced size and acceptance "during competition".

APPLICATIONS: High potential athletes detection, performance improvement and injury prevention

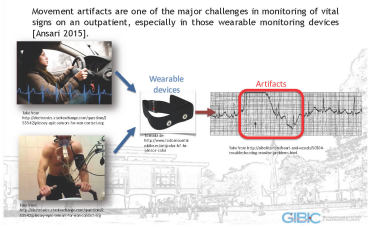
Collaboration Pro cycling team

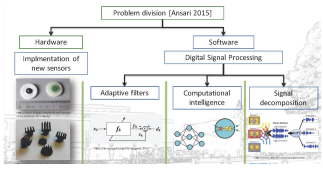
A. Bouillod et al.

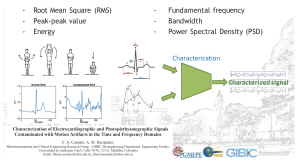
Focus on human direct sensing

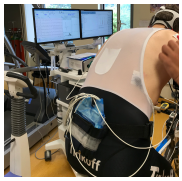
AIM: physiological sensing (with MA reduction) for common life activities

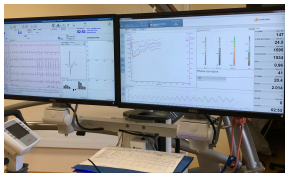
METHODS: Smart integration on both wearables and connected devices











Compromise between acceptance signal processing complexity.

APPLICATIONS: Health monitoring (ECG), risk prevention

University/hospital collaboration

F. Castanedo et al.