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 (accelerometers, piezoelectric sensors, magnetometers) resulting from the propagation of mechanical waves for « immobile » systems or displacements 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 node take the measurement closer to the structure

> Smart node do not modify structure behavior

> Smart node could be above or inside the structure

Smart sensing: above or inside?

Technological constraints
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).

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

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

---

**Focus on human direct sensing**

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

**METHODS:** Smart integration on both wearables and bike components

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

Compromise between reduced size and acceptance “during competition”.
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