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Cluster for Application and Technology Research in Europe on NanoElectronics

CT402 | Crucial ambient intelligence elements in place for consumer and healthcare applications [9D-Sense]

The 9D-Sense project developed and tested state of the art technologies suitable for installation in an autonomous sensing module that integrates key sensor elements in a single device. This development is crucial to ambient intelligence and the market for cost-competitive solutions in consumer and healthcare electronics. It also helps maintain European dominance in this global market.

Key to the 9D-Sense project and at the very heart of ambient intelligence is the ability to sense an object's physical movement in different directions — hence the so-called nine degrees of freedom or 9D for short — such as gesturing. The 9D sensing module developed in this project embraced key technologies crucial to fabricating micro-electrical sensors, efficient energy harvesting and storage, and secure wireless communications.

The smart wristlet illustrates a truly winning application of ambient intelligence

Crucial technologies, algorithms and applications

The main goal of the 9D-Sense project consortium, comprising seven technology concerns and two universities, from three European countries, was to provide novel processing technologies and innovative methods to produce a stand-alone 9D system. It was based on a three-axis accelerometer, three-axis gyroscope and three-axis magnetometer, and needed to communicate through a secure data-transmission protocol. These requirements were in response to application and market demands for small sensing modules with low-power consumption, a self-sustaining power supply and secure data transfer.

In particular, these demands called for the development of a wide range of semiconductor technologies for MEMS (microelectromechanical system) sensors (like on-chip integration), ASIC (application-specific integrated circuit) processes for high-capacity micro batteries, as well as, application-specific algorithms with protocols for secure data transfer. Furthermore, energy harvesters (which generate and provide enough energy to feed the system electrically) were also needed.

9D-Sense developed the following:

- Technologies for integration of micro sensors on a single chip and technologies for smaller package size;
- Technologies and processes for a thin film battery;
- Two types of energy harvesters — kinetic and thermos-electrical generator — capable of converting kinetic and thermal energy into electric energy;

- Efficient power management;
- Algorithms for specific applications;
- Secure communication framework for internet of things.

In addition, this project validated algorithms and secure communications in the 9D sensing module in three different use cases:

- Pedestrian Tracker: used to track a person's movements and path travelled, and graphically display them in real-time on a mobile device;
- Orthese Knee Control: used to track and control the movement of a type of prosthetic electronic knee joint;
- Smart Wristlet: a communicating, wearable device that manages access rights by recognising gestures of the wearer, and securely transmitting them to the internet of things.

Ideally suited healthcare and consumer applications

What we now have are key elements that will be integrated in ambient-intelligent applications. These elements are highly autonomous, energy-efficient, ultra-low-powered sensing systems which are found in 9D-Sense's two focus application areas with societal impact — medical/healthcare and consumer — where substantial demand and large market volumes are expected.

Healthcare and monitoring applications range from prosthetics/orthopaedic appliances and ambient-assisted living for the elderly and disabled, to joint-monitoring (such as orthopaedic knee braces for the disabled) and monitoring during patient rehabilitation.

There are other novel applications. Ambient intelli-

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Key project dates:

Start: November 2011
End: October 2014

Countries involved:

Finland
France
Germany

PROJECT CONTRIBUTES TO

Communication	✔
Automotive and transport	
Health and aging society	✔
Safety and security	✔
Energy efficiency	
Digital lifestyle	
Design technology	✔
Sensors and actuators	✔
Process development	
Manufacturing science	✔
More than Moore	✔
More Moore	
Technology node	<130nm

gence can also be applied to positioning or navigational devices for use indoors (where global positioning systems do not work); and in security or home automation, such as intrusion detection by movement, or control and condition monitoring in buildings for improving energy efficiency.

Strengthening European manufacturing and research

The focus areas addressed and investigated in 9D-Sense contribute to several initiatives of the European Union as well as to strengthening the market position of European manufacturers and researchers.

MEMS sensor production for non-automotive applications, for instance, is still an important business case for European companies. Notably, the demand for integrated sensors (so-called combos) is expected to grow in the coming years and will partly replace discrete sensors. Unlike many other semiconductor-based technologies, two key players among dominating suppliers are located in Europe.

Crucially, since most consumer-electronics manufacturing takes place outside Europe, it is important not to lose ground in the remaining enabling technologies. MEMS sensors and actuators – such as inertial, pressure, humidity and geo-magnetic sensors, and micro-mirrors for display applications – are meanwhile critical elements users expect in their mobile computing-devices. Recent market-share losses to players outside Europe need to be regained, and the overall market share has to increase to a leading position in order to leverage volume-scale effects.

Thanks to this project, European-produced inertial sensors are now available for innovative, future markets, like communication or healthcare, thereby strengthening the position of European companies in the field of MEMS technologies and products. This also means supporting a European effort in maintaining its leadership in more-than-Moore technologies, together with technologies for heter-

ogeneous integration and smart manufacturing. Furthermore, providers of systems using 9D sensors (such as internet of things or medical/health care applications) also benefit from 9D-Sense.

A case of success

The market for wearable devices is an important and rising one, but largely immature. Major issues still need to be resolved before it can reach its full potential:

- Connectivity: there is a lot of heterogeneity in the communication protocols today; no clear standard has emerged yet;
- Ergonomics: wearable objects are too small; efficient interaction schemes still have to be defined and need to be easy to use in everyday activities;
- Autonomy: users already have a lot of devices to keep charged every day; adding more of these devices will quickly become a big issue;
- Design: wearable devices are very personal, and their design very important to users;
- Security: the more control we relinquish to these devices, the more they become security weak-points; therefore good security must be built into these devices;
- Privacy: as personal objects, wearable devices are inherently gateways to personal activity-tracking.

That is why the Smart Wristlet is so remarkable. A by-product of this project (it was developed as a demonstrator), this innovative wearable device has excellent commercial potential. Notably, it also deals successfully with all the issues previously mentioned. In addition, it allows for seamless integration into existing systems; its protocol framework is built to be battery-friendly and independent of transport protocols; and it fully deploys power harvesting and thin film battery solutions delivered by 9D-Sense.

Even though there is still some work to be done before the Smart Wristlet is ready for the marketplace, the technical solutions it demonstrates could be integrated today in other products. More importantly, it sums up and embodies everything 9D-Sense set out to achieve.

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