题目的提案

RADIOSENSE 平台为 ubiquitous 人民感知

CALL INFO: H2020 R&I on IoT integration and platforms (Research and Innovation action)


The RadioSense Action aims at integrating environmental recognition capabilities into embedded devices by real-time processing of electromagnetic (EM) fields. The radio channel itself enables continuous non-intrusive and privacy preserving recognition of people's presence, count, activities, and gestures. Possible applications are Advanced Driver Assistant Systems (ADAS), Ambient Intelligence, Smart Environments and Assisted Living (AAL), or scalable indoor localisation and tracking of crowds and crowd flow.

Recent research has shown that the perturbations of radio-frequency (RF) signals can be used as powerful sensing tools for device and sensor-free environmental perception. Since the perturbations induced on RF signals depend on the surrounding environment and changing scene, RF signals can be processed to extract an understanding of a situation without the need of any ad-hoc physical metering device. Radio devices incorporate novel sensing capabilities to acquire an accurate human-scale understanding of space and motion. Mining RF data (e.g., RF signal strength, micro-Doppler fluctuations, Channel Quality Information (CQI), Fresnel-effects) promises to become a key component of emergent social-computational systems, to increase the quality of urban/social life and strengthen people safety and security.

RF data used as EM measurements for recognition can be in the form of:

- **Physical (PHY) layer values** processed at the baseband symbol level (radio channel state information CSI, micro-Doppler, dynamic phase-shifts, complex channel envelope).
- **Upper layer (application/link layer)** received signal strength (RSS) data or other aggregated link/channel quality information (CQI) metric forms (e.g., packet error rate, link quality information – LQI).

The use of augmented wireless-enabled devices configured to capture and exploit potentially massive RF data-sets for active and passive sensing at a large scale, is a radically new paradigm, enabling truly ubiquitous and pervasive human-centric services driven by people-to-people and people-to-environment interactions.
The Action will evaluate and develop innovative technologies, advanced system architectures, signal processing methodologies, and new software platforms tailored for embedded devices to leverage RF signals for sensing, learning, sharing and processing information about individuals and communities of people, and increase the understanding of the environmental situation. It will also debate means to encourage standardization, and identify relevant digital “living services” tailored for people daily life, that can learn, evolve and react in real-time to changes in the environment, detect patterns of person behaviour, prevent dangerous situations and help people during emergency conditions.

The topic demands different expertise spanning Information and Communication Technologies (ICT) in a broad sense. Researchers from signal processing, statistics, computer and social sciences will join domain specialists.

The prototype system will be tested in the intended environment close to the expected performance.

The expected scientific objectives and contributions of the Action are mapped onto the following working groups - WG (to be completed - TBC).

**WG-1 RadioSense systems**

The group will investigate the use of EM wavefields emitted by radio devices (e.g., 4G, WiFi, Bluetooth, RFID, NFC, 6LoWPAN, Z-Wave), including the use of future transceiver designs (e.g., 5G). The goal is to improve the spatial perception in the surrounding of the wireless device, and incorporate novel or augmented sensing capabilities for accurate recognition of human body movements, behaviour, motion and conditions of the surrounding environment. Key technologies for RF based human sensing are developed and integrated based on common performance indicators.

Main concepts/contributions underpinning WG-1:

- investigate the use of radio-frequency (RF) signals, such as 4G, WiFi, Bluetooth, as well as future 5G emerging ubiquitous wireless standards and broadband (UWB) transceiver devices operating in the E band and beyond up to the THz bands;
- develop advanced environmental sensing and signal processing capabilities to improve the spatial perception of embedded devices, and the ability to navigate/reconstruct the physical world surrounding the device;
- integrate EM modelling and ray-tracing techniques for RF-recognition and sensing.

**WG-2: Big-data analytics for high-dimensional RF data processing**

RadioSense requires information aggregation, processing and computation of massive amounts of RF data. In this WG, we consider the problem of learning and running analytics from these large volumes of sensory data. The focus of the research will be therefore on adaptive networks that perform distributed (consensus-based) in-network inference and control decisions acting as networks of cognitive systems. Conventional signal processing and statistical learning tools needs to be re-considered, if applied to these unprecedented high-dimensional data regimes.

Main concepts underpinning WG-2:

- realize new techniques to support efficient data analytics based on incomplete observations;
- adopt a wide range of signal processing-relevant data analytic tasks, namely robust high-dimensional and distributed pattern recognition methods, spiking neural networks (SNN) models, compressive sampling (CS), subspace/spectral clustering, and re-consider their feasibility and design techniques under distributed networks, extremely high dimensional and possibly incomplete data regimes, and for extremely under-determined estimation problems;
- definition and design of scalable architectures and optimization algorithms for decentralized and online learning/prediction problems, while revealing fundamental insights into the various analytic and implementation trade-off involved.

**WG-3: People-centric RadioSense platforms and services**

In people-centric systems the focus of sensing is on humans, while the visualization of sensor-based information is for the benefit of either a single person living in a smart-space (Personal Sensing) or groups of people or smart-communities (citizens at urban-scale) with social relationships (Social Sensing).

Main concepts underpinning WG-3:

- Personal Sensing. It considers different aspects of person “social settings” as human gesture, agitation, emotion and sentiment sensing, location, user habits, human non-verbal behaviour, health related conditions.
• Social and Crowd Sensing. It considers the problem of modelling crowd behaviour for dynamic estimation and prediction (e.g., monitoring and predicting pedestrian flows). RadioSense sensing is combined with flow tracking, for estimation of crowd dynamics, prediction and detection of possible anomalies in large public spaces (e.g., railways, airports, fairs, etc.) and critical infrastructures. RadioSense can be effectively exploited to study how global rational (or irrational) patterns of behaviour emerge in the crowd, thus providing an effective guide to the development of novel geospatial services.
• Robust Localization and Routing. It deals with the problem of robust and low maintenance ad-hoc indoor localisation and routing.

**WG-4: RadioSense platform applications and case scenarios**

To proof the capabilities of the RadioSense platform, a working prototype (min. TRL5) will be validated in relevant scenarios and application cases, according to people-centric services identified in WG-3.

Main scenarios validated in WG-4 (TBC according to the final consortium composition):

- automated driving and smart mobility systems;
- smart living and working, ambient perception and intelligence;

Some other general potential applications to be discussed according to the expertise and contributions of the final consortium members are described in the followings.

**Automated driving and smart mobility systems**

Sentiment-state and agitation, for instance, happiness, sadness, anger, tiredness, neutral and fear states can be recognized from discrete movements of the body, such as agitated hand gestures or slow body movements. Human movements showing rapid and jerky patterns can indicate anger while slow motions link to sadness.

Integrated into the passenger area, the RadioSense system can be exploited to detect driver state and risky driving situations such as driving in exhausted or tired state or angry, arguing, or agitated driving.
In addition, exploiting dense base station deployment in cities, the RadioSense technology can enable the distinction between pedestrian and vehicular traffic as well as size and direction. On a city scale, this enables the system to monitor and track crowd and vehicular flows in real time. There is significant demand for such data, including the optimization of heavy goods vehicle traffic (HGV), enabling better parking via real-time info, limiting speed in city districts or clean air route guide for public transport (e.g. stress-free option for route guide).

The project will also exploit existing road side installations of "base stations" / sensing kits in Helsinki Jätkäsaari.

Smart living and working, ambient perception and intelligence
RadioSense capabilities can be adopted for estimation of crowd dynamics, and perception of space inside public and industrial buildings. These features are instrumental to the definition of novel
interactive interfaces with smart environments. The RadioSense platform can be designed to support advanced motion/gesture-based human-machine interfaces for the control of dedicated devices e.g., robotic machines during assistive tasks. The technology can be also designed for recognition of patterns of people behavior, including the detection of possible anomalies and a dangerous conduct in public spaces, as well as critical infrastructures. The project will also exploit the existing smart work-space pilot plant of CNR unit (figure above) in Italy.

Partners (TBC)
- Aalto University (Finland);
- CNR (Italy): Institutes IEIIT, ITIA;
- Politecnico di Milano (Italy);
- HCL (Germany, Italy);
- Forum Virium Helsinki FVH, (Finland), to be confirmed.

Additional (potential) partners

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<th>Industry: Big-Data and analytics</th>
<th>Industry partner focusing on cloud storage and big data analytics.</th>
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<td>Expertise: Big Data system mining, cloud/back-end computing.</td>
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<td>Optimized RF data analyzing algorithms for Big Data and In-Memory</td>
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<td>systems (e.g. Smart Data Innovation Lab - SDILs - generalized</td>
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<td>Hadoop based, Spark, HANA platform). Speedup optimization:</td>
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<td>parallelization techniques for the used mining, learning and prediction</td>
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<td>algorithms.</td>
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<td>Contributions Expected (1): Develop the software corpus of an</td>
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<td>interface for high speed (in the order of GB/s for baseband RF data</td>
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<td>processing) data link to the RadioSense RF data collection systems</td>
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<td>and research on specific data curation methods for such data. Provide</td>
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<td>also an interface to collect high data volumes from distributed</td>
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<td>locations using a buffered collection system.</td>
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<td>Contributions Expected (2): Provide the basic application-layer data</td>
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<td>processing methods to be applied in demonstration development. The</td>
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<td>activity will also deliver a commonly usable software library corpus</td>
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<td>for open data model use.</td>
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<th>Technology supplier: wireless devices/equipment</th>
<th>Technology/equipment supplier focusing on IoT devices, wireless sensor networks, machine-type connectivity, multi-frequency and multi-standard (WiFi, ZigBee, LoRa, LTE, UWB, THz/sub-THz).</th>
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<td>Expertise: Wireless device manufacturer, Internet of Things, Smart</td>
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<td><strong>Cities and M2M platform provider. Experience in emerging &gt; 60 GHz technologies and ISM services (2.4 GHz and 5 GHz).</strong></td>
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<td><strong>Contributions Expected:</strong> Provide input for partners using its industrial experience and gathered information about long term applications envisioned by its customers. Integration of selected RadioSense functions into project demonstrator/prototype.</td>
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<td><strong>(Optional Contributions):</strong> Provide radio equipment (open / programmable at the base-band level).</td>
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| **Technology supplier: automotive** |
| Technology/equipment supplier focusing on control and automation in automotive applications. |
| **Expertise:** Automotive industry actuators, driver assistance systems, passive and safety sensors. |
| **Contributions Expected:** prepare the background for RadioSense demonstration, providing the specifics for one or more application-relevant case studies. Providing input for partners using its industrial experience and gathered information about long term applications envisioned by its customers. Integration of selected RadioSense functions into project demonstrator. |

| **Technology supplier: smart living, robotics, haptic devices** |
| Technology/equipment supplier focusing on control and automation in smart-living or smart-working applications, including assisted living as well as robotics and human-machine interfaces |
| **Expertise:** Industrial/home automation sensors, haptic technologies, home/industrial robots manufacturing. |
| **Contributions Expected:** prepare the background for RadioSense demonstration inside one or more application-relevant installation sites. Providing input for partners using its industrial experience and gathered information about long term applications envisioned by its customers. Integration of selected RadioSense functions into the project demonstrator. |

| **Customer or partner coordinating dissemination + potential long-term business plan, IP/patenting issues** |
| **Contributions Expected (1):** create interactions with Smart City / Automotive standardisation activities and contribute to several European initiatives, such as CitySDK, FIWARE, Open and Agile Smart Cities (OASC) network, and others mentioned in the H2020 IoT call. |
| **Contributions Expected (2):** Increase the public awareness for the RadioSense consortium and results, and promote the ideas of the Consortium in the industry. |
References

Websites: radio sense and vision, device-free recognition


