### **1st OpenDay and Workshop** 14th July 2022

# NSTITUTO DE SISTEMAS E ROBÓTICA UNIVERSIDADE DE COIMBRA



## **Cooperative and Multimodal Localization of** 5G-enabled Multi Robot Systems\*



UNIVERSIDADE E

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#### **Context and Motivation**

**\* Scope:** Mobile robot localization in outdoor scenarions can be a challenging task due to the inherent uncertainty of the process and the physical properties of the environment.

**\*Objective:** Develop a 5G Simultaneous Localization and Mapping (SLAM) approach that can assist robots in outdoor environments and evaluate its suitability for field applications.

**\*Features:** Ultra low latency, faster speeds than 4G LTE, wide area coverage and suitable for large data offloading to remote servers.

#### **Mobile Robotic systems**



**\*Contributions:** A 5G radio based SLAM approach can provide benefits for mobile robot Localization as it does not suffer from phenomena such as illumination and weather variations, terrain structure and GNSS denied scenarios.

#### **Research Objectives**

1) Analysis of user needs and requirements for the design of 5G-connected heterogeneous robotic platforms, based on 5G connectivity for pervasive localization, emphasizing triangulation optimization methods, as well as cooperative and multimodal-based localization.

2) Implementation of a Robot OS (ROS)-based solution for 5G localization in robotics.

3) Development of an advanced life-long localization architecture based on multimodal sensor fusion, encompassing 5G technology, possibly coupled with local ultrawide-band positioning, VLC, global positioning system (GPS), inertial measurement units (IMU), wheel encoders, scan matching and visual odometry.

4) Performance evaluation approach to assess the accuracy and precision of the 5G-based localization multi-robot system under real-world constraints.

Figure 1: (a) Vinebot robot, (b) Ranger robot, (c) UAV for outdoor applications.

#### Multimodal sensor fusion of 5G NR



Figure 2: Fusion of multiple odometries sources for robust pose estimation and signal mapping from 5G NR.

#### **5G Simultaneous Localization And Mapping**





gNB

1) A study of the technological and scientific viability of an innovative 5G-based localization system.

2) Incremental prototype of the proposed 5G SLAM system in ROS starting with one robot and a few sensor modalities, all the way up to a dynamic multi-robot team with several sensor modalities.

3) Secondment at i2CAT (Barcelona) and integration with Visible Light Communications (VLC)

3) Working proof-of-concept demonstration with a team of forestry robots in a challenging outdoor field environment.

4) Exploitation of possible business opportunities and patent filing.

#### 5G gnodeB (gnB) station



Figure 3: 5G SLAM process on the User Equipment (UE) with spatio temporal coherence and the use of inertial system to determine orientation.

Signal coverage



Figure 4: Cooperative multi robot systems enabled by 5G New Radio in a forestry environment.

Figure 5: Signal propagation map based on CSI-RSSI values.

\*This work is co-funded by the program Portugal 2020, under both SAFEFOREST (ref. CENTRO-01-0247-FEDER-045931) R\&D projects and the by the European Union's Horizon 2020 research and innovation programme 5GSmartFact (under the Marie Skłodowska-Curie grant agreement ID 956670).



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