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Software architecture for real and virtual sensors in GNC systems

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Abstract

Sensor integration and data processing is a key aspect in the design of GNC (Guidance, Navigation and Control) systems. Here we exemplify the integration of typical sensors used in USV (Unmanned Surface Vessel) for environmental perception (LIDAR (Light Detection and Ranging), RADAR (Radio Detection and Ranging), camera and IMU (Inertial Measurement Unit)) in a software framework that allows for connecting both virtual sensors and real-world sensors.

The proposed software framework is implemented in ROS2 (Roboter Operating System 2) and combined with a virtual environment generated in Unity3d. The virtual environment is used to generate the virtual sensors (raw) data, and, simultaneously, visualize the data and the processed information retrieved from the data, see Fig. 1. Internal communication and data exchange between software modules are based on Node.js. We ensured compliance with VDE 0803-3 and IEC 61508 standards during the software development process.

For development and testing purposes, we modelled in Unity3d an example USV and a scene resembling the USV's real-world operational area. The design process of virtual representations of LIDAR, RADAR, IMU and a camera are showcased and attached to the vessel that is embedded into the virtual scene.

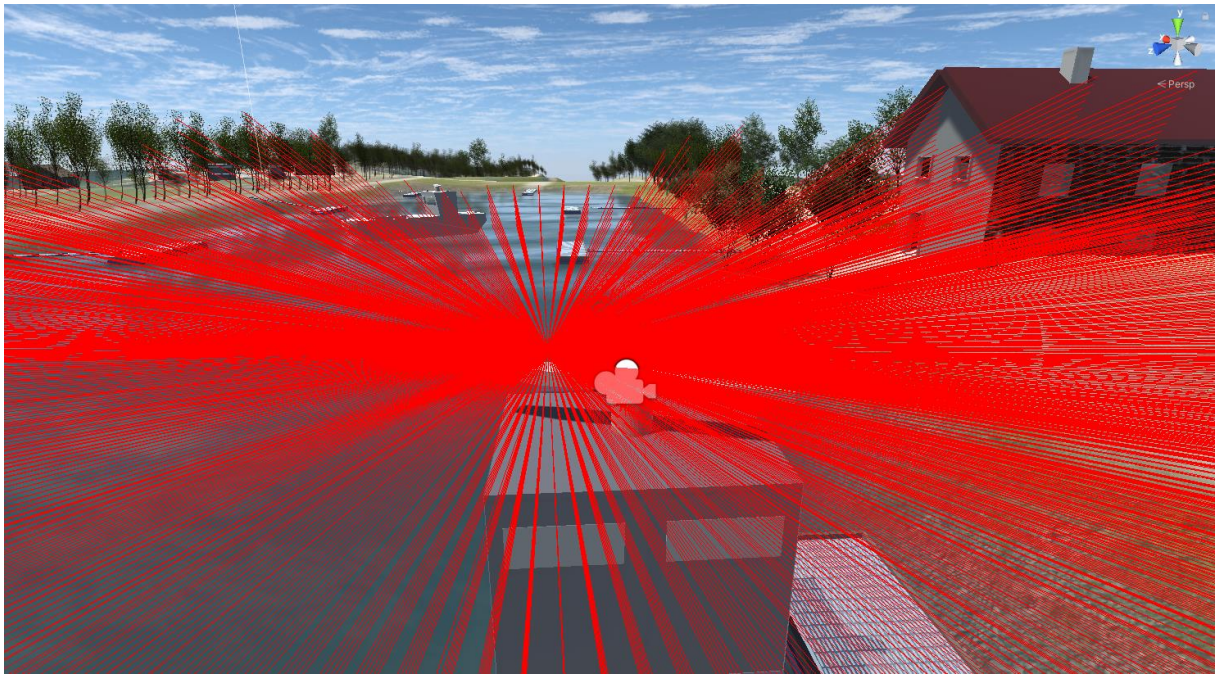

Fig 1. Unity3d scene with visualization of reflected RADAR rays.

Timely data processing and real-time capability are essential for the overall system performance. Therefore, a central aspect of the study is to assess the execution time of the system architecture and data processing algorithms, the latter comprising clustering, filtering and feature extraction. Furthermore, the capability of the software architecture in terms of object detection is demonstrated by tests conducted inside the virtual environment. A method is proposed for generating sparse bounding boxes for prolate and oblique features that usually produce large bounding boxes. Further suggestions for improvements of the overall system performance are outlined.

The proposed software framework enables the integration of various virtual sensors, also in combination with real sensors, and processing of their data for providing input to the downstream modules (e.g., object detection and localization). We plan to implement all other modules of the GNC system in the same ROS2 framework, allowing us to test the whole system in the virtual environment before smoothly transferring it onto a real world USV.