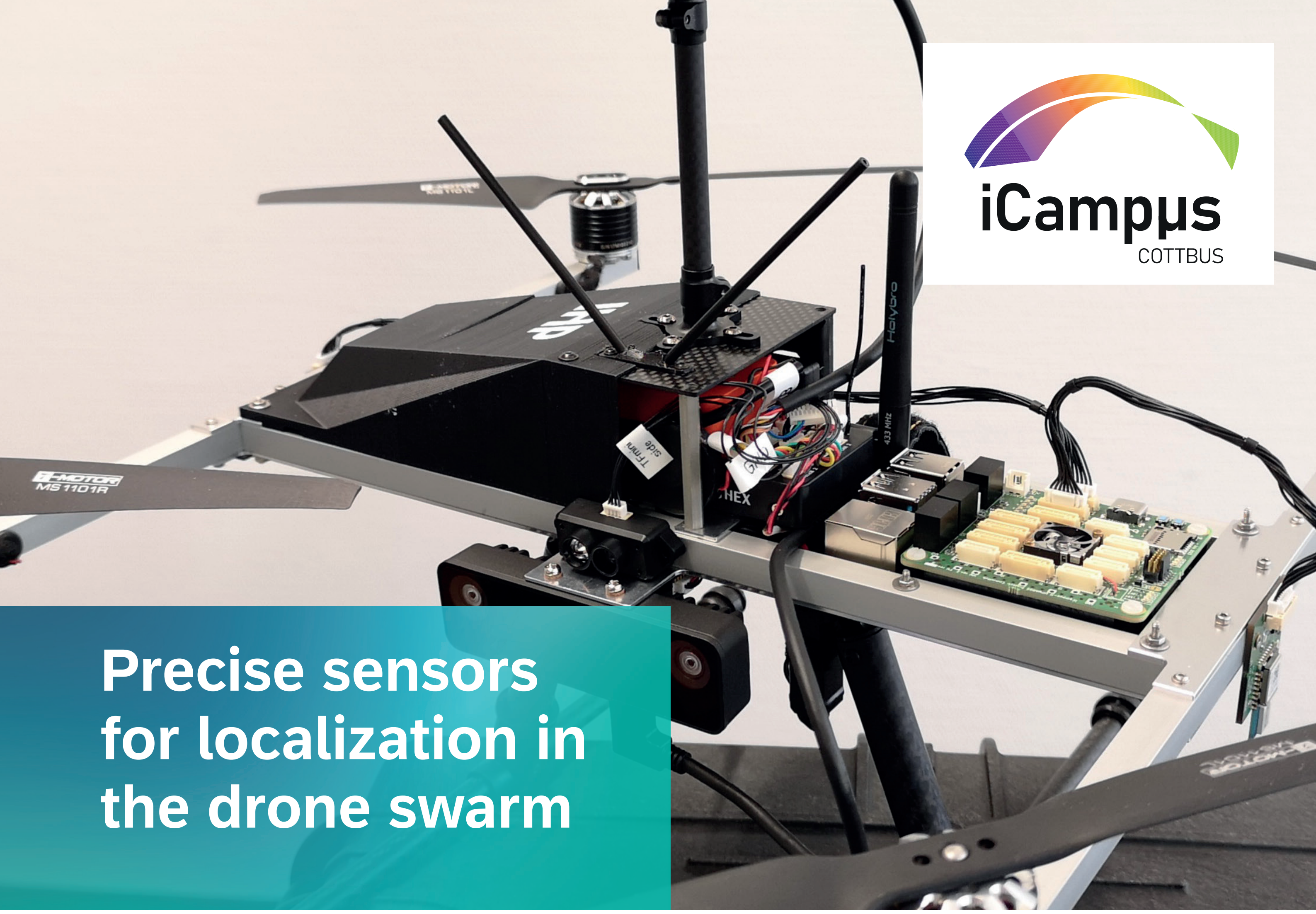

Precise sensors for localization in the drone swarm

Swarming Drone Applications in Agriculture

Drones can be cooperatively connected to form a swarming flock to precisely survey large agricultural areas, manage them more sustainably, and set up a test environment to check and characterize micro-sensor technology in critical real-world environments. In cooperation drones can solve complex tasks faster and be used in new or previously unsuitable scenarios.

Localization Technologies: RTK-GNSS and UWB

Reliable swarm flight requires accurate localization, reliable communication, and dynamic flight control. To ensure that, we first compare the localization accuracy of the Real-time kinematic global navigation satellite system (RTK-GNSS) based on sole and fused GNSS systems (GPS, GLONASS, GALLILEO etc.). We compare the obtained localization accuracy by RTK-GNSS with the one based on distance measurements by Ultra-wideband (UWB). We also present a precise localization method developed on this basis as a combination of RTK-GNSS and UWB.

Implementation of UWB Modules

Commercial-grade available on the market DWM1000 UWB modules were picked out to be used for point-to-point and multi-point connectivity at near distances. In this way, we obtain the relative positions of each drone within the swarm formation by UWB and globally within the flight area by RTK-GNSS. This approach enables resilient positioning in environments without GNSS reception and allows for a self-sufficient operation. This also enables efficient, high-speed flight missions in high solar radiation areas with year-round summer weather, which degrades GNSS signal reception.

As the second step, we integrate these results into our custom developed "UPWARDS" communication controller to enable the decentralized connection of all agents of the swarm.
It is then presented as a PCB communication hub with an integrated UWB controller. This communication hub also adds collision avoidance capabilities to the standard open-source Pixhawk based architecture of our drones via the connected flight controller. In addition, the drones can be used to test different obstacle avoidance strategies. Both, within-swarm, and external obstacles on the planned flight path are covered. We present artificial potential functions strategy as an example to avoid obstacles near the swarm.

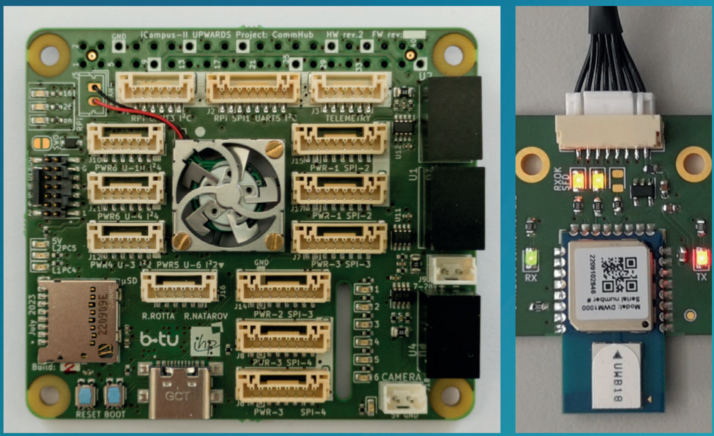

Fig. 1: The communication hub combines diff erent wireless links into a virtual radio for the UAV's fl ight controller and companion computer.

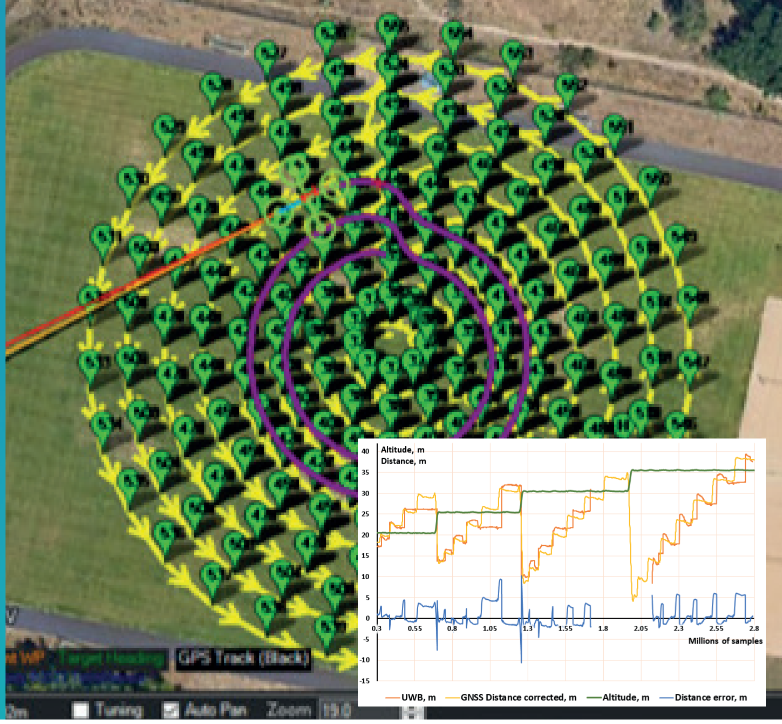

Fig. 2: Accuracy estimation of UWB-based localization: circular motion pattern of the drone; inset: accuracy estimation: the blue curve denotes diff erence between GNSS- and UWB-based distances to the static drone. The gap in the datarow corresponds to the removed invalid distance data.

The third step shows example measurements of a large agricultural field using multi-spectral imagery. This allows us to obtain information about the state of the field from the plant's perspective, with parameters such as drought, humidity, chlorophyll content and pest identification also being monitored.

Future Outlook: Digital Twin and Sustainable Yield Prediction

In the future, on this basis, a digital copy of the field will allow calculations on how to crop it at the resolution of a single plant. Future investigations can also offer predictions for sustainable yield estimation before harvest.

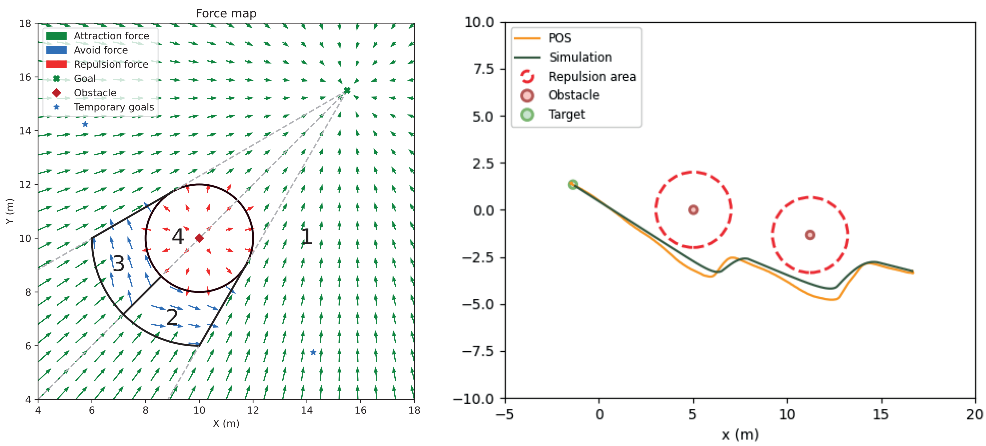

Fig. 3: Artificial potencial function map and experimental test of collision avoidance with two obstacles and one target position. Yellow Line correspond to the drone localization and green to simulation position.

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