An indoor MAV pose estimation system that leverages existing Wi-Fi infrastructure

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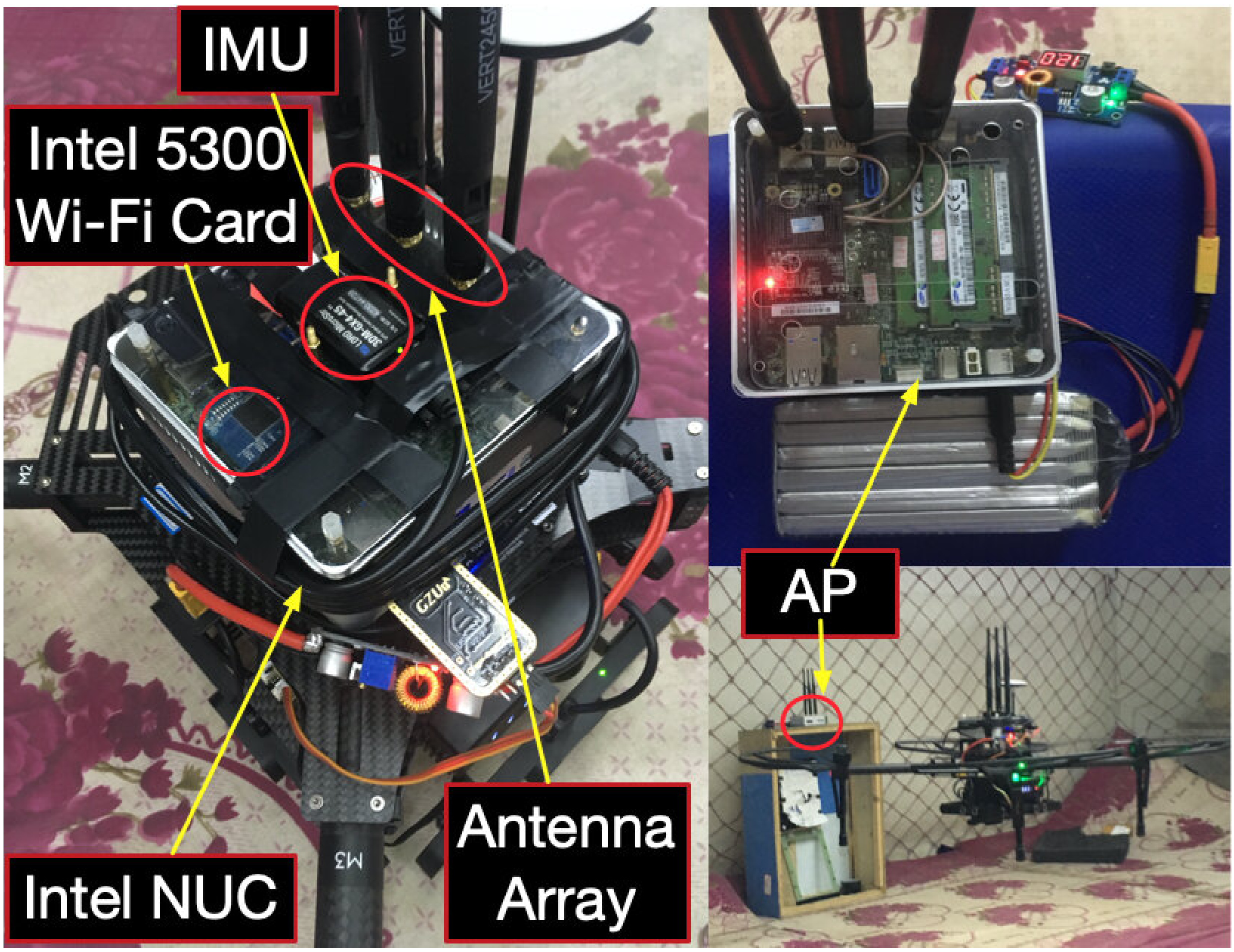

Credit: Zhang, Wang & Jiang.

Micro aerial vehicles (MAVs) could have numerous useful applications, for instance, assisting humans in completing warehouse inventories or search and rescue missions. While many companies worldwide have already started producing and using MAVs, some of these flying robots still have considerable limitations.

To work most effectively, MAVs should be supported by an efficient pose estimation system. This is a system or method that can calculate a drone's position and attitude, which can then be used to control its flight, adjust its speed and aid its navigation while it is operating autonomously and when controlled remotely.

Researchers at Huazhong University of Science and Technology in China have recently developed a new system for the pose estimation of MAVs in indoor environments. Their new approach, outlined in a paper pre-published on arXIv and set to be published in *IEEE Transactions on Industrial Electronics*, leverages existing WiFi infrastructure to enable more effective navigation in small and agile drones.

"In our previous work, we proved the feasibility of using WiFi's localizability to correct the onboard inertial sensor (IMU) drift," Shengkai Zhang, one of the researchers who carried out the study, told TechXplore. "However, the technique we developed, dubbed CWISE, only works in open spaces and without multipath fading. In our current study, we push this method further to address the multipath problem in indoor environments and make our proposed system more practical."

The main objective of the new study carried out by Zhang and his colleagues was to use readily available WiFi infrastructure to estimate 6-DoF poses of MAVs. In contrast with existing pose estimation techniques based on computer vision, the system they developed is free from visual limitations, which means that it works well under different lighting and environmental conditions.

Instead of analyzing visual stimuli collected by sensors, the system leverages the many subcarriers of WiFi orthogonal frequency-division multiplexing (OFDM) signals. More specifically, it uses these signals to find the angle of arrival (AoA) of the direct path between an MAV and a WiFi access point among the many reflections of the signal in indoor environments.

The system created by Zhang and his colleagues has two main components: an AoA estimation algorithm and a WiFi-inertial sensor fusion model. The AoA estimation algorithm is a computational method that estimates MAV attitudes and disentangles the AoA for positioning. The WiFi-inertial sensor fusion model, on the other hand, combines the estimated AoA and data collected using inertial sensors to optimize a drone's poses.

"It is well-known that angles can be used to localize a target via triangulation, however, without a metric scale," Zhang said. "On the other hand, the IMU of an MAV provides metric poses but suffers from temporal drift. We fuse WiFi AoAs and inertial measurements and take the best of both worlds."

The system developed by Zhang and his colleagues has numerous advantages over more conventional pose estimation techniques. First, it is lightweight and instantly deployable in any indoor environment covered by a WiFi network. Moreover, it performs well in workspaces with different lighting and texture conditions.

The study highlights the potential of using WiFi connections to improve sensing and navigation strategies in robots. When tested in a series of experiments in indoor environments, the new pose estimation system achieved remarkable results, presenting an average position error of 61.7cm and an attitude error of 0.92 degrees. In the future, it could be used to enhance MAV navigation in warehouses, offices or other indoor environments.

"Currently, the accuracy of our WiFi-inertial pose estimator is at the decimeter-level," Zhang said. "We would like to improve that. Meanwhile, WiFi itself has some limitations, e.g., structure blockage, interference, and so on. We believe that properly coupling visual sensing and wireless sensing would achieve more robust and accurate pose estimation, which results in more practical autonomous robots."

More information: WiFi-inertial indoor pose estimation for micro aerial vehicles. arXiv:2003.07240 [cs.RO]. arxiv.org/abs/2003.07240

CSI-based WiFi-inertial state estimation. DOI: 10.1109/MFI.2016.7849496. ieeexplore.ieee.org/document/7849496

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