Cooperative Drone Positioning Measuring in Internet-of-Drones

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***Abstract*— Recently, an unmanned aerial vehicles (UAVs) known as drones which offer advantages in mobility purposes due to its convenience, flexibility, and utility above other platforms. Several sensors, such as GPS receiver combining with the control module, attached to the autopilot system which enables navigation and autonomic flighting. However, due to its notoriously poor-quality positioning acquisition from a low-cost GPS device. For autonomic flighting tasks, UAV must have precise localization information while flighting. Recently, smart cities have become an important technology, and the Internet of Drones (IoD) is one of the popular technologies in smart cities, which is a combination of the Internet of Things (IoT) and drones. Therefore, communication technologies may be a satisfactory localization solution for the real-time and the cost that it requires. This study proposes a cooperative drone positioning measuring in internet-of-drones. Every drone connected, share their localization information, distance measuring information to other drones to obtain both of ego-drone's and obstacles' high accuracy position. Finally, the simulation result reveals the proposed method could increase the positioning accuracy through the IoD.**

Keywords—Unmanned aerial vehicles, Internet of Drones, Internet of Things, Cooperative Drone Positioning

I. INTRODUCTION

In recent decades, unmanned aerial vehicles (UAVs), or commonly known as drones, have received increasing attention from both academia and industry community. This is since micro-electromechanical Systems (MEMS) technological advancement. Drones are available for many purposes like traffic surveillance, pollution estimation, delivery etc. The aircraft controlled either remotely or autonomic through predefined paths. Such drones mostly use sophisticated perception technologies to effectively avoid obstacles, thereby, require high cost.

Recently, a smart city has become an important technology which can intelligently automatically to enhance life quality of citizen and improve the efficiency of future cities [1]. To achieve these advanced technologies, drones and the Internet of Things (IoT) are considered a crucial part of smart cities [2]. The combination of IoT and drone lead to IoT has added another dimension to the drone, which we know as the Internet of Drones (IoD) [3]. IoD utilizes drones as an IoT device to performs several smart city applications. However, it still faces several challenges, such as obstacle avoidance [4] and localization [5]. Wang *et al.* [6] develop a distributed collaborative autonomous generation (DCAG) method to locate a target by using angle-of-arrival (AOA) measurements. It also adapts the adjust the angular separations and distance to optimal swarm deployment. Lazzari *et al.* [7] proposed a method of tracking and control of an unmanned aerial vehicle (UAV) by using an ultra-wideband (UWB) localization technique. It estimates the distance between a ground station and UAV via UWB localization and then measuring the position of UAV through the relative moving speed between a ground station and UAV. Zhang *et al.* [8] exploited (an/the) indoor localization system to estimate the pose via Radio-frequency Identification (RFID) tags for UAVs. It applies the Bayesian filter-based algorithm to track the position of the tags and computes the 6 degrees of freedom pose of the UAV. Luo *et al.* [9] devised an adaptive algorithm by using extended Kalman filter (EKF) to estimate the path-loss factor of received signal strength (RSS) based position estimation during UAV flight.

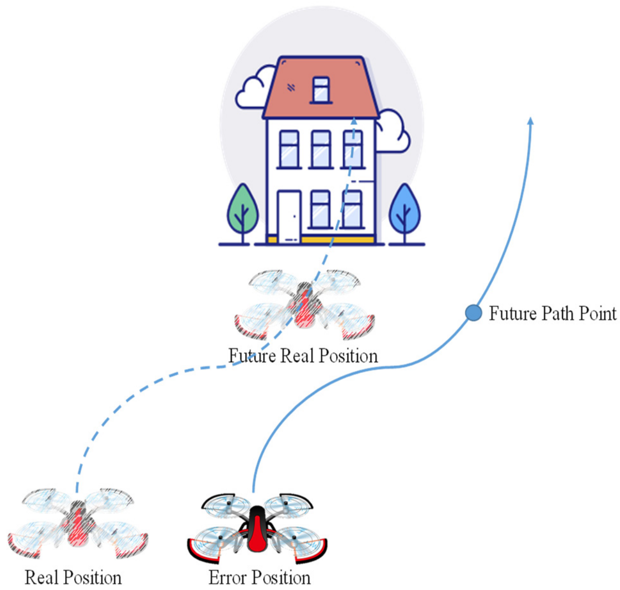

Fig. 1. The influences of the GPS error.

II. COOPERATIVE DRONE POSITIONING MEASURING

Unmanned aerial vehicles (UAVs) have received a growing interesting during the last decade. But, positioning is a substantial limitation in the drones. In the outdoor environment, drones often obtain localization by using the Global Positioning System (GPS) device. Due to not all drones are expected to be GPS-enabled. Moreover, drones often cannot equip a high accuracy GPS, because of the loading and energy issues. Most of the drones equips the common commercial GPS which is about more than 10 meters of error. So, there may cause accidents.

For example, in Fig. 1 shows the influences of the GPS error for a drone while flighting. When a drone performs a navigation task along a predefined path, it may hit some obstacle because of the fault GPS information. Due to the commercial GPS have the error, and it leads to the drone cannot avoid the obstacle in the front of the path. Thus, the recent commercial products of unmanned aerial vehicles

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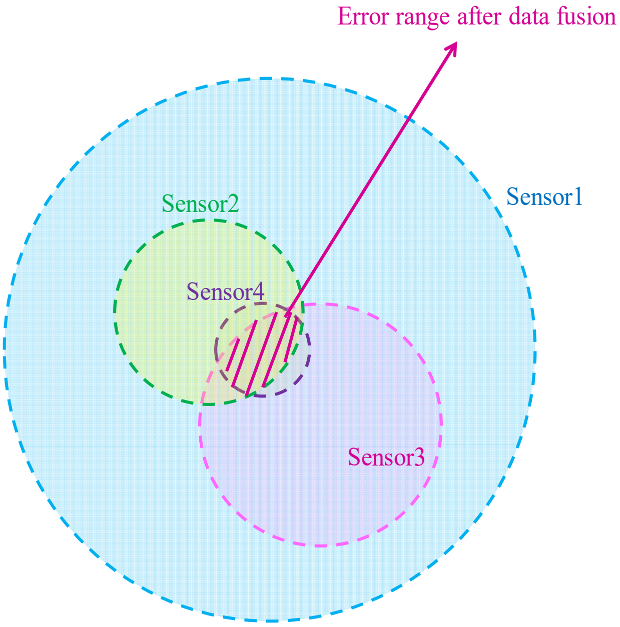

Fig. 2. Error range after data fusion.

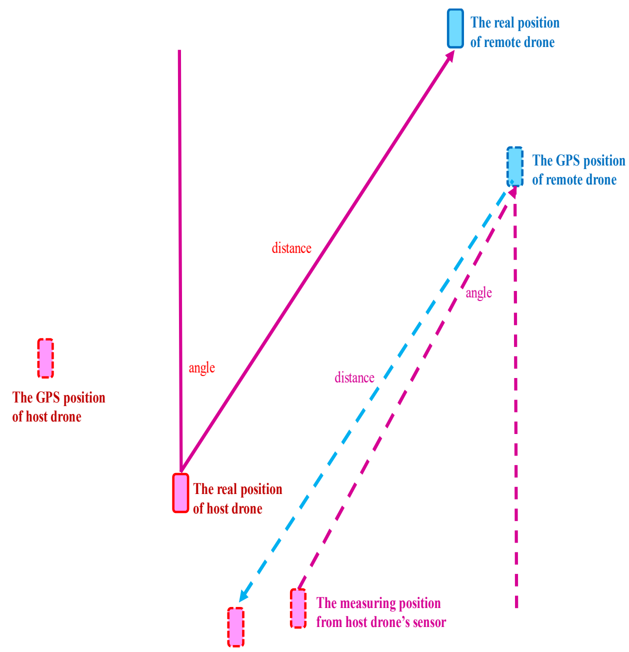

Fig. 3. Cooperative Drone Positioning Measuring.

(UAVs) have a lot of surrounding sensors for sensing the obstacle. However, these lots of sensors in a drone increase more cost. For example, DJI Mavic 2 is a very popular and high-cost drone, and it equips 7 cameras and several sensors to avoid obstacles. Therefore, communication technologies may be a satisfactory localization solution for the real-time and the cost that it requires. This study proposes a cooperative drone positioning measuring in internet-of-drones. So every drone connected, share their localization information, distance measuring information to other drones to obtain both of ego-drone's and obstacles' high accuracy position.

The cooperative drone positioning measuring method, brief as CDPM, is a positioning optimization method by using sensor fusion technology via internet-of-drone. The principle of the sensor data fusion is to capture more measuring information from sensors and then analyze the information to decrease the positioning error. As shown in Fig. 2, if we could obtain lots of positioning information from sensors, it can decrease the localization error via the intersection of the positioning data. However, the positioning device in a drone is limited. In common cases, a drone equips the GPS device, camera devices and ultrasonic devices. But, only the GPS device is using to obtain the self-positioning. Thus, this study tries to make the surrounding sensors that are equipped from other drones as a positioning device for self-drone via the connected drone network.

The object of the cooperative drone positioning measuring is each drone share their measuring distance vis internet-of-drones and make the communication device as a telematics sensor. The Fig. 3 draws an example of cooperative drone positioning measuring between any two drones which connected via internet-of-drones. There are two drones available which are host drone and remote drone. We assume that these drones equip the GPS device and one distance measuring sensor which sensing the surrounding environment. Thus, for host drone's position measuring, we could obtain the GPS data, the measuring position from host drone's sensors, and the measuring position from remote drone's sensors.

- GPS data: This information means that the position is obtained from a GPS device.
- The measuring position from the host drone's sensors: The host drone's sensor detects the remote drone and measuring the distance and angle between them. The remote drone sends its' GPS information to the host drone. Thus, the host drone calculates the ego-position by using GPS information of remote drone and distance measuring data from the host drone.
- The measuring position from remote drone's sensors: The remote drone's sensor also detects the host drone and measuring the distance and angle between them. The remote drone sends the information including the distance and angle to host drone. Thus, the host drone calculates the ego-position by using GPS information and distance measuring data from a remote drone.

III. Performance Evaluation

This study proposed a cooperative drone positioning measuring in internet-of-drones. The simulation environment is a 100m x100m field that has two UAVs available in it. We assume that each UAV equips a GPS device with a 10m error radius and a sensor that could be sensing the other obstacle. It means these two UAVs could detect the other one.

As shown in Fig. 4 is the comparison of position accuracy probability between GPS only and the proposed method. The proposed study can increase better positioning accuracy when a UAV using a low-cost GPS device. It is shown that if there are at least two UAVs available , connect and form an internet-of-drone. Through the positioning information sharing, all UAVs could obtain better positioning.

IV. Conclusion

In the last decade, drones have received a growing interesting and aim to be applied for several automatic tasks. In the outdoor environment, drones often obtain localization by using the low-cost Global Positioning System (GPS)

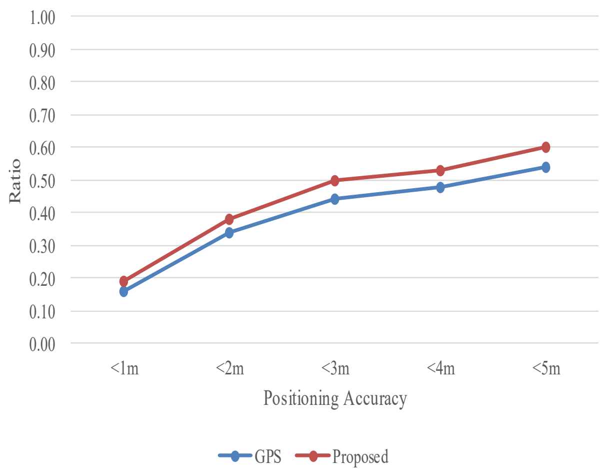

Fig. 4. Position accuracy probability.

device due to the loading problem. However, the positioning accuracy from low-cost GPS is not stratified to meet positioning requirements, it is a substantial limitation in the automatic drones. This study proposed a cooperative drone positioning measuring method, brief as CDPM, is a positioning optimization method by using sensor fusion technology via internet-of-drone (IoD). CDPM tries to make the surrounding sensors that are equipped from other drones as a positioning device for self-drone via the connected drone network to increase the localization accuracy. The simulation result further indicates that the proposed CDPM method achieves the increase the positioning accuracy.

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References

[1] R. Du, P. Santi, M. Xiao, A. V. Vasilakos, and C. Fischione, "The Sensable City: A Survey on the Deployment and Management for Smart City Monitoring," *IEEE Communications Surveys & Tutorials*, Vol. 21, Issue 2, pp. 1533-1560, Nov. 2019.

[2] S. H. Alsamhi, O. Ma, M. S. Ansari, and F. A. Almalki, "Survey on Collaborative Smart Drones and Internet of Things for Improving Smartness of Smart Cities," *IEEE Access*, Vol. 7, pp. 128125-128152, Aug. 2019.

[3] M. Gharibi, R. Boutaba, and S. L. Waslander, "Internet of Drones," *IEEE Access*, Vol. 4, pp. 1148-1162, Mar. 2016.

[4] K. McGuire, G. d. Croon, C. D. Wagter, K. Tuyls, and H. Kappen, "Efficient Optical Flow and Stereo Vision for Velocity Estimation and Obstacle Avoidance on an Autonomous Pocket Drone," *IEEE Robotics and Automation Letters*, Vol. 2, Issue 2, pp. 1070-1076, Apr. 2017.

[5] S. V. Sibanyoni, D. T. Ramotsoela, B. J. Silva, and G. P. Hancke, "A 2-D Acoustic Source Localization System for Drones in Search and Rescue Missions," *IEEE Sensors Journal*, Vol. 19, Issue 1, pp. 332-341, Oct. 2018.

[6] W. Wang, P. Bai, Y. Zhou, X. Liang, and Y. Wang, "Optimal Configuration Analysis of AOA Localization and Optimal Heading Angles Generation Method for UAV Swarms," *IEEE Access*, Vol 7, pp. 70117-70129, May 2019.

[7] F. Lazzari, A. Buffi, P. Nepa, and S. Lazzari, "Numerical Investigation of an UWB Localization Technique for Unmanned Aerial Vehicles in Outdoor Scenarios," *IEEE Sensor Journal*, Vol. 17, Issue 9, pp. 2896-2903, Mar. 2017.

[8] J. Zhang, X. Wang, Z. Yu, Y. Lyu, S. Mao, S. CG Periaswamy, J. Patton, and X. Wang, "Robust RFID Based 6-DoF Localization for Unmanned Aerial Vehicles," *IEEE Access*, Vol. 7, pp. 77348-77361, Jun. 2019.

[9] C. Luo, S. I. McClean, G. Parr, L. Teacy, and R. D. Nardi, "UAV Position Estimation and Collision Avoidance Using the Extended Kalman Filter," *IEEE Transactions on Vehicular Technology*, Vol. 62, Issue 6, pp. 2749-2762, Jul. 2013.