Drone Swarm, The Finnish UAV Ecosystem Trial

Kristian Ratia, Henry Hinkula, Vadim Kramar
Oulu University of Applied Sciences
Oulu, Finland
kristian.ratia, henry.hinkula, vadim.kramar @oamk.fi

Abstract - **Proof of concept of swarm flying. In this research, one drone was controlled by a person and three drones were controlled by a server. The server knows every drone’s location and controlled the drones based on other drones' locations. Flight code was tested on a simulator and a closed secured area. Automatic drones had only two commands which could be commanded: takeoff and land. Everything else was controlled by the server.**

I. INTRODUCTION

Using multiple drones at the same time will save a lot of time on cases that can benefit from drone swarms[1]. Operations that can benefit from swarm flying are examples of searching or filming operations. In best cases, multiple drones can reduce the time needed for operation more than the number of drones. If two points need to be examined, using one drone it needs to fly to point one and after that to point two. If points are far away and in different directions, the drone needs to fly point one, then fly back to the starting point, and after that fly to point two. When using two drones, points can be examined at the same time, and the time used is reduced by 2/3. Swarmflying does not have a precise definition. In the simplest form, it is when two persons are flying drones at the same time. The most complex form of swarm flying is when several hundreds of drones are used for making pictures and forms to the sky [2].

This research is proof of the concept of swarm flying. It has been made by using 4 Parrot Anafi drones which are connected to computers and computers have a connection to the server which controls 3 drones based on the location of other drones. One of the drones is controlled by a human and it will send the location to the server. The system has been tested on the Parrot Olympe simulator and with real equipment.

II. THEORY OF SWARM FLYING

There are multiple definitions for swarm flying. This research concentrate on swarm flying where multiple drones have information about other drones location and make movements based on that information. If every drone would be controlled by ai, then eventually all the drones would hover and would not move. Because one drone is controlled by a human, there is one moving part on the swarm. Other drones will notice movement and algorithms will calculate new positions for every drone, based on other drones' movement.

Parrot Anafi drones can be controlled using Python code. Parrot has a simulator where the code can be tested. There can be multiple drones on one simulator.

In this research, there have been used some basic principles on drones code. Drone tries to find out the closest drone on the upper left corner, upper right corner, lower left corner, and lower right corner. If there is a drone on every corner and those drones are further than safety distance, the drone will calculate the center position from those four drones and it will fly there. If one or more drones are closer than safety distance, then the drone will replace that drone location by itself location. Then drone will calculate the center position. Using drones' position on drones that are too close and calculating center position after that, makes the drone automatically fly away from the drone which is too close. The same algorithm applies to the drone which is too close and in the next round both of the drones have taken some distance to the drone which was too close. If there is not a drone on some of the squares, then the server will use the drone’s position when doing the center calculation.

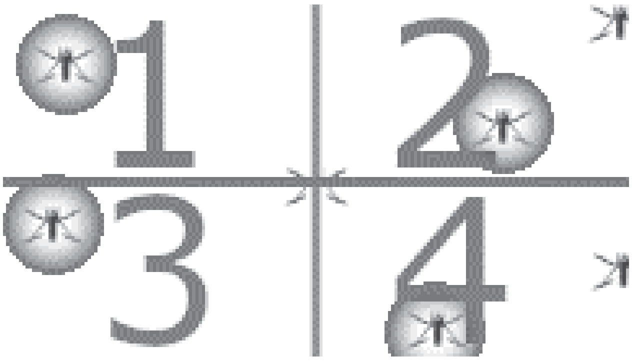

Fig. 1. In the middle of the image, there is a drone that looks its’ closest drone on every square. Circles mark as a founded closest drone

This swarm trial uses only Parrot Anafi drones, but for the future use of the system, it is built as easy to use as possible. The server receives the drone id and location as a JSON. The server uses that id and location for calculating the next position for the drone and sends back a JSON that has coordinates for the next position. Adding a different type of drone is possible if the drone can be controlled by a computer. Most likely different kinds of drones need some specific code for the computer, but after that, it should be easy to add another type of drone to the swarm.

Currently, server code does not handle all situations where a new drone is a different type of drone. For example, if the new drone is a car or submarine, then the algorithm cannot handle it perfectly. The location which the server sends to the drone where it should go next has also altitude information. Only flying drones can handle that altitude information well.

Different kind of drones has different specs. One of those is maximum speed. If server controlled drone is faster than a human-controlled drone, it does not matter. If the drone which the server controls are slower, then the person who is responsible for flying must remember that and pause flying all the drones are in the swarm again.

This research was done on the simplest possible way to do swarm flying. If swarm flying is done more correctly there are a lot more things to consider: object detection, path planning, navigation, collision avoidance, coordination, and environmental monitoring[3].

Swarm flying can be used on civil security, public safety[4], and agriculturar[5]. Swarms have a great potential for searching people or investigating areas that are potentially hazardous environments. On agricultural swarms can do some work better than land vehicles and faster than only one drone.

III.TESTING ON SIMULATOR

A simulator is a great help when testing different safety distances and different algorithms for swarm flying. Olympe simulator can emulate multiple drones. In this research final test was done with only four drones on the simulator. The real test could not be done with more drones because of a lack of equipment. When testing experimental code, it is better to test first on the simulator, then with a small amount of real equipment and after that, the test can be scaled up. The simulator test had a couple of problems. In the beginning drone's safety features on the code were too tight. When the distance between two drones was less than safety distance, both drones just stay there. At that test, there was a feature that if there is a drone too close to square one, then the drone would not move to the up, or left. The only possible moving place would be down and right. That is very secure, but it will also easily lock the position of the drone in a way that it cannot move anywhere.

The first algorithm was replaced with the final algorithm where the server uses drones' coordinates when calculating the position were to move on cases where one or more drones are too close. That algorithm prevents drones to lock their position. With that algorithm, drones will hover in one place only if there is no need for moving or there is a drone blocking the way on every corner.

IV.TESTING ON REAL ENVIRONMENT

On the test with real equipment for safety reasons, every drone had a unique altitude that the server could not change. There are a couple of differences between a simulator and a real environment. On a simulator, GPS coordinates are always really accurate. In the real environment, GPS is not that accurate. The real location can be even a meter away from the location which the GPS report. Other things which are missing from the simulator are wind and wind gusts. Those can have a huge effect on drones' movement. A drone will resist the wind, but the drone will always move a bit especially when a wind gust hits it.

For safety reasons, drones had different altitudes on the real test. The first test shows that the safety distance which was good on a simulator is not enough in the real environment. Partly because on simulator drones can be observed in any direction, but in the real environment, the observation point is locked below the drones and not directly below, but there is an angle between drones and the observation point. That angle makes it harder to estimate how far away the drones are from other drones. It is quite hard to estimate if the safety distance setting is big enough or should it be bigger if the exact distance is not available. The real environment needed some adjustment to the safety distance. Safety distance needs to be big enough that there is no need to think will the drones hit each other or not.

Testing in a real environment brings some new challenges to the testing, particularly in Finland those are associated with the Nordic challenges of UAS operations [2]. The simulator runs on one computer, but testing on a real environment need 6 computers, 4 real drones, 2 mobile network connection, and a wireless router. More equipment means that there are more possible situations where one or more of the devices has an error.

V.DISCUSSION

Proof of concept code needs to swarm size to be exactly 4 drones. Static swarm size helped to test the code. In the future, there is a need for testing swarm flying with different sizes of swarms.

Drones’ location information is sent in JSON format. JSON does not have anything else than drone id, location, and altitude. Adding different drones is possible, but on this test, all the drones were Parrot Anafi drones. For testing purposes, it was necessary to use the same drone model. That eliminates problems that come when using different drones. When sending location to the server and getting a new location from the server, a computer must change the commands to the drone-specific commands. Using a different kind of drone will increase needed work a lot and it would also increase a change of failures. Now that swarm flying works on one type of drone, code can be tested on different drones.

The algorithm which calculates drones’ next location could be improved a lot. It could handle the drone's speed and distances depending on the environment. There could be virtual fences or real obstacles which would affect the swarm model[6].

In this research, drones kept tight swarm and fly commands based on the locations of other drones. There are at least two interesting swarm fly scenarios that could be tested. One is where the server gets commands or a list of tasks which it would send to the drones based on which drone would be closest. That could be used when looking for a missing person. The area could be scanned and after that drones could check the most interesting or promising places. When using multiple drones, checking those areas would be faster.

Another interesting approach would be using a heat map. Multiple drones could be used for guarding the area. Heatmap would keep on track of the area and when every part has been checked last time. When there has been a long enough time that it has not been checked, the server would command the closest drone to check that area. That kind of system could be an example warn if some part of a factory or big machine is getting too hot to prevent a fire. Heat cameras are expensive and usually normal cameras are static. Drones can be used to check areas in different directions.

Instead of IoRT (Internet of Robotic Things)[7], where the swarm is controlled by the server. Every drone in the swarm could have its control system. That system would be safer to fly in areas where there might not be an internet connection. Without a need for a ground station, the swarm would be able to fly longer distances.

VI.CONCLUSION

There are some benefits to swarm flying. Currently, it can be done even with cheap equipment. The total cost of the equipment used in this research was less than 5000€. Equipment used in this research had minor reliable problems during the tests: internet connection was lost, connection to one drone was lost and safety distances needed to be adjusted even though it worked well on the simulator. Those problems can be solved by testing more and using more reliable equipment. This equipment can not be used as bvlos-flying, because reliability is not high enough. Swarmflying needs more persons to observe drones than flying with a single drone. On this research one person was needed for operating all the computers, one person was observing drones, and one person was needed for filming flying, and for helping observe drones.

ACKNOWLEDGEMENT

The authors would like to express gratitude to the members of the FUAVE project [8] and the Academy of Finland for funding the project.

REFERENCES

[1] ‘Swarms of Unmanned Aerial Vehicles — A Survey’, 2019 Anam Tahira, Jari Bölingb, Mohammad-Hashem Haghbayana, Hannu T.Toivonenb, Juha Plosilaa.
[2] ‘Drone Light Shows “Way Cooler” Than Fireworks’, 2020. [Online]. Available: https://www.forbes.com/sites/grrlscientist/2020/06/30/drone-light-shows-way-cooler-than-fireworks/?sh=5f15779942f1. [Accessed: 01-Oct-2021].
[3] ‘Distributed Processing Applications for UAV/drones: A Survey’, 2015Grzegorz Chmaj and Henry Selvaraj.
[4] ‘Review: Using Unmanned Aerial Vehicles (UAVs) as Mobile Sensing Platforms (MSPs) for Disaster Response, Civil Security and Public Safety’, 2019. Hanno Hildmann, and Ernö Kovacs
[5] ‘Research and development in agricultural robotics: A perspective of digital farming’, 2018. Redmond Ramin Shamshiri, Cornelia Weltzien, Ibrahim A. Hameed, Ian J. Yule, Tony E. Grift, Siva K. Balasundram, Lenka Pitonakova, Desa Ahmad, Girish Chowdhary.
[6] ‘Optimized flocking of autonomous drones in confined environments’, 2018. Gábor Vásárhelyi, Csaba Virágh, Gergő Somorjai, Tamás Nepusz, Agoston E. Eiben, Tamás Vicsek.
[7] ‘Internet of Robotic Things: Driving Intelligent Robotics of Future-Concept, Architecture, Applications and Technologies’, 2018. Anand Nayyar, Ranbir Singh Batth, Amandeep Nagpal,
[8] ‘FUAVE makes top drone research easily available for you’, 2021. [Online]. Available: https://www.fuave.fi/. [Accessed: 01-Oct-2021].