Swarm Intelligence Based Drones: Opportunities and Future Aspects

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The services provided by big telecommunication companies is no more restricted to provide 3G/4G services for Wireless networks rather a new Era for "Drones" has emerged to support "Zero Touch Technology" especially in the pandemic situations like corona virus. This situation of emergency has opened the adoption of drones for multiple purposes like taking tower images, food delivery, medicines routing, serving calamities etc. Data obtained from these drones is the potential source of data analysis. These multiple swarm intelligence-based drones are an edge to conventional systems where multiple units are used to complete a task. Data collected from these swarms is potential source to form networks. Drones can interact with each other forming the graph of nodes, sharing the responsibilities, and doing the multiple tasks. Present work aims at justifying needs, challenges of existing drones' system that can be overcome with the help of swarm Intelligence based drones. Also, idea of forming signed networks with the data collected by interaction of swarm drones will also be discussed.

Keywords: Drones, Swarm Intelligence, Signed Networks, Meta heuristics

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1 Introduction

According to recent survey[1], "Drones are the perfect way of bringing society together to support Internet of things in a very sophisticated way". The major hurdle of IoT based systems is lack of proper communication. This is where Telecommunication plays an important role as IoT is incomplete if devices can't communicate with each other. Moreover, establishment of robust and seamless communication is also one of the application of drones along with traditional uses such as taking image of tower for inspection, dropping food packets during disaster time, taking images of soil samples, land sample for irrigation etc. especially during pandemic time where reachability of humans is a challenge. With advent of 4G and 5G, use for drones accelerated to provide coverage and optimize network parameters even in crowded area. Internet of things makes robust hardware for this kind of technology as for high computation and complex activities seamless internet connectivity in terms of speed, hardware, software is required. Below figure illustrates role of "Internet of things" in drone based communication, components make drones capable of communicating with ground stations. These ground stations are capable enough to collect data, give instructions too. Once, data has been collected, application of techniques like metaheuristics and other AI based techniques can improve the working of drones a lot.

Some of the major challenges involved in current drone's installation and usage are enlisted as below:

1.1 Installation

To fly drone above line of sight and without driver is a major challenge which is to be addressed. To this end, infrastructure is still developing. Moreover, cost of the installation is also a major aspect of drone employability.

Drones' installation cost for various regions are defined by Telecommunication and Government bodies. It also depends upon the various factors like material, size, technology, applications for drones. Drones in Telecommunications Figure 1 is shown below:

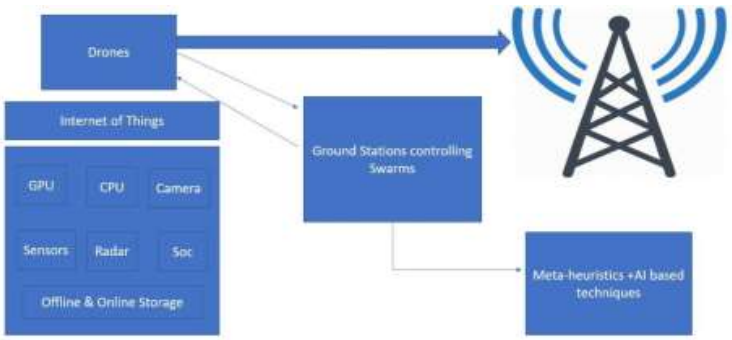

Figure 1 Drones in Telecommunications are highly benefited with Internet of Things

[1]https://www.gartner.com/en/documents/3987195/hypecyclefordronesandmobilerobots 2020

1.2 Lack of Efficient Hardware

Drones' hardware also determines the efficiency especially over the high-altitude regions. Material of the drone and design is still a research area especially for narrow regions like European markets that are known for their demographic location. Other aspects like battery, camera, mic and other necessities to capture data or do meaningful tasks like dropping of food etc. still needs to improve.

1.3 Single Unit Based Drones

These drones can't cover larger area and cover fewer applications to work upon. In case of any mishappening, operations need to be aborted because of no backup. Reliability of data collected by single unit is always less than the data collected by multiple units. Also, they have limited Payload capacity.

1.4 AI Based Drones

Use of drones is increasing at an alarming rate for various purposes. There are few tasks that require "artificial Intelligence" to interfere like analyzing images, capturing of relevant sound samples etc. Application of AI techniques for intelligent and rational behavior of drones is a prominent research area.

1.5 Safety, security & Privacy

Drones can be attacked by various hackers for stealing the data especially image data taken from tough terrains. Also, with techniques like traffic jamming, signal misleading, entering into different spectrum band, security and privacy is at utmost risk, coming to the safety aspects chances of collision of the drones with another aeronautical vehicle is very high which may result into drone damage. All these aspects can completely remove crucial data. Therefore, security of drones is a seminal concern.

Above challenges inculcates the need of improving existing single or multiple unit based drones especially in the following applications:

- Defense
- Telecommunications
- Natural Disaster Area

Hence, we need to have an integrated system that supports both robust hardware and software with decision making capability and intelligence. Moreover, these drone systems should be smart enough to learn in the scenarios where the problems cannot be solved in deterministic time. Hence, this work, "Metaheuristic based Technique" that can address many problems of conventional drones in epidemic, pandemic or natural calamity situations by employing "Swarm Intelligence in Drone systems". Swarm based drones can range from checking internet connectivity in high-altitude region by taking tower Images and studying network parameters of these towers that has been installed with difficulty at these areas. Europe is highly known for its snow beauty; these high-altitude drones can detect congestions or disasters that happened due to snow.

This article highlights that data collected by these Swarm drones forms a very potential data for Signed Networks. The networks in which both positive and negative relationships can exist between the nodes are knowns as “Signed Networks”.

2 Related Work

In 1990 and 2000, several projects were launched involving drone application, however, very few continued. IN 2014, technological giants “Google” and “Facebook “announced their Investments over the High-altitude platform projects to check Internet Access in these areas 2 A high-altitude drone is capable of flying above the height of 60,000 ft and can be in motion for long periods of time.
The authors of [1] conduct a comprehensive assessment of unmanned aerial vehicles (UAVs) and underline their potential for delivering Internet of Things (IoT) services from the skies. They offer their idea for an architecture based on UAVs and discuss the pertinent key problems and requirements. A recent extensive survey [2] discusses the day-to-day applications of UAVs and the accompanying challenges. The authors discuss many civil applications in terms of their current state of development and research trends, as well as their general challenges and possible future paths. The conversation begins with a high level overview; they then highlight specific UAV issues across a variety of application themes. Within the context of wireless sensor networks, [3] discusses the coverage issue when sensors are fitted with cameras for video surveillance applications, but only up to the year 2010. While this study is not specifically on UAVs, it does provide an in-depth examination of techniques including coverage, node deployment, and coverage metrics. Similarly, [4] reviews the coverage issue in WSNs, although only up to 2008. It is particularly concerned with determining the appropriate locations for sensors to ensure maximum coverage. Additionally, it discusses data fusion techniques for applications such as threat assessment. Another review of the literature focusing exclusively on motion planning approaches for UAVs in various applications is offered in [5], however its coverage is limited to the period up to 2010. However, the purpose of our study is to give a comprehensive state of the art on this key research area in conjunction with existing surveys.
Another architectural solution for robot navigation was given by Macek and colleagues [6]. They are concerned with the problem of vehicle navigation in an urban setting while maintaining safety. Rather than this, however, they concentrate them. efforts on addressing the challenges of safety related with the navigation of single unit drones. Petti and colleagues [7] have developed a strategy that relies on partial motion planning to ensure the safety of a single vehicle's navigation. It is their contention that because calculating a whole path is such a complex and computationally expensive job, the only viable approach is to compute and navigate within the next safe states. Quadrotor robots for communications network coverage area development in disaster areas are discussed in [8], as is the function of Swarm drones in this process, according to the research given there. GUERBER et al. [9] discussed about the security aspects in swarm-based Intelligence systems. Detailed description on underlying concepts of the security issue like attacks and their minimization is provided.

[2] https://www.wired.co.uk/article/googleprojectloonballoonfacebookaquilainternetafrica

3 Proposed Architecture

This work emphasizes on the multiple units based drones that has many advantages over single unit based drones like reliability, robustness, efficiency, workload sharing, self-adaptability and interactions between units etc. The seminal idea is to impart swarm Intelligence to drones along with machine learning and deep learning framework to do make the system of Swarm drones highly robust and powerful in nature. The following proposed architecture diagram (Figure 2) given below shows the integrated "Swarm Intelligence based drones system".

The proposed architecture shows Metaheuristics layer that is having multiple units known as "Swarms". These swarms can interact with each other and adjust according to the situation and take decision. They collect data and pass to second layer. The data collected is given to CPU/GPU controlling these swarms. Afterwards, within AI Engine various AI techniques like Fuzzy logic, security algorithms etc. can be used for computational analysis on data. Also, various machine and deep learning techniques can be employed to handle this amount of data. Finally, various tasks like image analysis, voice analysis, Text analytics, essential deliveries like medicines, food etc. can be done.

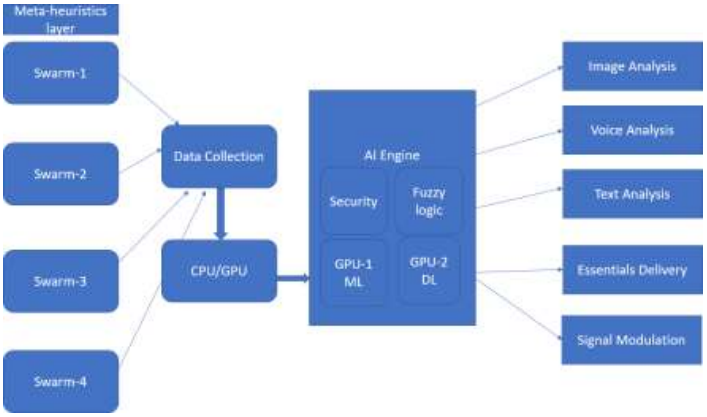

Figure 2 The proposed architecture involving Metaheuristics along ML/DL

Following the diagram above, data collected by AI Engine can form potential sources for forming signed networks. These signed networks help in studying positive and negative relationship among various swarms performing tasks. Swarms can be divided into communities sharing relationships within the community as well as outside the community. The relationship among these drones can be signed that is few drones should communicate to accomplish the task and few should not so that repetitive tasks are not done. Hence, Network of these swarms can be formed[Figure 3] as:

$G_{sig} = (V, E^{+}$, where V is the set of swarms^{+} is set of positive links,
$V, E^{-}, where\ E -$ is set of negative links) Equation

1: Signed Network of Swarm drones

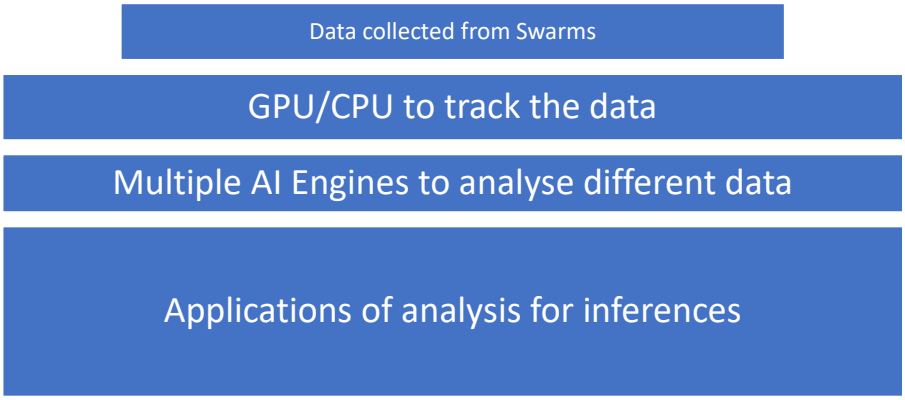

Figure 3 The proposed workflow for the Swarm based drones

3.1 Benefits of Proposed System over existing System [8-19]

- The Swarm drones are self-organizing in nature with each unit that can control, adapt and organize own its own.
- Among the swarm if one of the swarms gets damaged, other swarms can carry
- on the work and loss of useful information will be avoided.
- Each swarm can be assigned a dedicated task like Image sensing, voice recognition, packet delivery, sensing Towers signals etc. that is not a real case with single unit-based drones. This makes Swarm drones highly versatile in nature.
- Also, data is being collected by multiple units hence, biasness within the data
- set to be analyzed by machine learning or deep learning algorithms will be avoided. This is very promising application of swarm drones.
- In the field of Telecommunications, the area of Swarm Drones can be boon in many situations like taking image of towers from various angles, sensing the network signal especially in high-altitude areas where signals are bleak and installation too.
- Due to covid, many food delivering organizations like “Zomato” has opted for “zero Touch food delivery” Akin to this, here also swarm drones can benefit Telco’s to provide service for the same and benefit the business.
- The area being covered by swarm drones is definitely wider as compared to single unit based drones as swarm occurs in the group and organize their movement depending upon the situation, they interact with each other, sensing the environment and passing the information too.
- During the calamities especially in higher altitude, necessities for role of swarm drones increases a lot. They can be aided to provide medicines, food and other essentials in large quantities and in wider areas too.
- Swarm Drones can take image of towers and collect other heterogeneous data in large quantity that can be analyzed with Big Data techniques and meaningful insights can be drawn.
- The commercialization of this concept provides a very good opportunity for the industry to invest and reap benefits later especially Telecommunications.

4 Conclusion

In the proposed work, emphasizes on swarm Intelligence based drones is discussed where data captured by these drones can form signed networks. Also, the comparison has been drawn on the opportunities that swarm drones can provide in contrast to the single unit-based drones. Adoption of "Swarm drones" especially during covid times can prove to be high gain investment in terms of commercialization and social growth which in turn benefits both industries and society. It can be concluded that with era of drones and imparting techniques like nature inspired algorithms, deep learning, machine learning, a new era of study known as "Aerobatics" [20] has emerged and wide range of applications can be solved and studied with them. For Telecommunication industries, investing in this technology is a potential area as providing seamless services in terms of Internet, connectivity is uttermost things in these drones. The manufacturers of these drones will be highly dependent upon the Telecommunication service providers for flawless connectivity. Hence, it opens the wide range of opportunity especially for this industry.

5 Future Work

Present work can be extended in the next phase. As, a part of the implementation, data set will be simulated in the lab for swarm drones. This data would be image, voice, numeric data, signal data etc. Images will be analyzed with help of deep neural network. From the numeric data, graphs will be constructed with the help of oncology. These graphs will be constructed based on interaction among swarms and various computational tasks like community detection, link prediction, sign prediction etc. can be studied with the help of metaheuristics.

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