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Swarm of drones exploration in confined area

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***Abstract*---**Drones are used as helpful machine for the use of human in various mission to successfully complete the required work in less time .The swarm of drones is the advancement of the mission which are time typical and time complexity centered problems. Typical application with swarm drones are civil security ,distant and extended area, observation of hostile and other wide applications. While the Paper, used the lightweight and economical way to use swarm drone. Ad-hoc network is used as medium for the communication of multi drone for the exploration in confined areas. This paper the main point is that the swarm technology in the time complex missions and use it other than commercial purpose. The required data is collected form the real time flight of the drones and interpreted to find the successful path in completion of the required work. Predefined path defined to the multi drone in ordered for exploration in desired path. The purpose of this paper, acquisition and pattern formation in efficient manner of the successful path finding in confined areas for better exploration strategy. This work is developed with in framework to support robot operating system.

***Keywords*---**perception, planning, decision, and ad hoc network.

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1. Introduction

Swarm of drones partially autonomous vehicles which can be controlled remotely besides the aerial photography drones are used in numerous military work, search and various rescue operation and also for delivery of products. However the growing the quality of drones and use of drones in commercial application also quality of incidents are also increasing dramatically. Some work which have been solved by the swarm of drones. For example a set of drone which can co ordinate and analysis a tensile structure. They are also used in drone show and also in choreographies. Current these swarm of drones are used in the field of civil security for observation in an hostile environment or touch or gaint area. These swarm of drones requires a coordination system that gives the corresponding location of drones in an area and they are also used in interior atmosphere Due to these restrictions, the majority of recent research relies on relative positioning methodologies, which necessitate the preparation of pre-flight infrastructure (motion capture system, Indoor Positioning System, etc.).

Gunasekaran raja et.al[1] the unmanned aerial vehicles, Swarm optimization, Wireless mesh network, Advanced Encryption Standards. The power consumption in UAV and reduced power consumption in the UAVs. Unmanned aerial vehicle (UAV), sometimes known as a drone, is a rapidly expanding technology with a wide range of uses in today's market. Mini UAVs were created to compensate for the capacity constraints of larger UAVs in emergency scenarios. [2] The communication between the drone and the ground station. Swarm was scalable, adaptable, autonomous and have a good fault tolerance capability. Gives the comparison in the performance of CBR traffic flow of swarm with AODV and DSR. Quinan cui, peizhu liu et .al[3] the communications between the drones and between the drones and the ground control station (GCS). The mesh network topology used in communication of drones. . The system as a whole is greater than the sum of its components, capable of addressing complicated issues that no single agent could solve alone. Drone swarms and their provision is made rely heavily on effective communication protocols. [4] the use of small drones (UAVs), real time big data platform (KAFKA) , collecting information using the sensors .The objective of the paper is that to collect data for testing of obstacle avoidance algorithm and to evaluvate the communication performance end to end. Margot deruyck et.al [5]use of drones in emergency through the wireless network. The first findings indicate that this is a very promising technique, however a large number of drones will be required to cover all users in Ghent's downtown area during a one-hour intervention. Amin majd et .al[6] optimization, learning and automatic immediate responses of drones to ensure safe operations of swarms of drones.The increased safety and mostly Efficient route of drone is proposed in the approach.

The work have a tendency to show that it's doable to work a swarm of drones employing a software package with none alternative instrumentality than the drones themselves. sensors like measuring device, gyroscope, meter, measuring instrument or any specific sensors like the module that's inaccurate and inefficient in sure things (e.g. indoor), we have a tendency to propose an answer to synchronize and orchestrate a collection of drones supported impromptu communications. Indeed, by forming a poster hoc network (based on IEEE 802.11

in our experimentation), we will confirm the distances between drones in line with adequate information rates that rely upon received signal strengths. So, no position and no distance is present. . To clarify the concept, we have a tendency to use the analogy of 2 people transferral nearer, or moving removed from one another to debate, reckoning on the noise within the surroundings. Drones measure systematically adapting their relative positions to take care of identical received signal power, therefore making certain the requested application level in terms of knowledge rate. Our resolution relies on this idea and implements a replacement effective mechanism to take care of a swarm of drones exploitation solely organized communications, whereas ceaselessly making certain the standard of the service required to complete the mission. In the other papers, How the drone are communicated, the different type of mobile adhoc network in drone communication is proposed. In this paper, we used the drone communication in effective manner and used in exploration purpose in indoor region for hostage surveillance.

2. Single Drone Control

For this Control, The drone Is made to connect to the ground station via wifi . The ROS (Robot Operating System) is used to make a communication between the drone and the ground station .To establish the communication between ground station ROS is used in Linux .ROS core will run in the background. Drone is connect to the ROS master shown in figure1. ROS is a platform for distributed computing. A fully functional ROS system can include dozens, if not hundreds, of nodes distributed over numerous machines. Any node may need to communicate with any other node at any moment, depending on how the system is setup. Drone waits until the message from the master the published. ROS master acts as publisher and the drone or any other UAV acts as a subscriber. The subscriber which is a drone receives the message from the master .message carries data that is need to fly a drone or any other UAV .Drone asks for the flight Parameter .Flight parameters are pitch, yaw, roll.ROS publishes the needed flight parameters that are needed for the drone to run. Parameters are measured as x, y and z axis. when the required parameter are transmitted as ROS topic in message to the drone .drone have the trust to have a flight. The sensors information are received by the ROS master from the drone from which the drone location can be estimated. The information is passed to the monitor from drone by ROS master. Sensor data is visible in the monitor. The data such as flight parameter is passed from the ROS master to drone. Publication of ROS topic is continuously published without any interruption to the drone for the continuous drone movement. In the figure1 it is clear that the single drone communication is possible with the flow in the above information.

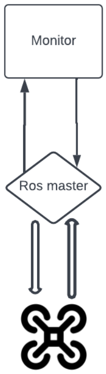


Figure1: single drone communication

3. Multi drone control

This project entails controlling many drones that are all connected to the same network. The drones can be programmed to move in a coordinated manner, with each drone following a predetermined course in relation to the other drones in the network. A number of coordinated tasks have been presented, each of which takes into account a particular amount of communication latency between the drones. For communication, drones are equipped with an esp8266 Wi-Fi module. Each drone is linked to an AP, and the ground control station (laptop) is linked to the same AP. Each drone's IP address is identified and marked. To communicate with each drone shown in figure2 , a separate thread is constructed in C++. Individually, each with their own socket For each thread, a unique one is formed. For each drone, perform operations such as read, write, and so on. Each drone's sensor data is published on its own topic. The subjects run on individual threads in service that receive sensor data as well C++ nodes make a request. Each drone has its own feedback control mechanism that runs on a separate thread in figure 2. Each thread calculates pitch, roll, yaw, and throttle for a single drone for a specified target position by reading the position of a specific drone from global variables. At start-up, each thread with its associated drone is initialized with its PID values and drone number as arguments. Drone numbers are used to identify a certain drone's IP address.

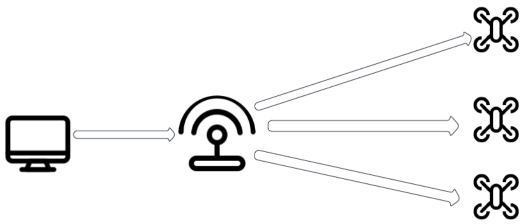


Figure 2: Multiple drone communication

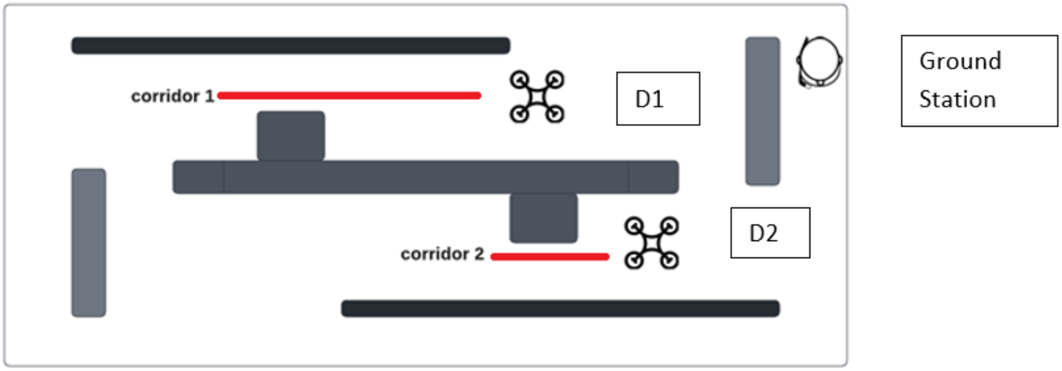


Figure3: working of drone in confined areas.

The figure3 which shows the working of drone in confined area if a single drone is worked in a confined area which requires a lot of time and power consumption is more. The multi drone is used in same situation the time complexity can be reduced in order to complete the desired mission. Exploring the confined areas with swarm technology can reduce the time of completion of mission which are said to be finished in limited time. Nano drones are specially used in confined area exploration which is compact and meant to be flied in confined areas with alluding to the figure3. For time complex Mission with the use of one drone and survey on battery consumption by single drone it is better to Explore with Multi drone even though the cost of mission is more compared to single drone usage.

4. Acquiring data from the drones

The drones which are used in confined areas have to provide some real time while working, the main purpose of using drones in confined areas is acquiring data such as images, temperature of the human body etc. here we acquired the datas from the sensors which are available in the drones. These sensor data where used to develop an algorithm which will be used to find the position of the drones in the area. When the Data of any Drone is stopped or missing we can assume that the drone has been caught or been damaged during the mission. From the acquired data the postion of the missing drone can be approximately found with the last data from the drone as in table1. The data's from the basic sensors which are used in drone like Accelerometer, Gyroscope, barometer and magnetometer

Provide the required data needed for the drone postion during the exploration in confined areas.The result of acquiried data is shown in the table1.

Table1: Flight parameter data's

Time	T	T10	T20	T30	T40
Battery Percentage	3.90	3.79	3.79	3.79	3.79
Power consumed	2	18	18	18	18
roll	0	1	2	3	3
pitch	0	4	4	3	3
yaw	3	328	330	331	331
Altitude	4.0	11.0	11.0	11.0	11.0

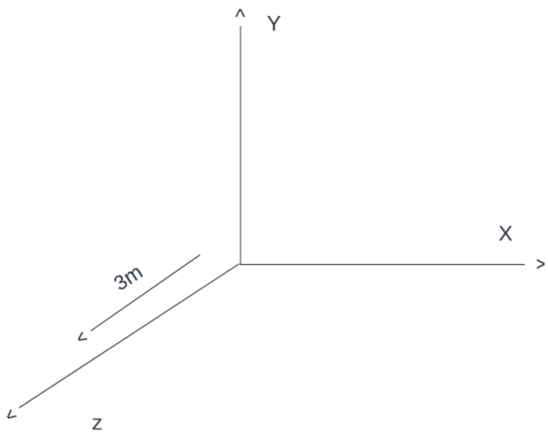
From the table1 flight parameter can be acquired. A rotation is a clockwise or anti-clockwise movement from around aircraft's central axis. Consider putting your drones on the ground and then driving a metal pole directly through it into the earth. Your drone won't be able to move, but it will be able to rotate on the pole. This is forward and backward movement. The nose of a drone will be tilted upwards or downwards due to the direction you want it to go. The third term for aerial movement is roll, which refers to the rotation of the aircraft from nose to tail (front to back on a copter). The movements of the uav forward, backward, left, and right along a x - axis is referred to as roll.These yaw, pitch, roll are the feedback from the basic drone sensors.

Axis data

Table 2: Accelerometer data's

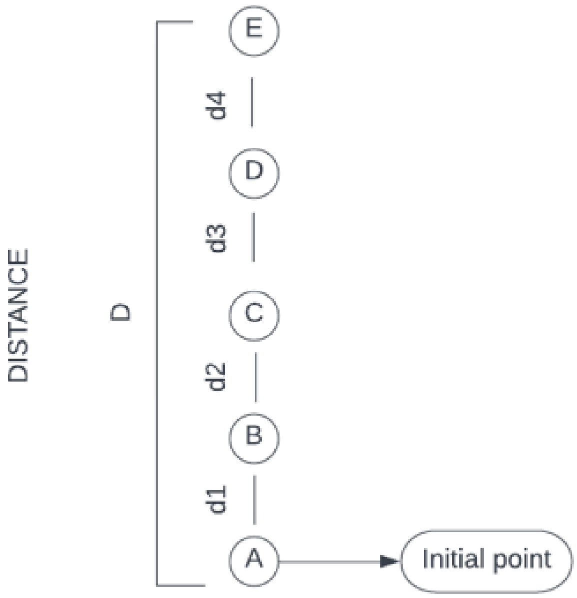
Time	T	T10	T20	T30	T40
Acc X (cm)	-3.0	-3.0	-3.0	-40.0	-37.0
AccY (cm)	-1.0	-1.0	-1.0	31.0	28.0
Acc Z (cm)	515.0	514.0	515.0	514.0	527.0

With the interpretation of the table2 helps in finding the current position of the drone with respect to x, y, z axis. The data' vary in every time instants it can be seen in the table 2.

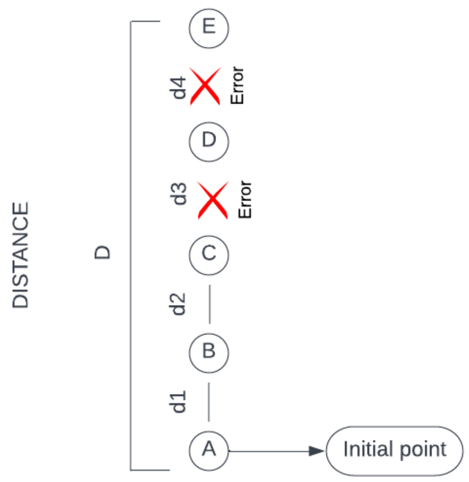


In the above axis data it is said that the drone is moving in the Z direction with respect to X and Y direction the increasing reading from the acc z data the drone moves in upward direction.

Scenario 1:



Scenario 2:



Standard equation for straight line = > ax + by=c.
Here is two scenario for the Exploration in Straight line .It is done with the help of the standard equation of straight line. D – is the total distance the drone is predefined, d1,d2,d3,d4 are the distance between the node of the moving path. In the scenario 1 , clearly we see that the predefined path using pattern formation is safe in its way. where as in the second scenario , there is a error in passing the distance d3 and d4 .the drone is not completely travelled through the path of nodes so, the path is not safe for the human to access. A,B,C,D and E are the Time Instant at time t1, t10,t20,t30,t40 respectively as in two scenario's.

Results

Analysis of Acquired data

Each drone provides a data that are required to find the drone postion during the exploration.There are various data can be analaysised like altitude, battery draining percentage, remaining battery left in drone, gyrometer, magnetometer, accelerometer, barometer, roll, pitch, yaw etc. The flight parameter can be analysised using the above extracted reading from the real time flying drone. The value is "0" at the initial stage of flight of drone before the drone gets the trust to takeoff. The value and the sensor reading changes along with the drone movement in the air. The command is passed to fly the drone in desiered path. The path of the drone is predefined path. In the predefined path the drone rovers and the various data as above mentioned can be acquired. The value as shown in the above table is the value received from the drone to the ground station. The value are plotted with the 3 axis point manner.

The three axis points are x, y, z. The acc x, acc y, acc z are the accelerometer's axis point. The mag x, mag y, mag z are the magnetometer's axis point. Similarly the each sensor gives the value withrespect to the position in the three axis points. The flight parameter are roll, pitch, yaw. The given flight commands is received by the drone in real time. From the data received from drone the increasing and decreasing value gives the position of the drone in the confined areas. If there is any changes in the data that is coming from the drone it is interpreted as any problem in the path. That path is not safe for a human to move. Multi drone data is analysied from the acquired data from the flight parameter value. This is the way the exploration in confined areas with aquication and analysis is used for finding the safe path for human to movement is found.

5. Pattern formation using drones

The drones which are used in confined areas for searching operation, the searching path to predefined or it have to be controlled using the ground station. For the patch predefined it has to published by using the topic using the ROS where the is flight parameter is used for the path formation. the following table is an example for the square pattern formation in the drone which will be useful for searching operation.

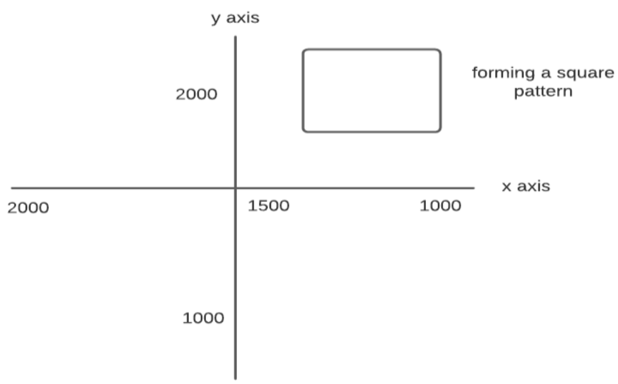


Figure 4: square pattern formation using drone in a 2D graph

By taking the value of 1500 as the ground level in an axis as zero the position of the drone is predetermined as the value ranges from 1000 to 2000.

Explortion Strategy

With the use of the acquired data and the pattern formation the exploration is done in a effective manner in confined areas .Pattern formation is the way in which the drone or UAV's move in a predefined path can be seen in the figure5. To predefine the path of the drone to explore in a confined areas pattern formation strategy is used in this approach. The acquired data is used to get the postion and sensor's reading from the real time flying drone. In the predefined path in confined areas the drone data and postion of the drone is received at every instant of time addition to that the exploration using the swarm technology is possible. If there is any traffic in the predefined path with the collection of drone data the possible effect to the drone is found. This the way in which the swarm of drone technology is used in exploration in confined areas.

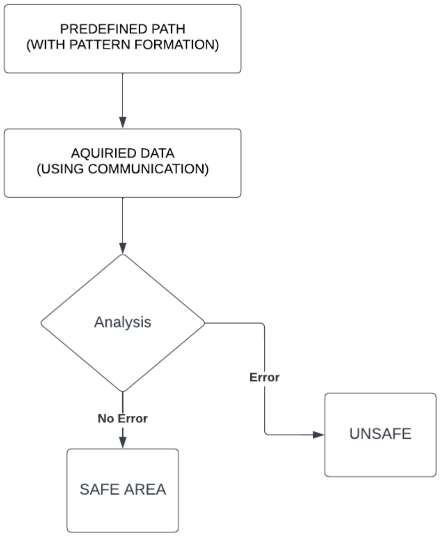


Figure 5: Exploration flow Chart

Thus we have completed the controlling of the single drone using the ros and it form various patterns and it also controlled using the keyboard which will be act as the ground station. Mulit drone is used as medium to explore a confined areas and a abandoned building were a human risky mission is carried out. The time complexity is reduced in the mission as compared to the use of single drone. Till date Swarm technology is used for commercial advertisement purpose. Here it is used for exploration purpose in confined areas successfully.

Conclusion and further work

As the UAVs are used in wide variety of fields till there are problems in the communication architecture of the UAV, A high range ground station infrastructure is required for controlling the multiple swarm drones. The advancement of the mission is the swarm of drones, which are time-dependent and time-complex challenges. Civil security, remote and prolonged area surveillance, hostile observation, and other broad applications are common uses for swarm drones. The Paper, on the other hand, used a compact and cost-effective method of using swarm drones. For multi-drone exploration in limited locations, an ad-hoc network is used as a communication medium. The fundamental thesis of this paper is that swarm technology can be used in time-sensitive missions and for purposes other than financial gain. The relevant data is collected from the drones' real-time flight and evaluated to determine the best path for doing the necessary task. If the communication system is made better they will be used in the field of security surveillance, pattern formation of various shapes .Other than basic sensors in the drone, special sensors can be used for the extension of the swarm of drone technology in better and advanced ideas can be implemented to reduce the human work.

By image processed data from the drone it can be used for fast agricultural survey, volcano eruption site analysis military application and many more advanced and smart ideas.

References

1) G. Raja, S. Anbalagan, V. S. Narayanan, S. Jayaram and A. Ganapathisubramaniyan, "Inter-UAV collision avoidance using Deep-Q-learning in flocking environment", *Proc. IEEE 10th Annu. Ubiquitous Comput. Electron. Mobile Commun. Conf.*, pp. 1089-1095, 2019.
2) P. J. Singh, R. de Silva and I. Seher, "Comparison of communication protocols for UAVs and VANETs", *Proc. IEEE Int. Conf. Comput. Commun. Automat.*, pp. 616-619, Apr. 2016.
3) T. C. Hong, K. Kang, K. Lim and J. Y. Ahn, "Network architecture for control and non-payload communication of UAV", *Proc. IEEE Int. Conf. Inf. Commun. Technol. Convergence*, pp. 762-764, Oct. 2016.
4) S. Rosati, K. Kruzelecki, L. Traynard and B. Rimoldi, "Speed-aware routing for UAV ad-hoc networks", *Proc. IEEE Globecom Workshops*, pp. 1367-1373, Dec. 2013.
5) R. Arul, G. Raja, A. K. Bashir, J. Chaudhry and A. Ali, "A console GRID leveraged authentication and key agreement mechanism for LTE/SAE", *IEEE Trans. Ind. Informat.*, vol. 14, no. 6, pp. 2677-2689, Jun. 2018.
6) S. B. M. Baskaran, G. Raja, A. K. Bashir and M. Murata, "QoS-aware frequency-based 4G+ relative authentication model for next generation LTE and its dependent public safety networks", *IEEE Access*, vol. 5, pp. 21977-21991, 2017.
7) O. K. Sahingoz, "Networking models in flying ad-hoc networks (FANETs): Concepts and challenges", *J. Intell. Robot. Syst.*, vol. 74, no. 1–2, pp. 513-527, Apr. 2014.
8) D. Zhang, Y. Liu, L. Dai, A. K. Bashir, A. Nallanathan and B. Shim, "Performance analysis of FD-NOMA based decentralized V2X systems", *IEEE Trans. Commun.*, vol. 67, no. 7, pp. 5024-5036, Jul. 2019.
9) C. A. Suescun and M. Cardei, "Unmanned aerial vehicle networking protocols", *Proc. LACCEI Int. Multi-Conf. Eng. Educ. Technol.: Eng. Innov. Glob. Sustainability*, Jan. 2016.
10) S. Hayat, E. Yanmaz and R. Muzaffar, "Survey on unmanned aerial vehicle networks for civil applications: A communications viewpoint", *IEEE Commun. Surv. Tut.*, vol. 18, no. 4, pp. 2624-2661, 2016.
11) M. Marcus, "Spectrum policy challenges of UAV/drones [Spectrum Policy and Regulatory Issues]" in IEEE Wireless Commun., vol. 21, no. 5, pp. 8-9, Oct. 2014.
12) S. A. Hussain, Adnan Fazil, "An efficient channel access scheme for vehicular Ad Hoc networks", *Mobile Inf. Syst. Hindawi*, vol. 2017, pp. 1-10, 2017.
13) I. Z. Boychev, "Research algorithms to optimize the drone route used for security", *Proc. IEEE XXVII Int. Sci. Conf. Electron.-ET*, pp. 1-4, Sep. 2018.
14) R. Jayaraman, G. Raja, A. K. Bashir, C. S. Hussain, A. Hassan and M. A. Alqarni, "Interference mitigation based on radio aware channel assignment for wireless mesh networks", *Wireless Pers. Commun.*, 2018.
15) Q. Cui, P. Liu, J. Wang and J. Yu, "Brief analysis of drone swarms communication", *Proc. IEEE Int. Conf. Unmanned Syst.*, pp. 463-466, 2017.

16) K. K. Kumaravel, R. Renugadevi and A. Marimuthu, "A study on protocols in wireless mesh network", *Int. J. Comput. Sci. Eng. Technol.*, vol. 6, pp. 413-415, Jul. 2015.
17) A. Nayyar, "Flying Adhoc network (FANETs): Simulation based performance comparison of routing protocols: AODV DSDV DSR OLSR AOMDV and HWMP", *Proc. Int. Conf. Adv. Big Data Comput. Data Commun. Syst.*, pp. 1-9, Aug. 2018.
18) C. L. Krishna and R. R. Murphy, "A review on cybersecurity vulnerabilities for unmanned aerial vehicles", *Proc. IEEE Int. Symp. Safety Secur. Rescue Robot.*, pp. 194-199, Oct. 2017.
19) E. Vattapparamban, I. Güvenc, A. I. Yurekli, K. Akkaya and S. Uluagac, "Drones for smart cities: Issues in cybersecurity privacy and public safety", *Proc. IEEE Int. Wireless Commun. Mobile Comput. Conf.*, pp. 216-221, Sep. 2016.
20) M. A. Javed, N. S. Nafi, S. Basheer, M. A. Bivi and A. K. Bashir, "Fog-assisted cooperative protocol for traffic message transmission in vehicular networks", *IEEE Access*, vol. 7, pp. 166148-166156, 2019.
21) Rashid Abbasi, Jianwen Chen, Yasser Al-Otaibi, Amjad Rehman, Asad Abbas, Weiwei Cui "Generalized PVO based dynamic block reversible data hiding for secure transmission using firefly algorithm", *Trans. Emerg. Telecommun. Technol.*.
22) J. Yu, B. M. Cho, K. J. Park and H. Kim, "Simultaneous attack on drone and GCS in UAV systems", *Proc. Int. Conf. Ubiquitous Future Netw.*, pp. 5-7, Jul. 2018.
23) Jung Hee Cheon, Dongwoo Kim, Duhyeong Kim, Hun Hee Lee, Keewoo Lee., "Toward a secure drone system: Flying with real-time homomorphic authenticated encryption", *IEEE Access*, vol. 6, pp. 24325-24339, 2018.
24) P. Diamond, "Detection mitigation recovery of GPS based assured timing critical infrastructure when under attack by spoofing or jamming", *Proc. IEEE Int. Symp. Technol. Homeland Secur.*, pp. 1-4, Apr. 2017.
25) G. Raja, S. Anbalagan, G. Vijayaraghavan, P. Dhanasekaran, Y. D. Al-Otaibi and A. K. Bashir, "Energy-efficient end-to-end security for software defined vehicular networks", *IEEE Trans. Ind. Informat.*, vol. 17, pp. 5730-5737.
26) Estevez, A. G., Espinosa, A. H. R., Rodríguez, D. L., & Leyva, T. F. (2019). Current approaches and controversies: legalization and non-legalization of drugs. *International Journal of Health & Medical Sciences*, *2*(1), 26-32. https://doi.org/10.31295/ijhms.v2n1.85
27) G. Raja, A. Ganapathisubramaniyan, M. S. Selvakumar, T. Ayyarappan and K. Mahadevan, "Cognitive intelligent transportation system for smart cities", *Proc. 10th IEEE Int. Conf. Adv. Comput.*, pp. 146-152, Dec. 2018.
28) M. Wazid, A. K. Das, N. Kumar, A. V. Vasilakos and J. J. Rodrigues, "Design and analysis of secure lightweight remote user authentication and key agreement scheme in internet of drones deployment", *IEEE Internet Things J.*, vol. 6, no. 2, pp. 3572-3584, Apr. 2019.
29) Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2022). Post-pandemic health and its sustainability: Educational situation. *International Journal of Health Sciences*, *6*(1), i-v. https://doi.org/10.53730/ijhs.v6n1.5949
30) S Sravani challa, mohammad wazid, ashok kumar das, neeraj kumar, Alavalapati gowtham reddy, Eun jun Yoo and kee Young Yoo, "Secure

signature-based authenticated key establishment scheme for future IoT applications", *IEEE Access*, vol. 5, pp. 3028-3043, 2017.

31) M. Turkanović, B. Brumen and M. Hölbl, "A novel user authentication and key agreement scheme for heterogeneous Ad Hoc wireless sensor networks based on the internet of things notion" in Ad Hoc Netw., vol. 20, pp. 96-112, 2014.