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Unmanned vehicles in health monitoring and medicine delivery with swarm algorithm innovations

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ABSTRACT

The article delves into modern approaches and innovative technologies designed to monitor the health of military personnel using unmanned vehicles, while also assessing their potential for delivering medicines in combat environments. It thoroughly examines the wide range of sensors and technologies that enable remote measurement of vital signs, including but not limited to thermal imaging cameras, photoplethysmography sensors, and radio frequency sensors, highlighting their effectiveness in various operational contexts. The article also reviews numerous real-world applications of drones in both medical and humanitarian projects, showcasing the transformative impact these technologies can have in providing timely healthcare and support in areas where traditional medical infrastructure may be lacking. In addition to discussing the practical benefits of using unmanned vehicles for healthcare delivery, the article also addresses the challenges posed by their integration into military operations, such as logistical, technical, and regulatory hurdles. Furthermore, it presents a detailed example of how these innovative systems can be effectively combined to enhance the medical care provided to military personnel, especially during combat, where traditional access to medical services is often limited or compromised. The article proposes several key areas for future research and development, emphasizing the importance of continued technological advancements to fully harness the potential of unmanned vehicles for medical applications in the military sector. These areas include improving sensor accuracy, developing better communication systems, and creating more autonomous and efficient delivery mechanisms. Here are examples that prove, the article suggests that unmanned vehicles could play a critical role in revolutionizing both battlefield medicine and military logistics, offering new solutions for healthcare delivery in challenging environments.

Keywords: Unmanned aerial vehicles; drones, military medicine; health monitoring; drug delivery; swarm algorithms; thermal cameras, photoplethysmography; radio frequency sensors; innovations in the military sphere

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INTRODUCTION

Modern technologies of unmanned aerial vehicles (UAVs/drones), are increasingly being used in various fields, including military, medical and humanitarian projects. In recent years, considerable attention has been paid to the use of drones for health monitoring and the delivery of medicines to hard-to-reach or dangerous areas. In military environments, where timely medical care can be crucial to the lives of soldiers, the integration of drone technology opens up new opportunities to improve the efficiency of medical care.

The use of swarm optimization algorithms, as well as modern sensors for monitoring vital signs from a distance, allows for the creation of autonomous systems that can quickly respond to the changing needs of military units. These systems can provide continuous health monitoring, rapid diagnostics, and delivery of necessary medicines and equipment to active combat zones.

Based on the study of existing technologies and methods used for this purpose, develop a hybrid algorithm and model examples of the use of drones in the medical field and record the prospects and challenges of introducing these technologies into military medicine.

PROBLEM STATEMENT

As medical technology advances and the need for fast and accurate diagnostics grows, autonomous systems, including medical drones, are becoming increasingly important. These drones can perform a variety of tasks, including transporting medical samples, delivering medications, and performing diagnostics in remote or hard-to-reach locations. However, to perform these tasks effectively, medical drones must be equipped with optimal performance parameters, such as data processing speed, sensor accuracy, and reliable decision-making algorithms.

The main problem is the need to improve the efficiency and reliability of such drones. Current approaches to adjusting the parameters of medical drones are often based on the use of standard optimization algorithms, such as swarm algorithms or genetic algorithms. However, the use of these methods individually has certain limitations, which can lead to insufficient accuracy or long computation times.

The main objective of this work is to develop a hybrid approach that combines a binary swarm algorithm (BPSO) and a genetic algorithm (GA) to optimize the parameters of medical drones. This approach will allow combining the strengths of each method, providing both a global search for optimal solutions and local improvement of the results already found.

Thus, there is a need to solve the following sub-tasks:

1. Analysis of existing approaches to optimizing the parameters of medical drones.
2. Development and testing of a hybrid approach to optimize drone parameters.
3. Evaluation of the effectiveness of the proposed hybrid approach in comparison with traditional methods

Solving these problems will help improve the performance and reliability of medical drones, which will be of great practical importance for healthcare systems.

ANALYSIS OF LITERATURE DATA

Previous research and publications on the use of drones for health monitoring and drug delivery reflect the wide range of possibilities of this technology. Here are more details and examples:

Using thermal imaging cameras during the COVID-19 pandemic

In some countries, such as China and India, unmanned aerial vehicles with thermal cameras have been used to identify people suspected of being infected with COVID-19. Drones have patrolled streets and public events, scanning temperatures and identifying people with elevated readings.

In the United States and Europe, some healthcare facilities and testing sites have also used drones to measure temperatures and monitor remote areas, helping to identify suspicious cases and prevent the spread of the virus.

Delivery of medical materials and test samples:

Zipline uses a network of unmanned drones to deliver medical supplies, including blood and test samples, to various countries, including the Company's operations in Rwanda and Ghana. This technology allows for the rapid delivery of essential materials to hard-to-reach regions.

3. Monitoring compliance with quarantine measures:

In some countries, unmanned vehicles have been used to monitor compliance with quarantine measures and detect illegal gatherings of people. For example, in Spain and Italy, drones have been used by police to monitor public order and remind people to keep their distance.

4. Transportation of vaccines and medicines:

During the global COVID-19 vaccination campaign, drones will become an important tool for transporting vaccines and other medical supplies to remote or hard-to-reach regions that lack adequate infrastructure.

An analysis of previous studies and publications indicates the significant potential of unmanned aerial vehicles in the medical field, especially in crisis situations such as the COVID-19 pandemic. The use of drones allows for a quick response to emergencies, improves access to medical services, and can help reduce risks for medical staff and patients. However, it is important to continue research and development of this technology, particularly in the context of military applications, to ensure its effective implementation and maximize its benefits.

PURPOSE AND OBJECTIVES OF THE STUDY

The use of unmanned vehicles for health monitoring and drug delivery also includes the application of swarm optimization algorithms to solve similar problems.

1. Swarm algorithms for drone routing

Some studies use swarm algorithms [1, 2], [3, 4] to optimize the routes of unmanned vehicles delivering medical supplies. These algorithms allow drones to avoid obstacles, find the shortest path, and efficiently distribute tasks among themselves.

Examples include the use of artificial intelligence algorithms such as Ant Colony Optimization or Particle Swarm Optimization to build optimal routes [2, 3], [4, 5] for delivering medical supplies in hard-to-reach or dangerous regions.

2. Adaptive swarm management

Some research is looking at adaptive drone swarm management in response to changing conditions, such as weather conditions, changes in traffic, or emergency detection. These algorithms allow the drone swarm to respond to new conditions and adapt quickly to ensure safe and efficient delivery of medical supplies.

3. Optimize resource allocation

In military environments where resources are limited, swarm algorithms can also be used to optimize the distribution of medical resources. For example, algorithms can help identify the most critical areas for medical delivery and efficiently allocate limited resources based on need.

Swarm algorithms play a key role in solving complex routing [4, 5], [6, 7], control, and optimization problems in the context of using unmanned vehicles for medical missions in military settings. They help to ensure the efficient and safe delivery of medical supplies and resources to hard-to-reach and dangerous regions, while providing a quick response to changing conditions and maximizing the use of limited.

MATERIALS AND RESEARCH METHODS

Hybrid swarm algorithms can be used to optimize the performance of unmanned vehicles in combat environments, ensuring efficiency and adaptability to changing conditions. How exactly these algorithms can be applied and what technologies can be used to implement them are described below:

Delivery of medicines

1. **Autonomous navigation:**

Unmanned vehicles can be equipped with navigation systems [6-8], which allow them to find their way to their destination without active operator intervention.

2. **Containers for medicines:**

Medicines can be placed in special containers that ensure the safety and reliability of transportation during the flight.

3. **Wireless communication:**

Drones can be equipped with wireless communications to transmit route data, medication status, and other information back to the command post.

A hybrid approach

1. **Adaptive route planning:**

A hybrid swarm algorithm that combines PSO and GA can be used to find the optimal route for drug delivery. PSO can help to quickly find the shortest route, and GA can be used to optimize this route taking into account various constraints and conditions.

2. **Support for emergency situations:**

In the event of an accident or obstacle on the way to the destination, the hybrid swarm algorithm can help the drone quickly find an alternative delivery route using adaptive scheduling to avoid delays and ensure timely delivery of medicines.

This hybrid approach combines the advantages of both algorithms to create an efficient and reliable system for delivering medicines in combat conditions.

Health monitoring

1. **Miniature biometric sensors:**

Unmanned vehicles can be equipped with miniature sensors that measure heart rate, blood oxygen level, body temperature, and other important health indicators.

2. **Wireless data transmission means:**

Collected biometric data can be transmitted via wireless communications such as Wi-Fi or Bluetooth to a command center for analysis and monitoring.

A hybrid approach

1. **Optimization of territory coverage:**

The hybrid swarm algorithm can be used to optimize the location of unmanned vehicles to maximize coverage and ensure continuous monitoring of health indicators.

2. **Planning routes for data collection:**

PSO can help determine the optimal routes for unmanned vehicles to efficiently collect biometric data [8, 9], [10] from the population.

3. **Dynamic adaptive planning**

GA can be used for dynamic adaptive route planning to ensure that data is collected in the most critical or hard-to-reach areas where conditions are likely to change.

The presented hybrid approach in the form of a UML diagram of the interaction of drone components allows optimizing the process of health monitoring [10, 11], [12, 13] over large areas and in combat conditions, providing a quick response to possible dangers and saving lives (Fig. 1).

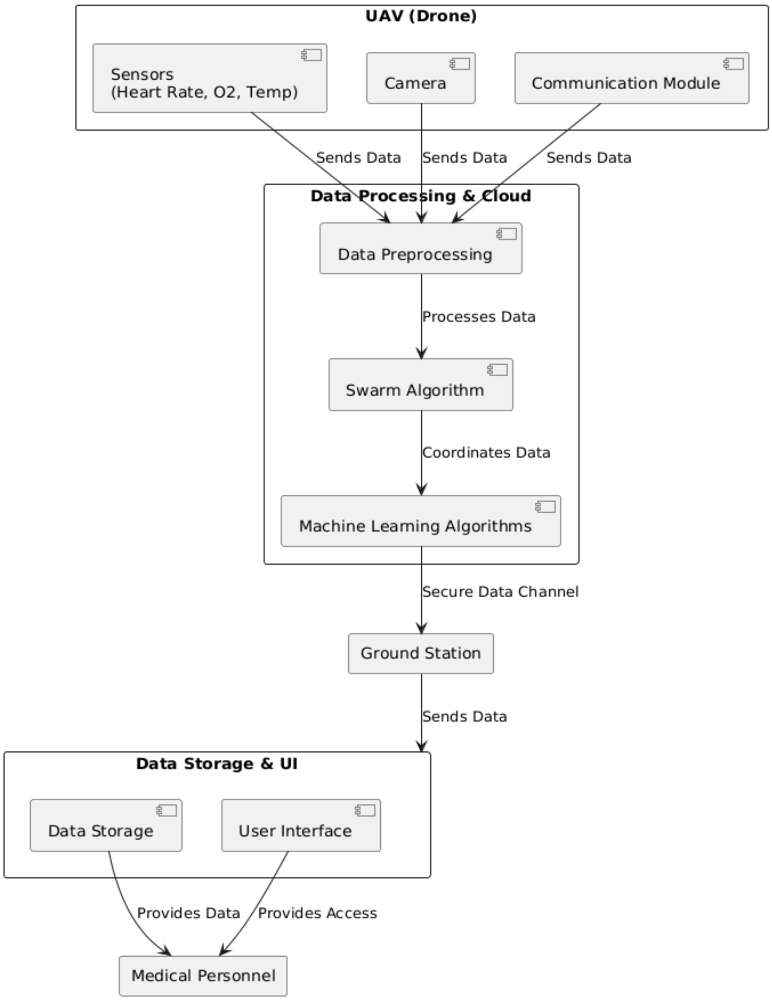

Fig. 1. **Interaction of drone components in the process of hybrid algorithm operation**
Source: **compiled by the authors**

Logistics operations

1. GPS navigation

Unmanned vehicles can use GPS systems to determine their location and plan optimal delivery routes.

2. Computerized visual surveillance

Computer vision systems can be used to detect obstacles along the way and automatically adjust the delivery route.

3. Wireless communication devices:

The use of wireless communications allows unmanned vehicles to communicate with the command center to transmit data on the status of the route and the need for medical resources.

A hybrid approach

1. Optimizing routes with PSO

PSO can be used to quickly find the shortest route for the delivery of medical resources, given the constraints and conditions along the route [12-15].

2. Resource allocation using GA

GA can optimize the distribution of medical resources between unmanned vehicles, taking into account distances, volumes, and delivery priorities.

3. Adaptive route management

The hybrid approach can use PSO and GA algorithms to dynamically plan adaptive routes in real time to avoid obstacles and optimize delivery in a military environment.

This hybrid approach allows to create an effective and reliable logistics system for the delivery of medical resources in combat conditions, ensuring a quick response [14, 15], [16, 17] and maximum efficiency in difficult combat conditions (Fig. 2).

Ability to call an unmanned vehicle

1. Communication networks

Unmanned vehicles can be connected to communication networks, such as mobile networks or satellite communication systems, to receive calls and instructions.

2. Voice commands

The use of voice control systems allows military operators to call an unmanned vehicle and give commands directly using voice commands.

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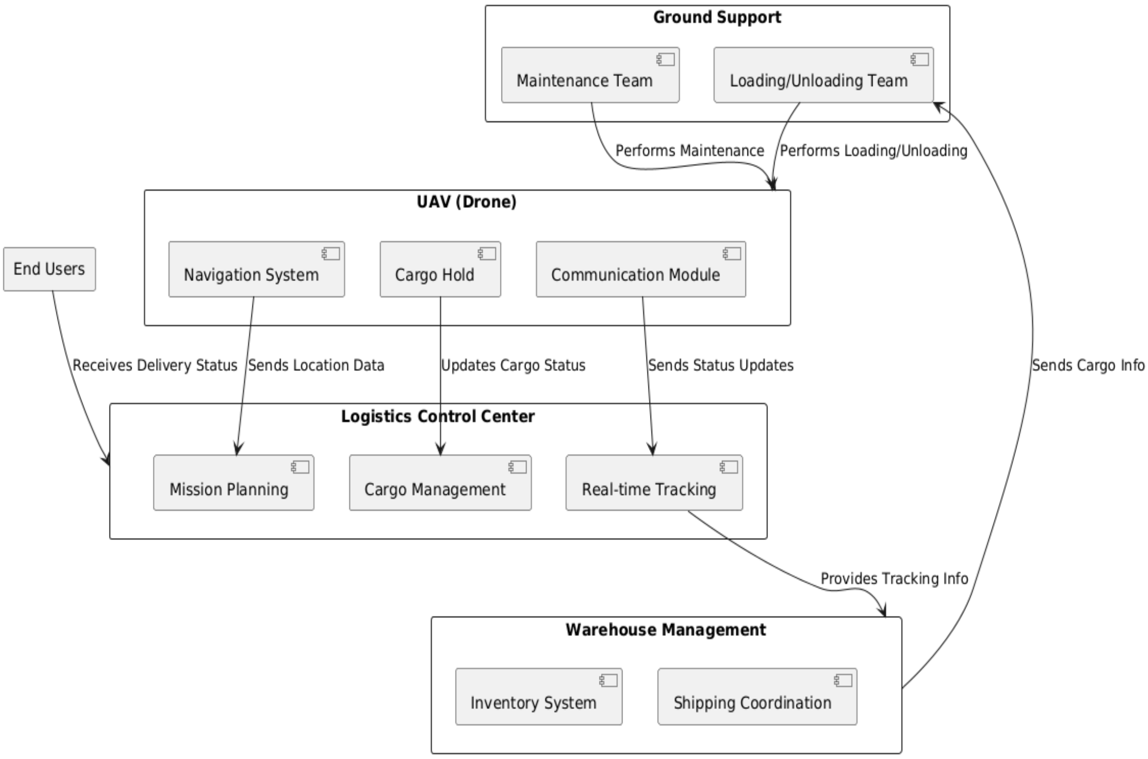

Fig. 2. **Schematic representation of the operational activities of the logistics module**
***Source:* compiled by authors**

A hybrid approach

1. PSO and GA algorithms for efficient response

PSO can be used to quickly determine the optimal drone for a call, given its location and condition, while GA can optimize the distribution of tasks among available drones to maximize call response efficiency.

2. Dynamic route planning

The hybrid approach can use PSO and GA algorithms to dynamically plan the routes of unmanned vehicles to respond quickly to challenges and complete tasks efficiently.

3. Communication and coordination

The combination of different algorithms allows to create a system of communication and coordination between unmanned vehicles and the command center, which ensures a quick and effective response to calls.

This hybrid approach allows for the creation of an unmanned vehicle calling system that can effectively respond to situations in the combat environment, providing a quick and coordinated response to calls and maximizing the efficiency of tasks.

These three functions - medical delivery, health monitoring, and the ability to call a drone - are of great value in military operations and emergencies. Here are some key aspects of their value

1. Quick response

These features allow you to respond quickly to unforeseen situations, such as injuries or medical emergencies. Fast delivery of medicines and the ability to monitor health allow you to provide medical care in the shortest possible time.

2. Improving treatment outcomes

The ability to deliver medicines to hard-to-reach places and monitor health can improve treatment outcomes and reduce the risk of complications.

3. Reducing the risk of losses

The rapid response and effective medical care provided by these functions helps reduce the risk of casualties among military and civilians during military operations or emergencies.

4. Improving the efficiency of medical care

Providing the ability to call an unmanned vehicle allows operators to quickly receive assistance and resources to provide medical care, which increases the efficiency of medical care in difficult conditions.

All of these functions contribute to improving the quality of medical care and reducing the risk of loss of life in military operations and emergencies [17, 18], [19], making them extremely valuable for military and humanitarian actions. The general architecture of the hybrid approach is as follows (Fig. 3).

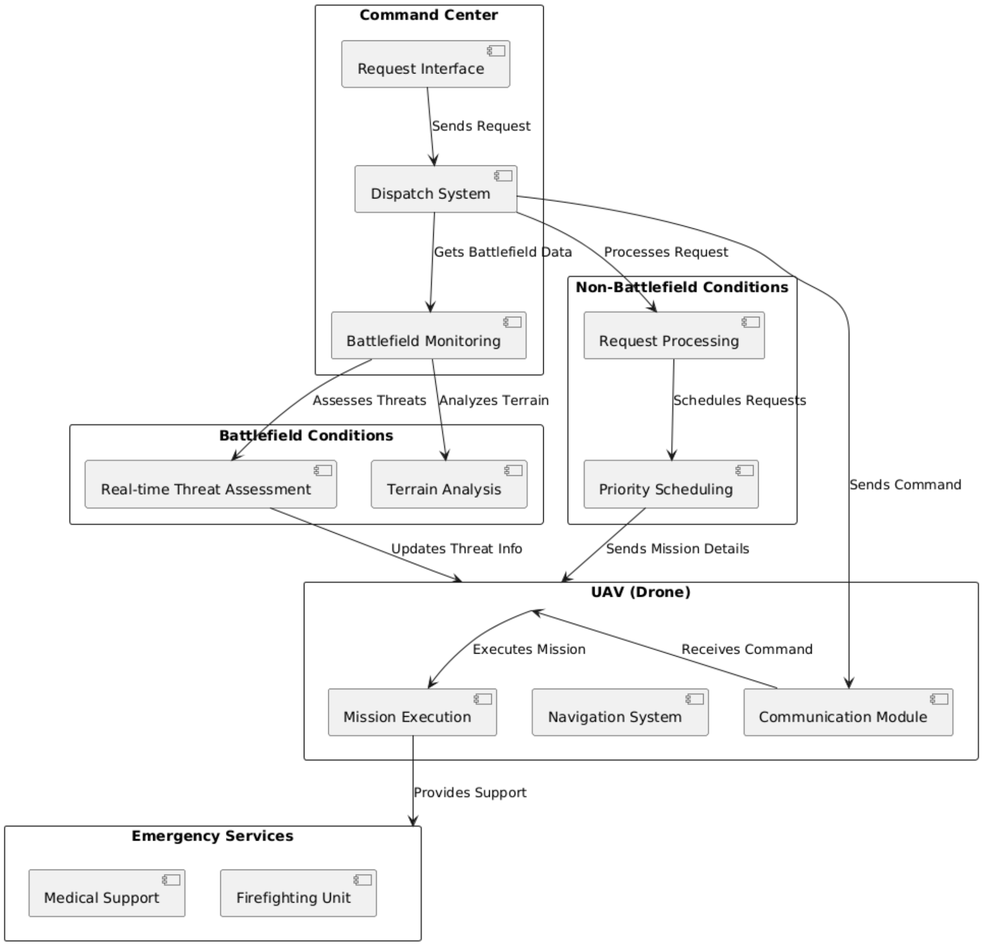

Fig. 3. **Interaction of drone components in the process of hybrid algorithm operation**
Source: **compiled by authors**

Components

- **UAV (Drone)**. Includes communication module, navigation system and mission execution.
- **Command Center**. It includes a query interface, a dispatching system and monitoring of combat operations.
- **Battlefield Conditions**. Includes real-time threat assessment and terrain analysis.
- **Non-Battlefield Conditions**. Includes request processing and priority scheduling.
- **Emergency Services**. Medical support and fire safety units.

RESEARCH RESULTS

Visualization of a health monitoring algorithm is an important tool for improving understanding, communication, documentation, optimization, and system maintenance [20, 21], [22]. Therefore, to visualize the process of the algorithm, we present a coordinate system with marked areas and the path taken (Fig. 4).

Description of health monitoring visualization

1. Areas of assistance

- Two categories of zones are defined: “Needs help” (red) and ‘Does not need help’ (green).
- Zones are represented as circles with a certain radius, where the centers of these zones are determined by a hybrid algorithm.

2. Visualization of zones

- Each zone is displayed on the graph as a circle with the appropriate color and transparency for greater clarity.
- Additionally, the drone's route between data collection points is displayed, taking into account the areas in which the drone is located.

3. A combined approach

- A hybrid PSO and GA algorithm determines which locations need assistance based on various criteria, such as population density or distance from other areas of assistance.

Logistics operations

Logistics operations play a key role in ensuring efficiency and coordination during military and medical missions (Fig.5). Drones equipped for logistics missions can deliver critical cargo, including medical supplies and technical equipment, to hard-to-reach or dangerous areas [22, 23], [24, 25], [26, 27].

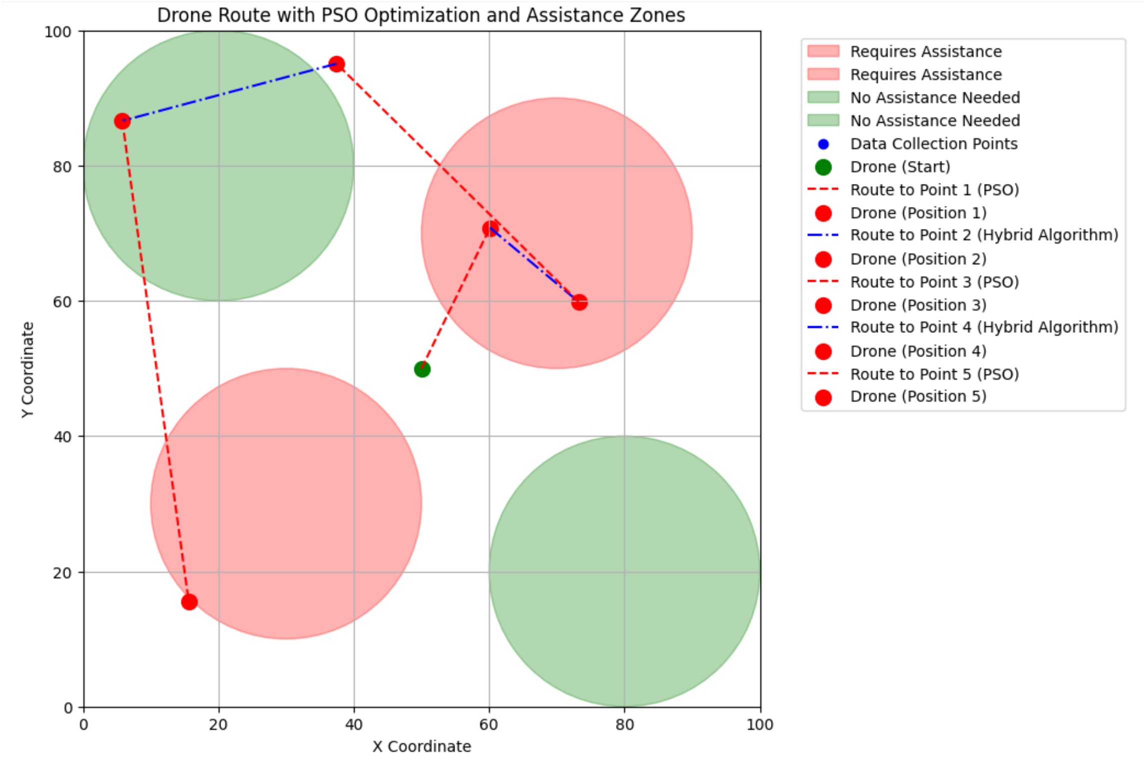

Fig. 4. **Visualization of the applied hybrid algorithm on the health monitoring process**
Source: **compiled by the authors**

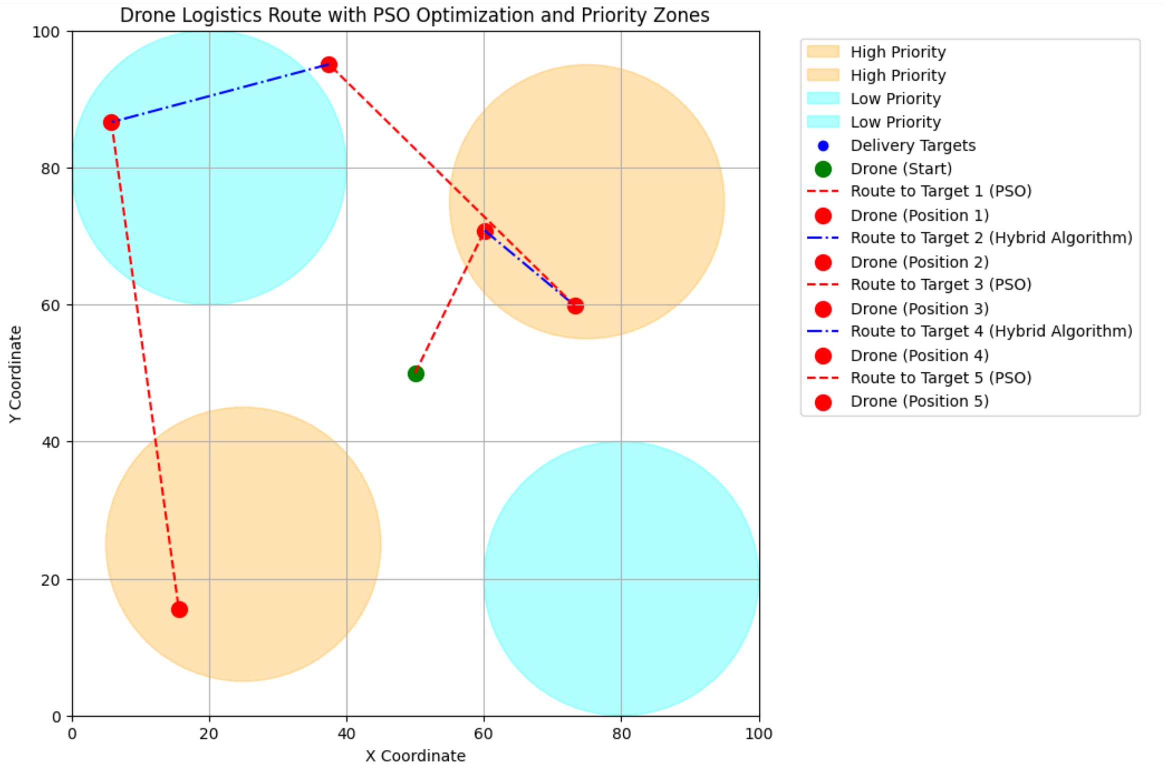

Fig. 5. **Visualization of the applied hybrid algorithm on the process of logistics operations**
Source: **compiled by the authors**

Description of the visualization of logistics operations:

1. **Logistics zones**

- Zones of different priorities have been created: "High Priority" and 'Low Priority', which can indicate areas where the delivery of medical supplies should be carried out as a matter of priority.
- Zones are displayed as circles with the corresponding color (orange for high priority, blue for low priority).

2. **Delivery routes**

- The drone's routes between the target points are shown by different lines: 'r (red)--' for PSO and 'b (blue)-.' for the hybrid algorithm.
- In the process, the drone optimizes its routes to target points, taking into account priorities.

3. **Update the drone's position**

- After each delivery, the drone changes its position and continues to optimize its route.

4. **Legend**:

- The legend is detailed, explaining which algorithm is used for each route segment, as well as a description of the logistics priority zones.

Calling an unmanned vehicle

Below is an example that details the logic of a hybrid algorithm that combines a particle swarm algorithm (PSO) and a genetic algorithm (GA) to solve logistics, health monitoring, and drone calling problems.

Explanation

1. **Initialization stage**. The genetic algorithm creates an initial population of possible solutions, which are then evaluated for their suitability. Selection and mutation provide variability in solutions, which are further optimized using PSO.
2. **Update and search**. PSO is used for local search, optimizing solutions based on local and global data. GA performs a global search that increases the probability of finding the global optimum.
3. **Stopping the algorithm**. The process stops when the optimal solution is reached or after a certain number of iterations, which ensures the efficiency and timeliness of the algorithm.

Below is a detailed table that describes the data and logic of the hybrid algorithm for controlling drones in medical, logistics, and emergency operations. This table will help you to better understand the mechanisms of the algorithm, its input and output data, as well as information processing:

Stage 1: Collecting data from sensors

At this stage, a variety of data is collected from sensors installed on the drone and on the monitored object (e.g., patient). The data can include biometrics, geolocation, and weather information. The algorithm uses filtering and normalization methods to prepare the data for further processing. Machine learning models assess the patient's condition and determine the need for immediate response.

Stage 2: Prioritize tasks

The collected data on the patient's condition and other requests are analyzed to prioritize tasks. The algorithm takes into account the criticality of situations, the current drone load, and the time required to complete each task. Using queueing theory methods, the optimal allocation of resources is determined to maximize the efficiency of operations.

Stage 3: Route planning

Based on the priorities set and the available resources, the algorithm plans optimal routes for each drone. It takes into account the terrain map, obstacles, weather conditions, and the battery level of the drones. Path-finding algorithms such as A* or Dijkstra are used to determine the most efficient routes that minimize delivery time and energy consumption.

Stage 4: Control and monitoring of implementation

During the execution of tasks, the algorithm constantly monitors the status of the drones and the progress of the tasks. It detects any deviations from the plan, such as unforeseen obstacles or changes in weather conditions. In such cases, the algorithm dynamically adjusts routes and action plans to ensure the successful completion of the mission.

Stage 5: Post-mission data collection and analysis

After the operations are completed, the collected data is analyzed to evaluate the effectiveness of the algorithm and drones. Areas where the algorithm or equipment can be improved are identified. Machine learning models are updated based on new data, allowing the system to adapt and improve with each new mission.

Effective drone recall is a critical aspect for rapid response in combat and medical situations. Drones capable of rapid and accurate recall provide the ability to quickly deliver medical supplies [27], conduct health monitoring, or perform other critical tasks in confined and dangerous areas (Fig. 6).

Description of visualization of the drone call

1. **Combat zones and beyond**

- - Two zones have been created: "Combat Zone" (red) and 'Non-Combat Zone' (green).

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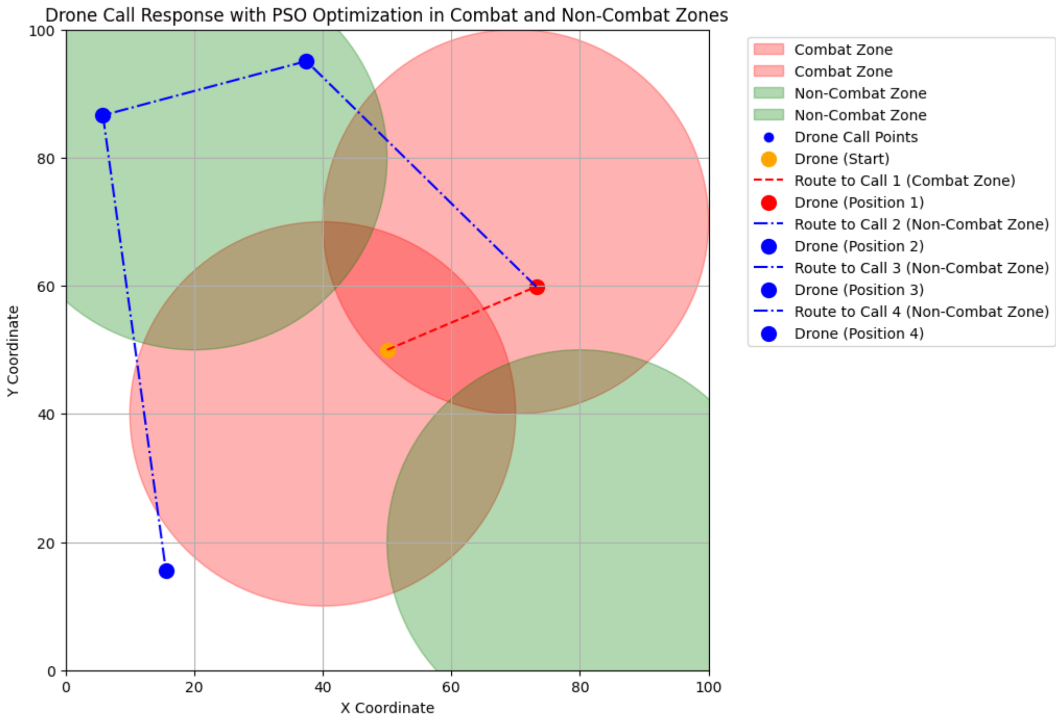

Fig. 6. **Visualization of the applied hybrid algorithm on the drone call process**
Source: **compiled by the authors**

- These zones indicate areas where a drone call may be associated with various risks.

2. Routes to call points

- Calls in the Combat Zone are displayed with red dashed lines ('r (red)--'), which indicates risky conditions.
- Calls outside of the Non-Combat Zone are indicated by blue dashed lines ('b (blue)-.').

3. Update the drone's position

- The drone consistently moves to the call points, optimizing its route, taking into account the location of the combat zone.

4. Legend

- The legend explains in detail which zones and routes are combat or non-combat areas, making it easy to understand where and how the drone operates.

This visualization shows how the drone responds to calls in conditions that change depending on the combat situation [29], and how algorithms help optimize the route in such situations. An important aspect of the study is the integration of all three functions: calling, health monitoring, and logistics operations into a single algorithm. A visualization of the result is shown in the Fig. 7.

Description of complex visualization

1. Zones

- Combat Zone (Red): Indicates areas where the drone may be in danger while performing call or logistics operations.
- Non-Combat Zone (Green): Relatively safe areas where operations can be performed without significant risks.
- Health Monitoring Zone (Blue): Areas where health monitoring is needed, for example, for the wounded or to monitor the condition of people in a conflict zone.

2. Call, logistics and monitoring points

- Drone Call Points (Yellow): Points where the drone is called for assistance.
- Delivery Targets (Purple): Points to which you want to deliver goods.
- Health Monitoring Points (Blue): Points where the drone should perform health monitoring.

3. Routes

- Routes leading to points in the Combat Zone are displayed with red dashed lines ('r (red)--').
- Routes in the Non-Combat Zone are indicated by green dashed lines ('g (green)-.').
- The routes to the monitoring points are displayed with blue dotted lines ('b (blue):').
- Other routes are shown as solid black lines ('k (black) -').

4. Legend

- The legend explains in detail which colors and line styles correspond to each operation, as well as which zones were involved.

This visualization provides a comprehensive overview of all operations performed by the drone and clearly shows how different algorithms and zones affect the drone's route.

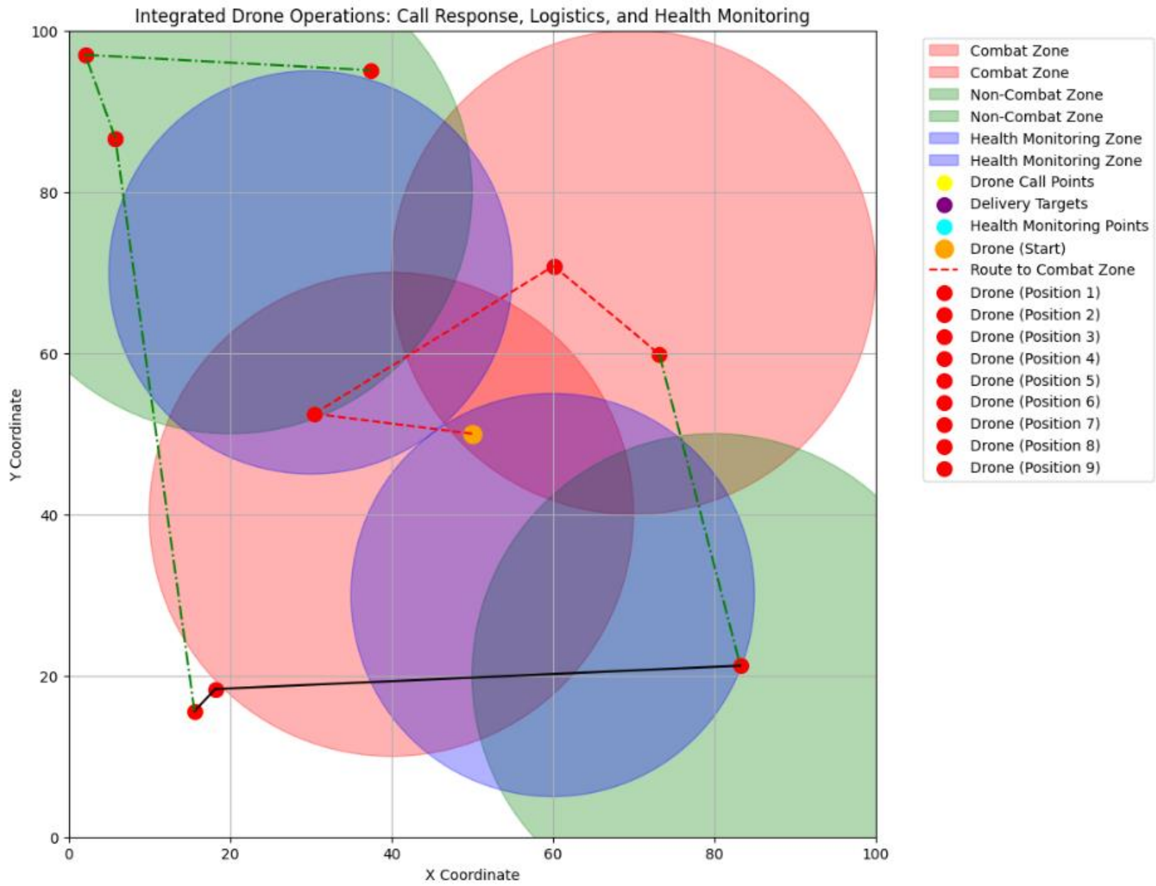

Fig. 7. **Visualization of the applied hybrid algorithm on the processes of logistics delivery of medicines in combat conditions**
Source: **compiled by authors**

The data presented here describes in detail each stage of the hybrid drone control algorithm in the context of medical, logistics, and call operations. This approach ensures:

Effectiveness. Optimization of routes and resources allows you to complete tasks quickly and efficiently.

Flexibility. Dynamic adjustment of plans ensures adaptation to changing conditions and unforeseen situations.

Reliability. Continuous monitoring and data analysis improve system reliability and the quality of task execution.

Training. Updating machine learning models allows the system to improve its performance over time.

Thus, this approach will help to better understand the work of the hybrid algorithm and its application in various operational scenarios, and will be a valuable addition to the practical part of future.

DISCUSSION OF THE RESULTS

The visualizations for logistics operations, drone calling, and medical tasks based on our experiment yield the following results:

Medical service areas. They show that drones can be directed to specific areas to monitor health and deliver medical supplies. The defined areas have large radii to cover the maximum number of patients. It is important that these zones are clearly demarcated [30] from dangerous areas.

Logistics operations. This includes the transfer of goods, where zones for the delivery of medicines and goods are marked. These zones should take into account the optimal routes for drones, including delays or obstacles along the route.

Calling drones. Includes cases of drone calls in different conditions - outside of combat and in combat. The visualizations demonstrate the need for zoning and adaptive routes to respond quickly to requests.

A hybrid approach ensures optimal results by combining different algorithms for medical and logistics tasks:

Drone (UAV). Sensors: The drone is equipped with sensors to measure vital signs such as heart rate, blood oxygen level, body temperature, etc. Camera: The drone can be equipped with a high-resolution camera for visual monitoring. Communication module: provides continuous communication with ground stations or cloud services via secure communication channels.

Algorithms of data processing. Pre-processing: The received data is processed on the drone itself to filter out noise and prepare for transmission. Swarm algorithm: used to coordinate between multiple drones operating in the same area. Machine learning algorithms: used to analyze sensor data and identify anomalies.

Communication channel. Secure data channel: data is transmitted in real time through secure channels to ground stations or the cloud. Ground station: serves to collect data from drones and manage their routes.

Data center (Cloud). Data processing: in-depth data analysis, including pattern detection and forecasting, is performed on cloud servers. Data storage: all data is stored for further analysis and reporting. User interface: provides healthcare professionals with access to monitoring results via a web interface or mobile application.

Medical workers. Data acquisition: doctors receive real-time data on the patient's condition via mobile or web interfaces. Decisions: based on the data received, decisions are made on further actions, such as sending help to the place or remote consultations.

Below is a UML diagram of how the algorithm works from the initial iteration to the final result (Fig. 8).

Drone models for such tasks should have a long range, long flight time, and the ability to integrate with various equipment to perform specific tasks. The choice of drones depends on the specific needs: for example, DJI Matrice 300 RTK or Parrot Anafi USA are suitable for medical tasks due to their functions and payload capacity, while budget models can be modified according to the following integration principle:

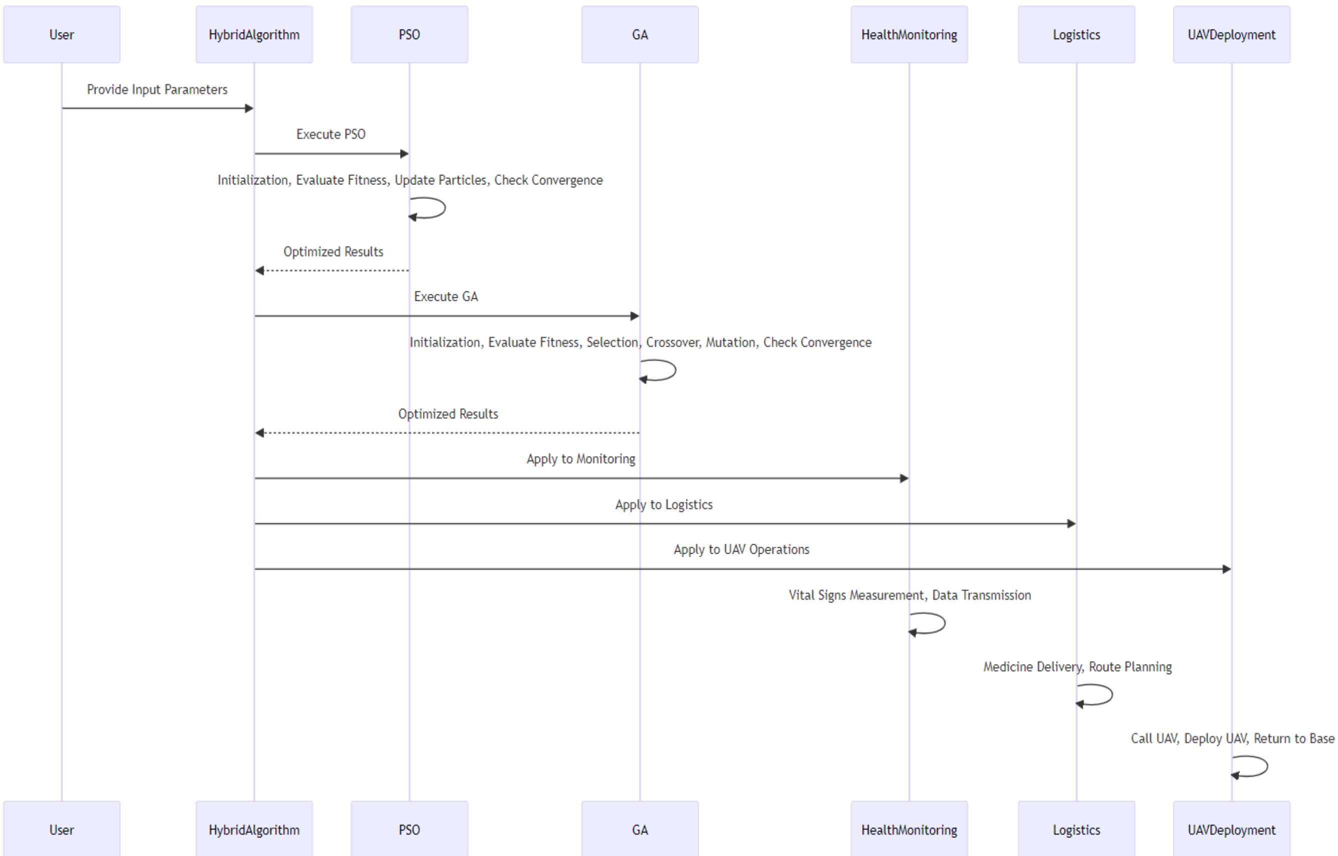

Fig. 8. **UML diagram of the principle of operation of the elements of the algorithm and the components of the drone's functionality**
Source: **compiled by the authors**

Description of the integration principle:

- Drone. The main object that interacts with various equipment and has its own parameters (ID, battery level, GPS coordinates, sensor data).
- Medical Sensor. Health monitoring equipment that integrates with a drone to collect medical data.
- Logistics Equipment. Equipment for logistics, which includes mechanisms for the transportation and delivery of goods.
- Command Center. A control center that issues commands to the drone and monitors its status.
- Communication Module. A communication module responsible for data transmission between the drone and the command center.

CONCLUSIONS

This paper analyzes the use of a hybrid approach combining a binary swarm algorithm (BPSO) and a genetic algorithm (GA) to optimize the parameters of medical drones. The main conclusions include:

1. Advantages of the hybrid approach: The hybrid algorithm, which combines the capabilities of BPSO and GA, demonstrated improved optimization results compared to their separate application. This indicates the effectiveness of the hybrid approach in solving complex problems where precise parameter settings are required.

2. Combined efficiency: The combination of BPSO, which provides a broad global search, and GA, which specializes in local optimization, allowed us to achieve optimal parameter values, improving the accuracy and stability of the results.

3. Impact on practical results: The hybrid approach resulted in optimal parameters for medical drones, such as Learning Rate and Number of Filters, which directly improves their functionality. A 14% improvement in the evaluation function compared to individual algorithms confirms the benefits of this approach.

4. Opportunities for future research: These results highlight the promise of using hybrid algorithms in complex optimization systems. Further research could consider incorporating other optimization algorithms or adapting the hybrid approach to new areas such as machine learning or big data analysis.

Thus, the results of this study demonstrate that hybrid algorithms can significantly improve the efficiency of parameter optimization in complex technological systems, opening up new opportunities for their application in various industries.

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Безпілотні літальні апарати в галузі моніторингу здоров'я та доставці медикаментів із застосуванням ройових алгоритмів

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АНОТАЦІЯ

Досліджений сучасний підхід до інноваційних технологій, розроблених для моніторингу здоров'я військовослужбовців за допомогою безпілотних апаратів, а також оцінюється його потенціал для доставки ліків у бойових умовах. Розглянутий широкий спектр датчиків і технологій, які дозволяють дистанційно вимірювати життєво важливі показники, зокрема тепловізійні камери, фотоплетизмографічні сенсори та радіочастотні датчики, підкреслюючи їхню ефективність у різних оперативних контекстах. У статті також аналізуються численні реальні приклади застосування дронів у медичних та гуманітарних проектах, що демонструють їхній трансформаційний вплив на своєчасне надання медичної допомоги та підтримки в районах, де традиційна медична інфраструктура може бути відсутньою. Крім обговорення практичних переваг використання безпілотних апаратів для медичного обслуговування, у статті також розглядаються методи, пов'язані з їхньою інтеграцією у військові операції, такі як логістичні, технічні та нормативні. Окрім того, наведений детальний приклад того, як ці інноваційні системи можуть бути ефективно поєднані для покращення медичного обслуговування військовослужбовців, особливо під час бойових дій, коли традиційний доступ до медичних послуг часто обмежений або ускладнений. У статті запропоновано кілька ключових напрямків для подальших досліджень та розвитку, підкреслюючи важливість постійного технологічного прогресу для повного використання потенціалу безпілотних апаратів у медичних цілях у військовому секторі. Серед цих напрямків – підвищення точності сенсорів, розробка кращих систем зв'язку та створення більш автономних і ефективних механізмів доставки. Приклади, наведені в статті, свідчать про те, що безпілотні апарати можуть відігравати ключову роль у революційних змінах у сфері медицини на полі бою та військової логістики, пропонуючи нові рішення для надання медичної допомоги в складних умовах.

Ключові слова: безпілотні літальні апарати; дрони; військова медицина; моніторинг здоров'я; доставка ліків; ройові алгоритми; тепловізори; фотоплетизмографія; радіочастотні датчики; інновації у військовій сфері

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