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Revolutionizing Transplantation: The Role of Artificial Intelligence IoT and Smart Drones to Enhance Organ Preservation and Transportation in Healthcare Innovation.

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Abstract

Organ transportation has yet to be substantially innovated. If organs could be moved by drone, Instead of ill-timed commercial aircraft or expensive charter flights, when a patient in need of an organ transplant is eventually paired with a donor, every second matters. As more time passes between the organ's removal and transplantation into the recipient, lifesaving organs could be transplanted more quickly. The organ's post-transplant performance deteriorates. To increase the odds of success, organs must be sent from point A to point B as fast and safely as feasible. Drones can save lives all over the world by carrying medical supplies or vaccines to difficult-to-reach locations, but there are a few problems that need to be resolved, such as monitoring and preserving container temperature and humidity. In order to address these issues, a smart container that is integrated with a thermoelectric cooler module and a temperature sensor has been created. This ensures that medical supplies or organs are transported safely by maintaining the temperature. We also look at the area where unmanned aerial vehicles are self-contained devices with propellers that may be turned in different directions to vary their motion. Technology for organ preservation and an Arduino drone control circuit. The Arduino part explains how to build up a breadboard circuit, including how to connect buttons, resistors, and sensors. It emphasizes how crucial correct wiring is to operation. The Cold Storage Preservation approach, namely the use of HTK and Collins solutions to preserve organ viability during transit, is covered in the section on organ preservation. The importance of these techniques in medical physiology is emphasized.

Keywords

Artificial Intelligence, Internet of Things, Arduino, Internet of Drones, Healthcare.

Introduction

In this paper we have discussed the evolution and significance of multirotor unmanned aerial vehicles (UAVs), commonly known as drones, in the field of autonomous robotics. It highlights the versatility and maneuverability of drones, which are self-contained machines equipped with propellers that can be rotated in various directions to control their movements. The paper emphasizes the growing interest in drone technology, particularly in applications such as organ transportation, where drones can potentially revolutionize the speed and efficiency of delivering organs for transplantation.

The paper also notes that significant advancements have been made in organ transportation over the past 60 years since the inception of organ transplantation. It points out the challenges faced in the current transportation methods, which can be slow and inefficient, potentially jeopardizing the viability of organs. By integrating medical technology for organ preservation with engineering innovations in drone design, the paper proposes the feasibility of creating a specialized drone capable of safely transporting organs while maintaining their integrity during transit.

Furthermore, the introduction sets the stage for discussing various technologies that enhance drone functionality, such as gyroscope stabilization, obstacle detection, and collision avoidance systems. These technologies are crucial for ensuring safe and reliable operation, especially in critical applications like organ transportation, where precision and reliability are paramount for saving lives. Overall, the introduction establishes the context for the research and the potential impact of drone technology on the future of organ transportation.

LITERATURE REVIEW:

In recent years, organ and vaccine preservation has become a difficult task during shipping. Liao et al. reported on blood preservation during storage and transportation. The authors also explored the numerous elements that influence the quality of stored blood, such as temperature variations, oxygenation, and the inclusion of certain additives. The scientists also described many methods for monitoring the temperature and oxygen levels of stored blood, such as temperature-sensitive labels and oxygen sensors. Jing et al provided an overview of organ preservation procedures, emphasizing the need of temperature management during the process. Nyemba et al. evaluated and assessed the viability of refrigeration systems for vaccine storage that do not use toxic refrigerants.

The authors highlighted the disadvantages of typical cooling methods and proposed better preservation approaches for organs and vaccines below. Minasian et al. reviewed the state-of-the-art in heart preservation technologies, emphasizing the significance of temperature management during organ preservation. The scientists also reviewed the limits of existing cooling technologies and proposed Peltier cooling modules as a more effective approach for organ preservation. Nyemba et al. examined the performance parameters of various refrigeration systems, such as cooling capacity, power consumption, and temperature stability. Furthermore, the authors found that Peltier cooling is a potential method for vaccine storage due to its low power consumption, compact size, and absence of toxic refrigerants. Sathyan et al.

Schubert et al. provided an overview of sensor technology for tracking the cold chain during travel. The authors addressed the many types of sensors available for monitoring temperature, humidity, and other elements that can affect the quality and safety of perishable commodities during transportation.

The authors reviewed the fundamentals of Peltier cooling and the parameters that influence its performance, such as the thermoelectric materials utilized, the temperature difference across the device, and the electrical input power as per Zeng et al.

Drone Technology

- Drone technology encompasses a range of advanced features and components that enable unmanned aerial vehicles (UAVs) to operate effectively in various applications. At the core of drone technology is the integration of Global

Navigation Satellite Systems (GNSS), such as GPS and GLONASS, which facilitate precise navigation and positioning. Drones are equipped with radar positioning systems that provide real-time location data relative to the controller, enhancing their navigational capabilities.

- Key components of drone technology include obstacle detection and collision avoidance systems, which utilize algorithms and sensors to create 3D maps of the surrounding environment, allowing drones to navigate safely. Gyroscope stabilization technology is also integral, ensuring smooth flight by providing critical navigational information to the drone's control systems. Additionally, the Inertial Measurement Unit (IMU) measures acceleration and rotational characteristics, further enhancing flight stability.

- Drones can be outfitted with various smart devices, including cameras, GPS trackers, LIDAR scanners, and distance sensors, expanding their functionality for applications in fields such as agriculture, traffic surveillance, and emergency medical services. The ability to fly at altitudes of up to 8000 meters and perform stationary flights allows drones to monitor and survey areas effectively. Overall, drone technology represents a significant advancement in robotics, offering versatile solutions for real-time applications across multiple industries.

Materials and Equipment

The document outlines specific materials and equipment essential for the operation and functionality of the drone designed for organ transportation.

Arduino UNO: This microcontroller board serves as the brain of the drone, enabling programming and control of various components. It allows for the integration of sensors, motors, and communication systems, facilitating the drone's autonomous functions.

USB A to B Cable: This cable is used to connect the Arduino UNO to a computer for programming and data transfer. It ensures that the microcontroller can be easily updated and configured as needed.

Optional Battery Power: To enhance the drone's portability and operational flexibility, a 9V battery can be used as an alternative power source instead of relying solely on the USB connection. This option includes a 9V battery snap to barrel jack plug, allowing for easy connection to the drone's power system as depicted in Figure 1.

PING Ultrasonic Sensor: This sensor is utilized for distance measurement and obstacle detection, providing critical data to the drone's control system. It helps ensure safe navigation by detecting nearby objects and preventing collisions during flight.

Temperature Sensor: A LM35 temperature sensor was used to measure the temperature of the medical box. The LM35 temperature sensor is widely used and can measure temperature in degrees Celsius. It also has a higher accuracy than thermistors for measuring temperature. The LM35 is a low-cost, small three-terminal device that operates from 4 to 30 V. Furthermore, it generates 10-mV per degree Celsius, which is linear and directly calibrated in Celsius.

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The LM35 temperature sensor can monitor temperatures ranging from -55 to 150 degrees Celsius, making it ideal for the proposed work.

These materials and equipment collectively contribute to the drone's ability to operate autonomously, navigate safely, and perform its primary function of transporting human organs efficiently and securely.

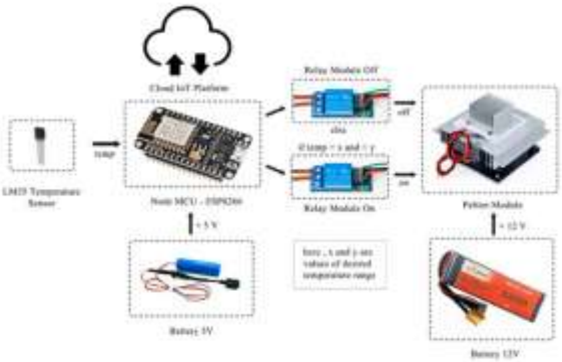

Figure 1 illustrates the overall diagram of an IoT-based smart healthcare diagnostic unit.

Connect to Arduino

The document provides detailed instructions for connecting the Arduino UNO to various components in the drone's control circuit.

To begin, ensure that the breadboard is oriented with the information facing you. The following connections should be made: Connect the positive bus of the breadboard to the 5V pin of the Arduino UNO. This supplies power to the components on the breadboard. Establish a ground connection by linking the Arduino's GND pin to the ground rail of the breadboard.

Connect the PING ultrasonic sensor by using male-female jumper wires: the sensor's GND pin should connect to the Arduino's GND, and the VCC pin to the 5V pin of the Arduino. The SIG pin of the PING sensor should be connected to digital pin 7 on the Arduino.

For the push button, connect its pins to holes E23, E25, F23, and F25 on the breadboard, spanning the center space. Connect one side of the button to Output Pin 3 of the Arduino and the other side through a 10 kΩ resistor to ground.

Additional connections include linking the Arduino's digital pin 10 to whole G10 on the breadboard, and ensuring that the input A0 of the Arduino connects through whole J17.

These connections are crucial for enabling the Arduino to control the drone's functions, process sensor data, and respond to user inputs effectively.

Cold Storage Techniques

The Cold Storage Preservation technique is essential for the preservation and transportation of organs, utilizing solutions like HTK and Collins Solution to inhibit organ function during hypothermic storage. HTK solution is specifically designed for perfusing and flushing organs such as the liver, kidney, heart, lung, and pancreas before removal and during transport. This method aims to minimize ischemia and reperfusion injury, ensuring organs remain viable for transplantation by maintaining a suitable temperature range and reducing metabolic activity. Healthcare products and organs should be stored at the following temperatures: RBCs (Red Blood Cells) or whole blood at 2 to 10 °C, FFP (Fresh Frozen Plasma) at 2 to 6 °C, cryoprecipitate at 2 to 4 °C, platelets at 20 to 24 °C, frozen vial transport at -25 °C to -15 °C, refrigerated vials transport at 2 °C to 8 °C, and organs at 4 °C to 8 °C.

To maintain these temperature ranges while also ensuring the safety of healthcare supplies and organs, this issue needed to be resolved. The goal of this project is to design and construct an IoT-Based Healthcare Medical Container for the transportation of organs and healthcare products by unmanned aerial vehicle.

Current OCS (Organ Care System)

The Organ Care System (OCS) is designed for the transportation of organs, maintaining a homeostatic cellular environment to prevent damage until transplantation. It features a compact design with a temperature range of -40 to 900°C and can be powered by D.C. current from vehicles. The system aims to provide adequate hydration, slow metabolic processes, and minimize ischemia and reperfusion injury during organ transport.

Organs with Preservation Considerations

Kidney: Viable for 24 to 36 hours, it requires preservation at temperatures between 2 and 6°C, commonly using Static Cold Storage (SCS) methods.

Heart: Viable for less than 6 hours, it is best preserved at temperatures greater than 4°C, ideally between 5-10°C, often utilizing static cold storage in a crystalloid heart preservation solution.

Liver, Lung, and Pancreas: These organs are preserved using solutions like HTK, which inhibit organ function during hypothermic storage and transport, ensuring their viability for transplantation.

Organ Preservation Technology

Organ preservation technology involves methods and techniques to maintain the viability of organs for transplantation by preventing cellular damage during removal, storage, and transport. Key techniques include:

Hypothermic Machine Perfusion (HMP): A dynamic cold preservation method that supplies metabolic substrates at 4°C, ensuring continuous nourishment to the organ.

Normothermic Machine Perfusion (NMP): Provides oxygen and nutrition during preservation, allowing aerobic metabolism, which helps maintain organ functionality.

Oxygen Persufflation (OP): Achieves effective oxygenation of organs, such as kidneys, through the venous system without direct perfusion, promoting diffusion throughout the organ

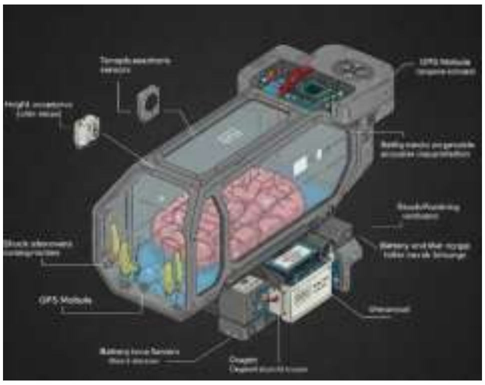

Figure 2 AI and IoT-based smart healthcare Container.

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Techniques of Preservation

The techniques of organ preservation focus on maintaining organ viability and functionality during storage and transport as depicted in Figure 3. Key methods include:

HTK Solution: Used for perfusion and flushing of organs like the liver, kidney, heart, lung, and pancreas, HTK solution inhibits organ function and is essential for hypothermic storage.

Hypothermic Machine Perfusion (HMP): This method provides a continuous supply of metabolic substrates at 4°C, ensuring a homogeneous preservation environment for the organ.

Normothermic Machine Perfusion (NMP): This technique allows for aerobic metabolism by supplying oxygen and nutrients during preservation, stabilizing cell permeability and reducing metabolic activity.

Oxygen Persufflation (OP): This method oxygenates the organ through the venous system, promoting diffusion without direct perfusion, which is particularly effective for kidneys.

Freezer arrangement (FA):

The freezer configuration is made possible by the Peltier, also known as a thermoelectric cooler. The Peltier requires a supply voltage of 12 V to 15 V and can draw a maximum current of 10 A. When the Peltier is turned on, it generates a temperature difference, which is represented by a hot and cold side on each side.

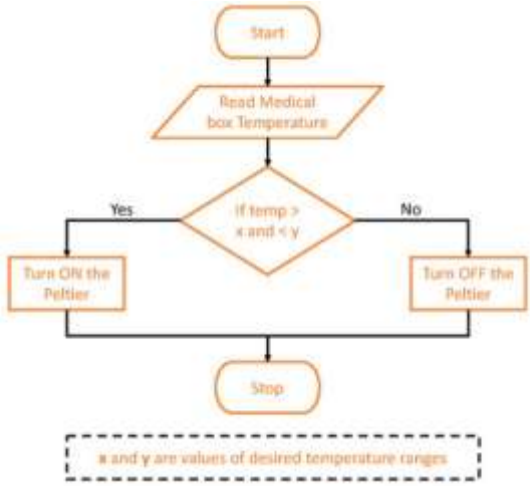

Figure 3. Flowchart for the operation of a smart healthcare healthcare unit.

Organ Transportation through Drones

The organ transportation drone is an unmanned aerial vehicle (UAV) specifically designed to safely and efficiently transport human organs as depicted in Figure 4(a) & (b). Key features include:

Advanced Stability Mechanisms: The drone incorporates a gimbal system to ensure the organ remains stable and protected during flight, minimizing the risk of damage.

Battery Technology: It utilizes high-capacity batteries and battery-sweeping technology to extend its range, allowing for quicker transport compared to traditional methods reliant on commercial flights.

Rapid Delivery: By bypassing the limitations of current transportation infrastructure, the drone can significantly reduce the time taken to deliver organs, which is critical for successful transplantation and saving lives.

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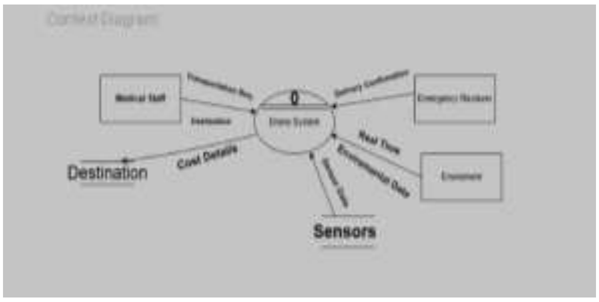
Figure 4. (a) Data Flow Diagram of the Process



Level 0

(b) Data Flow Diagram of the Process Level 1

Gyroscopic System

A gyroscopic system is a device used to measure or maintain orientation and direction based on the principles of angular momentum. Key aspects include:

Stability: When rotating, the orientation of the gyroscope's axis remains unaffected by tilting or rotation of its mounting, providing stability and reference for navigation.

Gimbal Mechanism: Gyroscopes often utilize a gimbal system, allowing them to pivot freely about multiple axes, which helps maintain their orientation regardless of the movement of the supporting structure.

Applications: Gyroscopic systems are widely used in navigation systems for aircraft, ships, and drones, as well as in various consumer electronics for stabilization and orientation detection.

Gimbal

A gimbal is a pivoted support system that allows an object to rotate freely about one or more axes. Key features include:

Multi-Axis Rotation: Gimbals typically consist of multiple rings stacked with orthogonal pivot axes, enabling smooth rotation and stabilization of mounted objects, such as cameras or gyroscopes.

Stability: They maintain the orientation of the mounted object relative to a fixed reference, compensating for movements of the support structure, which is crucial in applications like photography and navigation.

Applications: Gimbals are used in various fields, including aerospace for stabilizing instruments, in photography for smooth camera operation, and in organ transportation drones to ensure the safety and stability of delicate cargo.

CONCLUSIONS

The research concludes that it is feasible to develop a drone for organ transportation by integrating medical and engineering technologies, allowing for safe and efficient movement of organs. Applications: Gimbals are used in various fields, including aerospace for stabilizing instruments, in photography for smooth camera operation, and in organ transportation drones to ensure the safety and stability of delicate cargo.

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While the drone can preserve organs for extended periods, its range is limited by battery capacity, which can be improved through battery swapping technology. This innovation offers a faster transportation method compared to current practices, crucial for saving lives during organ transport. The proposed innovation provides high levels of safety for the transportation of healthcare materials such as organs, medicinal goods, and vaccines, as well as the ability to quickly and safely transfer medical products to remote locations, saving lives all over the world. Furthermore, the proposed technique does not require cryogenic systems, which can be costly and difficult to maintain. This will lessen the likelihood of product damage, deterioration, or loss during transportation. Overall, the invented technology has the potential to significantly improve the healthcare sector and, ultimately, quality of life.

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