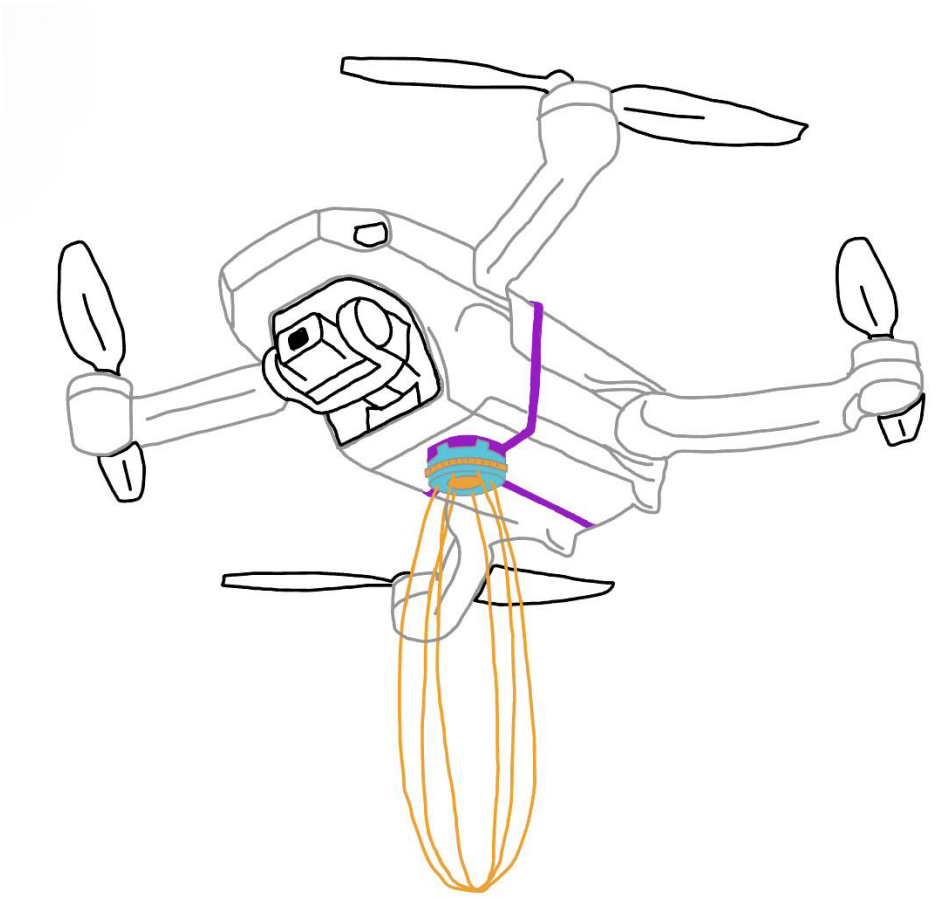

Search and Rescue Drone Attachment

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Introduction

In today's complex world, search and rescue (SAR) operations serve as an indispensable addition to emergency response systems around the globe. As human activities continue to expand into challenging environments, ranging from remote wilderness areas to densely populated urban centers, the likelihood of emergencies needing immediate attention continues to rise. SAR operations play a very important role in keeping human lives safe, whether that be responding to natural disasters, wilderness mishaps, or city emergencies.

In the past decade or so, drones have become an increasingly hot topic due to their adaptability into so many different fields, including search and rescue. Since this new addition of unmanned aerial systems (UAS) devices into SAR, many lives have been saved. In most SAR missions, the lost person is often trapped in a life-threatening situation where time is not on their side. Many times they are trapped in tough terrain that is hard to move through or even access. Drones are able to bypass these factors of time and location by flying directly to the scene, over cars, traffic, cliffs and mountains, to locate this missing person using technologies that already exist in the field (thermal cameras, sensors, and spotlights). This solves the problem of finding the missing person, but our question is, what can be done to aid our rescuee between the time they are found by a SAR drone and when help can arrive on the scene?

In response, the need to develop a system to help those while waiting for rescue has led us to create a drone system that can be equipped with versatile attachments capable of delivering vital supplies to individuals. A manufactured adapter would be capable of attaching to any commercial drone through the use of easily modified parent parts and additive manufacturing (3D printing). With the provided parent part model, any search and rescue team may edit the dimensions to fit the SAR drones they have already been using, followed by a quick print that could have their adapter ready in 24 hours. This eliminates the need to buy a specialized drone and lets SAR teams have functioning payload carriers for their drones in record speed.

The next question at hand is what items are able to be carried to the rescuee. With a payload attachment hanging from the drone adapter, this could range anywhere from a bottle of water, medicine, a wound kit, a small splint, food, or even a radio so the missing person can communicate with the search and rescue team. In the hours it might take to locate this person, something as simple as fresh water might mean the difference of life or death. The payload attachment will consist of adjustable and resizable cables capable of wrapping around any object.

A strength of this design is its easy integration into already in place systems. SAR drones already exist, and this solution only adds to its effectiveness. As this design could be vital to saving lives, the social impact of such a design is expected to be met with enthusiasm. Additionally, the use of 3D printing ensures that material waste will be kept at a minimum, as well as eliminating the need for manufacturing plants.

Industry Overview

Natural disasters claim the lives of 68,000 people per year and affect over 200 million people worldwide [5]. Drones have already found their way into search and rescue teams due to their ability to cover large areas very quickly. It's estimated that in an urban setting, a drone is around 120% more efficient than a road vehicle at finding people [1]. These drones are typically outfit with cameras to aid in searching operations, but are capable of carrying much more. One of the more popular options for search and rescue drones, the DJI Matrice 350 RTK Public Safety Package version, is capable of carrying up to 2.7 kilograms while most camera-and-gimbal combinations only weigh about 1 kilogram. These drones are designed to cover difficult terrain very quickly and reach the victims before anyone else can, and that is all most search and rescue teams use them for. However, these drones are much more capable and could be delivering vital supplies to the victims while they wait for the proper search and rescue team to arrive. One of the most limiting factors for UAVs in the search and rescue space is having or learning the ability to fly them. Search and rescue teams are busy enough with standard training that it can be difficult for operators to find time to learn a new skill of flying rescue drones. The search and rescue teams that have put in the time to learn and use drone systems have found it very rewarding in speeding up the rescue operations where speed is crucial to finding victims before it's too late. Current consumer devices designed to carry payloads range in price from around $30-$100 and are primarily designed to fit only 1 or 2 specific models of UAV.

Design, Functionality, and Durability

The design solution must be able to carry a wide range of payloads that could be of varying sizes and shapes, so it must be flexible enough to hold strange shapes and still be secure. The limits of the payload are the size of the drone and its maximum carrying capacity. The design will feature an adapter that allows the payload attachment to be fixed to a wide variety of drones for the greatest compatibility with search and rescue teams. The design should be able to accommodate a 10x6x2" cube which is approximately the size of a standard Class A first aid kit.

Our design features two main components. The first of these is the primary device which is a cylindrical design that has cables protruding from its bottom face that will surround the payload and secure it for the UAV to be able to carry. The payload will be held by a system of cables that will be made from a lightweight but strong nylon or polyethylene that will feed into a gear system, similar to the BOA lacing system from hiking boots, that can be twisted and will tighten all of the cables around the package. This system is flexible enough to allow a variety of sizes and shapes of payloads to be attached and still strong enough to make sure it isn't lost during flight. On the bottom of the main part will be a large button that will release the tension in the cables so that the package can be retrieved. The second component in our design is an adapter piece that will be 3D printed from a carbon fiber filament material and its function is to attach the universal rope system to any type of drone with a tight snap-fit mechanism. This piece

will be easily-modifiable so that customers can adapt it to be printed and then fit onto their drone with minimal effort.

If this design were to be used to carry food to someone, the food would need to be placed in a separate container before being secured in the device because carbon fiber filament is not certified as being food safe by the FDA and it could come in contact with the food during use [6]. The adapter system must be secure enough to support the weight of a full load in the payload system and stay attached to the drone without coming apart, which could be very dangerous for people below the flying drone.

Testing this product before its use by search and rescue teams will be crucial so that they can know that it will be reliable in cases of emergency when the teams would need it. Repeated drop testing would be one of the methods used to ensure that the part as a whole can withstand being handled roughly and from possible harsh landings by the UASs. Another method of testing will be wear tests between the adapter piece and a drone mount in order to test the effects of long-term usage and removing the carrying device to swap it for another tool, such as a camera. The twist-to-tighten design also needs to be tested for its durability after being loosened and tightened many times.

Below are our basic sketches showcasing our idea. Take note of the color coded parts to help differentiate each piece.

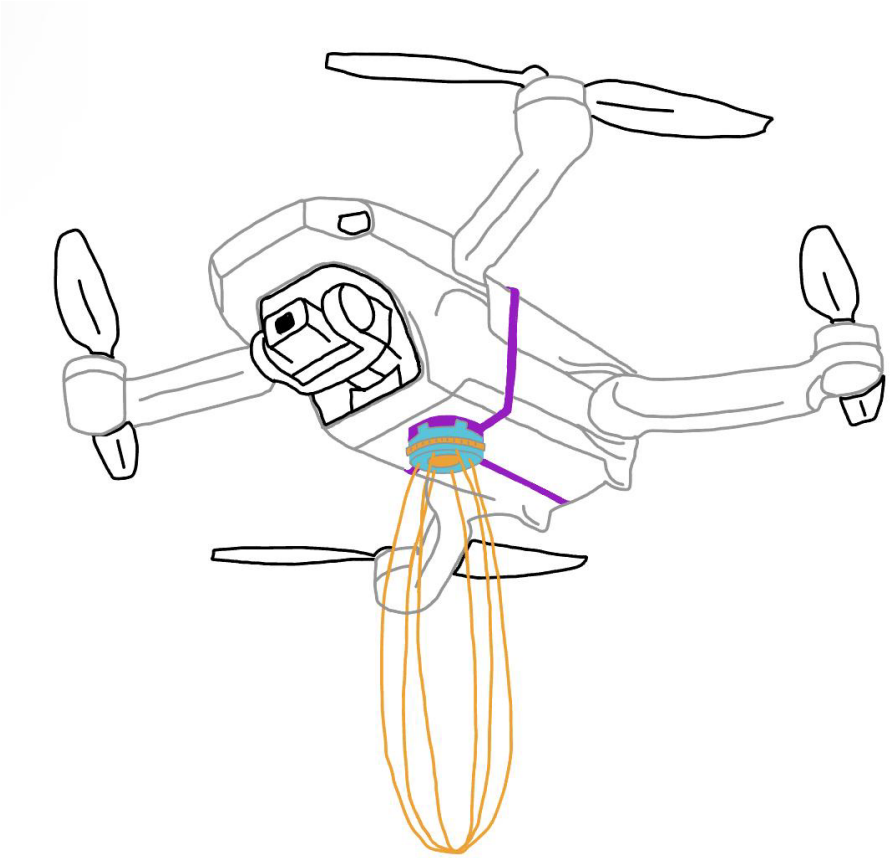

Figure 1. Isometric view of entire attachment

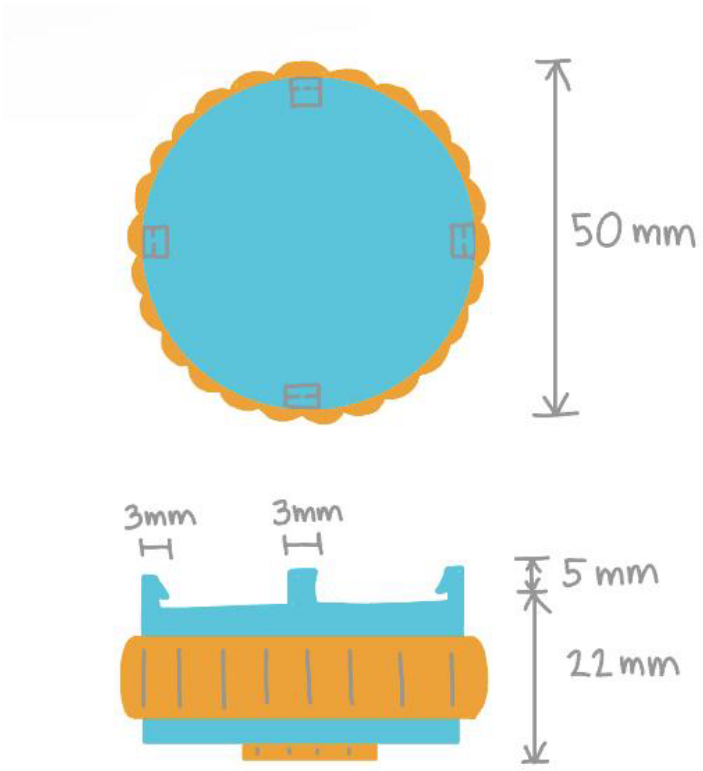

Figure 2. Top and front view of payload attachment

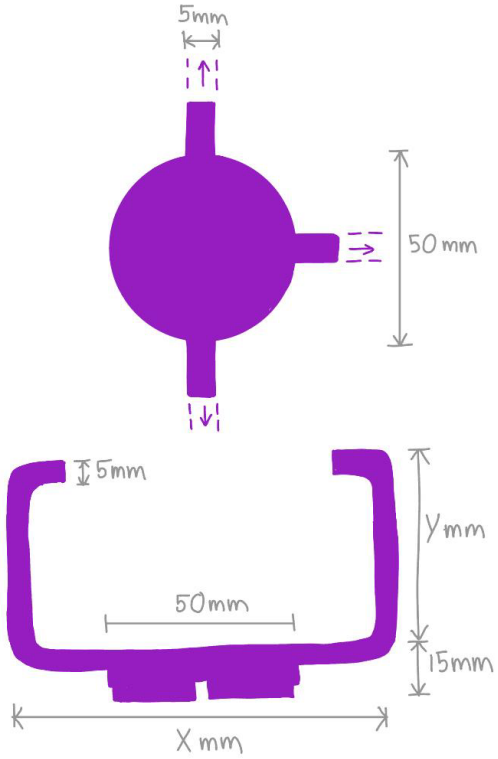

Figure 3. Top and front view of drone attachment

X and Y in Figure 3 above will vary depending on the size of drone the device is being attached to.

Design Integration & Additive Manufacturing

Material

A multitude of material types were considered for this system, including ABS, PLA, nylon, and a carbon fiber mix. Nearly all of these materials are tough and have a high strength factor, but two stood out the most: nylon and carbon fiber. Nylon is tough and inexpensive, good for the outdoors, and very durable. Carbon fiber is lightweight, rigid, strong, but slightly more expensive. Based on the specific criteria of our design and the importance of being able to carry a payload on a drone not specifically designed for heavy weight, the carbon fiber mix was chosen because of its lightweight properties. Having the drone adapter and payload attachment be as light as possible allows for heavier payloads that would not have been possible with other material types. Although it is more expensive, the priority leans towards the flexibility of supplies that can be sent to the rescuee.

Compared to materials traditionally manufactured in the industry, carbon fiber weighs 25% as much as steel and 70% as much as aluminum, while also being stronger and stiffer than both. Composites such as this one are known to be more durable than metals and can never rust, which is an important factor when creating something made for outdoor use.

Justification

Although this design is meant to be built through the use of 3-D printing processes, other additive manufacturing techniques can be used depending on availability. Additionally, the post processing time for this part is very minimal and would only require the disassembly of supports created during the printing process. Depending on the type of manufacturing, there may be little to no support at all. As this piece will be two to three distinct parts to print, the only other task required would be a simple assembly of parts.

The largest benefit this product receives from additive manufacturing is in the adapter piece that connects the payload device to the drone. There are a wide variety of drones available to search and rescue teams and many of them have their own mounting systems for accessories, and this piece will be modular so that it can be printed to fit a specific type of drone. This cuts down on manufacturing costs because otherwise, each unit would need to include at least a dozen different adapter pieces or each unit of the product would have to be specially packed for each of the different adapter types. Ideally, a library would exist of as many adapter types as possible and that would be accessible to search and rescue teams who could either print that part themselves or send it to a nearby facility that has the capability to 3-D print the part the way they need it.

Environment

The device features very few moving parts, and due to the goal of the product being 3-D printable, it should be very serviceable by its users. This is actually very important so that search and rescue teams can have the ability to print replacement parts whenever they need instead of having to order the parts and wait, which could be the difference of someone's life in a disaster scenario. Additionally, with its greater strength over other materials, it will last longer and can be used many more times before its lifespan has ended. This increased life reduces the amount of total material used over the years, and lessens the amount of materials being thrown away. Carbon fiber also has the capability of being recycled with the proper equipment, allowing for no further waste to be produced.

Digital and Physical Infrastructure

The majority of this product can be 3-D printed on-demand, representing a shift in the operations of SAR teams, offering unparalleled flexibility while reducing dependency on traditional mass manufacturing. Through this innovative approach, SAR teams can swiftly fabricate the drone and payload attachments to match the precise parameters of their drones, circumventing the delays and logistical challenges with mass manufacturing methods. However, while the specialized components of the drone attachment necessitates the need for 3D printing, constant parts like the payload adapter have the capability of being mass produced, considering some components cannot be 3D printed. With this method, these payload attachments can be purchased in large quantities for entire fleets of drones, reducing the time it would take to print the entire device by half. This hybrid manufacturing strategy not only optimizes resource allocation, but diversifies the supply chain and mitigates risks associated with disruptions.

Cost Benefit/Value analysis

Approximately 0.5 kilograms of carbon fiber filament costs about $60, and based on estimations for the product, this amount should be able to print 15 complete assemblies. This gives a rough estimate for how much our product will cost, which is $5 in materials to make each assembly. Compared to the current market, this is much cheaper than what is currently available, which is nearly $40. The testing types described in this document to ensure the device is capable for market-release are durability and stress testing, which will require a drone, but no further special equipment, which should not increase the price. Most of the testing could be done without a drone and involves the repeated use of the features of the device and drop testing it with some weight attached to simulate the product hanging down from the drone.

Conclusion

In conclusion, the integration of drones equipped with supply-carrying inventions marks a significant advancement in search and rescue (SAR) operations, revolutionizing the efficiency and effectiveness of emergency response efforts. By bridging the gap between initial distress calls and the arrival of traditional rescue teams, this innovative solution holds the potential to save precious time and lives in critical situations. The ability of these drones to swiftly deliver essential supplies to lost or stranded individuals not only enhances their chances of survival but also highlights the adaptability of technology through the use of additive manufacturing. As SAR teams continue to embrace cutting-edge tools and methodologies, the fusion of drones and supply-carrying inventions exemplifies a forward-thinking approach to safeguarding human lives and ensuring swift assistance in times of need.

References

[1] Drones, A. (2024, February 7). *Search and rescue with drones. key advantages when time is critical.* Nextech. https://nextech.online/search-rescue/

[2] Basali. (2024, March 28). *Drones for search and rescue operations: SAR Drones*. Drones for Search and Rescue Operations | SAR Drones. https://www.flytbase.com/blog/drones-for-search-rescue#advantages-of-search-and-rescue-drones

[3] Baguley, R. (2017, December 29). *3D printing materials: The Pros and cons of each type*. Tom's Guide. https://www.tomsguide.com/us/3d-printing-materials,news-24392.html

[4] Soloe. (2022, October 5). *4 advantages of using composites over traditional materials*. Fortify. https://3dfortify.com/composites-replace-traditional-materials/#:~:text=Carbon%20fiber%20weighs%20about%2025,than%20both%20materials%20per%20weight

[5] Natural disaster statistics and facts [updated data from 2020] ... (n.d.). https://www.thezebra.com/resources/research/natural-disaster-statistics/

[6] CFR - Code of Federal Regulations Title 21. *Substances for Use as Food Contact Surfaces.* https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?CFRPart=177