APPLICATION OF UNMANNED AERIAL VEHICLES IN LOGISTICS

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Abstract: This article discusses the possibilities of using unmanned aerial vehicles (UAVs) and drones in logistics, their problems in application, the possibility of obtaining both financial and social benefits. Also, traveling salesman problems and other path planning problems will be considered. Based on the research, a solution is proposed and the profit and benefit that will be obtained as a result of this is estimated.

Keywords: *drones, unmanned aerial vehicles, logistics, location, algorithm, control.*

ПРИМЕНЕНИЕ БЕСПИЛОТНЫХ ЛЕТАТЕЛЬНЫХ АППАРАТОВ В ЛОГИСТИКЕ

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Аннотация: В данной статье рассматриваются возможности использования беспилотных летательных аппаратов (БПЛА) и дронов в логистике, их проблемы в применении, возможности получения как финансовой,

так и социальной выгоды. Также, будут рассмотрены задачи коммивояжера и другие задачи планирования пути. Исходя из исследований, предлагается решение и оценивается прибыль и выгода, которые в результате этого будут получены.

Ключевые слова: *дроны, беспилотные летательные аппараты, логистика, местоположение, алгоритм, управление.*

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Annotatsiya: Ushbu maqolada logistikada uchuvchisiz uchish apparatlari va dronlardan foydalanish imkoniyatlari, ularni qo‘llashdagi muammolari, ham moliyaviy, ham ijtimoiy foyda olish imkoniyatlari muhokama qilinadi. Shuningdek, sayohatchi sotuvchi muammolari va boshqa yo'lni rejalashtirish muammolari ko'rib chiqiladi. Tadqiqotlar asosida yechim taklif qilinib va uning natijasida olinadigan foyda va daromad baholanadi.

Kalit so‘zlar: *dronlar, uchuvchisiz uchish vositalari, logistika, joylashuv, algoritm, boshqaruv.*

Introduction

The widespread use of environmentally friendly cars in logistics could help address issues including air pollution, climate change, and dependence on oil. Unmanned aerial vehicles (UAVs) or drones may serve as a practical and cutting-edge mode of transportation in this situation [1]. Unmanned aerial vehicles (UAVs) are aircraft that are not piloted and are controlled by onboard computers, radio remote controls, or self-contained program control systems. Regional UAV transportation, UAV express delivery (terminal distribution), UAV rescue (emergency logistics), and UAV storage management (inventory, inspection, etc.) are the four subcategories under

which the use of UAVs in logistics can be divided. Regional UAV transportation and UAV terminal distribution are the two main categories. There are two different kinds of UAV distribution systems, with branch line UAV transportation and UAV terminal distribution serving as their two primary forms. As an illustration, consider the UAVs used by two well-known logistics firms in China: JD represents the "point-to-multiple" UAV logistics distribution mode, which requires control of several UAVs, and S.F. Express represents the "peer-to-peer" UAV logistics distribution mode, which only requires control of one UAV. Examining some of the UAV technical and operational management constraints, such as intelligent obstacle avoidance, flight distance, endurance, and load capacity, several mathematical models and research methodologies are examined.

Theoretical Models

It is difficult for UAVs to accomplish deployment tasks under various safety risks (such as accidents and collisions) because of the complexity and dynamics of the road environment, and the development of effective and adaptable UAV path planning algorithms has become necessary [2]. Different algorithms are employed by many scientists to accomplish objectives such as path minimization, cost reduction, etc. The traveling salesperson issue is one of them. The traveling salesman problem is categorized into one category and other route planning problems into another because it is a unique route planning problem.

The Traveling Salesman Problem

A specific kind of path planning issue is the traveling salesman dilemma. In a path planning problem, the goal is to safely and accurately transport the designated goods from the starting point to the destination while adhering to the given constraints (avoiding obstacles, minimizing energy consumption, finding the shortest path, and using the least amount of time). A common combinatorial optimization problem is the traveling salesman problem. The ant colony optimization algorithm, seagull algorithm, differential evolution algorithm, sparrow search method, and many other algorithms are frequently used to tackle this problem.

In order to reduce the amount of time needed to serve all devices, it has been suggested that trucks or unmanned aerial vehicles (UAVs) complete customer delivery services using a branch and bound algorithm specifically created to efficiently target small instances up to 15 customers [3]. In order to find a minimum time route for a single truck that can receive newly available orders and route via a UAVs sent from the depot, there is another traveling salesman problem involving release dates and UAVs resupply. To solve this issue, they developed a Mixed-Integer Linear Program and a solution method for larger instances. The tests reveal that resupply via UAVs can cut the overall delivery time by up to 20%.

Setting a time constraint is only one issue with using UAVs; another is the payload restriction. After loading some of the merchandise onto the truck, it is required to examine the problem of giving the remaining cargo with UAV, develop optimal optimization algorithms, and apply them to static and dynamic problem settings[4] in order to reduce the overall cost of delivery.

UAV deployment paths are varied and must take into account a variety of environmental elements as a result of the traveling salesman problem's practical implementation. two sets of mathematical programming formulas and designed routes for UAVs and other vehicles that need to visit a variety of geographic locations in order to provide products or services. The findings demonstrate the value of these models and the ability of these formulations to optimize cases of medium size, much like other combinatorial issues [5]. To investigate the issue of deploying UAVs for urban cargo transportation, a mixed meta-heuristic algorithm, a mixed integer linear programming formulation, and a straightforward band-and-cut method should be utilized [6].

Other Path Planning Problems

Aside from the traveling salesman problem, this paper classifies other path planning problems into one category.

In order to maximize the overall number of products supplied, a novel mixed integer linear programming (MILP) model for the vehicle routing problem with UAVs (VRPD) has been developed. This model has two alternative time-oriented objective functions for vehicle routing. The findings demonstrate that incorporating truck UAV tandems into transportation systems can be used to decrease fleet size in addition to improving delivery speed [7]. The VRPTWDR problem was addressed using the big neighborhood search heuristic algorithm; the results demonstrate that adding robots as consumers significantly reduces the objective value [9].

In the path planning problem, the detailed setting of routes and stations is also one of the keys to obtain the best path. Abhishake Kundu et al. presented a routing heuristic for the Flying Sidekick Traveling Salesman Problem. They developed a novel split algorithm that utilizes the shortest path approach for determining the optimal routing solution to a given order of customer locations [8]. Mohamed R. Salama and Sharan Srinivas pointed out that the existing truck-UAV tandems predominantly restrict the UAVs launch and recovery operations to customer locations. In order to solve these problems, they introduced a new variant of truck-UAV tandem that allows the truck to stop at non-customer locations (referred to as flexible sites) for UAVs [12]. The synchronization of UAVs and delivery trucks is another innovation, and a multi-objective optimization model was designed to maximize customer service in terms of on-time deliveries while minimizing trip expenses. To reduce overall trip expenditures, a mixed-integer programming paradigm is proposed [11]. The results

indicate that the ability to launch along an edge has a nontrivial impact on objective values on truck-and-UAV coordination problems [10], and that the UAV is capable of carrying multiple packages at once and that it can be launched and retrieved along an edge, as well as a flexible launch/retrieval site set.

Summary of Theoretical Models and Related Sustainability Issues

The primary goal of path planning is path optimization, however the more cars on the road and the farther they must drive, the more energy is consumed, and the more of an impact the delivery phase has on the environment. At this time, batteries power the majority of drones. Drones are more eco-friendly than conventional transportation techniques since they produce fewer carbon emissions and use less energy while delivering packages [13]. Road traffic congestion could get worse as more deliveries are made, but drones that operate in the air and are only controlled by their operator via a remote network can effectively avoid congestion issues, saving time and cutting the distance traveled, which saves energy [14].

Conclusions

UAVs continue to exhibit distinctive performance advantages when used in logistics, such as cheap cost, environmental protection, and energy savings, as a result of the constant upgrading and maturing of UAV-related technology. Thus, the use of UAVs can lessen its negative effects on society and the environment while also promoting the sustainability of logistics. In the Web of Science database, 36 studies from 2021 and 2022 were reviewed in this research. The research chosen for this study and the literature chosen for the last three UAV-related reviews (2020–2022) barely coincide. The chosen studies are divided into three categories: theoretical models (such as the traveling salesman problem and other path planning issues), application scenarios (such as the last-mile delivery issue and the medical security application), and other issues (such as UAV implementation challenges, expenses, and pricing, for example). A very reasonable vehicle transportation route can be ensured through reasonable path planning, which will have a significant impact on accelerating distribution, cutting expenses, and boosting efficiency. Previous analyses of theoretical models, which explicitly included mathematical models, experimental restrictions, UAV kinds, etc., concentrated on the UAV route planning problem and detailed numerous techniques that can achieve path optimization. The research has recently concentrated on the UAV path problem due to the significance of path planning in logistics. Many researchers have tested the algorithms using examples to confirm their superiority and accuracy, and many of them have studied the traveling salesman problem. Algorithm optimization has been carried out based on the models and algorithms used by prior researchers, and new solutions have been proposed. We think

that both current and future research trends will continue to show a lot of interest in the UAV path planning problem.

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