The Analysis of Drone Track Planning Based on Machine-visual.

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Abstract. With the proliferation of drones, there has been a surge in demand for highly efficient navigation systems. This article delves deep into the evolution of machine vision-based drone trajectory planning to meet this demand. By harnessing machine vision technology, including visual SLAM, three-dimensional vision, depth cameras, convolutional neural networks, and other methods, drones have significantly enhanced their operational capabilities in complex environments. Through case studies, this article illustrates how machine vision technology optimizes trajectory planning by facilitating obstacle detection, target recognition, and tracking. Furthermore, it underscores the challenges posed by computing resource constraints, deep learning model training, and optimization. Addressing these challenges is crucial for the continued advancement of machine vision-based navigation systems for drones. Additionally, the article proposes future research directions such as improving environmental perception, integrating multiple sensors, and optimizing algorithms and hardware to further enhance drone navigation systems. By exploring these avenues, researchers can pave the way for more efficient, reliable, and adaptable drone navigation systems capable of operating seamlessly in diverse environments and scenarios.

Keywords: Drone trajectory planning, machine vision, vision SLAM.

1. Introduction

Unmanned aerial vehicle (UAV) is an unpopular aircraft controlled by a radio remote control device and its own program control device, or the vehicle computer is completely or intermittently operated by the vehicle computer. Compared with traditional methods, drone technology has the advantages of reducing costs, improving efficiency and productivity, saving time, and reaching difficulty or dangerous areas. Therefore, in the military, agriculture, environmental monitoring, logistics, transportation, etc. In multiple fields, the application of drones is increasing. For example, in the military field, drones play key roles in monitoring, reconnaissance, cracking goals, and battlefield communication. They provide real -time data to help the military make fast decisions [1]. In the field of agriculture, drones can be used for precision agriculture, such as monitoring the health of crops, accurately spraying pesticides and fertilizers, and evaluating crop yields [2]. In environmental monitoring and natural resource management, it is used to monitor natural disasters, such as forest fires, floods and storms, and wild animal and plant protection [3-5]. In this process, an efficient navigation system is essential to ensure that drones can complete the task safely, accurately and autonomously.

In order to adapt to complex and dynamic environmental conditions, efficient navigation systems not only require accurate positioning capabilities but also need to process environmental information in real-time, automatically plan the path, and have independent decision-making capabilities. Machine vision technology gives the drone environmental perception in this regard. By deploying the camera and sensor on the drone, the visual information of the surrounding environment is captured, and then the algorithm is used to analyze the data to achieve target recognition and tracking, thereby completing the functions of obstacle detection and obstacles, precise landing, and other functions. The method of deciding environmental perception includes the use of efficient open-source SLAM systems such as ORB-SLAM2 and the application of deep learning technology to visual SLAM. [6,7]. At the same time, LIU, F., and others apply deep learning technology to visual SLAM methods [8] to solve this problem. In terms of obstacle detection, the researchers quickly identified obstacles using

the real-time object detection system YOLOV3 [9]. In addition, the researchers also used the PRM-RL method to achieve obstacle avoidance [10]. In terms of path planning and optimization, relevant scholars use global path planning and polynomial trajectory planning methods to achieve this goal so that drones can fly independently without humans.

This article aims to provide a comprehensive perspective to explore the practical application of machine vision technology in promoting the development of drone technology. This article details the application of these technologies in the planning of drone trajectories and real-time navigation, including the navigation method of visual SLAM, and shows its potential application in the actual scenario through case studies. At the same time, this article also discusses the challenges facing the current technology and put forward the future research direction.

2. Analysis of the Advantages of Machine Vision in Drone Navigation

Machine vision is an important branch in the field of artificial intelligence and computer vision. It involves the contents of letting machines "see" and "understand" images or videos. "Looking" and "understanding" here are not just capturing images, but more importantly, analyze and explain these images. Generally, the visual system process of the machine consists of several steps, as shown in Fig.1: image acquisition, pre-processing, feature extraction, detection, identification, and decision-making formulation.

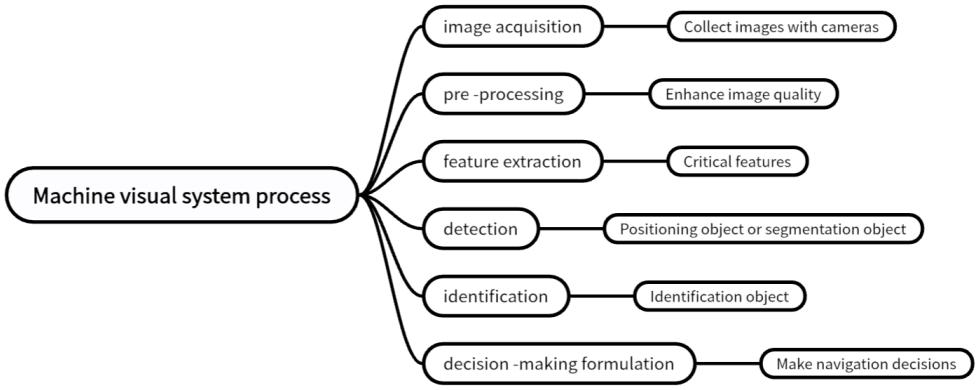


Fig. 1 Machine visual system process

Machine vision is very important for the space perception of drones. Through space perception, we can realize problems such as obstacle detection, target recognition and tracking, and precise landing. The development of this technology has greatly improved the autonomy and security of drones in various application scenarios.

Obstacle problem.

Machine vision can analyze the obstacles in front of the drone in real time, such as buildings, trees or other aircraft, and calculate the obstacle avoidance path. This ability allows drones to fly safely in complex environments, especially applicable to complex terrain such as cities and forests. Researchers such as J. Delmonico, T. Cieslewski, etc. have created a data set aimed at promoting the research of drone cars and high -speed state estimates. This data set focuses on providing high -speed and radical flight trajectory data and records the free flight trajectory of the first perspective (FPV) drone equipped with sensors on the track and surrounding obstacles. Essence These trajectories include not only fast lap speeds on the track, but also free morphological trajectories in indoor and outdoor environments. [4] This dataset is not only valuable for researchers in drones, but also is of great significance to conducting precise navigation and state estimates in other high -speed and dynamic environments. By testing and improving algorithms in these challenging scenarios, researchers can improve the flying performance of drones in complex environments by using visual inertia mileage data sets, including obstacle detection and obstacles.

2.1. Target recognition and tracking

Machine vision can also be used to identify specific objects or people and track them in real time. Through advanced image processing and machine learning algorithms, drones can recognize and track multiple targets. A. Robicquet and other researchers are committed to understanding and predicting human movements in complex environments through machine learning models, especially navigation behaviors in the crowd. They proposed a large -scale data set (SDD). This dataset collects a variety of types of motion behaviors (pedestrians, cars, buses, etc.). By analyzing the number of objects appearing in the video, the movement of each object is predicted. [5] Through this data set, researchers can train machine learning models to predict the movement of humans in specific scenarios.

2.2. Precise landing

Machine vision can also help the drone to achieve accurate landing. By identifying specific marks or features of the landing area, the drone can automatically adjust its posture and speed to achieve an accurate and safe landing. An article published in the magazine published in Aerospace discusses the progress of drone -based independent landing technology and research progress. As shown in Fig. 2, it introduces the cooperation goals and natural landmarks in static scenarios in detail, as well as the autonomous landing of vehicles and ships in dynamic scenarios. The article pointed out that visual navigation and other navigation methods (such as GPS/INS) can greatly improve the accuracy of navigation and positioning [6].

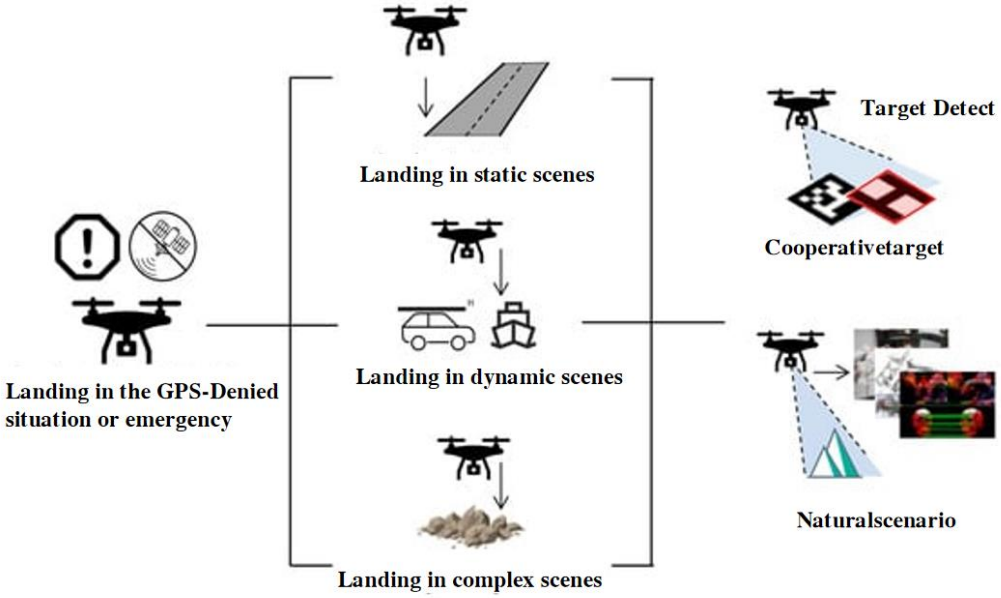


Fig. 2 UAV independent landing environment map

3. Plan for Drone Trajectory Based on Machine Vision

The use of machine vision for environmental perception and trajectory optimization is an important research direction in drone technology. It involves enabling drones to understand their surrounding environment and make intelligent decisions based on this to optimize their flight path. This process usually includes key steps such as environmental perception, obstacle detection and avoidance, path planning and optimization. Explore these aspects in detail in this section.

3.1. Environmental Perception

Environmental perception refers to the process of using machine vision and other sensors to collect environmental information and understand the surrounding environment through data processing and analysis. This includes the use of cameras to obtain environmental information, handle feature data, and use deep learning to improve environmental perception ability. The specific steps are as follows.

First of all, in-depth perception of drones must be performed, and the use of three-dimensional vision or deep camera (such as structural light camera and TOF camera) to obtain deep information of the environment can help identify the position and shape of obstacles.

Secondly, the camera can be used to capture images of the surrounding environment in real time. Simultaneous positioning and map construction through feature points and frame tracking. This allows drones to navigate without the GPS signal. RGNED, Mur-ORTAL, R. and others, has developed ORB-SLAM2, which provides an efficient open-source SLAM system that is suitable for monocular, binocular and deep cameras, which can achieve high-precision positioning and map construction [7].

Finally, through deep learning models, such as convolutional neural networks (CNN), drones can recognize and classify objects in images so as to understand important elements in the environment, such as buildings, people, vehicles, etc. LiU, F., SHEN, C., & Lin, G. provide a comprehensive review about how to apply deep learning technology to visual SLAM. Using the strong capabilities of convolutional neural networks in image processing and feature recognition to improve data associations, that is, determine the corresponding relationship between the characteristic points between different images. [8] Through learning methods, you can more accurately match the feature points. In addition, deep learning can also be estimated. It can directly mapper from the image position in the position of the end-to-end method to reduce the complex geometric calculation process in traditional SLAM, so as to thus, so as to thus, thereby Make a significant improvement of the performance of the visual SLAM.

3.2. Obstacles Detection and Avoidance

The detection function of drone obstacles can be achieved by analyzing deep images. Deep images can provide direct information on object distance, helping drones to determine the location and size of the obstacles. For example, the YOLOV3 designed by Redmon, J., & Farhadi, A. A. designed as a real -time object detection system [9]. Its speed and accuracy are essential for drones to identify and avoid obstacles during flights. Training can quickly detect obstacles in front of the drone.

Secondly, for the avoidance strategy after detecting obstacles, the drone needs to plan the avoidance path according to the location, size, flight speed, and dynamic characteristics of the obstacles. This usually involves a new path that can avoid both obstacles and as efficient as possible. The PRM-RL method that combines enhanced learning and sampling planning on this issue can effectively solve the problem of obstacles in long-distance navigation [10], providing a new strategy for the dynamic path planning of the drone.

3.3. Path Planning and Optimization

The global path planning needs to be planned based on known environmental information or pre-built maps before the flight task starts. We can apply classic search algorithms, such as A*, Dijkstra, etc., or the method based on graphs, such as Rapidly EXPLORING RANDOM TREE (RRT) proposed by researchers to find the best path from the starting point to the endpoint.

In terms of trajectory optimization of drones, after determining the basic path, it is necessary to further improve flight performance through trajectory optimization, such as reducing energy consumption and shortening flight time. Target optimization considers the dynamic constraints and environmental factors of drones, and through mathematical optimization methods, such as dynamic planning or non -linear planning, refine and adjust the flight trajectory. For example, Richter, C., Bry, A., & ROY, N. Polynomial trajectory planning proposed in its research. It is a method that is effective for optimizing drones in a complex and dense environment, especially for radical flight tasks that

require high -speed and high flexibility. This method describes the flying path of the drone by constructing a series of polynomial functions so that the drone can smoothly pass the various obstacles in the environment.

4. Discussion

The advancement of machine vision technology has greatly promoted the application capabilities of drones in complex environments, especially in terms of obstacle detection and obstacles, target recognition and tracking, and precise landing. Through advanced image processing and machine learning algorithms, drones can understand the surrounding environment in real time and make rapid reactions, which is essential for improving the autonomy and safety of drones. The application of technologies such as visual SLAM, deep perception, and object recognition enables drones to achieve high-precision positioning and navigation in the absence of GPS signals.

However, although machine vision technology has made significant progress in drone navigation, there are still some problems, such as computing resource restrictions and training and optimization of deep learning models. For computing resource restrictions, the optimization of the algorithm can be considered, the computing load is reduced, or the computing resources are expanded through cloud computing and marginal computing technology. For training and optimization of deep learning models, technologies such as migration learning can be used to reduce dependence on large -scale marking data and improve the training efficiency and generalization of models.

In addition, future research on drones based on machine vision can start from the following perspectives.

First of all, we need to further enhance the ability to identify and understand the complex environment of the drone, such as improving the accuracy and speed of object recognition by improving deep learning algorithms.

Secondly, multi -sensor integration should be promoted. In addition to visual information, combined with data from other types of sensors (such as radar and laser scanners), more comprehensive environmental information can be provided to enhance the space perception and navigation capabilities of drones.

Adaptive and intelligent decision-making: Study how to make drones adjust the flight strategy and trajectory based on environmental changes to improve flight efficiency and safety.

Finally, regarding the optimization of algorithms and hardware and the restrictions on the computing resources of drones, more efficient algorithms and special hardware should be studied to support complex machine visual tasks.

5. Conclusion

This article comprehensively discusses the application, advantages, and challenges facing machine vision technology in drone navigation systems. It also looks forward to future research. Through the application of comprehensive analysis of the application of machine vision in the aspects of obstacle detection and obstacle avoidance, target recognition and tracking, and precise landing, this article mainly analyzes how the technology enhances the autonomy and safety of the drone, especially navigation in complex environments ability.

Studies have found that machine vision technology captures the visual information of the surrounding environment by capturing the surrounding environment by the camera and sensor deployed on the drone, and uses algorithms to analyze these data, which greatly improves the autonomy and security of the drone in various application scenarios. In particular, through the application of visual SLAM, deep perception, and object recognition technology, drones can achieve high-precision positioning and navigation ORB-SLAM2 systems with lack of GPS signals. And the high -efficiency open-source SLAM system of the deep camera can achieve high -precision positioning and map construction. In addition, the application of deep learning models such as CNN

enables drones to identify objects and classify objects more accurately so as to understand important elements in the environment.

Nevertheless, the application of machine vision technology in drone navigation still faces some challenges, such as the limitations and optimization of computing resources and the training and optimization of deep learning models. In response to these issues, this article proposes some solutions, including algorithm optimization, using migration learning technology to reduce the dependence of large-scale marking data, and considering using cloud computing and marginal computing technology to expand computing resources. In the future, the direction of research should focus on further improving the ability to identify and understand the complex environment, promote multi -sensor integration, and study more efficient algorithms and hardware optimization to support complex machine visual tasks. It is believed that through continuous innovation and technological improvement, drones based on machine vision will have wider application prospects and bring more benefits to human society.

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