UKRAINIAN CATHOLIC UNIVERSITY

BACHELOR THESIS

Multi-camera visual collision avoidance for micro aerial vehicles

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Declaration of Authorship

I, Mykola MORHUNENKO, declare that this thesis titled, "Multi-camera visual collision avoidance for micro aerial vehicles" and the work presented in it are my own. I confirm that:

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- I have acknowledged all main sources of help.
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"Science, my lad, is made up of mistakes, but they are mistakes which it is useful to make, because they lead little by little to the truth."

Jules Verne

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Abstract

We live in a twenty first century - time of extremely fast developing of all electronic devices. Each month we see some brake-through in such directions as microchips modeling, flying vehicles developing, quantum computing and space exploration, bioengineering and medicine.

in the thesis I would like to focus on micro aerial vehicles as one of the most perspective development directions and interesting personally for me. During my internship in the MRS Group I was working a lot with computer vision, and I see it as quite promising direction.

Specifically, visual collision avoidance is one of the relevant topics that is being actively researched nowadays. Drones with this feature becomes more preferable - they are safer, can last longer and easier to control. Visual collision avoidance is much less expensive than Lidars.

:TODO

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Finally, I would like to thank my family who supported me during whole my life, my mother Svitlana and my father Roman.

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List of Abbreviations

UAV	**U**nmanned **A**erial **V**ehicle
MAV	**M**icro Unmanned **A**erial **V**ehicle
ROS	**R**obotic **O**perating **S**ystem
DoF	**D**egree **o**f **F**reedom

List of Symbols

Chapter 1

Introduction

Micro unmanned aerial vehicles (MAVs) recently saw a rise in usage across various fields. Drones are already wide used in cinematography[1] and advertising[2], In Ukraine they are very helpful in farming (to apply pesticides to fields)[3]. City emergency departments use UAVs - firefighters can use them to see and evaluate the situation from the sky, localise the source of fire and deal with that[4], sometimes it even can have some fire-extinguishing capsules as projectiles[5]. They are also quite popular in military industry.

The inspiration for this project was taken from DJI obstacle avoidance technology introduced with the release of the DJI Mavic 3 drone[6] on fifth November 2021. Despite the fact that the idea is old, neither DJI nor MRS nor other research groups have a well-developed visual obstacle avoidance system, the best for now can be Skydio obstacle avoidance system , so this direction is very perspective for researchers. Many drones available for sale are costly, and even a well-trained pilot is afraid of crashing. At the same time, autonomous drones are more predictable than a human pilot, behave acording to algorithms and can react much faster, but only if they have a well-designed system running on board, so obstacle avoidance for autonomous MAVs will be both more challenging and more critical in future trends.

1.1 Problem definition

While obstacle avoidance considers static objects, collision avoidance is related to averting crash with moving objects like other MAVs, cars or people. It is a complicated task but more relevant to multi-robot systems, because during interactions between robots they should not brake each other.

The goal of this thesis is to implement an obstacle avoidance system, and expand it to collision avoidance system for autonomous MAVs driven by a Robotic operating system (ROS)[7] using the MRS UAV system [1] [8].

The problem solution can be devided into several steps: firstly it is necessary to model such device, assemble and calibrate it, then find a pointcloud using a structure from motion algorithm for each camera in a system and find moving objects using the fact of overlaping zones for each camera pair. Then use some algorithm

1 Coptrz, "How drones are used in big-budget films
2 Bangkokpost, "The future of advertising could be drones"
3 DroneUA
4 Fire Fighting Drones
5 Autonomous Firefighting Inside Buildings by an Unmanned Aerial Vehicle
6 DJI Mavic 3
6 Skydio autonomy
7 ROS home page
8 MRS UAV system

for path planing to correct and update the previous path. As for now, the most complecated task is to find an obsticle using a visual method, so this thesis focuses on this particular part of a problem.

1.2 Related Works

There are several obstacle avoidance sensors used by various MAVs: stereo vision [2], depth cameras (as Intel RealSense), monocular vision [3], lidar (2d or 3d) [4], sonar (ultrasonic), time of flight sensors, also combinations of them can be used. In [5] the sensor fusion of ultrasonic and infrared sensors is presented.

Each of them has its pros and cons. 3d lidars are extremely expensive but the most efficient for today; 2d lidars are used for small ground vehicles, but not suitable for most tasks for MAVs (because a car can be modelled as a 2 DoF system, while MAV always has 6 DoF), depth cameras are relatively expensive too, ultrasonic and infrared sensors both have distance limits and other minor issues. Overall, stereo vision is the most promising approach for the nearest future.

Most articles uses stereo pair of two parallel cameras looking in the same direction (classical stereo pair) [6, 7, 8] or deep learning approaches [9, 10, 11, 12]. Real-time multi-camera feedback control system is introduced in [13], but this solution does not imply that drone can fly in any direction, only forward moving counted, still this work is incredibly inspiring.

Chapter 2

Basic geometry

2.1 Basic concepts

Chapter 3

Calibration

3.1 Camera calibration

Camera calibrat

3.2 Stereopair calibration

Chapter 4

Conclusion

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