FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO

Robust obstacle detection and avoidance

Alojz Gomola

Doutoramento em Matemática Aplicada

Supervisor:	Dr. João Tasso de Figueiredo Borges de Sousa
Co-supervisors:	Dr. Fernando Manuel Ferreira Lobo Pereira
	Ing.Tomáš Kábrt

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I declare that I carried out this research plan independently, and only with the cited sources, literature and other professional sources.

In Porto on .... Alojz Gomola

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Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Problem statement

1.2 Assumptions

1.3 Concept specification

LiDAR

LiDAR is planned to be used as main active data input. Low-density lidar (https://www.kickstarter.com/projects/scanse/sweep-scanning-lidar/description) can be used in UAV applications in standby mode or scan/sweep mode. Low density LiDAR is ideal for feature extraction which is used mainly in Geographical Information Systems

Role

Data gathering of current vehicle surroundings

Output:

1. Point cloud of data

Edge detector

Algorithm to detect edges in 3D point cloud

Role:

Initial object reconstruction from given point cloud. The greedy approach can be used to reconstruct planes and create triangular based model which is the base for feature extraction and reconstruction. Use of fast algorithms for edge reconstruction [1] and plane detection.

Input:

1. LiDAR point cloud.

Output:

1. Extracted edges - aggregation of multiple 3D points into edge which satisfies
2. Crosscutting point of edges

Feature extraction

Algorithm to extract features from detected edges (notable features are outer boundaries or object cubes)

Role:

Notable points, like corners, bordering edges of physical objects extraction Minimalisation of surroundings representation, before data fusion and trajectory calculation.

Goal is to have reduced model of surroundings, therefore applied data fusion and obstacle avoidance calculations are reduced to minimum

Input:

1. Extracted edges
2. Crosscutting points

Output:

1. Feature edges
2. Feature crosscutting points

IMU (Internal measurement unit)

Standard hardware unit to measure internal vehicle state

Role:

Provide local state of vehicle, roll, pitch, yaw angles, heading and speed

Output:

1. Roll, pitch, yaw angles
2. Heading speed

GPS

Global Positioning System, with very precise vehicle location

Role:

Provide precise position of vehicle in terms of global position. Expected to use RTK GPS for precise location [2]. Precise location of vehicle 1-2 cm horizontal plane, 3-4 cm vertical *(Altitude estimation). Technical solution from NTNU will be reused (probably).

Input:

1. RTK GPS from ground station position.
2. IMU differentials.

Output:

1. Precise global position of vehicle.

External map

External obstacle map, which can be reconstructed from previous flights data, or shared obstacle database

a. Source databases to be determined.

b. Used technologies to be determined.

Role:

Provide preexisting obstacles and limitations in flight area (like high voltage cables, restricted flight areas, etc.).

Output:

Local obstacle map in plane surroundings (It must be determined if whole mission area or radius area around vehicle will be used)

Data fusion:

Fuse data from various sources and complete plane surroundings model for immediate or planned obstacle, model. Data Fusion will merge existing obstacles from obstacle databases with newly detected obstacles and their features. Data fusion will recognize and name moving obstacles (I am uncertain at this more material review is required)Data fusion will use global position to assign global position to newly detected obstacles.

Role:

Main data fusion and operation environment calculation, merging point of all inputs.

Input:

1. RTK GPS: global position.
2. IMU: roll, pitch, yaw angles, heading and speed (vectorized)
3. Feature extraction: extracted features corners and positions
4. External obstacle map: global position of known static obstacles

Output:

1. Fused data of obstacles
2. Expected trajectories of moving obstacles

Obstacle model (Moving oblstacle model)

Predictor of obstacle movement.

Role:

Predict obstacle movement and possible collision points in terms of current mission plan.

Input:

1. Data fusion - moving obstacles position (Global).
2. Data fusion - moving obstacle heading (Vectorized).
3. Actual mission plan.

Output:[1.]

(a) Predicted Collision points for actual mission plan.
(b) Additional movement constraints based on predicted trajectories.

Smart J* (Optimal trajectory calculation)

Optimal trajectory calculation with flight cost minimalization

Role:

Calculate optimal path to avoid all static and moving obstacles.

Input:

1. IMU: vehicle state(roll, pitch, yaw, heading).
2. Data fusion - static obstacle map for target area.
3. Obstacle model - moving obstacle model, with projected trajectories and constraints.

Output:

1. Optimal trajectory to avoid obstacles.
2. Update to actual mission plan.

PID (Vehicle controller - Autopilot)

Low level control of vehicle on desired trajectory

Role:

Low level control of vehicle motors ...

Input:

1. Desired trajectory

Output:

2. Control inputs