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POSITION CONTROL FOR AUTOMATIC LANDING OF UAV IN A NET ON SHIP

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Abstract

Automatic landing of a fixed wing Unmanned Aerial Vehicle (UAV) in a net on a ship require an accurate positioning system. There exist today high-end systems with such capability for special applications, e.g military systems and costly commercial systems, which restrict the availability of such systems. To increase the general availability these systems must consist of low-cost components. Here, an alternative is the use of low-cost Global Navigation Satellite System (GNSS) receivers and apply Real Time Kinematic GPS (RTK-GPS), which can provide centimeter level position accuracy. However the processing time for the RTK-GPS system results in degraded accuracy when exposed to highly dynamical behaviour.

This work present two alternative software and hardware position systems suitable for use in navigation system which apply RTK-GPS, namely Real-Time Kinematic Library (RTKLIB) with a Ublox Lea M8T receiver and a Piksi system. Both the Piksi and the Ublox receiver are single-frequency GNSS receivers. These systems will in this work be compared and their individual capability to provide accurate position estimate will be evaluated.

The RTK-GPS system is implemented in DUNE (DUNE:Unified Navigation Environment) framework running on an embedded payload computer on-board an Unmanned Aerial Vehicle (UAV).

The performance of these position systems are in this work investigated by experimental testing. The testing showed that the RTKLIB performed better than the Piski alternative, and further showed the tested navigation system provide sufficient quality for integration into a control and guidance system, allowing for automatic landing of an UAV in a net.

Contents

Chapter 1

Introduction

1.1 Background and motivation

Recent development of flying UAVs has been recognized to provide an attractive alternative to work previously performed by manned operations. Typical work which has attracted attention includes inspection, aerial photography, environmental surveillance and search and rescue. Today UAVs are mostly operated over land, however in the future this will include over sea as well. This will give some challenges which must be overcome. One of these challenges is that the UAV need to be able to perform a automatic landing.

An UAV can provide an attractive alternative for many maritime operation where today manned aircraft or satellites is the only solution. In the maritime sector UAV can be used in iceberg management, monitoring of oil spills, search and rescue and maritime traffic monitoring.

An important premise for successful and safe UAV operation, in particular at sea, is the provision of a robust system for safe landing of the UAV on a vessel following completed operations. In order to perform an automatic landing a path planner, a guidance system, and an accurate position estimation system is required, in addition to the low level control system in the UAV. Present UAV

UAV in a maritime environment

A robust navigation system, which include two position estimation system for relative position determination of the UAV.

This thesis contain a concept of a robust navigation system for autonomous landing of a UAV, and the implementation of the autonomous landing system. The landing system has been implemented together with a other student, and is a continuation of the master thesis from [?]. The navigation system that has been implemented apply rtk-gps for position estimation, and the robust navigation system apply range measurement from local transmitters together with the rtk-gps for position estimation. The range measurement hardware was not ready by the time this master thesis was written, however this thesis will explore different methods that can be applied in order to achieve a robust navigation system.

Chapter 2

System

2.1 Navigation system

The navigation system apply RTKGPS for position and velocity measurement. The output from the RTKGPS software contains only the relative position from the base station, and not the position of the base station. Therefore a task was created to send send the global base station location to the navigation system, which enable the rest of the system to calculate the global position of the uav.

The base station position is received in the RTKGPS task in DUNE, were it's included in the GpsFixRtk message.

A task in the nest receive the gps position of the base, and the operator can monitor it in neptus. When the operator choose to fix the base station gps position a parameter update is send to the task, which will start to send a gpsfixrtk message to the uav.

TODO: Create figure that shows the information flow that is used to create the rtkfix message.

2.2 Path generation

The landing path is separated into three stages; AP, Decent and final approach. The decent path is constructed as a Dubins path, ensuring a smooth and optimal decent toward the final approach. The details for the path is given in the Msc thesis cite(), however a summary will be given.

2.3 Evasion

To ensure the safety of the operator a evasion controller is used to abort the landing when a successful landing is deemed infeasible.

2.4 Guidance system

The guidance system consist of two part. Sliding mode controller, and a los controller

2.4.1 Sliding mode controller

For course control the system use a sliding mode controller that was proposed in the paper [**?**], which USGES stability property.

$$\dot{x} = V_a \cos(\psi) + W_x = V_g \cos(\psi) \tag{2.1a}$$

$$\dot{y} = V_a \sin(\psi) + W_y = V_g \sin(\psi) \tag{2.1b}$$

$$\dot{phi} = \frac{g}{V_a} \tan(\varphi) \tag{2.1c}$$

$$\dot{\varphi} = -\frac{\varphi - \varphi_{cmd}}{T_\varphi} \tag{2.1d}$$

$$W = \sqrt{W_x^2 + W_y^2} \tag{2.1e}$$

$$\epsilon(\varphi) = \begin{cases} \cos(\varphi), & \text{if } |\cos(\varphi)| \geq \epsilon' \\ \epsilon', & \text{if } 0 \leq \cos(\varphi) < \epsilon' \\ -\epsilon', & \text{if } -\epsilon' < \cos(\varphi) < 0 \end{cases} \tag{2.2}$$

$$\chi = \tan^{-1}(\frac{\dot{y}}{\dot{x}}) \tag{2.3}$$

$$\dot{\chi} = \frac{g \sin(\varphi)(V_a + \cos(\psi)W_x + \sin(\psi)W_y}{\epsilon(\varphi)V_g^2} \tag{2.4}$$

$$\chi_d = \tan^{-1}(-\frac{t}{\Delta} \tag{2.5a}$$

$$\dot{\chi_d} = -\frac{\Delta}{\Delta^2 + y^2}\dot{y} \tag{2.5b}$$

$$\ddot{\chi} = \frac{\Delta}{(\Delta^2 + y^2)^2}(2y\dot{y}^2 - (\Delta^2 + y^2)\ddot{y}) \tag{2.5c}$$

$$\tilde{\chi} = \chi - \chi_d \tag{2.6}$$

$$s = \dot{\tilde{\chi}} + \lambda\tilde{\chi} \tag{2.7}$$

$$u = -\lambda \dot{\tilde{\chi}} - \rho \operatorname{sgn}(s) - K_d s \tag{2.8}$$