UAV Autonomous Landing

Team Expeditus

SDSMT MCS

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Introduction

UAV Autonomous Landing Project

Team Expeditus

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Sponsor

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Goal

Demonstrate the capability of a UAV to autonomously take-off, navigate through some waypoints, return to the landing pad, and land with a minimum of distance and orientation error.

Requirements

Goal

- receive a set of waypoints
- autonomously take-off
- navigate through waypoints
- return to launch pad
- **land with $\pm$.1m distance and $\pm 15^\circ$ orientation error**

Limitations

- landing platform is a fixed position
- landing platform is a stable, horizontal surface
- environment is ideal(no wind, gps available, no obstacles)

User Stories/Backlog

- **User 1(U-1):**
  As a user, I want to communicate the waypoints to the UAV.
- **Owner 1(O-1):**
  As an owner, I want the UAV to autonomously take-off from the landing pad.
- **Owner 2(O-2):**
  As an owner, I want the UAV to autonomously navigate through a set of waypoints.
- **Owner 3(O-3):**
  As an owner, I want the UAV to autonomously return to the location of the landing pad.
- **Owner 4(O-4):**
  As an owner, I want the UAV to autonomously land on the landing pad without damaging the craft.
- **Owner 5(O-5):**
  As an owner, I want the UAV to autonomously land on the landing pad with the correct orientation.

As a user, I want to communicate the waypoints to the UAV.

Task No.	Task	Date Completed	Sprint
1	Review previous method/interface for communicating coordinates to UAV.	10/05/15	1
2	Review code that communicates with quadrotor	10/16/15	2
3	Review code that allows a user to input waypoints	10/16/15	2
4	Modify/Rewrite imlementation as necessary	01/23/2016	4

As an owner, I want the UAV to autonomously take-off from the landing pad.

Task No.	Task	Date Completed	Sprint
1	Review previous implementation for autonomous take-off.	10/05/15	1
2	Review code that enables the quadrotor to autonomously take-off from landing pad	10/16/15	2
3	Modify/Rewrite take-off imlementation as necessary	01/23/2016	4

O-2

As an owner, I want the UAV to autonomously navigate through a set of waypoints.

Task No.	Task	Date Completed	Sprint
1	Review previous implementation for navigating waypoints.	10/05/15	1
2	Review code that enables the quadrotor to autonomously navigate through a series of way-points	10/16/15	2
3	Modify/Rewrite take-off imlementation as necessary	01/23/2016	4

As an owner, I want the UAV to autonomously return to the location of the landing pad.

Task No.	Task	Date Completed	Sprint
1	Review previous implementation to autonomously return to location of landing pad	10/05/15	1
2	Review code that allows the autonomous return of the UAV to the landing pad.	10/16/15	2
3	Modify/Rewrite take-off imlementation as necessary	01/23/2016	4

As an owner, I want the UAV to autonomously land on the landing pad without damaging the craft

Task No.	Task	Date Completed	Sprint
1	Review previous implementation for autonomous landing	10/05/15	1
2	Install previous implementation	10/19/15	2
3	Test previous implementation	10/26/15	2

As an owner, I want the UAV to autonomously land on the landing pad with the correct orientation.

Task No.	Task	Date Completed	Sprint
1	Review previous implementation for autonomous landing	10/05/15	1
2	Install previous implementation	10/19/15	2
3	Test previous implementation	10/26/15	2

Initial Common Tasks

Task No.	Task	Date Completed	Sprint
1	Install Ubuntu 14.04 or some other ROS Indigo/Jade distro compliant OS.	09/25/15	1
2	Setup Gazebo 6.+	09/25/15	1
3	Download Rviz package	09/25/15	1
4	Setup Simulation Environment	11/02/15	2

Initial Common Tasks

Task No.	Task	Date Completed	Sprint
5	Review previous iteration of project documentation	09/25/15	1
6	Inspect current quadrotor configuration	09/28/2015	2
7	Identify parts needed for quadrotor	11/02/2015	2
8	Acquire parts needed for hexrotor	12/01/2015	3
9	Build UAV	01/17/16	4
10	Test flight under manual control	01/17/16	4

Sprint 1

Sprint 1 - Successes

- Revised project scope
- Product Backlog - User Stories
- Setup Development Environment
- Review previous years hardware and software

Sprint 1 - Setbacks

- Previous years UAV unusable
- Previous years flight code unusable

Sprint 2

Sprint 2 - Successes

- Visual Homography Code repurposed
- Created simulation environment
- Ordered parts for new Hex-copter

Sprint 2 - Setbacks

- Simulation only supports manual control

Sprint 3

Sprint 3 - Successes

- Assembled Frame, Motors, ESC's
- Many SITL simulations
- Waypoint Publisher publishes mavros commands
- Working image homography code
- Becoming familiar with python openCV libraries

Sprint 3 - Setbacks

- Pixhawk delayed 2 weeks, build not completed
- SITL simulations rejected waypoint files
- SITL simulations rejected mavros commands

Sprint 3.5 + 4 Successes

- Finished construction of UAV
- Manual flight of the UAV achieved
- Autonomous flight of the UAV achieved
- GPS Waypoint navigation achieved

Sprint 3.5 + 4 Setbacks

- AR Track Alvar not working
- Simulation tasks abandoned

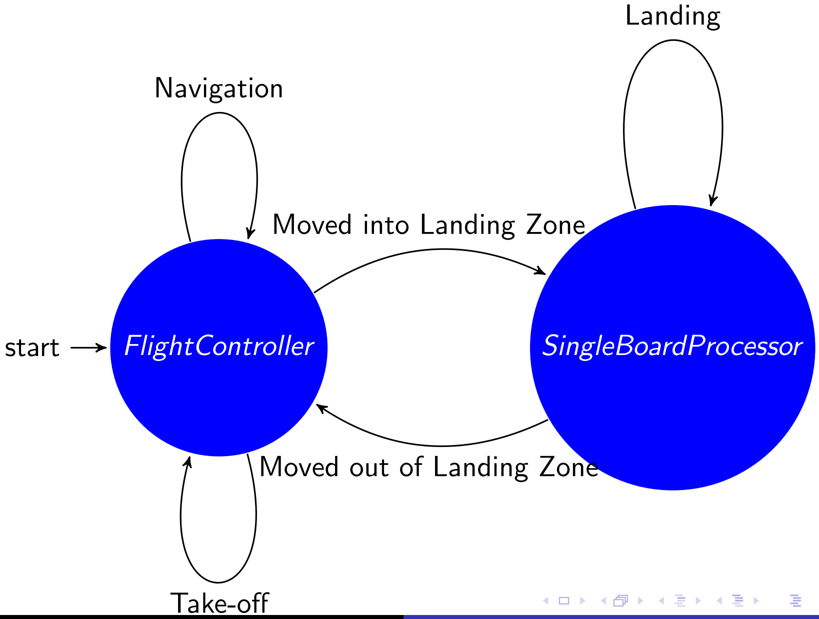
Sprint 5 Successes

- Non-ROS Alvar reading pose and position
- AR Track Alvar reading pose and position
- Basic off-board control on the Pixhawk

Sprint 5 Setbacks

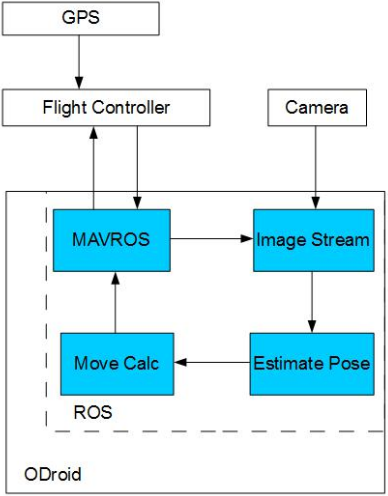
- Localization in off-board control

Design



Landing
Navigation
Moved into Landing Zone
start
FlightController
SingleBoardProcessor
Moved out of Landing Zone
Take-off

Architecture



Hardware Requirements

- ODroid XU4
- Pixhawk Flight Controller
- GPS peripheral
- Camera
- Battery
- UAV(Frame, Motors, ESCs, Power Distribution Board)

Software Requirements

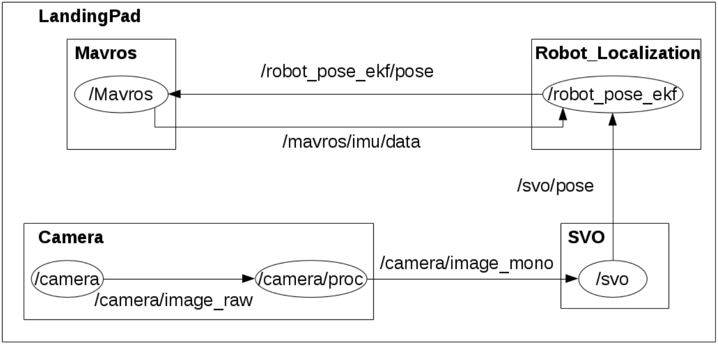
- Mavlink
- Python
- OpenCV
- Robot Operating System(ROS) Indigo/Jade Distro
- Ubuntu 14.04

UAV Design & Tech Specs

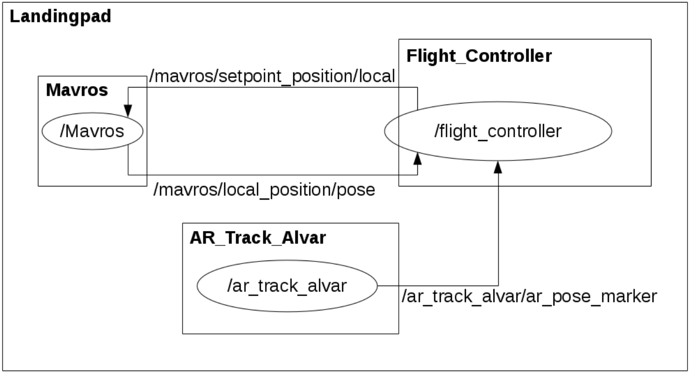
Physical design of the hex-copter is the **Turnigy Talon Hexcopter**

Localization Software Architecture

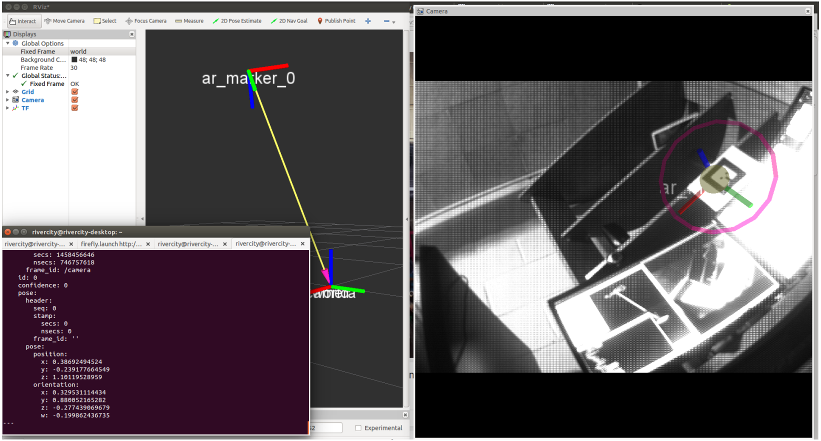
Architecture for communication between ROS nodes for evaluating a local position:



Architecture for communication between ROS nodes to accomplish laninding on the landing pad:



AR Track Alvar can provide pose and orientation of the AR tag relative to the frame of the camera:



As an owner, I want the UAV to autonomously take-off from the landing pad.

Task No.	Task	Testing
1	Review previous implementation for autonomous take-off.	Send mission containing takeoff followed by hover command in simulation.
2	Review code that enables the quadrotor to autonomously take-off from landing pad	Upload code to physical UAV and send mission containing takeoff followed by hover command with manual override enabled.

UAV Testing - O-2

As an owner, I want the UAV to autonomously navigate through a set of waypoints.

Task No.	Task	Test
1	Review previous implementation for navigating waypoints.	Send mission containing takeoff followed by way-points and once the last waypoint is reached a hover command all in simulation.
2	Review code that enables the quadrotor to autonomously navigate through a series of way-points	Upload code to physical UAV and send mission again with manual over-ride enabled

As an owner, I want the UAV to autonomously return to the location of the landing pad.

Task No.	Task	Test
1	Review previous implementation to autonomously return to location of landing pad	The last waypoint from the previous test should be the landing pad but to verify a image match will be used in simulation that will verify that the UAV is in fact above the landing pad.
2	Review code that allows the autonomous return of the UAV to the landing pad.	The physical UAV will match what it sees with its camera to a image it has stored of the landing pad at multiple heights.

As an owner, I want the UAV to autonomously land on the landing pad without damaging the craft

Task No.	Task	Test
1	Review previous implementation for autonomous landing	The UAV should be able to detect the landing pad
2	Install & modify previous implementation	The UAV should be able to begin to lower onto the pad
3	Test implementation	The UAV should land gently on the pad

Visual Homography Landing Testing - O-5

As an owner, I want the UAV to autonomously land on the landing pad with the correct orientation.

Task No.	Task	Test
1	Review previous implementation for autonomous landing	The UAV should be able to calculate its angle wrt the pad
2	Install& modify implementation	The UAV should be able to rotate to match the pad
3	Test implementation	UAV should maintain orientation throughout descent

Integration - U-1

As a user, I want to communicate the waypoints to the UAV.

Task No.	Task	Test
1	Review previous method/interface for communicating coordinates to UAV.	Connect GPS to pixhawk and verify it recieves a connection and in Mavros verify we can retrieve gps coordinates from gps in ROS.
2	Review code that communicates with quadrotor	Verify that all commands in Mavros can be sent to and accepted by the Pixhawk and it acts appropiately
3	Review code that allows a user to input waypoints	Verify that user entered waypoints can be uploaded into Pixhawk Successfully with mavros.

Remaining Backlog

- **Owner 4(O-4)**
- **Owner 5(O-5)**

Revised Goals

- User will need to create file containing missions for offboard control to use, not
- Use of only AR Tag, not AR Tag + Landing Lights.

Risk Analysis

- Localization: Without a better approach to localization, our estimates of our current pose are very poor. As a result our UAV is unable to navigate to the AR tag.

Risk Mitigation

- Localization
  - Use visual odometry with the camera we already are using
  - Attach more sensors if necessary

Timeline

Sprint 6 3/21/16 4/15/16

- Finish Landing Algorithm Simulations(O-4,O-5)

Sprint 6 necessitates solving our localization issues, so that we can combine our vision and message passing framework to complete this project.

Budget

Item	Qty	Price	Total
Frame	1	$79.99	$79.99
Motors	8	$23.99	$191.92
ESCs	8	$17.78	$142.24
Pixhawk	1	$199.99	$199.99
Power Distribution	1	$19.99	$19.99
GPS Mast	2	$10.00	$20.00
GPS	2	$89.99	$179.98
Power Module	1	$24.99	$24.99
Odroid XU4	1	$75.95	$75.95
Props(set of 4)	3	$7.55	$22.65
TOTAL			$957.70

IP & Licensing

Intellectual Property:
Project is owned by SDSMT

Licensing for Dependencies:

- OpenCV: BSD
- ROS: BSD
- Mavlink: LGPL version 3
- QGroundControl: GPL version 3
- ROS Packages
  - mavros: GPLv3, LGPLv3, BSD
  - ar_track_alvar: BSD
  - pointgrey_camera_driver: BSD
  - usb_cam: BSD

Additionally, all members of the team are registered with the FAA and have received their drone pilot's license.

Demos

- Communication
- Offboard Control
- AR Track Alvar

END

Questions