Testing Strategy

Rev 1.2

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1. Introduction

1.1 Conduct: The designer of each module will not play a role in testing that specific module as it can cause a conflict of interest.

1.2 Recording of the Results: Test results will be recorded by a team member who was not involved with the development of the specific module.

1.3 Witness: There will be a witness who will testify that the recorder of the results was not the designer and attest to the accuracy of the recordings.

2. Reference Documents:

2.1 Industry Standards

2.2 Design Documentation

2.3 Other Documents

2.3.1 Robot Motion Planning, Jonathan Eskritt, August 2009

2.3.2 Flying Fast and Low Among Obstacles: Methodology and Experiments, Scherer, S, INTERNATIONAL JOURNAL OF ROBOTICS RESEARCH Volume: 27 Issue: 5 Pages: 549-574 Published: MAY 2008

3. System Specifications:

3.1 Features:

1.0 The software will have five modules: the main program, occupancy grid creator, global path planner, local path planner, and speed controller.

The simulated environment:

- 2.0 will be alterable independent of the control software. This includes changing the obstacles, helicopter physics and sensors.
- 2.1 will have a representation of the helicopter with a rotor span of 3.1 m, a length of 3.6 m and a height of 1.1 m.

The main program:

- 3.0 will have a mode allowing the simulated helicopter to fly above the environment and create an occupancy grid.
- 3.1 will have a mode allowing the simulated helicopter to navigate from a set starting position to a destination through an unknown, but passable environment.

The occupancy grid creator:

- 4.0 will be able to use the laser range finder's output to create and update an occupancy grid of the area seen.
- 4.1 will create an occupancy grid that will represent the likelihood that a particular cell contains an obstacle.
- 4.2 will create an occupancy grid that represents areas below 5m elevation, above 11m elevation, and outside a specifiable boundary as occupied.

The global path planner:

- 5.0 will be able to use an occupancy grid and a user-specified destination to calculate a vector field of potentials that points away from obstacles and towards the destination.
- 5.1 will be capable of running in real-time, while the helicopter is in flight.

The local path planning algorithm:

6.0 will provide real-time corrections to the global path plan based on newly discovered obstacles in the flight path of the helicopter.

6.1 will smooth out waypoints in the global path plan to provide a smoother plan that will be more easily executed by the helicopter.

The speed controller that will:

7.0 adjust the speed and direction of the helicopter to follows the plan developed by the local path planner.

7.1 maintain a minimum stopping distance from all obstacles, guaranteeing that the helicopter will not collide with any object in the simulated environment.

3.2 Performance Specifications

The performance specifications are based on a simulation run on an computer with an AMD Athlon 64 3700+ "San Diego" processor and 2GB of RAM.

8.0 The simulated helicopter will be able to fly at an average speed exceeding 10m/s, while navigating to a destination.

9.0 Any obstacle free space larger than 10.8m wide by 10.8m long by 3.3m high will be passable by the helicopter.

10.0 The global path planner will be able to update the global path faster than once per 2 seconds.

<u>4.0 Pre-Test Preparation</u>

4.1 Test Equipment

4.2 Test Set-up

The Environment 1 specification is created to roughly represent the McKenna MOUT site at Ft. Benning, GA, US, used in testing in the paper *Flying Fast and Low Among Obstacles: Methodology and Experiments*.

The Environment 2 specification is created to represent a flat environment with a single impassable wall separating the environment in to two sections.

The Environment 3 specification is created with a single obstacle, a building that separates the environment in half, with narrow tunnel measuring 10.8 m by 3.3 m.

<u>5.0 System Tests</u>

Functional Spec 1.0

Test 1.0.0 Analyze the source code and verify the existence of five modules: the main program, occupancy grid creator, global path planner, local path planner, and speed controller.

Functional Spec 2.0

Test 2.0.0 Run the simulation three times, loading a new environment each time. Verify that the simulation runs successfully with each new environment.

Test 2.0.1 Alter any of the environments, changing the helicopter to the alternate model. Run the simulation and verify that the helicopter's model has changed.

Test 2.0.2 Alter any of the environments, changing the sensor to the alternate sensor. Run the simulation and verify that the simulation runs successfully.

Functional Spec 2.1

Test 2.1.0 Analyze the source code, helicopter model, and all environments, verifying that the helicopter has a rotor span of 3.1 m, a length of 3.6 m, and a height of 1.1m.

Functional Spec 3.0

Test 3.0.0 Using the alternate main program module, run the simulation on Environment 1. Verify that the helicopter flies above the environment. Dump the occupancy grid. Verify that the occupancy grid exists.

Functional Spec 3.1

Test 3.1.0 Using the regular main program, run the simulation on Environment 1, setting arbitrary but reachable starting point and destination. Verify that helicopter successfully navigates from the start point to the destination.

Functional Spec 4.0

Test 4.0.0 Run the simulation on Environment 1. Dump the occupancy grid and verify its creation.

Functional Spec 4.1

Test 4.1.0 Run the simulation on Environment 1. Dump the occupancy grid and compare the occupancy grid to the environment specification, the location and size of likely objects in the occupancy grid should match with the location and size of objects in the environment specification.

Functional Spec 4.2

Test 4.2.0 Run the simulation on Environment 1. Dump the occupancy grid. Verify that all areas above 11 m, below 5 m and outside of the environment are considered occupied.

Functional Spec 5.0

Test 5.0.0 Run the simulation on Environment 1. Dump the occupancy grid and vector field. Verify that the vector field points away from all obstacles in the occupancy grid and towards the specified destination.

Functional Spec 5.1

Test 5.1.0 Run the simulation on Environment 1. Dump the vector field. Wait at least 2 seconds. Dump the vector field again. Verify that the vector field has changed.

Functional Spec 6.0

Test 6.0.0 Using the alternate global path planner, run the simulation on Environment 1. Dump the global path waypoints. Dump the local path waypoints. Verify that the local path waypoints are different than the global path waypoints, and that they avoid collision with all objects.

Functional Spec 6.1
Test 6.1.0 Using the regular global path planner, run the simulation on Environment 1. Dump the global path waypoints. Dump the local path waypoints. Verify that the local path waypoints are different than the global path waypoints, and that they have been smoothed.
Functional Spec 7.0
Test 7.0.0 Using the alternate local path planner, run the simulation on Environment 1. Dump the local path waypoints. Watch the path followed by the helicopter and verify that it matches the local path waypoints.
Functional Spec 7.1
Test 7.1.0 Using the regular local path planner, run the simulation on Environment 1. Watch the speed of the helicopter and that it flies faster when obstacles are further away and slows as obstacles approach.
Test 7.1.1 Run the simulation on Environment 2. Set the start point on one side of the wall and the destination on the other. Verify that the helicopter approaches the wall, but slows to a stop before colliding with it.
Performance Spec 8.0
Test 8.0.0 Run the simulation on Environment 1. Set an arbitrary but reachable start point and end point, separated by no less than 100 m. Once the helicopter has reached the destination, verify that the average speed is above 10 m/s. Repeat 10 times.
Performance Spec 9.0
Test 9.0.0 Run the simulation on Environment 3. Set the start point on one side of the obstacle and the destination on the other. Verify that the helicopter is able to reach the destination.
Performance Spec 10.0
Test 10.0.0 Run the simulation on Environment 1. View the console output of the global path planner and verify that it is running at least once every 2 seconds for the duration of the simulation.

6.0 Test Record Sheet

Spec.	Test	Expected Result	Observations	P/F	Comments
1.0	1.0.0	5 modules exist.			
2.0	2.0.0	3 successful runs.			
	2.0.1	Successful run, helicopter model has changed.			
	2.0.2	Successful run.			
2.1	2.1.0	Helicopter dimensions verified.			
3.0	3.0.0	Helicopter flies above environment, occupancy grid exists.			
3.1	3.1.0	Navigation successful.			
4.0	4.0.0	Occupancy grid exists.			
4.1	4.1.0	Occupancy grid matches environment.			
4.2	4.2.0	Areas are considered occupied			
5.0	5.0.0	Vector field points away from obstacles and towards destination.			
5.1	5.1.0	Vector field changed.			
6.0	6.0.0	Local path waypoints are different than global path waypoints and avoid collisions.			
6.1	6.1.0	Local path waypoints are different than global path waypoints and are smoother.			
7.0	7.0.0	Helicopter path matches waypoints.			
7.1	7.1.0	Helicopter travels faster further from objects.			
	7.1.1	Helicopter avoids collision.			
8.0	8.0.0	Average speed > 10 m/s.			
9.0	9.0.0	Helicopter reaches destination.			
10.0	10.0.0	Global path planner runs more than once per 2 seconds.			