Autonomous Aerial Assistance for Search and Rescue

Team F

Project Update - November, 15, 2016
Systems Engineering and Management for Robotics

The team

Juncheng Zhang
Karthik Ramachandran
Sumit Saxena
Xiaoyang Liu

Sponsor:
Near Earth Autonomy

Work Breakdown Structure (High-level)

Rescue Rangers
Search and Rescue Assistance System

1. Autonomous Flight System

- *1.1. Set up Matrice 100*
- *1.2. Set up Matrice 600*
- *1.3. Implement autonomous waypoint navigation*
- *1.4. Implement Local Search strategy*

2. Sensing

- *2.1. Finalize sensors*
- *2.2. Test individual sensor performance*
- *2.3. Software: process NEA payload data*
- *2.4. Software: process specific sensor data*
- *2.5. Design sound sensor mounting*

3. Rescue assembly system

- *3.1. Mechanical structure*
- *3.2. Actuation system*
- *3.3. Integrate mechanical structure & actuation system*

4. Signature detection and analysis

- *4.1. Finalize human signatures to detect*
- *4.2. Basic visual signature detection*
- *4.3. Visual+Thermal signature detection*
- *4.4. Human sound detection*
- *4.5. Optimize/scale Performance*

5. System Integration and Testing

- 5.1. Test flight
- *5.2. Build SDPD payload; integrate*
- *5.3. Data collection pipeline: UAV to base*
- *5.4. Test end to end system*

6. Project Planning

- *6.1. Initial Planning*
- *6.2. Project Continuity*
- *6.3. Project Delivery*
- *6.4. Risk Management*

WBS (Detailed)

1. Autonomous Flight System

1.1. Set up Matrice 100
- *1.1.1. Assembly*
- *1.1.2. Test simulator*
- *1.1.3. First teleoperated flight*
- *1.1.4. Test basic autonomous flight*

1.2. Set up Matrice 600
- *1.2.1. Assembly*
- *1.2.1. Test simulator*

1.3. Implement autonomous waypoint navigation
- *1.3.1. Software for waypoint navigation*
- *1.3.2. Test on Simulator*
- *1.3.3. Test on external site*
- *1.3.4. Software to autonomously determine likely search locations*
- *1.3.5. Revise software for waypoint navigation*
- *1.3.6. Test on Simulator*
- *1.3.7. Test on external site*

1.4. Implement Local Search strategy
- *1.4.1. Design basic strategy*
- *1.4.2. Software to implement basic strategy*
- *1.4.3. Test on simulator*
- *1.4.4. Test on external site*
- *1.4.5. Software to plan local search with high quality sensor coverage*
- *1.4.6. Software to plan rescue operation*
- *1.4.7. Test on simulator*
- *1.4.8. Test on external site*

2. Sensing

2.1. Finalize sensors
- *2.1.1. RGB camera*
- *2.1.2. Thermal camera*
- *2.1.3. Sound sensor*

2.2. Test individual sensor performance
- *2.2.1. RGB camera*
- *2.2.2. Thermal camera*
- *2.2.3. Sound sensor*

2.3. Software: process NEA payload data

2.4. Software: process specific sensor data
- *2.4.1. RGB camera*
- *2.4.2. Thermal camera*
- *2.4.3. Sound sensor*

2.5. Design sound sensor mounting

3. Rescue assembly system

3.1. Mechanical structure
- *3.1.1. Design*
- *3.1.2. Prototype*
- *3.1.3. Fabricate*

3.2. Actuation system
- *3.2.1. Finalize actuation method*
- *3.2.2. Finalize actuators*
- *3.2.3. Finalize electronic components needed*
- *3.2.4. Develop actuation mechanism*
- *3.2.4. Interface actuator with SDPD computer*
- *3.2.5. Test drop mechanism*

3.3. Integrate mechanical structure & actuation system

4. Signature detection and analysis

4.1. Finalize human signatures to detect

4.2. Basic visual signature detection
- *4.2.1. Literature study/Datasets*
- *4.2.2. Implementation (SVR)*
- *4.2.3. Debugging/Improvements (FVR)*

4.3. Visual+Thermal signature detection
- *4.3.1. Literature study/Dataset (SVR)*
- *4.3.2. Implementation (SVR)*

4.4. Human sound detection
- *4.4.1. Literature study/Dataset (SVR)*
- *4.4.2. Implementation (SVR)*

4.5. Optimize/scale Performance

5. System Integration and Testing

5.1. Test flight
- *5.1.1. Waypoint navigation; NEA payload*
- *5.1.2. Waypoint navigation + basic hover; no payload*

5.2. Build SDPD payload; integrate
- *5.2.1. Schematic for PDS*
- *5.2.2. Layout for PDS*
- *5.2.3. PCB Fabrication for PDS*
- *5.2.4. Interface sound sensor with drone and onboard computer*
- *5.2.5. Form SDPD payload; integrate into the system*

5.3. Data collection pipeline: UAV to base

5.4. Test end to end system
- *5.4.1. Navigation + search; NEA payload*
- *5.4.2. Whole operation*

6. Project Planning

6.1. Initial Planning
- *6.1.1. Define project scope/requirements*
- *6.1.2. Conduct trade studies*
- *6.1.3. Develop functional and cyber-physical architectures*

6.2. Project Continuity
- *6.2.1. Develop and maintain project website*
- *6.2.2. Design Fall and Spring demo*
- *6.2.3. Procure RGB sensor*
- *6.2.4. Procure Thermal sensor*
- *6.2.5. Procure Sound sensor*
- *6.2.6. Procure Matrice 100*
- *6.2.7. Procure material for drop assembly*
- *6.2.8. Fall demo preparation*
- *6.2.9. Field Tests*
- *6.2.10. Spring demo preparation*

6.3. Project Delivery
- *6.3.1. Deliver Conceptual Design Review*
- *6.3.2. Deliver Preliminary Design Review*
- *6.3.3. Deliver Critical Design Review*
- *6.3.4. Fall Demo*
- *6.3.5. Spring Demo*

6.4. Risk Management
- *6.4.1. Risk analysis and mitigation plans*
- *6.4.2. Execute risk mitigation plans*

Completed | Still pending(Fall)

In-progress | Still pending(Spring)

Schedule

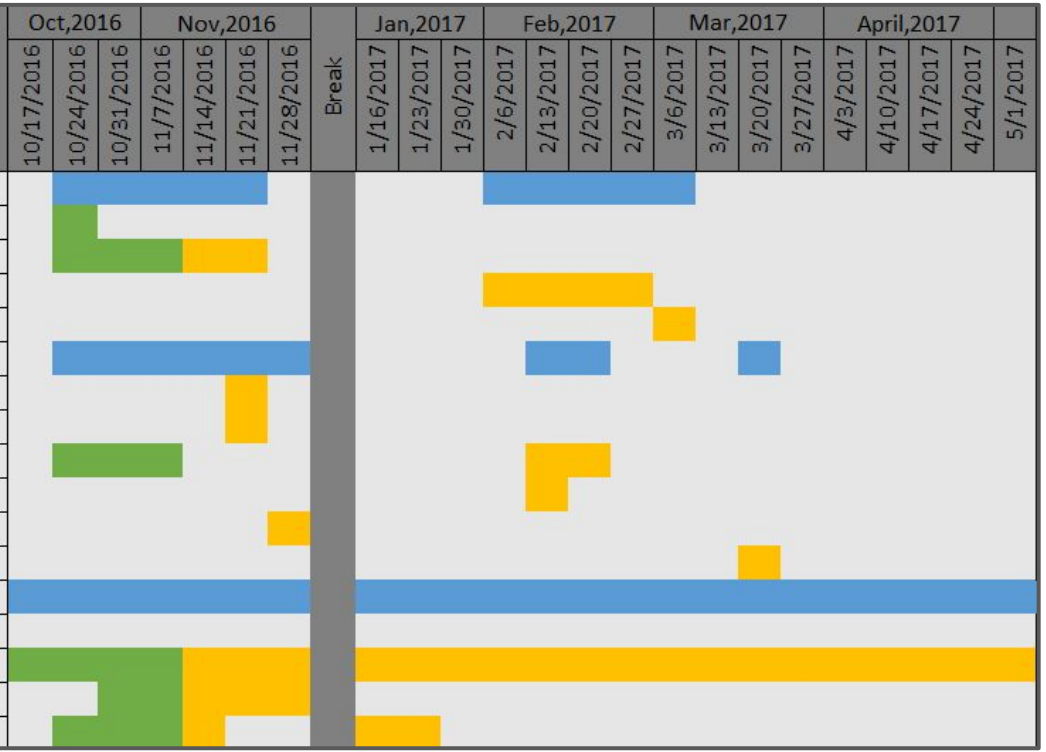
Plan
Not finished
Finished

	Tasks	Sems	Hours
1	**Autonomous Flight System**		**117**
1.1	Matrice 100 setup	FV	17
1.2	Matrice 600 setup	FV	5
1.3	Implement autonomous waypoint navigation	Both	46
1.4	Implement Local Search strategy	SV	49
2	**Sensing**		**110**
2.1	Finalize sensors	Both	20
2.2	Test individual sensor performance	Both	18
2.3	Process NEA payload data	SV	16
2.4	Process specific sensor data	Both	48
2.5	Design sound sensor mounting	FV	8
3	**Rescue assembly system**		**70**
3.1	Design mechanical system	FV	16
3.2	Prototype mechanical system	FV	6
3.3	Procure mechanical/electronic components	FV	4
3.4	Fabricate mechanical system	SV	24
3.5	Develop electronics	SV	12
3.6	Integrate mechanical assembly + electronics	SV	8

Schedule

Plan
Not finished
Finished

	Tasks	Sems	Hours
4	**Signature detection and analysis**		**150**
4.1	Finalize human signatures to detect	FV	10
4.2	Develop basic visual signatures' detection algorithm	FV	60
4.3	Develop visual+thermal signatures' detection algorithm	Both	60
4.4	Performance optimizations/scaling (as per SVR)	SV	20
5	**System Integration and Testing**		**107**
5.1	Test flight: waypoint navigation; NEA payload	FV	10
5.2	Test flight: waypoint navigation + basic hover; no payload	FV	10
5.3	Build SDPD payload; integrate into the syatem	Both	51
5.4	Data collection pipeline from UAV to base	SV	6
5.5	Test end to end system: waypoint navigation + search; NEA	SV	10
5.6	Test end to end system for the whole operation	SV	20
6	**Project Planning**		**143**
6.1	Initial Planning	FV	30
6.2	Project Continuity	Both	56
6.3	Project Delivery	Both	40
6.4	Risk Management	Both	17



Schedule

Date	*Milestone*
10/27/2016	- Global waypoint navigation
11/08/2016	- Power distribution System for non-NEA payload
11/25/2016	- Build a rudimentary RGB based signature detection module
12/01/2016	- Fall Validation Experiment
01/20/2017	- Software to detect likely search locations in the absence of the operator
02/03/2017	- Software for planning localized navigation pattern to drop packet accurately
02/24/2017	- Integrate rescue drop assembly with electronics and onboard processor
03/17/2017	- Mount rescue system assembly on the drone
03/25/2017	- Test end to end system for search and rescue operation

Fall Validation Experiment (1/3) : *70% success achieved*

Test A	***UAV Waypoint Navigation Test***	
Description	Validates the autonomous flight control and waypoint navigation capability of the UAV (Matrice 100)	
Location	Open 50m x 50m area with GPS access and normal wind conditions	
Equipment	UAV, Laptop for waypoint control	
Steps	**Step Description**	**Performance Measures**
A.1.	Place UAV on the ground. Feed waypoints on map on a mobile app	
A.2.	UAV takes off and goes to the first location	Accuracy in reaching desired height (+-1m tolerance)
A.3.	UAV navigates from one waypoint to another	Accuracy in reaching the waypoints (+-5m tolerance)
A.4.	UAV returns to the starting location	Accuracy in reaching the starting location (+-5m tolerance)

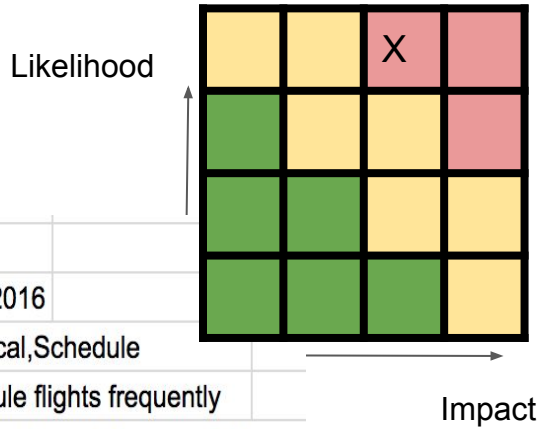
Fall Validation Experiment (2/3) : *50% success achieved*

Test B	***Human detection algorithm test***	
Description	Validates the capability of the algorithm to detect human signatures in RGB images	
Location	Lab	
Equipment	Laptop to run the detection algorithm, images with relevant human signatures	
Steps	**Step Description**	**Performance Measures**
B.1.	Run the algorithm on the set of images	Ability to detect humans in at least 60% of the images

Fall Validation Experiment (3/3) : *10% success achieved*

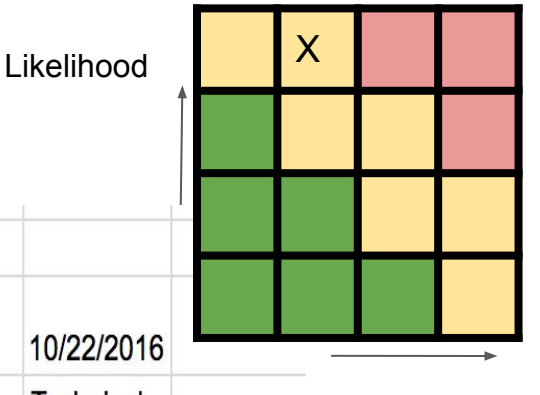
Test C	***Package drop mechanism prototype test***	
Description	Validates the working of the mechanism to be used for dropping the rescue package	
Location	Lab	
Equipment	Prototype for the dropping mechanism, sample package	
Steps	**Step Description**	**Performance Measures**
C.1.	Validate package size and weight. Secure the package in the mechanism	Should be able to hold package of weight 100g, and size 10cmx10cm
C.2.	Subject the mechanism to accelerations in x, y and z directions manually	Should not lose grip of the package under realistic accelerations
C.4.	Manually demonstrate the mechanism's ability to release the package	Should release the package safely without any damage, 3 times in a row

Risks and Mitigation



RISK SUMMARY					
Title	Unavailability of drone/payload for frequent testing		**Date Submitted**	10/19/2016	
Owner	Karthik/Sumit		**Risk Type**	Technical,Schedule	
Description	Sponsor requires drone to remain in their premise and may not be able to schedule flights frequently				
Consequence	Will impact ability to iterate quickly on various navigation strategies/sensing evaluation and rescue strategy				
RISK MITIGATION					
Action	**Date**	**Success criteria**		**Risk level**	**Status**
Order dev drone	10/25/2016	Ability to test and run navigation strategies iteratively		60	DONE
Validate using sensor payload manually to generate data	11/10/2016	Ability to generate sensor data very similar to aerial flight		50	
Use data from flights scheduled for other projects	11/10/2016	Validate if data matches what we expect		40	
Device sensor mounting strategy for dev drone	11/20/2017	Ability to use rgb and thermal camera for sensing on dev drone		30	

Risks and Mitigation



RISK SUMMARY					
Title	Inability to achieve high accuracy in signature detection		**Date Submitted**	10/22/2016	
Owner	Juncheng/Sumit		**Risk Type**	Technical	
Description	Sensor data especially sound might be very noisy and could generate inaccurate results				
Consequence	Will impact accuracy with which system can detect signatures				
RISK MITIGATION					
Action	**Date**	**Success criteria**		**Risk level**	**Status**
Evaluate feasibility of VAD offline	11/10/2016	Ability to detect human voice in offline noisy data with moderate accuracy		10	DONE
Evaluate design for suspended microphone sensor	1/20/2017	Ability to suspend microphone 10 feet below the drone and fly the drone safely		10	

Thank you