



# ROBOGRAPHERS

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FACIAL EXPRESSION RECOGNITION USING SWARMS

## TEST PLAN

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## Table of Contents

1. Introduction .....	2
2. Logistics.....	2
2.1 Test Locations .....	2
2.2 Personnel .....	2
2.3 Tools.....	2
3. Test Schedule .....	3
4. Tests .....	4
4.1 Progress Review 7 .....	4
4.1.1 Single Robot Integration Test.....	4
4.1.2 Photo-clicking Test.....	4
4.2 Progress Review 8 .....	5
4.2.1 Communication Test .....	5
4.2.2 Multi-Robot Navigation Test.....	5
4.3 Progress Review 9 .....	6
4.3.1 Multi-Robot Pan-tilt Face tracking Test .....	6
4.3.2 Expression Detection Test.....	6
4.3.3 Head Pose Tracking Test .....	7
4.4 Progress Review 10 .....	8
4.4.1 Multi-Robot Integration Test .....	8
4.5 Progress Review 11 .....	9
4.5.1 Multi-Robot Multi-people Test .....	9
4.6 Progress Review 12 .....	10
4.6.1 Complete Integration Test .....	10
4.6.2 Voice Command Feature Test.....	11
4.7 Spring Validation Experiment .....	12
5. Appendix .....	13
5.1 Functional Requirements .....	13
5.2 Non-functional Requirements .....	13

## 1. Introduction

This document contains the detailed spring semester test plan for Team G: Robographers. The goal is that by Spring Validation Experiment (SVE) on April 20, 2016, we will have a fully functional multi-robot system that can navigate autonomously in the given environment and click smiling photos of the people. This test plan presents detailed information on each of the progress reviews involved in the present semester and hence leading the progress to the SVE. Also, we will be working on various sub-systems and their integration till the Progress Review 11 and are planning to have a complete rehearsal of the SVE in the Progress Review 12.

## 2. Logistics

### 2.1 Test Locations

All tests in this document will be performed at the following location in Newell-Simon Hall of Carnegie Mellon University:

- Advanced Agent Technology Lab (1604), Level 1, Newell Simon Hall.

### 2.2 Personnel

All tests will be conducted by the following personnel:

- Jimit Gandhi
- Gauri Gandhi
- Tiffany May
- Rohit Dashrathi
- Sida Wang

Each test may require these roles:

**Operators:** to perform the test

**Mechanical Assembler:** To integrate mechanical components of the system

**Electronics Assembler:** To integrate and check electronic components of the system

**Performance Tracking:** To evaluate performance matrix after each test

**Photographer/Videographer:** To record the test progress via pictures or videos

### 2.3 Tools

Tools and materials specific to each test will be listed in each test case. It is assumed all tests will require:

- Head covering Safety glasses
- AprilTags
- Turtlebot WiFi network
- Asus Chromebooks
- Workstation laptop

### 3. Test Schedule

Date	Progress Review	Test	Capability Milestone
January 27, 2016	PR #7	<ul style="list-style-type: none"> <li>- Single Robot Integration Test</li> <li>- Photo-clicking Test</li> </ul>	<ul style="list-style-type: none"> <li>- Integrate the navigation and face detection sub-system on a single turtlebot</li> <li>- Implement photo-clicking algorithm</li> </ul>
February 10, 2016	PR #8	<ul style="list-style-type: none"> <li>- Communication Test</li> <li>- Multi-Robot navigation Test</li> </ul>	<ul style="list-style-type: none"> <li>- Establish communication among 3 turtlebots using ROCON</li> <li>- Demonstrate multi-robot navigation using flocking behavior</li> </ul>
February 24, 2016	PR #9	<ul style="list-style-type: none"> <li>- Multi-Robot Pan-tilt Face tracking Test</li> <li>- Expression detection Test</li> <li>- Head Pose Tracking Test</li> </ul>	<ul style="list-style-type: none"> <li>- Track face of person of interest using multiple robots</li> <li>- Estimate smile expression percentage and click photo from the best view</li> </ul>
March 16, 2016	PR #10	<ul style="list-style-type: none"> <li>- Multi-Robot Integration Test</li> </ul>	<ul style="list-style-type: none"> <li>- Integrate multi-robot navigation and multi-robot facial expression detection sub-systems</li> </ul>
March 30, 2016	PR #11	<ul style="list-style-type: none"> <li>- Multi-Robot Multi-people Test</li> </ul>	<ul style="list-style-type: none"> <li>- Improve the developed algorithms for multiple people in the environment</li> </ul>
April 11, 2016	PR #12	<ul style="list-style-type: none"> <li>- Complete Integration Test</li> <li>- Voice Command feature Test</li> </ul>	<ul style="list-style-type: none"> <li>- Integrate all the above mentioned algorithms</li> <li>- Add additional features like Voice Commands and improve aesthetics</li> </ul>
April 20, 2016	Final System Demo	<ul style="list-style-type: none"> <li>- Spring Validation Experiment</li> </ul>	

*Table 1 Test Plan Summary for Spring 2016*

## 4. Tests

### 4.1 Progress Review 7

#### 4.1.1 Single Robot Integration Test

**Objective**

Demonstrate and verify the integrated single robot system

**Equipment**

1 turtlebot with 1 laptop mounted on it  
Intraface  
Web camera  
Pan-tilt unit  
Apriltags

**Procedure**

1. AprilTag will be located on human's chest while single robot system will be located at the predefined center position of the room.
2. The single robot system will be checked for any mechanical joint inaccuracies as well as the discrepancies in the electronic connections before starting the system.
3. After initiation, the single robot system will rotate and check the position of April tag.
4. Once it detects the April tag, it will start navigating towards the person and stop at 1m distance from him.
5. The Intraface node will be launched henceforth and the pan-tilt unit will be adjusted
6. Once the smiling expression is detected and the photo will be clicked and saved.

**Verification Criteria**

There should be no visible excessive vibrations/oscillations in the system  
There should be no toppling of the single robot system  
All the performance requirements mentioned in FVE must be fulfilled.

#### 4.1.2 Photo-clicking Test

**Objective**

Click the photo of the person detected if he or she smiles for at least 2s

**Equipment**

1 turtlebot with 1 laptop mounted on it  
Intraface  
Web camera  
Pan-tilt unit

**Procedure**

1. Set up the web camera on the pan-tilt unit.
2. As soon as the face is detected, report the percentage of smile expression.
3. Click the photo if the smile value is greater than the set threshold for at least 2s.
4. Save the clicked image in a folder in the master computer.

**Verification Criteria**

Only smiling photos must be clicked every time.  
The photo should be clicked only if the person maintains the expression for at least 2s.

## 4.2 Progress Review 8

### 4.2.1 Communication Test

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**Objective**

Establish communication between the turtlebots

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**Equipment**

3 Turtle bots with 1 laptop each  
Master computer  
Turtlebots wifi  
ROCON setup

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**Procedure**

1. Create a testing information such as “hello world”
  2. Publish and Subscribe the information from master turtlebot to the other two turtlebots
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**Verification Criteria**

Turtlebots can publish and subscribe at least 4 out of 5 times amongst themselves  
Communication speed within 20mbit/s  
Overall transfer within 0.5 seconds

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### 4.2.2 Multi-Robot Navigation Test

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**Objective**

Demonstrate multi-robot navigation from one place to another using flocking behavior

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**Equipment**

3 Turtle bots with 1 laptop each  
Turtlebots wifi  
Apriltags  
Web camera  
ROCON setup

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**Procedure**

1. One single robot will rotate and check the position of April tag
  2. Once the April tag is detected other turtlebots will be notified
  3. All the turtlebots flock towards the person using april tag estimate
  4. Pose 1 meter away with the angles of 0, 45, -45 around the target person
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**Verification Criteria**

Once performance matrix for navigation sub-system mentioned in CDR reaches 80%, performance requirement is considered as fulfilled.

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## 4.3 Progress Review 9

### 4.3.1 Multi-Robot Pan-tilt Face tracking Test

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**Objective**

Demonstrate that all the three cameras with the pan-tilt units will track the person's face as long as one of them can capture the facial expression.

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**Equipment**

3 Turtle bots with 1 laptop each  
Turtlebots wifi  
Pan-tilt units  
Intraface  
Web camera  
ROCON setup

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**Procedure**

1. Set up the face tracking and facial expression detection subsystem. The swarm of robots is placed at predefined positions around the person.
2. The person turn around his or her head in normal angle repeatedly.
3. Observe the tracking state of the 3 pan-tilt units.

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**Verification Criteria**

The pan-tilt unit can track the person's face when the person is facing or nearly facing the robot, i.e., the Intraface can detect the facial expression of the person.

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### 4.3.2 Expression Detection Test

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**Objective**

Demonstrate that if there are more than 1 cameras that can see the facial expression of the person, the robot which gets the highest smiling percentage will click the photo.

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**Equipment**

3 Turtle bots with 1 laptop each  
Turtlebots wifi  
Pan-tilt units  
Intraface  
Web camera  
ROCON setup

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**Procedure**

1. Record the smiling percentage of the person in front of the robots.
2. The system will take a photo for the person after he or she has smiled more than 2 seconds.
3. Check the smiling percentage of the three robots before photo clicking.

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**Verification Criteria**

The photo will be clicked after the person has smiled continuously for more than 2 seconds. If there are more than 1 camera detecting the person's facial expression, the robot with the highest smiling percentage will capture the smiling photo.

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### 4.3.3 Head Pose Tracking Test

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**Objective**

Verify that there will be at least 1 camera can capture the person's facial expression

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**Equipment**

3 Turtle bots with 1 laptop each  
Turtlebots wifi  
Pan-tilt units  
Intraface  
Web camera  
ROCON setup

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**Procedure**

1. The person turn around his or her head in normal angle repeatedly.
  2. Record the number of cameras that detects the person's facial expression.
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**Verification Criteria**

When the person moves his or her head in normally, there will be at least 1 robot capturing his or her facial expression.

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## 4.4 Progress Review 10

### 4.4.1 Multi-Robot Integration Test

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#### Objective

Integrate the two swarm subsystems: The multi-robot navigation system and the multi-robot expression detection/ photo-clicking system.

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#### Equipment

3 Turtle bots with 1 laptop each  
Turtlebots wifi  
Pan-tilt units  
Intraface  
Web camera  
Apriltags  
ROCON setup

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#### Procedure

1. One Turtlebot will rotate in its place until it detects an April tag of the person.
2. Once detected, it will communicate the location of the person to other two Turtlebots.
3. The two Turtlebots will move towards the lead Turtlebot.
4. The three Turtlebots will move towards the person in a flocking behavior.
5. As they reach at a distance of 1 meter from the person, the flock formation will break and the Turtlebots will align themselves around the person at angles -45, 0 and +45 degrees.
6. The Turtlebots will then evaluate the head pose and expression of the person's face.
7. The Turtlebot with the least deviation of head pose from the camera axis and highest smile expression will click the photo.
8. The photo will be sent to the nearby workstation.

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#### Verification Criteria

Both the subsystems should perform with verification criteria of Progress reviews 8 and 9 together as a system.

The system should not click same person more than 3 times.

The Turtlebots must not collide with each other

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## 4.5 Progress Review 11

### 4.5.1 Multi-Robot Multi-people Test

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#### Objective

Improvise the developed system and demonstrate various use cases for multiple people in the environment

#### Equipment

3 Turtle bots with 1 laptop each  
Turtlebots wifi  
Pan-tilt units  
Intraface  
Web camera  
Apriltags  
ROCON setup

#### Procedure

1. The three turtlebots will perform all the steps listed in PR10 for a single person.
2. If there are multiple people in the single frame, the robots will select the person with best aligned head pose.
3. Once this cycle is complete, the master turtlebot will rotate around its axis to search for an apriltag with a different Id.
4. The other two turtle bots will form a flock around the master turtlebot facing towards the next person of interest.
5. Again the same procedure of swarm navigation and face detection will be followed.

#### Verification Criteria

All the verification criteria of the previous progress review must be fulfilled.  
The turtlebots should perform at least 3 such runs of detecting the people and going towards them to click the photo.

## 4.6 Progress Review 12

### 4.6.1 Complete Integration Test

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#### Objective

Demonstrate and verify the mechanical and electronic stability of the complete integrated SWARM robot system, without excess vibrations while carrying out successful human detection and tracking.

#### Equipment

3 Turtle bots with 1 laptop each  
Turtlebots wifi  
Pan-tilt units  
Intraface  
Web camera  
Apriltags  
ROCON setup

#### Procedure

1. AprilTag will be located on human's chest while single robot system will be located at the predefined center position of the room.
2. All the turtlebots in SWARM will be checked for any mechanical joint inaccuracies as well as the discrepancies in the electronic connections before starting the system while the system is offline.
3. After initiation of the start node, the single robot will rotate and check the position of April tag.
4. Once the April tag is detected other turtlebots will be notified and will start navigating towards the person of interest.
5. As they reach at a distance of 1 meter from the person, the flock formation will break and the Turtlebots will align themselves around the person at angles -45, 0 and +45 degrees.
6. The Turtlebots will then evaluate the head pose and expression of the person's face.
7. The Turtlebot with the least deviation of head pose from the camera axis and highest smile expression will click the photo.
8. If the person is not looking into the camera or not smiling, then a voice command saying 'Say Cheese' will be generated.
9. Similar procedure will be followed for detecting other people in the room.

#### Verification Criteria

All the verification criteria of all the previous progress reviews must be fulfilled.

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#### 4.6.2 Voice Command Feature Test

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**Objective**

To demonstrate and verify the 'Look at the Camera' & 'say cheese' voice command feature activations when the person of interest is not looking in camera and not smiling.

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**Equipment**

3 Turtle bots with 1 laptop each  
Turtlebots wifi  
Pan-tilt units  
Intraface  
Web camera  
Apriltags  
ROCON setup

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**Procedure**

1. The three turtlebots will perform all the steps listed in the Complete Integration Test.
  2. If the person does not look into the frame of the camera or the Intraface is unable to detect his or her gaze or headpose, then 'Look at the Camera' voice command will be generated.
  3. If the person is not smiling for 3s, then 'Say Cheese' will be activated.
  4. Additional steps will be taken to improve the aesthetics of the system.
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**Verification Criteria**

After system fails to detect the face, 1st voice command will activate within 1 second.  
After system fails to detect the smile, 2nd voice command will activate within 3 second.

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## 4.7 Spring Validation Experiment

### Objective

To demonstrate the Robographer system working as a whole: Single robot rotating in the room and finding person of interest, sending signals to other turtlebot, flock formation and navigation towards the person, stopping after reaching to the desired positions, voice command initiations, face and smile detection and photo capture.

### Equipment

3 Turtle bots with 1 laptop each  
Turtlebots wifi  
Pan-tilt units  
Intraface  
Web camera  
Apriltags  
ROCON setup

### Procedure

1. AprilTag will be located on human's chest while single robot system will be located at the predefined center position of the room.
2. All the turtlebots in SWARM will be checked for any mechanical joint inaccuracies as well as the discrepancies in the electronic connections before starting the system while the system is offline.
3. After initiation of the start node, the single robot will rotate and check the position of April tag.
4. Once the April tag is detected other turtlebots will be notified and will start navigating towards the person of interest.
5. As they reach at a distance of 1 meter from the person, the flock formation will break and the Turtlebots will align themselves around the person at angles -45, 0 and +45 degrees.
6. The Turtlebots will then evaluate the head pose and expression of the person's face.
7. The Turtlebot with the least deviation of head pose from the camera axis and highest smile expression will click the photo.
8. If the person is not looking into the camera or not smiling, then a voice command saying 'Look at the Camera' or 'Say Cheese' will be generated.
9. Similar procedure will be followed for detecting other people in the room.

### Verification Criteria

Turtlebot detects the human and communicates with the other turtlebots  
Flock is formed successfully and it navigates towards the person.  
Robots arrange themselves at -45, 0, 45 angles in front of the human.  
Turtlebots detect the face of the human. The robot with largest smile estimation will click the photo and send to the workstation.  
Voice commands do their desired work.  
The performance matrix evaluation satisfies the given performance requirements.

## 5. Appendix

### 5.1 Functional Requirements

Robots in the system shall:

M.F.1: Detect Human in the room.

M.F.2: Drive Autonomously Between Multiple Locations at 15-20cm/s

M.F.3: Recognize Smiling Expression collaboratively

M.F.4: Click Photos When Collaborative Smile Assessment  $>0.9$  (probability)

M.F.5: Take Pictures within 1-2 meter Range

### 5.2 Non-functional Requirements

Robots in in the system shall:

M.N.1: Have Wireless Communication mode

M.N.2: Have adjustable elevation

M.N.3: Be easy to operate

M.N.4: Maintain physical stability (Robots should not topple)

M.N.5: Have minimum 3 robots in SWARM