

# Team G:Robographers 29 Feb 2016 System Development Review

Project Name: The Robographer

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**Project Description** 

# Problem:

At social gatherings, it becomes difficult for a single photographer to click good photos of the people as these environments are dynamic in nature.

## **Project Description**

# Solution:

• Develop autonomous photography assistants that analyse expressions and click accurate photos collaboratively.

# Use Case

Final Output

# Single robot integrated system video:

https://drive.google.com/open?id =0B94ia4l0sZa0UGNDanNDWINDa Tg



# Use Case

#### Next task:

Same operations, but with multiple robots i.e. 3 turtlebots





# Requirements

Human detection :

• Detect human **collaboratively** (Min. 70% success)

Planning-Navigation :

- Drive Autonomously to target **collaboratively** at 15-20cm/s
- Navigate to the desired 1 meter position and stop

Face & smile detection:

- Detect Faces in 2s
- Recognize Smiling Expression **collaboratively** At 0.4s
- Detects face of person within 3.5 Ft to 6 Ft height
- Click photo

# **Current Status**

Mechanical Subsystem (Functional Description)

# **Functional Description**



Mechanical Subsystem (Current Stage of Development)



# **Problem Analysis**

- A. Tilt Motor collides with elevation Rod during panning
- B. Horizontal Reinforcement obstructs the Tilt motion
- C. Heavy load on Pan motor axle
- **D.** 4 cm X 4 cm Extrusion bar, (Huge inertia)
- E. Bigger overall dimensions (Very big and fat!)

# Rev 2.0



# Rev 2.0 (Achievements)



1.No restriction for pan tilt motion

- 2. 44% 27% 26% reductions in the l,b and h of pan tilt
- 3. 60% reduction in the pan tilt elevate assembly weight
- 4. Compact and lightweight
- 5. 3 x 3 Al extrusion bar for elevation, less inertia
- 6. Reduced elevation height by 12%
- 7. Will reduce inertial vibrations

#### **SMALLER THE BETTER!**

# Future Work and Challenges

### Work ahead:

- 1. 3D print the parts
- 2. Make 3 Pan Tilt Elevate assemblies
- 3. Integrate with the turtlebots

### **Challenges Faced:**

- 1. Printer availability
- 2. Design conceptualization

### **Remaining Challenges:**

Reduce/eliminate the inherent vibrations due to turtlebot base

Human Detection and Navigation Subsystem (Functional Description)

# For Single Turtlebot





Human Detection and Navigation Subsystem (Current Stage of Development)

# Current Level of Functionality Single Turtlebot



#### Multiple Turtlebots



# Single Turtlebot

# Multiple Turtlebots

Link to video



**Global Camera Setup** 



Setup for Extrinsic Calibration

# System Testing (Performance Matrix for Single Turtlebot System)

Human Detection & Navigation Subsystem: Net Success Percentage=90%								
Run No.	Launched:1 Does Not Launch: 0	Starts Rotation: 1 Does not start: 0	Detects first tag:1 Detects 2nd April Tag: 0.5 Detects nothing: 0	Starts navigation towards tag at 15cm/s	Tracks human in field of view	Stops at : 1m : 1 0.89-0.99 m:0.5 Does not stop:0	Tracks human after stopping	Total (>4.9 success)
1	1	1	1	1	1	0.5	1	6.5
2	1	1	1	1	1	0.5	1	6.5
3	1	1	1	1	1	0	1	6
4	1	1	1	1	1	0.5	1	6.5
5	1	1	1	1	1	0.5	1	6.5
6	1	1	0.5	1	1	0.5	1	6.5
7	1	1	1	1	1	0	1	6
8	1	1	1	1	1	0.5	1	6.5
9	1	1	1	1	1	0	1	6
10	1	1	1	1	1	0.5	1	6.5

# **Challenges Faced**

- 1. Video feed losing track of detected human
- 2. Issues in integration with Intraface nodes due to parallel launching of ROS nodes

# Major Remaining Challenges

- 1. SWARM Localization and Navigation
- 2. Relaunching of rotation node after 1 complete cycle

Face Detection Subsystem (Current Status)

### Face & Smile Detection





#### NODES

intraface (intraface/intraface\_node)
usb\_cam (usb\_cam/usb\_cam\_node)

imit@jimit-inspiron-5547: ~
header:
seq: 1123
stanp:
 secs: 1450107613
 nsecs: 717116079
frame\_1d: ''
emotions:

tag: Neut confidence: 1.11486590793e-10

tag: Disg confidence: 0.00012417754624

tag: Happ confidence: 0.9844588888875

tag: Sadn confidence: 0.0154160391539

tag: Surp confidence: 1.66628359388e-06 HAPPINESS: 0.9844 (probability)



tag: Happ confidence: 8.67310987474e-08

tag: Sadn confidence: 0.00267834549233

tag: Surp confidence: 6.13779233099e-09 Happiness is close to zero

- \* /usb\_cam/image\_width: 640
- \* /usb\_cam/io\_method: mmap
- \* /usb\_cam/pixel\_format: yuyy
- \* /usb\_cam/video\_device: /dev/video0

#### NODES

intraface (intraface/intraface\_node) usb\_cam (usb\_cam/usb\_cam\_node)

#### jimit@jimit-Inspiron-5547:~ 😠 🖾 面

y: [263, 256, 251, 250, 252, 251, 247, 246, 248, 255, 275, 287, 298, 310, 320, 3 22, 323, 322, 319, 282, 279, 278, 280, 282, 283, 278, 275, 275, 277, 280, 280, 3 45. 340. 336. 338. 336. 339. 343. 350. 354. 356. 355. 351. 345, 345, 345, 345, 3 47, 346]

x: [259, 267, 279, 292, 305, 345, 357, 370, 381, 391, 327, 328, 329, 330, 313, 3 21, 331, 340, 348, 274, 283, 292, 301, 292, 283, 351, 360, 369, 377, 369, 360, 2 198, 308, 318, 331, 341, 352, 362, 353, 343, 330, 318, 307, 310, 330, 343, 343, 3 30. 317]

y: [263, 256, 251, 250, 252, 251, 247, 246, 248, 255, 275, 287, 298, 310, 320, 3 22, 323, 322, 319, 282, 279, 278, 280, 283, 283, 278, 275, 275, 278, 280, 280, 3 46, 340, 336, 338, 336, 339, 343, 350, 354, 356, 355, 351, 345, 345, 345, 345, 3 47, 346]

x: [259, 267, 279, 292, 305, 344, 357, 370, 382, 392, 327, 328, 329, 330, 312, 3 ---21, 331, 340, 348, 274, 283, 292, 301, 292, 283, 351, 360, 369, 377, 369, 360, 2 98, 307, 318, 330, 341, 351, 362, 353, 342, 330, 318, 307, 316, 330, 342, 343, y: [264, 256, 251, 250, 252, 251, 247, 246, 249, 257, 275, 287, 298, 310, 320, 3 22, 323, 322, 319, 282, 279, 279, 280, 283, 283, 278, 276, 276, 278, 280, 280, 3 46, 341, 337, 338, 337, 340, 344, 350, 354, 356, 355, 351, 345, 345, 345, 345, 3

FACIAL LANDMARKS (Green colored points in image above

47, 346]

TNE01	[1453951933 261000910].	Hanny	Percentage.	[0 991355]
TNF01	[1453951933_323120216]:	Hanny	Percentage:	[0.991678]
TNF01	[1453951933 384514367] .	Hanny	Percentage:	[0.992972]
TNEOI	[1453951933 438600287].	Hanny	Percentage:	[0.991926]
TNEOI	[1453051033 402433050].	Hanny	Dercentage:	[0.991720]
TNEOI	[1453951933 546392926].	Hanny	Dercentage:	[0.991108]
TNEO	[1453051033 508850015].	Hanny	Dercentage:	[0.0006//1]
TNEOL	[1453951933.653282869].	Happy	Dercentage.	[0.992060]
TNEO	[1453051033 712555202].	Happy	Percentage.	[0.992000]
TNEOI	[1452051022 770002409].	Happy	Porcontage.	[0.991039]
TNEO	[1452051022 022562410].	Нарру	Percentage.	[0.990494]
TNEO	[1452051022 004162140].	Happy	Percentage.	[0.990094]
TNEOL	[1453951933.094102140]:	Нарру	Percentage:	[0.991190]
INFOI		парру	Percentage:	[0.991511]
INFUI	[1453951934.000298927]:	нарру	Percentage:	[0.9919/3]
INFUI		нарру	Percentage:	[0.990549]
INFO		нарру	Percentage:	[0.991550]
INFO	[1453951934.165242826]:	нарру	Percentage:	[0.992133]
INFO	[1453951934.222279039]:	нарру	Percentage:	[0.991839]
INFO	[1453951934.2//446431]:	Нарру	Percentage:	[0.990/38]
INFO	[1453951934.333928075]:	Нарру	Percentage:	[0.991373]
INFO	[1453951934.390762545]:	Нарру	Percentage:	[0.992201]
INFO	[1453951934.442574656]:	Нарру	Percentage:	[0.992675]
INFO	[1453951934.497712026]:	Нарру	Percentage:	[0.992531]
INFO	[1453951934.553002537]:	Нарру	Percentage:	[0.992669]
INF0]	[1453951934.597285954]:	Нарру	Percentage:	[0.992173]
INF0]	[1453951934.643671851]:	Нарру	Percentage:	[0.991990]
INF0]	[1453951934.692643745]:	Нарру	Percentage:	[0.991961]
INF0]	[1453951934.741092150]:	Нарру	Percentage:	[0.991900]
INF0]	[1453951934.789472944]:	Нарру	Percentage:	[0.992184]
INF0]	[1453951934.836780439]:	Нарру	Percentage:	[0.992757]
INF0]	[1453951934.877326817]:	Нарру	Percentage:	[0.993456]
INF0]	[1453951934.920918805]:	Нарру	Percentage:	[0.993893]
INF0]	[1453951934.971273357]:	Нарру	Percentage:	[0.993524]
INF0]	[1453951935.024736976]:	Нарру	Percentage:	[0.993521]
INF0]	[1453951935.077749979]:	Нарру	Percentage:	[0.994361]
INF0]	[1453951935.133670415]:	Нарру	Percentage:	[0.993730]
INF0]	[1453951935.183615393]:	Нарру	Percentage:	[0.993677]
INF0]	[1453951935.236304084]:	Нарру	Percentage:	[0.993482]
INF0]	[1453951935.287867986]:	Нарру	Percentage:	[0.993682]
INF0]	[1453951935.345881452]:	Нарру	Percentage:	[0.994062]
INF0]	[1453951935.408043434]:	Нарру	Percentage:	[0.993878]
INF0]	[1453951935.463429969]:	Нарру	Percentage:	[0.993844]
INF0]	[1453951935.521086434]:	Нарру	Percentage:	[0.993576]
INF0]	[1453951935.578390546]:	Нарру	Percentage:	[0.993339]
INF0]	[1453951935.633418521]:	Нарру	Percentage:	[0.992879]
INF0]	[1453951935.719889838]:	Нарру	Percentage:	[0.992194]
INF0]	[1453951935.854678058]:	Нарру	Percentage:	[0.993021]
INF0]	[1453951935.912326254]:	Нарру	Percentage:	[0.993562]
INF0]	[1453951935.966904545]:	Happy	Percentage:	[0.993201]





# System Testing (Performance Matrix)

Face & Smile Detection Subsystem: Net Success Percentage=88%

Run No.	Launched:1 Does Not Launch: 0	Detects Faces in 2s: 1 Detects Faces in > 2s: 0.5 Does not detect: 0	Tracks faces in pan direction:1 Does not track:0	Tracks faces in tilt direction(3.5- 6ft):1 Does not track:0	Detects Smile in 0.4s: 1 in > 0.4s: 0.5 Does not detect: 0	Clicks Photo:1 Else:0	Total (>4.5 success)
1	1	1	1	1	1	1	6
2	1	1	0	0	1	1	4
3	1	1	1	1	1	1	6
4	1	1	1	1	1	1	6
5	1	1	0	1	1	1	5
6	1	1	1	0	1	1	5
7	1	1	1	1	1	1	6
8	1	1	1	0	1	1	5
9	1	1	1	1	1	1	6
10	1	1	0	1	1	1	5

# Challenges

- Noisy data. (solved to some extent with the new camera)
- Multiple faces in vicinity

Swarm Subsystem (Functional Description)

# Swarm Communication

We implement a multi-master approach for multiple Turtlebots. In ROS we have Robotics in Concert framework (RoCoN). Features:

- Customised Multi-master support
- Decoupling of different robotic systems
- Works robustly over WiFi by continuous exposing and handling latency in the system
- Designed to regulate and control information flow.
- Auto- discovery of other systems over same network. Thus scalable.



Figure 1: Rocon setup. The IP addresses are taken directly from the demonstration setup.

# Swarm Communication- ROCON Framework

Components:

Hub:

- Responsible for gateway discovery, unique identification of connection
- Keeps track of which gateways are active in the system, which information those active gateways are looking for and which information they provide.

Gateway:

- Act as interface between the Hub and the ROS master.
- Controls which topic the ROS master wants from the Hub and only permits flow of these topics.

Swarm Subsystem (Current Status)

# **Current Functionalities**

- Multi-master Publisher Subscriber on two different machines.
- Multi-master Turtlebot Teleop simulation on Gazebo.



\*

	@ 🗇 🗊 dudette:11312	0 0 0 dude:11314
Q.	[INFO] [WallTime: 1455143169.716066] hello world 1455143169.72	d 1455143170 45
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	[INF0] [WallTime: 1455143169.916016] hello world 1455143169.92	[TINEO] [Wallime: 1455143170 583236] /hodacious dude1/listenerT heard hello wor]
	[INF0] [WallTime: 1455143169.982705] hello world 1455143169.98	[1145] [Matthing 145145170.505250] /boddetods_dddet/(tistener 1 neard netto wor con
	[INF0] [WallTime: 1455143170.049405] hello world 1455143170.05	[TINFO] [WallTime: 1455143170.649867] /bodacious dude1/listenerT heard hello worl
	[INF0] [WallTime: 1455143170.116018] hello world 1455143170.12	1 1451143170-65
	[INF0] [WallTime: 1455143170.182679] hello world 1455143170.18	[INFO] [WallTime: 1455143170.716578] /bodacious dude1/listenerI heard hello worl
	[INF0] [WallTime: 1455143170.249323] hello world 1455143170.25	d 1455143170.72
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and the set	[INFO] [WallTime: 1455143170.916039] hello world 1455143170.92	d 1455143171.05
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	Pruning Resolvable Branches rocon:/*/*#rocon_apps/listener : ['Bodacious Dude']	1455143170.52 [INFO] [WallTime: 1455143170.583345] /bodacious_dude/listenerI heard hello world
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Terminal

Gazebo



concert\_qt\_teleop\_\_Teleop - rqt



concert\_qt\_teleop\_\_Teleop - rqt



# Swarm Communication- Challenges

- Multi-master over different machines is tricky.
- Auto Discovery is a boon as well as bane. Interferes with other systems on the network.
- Gateway connection not guaranteed every time even after correct set up. Sometimes fails to connect. (Solution: Configure static IPs)

**Project Management** 

# Project Schedule (Spring 2016)

ID	Name	Responsibility	Start	Finish	% Completion	
1	Parts ordering					
1.1	Trade study (Chromebooks, cameras)	Rohit	20-Jan-16	22-Jan-16	100	PB7
1.2	Order chromebook and camera	Rohit	23-Jan-16	23-Jan-16	100	PB7
1.3	Testing with the system and order 2 more sets	Rohit	31-Jan-16	08-Feb-16	100	
2	Mechanical Vork					
2.1	Problem analysis in current assembly (rev 1.0)	Rohit	07-Feb-16	10-Feb-16	100	PR9
2.2	Elevation Mechanism CAD re-design (rev 2.0)	Rohit	13-Feb-16	22-Feb-16	100	PR9
2.2	Elevation Mechanism fabrication	Rohit	24-Feb-16	02-Mar-16	0	PR 10
2.3	PTZ • Elevation assembly on Turtlebots	Rohit	12-Mar-16	14-Mar-16	0	PR 10
3	Detection					
3.1	Testing human detection + face detection using same camera	Gauri, Jimit	23-Jan-16	25-Jan-16	100	PB7

# Project Schedule (Spring 2016)

6	Image fusion					
6.1	Algorithm to obtain image from TB2 on workstation	Jimit	25-Jan-16	26-Jan-16	100	PB7
6.2	Photo capture using multiple turtlebots	Jimit,Sida	08-Mar-16	15-Mar-16	0	PR 10
4	Planning and Navigation					
4.1	ROCON simulation	Jimit, Tiffany	24-Feb-16	08-Mar-16	0	PR 10
4.2	Physical ROCON setup	Gauri, Jimit	08-Mar-16	14-Mar-16	0	PR 10
4.3	Global camera setup	Gauri, Jimit,Sida	08-Mar-16	10-Mar-16	100	shown in PR9
4.4	Global camera calibration	Gauri, Jimit,Sida	10-Mar-16	14-Mar-16	100	shown in PR9
4.5	Apriltag detection algorithm	Gauri, Jimit,Sida	16-Mar-16	23-Mar-16	0	PB 11
4.6	Turtlebot localization	Gauri, Jimit,Sida	16-Mar-16	23-Mar-16	0	PB 11
4.7	Flock formation	Gauri, Jimit,Sida	24-Mar-16	31-Mar-16	0	PB 11
7	Integration & testing					
7.1	Integrate mechanical, detection & Planning-navigation	ALL	03-Apr-16	10-Apr-16	0	PR12
7.2	Testing the whole system	ALL	11-Apr-16	16-Apr-16	0	PR12

# High Level Test Plan

Date	Progress Review	Test	Capability Milestone
March 16, 2016	PR #10	<ul> <li>Multi-Robot Pan-tilt Face</li> <li>tracking Test</li> <li>Expression detection Test</li> <li>Head Pose Tracking Test</li> <li>Multi-Robot navigation Test</li> </ul>	<ul> <li>Track face of person of interest using multiple robots</li> <li>Estimate smile expression percentage and click photo from the best view</li> <li>Demonstrate multi-robot navigation using flocking behavior</li> </ul>
March 30, 2016	PR #11	- Multi-Robot Integration Test	- Integrate multi-robot navigation and multi-robot facial expression detection sub-systems
April 11, 2016	PR #12	- Multi-Robot Multi-people Test	- Improvise the developed algorithms for multiple people in the environment
April 20, 2016	Final System Demo	- Spring Validation Experiment	

# Spring Validation Experiment

#### Location

All tests in this document will be performed at Advanced Agent Technology Lab (1604), Level 1, Newell Simon Hall.

#### Personnel

- **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

### Needed equipment

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

# SVE

**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 navigate towards the person, stopping after reaching to the desired positions, face and smile detection and photo capture. **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 -30, 0 and +30 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. Similar procedure will be followed for detecting other people in the room.







# SVE

#### **Success Scenario**

- 1. Turtlebot detects the human and communicates with the other turtlebots(atleast 70% of all runs).
- 2. Flock is formed successfully and it navigates towards the person(atleast 70% of all runs).
- 3. Robots arrange themselves at -30, 0, 30 angles in front of the human(atleast 80% of all runs).
- 4. Turtlebots detect the face of the human. The robot with largest smile estimation will click the photo and send to the workstation(atleast 70% of all runs).
- 5. The performance matrix evaluation satisfies the given performance requirements

#### System Requirements to fulfill in Spring validation experiment

- 1. Recognizing expressions collaboratively
- 2. Plan path
- 3. Communicate within themselves
- 4. Move autonomously from one location to another
- 5. Click photos from best possible angles

# **Budget Status**

S.No.	Sub-system	Item(Qty.)	Obtained from	MRSD Budget used
1	Robographer	Acer Chromebook C720(3)	Amazon	358x3
2	Navigation	Turtlebots(3)	Advanced Agents Lab	0
3	Mechanical	Aluminium Rods(3)	FRC	0
4	Mechanical	Pan-tilt mounts(3)	3D-printer (MRSD Lab)	0
5	Mechanical	Servo motors(6)	MRSD Lab Inventory	0
6	Detection	Logitech C920 Camera(3)	Amazon	67x3
7	Detection	Intraface software	Human Sensing Lab	0
8	Detection	April Tags	Advanced Agents Lab	0
9	Detection	Arduino(3)	MRSD Lab Inventory	0

Total Budget Used = 1275 USD (~32%)

Total Budget Left = 2725 USD (For spares & emergencies)



# **Overall Risk Management**

Risk ID	Risk Name	Mitigation Strategy			
1	Noisy detection in moving data	Make height adjustment design robust with Base Support. <u>(Solved with new</u> pan tilt design and new HD camera)			
2	Intraface crashes	Get a more stable version of Intraface for the system. <u>(solved using</u> ros::spawn())			
3	Battery drain of Turtlebots	Request sponsors & new set of batteries ( <u>5 spare batteries collected</u> )			
4	Single robot failure	<ul> <li>a. Make the swarm robust to work without the non-operative robot. <u>(ROCON)</u></li> <li>b. Ask sponsor &amp; get custody of 2 extra turtlebot. <u>(5 turtlebots spare in lab)</u></li> </ul>			
5	Multiple faces Use zoom features and crop the imagination in vicinity frame. Then input to Intraface				



# Questions?

Thank you!