Team G:Robographers

14 Dec 2015

Critical Design Review

Project Name: The Robographer

Sponsored By: Dr. Katia Sycara

Team Members: Gauri Gandhi Sida Wang Tiffany May Jimit Gandhi Rohit Dashrathi

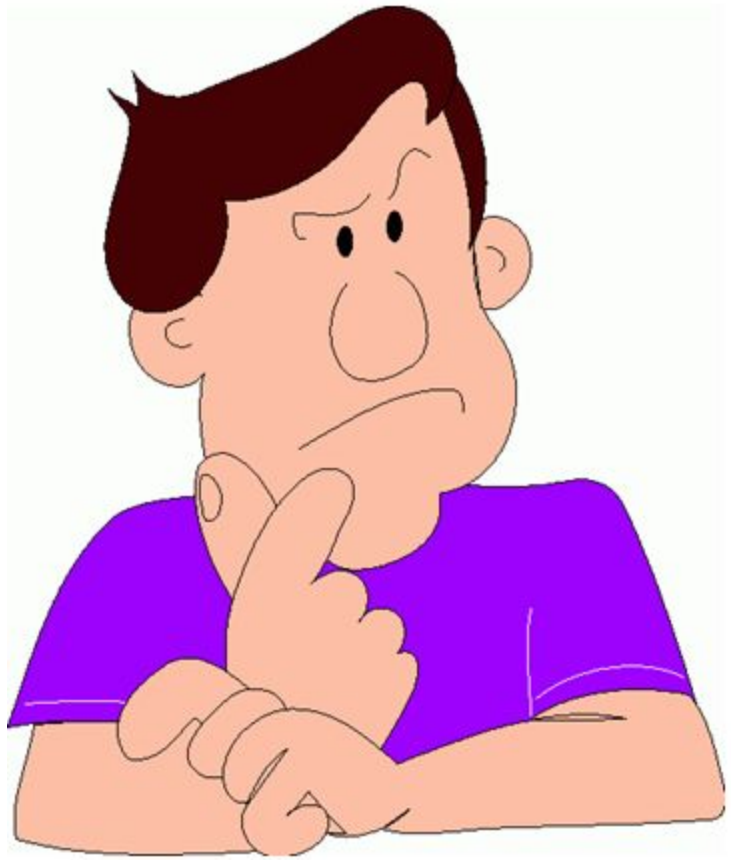
Description

- Preliminary effort aimed at developing autonomous photography assistants
- In addition to clicking photos, they recognize and capture human expressions accurately.
- Project principle: facial expression recognition and accurate head pose tracking using a swarm of robots.
- Attempt to improve the robustness and efficiency of collaborative strategies over individual planning strategies.

Use Case

Rohit liked a girl, they went on a date,
His photography went bad, alike his fate!

Use Case



How to click good Pic with her, one fine day he thought!
Éureka! He cheered, and made a robot!

Use Case

To impress her more, he sung a Bollywood song,
Let's get married! She cheered, 'I can't wait any long'

Use Case

They hired a photographer, flirtatious he was,
He tried on Tiffany, she kicked his , You know what.

Use Case

What to do now? Rohit asked Jimit, the best man,
Don’t worry dear, he said, I know the backup plan!

Use Case

Wedding was on and guest started coming faster,
Photos were clicked, with smiles and laughter!

Use Case

Gauri & Sida were stunned,, To see the best man conquer
Thus ends dear friends, tale of the Robographer!

Requirements

Human detection :

- Detect human (Min. 70% success)

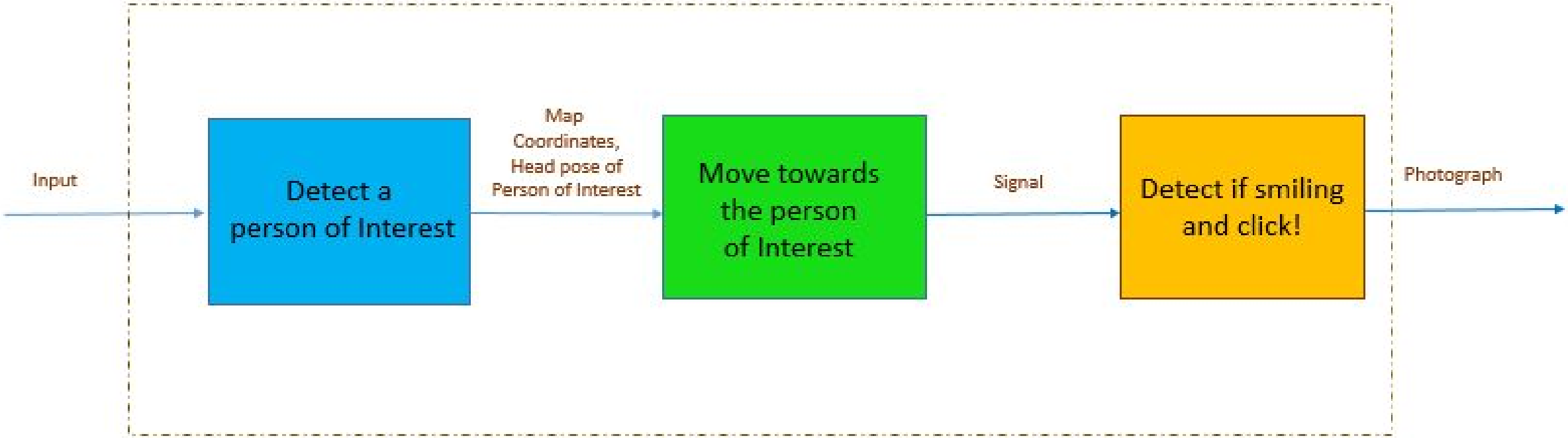
Planning-Navigation :

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

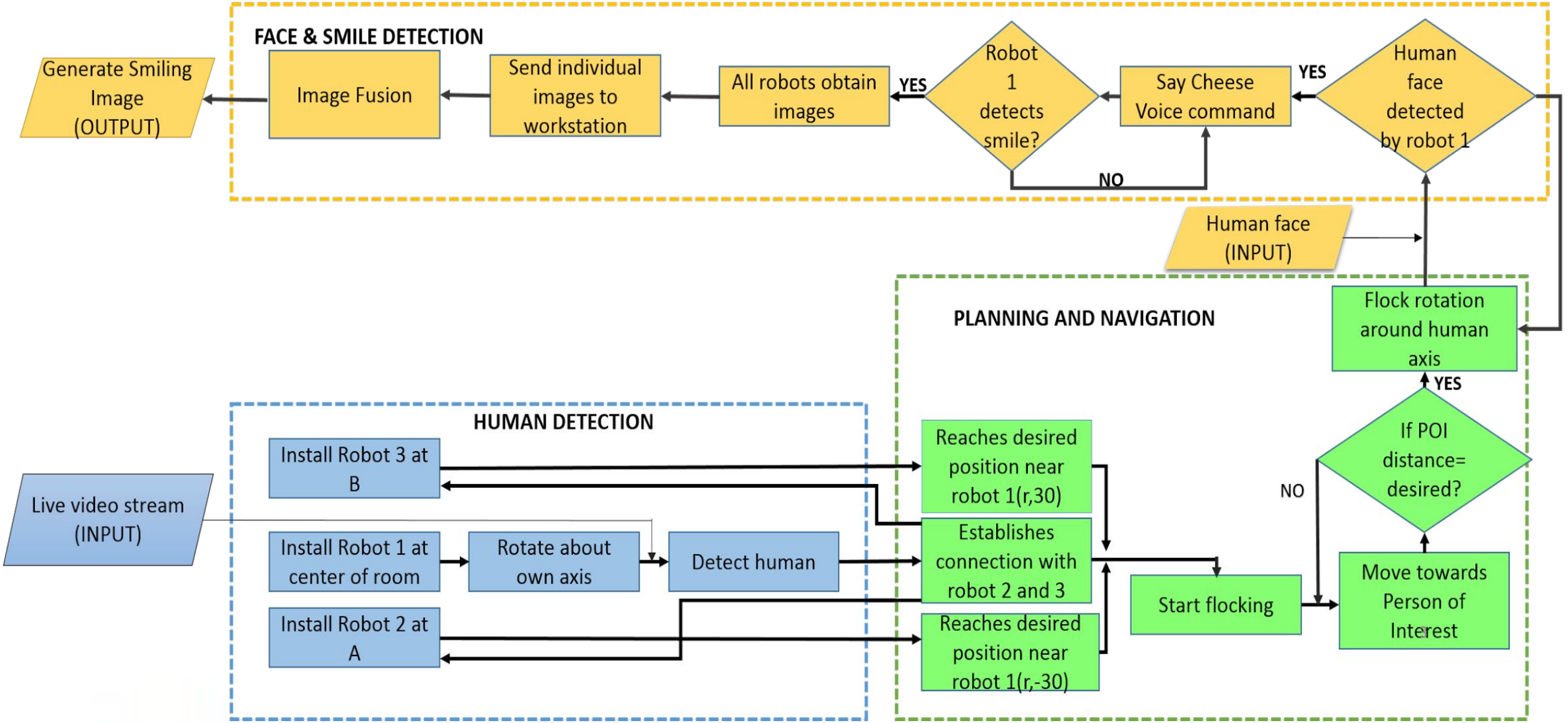
Face & smile detection:

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

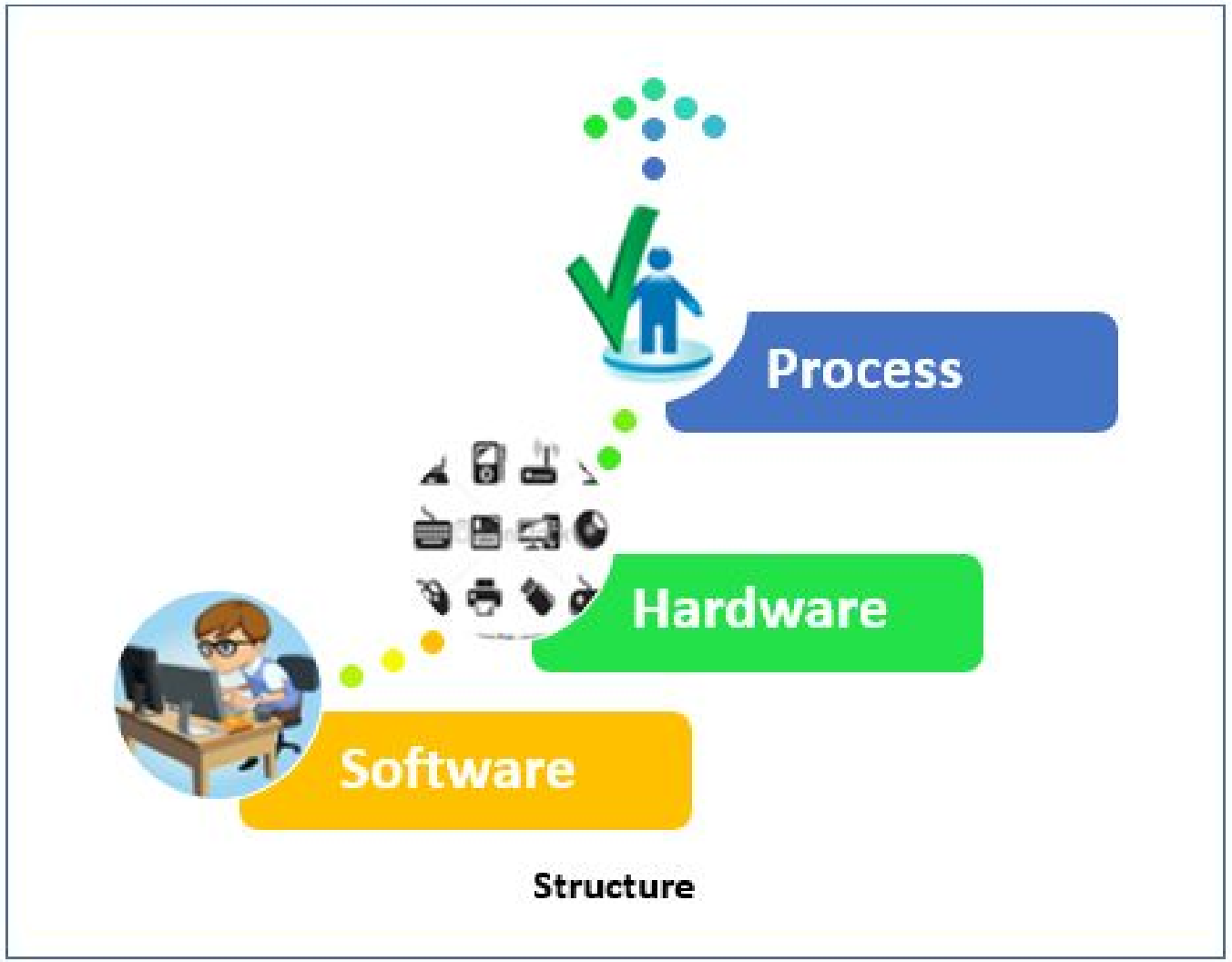
Functional Architecture



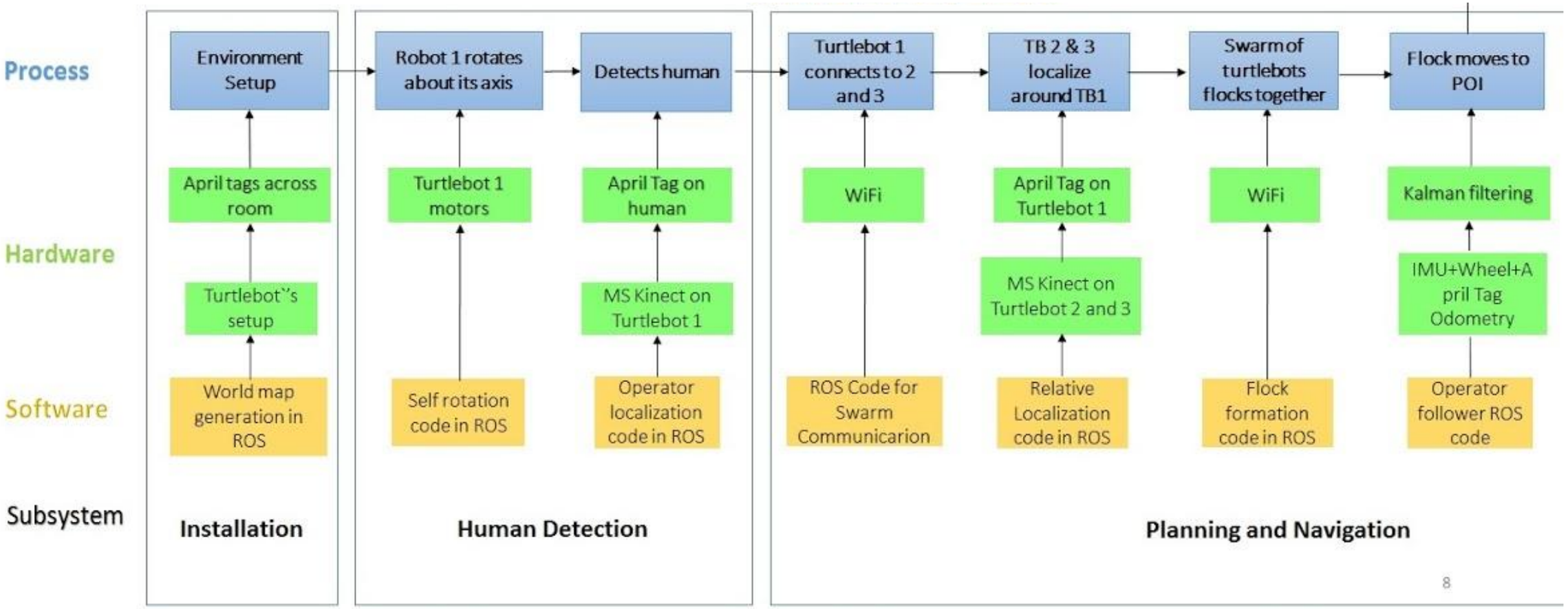
Functional Architecture



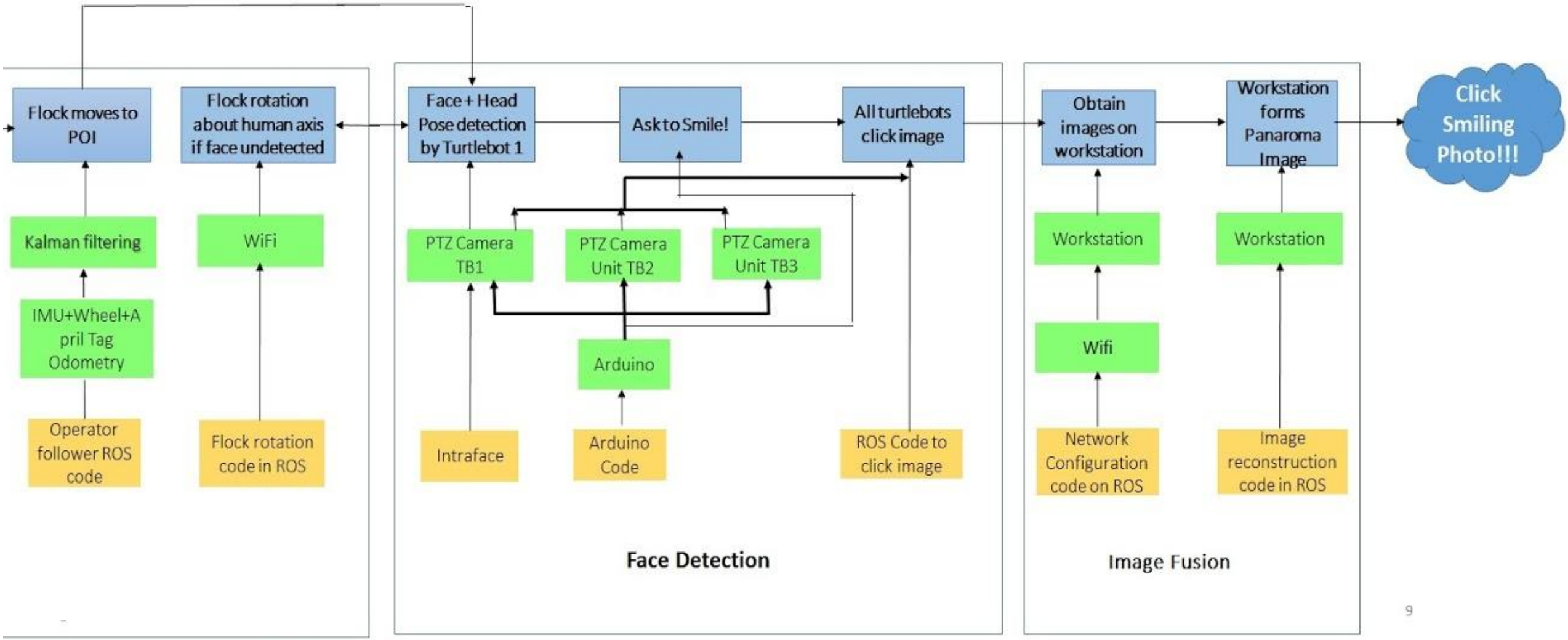
Cyber Physical Architecture



Cyber Physical Architecture



Cyber Physical Architecture



Current Status

Current System Status (Targeted Requirements)

Human detection :

- Detect human (Min. 70% success)
- Design pan tilt unit which tracks the human face

Planning-Navigation :

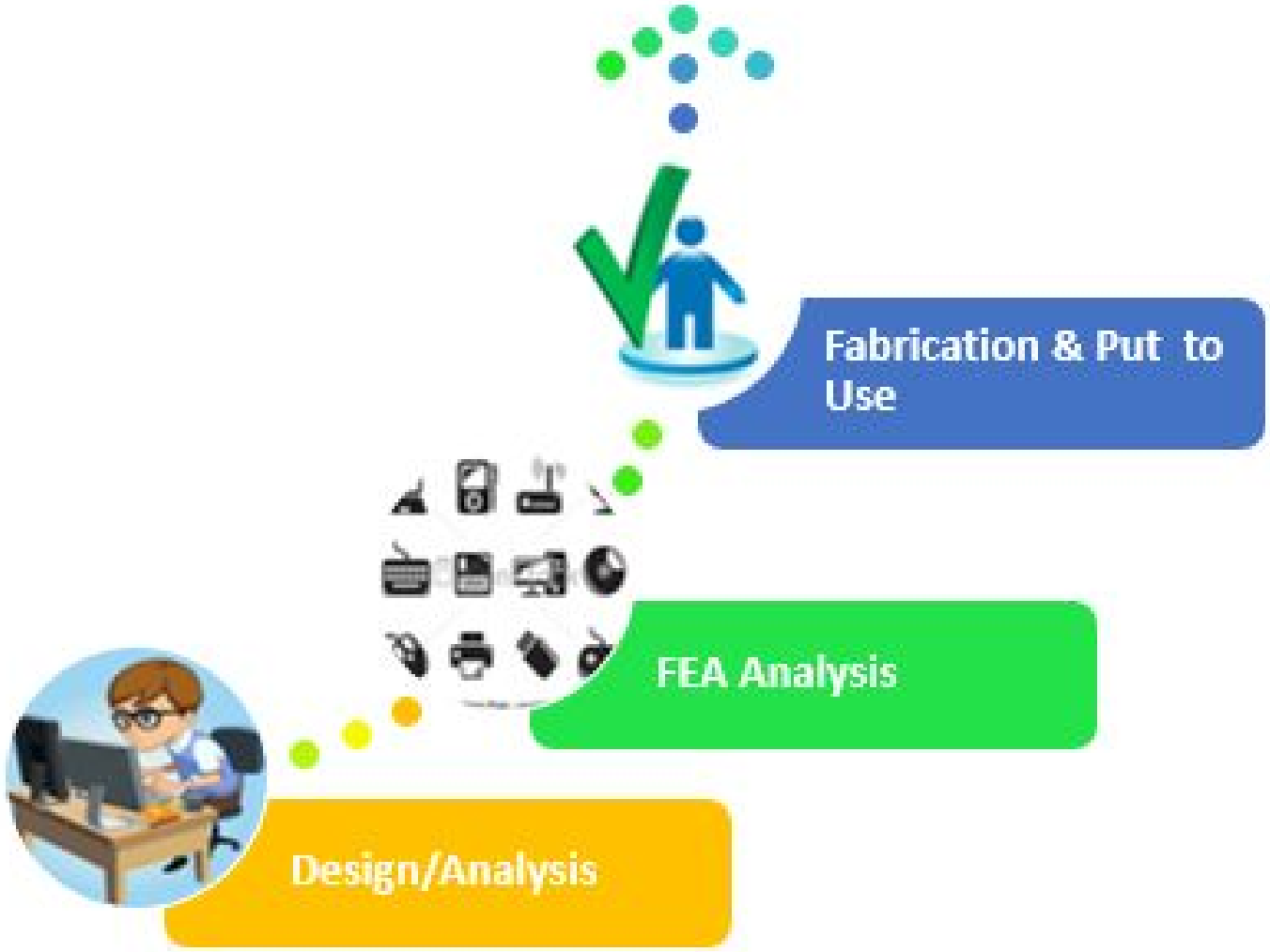
- Drive Autonomously to target at 15-20 cm/s
- Navigate to the desired 1 meter position and stop

87.5%

Face & smile detection:

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

Mechanical



Initial design

Mechanical

Analysis

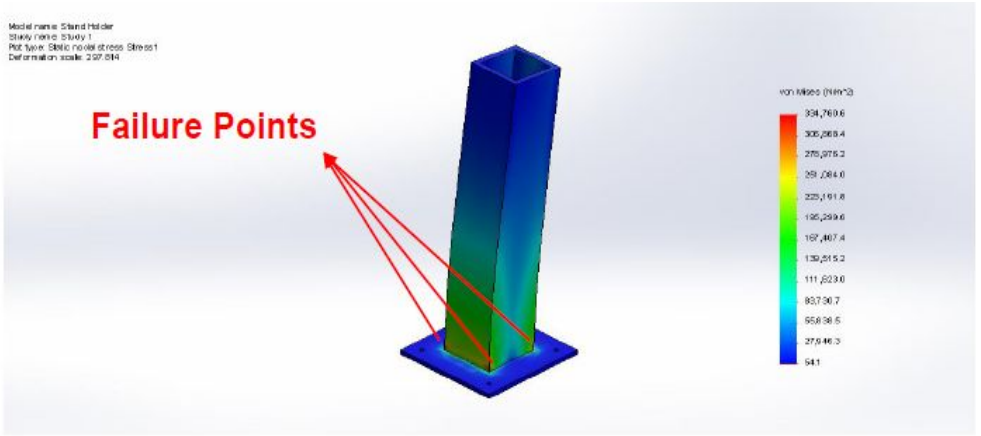
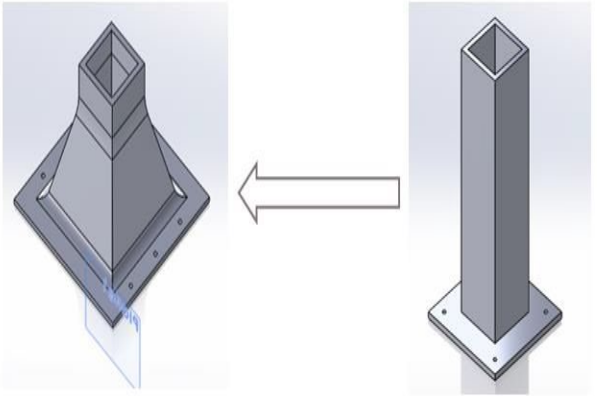
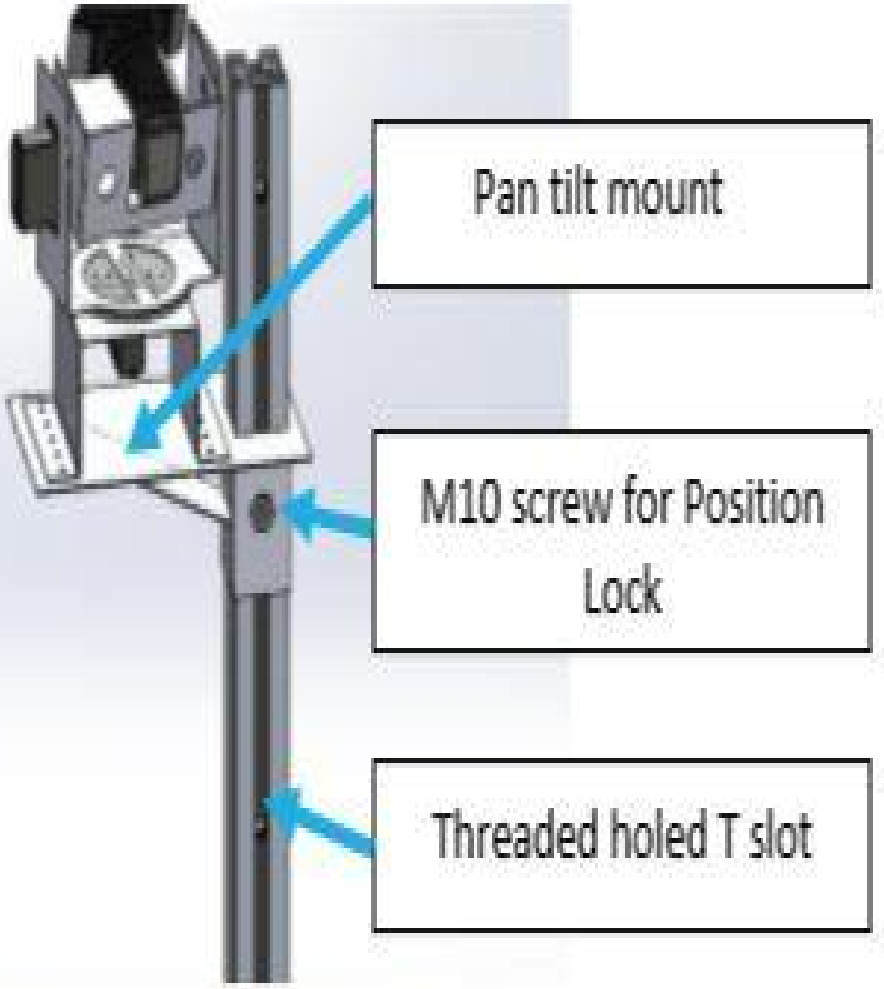


Figure 4: FEA Simulation stress analysis for Force condition1: F=mass(Al Rod) * g

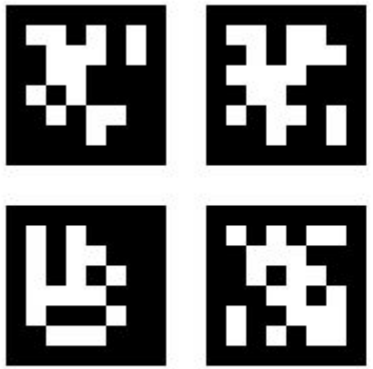
Design Change



Mechanical


Pan tilt mount
M10 screw for Position Lock
Threaded holed T slot

Human Detection



Get familiarized with ROS, April Tags and Turtlebots

Create ROS node for April Tag Detection

Fit Camera Calibration parameters

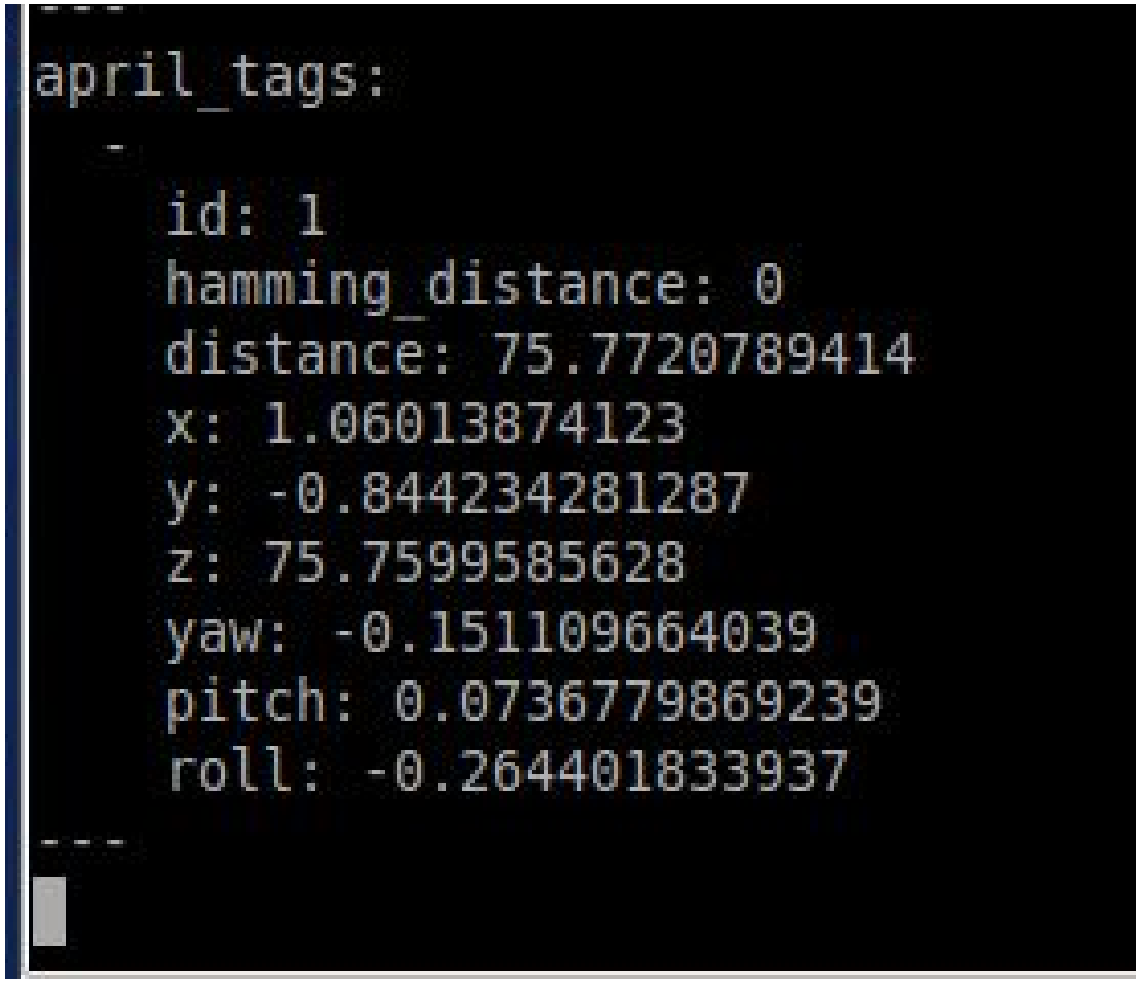
Calibrate Webcam

Detect April tags using Michael Kaess' library

Subscribe to April tags published parameters

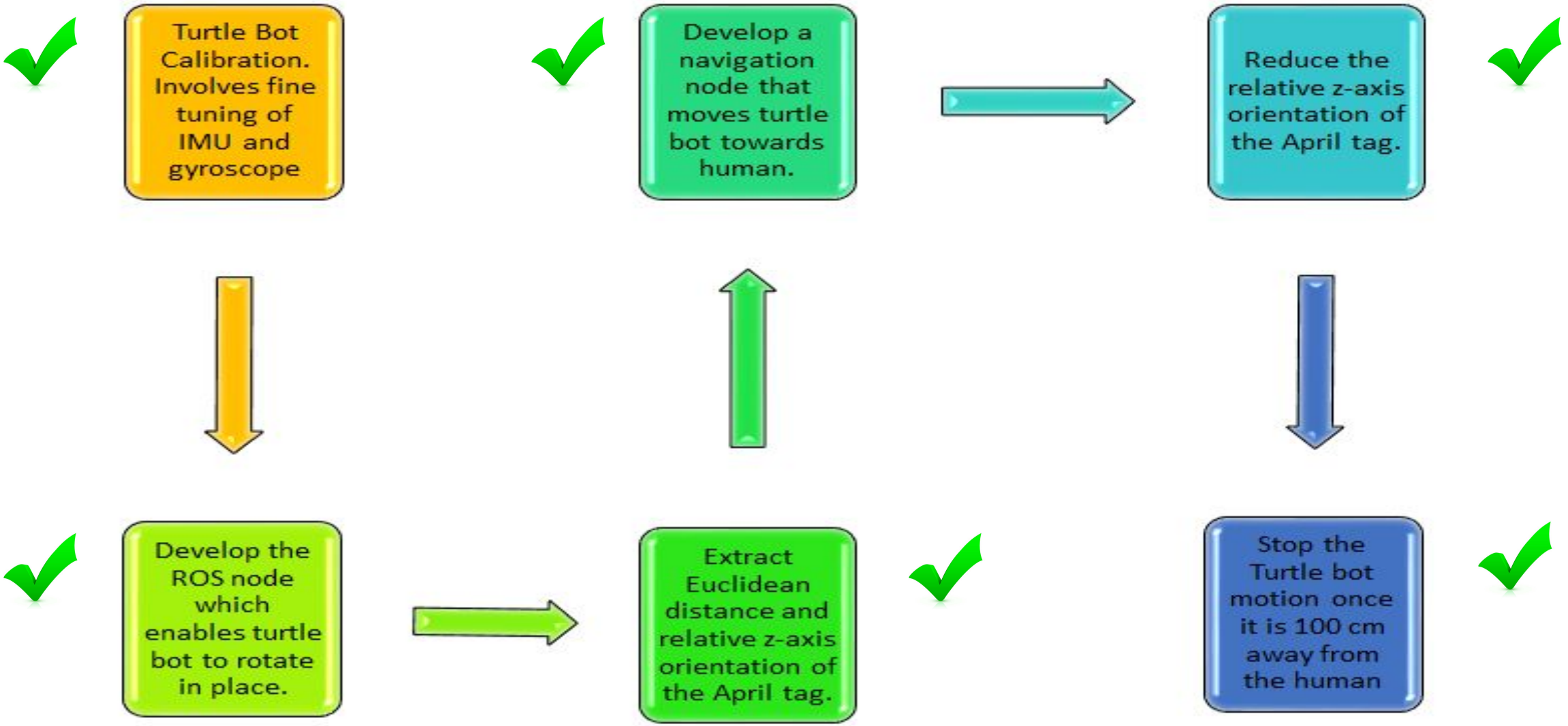
Obtain position parameters to publish to navigation node

Human Detection



Values obtained from the published /april_tags topic after detection

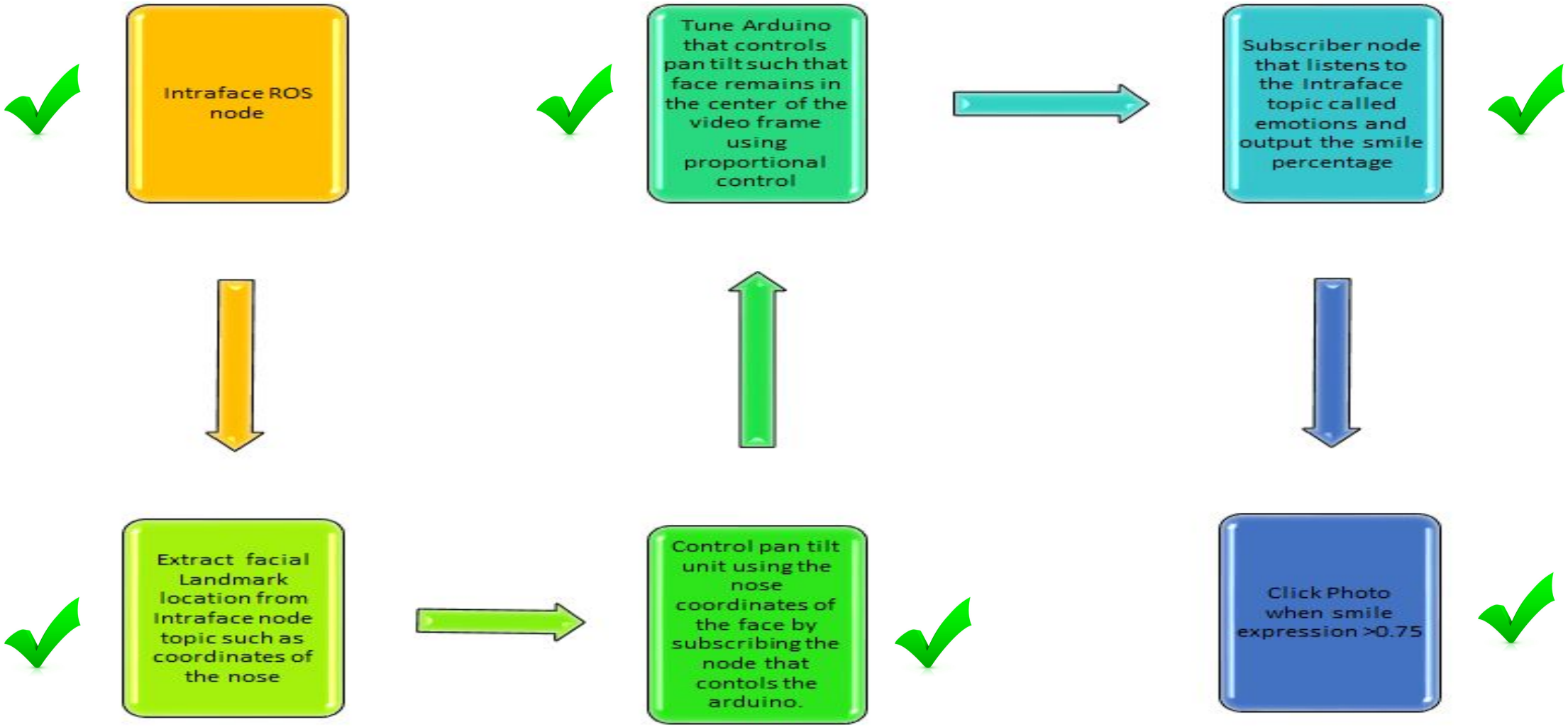
Planning-Navigation



Planning-Navigation

Turtlebot detects april tag, navigates and stops at a distance of 100cm from the detected human

Face & Smile Detection



FVE & FVE encore evaluation

Subsystem 1: Human Detection & Navigation

Requirements fulfilled

- Detect human in the vicinity
- Approach the human once detected
- Move with a speed of 15 cm/sec
- Stop at 1 meter away from the human

Testing Criteria for Human detection and navigation subsystem:

- ✓ Does the robot rotate in place?
- ✓ Does the robot stop rotating in place instantly if Apriltag is detected for atleast 70 percent of the times?
- ✓ Does the robot move toward the April tag?
- ✓ Does the robot stop at 1 meter away from the Human?
- ✓ How much does the final distance deviate from 1m? **10 percent**

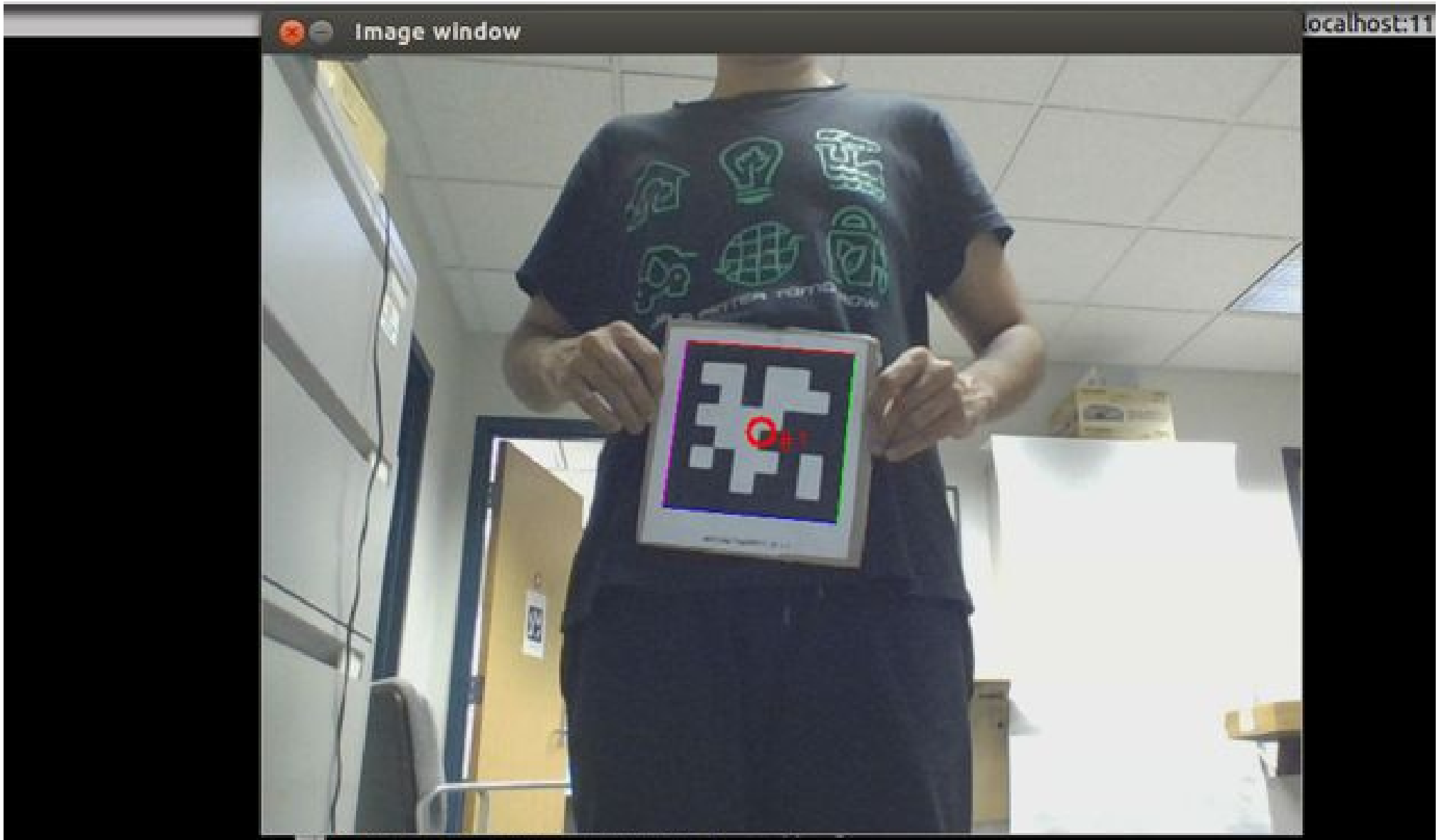


Image window
localhost:11
[INFO] [1450082718.597514776]: 96.13
[INFO] [1450082718.597619718]: Stopping turtlebot
[INFO] [1450082718.821900541]: 96.2246
[INFO] [1450082718.822005615]: Stopping turtlebot
[INFO] [1450082719.044140544]: 96.3041
[INFO] [1450082719.044244933]: Stopping turtlebot

FVE & FVE encore evaluation

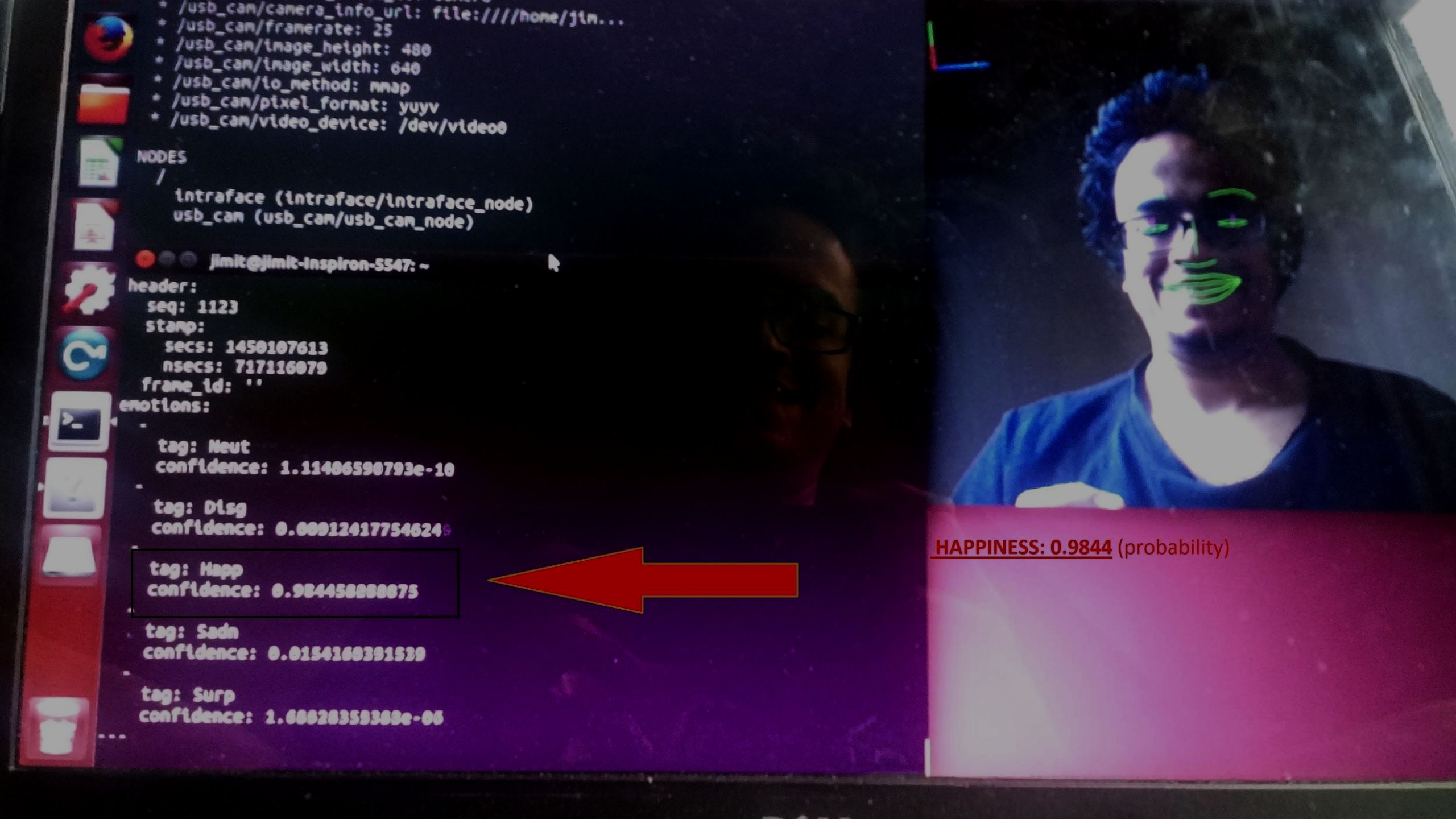
Subsystem 2: Face & Smile Expression Detection

Requirements checked

- Detect Face
- Pan tilt unit tracks the face using head pose estimate from Intraface
- Accurate smile expression detection

Testing criteria for face detection and expression detection

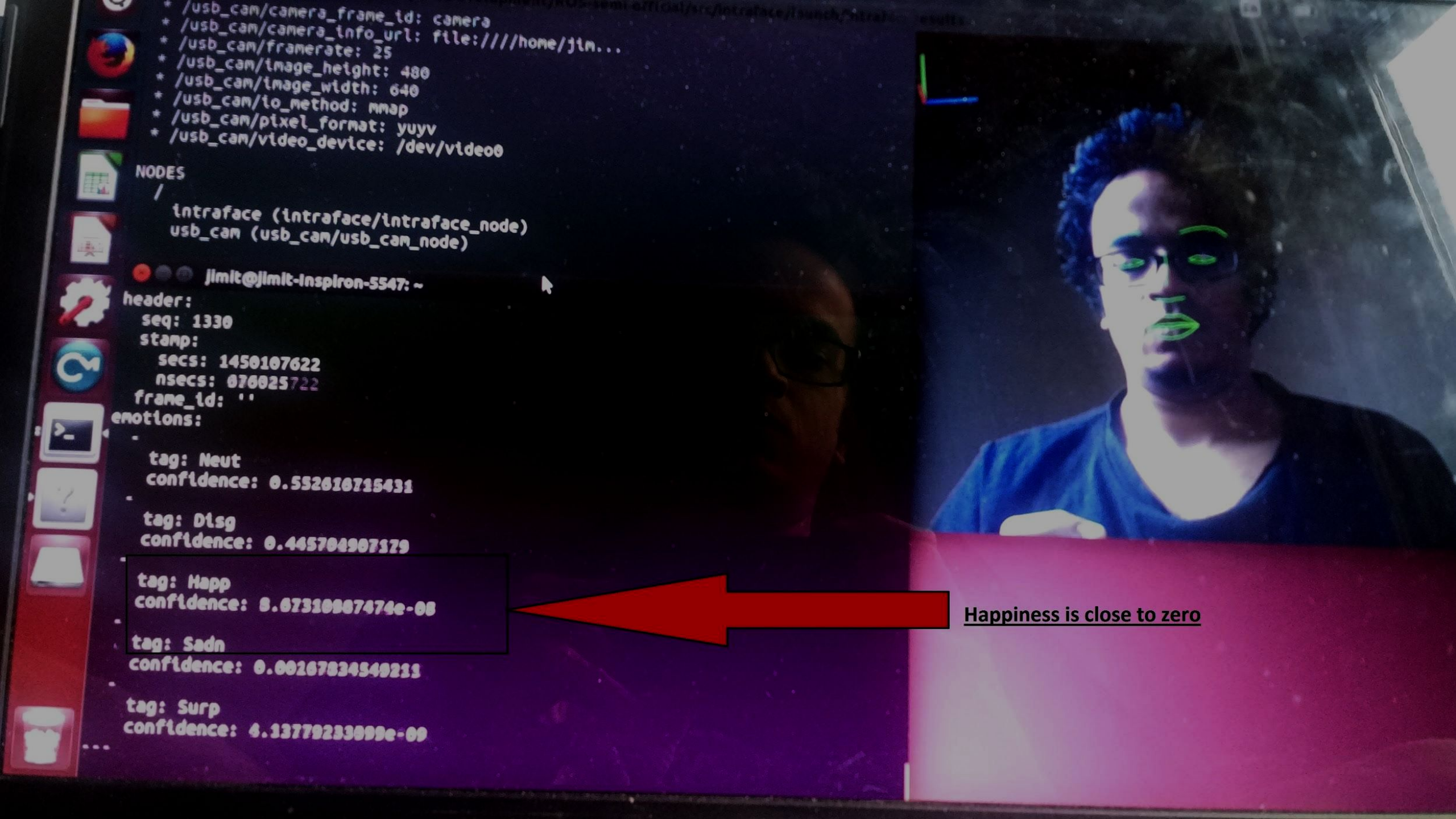
- ✔ Does Intraface detect face at least 80 percent of the time
- ✔ Does the pan tilt unit adjust itself such that face is in center of the frame?
- ✔ Do we get expression output everytime?
- ✔ Time taken to do the above task **Well Within the promised 2 seconds.**


* /usb_cam/camera_info_url: file:////home/jim...
* /usb_cam/framerate: 25
* /usb_cam/image_height: 480
* /usb_cam/image_width: 640
* /usb_cam/io_method: mmap
* /usb_cam/pixel_format: yuyv
* /usb_cam/video_device: /dev/video0
NODES
/
intraface (intraface/intraface_node)
usb_cam (usb_cam/usb_cam_node)
jimit@jimit-Inspiron-5547: ~
header:
seq: 1123
stamp:
secs: 1450107613
nsecs: 717116079
frame_id: ''
emotions:
-
tag: Neut
confidence: 1.11486590793e-10
-
tag: Disg
confidence: 0.000124177546249
-
tag: Happ
confidence: 0.984458888875
-
tag: Sadn
confidence: 0.0154160391539
-
tag: Surp
confidence: 1.68828353388e-05
...
HAPPINESS: 0.9844 (probability)

```
 * /usb_cam/camera_frame_id: camera
 * /usb_cam/camera_info_url: file:////home/jim...
 * /usb_cam/framerate: 25
 * /usb_cam/image_height: 480
 * /usb_cam/image_width: 640
 * /usb_cam/io_method: mmap
 * /usb_cam/pixel_format: yuyv
 * /usb_cam/video_device: /dev/video0

NODES
  /
    intraface (intraface/intraface_node)
    usb_cam (usb_cam/usb_cam_node)
```

```
jimit@jimit-Inspiron-5547: ~
header:
  seq: 1330
  stamp:
    secs: 1450107622
    nsecs: 076025722
  frame_id: ''
emotions:
-
  tag: Neut
  confidence: 0.552610715431
-
  tag: Disg
  confidence: 0.445704907179
-
  tag: Happ
  confidence: 8.67310887474e-08
-
  tag: Sadn
  confidence: 0.00167834549211
-
  tag: Surp
  confidence: 4.13779233899e-09
---
```



```
 * /usb_cam/image_width: 640
 * /usb_cam/io_method: mmap
 * /usb_cam/pixel_format: yuyv
 * /usb_cam/video_device: /dev/video0

NODES
  /
    intraface (intraface/intraface_node)
    usb_cam (usb_cam/usb_cam_node)
```

```
jimit@jimit-Inspiron-5547: ~
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
98, 308, 318, 330, 341, 352, 362, 353, 343, 330, 318, 307, 317, 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, 3
30, 316]
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
47, 346]
---
```

FACIAL LANDMARKS
(Green colored points in image above

System Testing
(Performance Matrix)

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

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**	**Total (>3.5 success)**
1	1	1	1	1	1	5
2	1	1	0	0	1	3
3	1	1	1	1	1	5
4	1	1	1	1	1	5
5	1	1	0	1	1	4
6	1	1	1	0	1	4
7	1	1	1	1	1	5
8	1	1	1	0	1	4
9	1	1	1	1	1	5
10	1	1	0	1	1	4

Strengths

Intraface is robust. Works well with webcam

April Tag detection subsystem is quite accurate and provides acceptable results with small errors.

Well equipped sponsor lab. 10 Turtlebots available at dispense with a plush office space. Also we had great support from the lab.

Turtlebot moves with steady speed and performs accurate turns. Also easy to calibrate and control

Project has been analyzed well in detail in terms of subsystems. Offers flexibility without changing requirements

Weakness

Less control over Intraface.

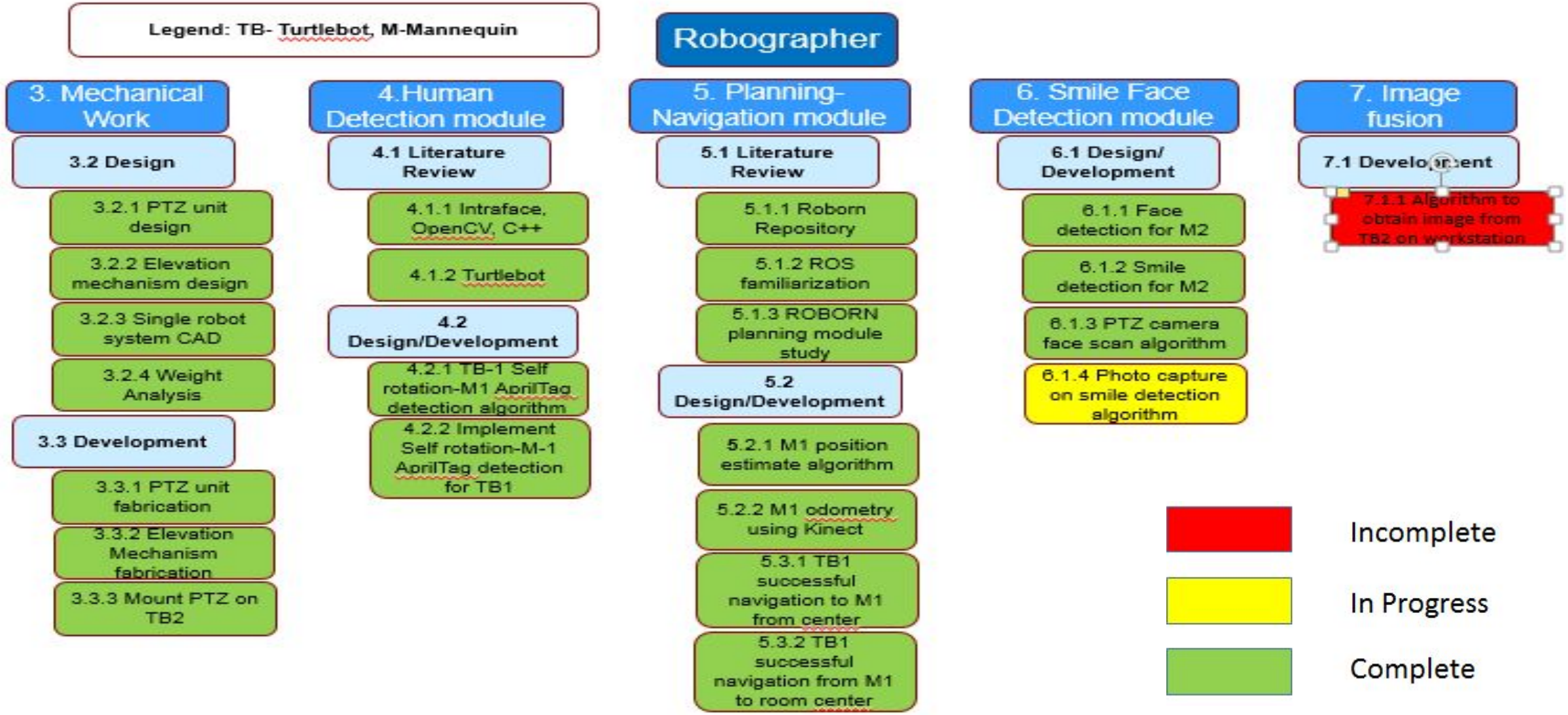
Lighting conditions can seriously affect the performance of the system

Turtlebot netbooks are excruciatingly slow. Need to replace them.

Could not complete integration because Turtlebot and Intraface work on different versions of ROS.

Project Management

Work Breakdown Structure



Project Schedule (FALL)

ID	Name	Responsibility	Start	Finish	% Completion
2	**Mechanical Work**				
2.1	Elevation Mechanism CAD design	Rohit	07-Nov-15	08-Nov-15	100
2.2	Elevation Mechanism fabrication	Rohit	08-Nov-15	10-Nov-15	100
2.3	PTZ + Elevation assembly on TB2	Rohit	11-Nov-15	11-Nov-15	100
3	**Human detection**				
3.1	Turtlebot 1 self rotation-Mannequin 1 AprilTag detction algorithm in ROS	Gauri, Jimit	09-Nov-15	15-Nov-15	100
4	**Planning and Navigation**				
4.1	Mannequin 1 position estimation algorithm	Gauri, Jimit	17-Nov-15	25-Nov-15	100
4.2	Mannequin 1 odometry using Webcam	Gauri, Jimit	25-Nov-15	28-Nov-15	100
4.3	Apriltag detection algorithm	Gauri, Jimit	28-Nov-15	30-Nov-15	100
4.4	Turtlebot 1 successful navigation to Mannequin 1 (Accurate 5 Ft distance)	Gauri, Jimit	30-Nov-15	01-Dec-15	100
5	**Smile face detection**				
5.1	Face detection using webcam & IntraFace/MATLAB for Mannequin 2	Tiffany, Sida	07-Nov-15	10-Nov-15	100
5.2	Smile Expression detection using IntraFace and Webcam for Mannequin 2	Tiffany, Sida	11-Nov-15	18-Nov-15	100
5.3	PTZ camera face scan algorithm in Arduino and Intraface	Tiffany, Sida	19-Nov-15	25-Nov-15	100

Project Schedule (FALL)

6	**Image fusion**				
6.1	Photo capture on smile detection algorithm in ROS	Tiffany, Sida	25-Nov-15	01-Nov-15	50
6.2	Algorithm to obtain image from TB2 on workstation	Jimit	03-Nov-15	10-Nov-15	0
7	**Integration**				
7.1	Integrate Human detection & Planning-navigation	Gauri, Jimit	23-Nov-15	01-Dec-15	100
7.2	PTZ unit mounting on TB1 & testing	Rohit	12-Nov-15	20-Nov-15	100
7.3	PTZ camera + Face detection algorithm	Sida, Tiffany	26-Nov-15	01-Dec-15	100

Test Plan

# PR	Task
#7	Single Robot System: Full Integration
#8	3 Robot Flock Formation
#9	SWARM navigation & Accuracy improvement
#10	Accurate SWARM self-arrangement around human (-30,0 30) deg
#11	Integration & testing of SWARM system
#12	Validate requirements and Troubleshooting

SVE

Description- Autonomous human detection by 3 robot SWARM, detect the face & expression, click a photograph if he/she is smiling.

Set-up- Three turtle bot with pan tilt camera units. One person standing in environment.

Procedure-

1. A lead turtle bot rotates in its place, detects April tag mounted on the human.
2. Sends human location to other Turtle bots
3. SWARM navigates to desired position (1 meter from Human)
4. SWARM arranges itself around human at every (-30, 0 ,30)
4. The lead Turtle bot tracks the head pose.
5. Collectively finds the expression reading of the human
6. One turtle bot with highest smile reading will click the photo
7. Photo is sent to the remote laptop workstation.

SVE

Success Scenario-

1. Successful SWARM navigation (70 % success)
2. SWARM self arrangement at (-30,0,30) deg around human (80 % success)
3. Collective smile expression detection (80 % success)
5. Click photo from best angle (more facial expression coverage) (80 % success)

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. Avoid obstacles
6. Click photos from best possible angles

Budget Status

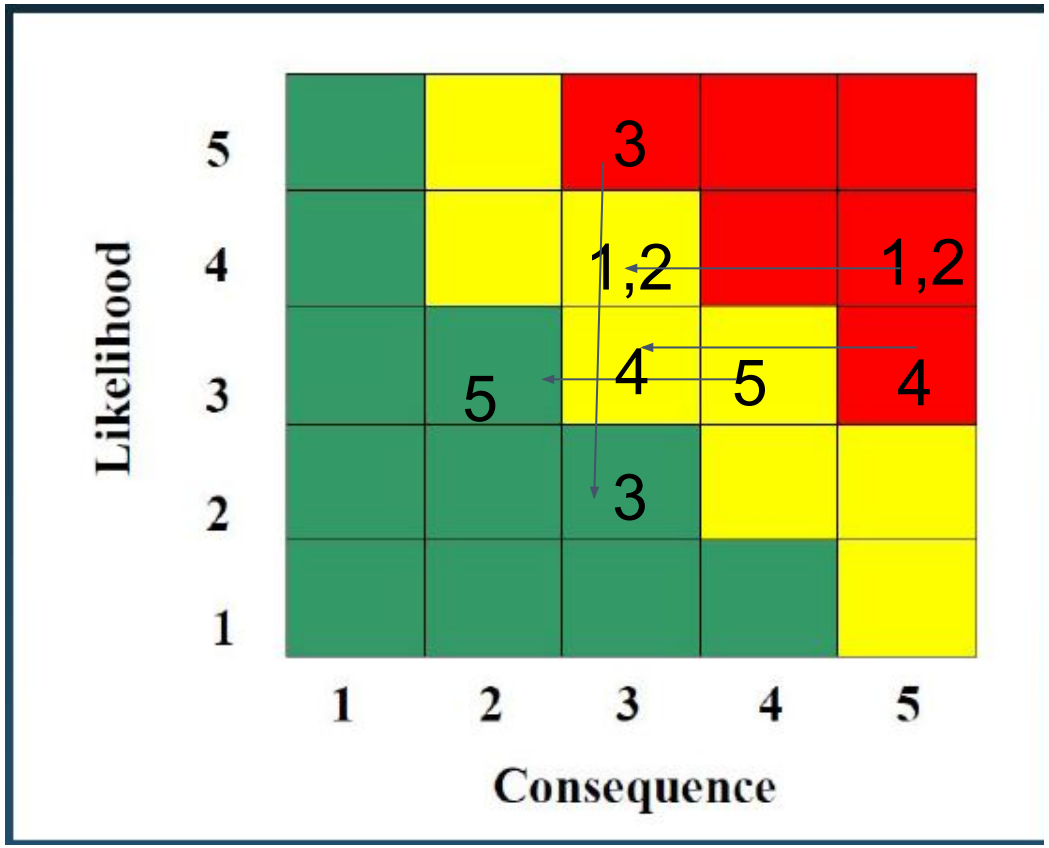
S.No.	Sub-system	Item	Obtained from	MRSD Budget used
1	Navigation	Turtlebots	Advanced Agents Lab	0
2	Mechanical	Aluminium Rods	FRC	0
3	Mechanical	Pan-tilt mounts	3D-printer (MRSD Lab)	0
4	Mechanical	Servo motors	MRSD Lab Inventory	0
5	Detection	USB Camera	Own	0
6	Detection	Intraface software	Human Sensing Lab	0
7	Detection	April Tags	Advanced Agents Lab	0
8	Detection	Arduino	MRSD Lab Inventory	0

Total Budget Used = 0 USD

Total Budget Left = 4000 USD

Overall Risk Management

Risk ID	Risk Name	Mitigation Strategy
1	Noisy detection in moving data	Make height adjustment design robust with Base Support
2	Intraface crash	Get a more stable version of Intraface for the system
3	Battery drain of Turtlebots	Request sponsors & new set of batteries
4	Single robot failure	a. Make the swarm robust to work without the non-operative robot. b. Ask sponsor & get custody of 2 extra turtlebot
5	Extra Payload	Improve design



Lessons learnt

1	Try to see the future. Find out the risks
2	Do not expect magic from day 1
3	Keep everyone on same page
4	Gel well to work well
5	Communicate
6	Do not reinvent the wheel
7	Take small steps to achieve required goals

Key Spring Activities

Short-Term Goals
Integration of all Subsystems developed in Fall
Define and implement parameters for accurate and aesthetic photo clicking
Long-Term Goals
Swarm coordination and communication
Navigation and path planning by multiple robot
Image processing of video such that input to Intraface is desired human face
Different face reorganization & Multi-face recognition

The Robographer (Video)

https://drive.google.com/open?id=0BwGrZni8EBAmXzVPNGdsMnUxVjQ

Thank you!