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Developing an experimental platform for Human Robot Interaction based on human motions

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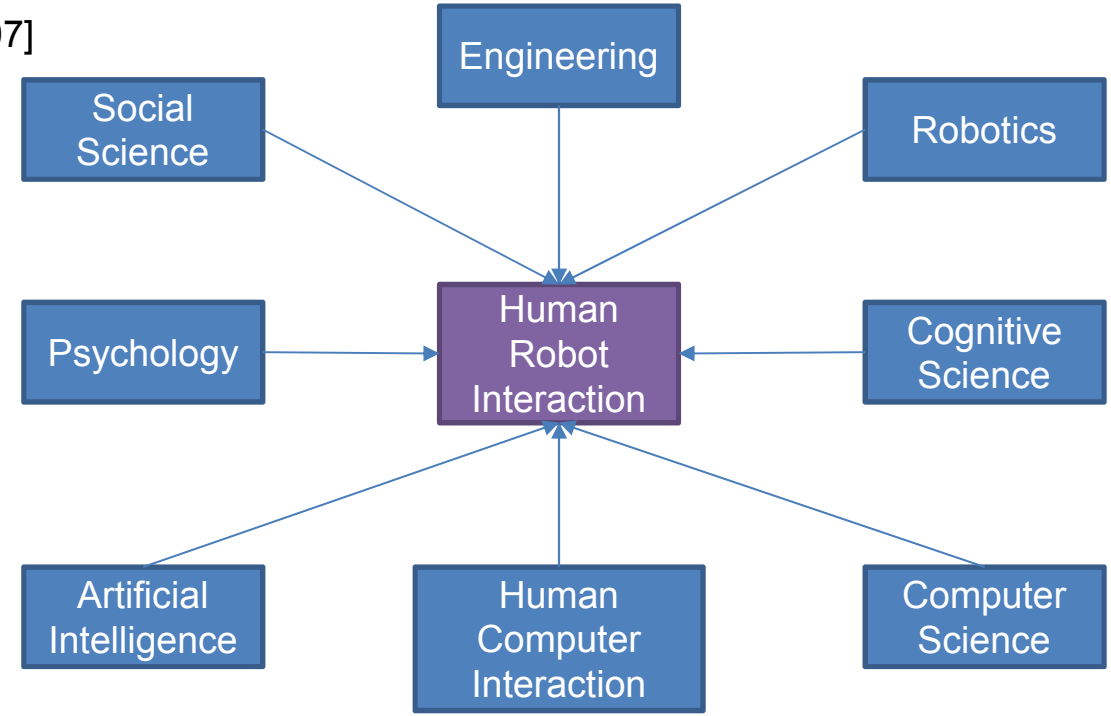
Human Robot Interaction (HRI) and Social Robots

- [Dautenhahn, 2007]



- A Social robot should have the ability to interact with humans by adhering to certain social cues and rules. [Yan et al, 2014]

Where is HRI now?

ASKNao (Autism Solution)

Nao in Education

Romeo - Physical Interaction

Juliette (Pepper) - Casual interaction

Images from Aldebaran (https://www.aldebaran.com/en)

Motivation(s)

- Humans interacting with intelligent Robots has been seen as a potential game changer in the future.

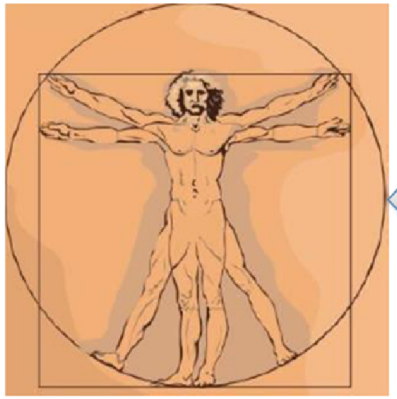
- Human motion (Non-verbal communication) is rich in information and understanding it is very important to improve the interaction.
  - Motion conveys intention, health, emotion etc.,

- Existing tools for designing HRI scenarios and robot behaviors are not scalable and requires skilled roboticists' assistance

- **Goal : To develop an experimental platform which**
  - **Facilitates interaction based on human motion**
  - **Is easy to use by a common user to design and execute interaction scenarios**

Problem Statement(s)

Interaction Scenario



Human Robot Interaction

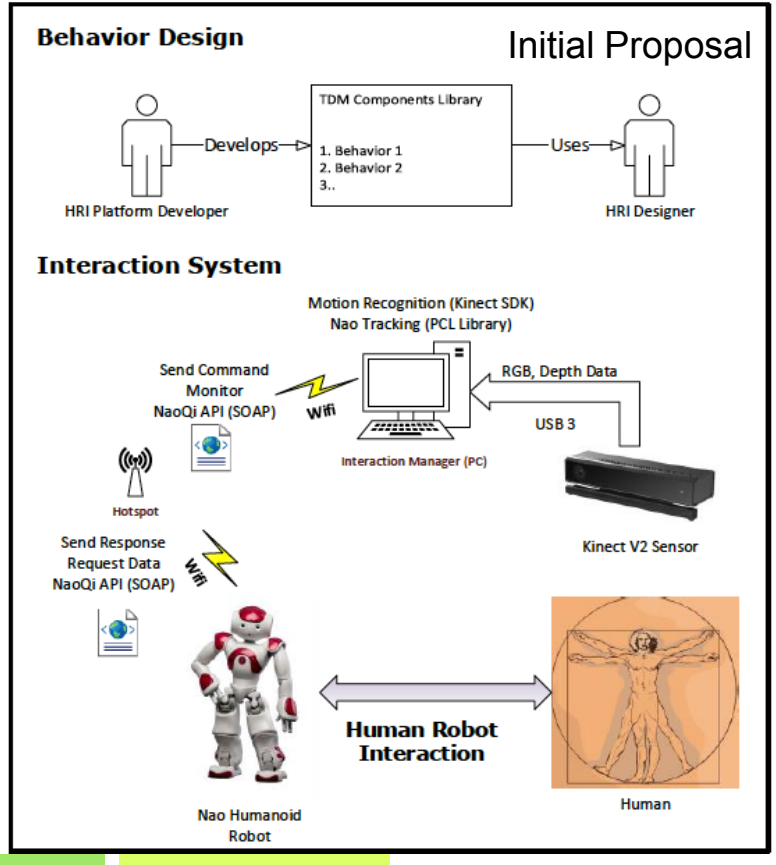
From Robot-Viewpoint:
- Where am I?
- What is the human trying to convey?
- Where is the object I have to manipulate?

HRI Platform Designer

How to
- Capture & understand Human motion?
- Localize Nao?
- Communicate Information?
- Design behaviors?

Summary on Bibliographic study

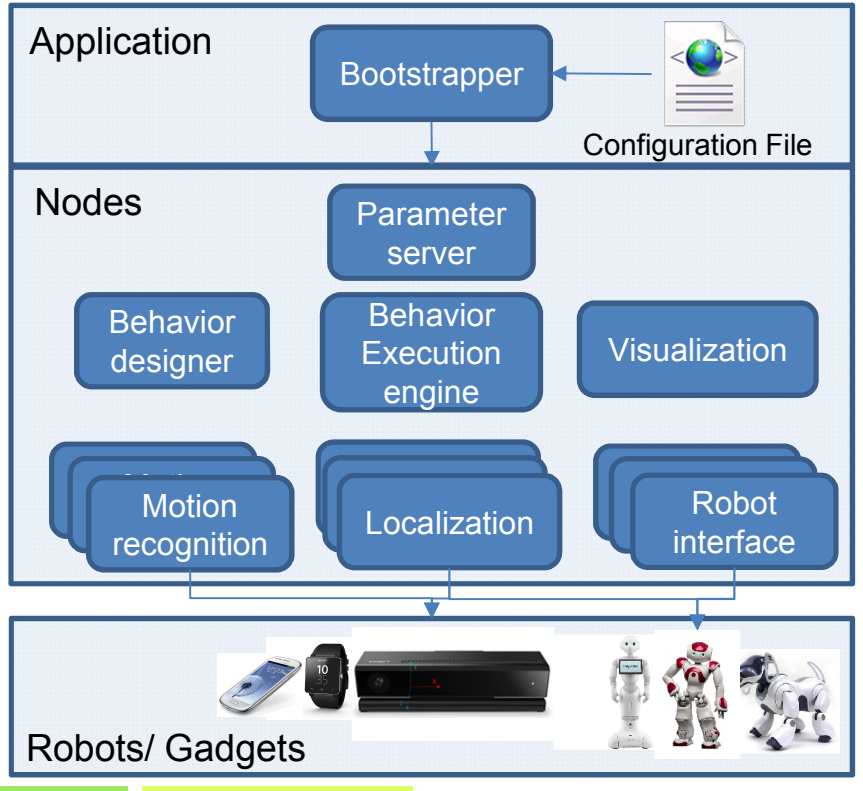
- **Motion capture**:
  - Stereophotogrammetric system, Monocular Cameras, IMU, **RGB-D Cameras** (Kinect V2)
- **Localization:**
  - **Marker based approaches**, Point cloud library algorithms (Monte carlo localization)
- **Designing behaviors:**
  - ROS, Choregraphe, Task Description Language, URBI, Microsoft Robotics Developer studio, **Target Drives Means?**
- **Evaluation techniques:**
  - **Self-assessment**, Interviews, **Behavioral measures**, Psychophysiolgy measures, Task performance metrics



Platform infrastructure design

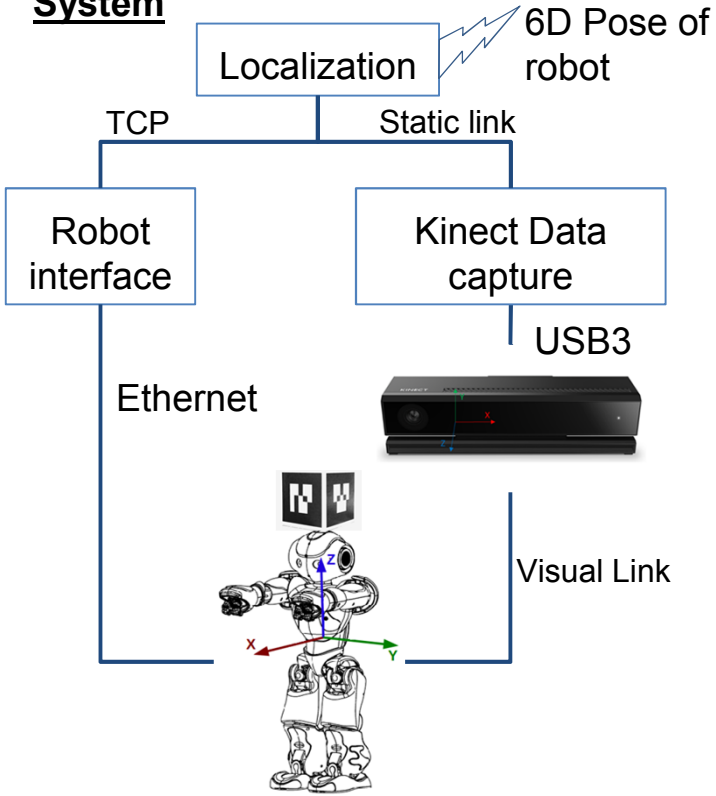
- Goals
  - Distributed nodes
    - Achieved using ZeroMQ (TCP, UDP, IPC)
    - PUB-SUB Protocol, REQ-REP protocol
  - Transparent messaging protocol that enables good interoperability
    - Google protocol buffers. Many primitive messages are imported from Gazebo
  - Visualization capability
    - OpenRAVE – Open source robotics planning / simulation framework
  - Visual Programming/ Natural language description of behaviors
    - Under investigation

- Software design concept



Robot Localization module

System



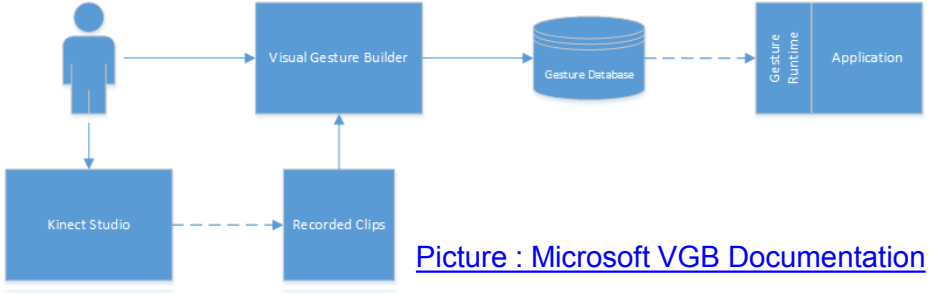
Algorithm

Data: Marker_size, Cube_size, MDH_Params
Result: TORSO_POSE

1 ***Init***:;
2 k_model := INIT_MDH_PARAM(MDH_Params);
3 m_model := MARKER_MODEL(Marker_size, Cube_size);
4 **while** *True* **do**
5 data = READ_SENSOR();
6 marker_poses = DETECT_MARKERS(data);
7 ${}^{W}T_{M}$ = TRANSFORM_TO_TOP_FRAME(marker_poses, m_model);
8 $[head_{yaw}, head_{pitch}]$ = READ_JOINT_VALUES();
9 ${}^{T}T_{M}$ = COMPUTE_TOP_FRAME(k_model, $head_{yaw}$, $head_{pitch}$);
10 ${}^{W}T_{T} = {}^{W}T_{M} \times {}^{T}T_{M}{}^{-1}$;
11 TORSO_POSE = MEDIAN_FILTER(${}^{W}T_{T}$);
12 PUBLISH(TORSO_POSE);

Motion Recognition Module

- **Kinect Visual Gesture builder work flow**



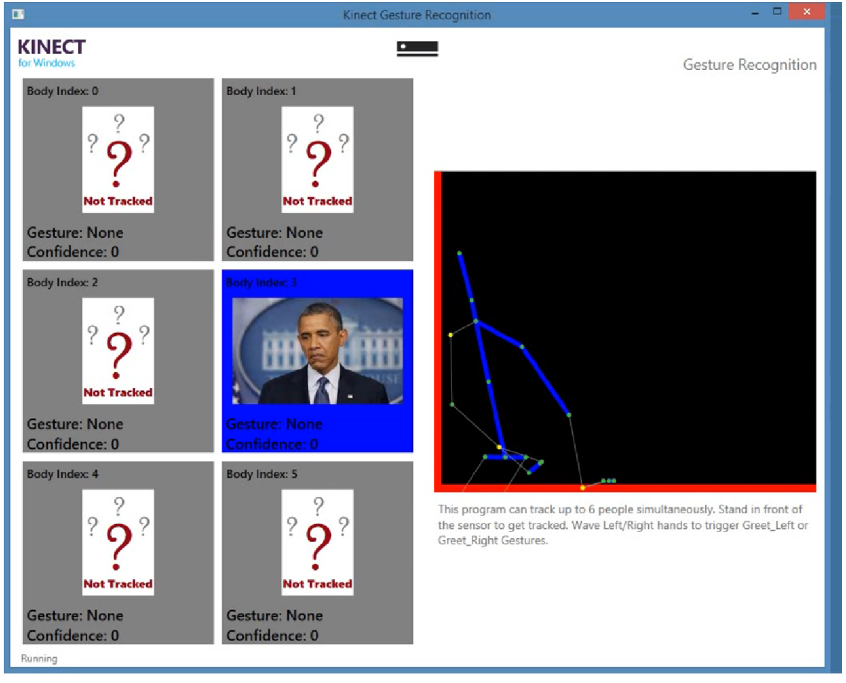
Picture : Microsoft VGB Documentation

- **Algorithm**

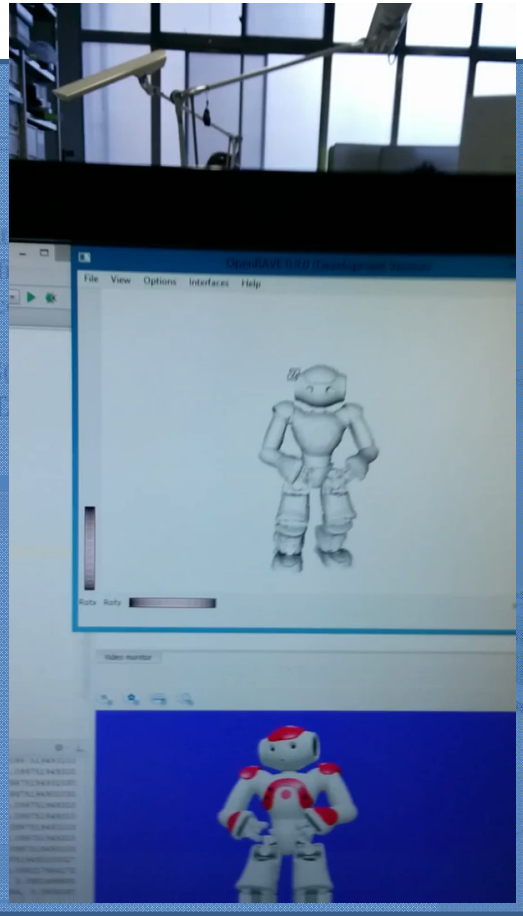
Data: Gesture database
Result: Gesture Triggers

```
1 Init:;
2   gestures = READ_DATABASE() ;
3   REGISTER_GESTURES(gestures) ;
4 while True do
5   skeletons = GET_SKELETONS() ;
6   gesture = DETECT_GESTURE() ;
7   if detected then
8     PUBLISH(gesture) ;
9   PUBLISH(skeletons) ;
```

- **Hand wave discrete gesture**

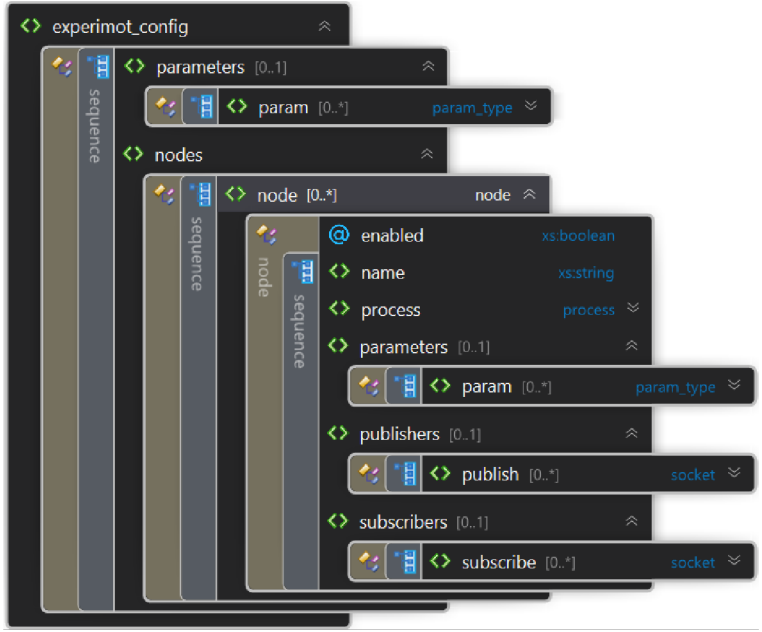


Visualization Module



Platform implementation

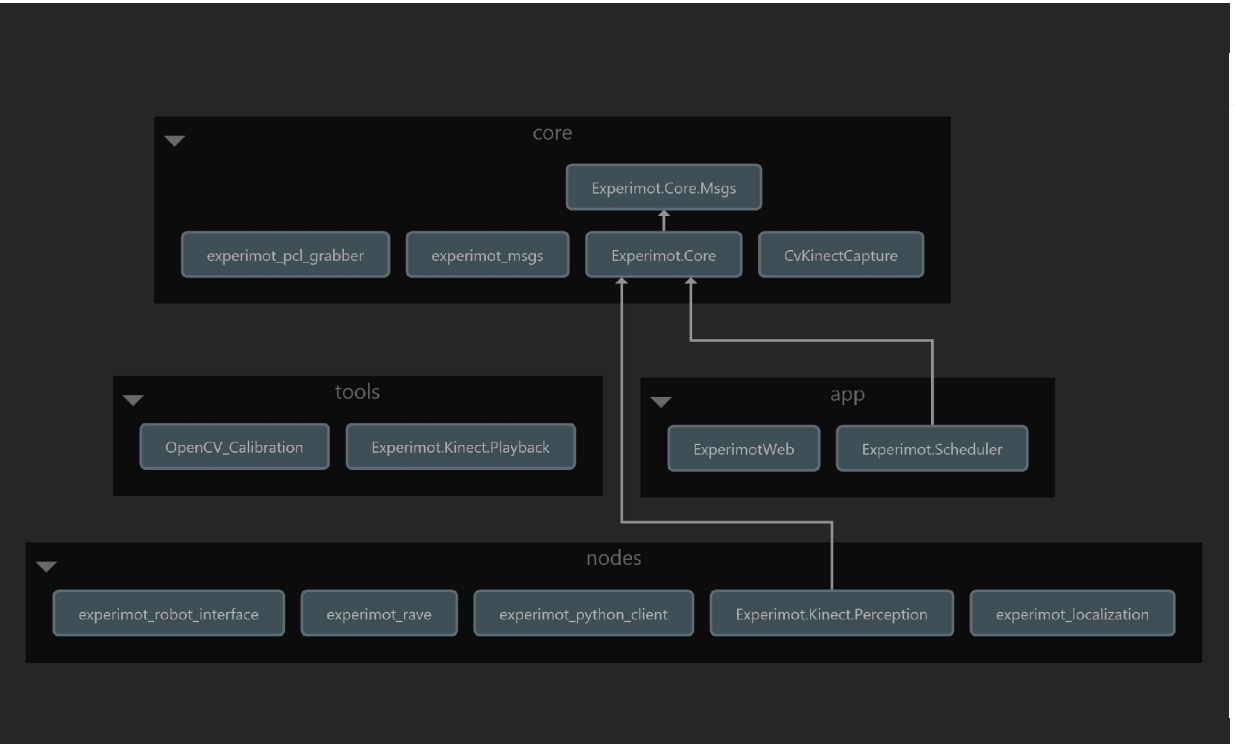
- Configuration Management



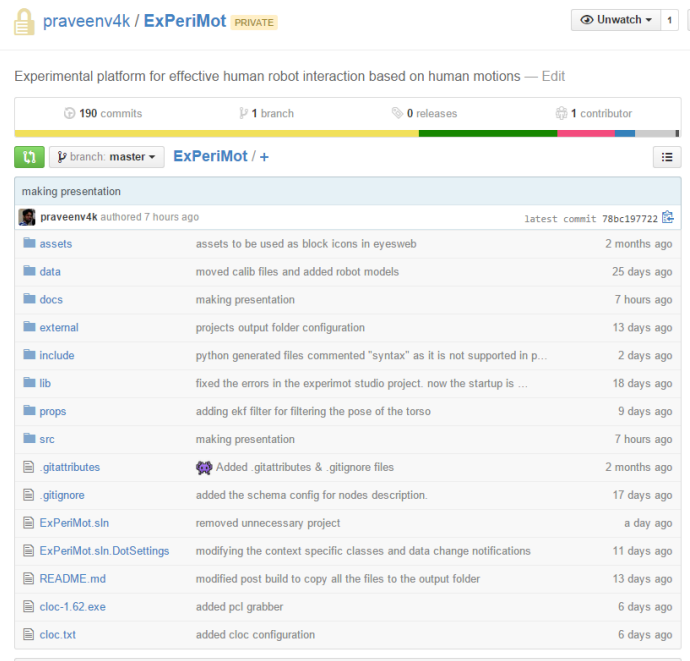
- Example node configuration

```
<node enabled="true">
  <name>gesture_recognition</name>
  <process>
    <type>executable</type>
    <path>%DEV_SDK_ROOT%\experimot\bin\nodes\Experimot.Kinect.Perception\
    <args></args>
  </process>
  <parameters>
    <param key="database" type="string" value="Database\experimot.gbd"/>
  </parameters>
  <publishers>
    <publish>
      <host>tcp://*</host>
      <port>5570</port>
      <topic>KSP</topic>
      <msg_type>KinectBodies</msg_type>
      <name>KinectBodyPublisher</name>
    </publish>
  </publishers>
</node>
```

Platform implementation contd.,



Source Code



https://github.com/praveenv4k/ExPeriMot

TO-DO List

- Improvement of Pose estimation of marker
  - Some times the Z-Axis of the detected markers is inward instead of outward
    - Possible solution: Check the detected frame is right handed/left handed?
- Collaborate with Mr. Vincent Berenz to use TDM framework for behavior execution
- Improve the data structure that contains the description of the world
- Natural Language representation and translation of high level representation into gesture triggers and robot behaviors
  - Example: "**When some one waves their hand, respond by waving hands**"
    - Gestures Trigger : Hand waving
    - Robot behavior : Say hello behavior
- Develop an easy to use interface for designing behaviors using high level language
- Designing concrete scenarios and evaluate (Receptionist, Exercise cheer leader)