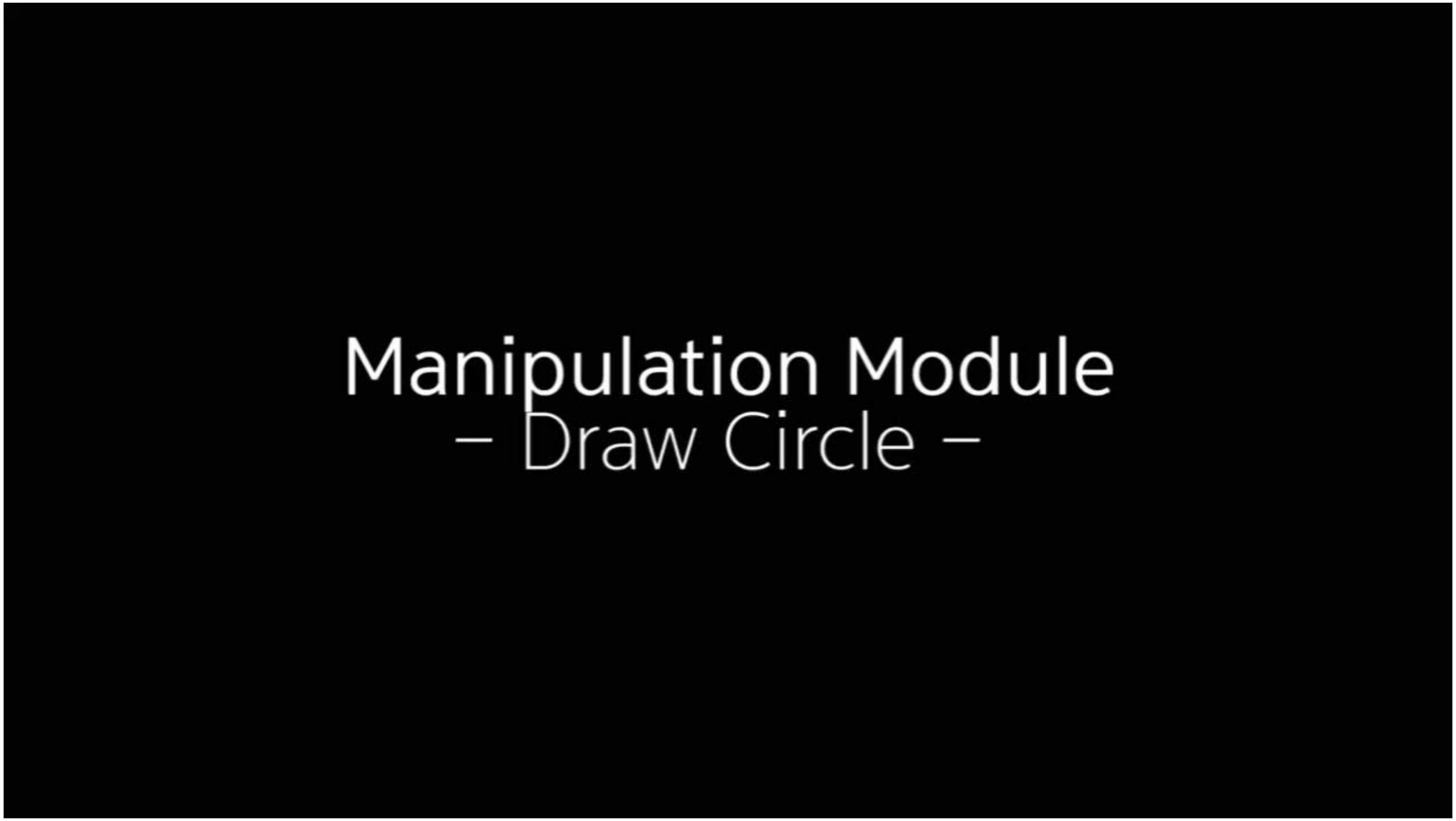
ROS Framework Tutorial

Manipulation Module

Manipulation Demonstration



Manipulation Module

– Draw Circle –

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1. **Background**
    1. Kinematics
    2. Motion Planning
2. **Manipulation Module**
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    2. ROS Topic List
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3. **GUI Example**
    1. Joint Space Control
    2. Task Space Control

Background

Background

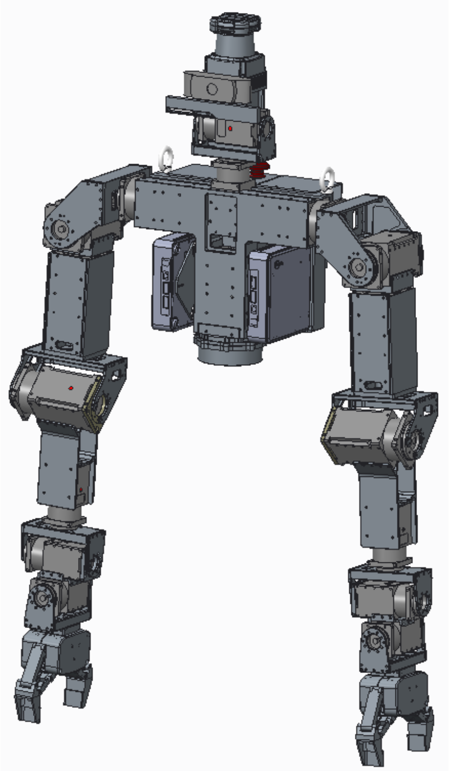
CONTENTS

1. **Kinematics**
   - Kinematics Tree Structure
   - Forward Kinematics
   - Inverse Kinematics
2. **Motion Planning**
   - Trajectory Interpolation

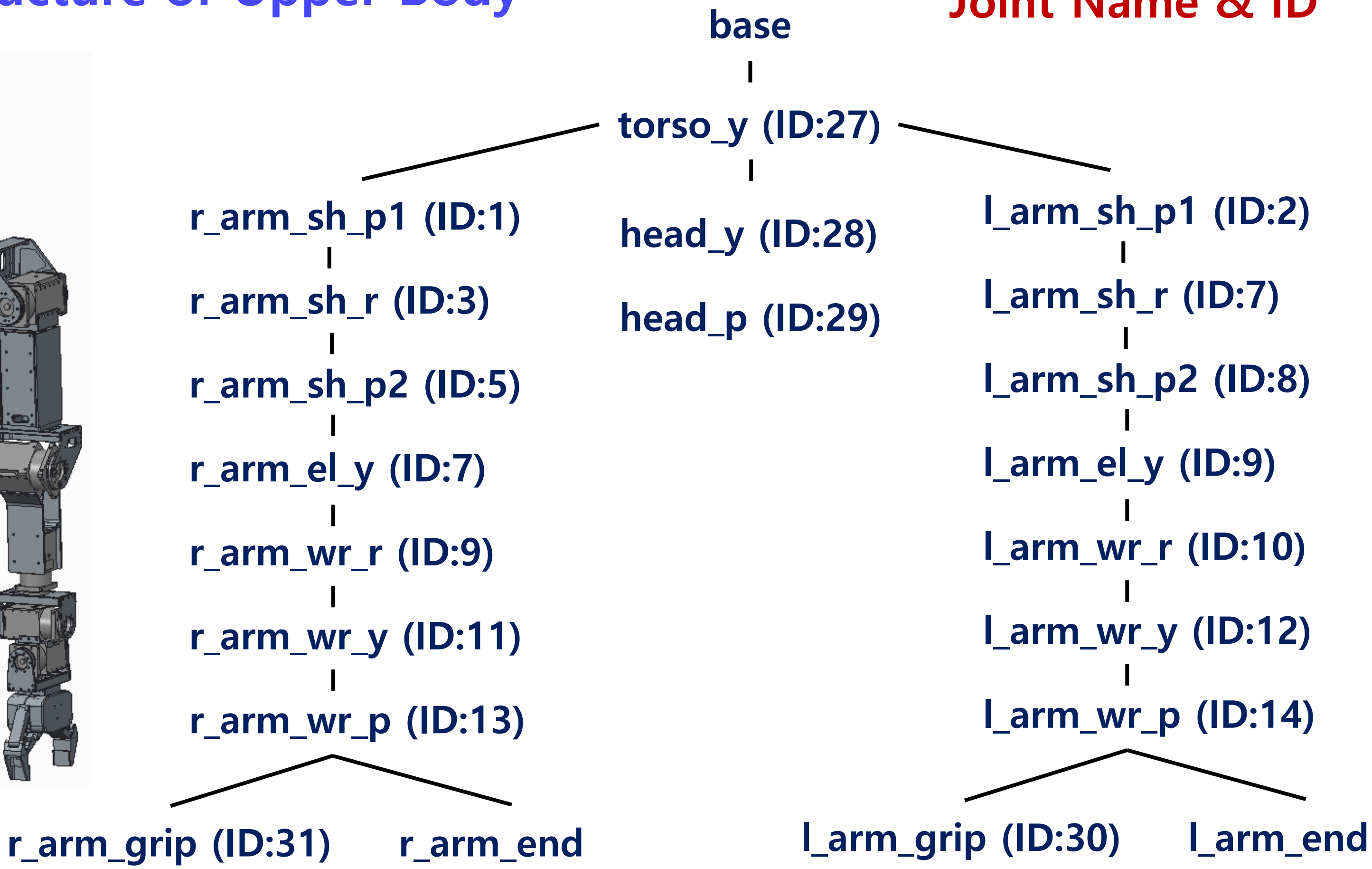
Background

1. Kinematics

- **Tree Structure of Upper Body**



Joint Name & ID



base

torso_y (ID:27)

r_arm_sh_p1 (ID:1)

r_arm_sh_r (ID:3)

r_arm_sh_p2 (ID:5)

r_arm_el_y (ID:7)

r_arm_wr_r (ID:9)

r_arm_wr_y (ID:11)

r_arm_wr_p (ID:13)

r_arm_grip (ID:31)

r_arm_end

head_y (ID:28)

head_p (ID:29)

l_arm_sh_p1 (ID:2)

l_arm_sh_r (ID:7)

l_arm_sh_p2 (ID:8)

l_arm_el_y (ID:9)

l_arm_wr_r (ID:10)

l_arm_wr_y (ID:12)

l_arm_wr_p (ID:14)

l_arm_grip (ID:30)

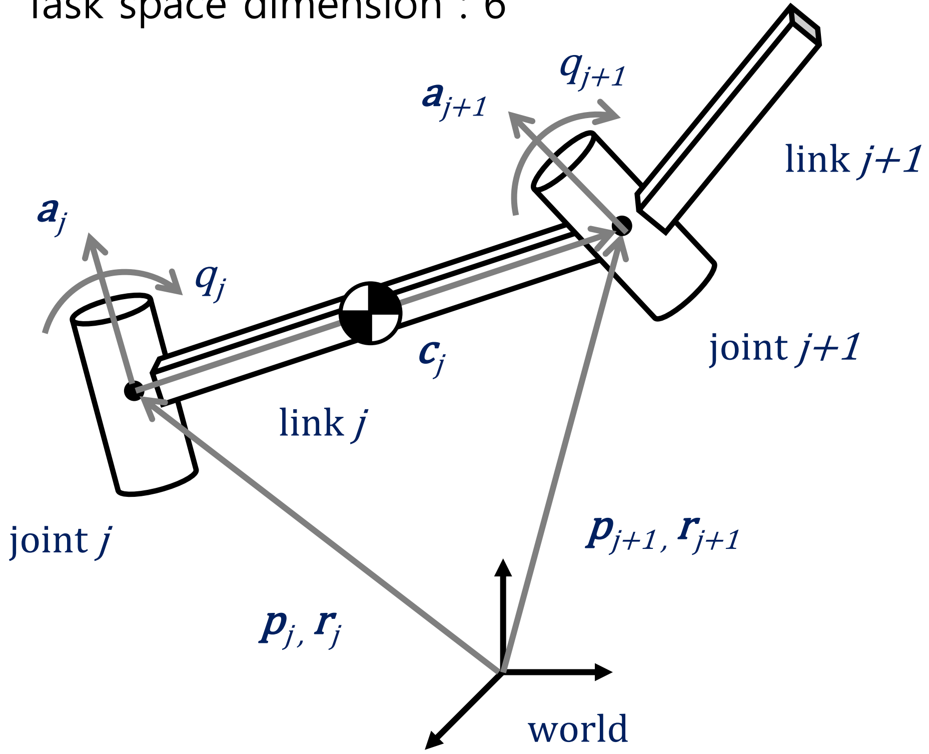
l_arm_end

ROBOTIS

1. Kinematics

Forward Kinematics

- Transformation from joint space to task space information (from chain rule).
- Thormang's arm (joint space) dimension : 7
- Task space dimension : 6



a : joint axis vector

Joint space information

q : joint angle

Task space information

p :position vector (3-DOF)

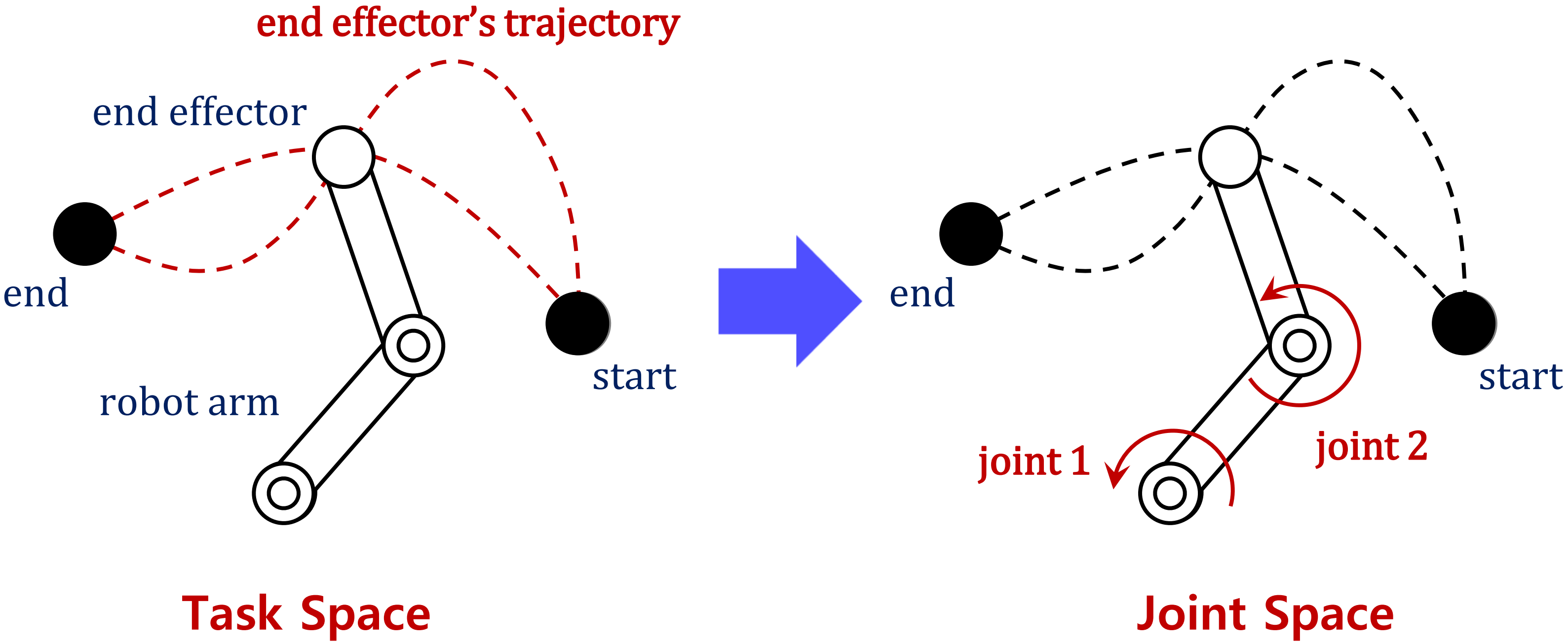
r : orientation vector (3-DOF)

c : center of mass vector

Background

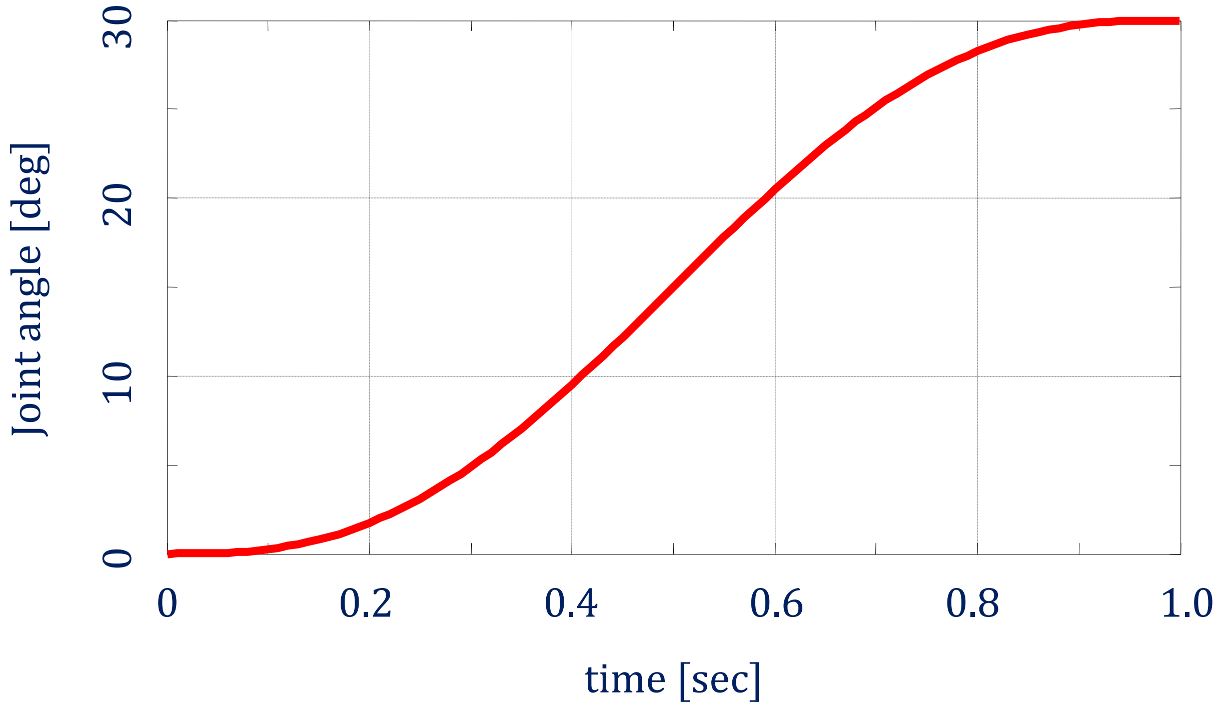
1. Kinematics

- Inverse Kinematics
  - Transformation from task space to joint space information
  - Redundancy problem has to be considered
    (thormang's arm dimension : 7 > task space dimension : 6)



2. Motion Planning

- **Trajectory Interpolation**
  - It is necessary to generate smooth path to connect from start to end.
  - For example, we use **minimum jerk trajectory**
    that can be formulated as fifth-order polynomial.



Manipulation Module

Manipulation Module

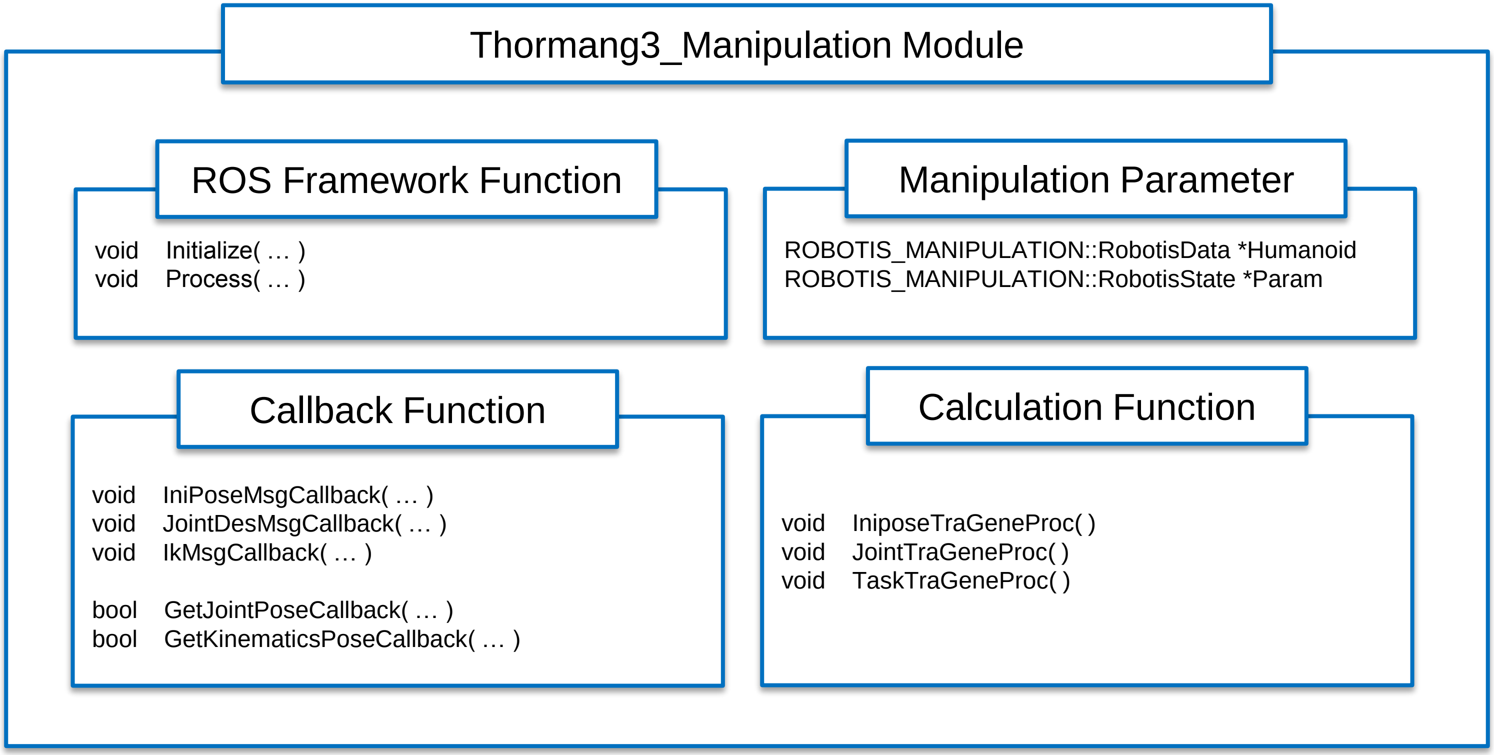
CONTENTS

1. Overview
   - Structure
   - Files
2. Topic List
3. Programming Example
   - Structure
   - Write desired joint angle
   - Write desired end effector’s pose

Manipulation Module

1. Overview

- Structure



Thormang3_Manipulation Module

ROS Framework Function

```
void    Initialize( … )
void    Process( … )
```

Manipulation Parameter

```
ROBOTIS_MANIPULATION::RobotisData *Humanoid
ROBOTIS_MANIPULATION::RobotisState *Param
```

Callback Function

```
void    IniPoseMsgCallback( … )
void    JointDesMsgCallback( … )
void    IkMsgCallback( … )

bool    GetJointPoseCallback( … )
bool    GetKinematicsPoseCallback( … )
```

Calculation Function

```
void    IniposeTraGeneProc( )
void    JointTraGeneProc( )
void    TaskTraGeneProc( )
```

Manipulation Module

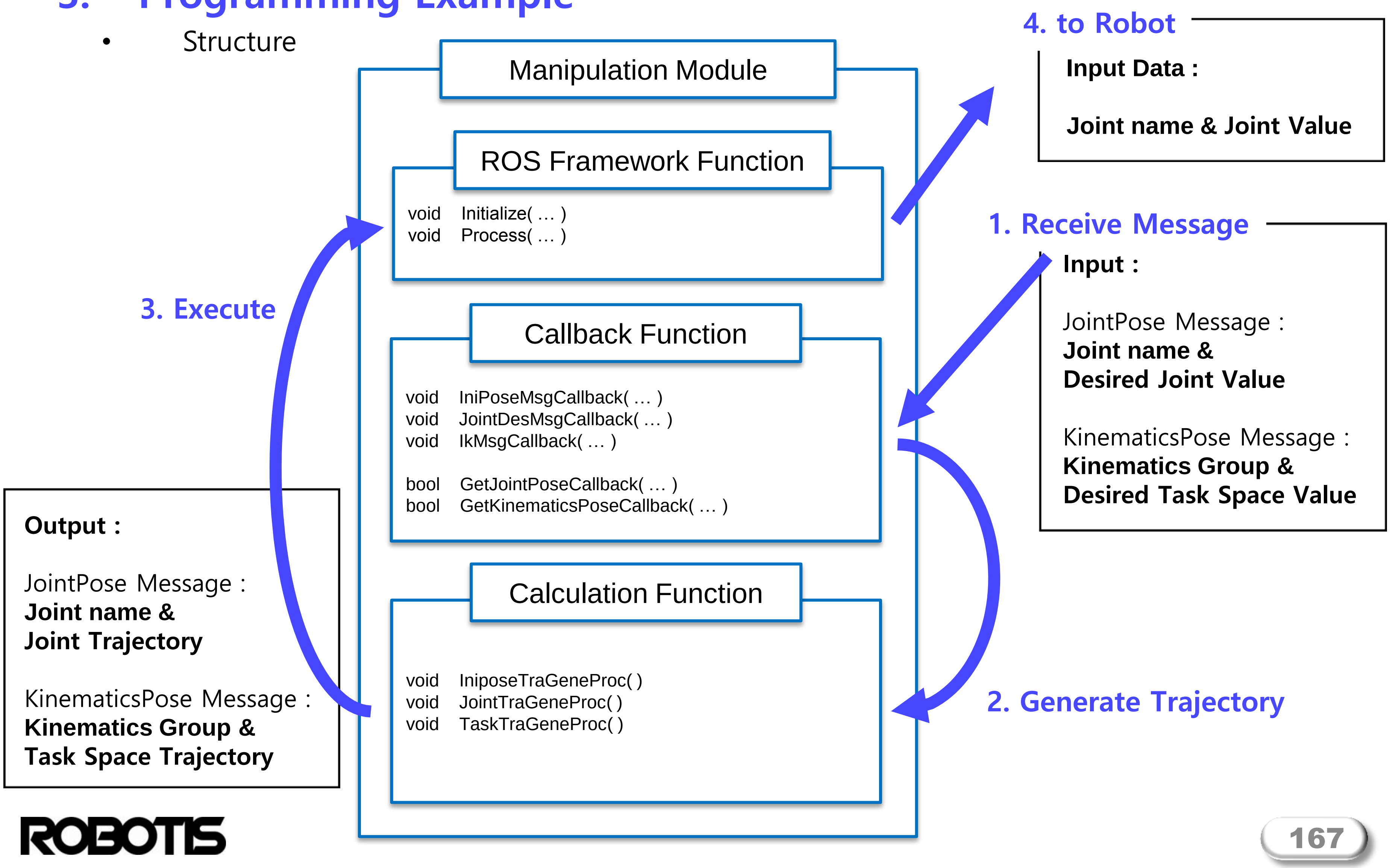
2. Topic List

	Name		Description
Topic (Subscribe)	/robotis/manipulation/ini_pose_msg		command for moving to initial pose
	/robotis/manipulation/des_joint_msg		command for writing desired angle
	/robotis/manipulation/ik_msg		command for writing desired end effector’s pose
Service (Server)	/robotis/manipulation/get_joint_pose	req	name for user specified joint
		res	current angle if user specified joint
	/robotis/manipulation/get_kinematics_pose	req	name for user specified group
		res	current pose for user specified group

Programming Guide

3. Programming Example

- Structure



Manipulation Module

ROS Framework Function

```
void   Initialize( … )
void   Process( … )
```

Callback Function

```
void   IniPoseMsgCallback( … )
void   JointDesMsgCallback( … )
void   IkMsgCallback( … )

bool   GetJointPoseCallback( … )
bool   GetKinematicsPoseCallback( … )
```

Calculation Function

```
void   IniposeTraGeneProc( )
void   JointTraGeneProc( )
void   TaskTraGeneProc( )
```

1. Receive Message

Input :

JointPose Message :
Joint name &
Desired Joint Value

KinematicsPose Message :
Kinematics Group &
Desired Task Space Value

2. Generate Trajectory

3. Execute

Output :

JointPose Message :
Joint name &
Joint Trajectory

KinematicsPose Message :
Kinematics Group &
Task Space Trajectory

4. to Robot

Input Data :

Joint name & Joint Value

ROBOTIS

Manipulation Module

3. Programming Example

- Write desired joint angle

  - **Receive msg (** JointDesMsgCallback(…) **)**

```
thormang3_manipulation_module_msgs::JointPose msg;
msg.name = "joint_name";
msg.value = joint_value;(desired joint angle in rad)
```

  - **Generate trajectory (** JointTraGeneProc(…) **)**
    - ✓ ROBOTIS_MANIPULATION::minimum_jerk_tra
    - ✓ Is_moving = true

  - **Execute (** Process(…) **)**

Manipulation Module

3. Programming Example

- Write desired end effector's pose

- **Receive msg (** IkMsgCallback (…) **)**

```
thormang3_manipulation_module_msgs::KinematicsPose msg;
msg.pose.name = "group_name"
msg.pose.position.x = … ;
msg.pose.position.y = … ;
msg.pose.position.z = … ;
msg.pose.orientation.w = … ;
msg.pose.orientation.x = … ;
msg.pose.orientation.y = … ;
msg.pose.orientation.z = … ;
```

- **Generate Trajectory (** TaskTraGeneProc(…))

✓ ROBOTIS_MANIPULATION::minimum_jerk_tra

✓ is_moving = true

✓ ik_solve = true

- **Execute** (Process(…) **)**
  - set_inversekinematics( )
  - solve_inversekinematics( )

GUI Example

GUI Example

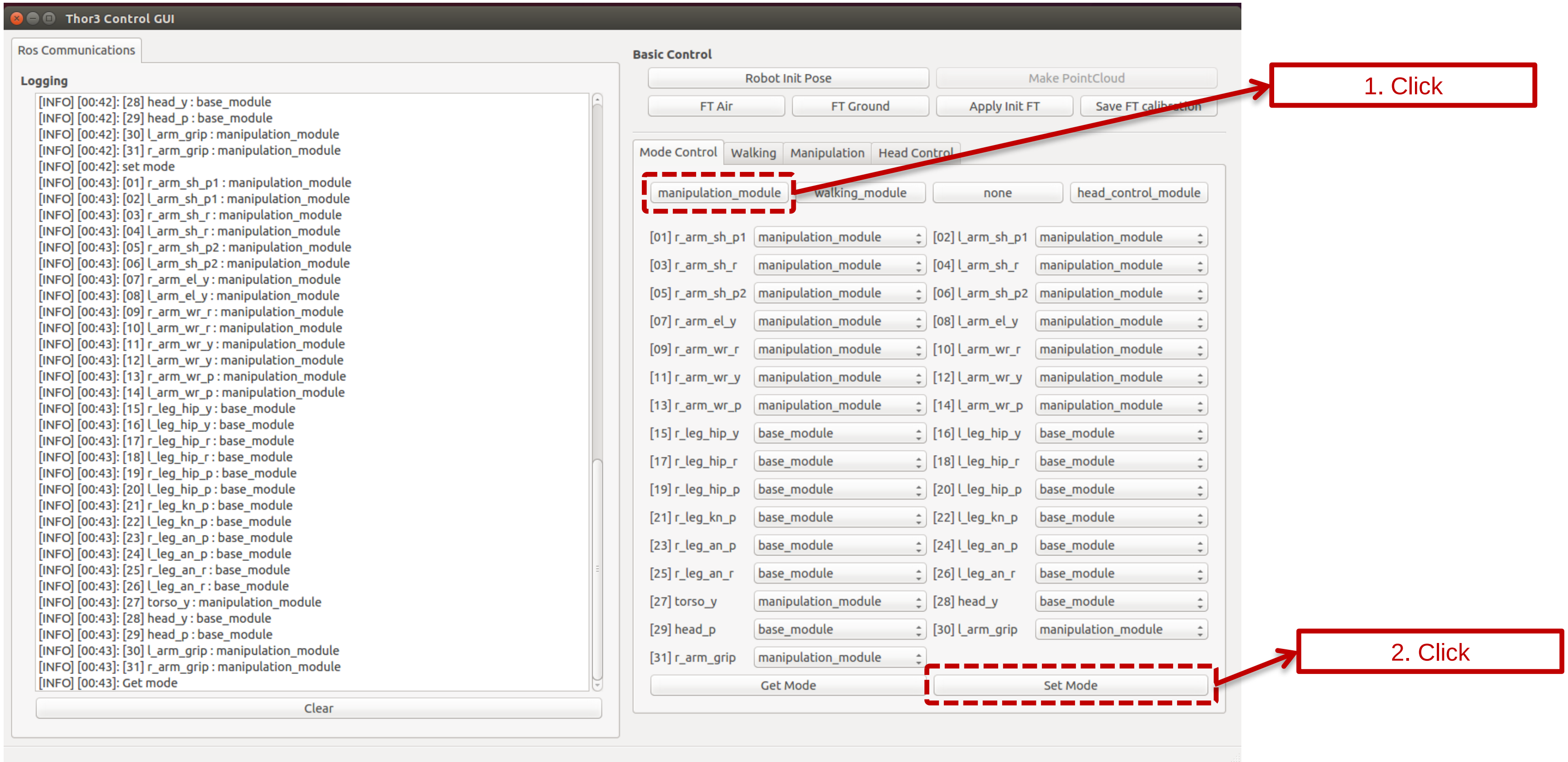
CONTENTS

1. Initialization
2. Joint Space Control
   - Go to manipulation initial pose
   - Read present joint angle
   - Write desired joint angle
3. Task Space Control
   - Read present end effector’s pose (Forward Kinematics)
   - Write desired end effector’s pose (Inverse Kinematics)
4. Manipulatoin Demonstration
   - Line Trajectory
   - Circle Trajectory
   - Gripper On/Off

GUI Example

1. Initialization

- Set manipulation module



```
[INFO] [00:42]: [28] head_y : base_module
[INFO] [00:42]: [29] head_p : base_module
[INFO] [00:42]: [30] l_arm_grip : manipulation_module
[INFO] [00:42]: [31] r_arm_grip : manipulation_module
[INFO] [00:42]: set mode
[INFO] [00:43]: [01] r_arm_sh_p1 : manipulation_module
[INFO] [00:43]: [02] l_arm_sh_p1 : manipulation_module
[INFO] [00:43]: [03] r_arm_sh_r : manipulation_module
[INFO] [00:43]: [04] l_arm_sh_r : manipulation_module
[INFO] [00:43]: [05] r_arm_sh_p2 : manipulation_module
[INFO] [00:43]: [06] l_arm_sh_p2 : manipulation_module
[INFO] [00:43]: [07] r_arm_el_y : manipulation_module
[INFO] [00:43]: [08] l_arm_el_y : manipulation_module
[INFO] [00:43]: [09] r_arm_wr_r : manipulation_module
[INFO] [00:43]: [10] l_arm_wr_r : manipulation_module
[INFO] [00:43]: [11] r_arm_wr_y : manipulation_module
[INFO] [00:43]: [12] l_arm_wr_y : manipulation_module
[INFO] [00:43]: [13] r_arm_wr_p : manipulation_module
[INFO] [00:43]: [14] l_arm_wr_p : manipulation_module
[INFO] [00:43]: [15] r_leg_hip_y : base_module
[INFO] [00:43]: [16] l_leg_hip_y : base_module
[INFO] [00:43]: [17] r_leg_hip_r : base_module
[INFO] [00:43]: [18] l_leg_hip_r : base_module
[INFO] [00:43]: [19] r_leg_hip_p : base_module
[INFO] [00:43]: [20] l_leg_hip_p : base_module
[INFO] [00:43]: [21] r_leg_kn_p : base_module
[INFO] [00:43]: [22] l_leg_kn_p : base_module
[INFO] [00:43]: [23] r_leg_an_p : base_module
[INFO] [00:43]: [24] l_leg_an_p : base_module
[INFO] [00:43]: [25] r_leg_an_r : base_module
[INFO] [00:43]: [26] l_leg_an_r : base_module
[INFO] [00:43]: [27] torso_y : manipulation_module
[INFO] [00:43]: [28] head_y : base_module
[INFO] [00:43]: [29] head_p : base_module
[INFO] [00:43]: [30] l_arm_grip : manipulation_module
[INFO] [00:43]: [31] r_arm_grip : manipulation_module
[INFO] [00:43]: Get mode
```

[01] r_arm_sh_p1	manipulation_module	[02] l_arm_sh_p1	manipulation_module
[03] r_arm_sh_r	manipulation_module	[04] l_arm_sh_r	manipulation_module
[05] r_arm_sh_p2	manipulation_module	[06] l_arm_sh_p2	manipulation_module
[07] r_arm_el_y	manipulation_module	[08] l_arm_el_y	manipulation_module
[09] r_arm_wr_r	manipulation_module	[10] l_arm_wr_r	manipulation_module
[11] r_arm_wr_y	manipulation_module	[12] l_arm_wr_y	manipulation_module
[13] r_arm_wr_p	manipulation_module	[14] l_arm_wr_p	manipulation_module
[15] r_leg_hip_y	base_module	[16] l_leg_hip_y	base_module
[17] r_leg_hip_r	base_module	[18] l_leg_hip_r	base_module
[19] r_leg_hip_p	base_module	[20] l_leg_hip_p	base_module
[21] r_leg_kn_p	base_module	[22] l_leg_kn_p	base_module
[23] r_leg_an_p	base_module	[24] l_leg_an_p	base_module
[25] r_leg_an_r	base_module	[26] l_leg_an_r	base_module
[27] torso_y	manipulation_module	[28] head_y	base_module
[29] head_p	base_module	[30] l_arm_grip	manipulation_module
[31] r_arm_grip	manipulation_module		

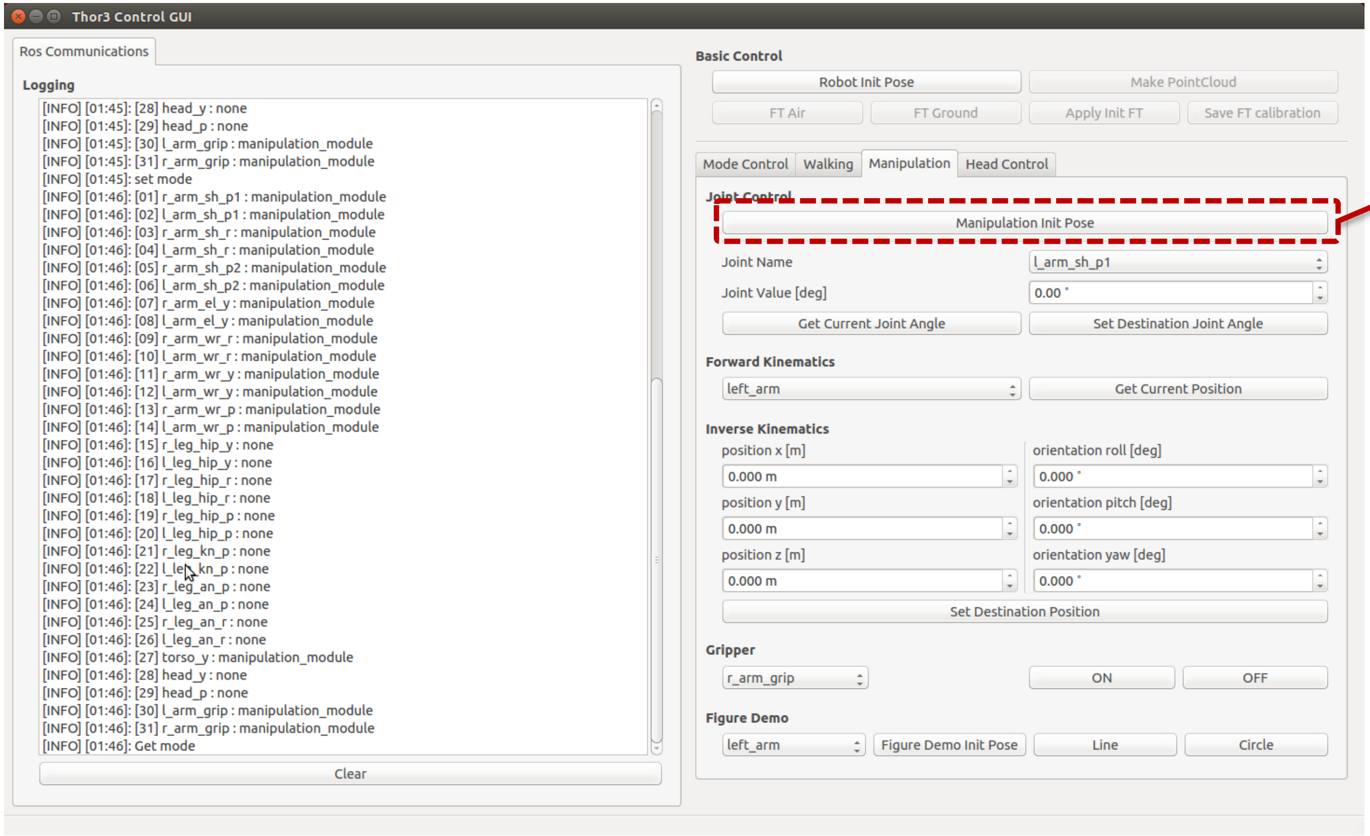
1. Click

2. Click

GUI Example

2. Joint Space Control

- Go to manipulation initial pose



Logging

```
[INFO] [01:45]: [28] head_y : none
[INFO] [01:45]: [29] head_p : none
[INFO] [01:45]: [30] l_arm_grip : manipulation_module
[INFO] [01:45]: [31] r_arm_grip : manipulation_module
[INFO] [01:45]: set mode
[INFO] [01:46]: [01] r_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [02] l_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [03] r_arm_sh_r : manipulation_module
[INFO] [01:46]: [04] l_arm_sh_r : manipulation_module
[INFO] [01:46]: [05] r_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [06] l_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [07] r_arm_el_y : manipulation_module
[INFO] [01:46]: [08] l_arm_el_y : manipulation_module
[INFO] [01:46]: [09] r_arm_wr_r : manipulation_module
[INFO] [01:46]: [10] l_arm_wr_r : manipulation_module
[INFO] [01:46]: [11] r_arm_wr_y : manipulation_module
[INFO] [01:46]: [12] l_arm_wr_y : manipulation_module
[INFO] [01:46]: [13] r_arm_wr_p : manipulation_module
[INFO] [01:46]: [14] l_arm_wr_p : manipulation_module
[INFO] [01:46]: [15] r_leg_hip_y : none
[INFO] [01:46]: [16] l_leg_hip_y : none
[INFO] [01:46]: [17] r_leg_hip_r : none
[INFO] [01:46]: [18] l_leg_hip_r : none
[INFO] [01:46]: [19] r_leg_hip_p : none
[INFO] [01:46]: [20] l_leg_hip_p : none
[INFO] [01:46]: [21] r_leg_kn_p : none
[INFO] [01:46]: [22] l_leg_kn_p : none
[INFO] [01:46]: [23] r_leg_an_p : none
[INFO] [01:46]: [24] l_leg_an_p : none
[INFO] [01:46]: [25] r_leg_an_r : none
[INFO] [01:46]: [26] l_leg_an_r : none
[INFO] [01:46]: [27] torso_y : manipulation_module
[INFO] [01:46]: [28] head_y : none
[INFO] [01:46]: [29] head_p : none
[INFO] [01:46]: [30] l_arm_grip : manipulation_module
[INFO] [01:46]: [31] r_arm_grip : manipulation_module
[INFO] [01:46]: Get mode
```

Joint Name: l_arm_sh_p1

Joint Value [deg]: 0.00 °

Forward Kinematics: left_arm

position x [m]: 0.000 m

orientation roll [deg]: 0.000 °

position y [m]: 0.000 m

orientation pitch [deg]: 0.000 °

position z [m]: 0.000 m

orientation yaw [deg]: 0.000 °

Gripper: r_arm_grip

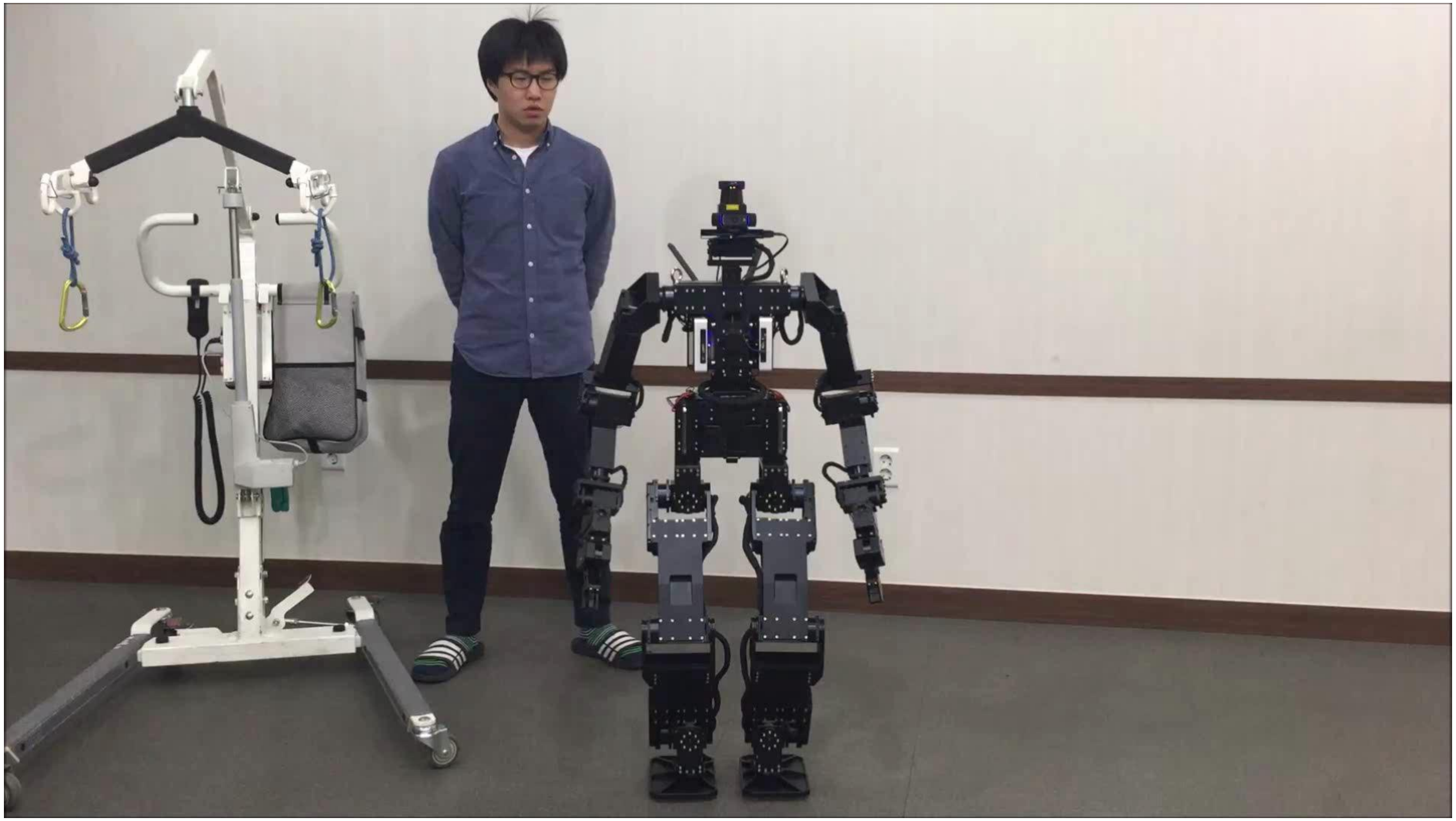
Figure Demo: left_arm

1. Click

GUI Example

2. Joint Space Control

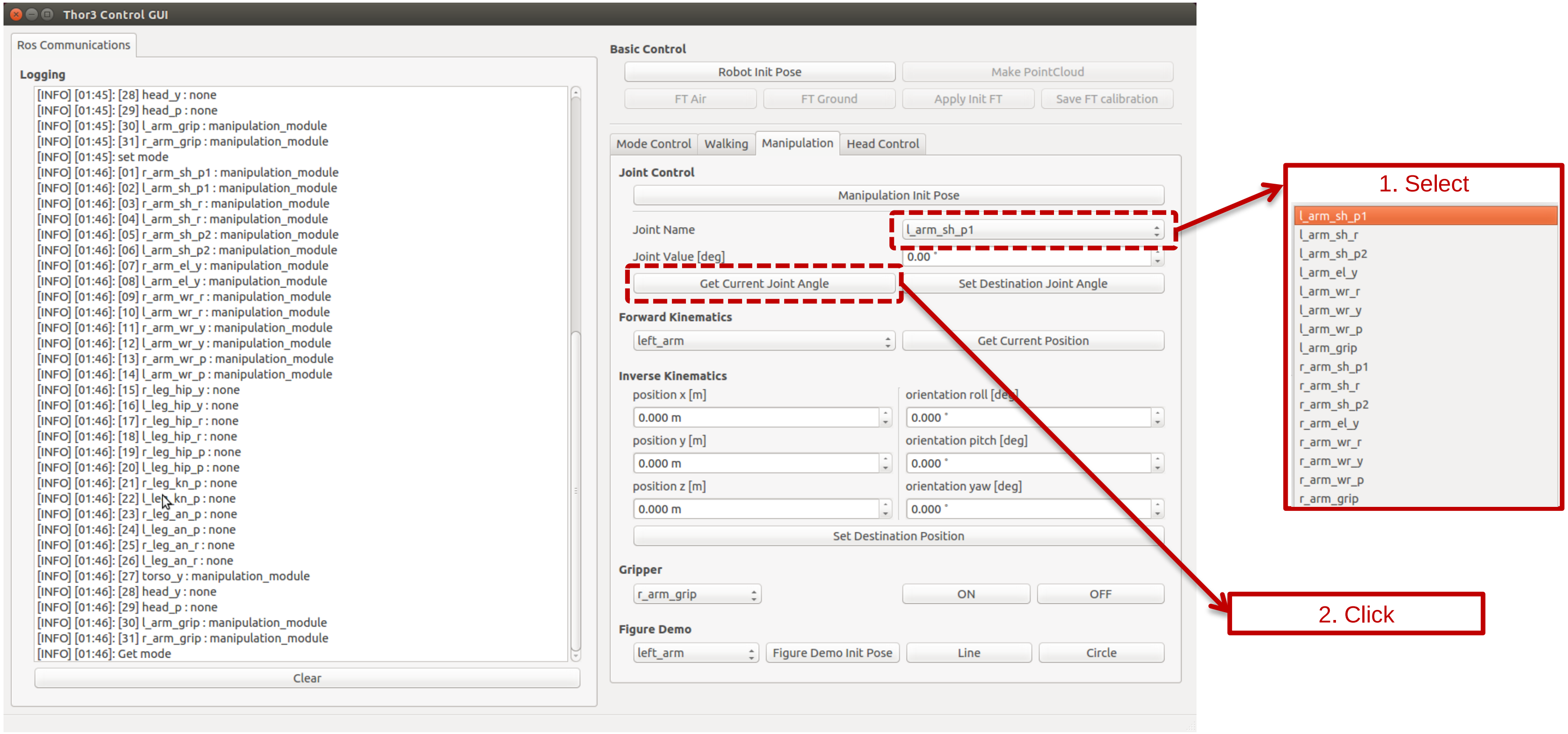
- Go to manipulation initial pose



GUI Example

2. Joint Space Control

- Read present joint angle



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[INFO] [01:45]: [28] head_y : none
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[INFO] [01:45]: [31] r_arm_grip : manipulation_module
[INFO] [01:45]: set mode
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[INFO] [01:46]: [04] l_arm_sh_r : manipulation_module
[INFO] [01:46]: [05] r_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [06] l_arm_sh_p2 : manipulation_module
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[INFO] [01:46]: [31] r_arm_grip : manipulation_module
[INFO] [01:46]: Get mode
```

Joint Name: l_arm_sh_p1

Joint Value [deg]: 0.00 °

Forward Kinematics: left_arm

position x [m]: 0.000 m
orientation roll [deg]: 0.000 °
position y [m]: 0.000 m
orientation pitch [deg]: 0.000 °
position z [m]: 0.000 m
orientation yaw [deg]: 0.000 °

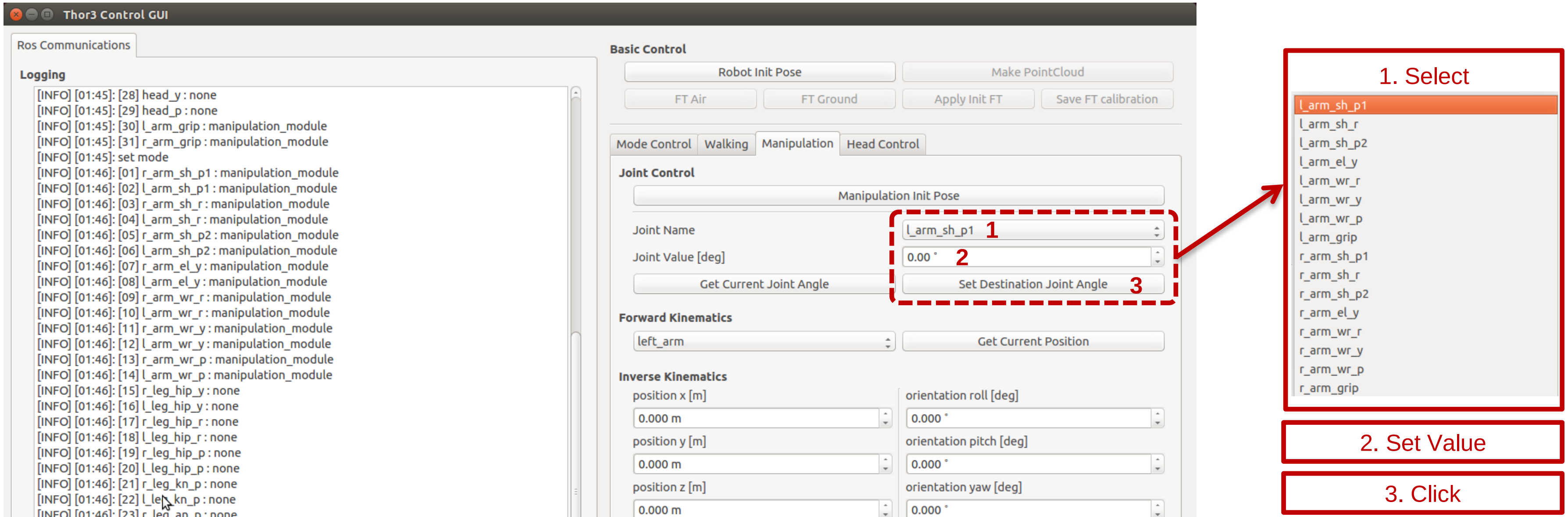
Gripper: r_arm_grip

Figure Demo: left_arm

GUI Example

2. Joint Space Control

- Write desired joint angle



```
[INFO] [01:45]: [28] head_y : none
[INFO] [01:45]: [29] head_p : none
[INFO] [01:45]: [30] l_arm_grip : manipulation_module
[INFO] [01:45]: [31] r_arm_grip : manipulation_module
[INFO] [01:45]: set mode
[INFO] [01:46]: [01] r_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [02] l_arm_sh_p1 : manipulation_module
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[INFO] [01:46]: [04] l_arm_sh_r : manipulation_module
[INFO] [01:46]: [05] r_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [06] l_arm_sh_p2 : manipulation_module
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[INFO] [01:46]: [08] l_arm_el_y : manipulation_module
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[INFO] [01:46]: [24] l_leg_an_p : none
[INFO] [01:46]: [25] r_leg_an_r : none
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[INFO] [01:46]: [27] torso_y : manipulation_module
[INFO] [01:46]: [28] head_y : none
[INFO] [01:46]: [29] head_p : none
[INFO] [01:46]: [30] l_arm_grip : manipulation_module
[INFO] [01:46]: [31] r_arm_grip : manipulation_module
[INFO] [01:46]: Get mode
```

Joint Name: l_arm_sh_p1

Joint Value [deg]: 0.00 °

Forward Kinematics: left_arm

Inverse Kinematics:

position x [m]: 0.000 m

position y [m]: 0.000 m

position z [m]: 0.000 m

orientation roll [deg]: 0.000 °

orientation pitch [deg]: 0.000 °

orientation yaw [deg]: 0.000 °

Gripper: r_arm_grip

Figure Demo: left_arm

1. Select

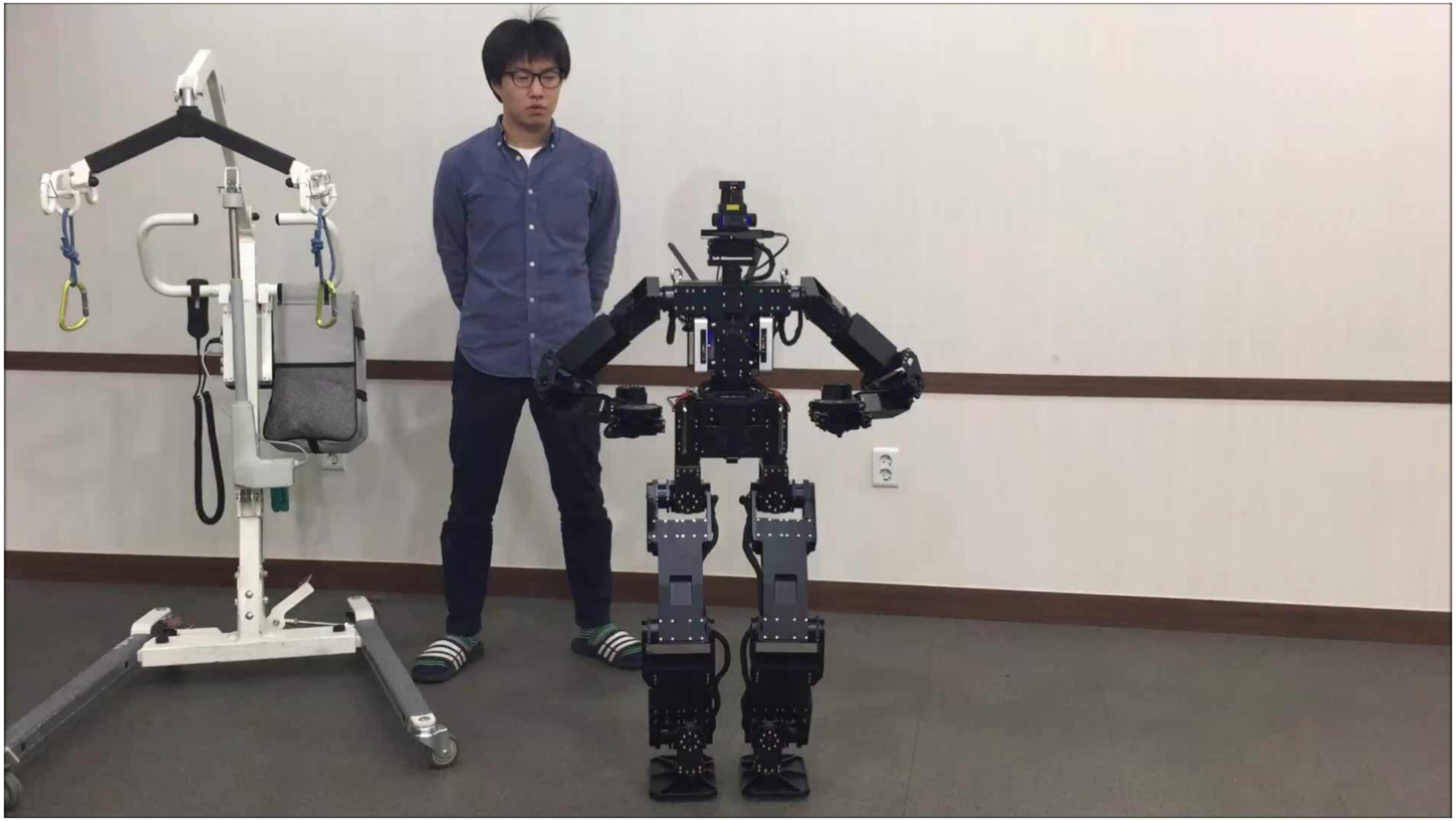
2. Set Value

3. Click

GUI Example

2. Joint Space Control

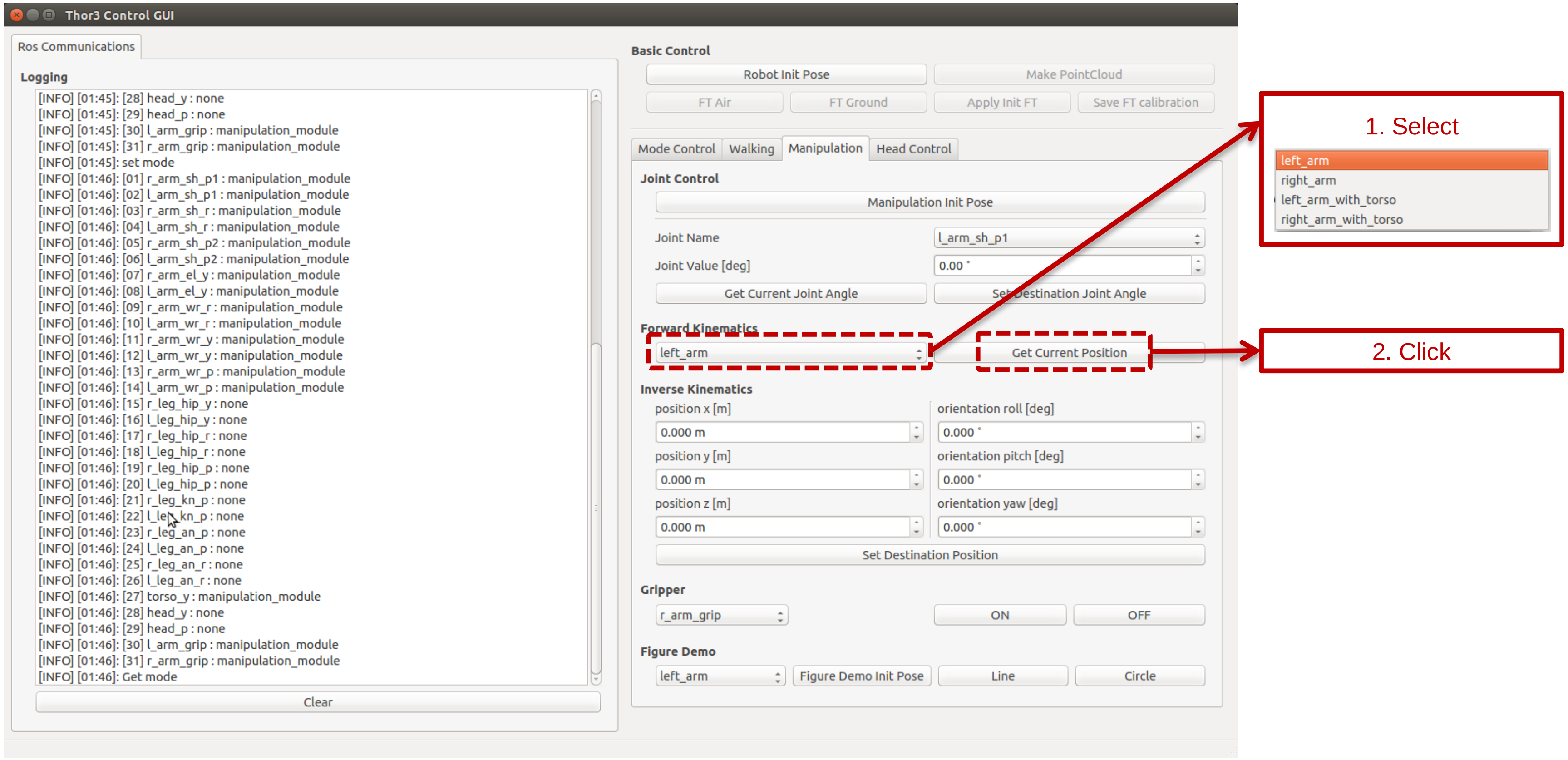
- Write desired joint angle



GUI Example

3. Task Space Control

- Read present end effector's pose (Forward Kinematics)



Thor3 Control GUI

Ros Communications

Logging

```
[INFO] [01:45]: [28] head_y : none
[INFO] [01:45]: [29] head_p : none
[INFO] [01:45]: [30] l_arm_grip : manipulation_module
[INFO] [01:45]: [31] r_arm_grip : manipulation_module
[INFO] [01:45]: set mode
[INFO] [01:46]: [01] r_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [02] l_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [03] r_arm_sh_r : manipulation_module
[INFO] [01:46]: [04] l_arm_sh_r : manipulation_module
[INFO] [01:46]: [05] r_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [06] l_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [07] r_arm_el_y : manipulation_module
[INFO] [01:46]: [08] l_arm_el_y : manipulation_module
[INFO] [01:46]: [09] r_arm_wr_r : manipulation_module
[INFO] [01:46]: [10] l_arm_wr_r : manipulation_module
[INFO] [01:46]: [11] r_arm_wr_y : manipulation_module
[INFO] [01:46]: [12] l_arm_wr_y : manipulation_module
[INFO] [01:46]: [13] r_arm_wr_p : manipulation_module
[INFO] [01:46]: [14] l_arm_wr_p : manipulation_module
[INFO] [01:46]: [15] r_leg_hip_y : none
[INFO] [01:46]: [16] l_leg_hip_y : none
[INFO] [01:46]: [17] r_leg_hip_r : none
[INFO] [01:46]: [18] l_leg_hip_r : none
[INFO] [01:46]: [19] r_leg_hip_p : none
[INFO] [01:46]: [20] l_leg_hip_p : none
[INFO] [01:46]: [21] r_leg_kn_p : none
[INFO] [01:46]: [22] l_leg_kn_p : none
[INFO] [01:46]: [23] r_leg_an_p : none
[INFO] [01:46]: [24] l_leg_an_p : none
[INFO] [01:46]: [25] r_leg_an_r : none
[INFO] [01:46]: [26] l_leg_an_r : none
[INFO] [01:46]: [27] torso_y : manipulation_module
[INFO] [01:46]: [28] head_y : none
[INFO] [01:46]: [29] head_p : none
[INFO] [01:46]: [30] l_arm_grip : manipulation_module
[INFO] [01:46]: [31] r_arm_grip : manipulation_module
[INFO] [01:46]: Get mode
```

Joint Name: l_arm_sh_p1

Joint Value [deg]: 0.00 °

Forward Kinematics: left_arm

Inverse Kinematics

position x [m]: 0.000 m

orientation roll [deg]: 0.000 °

position y [m]: 0.000 m

orientation pitch [deg]: 0.000 °

position z [m]: 0.000 m

orientation yaw [deg]: 0.000 °

r_arm_grip

left_arm

1. Select

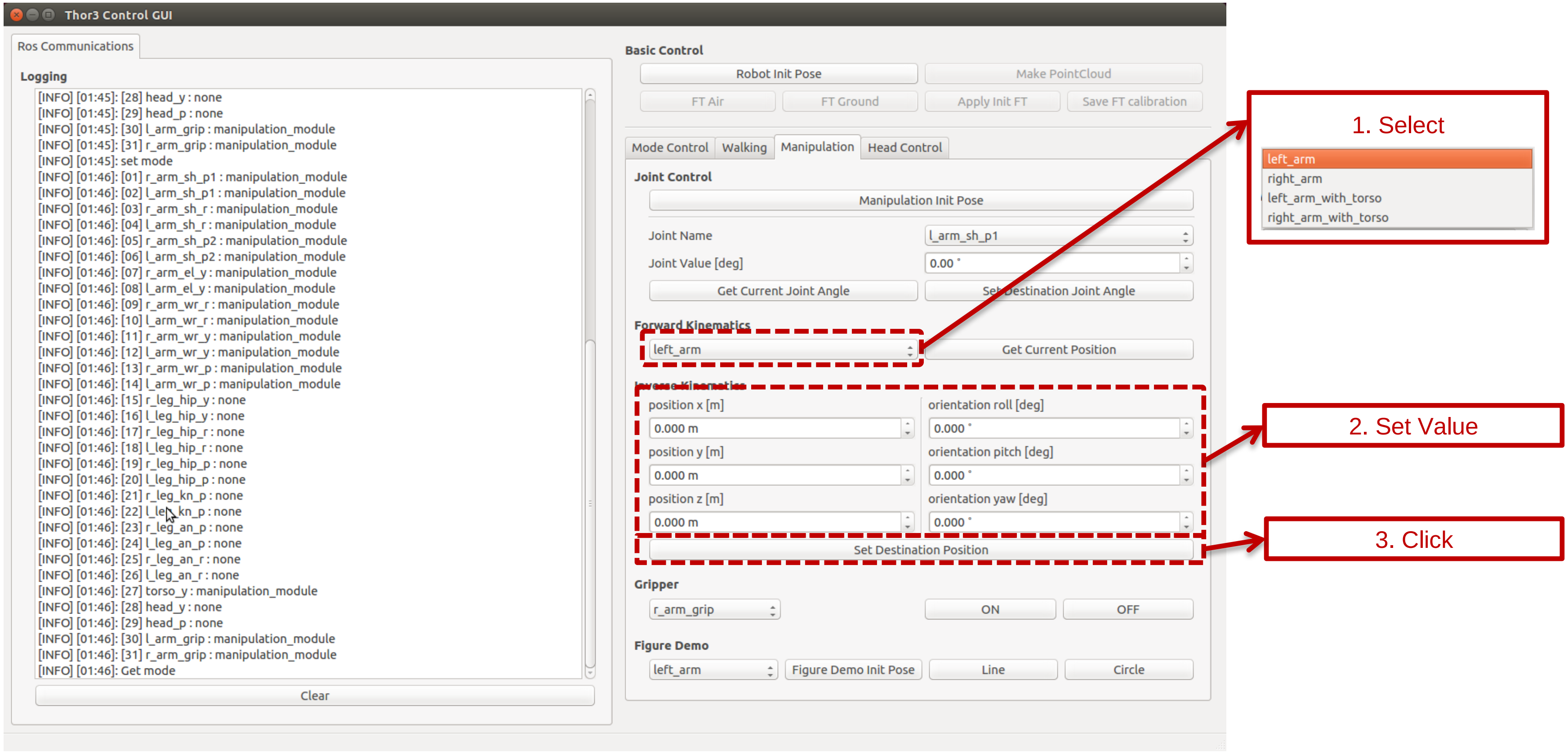
- left_arm
- right_arm
- left_arm_with_torso
- right_arm_with_torso

2. Click

GUI Example

3. Task Space Control

- Write desired end effector's pose (Inverse Kinematics)



```
[INFO] [01:45]: [28] head_y : none
[INFO] [01:45]: [29] head_p : none
[INFO] [01:45]: [30] l_arm_grip : manipulation_module
[INFO] [01:45]: [31] r_arm_grip : manipulation_module
[INFO] [01:45]: set mode
[INFO] [01:46]: [01] r_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [02] l_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [03] r_arm_sh_r : manipulation_module
[INFO] [01:46]: [04] l_arm_sh_r : manipulation_module
[INFO] [01:46]: [05] r_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [06] l_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [07] r_arm_el_y : manipulation_module
[INFO] [01:46]: [08] l_arm_el_y : manipulation_module
[INFO] [01:46]: [09] r_arm_wr_r : manipulation_module
[INFO] [01:46]: [10] l_arm_wr_r : manipulation_module
[INFO] [01:46]: [11] r_arm_wr_y : manipulation_module
[INFO] [01:46]: [12] l_arm_wr_y : manipulation_module
[INFO] [01:46]: [13] r_arm_wr_p : manipulation_module
[INFO] [01:46]: [14] l_arm_wr_p : manipulation_module
[INFO] [01:46]: [15] r_leg_hip_y : none
[INFO] [01:46]: [16] l_leg_hip_y : none
[INFO] [01:46]: [17] r_leg_hip_r : none
[INFO] [01:46]: [18] l_leg_hip_r : none
[INFO] [01:46]: [19] r_leg_hip_p : none
[INFO] [01:46]: [20] l_leg_hip_p : none
[INFO] [01:46]: [21] r_leg_kn_p : none
[INFO] [01:46]: [22] l_leg_kn_p : none
[INFO] [01:46]: [23] r_leg_an_p : none
[INFO] [01:46]: [24] l_leg_an_p : none
[INFO] [01:46]: [25] r_leg_an_r : none
[INFO] [01:46]: [26] l_leg_an_r : none
[INFO] [01:46]: [27] torso_y : manipulation_module
[INFO] [01:46]: [28] head_y : none
[INFO] [01:46]: [29] head_p : none
[INFO] [01:46]: [30] l_arm_grip : manipulation_module
[INFO] [01:46]: [31] r_arm_grip : manipulation_module
[INFO] [01:46]: Get mode
```

Joint Name: l_arm_sh_p1

Joint Value [deg]: 0.00 °

Forward Kinematics: left_arm

position x [m]: 0.000 m
orientation roll [deg]: 0.000 °
position y [m]: 0.000 m
orientation pitch [deg]: 0.000 °
position z [m]: 0.000 m
orientation yaw [deg]: 0.000 °

Gripper: r_arm_grip

Figure Demo: left_arm

1. Select

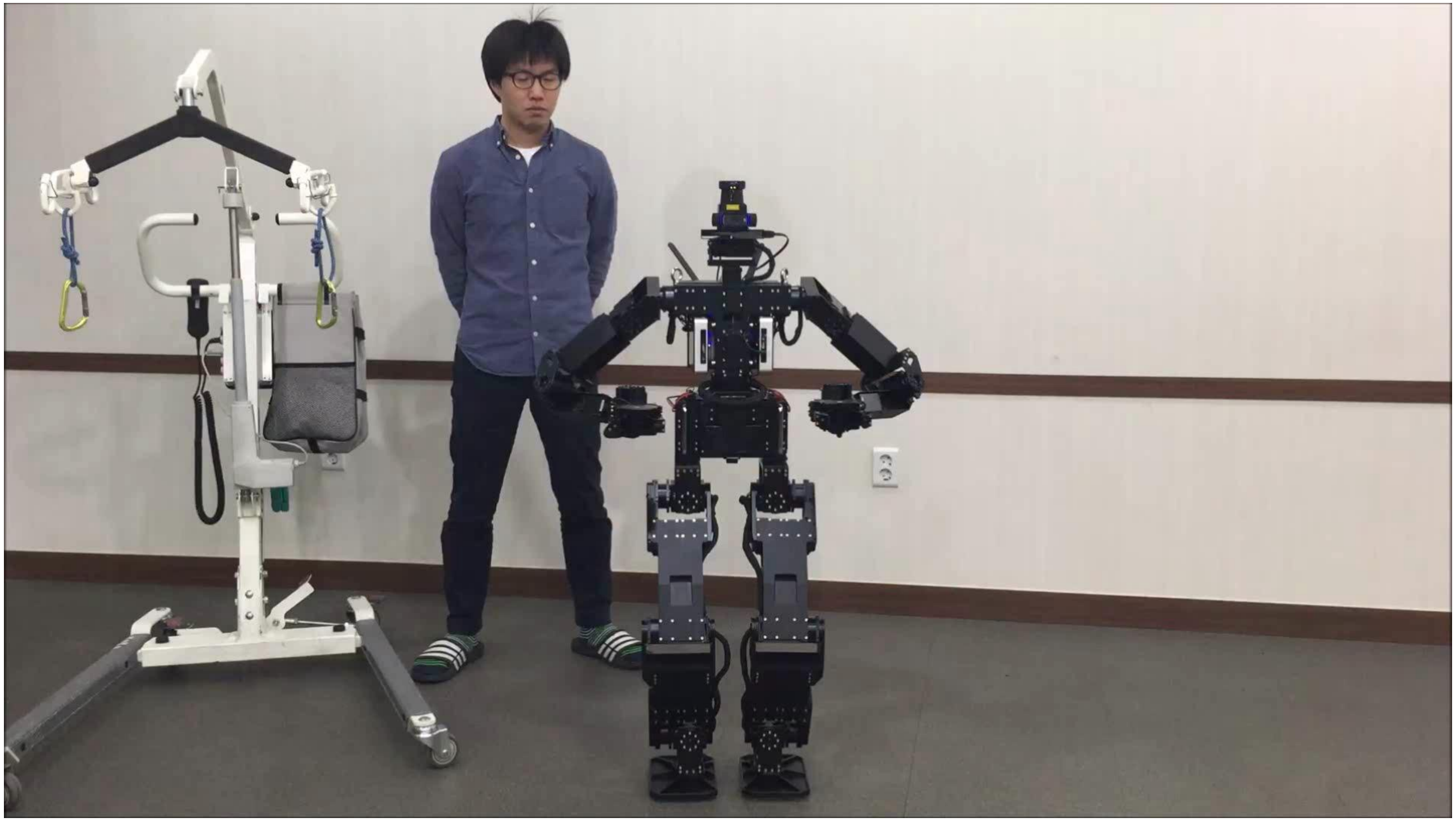
2. Set Value

3. Click

GUI Example

3. Task Space Control

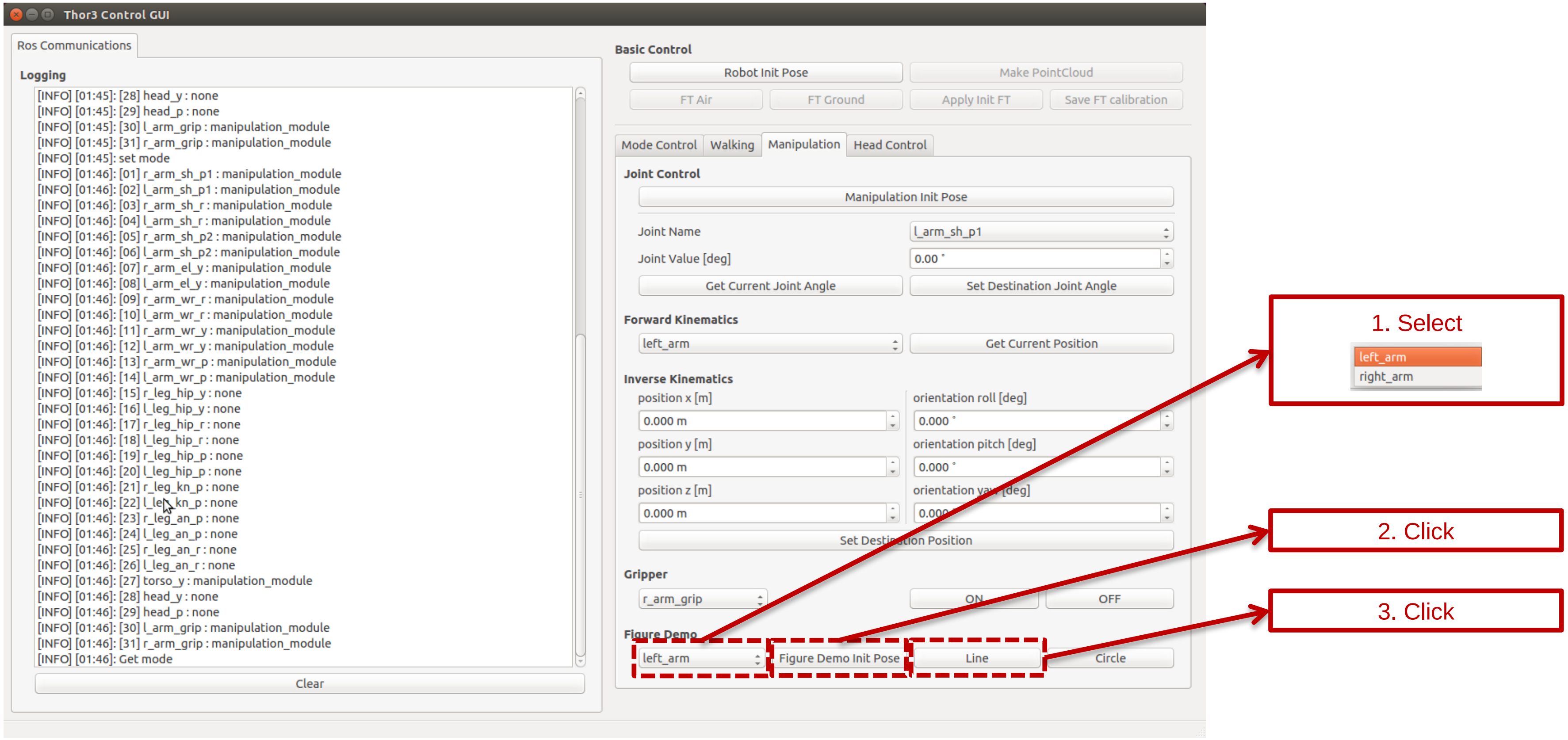
- Write desired end effector's pose (Inverse Kinematics)



GUI Example

4. Manipulation Demonstration

- Draw line trajectory



Thor3 Control GUI

Ros Communications

Logging

```
[INFO] [01:45]: [28] head_y : none
[INFO] [01:45]: [29] head_p : none
[INFO] [01:45]: [30] l_arm_grip : manipulation_module
[INFO] [01:45]: [31] r_arm_grip : manipulation_module
[INFO] [01:45]: set mode
[INFO] [01:46]: [01] r_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [02] l_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [03] r_arm_sh_r : manipulation_module
[INFO] [01:46]: [04] l_arm_sh_r : manipulation_module
[INFO] [01:46]: [05] r_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [06] l_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [07] r_arm_el_y : manipulation_module
[INFO] [01:46]: [08] l_arm_el_y : manipulation_module
[INFO] [01:46]: [09] r_arm_wr_r : manipulation_module
[INFO] [01:46]: [10] l_arm_wr_r : manipulation_module
[INFO] [01:46]: [11] r_arm_wr_y : manipulation_module
[INFO] [01:46]: [12] l_arm_wr_y : manipulation_module
[INFO] [01:46]: [13] r_arm_wr_p : manipulation_module
[INFO] [01:46]: [14] l_arm_wr_p : manipulation_module
[INFO] [01:46]: [15] r_leg_hip_y : none
[INFO] [01:46]: [16] l_leg_hip_y : none
[INFO] [01:46]: [17] r_leg_hip_r : none
[INFO] [01:46]: [18] l_leg_hip_r : none
[INFO] [01:46]: [19] r_leg_hip_p : none
[INFO] [01:46]: [20] l_leg_hip_p : none
[INFO] [01:46]: [21] r_leg_kn_p : none
[INFO] [01:46]: [22] l_leg_kn_p : none
[INFO] [01:46]: [23] r_leg_an_p : none
[INFO] [01:46]: [24] l_leg_an_p : none
[INFO] [01:46]: [25] r_leg_an_r : none
[INFO] [01:46]: [26] l_leg_an_r : none
[INFO] [01:46]: [27] torso_y : manipulation_module
[INFO] [01:46]: [28] head_y : none
[INFO] [01:46]: [29] head_p : none
[INFO] [01:46]: [30] l_arm_grip : manipulation_module
[INFO] [01:46]: [31] r_arm_grip : manipulation_module
[INFO] [01:46]: Get mode
```

Basic Control

Manipulation

Joint Control

Joint Name: l_arm_sh_p1

Joint Value [deg]: 0.00 °

Forward Kinematics: left_arm

Inverse Kinematics

position x [m]: 0.000 m

orientation roll [deg]: 0.000 °

position y [m]: 0.000 m

orientation pitch [deg]: 0.000 °

position z [m]: 0.000 m

orientation yaw [deg]: 0.000 °

Gripper: r_arm_grip

Figure Demo: left_arm

1. Select

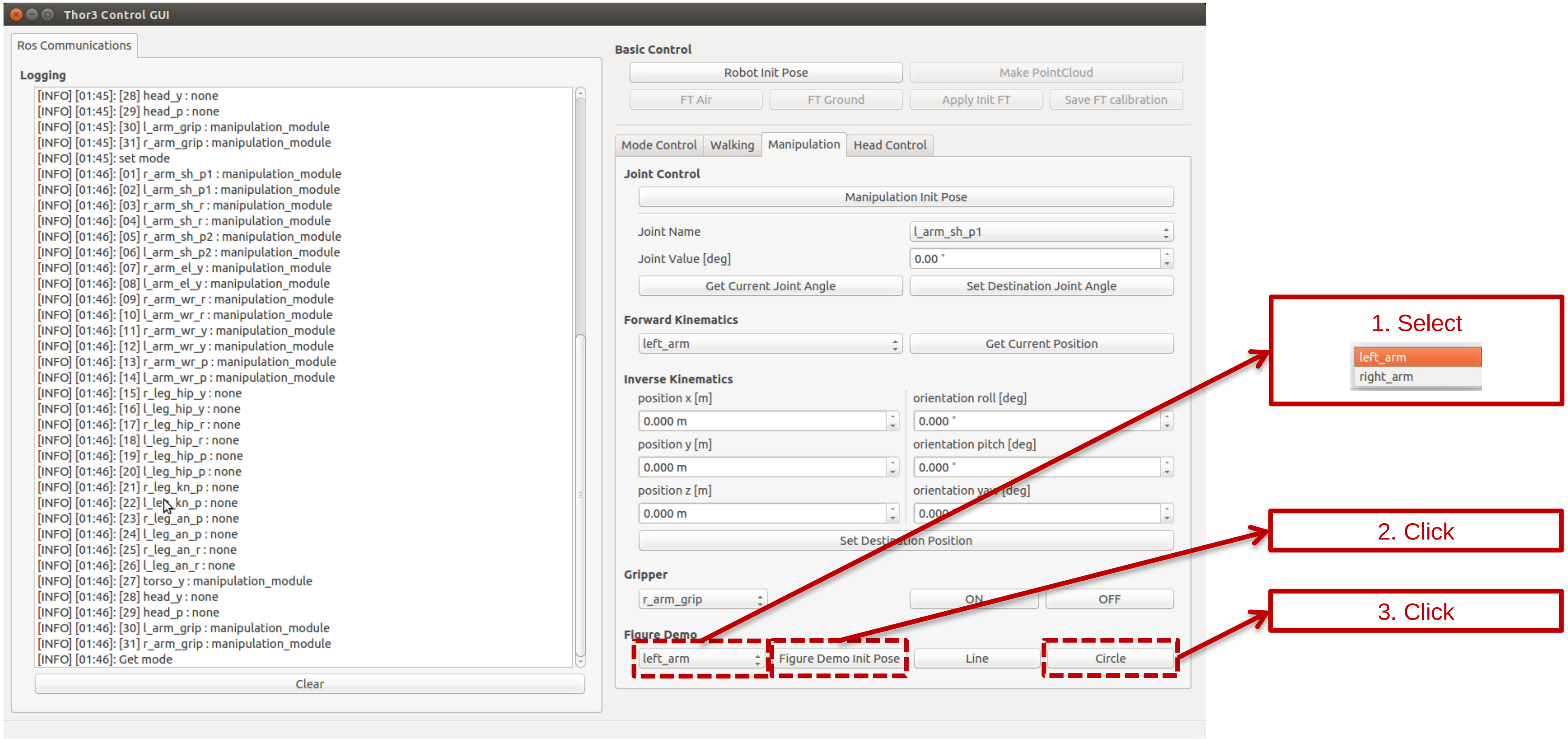
2. Click

3. Click

GUI Example

4. Manipulation Demonstration

- Draw Circle trajectory



```
[INFO] [01:45]: [28] head_y : none
[INFO] [01:45]: [29] head_p : none
[INFO] [01:45]: [30] l_arm_grip : manipulation_module
[INFO] [01:45]: [31] r_arm_grip : manipulation_module
[INFO] [01:45]: set mode
[INFO] [01:46]: [01] r_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [02] l_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [03] r_arm_sh_r : manipulation_module
[INFO] [01:46]: [04] l_arm_sh_r : manipulation_module
[INFO] [01:46]: [05] r_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [06] l_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [07] r_arm_el_y : manipulation_module
[INFO] [01:46]: [08] l_arm_el_y : manipulation_module
[INFO] [01:46]: [09] r_arm_wr_r : manipulation_module
[INFO] [01:46]: [10] l_arm_wr_r : manipulation_module
[INFO] [01:46]: [11] r_arm_wr_y : manipulation_module
[INFO] [01:46]: [12] l_arm_wr_y : manipulation_module
[INFO] [01:46]: [13] r_arm_wr_p : manipulation_module
[INFO] [01:46]: [14] l_arm_wr_p : manipulation_module
[INFO] [01:46]: [15] r_leg_hip_y : none
[INFO] [01:46]: [16] l_leg_hip_y : none
[INFO] [01:46]: [17] r_leg_hip_r : none
[INFO] [01:46]: [18] l_leg_hip_r : none
[INFO] [01:46]: [19] r_leg_hip_p : none
[INFO] [01:46]: [20] l_leg_hip_p : none
[INFO] [01:46]: [21] r_leg_kn_p : none
[INFO] [01:46]: [22] l_leg_kn_p : none
[INFO] [01:46]: [23] r_leg_an_p : none
[INFO] [01:46]: [24] l_leg_an_p : none
[INFO] [01:46]: [25] r_leg_an_r : none
[INFO] [01:46]: [26] l_leg_an_r : none
[INFO] [01:46]: [27] torso_y : manipulation_module
[INFO] [01:46]: [28] head_y : none
[INFO] [01:46]: [29] head_p : none
[INFO] [01:46]: [30] l_arm_grip : manipulation_module
[INFO] [01:46]: [31] r_arm_grip : manipulation_module
[INFO] [01:46]: Get mode
```

Joint Name: l_arm_sh_p1

Joint Value [deg]: 0.00 °

Forward Kinematics: left_arm

position x [m]: 0.000 m

orientation roll [deg]: 0.000 °

position y [m]: 0.000 m

orientation pitch [deg]: 0.000 °

position z [m]: 0.000 m

orientation yaw [deg]: 0.000 °

Gripper: r_arm_grip

Figure Demo: left_arm

1. Select

left_arm
right_arm

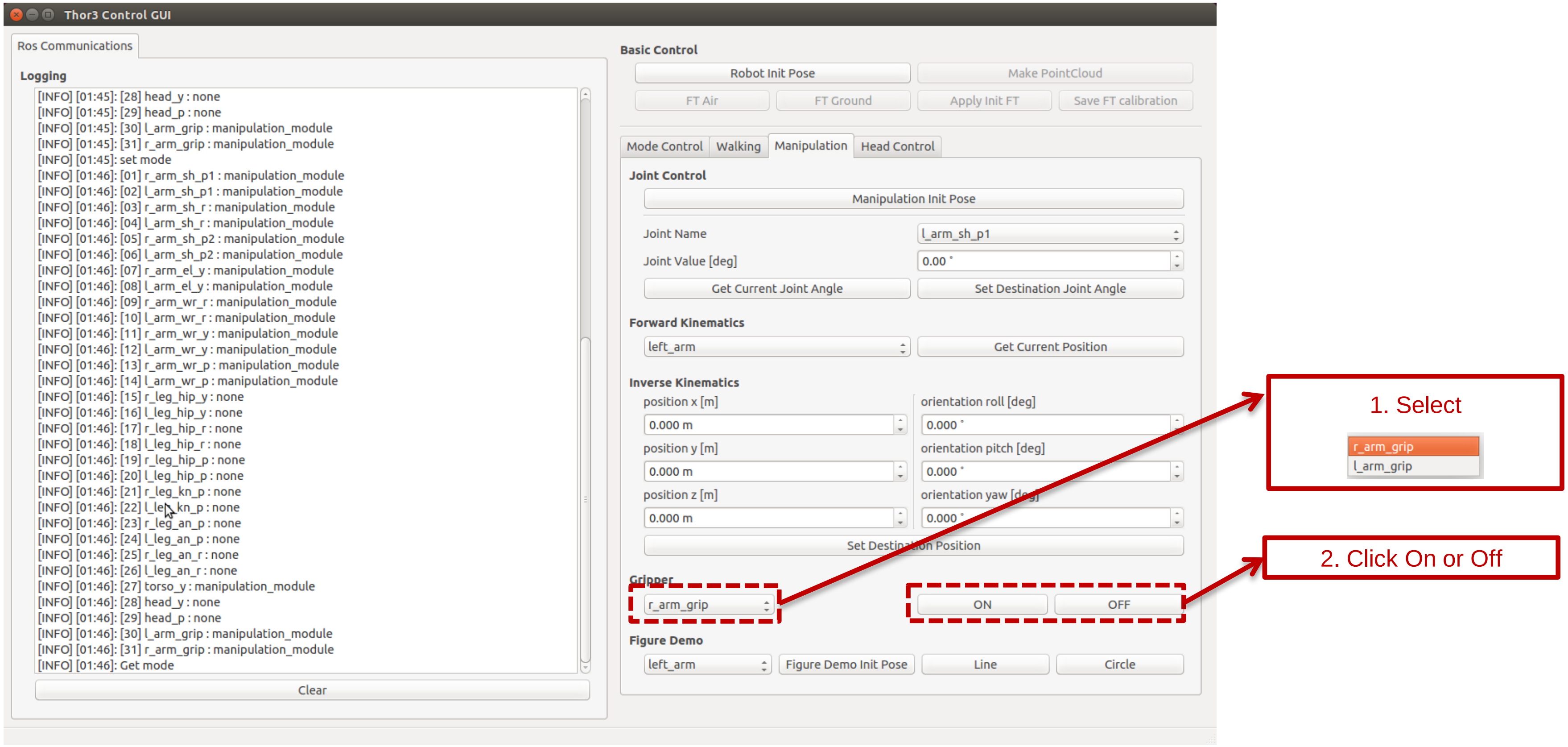
2. Click

3. Click

GUI Example

4. Manipulation Demonstration

- Gripper On/Off



```
[INFO] [01:45]: [28] head_y : none
[INFO] [01:45]: [29] head_p : none
[INFO] [01:45]: [30] l_arm_grip : manipulation_module
[INFO] [01:45]: [31] r_arm_grip : manipulation_module
[INFO] [01:45]: set mode
[INFO] [01:46]: [01] r_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [02] l_arm_sh_p1 : manipulation_module
[INFO] [01:46]: [03] r_arm_sh_r : manipulation_module
[INFO] [01:46]: [04] l_arm_sh_r : manipulation_module
[INFO] [01:46]: [05] r_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [06] l_arm_sh_p2 : manipulation_module
[INFO] [01:46]: [07] r_arm_el_y : manipulation_module
[INFO] [01:46]: [08] l_arm_el_y : manipulation_module
[INFO] [01:46]: [09] r_arm_wr_r : manipulation_module
[INFO] [01:46]: [10] l_arm_wr_r : manipulation_module
[INFO] [01:46]: [11] r_arm_wr_y : manipulation_module
[INFO] [01:46]: [12] l_arm_wr_y : manipulation_module
[INFO] [01:46]: [13] r_arm_wr_p : manipulation_module
[INFO] [01:46]: [14] l_arm_wr_p : manipulation_module
[INFO] [01:46]: [15] r_leg_hip_y : none
[INFO] [01:46]: [16] l_leg_hip_y : none
[INFO] [01:46]: [17] r_leg_hip_r : none
[INFO] [01:46]: [18] l_leg_hip_r : none
[INFO] [01:46]: [19] r_leg_hip_p : none
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[INFO] [01:46]: [21] r_leg_kn_p : none
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[INFO] [01:46]: [24] l_leg_an_p : none
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[INFO] [01:46]: [26] l_leg_an_r : none
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[INFO] [01:46]: [28] head_y : none
[INFO] [01:46]: [29] head_p : none
[INFO] [01:46]: [30] l_arm_grip : manipulation_module
[INFO] [01:46]: [31] r_arm_grip : manipulation_module
[INFO] [01:46]: Get mode
```

Joint Name: l_arm_sh_p1

Joint Value [deg]: 0.00 °

Forward Kinematics: left_arm

position x [m]: 0.000 m

orientation roll [deg]: 0.000 °

position y [m]: 0.000 m

orientation pitch [deg]: 0.000 °

position z [m]: 0.000 m

orientation yaw [deg]: 0.000 °

Gripper: r_arm_grip

Figure Demo: left_arm

1. Select

r_arm_grip
l_arm_grip

2. Click On or Off