

Robot basic architecture based on SSES Blueprint Architecture document

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1. Introduction

Robotics is an important tool for achieving the SDGs. Workers will be able to focus on decent work and new innovations by improvement of labor productivity using robot. As a result, we can move toward new economic growth. However, there are two big challenges in current robot.

The first challenge is how to control elastic and non-uniform object under variable circumstance. This challenge is most evident in areas where robots are not currently widespread, such as restaurants and agriculture.

The SIP SSES project which Ritsumeikan university leads in Japan tries to solve this challenge through an approach of enhanced cognitive capabilities by fusion of sensors and robots, new mechanical mechanisms, and enhanced maintenance technologies. They also aim to build CPS by integrating many elements, including AI, IoT, sensor platforms and mechanics.

The second challenge is co-working with humans. Speech recognition is one of the key technologies to solve this challenge. First and foremost, enterprise robots need to recognize “immediate and urgent” voice commands in order to prioritize human safety; for example if someone shouts “Stop Now” the robot must stop — regardless of who is the speaker, level of background noise, or other circumstance. Second, enterprise robots need to accept verbal instructions, rather than programming interfaces (e.g. keyboard, app) inconvenient for rugged, wet, and fast-paced environments.

Signalogic developed automated speech recognition (ASR) functionality. It is light weight enough to implement 20,000 words real-time vocabulary on a small board such as pico ITX Atom board (quad-core, 3.5” x 3.5”, 10 W). And it is suitable for a range of robotics use cases in manufacturing, production, agriculture, and retail. The implementation includes robust audio noise processing to deal with background and robot mechanical noise.

This blueprint develops and provides open software stack for “enhanced cognitive capabilities by fusion of sensor and robots” and “automated speech recognition” based on the achievements of SSES and Signalogic to apply robotics to any industry easily.

*SIP: The Cross-ministerial Strategic Innovation Promotion Program

SIP is a national program led by the Council for Science, Technology and Innovation (CSTI) of the Japanese Government with interdisciplinary management to realize scientific and technological innovation in our country.

[About SIP | SIP | JST](#)

*SSES: Sensor-rich Soft End effector System

[立命館大学 SSES Platform - Ritsumeikan Univ. \(sip-sses.net\)](#)

2. Use cases

Source: SIP SSES project

[公開情報 - Ritsumeikan Univ. SSES platform \(sip-seses.net\)](http://sip-seses.net)

I. Food presentation



II. Put dishes into the dishwasher

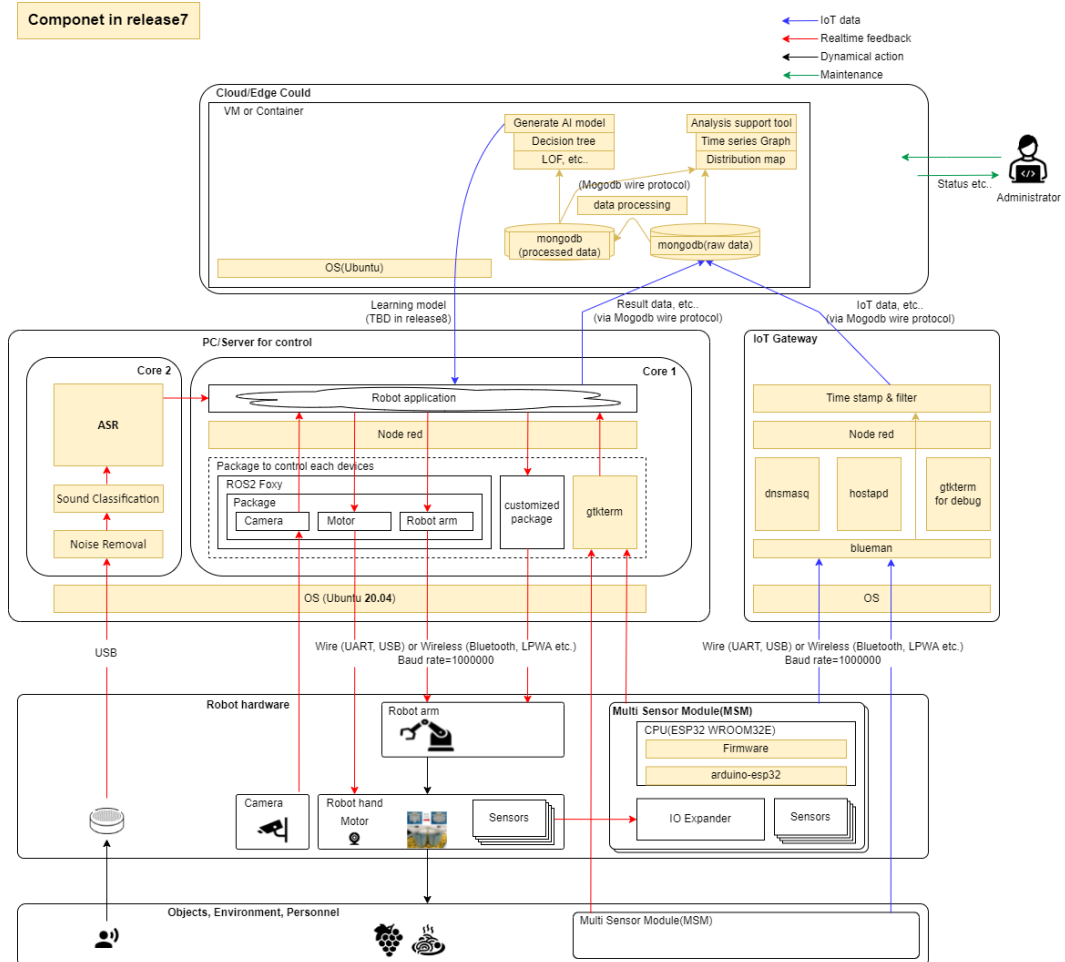


III. Automatic collection of tableware



3. Overall Architecture

The following figure indicates overall architecture of this blueprint.

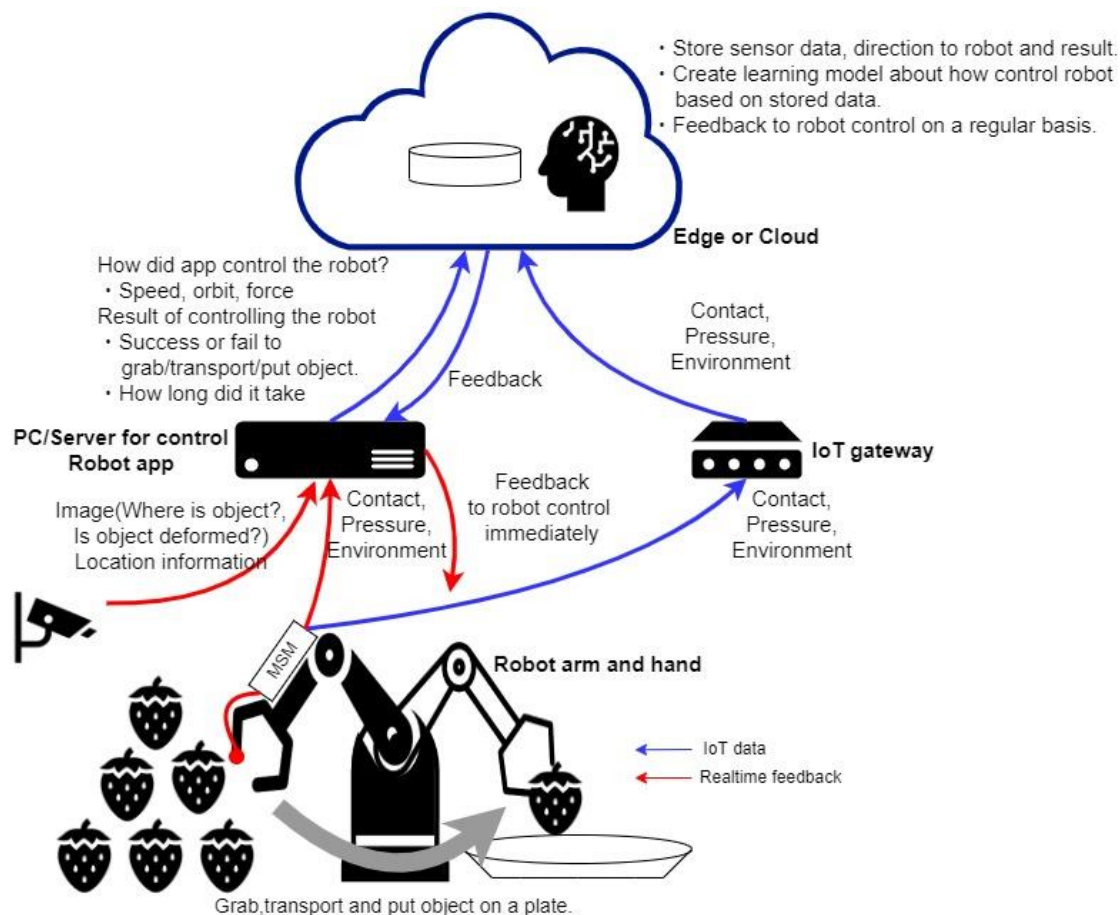


- Cloud, Edge Cloud
 - Create data base of IoT data and operation result data
 - Create teaching data for AI based on the data base, and feedback to PC/Server for robot control.
 - Detect failure, deviation from standard, and individual difference about robot hardware based on stored data.
E.g.
 - Measure the value of the pressure sensor under no load, and judge whether sensor is broken or not, or there is deviation from standard or not.
 - Calculate individual values such as the number of revolutions of the robot motor based on time the motor was driven and distance robot moved.
- PC/Server for robot control
 - Recognize objects based on information such as a camera
 - Control arms and hands based on real-time feedback from sensors
 - Optimize grip strength, orbit and speed, etc... based on teaching data from cloud/edge cloud.
 - Recognize voice command by ASR
E.g.
 - Immediate and urgent voice command
 - Instead of current programming interfaces(e.g. keyboard,app) in wet environment
- IoT Gateway
 - Shape IoT data from MSM so it can be organized in a cloud database
E.g. Time stamp, Add units, Scale conversion etc..
- Robot arm
- Hand
- Multi Sensor Module
 - Control various sensors
 - Send information from sensors to PC/Server for control and IoT Gateway via wire or wireless communication.

This architecture is characterized by two data flows “real-time feedback flow” and “IoT data flow”. The microcomputer simultaneously distributes the data measured by the sensor in physical space to two systems, the real-time feedback flow “red arrow” and the IoT data flow “blue arrow”. The route of the real-time feedback is directly connected to the PC for robot control and used as sensing data for robot control. On the other hand, data flow sends data to the edge server cloud via the gateway to analyze data in the cloud (cyberspace) and provide feedback to robot control on a regular basis. In addition, real-time feedback can be controlled using only the signal strength (gradation value) of the sensor signal, but data analysis on the IoT side requires not only the signal strength of the measured value but also a meaning that matches the physical quantity chemical quantity. Therefore, MSM transmits raw data for low latency. On the other hand, the gateway assigns units to measured values and performs scale conversion according to the units. The following is examples of how to use these two data flows.

E.g. Food presentation

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•Real-time feedback flow

Sensors measure contact, pressure, and other information. Camera provides images for object detection, deformation. Robot app on PC/Server immediately feeds this information back to the robot control.

•IoT data flow

Edge or cloud store data measured by sensors via IoT gateway. Addition to that, edge or cloud store data about how app control the robot and result.

E.g. Speed, orbit, force

Success or fail to grab/transport/put object,

How long did it take.

Edge or cloud create a learning model to control the robot more optimally and feed it back to robot control less frequently than real-time feedback.

4. Platform Architecture for release7

Component	Hardware name	
Cloud/Edge Cloud		We are using google cloud platform "e2-standard-8" as computing resources. For more details about settings, refer to installation guide.
PC/Server for control		We are using google cloud platform "e2-standard-8" as computing resources. For more details about settings, refer to installation guide.
IoT gateway	Raspberry pi 4model B	
MSM	Pre Multi Sensor Module	https://sip-sSES.net/quick-reference/
Robot arm		TBD. Will be updated in future release.

5. Software Platform Architecture for release7

Component	Software name	repository
PC/Server for control	Ubuntu	20.04
	Node red	1.3.4
	gtkterm	0.99.7+git9d63182-2
IoT gateway	Raspbian	Raspberry Pi OS – Raspberry Pi
	Node red	1.3.4
	gtkterm	0.99.7+git9d63182-2
	hostapd	2:2.7+git20190128+0c1e29f-6+deb10u3
	dnsmasq	2.80-1+rpt1+deb10u1
	blueman	2.0.8-1+deb10u1
MSM	arduino-esp32	https://github.com/espressif/arduino-esp32

- 6. API
NA

- 7. Hardware and Software Management

Software

Component	Software name	repository
PC/Server for control	Ubuntu	20.04
	Node red	1.3.4
	gtkterm	0.99.7+git9d63182-2
IoT gateway	Raspbian	Raspberry Pi OS – Raspberry Pi
	Node red	1.3.4
	gtkterm	0.99.7+git9d63182-2
	hostapd	2:2.7+git20190128+0c1e29f-6+deb10u3
	dnsmasq	2.80-1+rpt1+deb10u1
	blueman	2.0.8-1+deb10u1
MSM	arduino-esp32	https://github.com/espressif/arduino-esp32

8. Licensing

Software

Component	Software name	License name
PC/Server for control	Ubuntu	GPL
	Node red	Apache License2.0
	gtkterm	GPL 3.0
IoT gateway	Raspbian	BSD 3Clause,MIT,GPL
	Node red	Apache License2.0
	gtkterm	GPL 3.0
	hostapd	GPL 2.0
	dnsmasq	GPL 2.0 or 3.0
	blueman	GPL 3.0
MSM	arduino-esp32	LGPL 2.1

Revision history

Version	Date	Editor	Contents
0.1	01/28/2022	Fukano	Draft version
1.0	09/05/2022	Fukano	Updated for Akraino R7
1.1	12/07/2022	Fukano	Updated software version
1.2	12/12/2022	Fukano	Updated the followings. Overall architecture figure Platform Architecture for release7