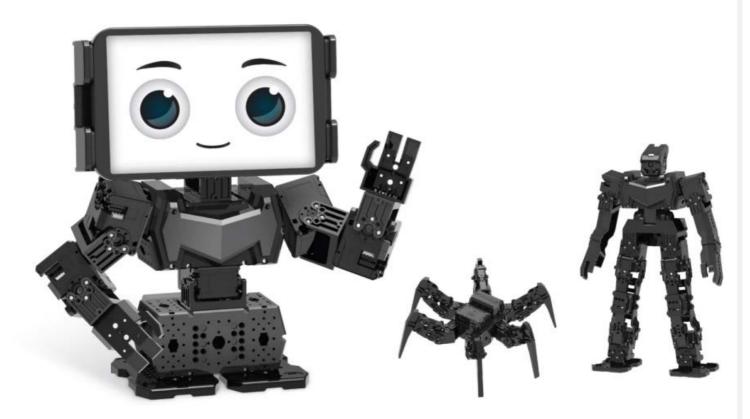
1. Introduction

ROBOTIS ENGINEER KITT

ROBOTIS



ROBOTIS ENGINEER is the next generation robot that adopts AI technology based on smart devices.

- ROBOTIS ENGINEER Kit offers standardized curriculum for multi level robotics educational courses
- Joint structure allows diverse motions for versatile robots
- Supports 3D part designing and printing
- Compatible with R+ ENGINEER(Smart device app), R+ Task 3.0(PC software)
- Upgrade to Raspberry Pi and Camera

1.1. Parts List



CM-550 ×1











EF-A01 ×1



EF-A02 ×4

EF-A03 ×1



EF-A04 ×1



EF-A05 ×1

















EF-A12 ×6

EF-A06 ×1

EF-A07 ×1

EF-A08 ×1





EF-A11 ×6









EF-B01 ×1

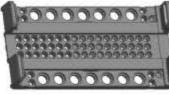


EF-A15 ×2





(LI-PO BATTERY LB-020) ×1



PHONE CRADLE ×1

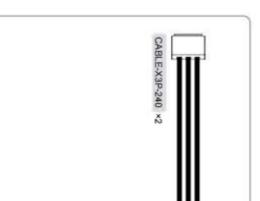
0 CABLE HOLDER ×4



SPD-365(8) ×2





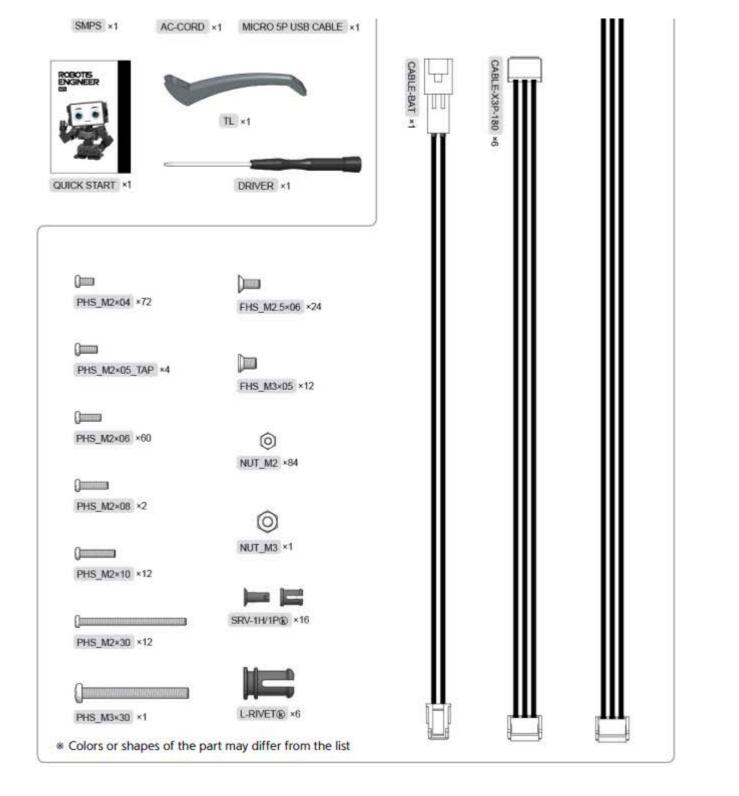






EF-A16 ×6

EF-A17 ×1



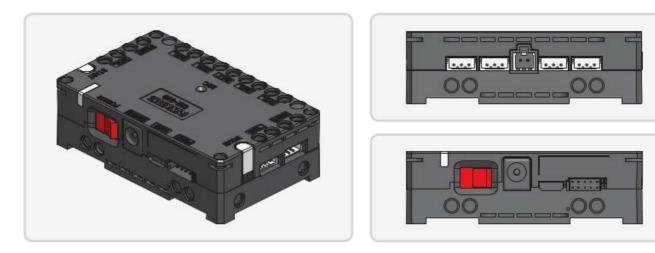
1. 1. 1. CM-550 Controller

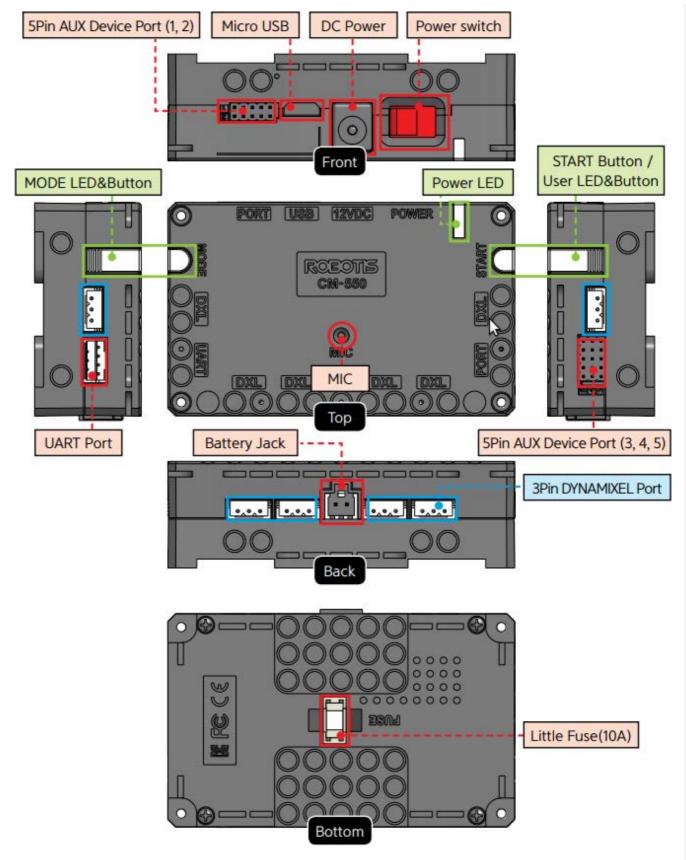
1.1.1.Specifications

Item	Specifications
Weight	58.8 [g]
MCU	ARM Cortex-M4 (168 [MHz], 32 [Bit])
Operating Voltage	Battery : 6.5 ~ 15 [V], Recommended 11.1 [V] (Li-PO 3cell) SMPS : 6.5 ~ 15 [V], Recommended 12.0 [V] Micro USB : 4.75 ~ 5.25 [V], Recommended 5.0 [V]

Item	Specifications
	Standby : 50 [mA]
Current Consumption	Port 1 ~ 2 I/O Max : 0.5 [A]
Current Consumption	Port 3 ~ 5 I/O Max : 0.02 [A]
	Total : 10 [A] (Fuse)
Operating Temperature	-5 ~ 70 [°C]
Communication Module	BLE Slave Module
	Buttons : 2 (MODE, START)
	Mic (Sound Detection) : 1
	Buzzer : 1
Internal I/O Devices	Voltage Sensor : 1
	Gyro Accelerometer : 1
	Temperature Sensor : 1
	RGB LED : 3
External I/O Devices	ROBOTIS 5 Pin Port : 5 (SM-10 / IR Array / TMS-10 : Use Port 1 or 2) X series DYNAMIXEL Ports : 6

1. 1. 1. 2. CM-550 Layout





- USB Micro USB Port : The 5 pin micro USB cable can be used to connect to the USB port of the PC.
- UART Communication Port : BT-210, BT-410, LN-101, IR receiver or other communication modules can be connected.
- BAT Battery Socket : Provided Li-Po battery can be connected.
- 12VDC DC Input : The DC barrel jack of provided SMPS can be connected.
- POWER Power Switch : Controls the power supply of the controller.
- Status LED : Displays voltage level and wireless device connection status with RGB LED.

- MODE MODE LED : This RGB LED displays the operating mode of CM-550. Please refer to the Operating Mode of CM-550.
- (START) START LED : Please refer to the Operating Mode of CM-550.
- MODE MODE Button : The operating mode can be changed with this button. Please refer to the Operating Mode of CM-550.
- START START Button : This button runs selected operating mode. Please refer to the Operating Mode of CM-550.
- DXL DYNAMIXEL X Series Port : DYNAMIXEL X series can be connected in any of these ports.
- PORT ROBOTIS 5 Pin Port : Sensors such as DMS, Touch sensor, IR sensor can be connected.

Servo motor, IR array sensor, Temperature & Humidity sensor can only be connected to Port 1 or 2.

- MIC Internal Microphone : The integrated microphone detects clapping sound.
- FUSE Fuse : 10A fuse protects electric damage.

CAUTION : The USB port on CM-550 is designed to be connected with the PC. Please do **NOT** connect other USB devices, or it may cause damage to the controller.

CM-550 eManual

1. 1. 2. 2XL430-W250 DYNAMIXEL



2XL430-W250 is a ground breaking DYNAMIXEL that allows to control **2 axis(2 DOF)** with a single module. In order to control 2 axis at the same time, each axle is assigned with different ID while sharing an identical Baudrate. Since the Control Table for each axle is separated except the Baudrate, 2XL can be applied in various applications.

The usage is identical to other DYNAMIXEL's, but be aware that Firmware Recovery will reset both axis to factory settings.

Item	Specifications
MCU	ARM CORTEX-M3 (72 [MHz], 32Bit)
Position Sensor	Contactless absolute encoder (12Bit, 360 [°]) Maker : ams(www.ams.com), Part No : AS5601
Motor	Cored
Baud Rate	9,600 [bps] ~ 4.5 [Mbps]
Control Algorithm	PID control
Resolution	4096 [pulse/rev]
Operating Modes	Velcoity Control Mode Position Control Mode (0 ~ 360 [°]) Extended Position Control Mode (Multi-turn) PWM Control Mode (Voltage Control Mode)
Weight	98.2 [g]
Dimensions (W x H x D)	36 x 46.5 x 36 [mm]
Gear Ratio	257.4 : 1
Stall Torque	1.0 [N.m] (at 9.0 [V], 1.0 [A]) 1.4 [N.m] (at 11.1 [V], 1.3 [A]) 1.5 [N.m] (at 12.0 [V], 1.4 [A])
No Load Speed	47 [rev/min] (at 9.0 [V]) 57 [rev/min] (at 11.1 [V]) 61 [rev/min] (at 12.0 [V])
Operating Temperature	-5 ~ +72 [°C]
Input Voltage	6.5 ~ 12.0 [V] (Recommended : 11.1 [V])
Command Signal	Digital Packet
Protocol Type	TTL Half Duplex Asynchronous Serial Communication (8bit, 1stop, No Parity)
Physical Connection	TTL Multidrop Bus
ID	253 ID (0 ~ 252)
Feedback	Position, Velocity, Load, Realtime tick, Trajectory, Temperature, Input Voltage, etc
Part Material	Full Metal Gear Engineering Plastic(Front, Middle, Back)
Standby Current	49 [mA]

2XL430-W250 eManual

1.2. Cautions

1. 2. 1. Safety Precautions



- 1. Read this manual carefully before getting started.
- 2. Only use provided tools in the kit.
- 3. Keep the robot away from the face and body when the robot is operating.
- 4. Be careful for getting fingers or part of the body stuck in the robot joints.
- 5. Do not operate or store the robot under the direct sunlight.
- 6. Do not operate or store the robot near water or heat source.
- 7. Do not tamper or disassemble components.
- 8. Keep the robot and parts away from infants or younger children.
- 9. Do not impact or poke the robot with sharp objects.

1. 2. 2. Precautions on Use

- 1. Use provided screwdriver(PH 1) in the kit for tightening screws.
- 2. Do not apply excessive force on screws and parts when assembling.
- 3. Operate the robot on the floor to avoid any damages from falling.
- 4. Accidental damages from falling is not covered by warranty.
- 5. DYNAMIXEL internal gears and robot joints are expendables. Excessive use or long term use may develop the backlash.

1. 2. 3. Precautions on Battery



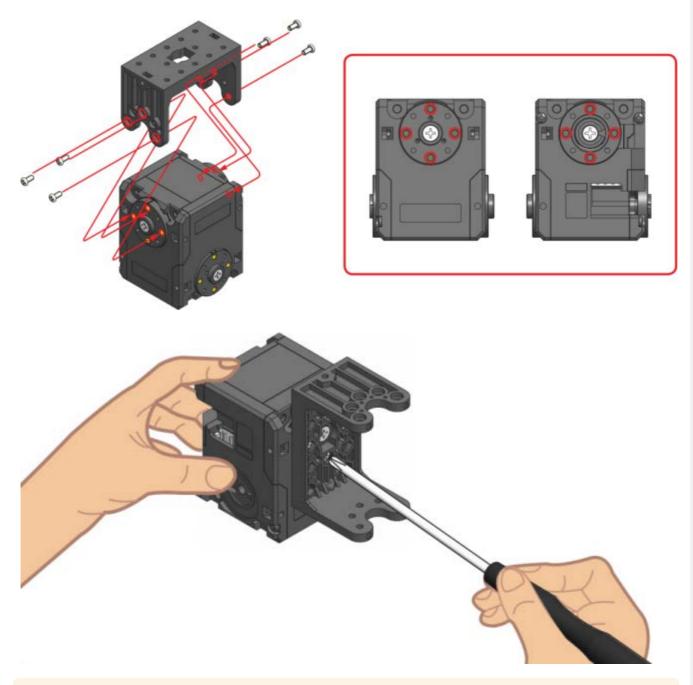
- 1. The battery must be disconnected from the robot when not used or charged with the designated charger.
- 2. Do not disassemble or impact the battery or charger.
- 3. Do not heat the battery and avoid contact with fire and liquids.
- 4. Do not place battery in the microwave, laundry machine, refrigerator, or dryer.
- 5. Do not use damaged batteries (deformed, swollen, external damages).
- 6. Do not short the battery.
- 7. Do not reverse the polarity of the battery when charging.
- 8. Do not charge the battery when it is hot. Let the battery cools down to the room temperature before charging
- 9. Do not store the battery in hot or humid place.
- 10. Do not charge multiple batteries with the charger at the same time.
- 11. Do not connect the battery to the charger when the charger is not connected to the power source.

1. 2. 4. Assembly Precautions

1. 2. 4. 1. DYNAMIXEL Assembly

- In order to control 2 axis at the same time, each axle is assigned with different ID while sharing an identical Baudrate.
- The ID and Status LED is located on the opposite side of the output horn.

• ROBOTIS ENGINEER uses bolts to securely assemble the robot joints (Below image shows where bolts are required to attach the frame on DYNAMIXEL).

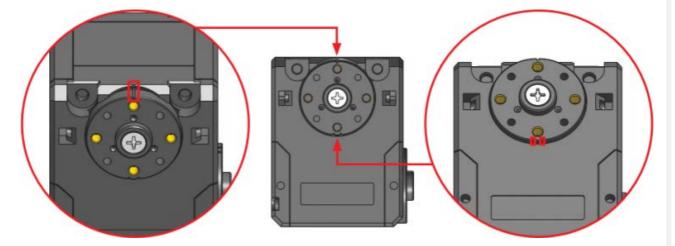


CAUTION : Please use the designated screw driver(PH 1) when assembling bolts.

Check DYNAMIXEL ID



Check DYNAMIXEL Horn Position

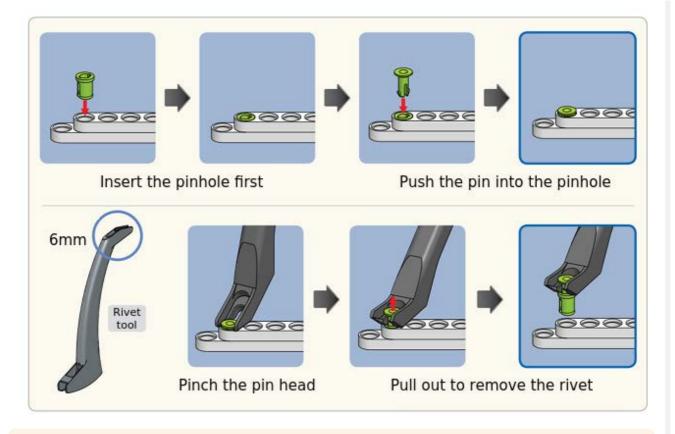


CAUTION

- The marking on the housing should match to the horn marking when properly centered.
- In order to align the horn to the center, use PH 1 screw driver to rotate the horn screw to clockwise. Be aware of rotating the screw to counter clockwise as it will release the screw.

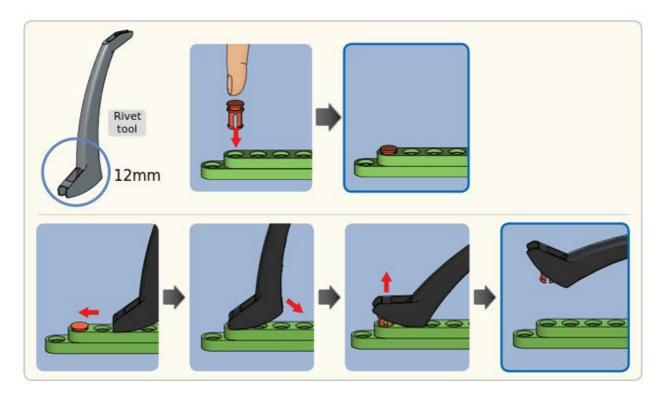
1. 2. 4. 2. Rivet Assembly

6mm Rivet



CAUTION : When reusing rivets, the pin hole must be inserted first. Used rivet will not be separated into pin and pinhole.

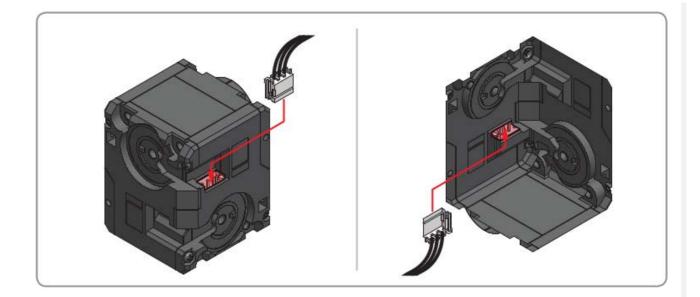
12mm Rivet



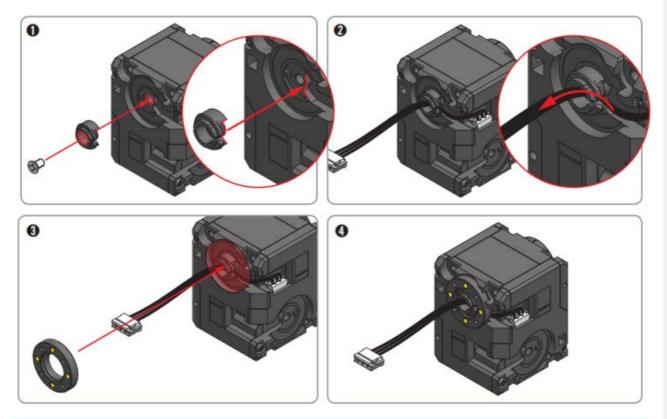
1. 2. 4. 3. Cable Assembby

Connector

Both connectors are linked to supply power and communication to the module. Please use any connector for easier assembly.



Wiring through Idler Cap



NOTE :

Through hole wiring method helps to increase the durability of cable and to simplify cable assembly.

It is not a mandatory and it may require more time to replace the cable afterward.

2. Quick Start

2. 1. App Installation



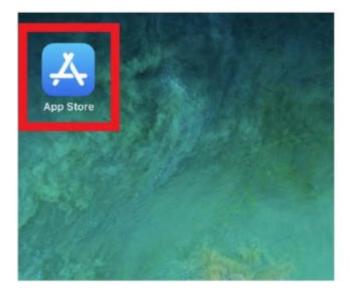
R+ ENGINEER : Android App Download



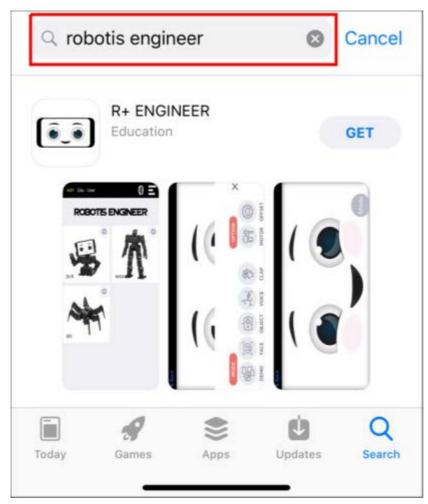
R+ Task 3.0 : Android App Download R+ Task 3.0 : Windows Installer Download

1. Open Play Store or App Store from the smart device.

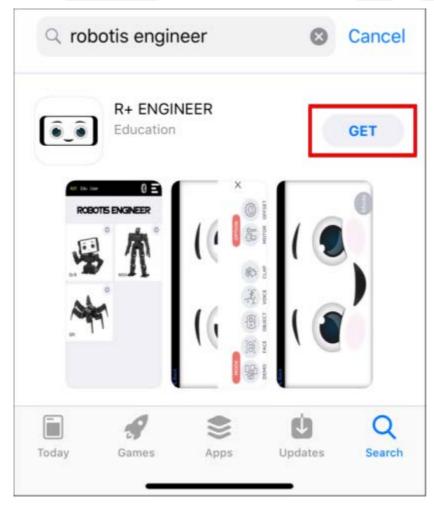




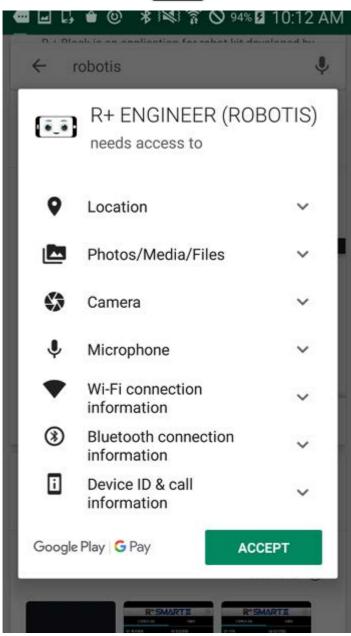
2. Search for **ROBOTIS** or **ROBOTIS ENGINEER** from the store.



3. Select R+ ENGINEER from the list and press the Get or Install button.

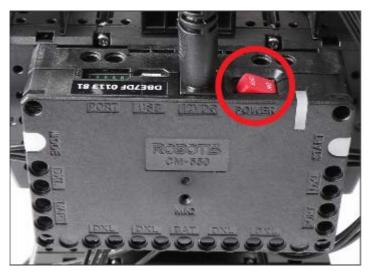


4. **Android** : Press the Agree button to proceed installation.



2. 2. Pairing Bluetooth

1. Turn on the CM-550 controller with power switch.



2. Press the MODE button until green light flashes.



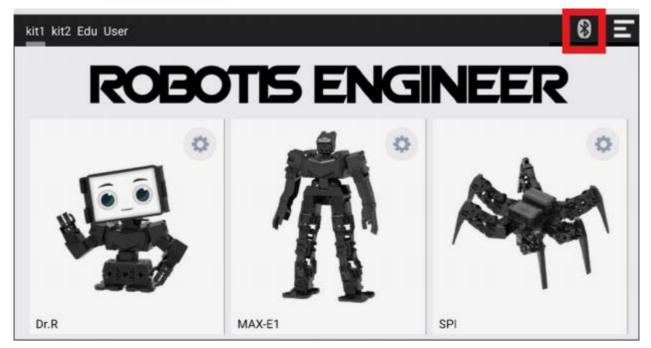
NOTE : The MODE button flashes in green when the controller is ready to run the task program.

3. Press the START button.



NOTE : While the MODE button flashes in green, pressing START button will run the task program.

4. Launch the **ROBOTIS ENGINEER** app from the smart device and press the Bluetooth icon.



5. Find the BLE MAC address of the CM-550 controller.



6. Enter the last two characters of BLE MAC address in the left box and press [Search] icon.

Device	
ROBOTIS_410_75 DB:E7:DF:01:13:79	
ROBOTIS_BT-410 DB:E7:DF:00:51:37	
75	SCAN

7. Select the BLE MAC address from the search list.

Device	
ROBOTIS_410_79 DB:E7:DF:01:13:79	
ROBOTIS_BT-410 DB:E7:DF:00:51:37	
ROBOTIS_410_75 DB:E7:DF:01:13:75	
75	SCAN

2. 3. Download Examples

- CM-550 controller is initially programmed with Kit1 example.
- The Complete Example includes Dr.R, MAX-E1, SPI examples.

Example	Task Files	Motion Files
Complete Example	01_ENG1_TOTAL_EN.tsk3	01_ENG1_TOTAL_EN.mtn3
Dr.R	02_ENG1_DR_R_EN.tsk3	02_ENG1_DR_R_EN.mtn3
MAX-E1	03_ENG1_MAX_E1_EN.tsk3	03_ENG1_MAX_E1_EN.mtn3
SPI	04_ENG1_SPI_EN.tsk3	04_ENG1_SPI_EN.mtn3

How to open tsk3 file in R+ Task 3.0 How to download task program to CM-550 controller

How to open mtn3 file in R+ Task 3.0 How to download motion to CM-550 controller

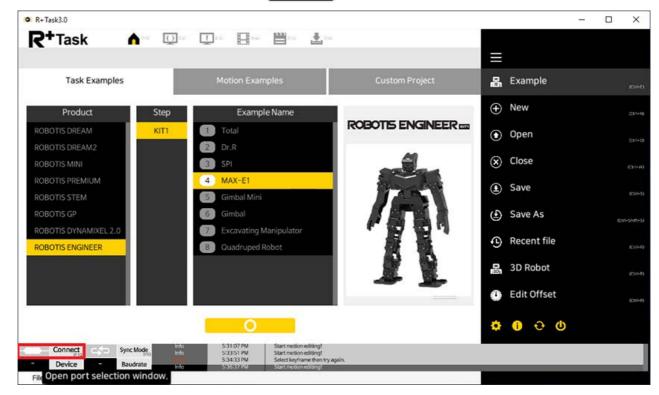
2. 3. 1. Download from PC

2. 3. 1. 1. Connect with USB Cable

The CM-550 can be connected to the PC via Micro USB port to download task(.tsk3) and motion(.mtn3) files.

- 1. Connect USB cable to PC.
- 2. Connect the other side of Micro USB cable to CM-550 controller. The controller will be powered by USB and turned on automatically.

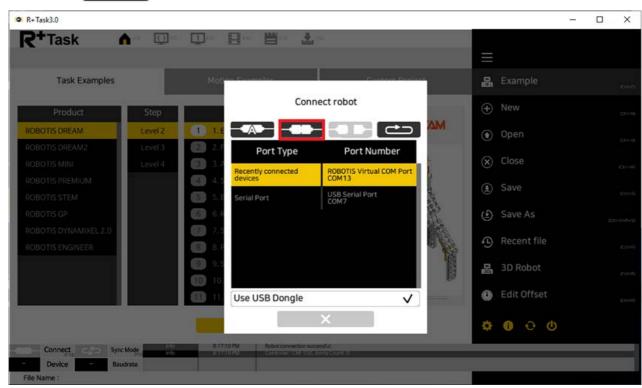
3. Luanch R+ Task 3.0 and press the Connect icon on the bottom left corner.



4. Select the serial port to use.

2+ Task A	n in the second							
						Ξ		
Task Examples		Moti	es Frameler	Custom Dia		ដឹ	Example	
Product	Step		Con	nect robot		÷		
OBOTIS DREAM	Level 2	1.6			AM	۲	Open	
	Level 3 Level 4	2.F	Port Type	Port Number		\otimes	Close	
		6 4.5	Recently connected devices	ROBOTIS Virtual COM Port COM13		٤	Save	
		(2) 5.6	Serial Port	USB Serial Port COM7	and a			
OBOTIS GP OBOTIS DYNAMIXEL 2.0		(C) (6.6 (7.5					Save As	
OBOTIS ENGINEER		(1) 8.4				9	Recent file	
		9.510.			T	B	3D Robot	
		(D 1).	Use USB Dongle	V		٩	Edit Offset	
				×		ø	0 0 U	
Connect Sync	Mode		10 PM Robot connection sur 10 PM Construction sur	xenstul.				

5. Press the Connect icon.



6. CM-550 will be connected to the PC with 3 beeps.

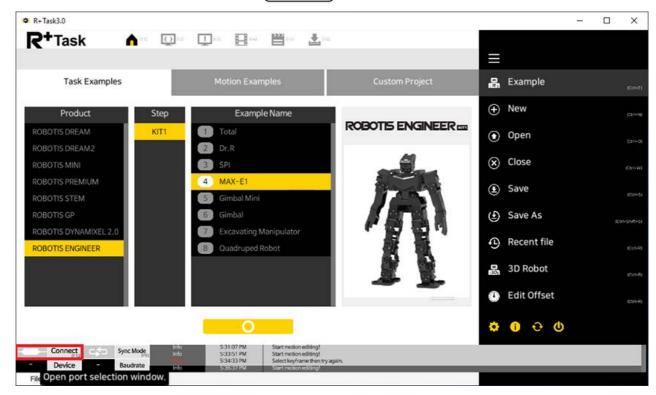
R+Task (B* B* &*			-	
Task Examples		in second and the	Chief and Date			
Product	Step	Connec	t robot			
ROBOTIS DREAM	Levid 7			AM .		
ROBOTIS DREAM2		Port Type Recently connected	Port Number			
ROBOTIS PREMIUM		devices Serial Port	COM13 USb Terial Port			
ROBOTIS GP)	2		
ROBOTIS OVNAMIXEL 2.0 ROBOTIS ENGINEER						
		Use USB Dongle	V		🚯 Edit Offset	
					¢ • • •	
Private States	Mode, and the second					

2. 3. 1. 2. Connect with Bluetooth

The BLE module in CM-550 can be also paired with BT-410 Dongle to connect the PC, but wireless connection will be slower than wired connection when downloading.

- 1. Turn on the CM-550.
- 2. Connect BT-410 Dongle to the USB port of the PC.
- 3. Bring the MODE button of CM-550 closer to the BT-410 Dongle to pair automatically.

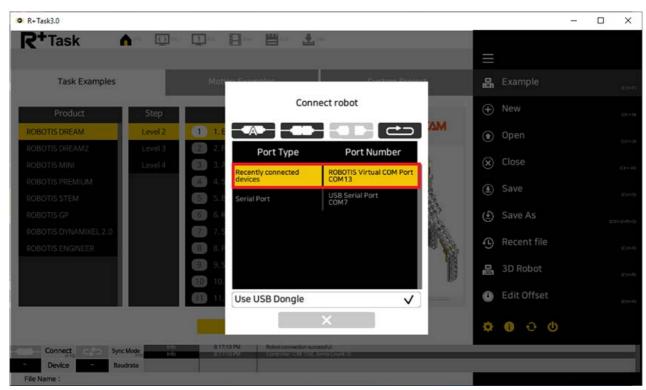
4. Luanch R+ Task 3.0 and press the Connect icon on the bottom left corner.



5. Make sure to check on Use USB Dongle option when using BT-410 Dongle.

Task Examples		Moti	a Damilie	Curton Br	22.24 A ()	옯	Example	
Product	Step		Con	nect robot		÷		
OBOTIS DREAM	Level 2	1 1.8			AM C	۲	Open	
	Level 3 Level 4	2.F	Port Type	Port Number		\otimes	Close	
		4.5	Recently connected devices	ROBOTIS Virtual COM Po COM13	<mark>а</mark> .	٤	Save	
		6 F	Serial Port	USB Serial Port COM7			Save As	
OBOTIS DYNAMIXEL 2.0		100 7.5				9	Recent file	
OBOTIS ENGINEER		(3) 8.4(4) 9.5				ga (3D Robot	
		10.			P		Edit Offset	
		0.00	Use USB Dongle	v l			Editoniset	

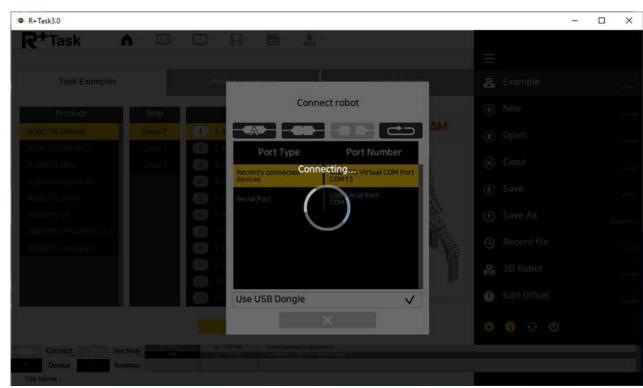
6. Select the serial port to use.



7. Press the Connect icon.

R+Task3.0						- 🗆 X
R+Task	u 🚺 est 🛄 est		a paar A ri			
			r			
Task Examples		lon Exampler	Cilcioni Brah		🖁 Example	
Product	Step	Con	nect robot		₽ New	
ROBOTIS DREAM	Level 2 1 1.			ΔM	 Open 	
	Level 3 🙆 2.	Port Type	Port Number			
ROBOTIS MINI ROBOTIS PREMIUM	Level 4 (E) 3.	Recently connected devices	ROBOTIS Virtual COM Port COM13		Close	
ROBOTIS STEM	6 5	Serial Port	USB Serial Port. COM7		Save	
ROBOTIS GP	6	F.			Save As	
ROBOTIS DYNAMIXEL 2.0 ROBOTIS ENGINEER	(5 6. (7 7. (8 8. (9 9. (10 10	5			B Recent file	
ROBOTIS ENGINEER		s -			🖁 3D Robot	
	(1)			12		
I_	0 1	Use USB Dongle	~		🕒 Edit Offset	
			×		0 0 O	
Connect Sync Mode		7:10 PM Robot connection su (A1012A) Connection su				
File Name :						

8. CM-550 will be connected to the PC with 3 beeps.



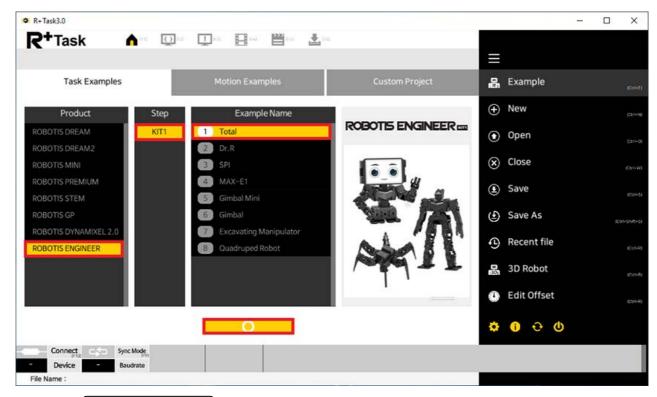
NOTE :

- Bring the MODE button of CM-550 closer to the BT-410 Dongle to pair automatically.
- Once BT-410 Dongle is paired successfully, the connection will be maintained within the range of Bluetooth signal.
- Once BT-410 Dongle is paired successfully, paired device will be automatically connected within the range of Bluetooth signal.

2. 3. 1. 3. Task Download (PC)

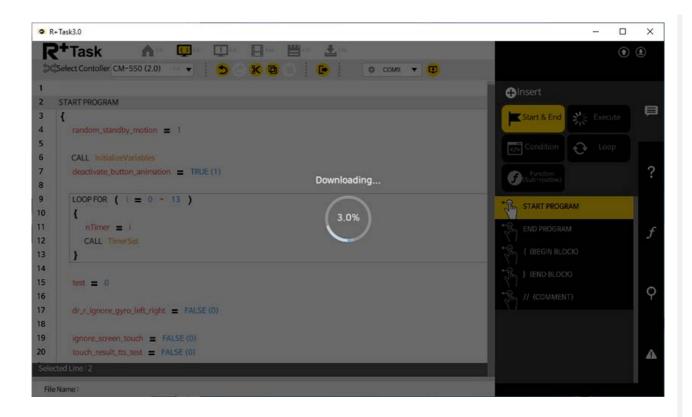
Please follow the instruction below to download the task(.tsk3) file to CM-550 controller.

1. Connect the controller to PC and select the assembled task example.



2. Click the (Program Download) button in the menu.

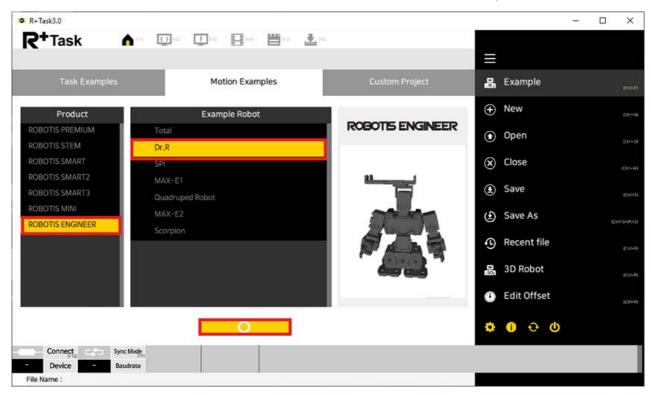
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P	🖏 Select Contoller CM-550 (2.0) 🕤 🔹 🏠 🕲 🕐 💽 🚱 👘 😨 com 13 🔻 🔯	Program (shift + F6)	
1		Dinsert	
2 3 4	START PROGRAM { random_standby_motion = 1	Start & End	þ
5		Condition 🔂 Loop	
6 7 8	CALL InitializeVariables deactivate_button_animation = TRUE (1)	(Sub-rougine)	?
9	LOOPFOR ($i = 0 \sim 13$)	The START PROGRAM	
10	{		
11 12	nTimer = i CALL TimerSet	The END PROGRAM	f
13	}	Shy ((BEGIN BLOCK)	
14		(END BLOCK)	
15	test = 0	X	
16		(fing // (COMMENT)	Ŷ
17 18	max_e1_alternative_walking_motion = FALSE (0)		
19	dr_r_ignore_gyro_left_right = FALSE (0)		
20	ignore_gyro_collapse = TRUE (1)		
Sele	ected Line : 5		
Fil	le Name :		



2. 3. 1. 4. Motion Download (PC)

Please follow the instruction below to download the motion(.mtn3) file to CM-550 controller.

1. Connect the controller to PC and select the assembled motion example.



2. Select the motion example to download.

2+ Task ▲				Ξ		
	Motion	Examples		8	Example	
Product	Example	Robot		÷		
OBOTIS PREMIUM	Total		GINEER	۲	Open	
OBOTIS STEM OBOTIS SMART	Dr.R SPI	Select the example		\otimes	Close	
OBOTIS SMART2		Empty File				
OBOTIS SMART3		2 02_ENG1_DR_R_EN		٤	Save	
OBOTIS MINI				٢	Save As	
OBOTIS ENGINEER				Ð	Recent file	
		0	× 87	ß	3D Robot	
				0	Edit Offset	
				÷	0 ÷ O	

3. Click the Motion Download tab in the menu.

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	Robot P	ose									COW - Left Cick	Joint Group
	3D Robot	Real Robot								เพิ	Cov - Right Click	Al (Alt+1)
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M13	Device	57600	Baudrate	Info	8853926 AM		MPISO, Joints Count	0	_		_	
File	Name :											

4. Select the motion group to download from the left column and click the Download button.

• R+Task3.0	A 🔘 .	D en B en L en	- □ ×
		Download Motion	
	+ - / B	 main 001P_InitPose Downloading 002P_Starte0/2 003P_Starte/2 003P_Starte/2 004P_Got(tessage) 005P_Starte0(te) 006P_StandUp(8) 007P_WarmUp 008P_Dumbbell(R) 008P_Dumbbell(R) 010P_SaySomething 124 	ROBOTIS
	7600 Baudrate	853247.4M Start motion eding! 853254 Robot convection sponsitul. 853243 M Robot convection sponsitul.	

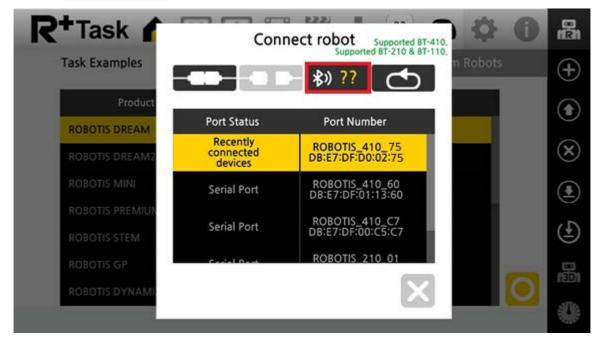
2. 3. 2. Download from Smart Device

In order to upload an example to CM-550 controller with R+ Task 3.0 app, the smart device and CM-550 must be paired with Bluetooth.

1. Launch the R+ Task 3.0 app from the smart device and press the button in the red box.



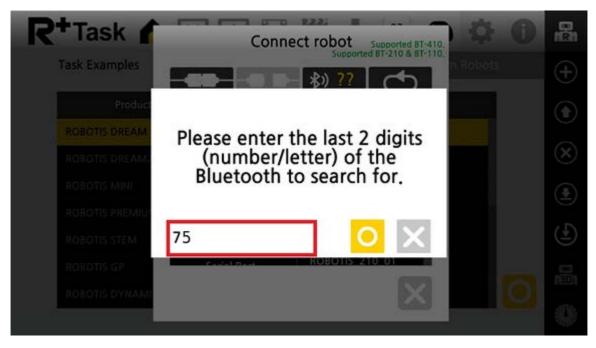
2. When Connect Robot window pops up, press the Bluetooth search button in the red box.



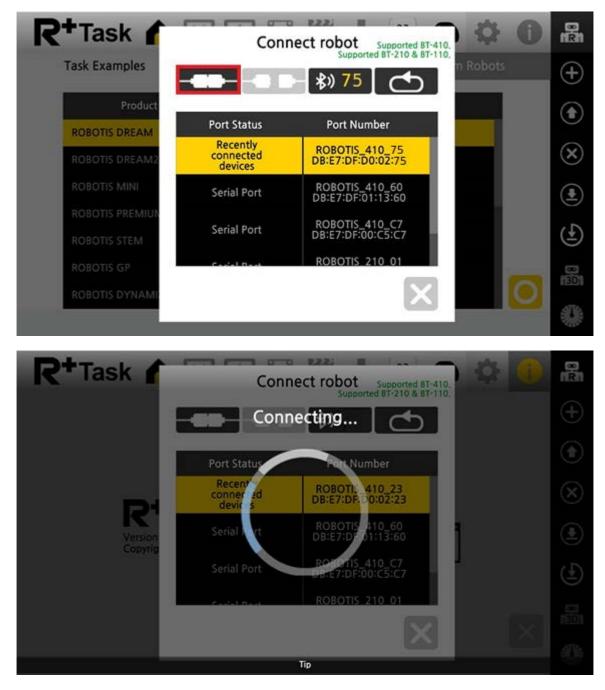
3. Find the BLE MAC address of the CM-550 controller.



4. Enter the last two characters of BLE MAC address in the left box.



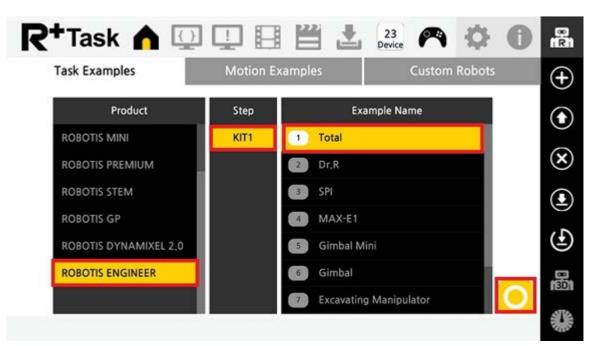
5. Select the BLE MAC address from the search list.



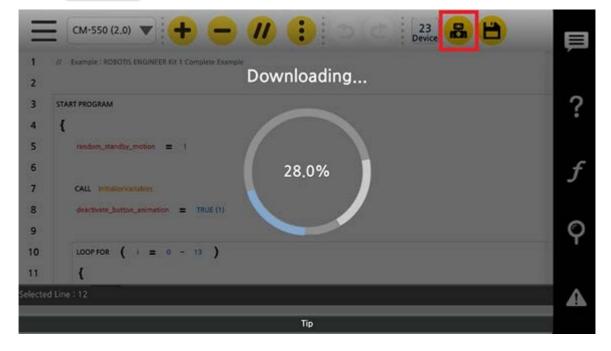
2. 3. 2. 1. Task Download (Smart Device)

The task file(.tsk3) can be uploaded to CM-550 controller wirelessly.

1. While CM-550 controller is connected to the R+ Task 3.0 app, go to **Task Examples** tab and select the example to upload.

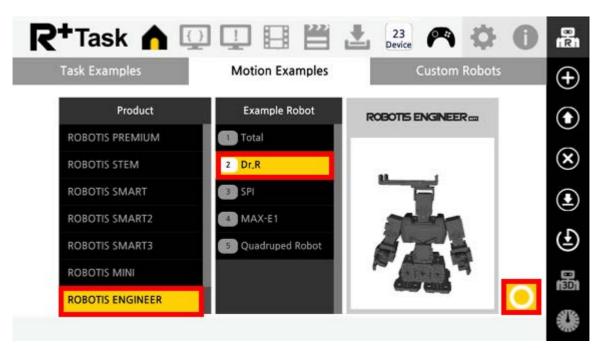


2. Press Download button to start uploading the task to CM-550 controller.



2. 3. 2. 2. Motion Download (Smart Device)

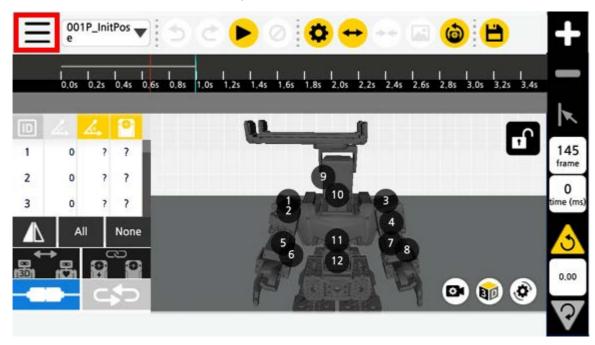
1. While CM-550 controller is connected to the R+ Task 3.0 app, go to **Motion Examples** tab and select the example to upload.



2. Select the example file in the Select the Example window.



3. Press the menu button on the top left corner of the screen.



4. Select Motion Download tab.

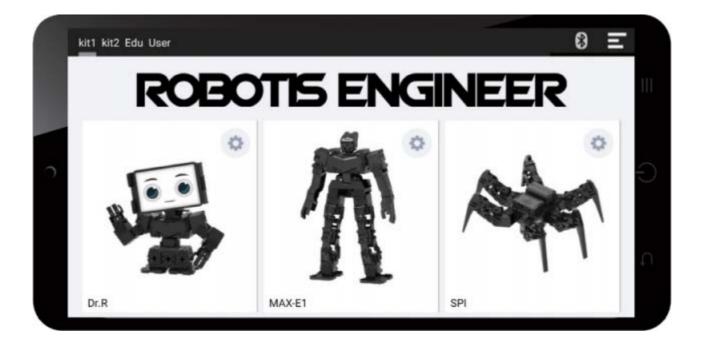
Dow	nload Mo	tion			
+ - 🖍 🖬		main		P	
Motion Group List	Index	Motion	Exit Index		
main	1	001P_InitPose			
	2	002P_Standby1			
	3	003P_Standby2			
	4	004P_GotMessag e			
	5	005P_StandUp(F)			
	6	006P_StandUp(B)		12.6%	E

5. Press the Motion Download button in the red box, selected motion file will be uploaded to CM-550 controller.

?+ Task 🏠 🛄 🖳	
Dow	vnload Motion Downloading
+ - / 🖬	main
Motion Group List	Index otion Exit Index
main	1 001P_) tPose
	002P_St hdby1
	B 003P (landby2
	e Dod P_GotMessag
	5 005P_StandUp(F)
	6 006P_StandUp(B) 12.6%
	Тір

2. 4. Run Examples

Launch the R+ ENGINEER app and select the assembled robot example to operate the robot.



CAUTION : Selecting wrong example may result in malfunction of the robot.

Select the menu button on the top right corner of the app for app configuration.

←	Settings
*	Connect to Robot Select Bluetooth device.
\bigcirc	Reset Example Contents (including code / images) of selected examples will be deleted.
B	Range of Gesture Error Settng Gesture tolerance setting
~	Display example image on gallery Several smart device won't work.
Q	Scanning media If folder or file doesn't display on PC, it might be solved after scanning and reconnecting.
	Version Information 1.0.2

Connect to Robot : Select Bluetooth device to connect.

Reset Example : Reset selected examples.

Range of Gesture Error Setting : Configure the error margin of the gesture.

Display Example Image on Gallery : Show example images in the smart device gallery.

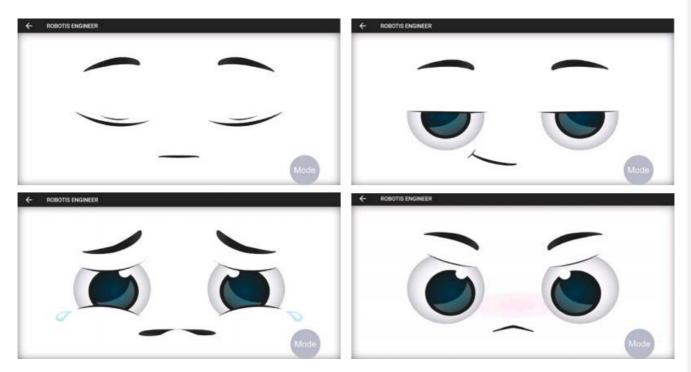
Scanning Media : Refresh the smart device files/folders when not detected from PC.

Version Information : Display the current app version.

2. 4. 1. Dr.R

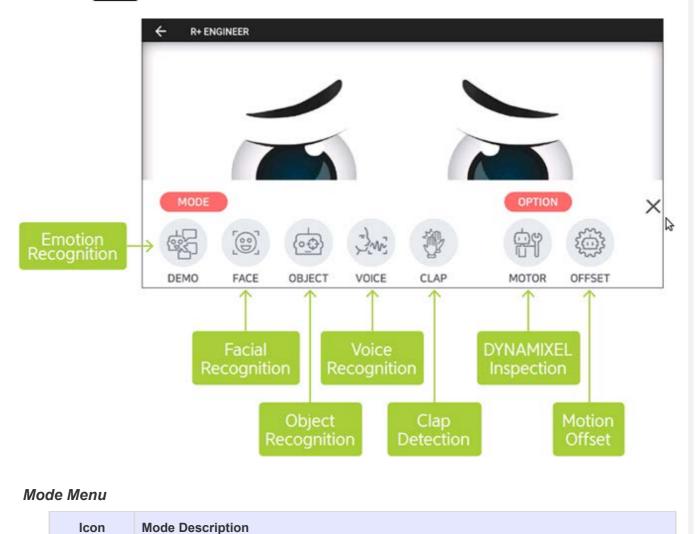
2.4.1.1. Emotion

Selecting Dr.R example from R+ Engineer app will display robot face on the screen. Touch robot or trigger events to change the emotion of the robot with facial expressions, motions and speeches.



2. 4. 1. 2. Select Mode

Press the Mode button to display supported modes and options.



lcon	Mode Description
	DEMO : Emotion Recognition This default demo mode expresses Dr.R's emotion on the smart device screen. Touch the robot or smart device will affect to Dr.R's emotion and behavior.
	FACE : Face Recognition The robot detects and tracks the face with the camera of the smart device. AR technology will overlay an image on the detected face.
- - -	OBJECT : Object Recognition The robot recognizes machine learned objects with the smart device camera. Dr.R can distinguish 12 different objects including banana, pen, car key, wallet, paper money etc.
	VOICE : Voice Recognition The robot recognizes registered voice commands. Commands such as mode change, option menu execution, and termination are registered.
	CLAP : Clap Detection The robot detects clapping sound with the controller microphone. Dr.R will clap as many as perceived claps.

Option Menu

lcon	Option Description
	MOTOR : DYNAMIXEL Inspection This feature inspects each joint of the robot.
	OFFSET : Motion Offset This feature calibrates the offset position of each joint for proper motions.

NOTE : The Option Menu is available in all examples. Please refer to Setting Up the Robot for more details.

2. 4. 2. MAX-E1

2. 4. 2. 1. Remote Controller Screen



Control Modes : Select Normal / Fight / Soccer mode for MAX-E1. Control Buttons : Control robot's motion speed and moving directions. Motion Buttons : Registered motions of MAX-E1 can be played. Torque Button : DYNAMIXEL Torque On/Off switch. Menu Button : Open additional menu for MAX-E1.

2. 4. 2. 2. Mode Menu

lcon	Mode Description
لے (+:::)	REMOTE : Use smart device as a remote controller.
ŀ	GESTURE : Use registered gestures in the smart device to control the robot.
	CLAP : The robot detects clapping sound and MAX-E1 will clap as many as perceived claps.

2.4.3.SPI

2. 4. 3. 1. Remote Controller Screen



<u>Control Buttons</u> : Control robot's motion speed and moving directions. <u>Motion Buttons</u> : Registered motions of SPI can be played. <u>Torque Button</u> : DYNAMIXEL Torque On/Off switch. <u>Menu Button</u> : Open additional menu for SPI.

2. 4. 3. 2. Mode Menu

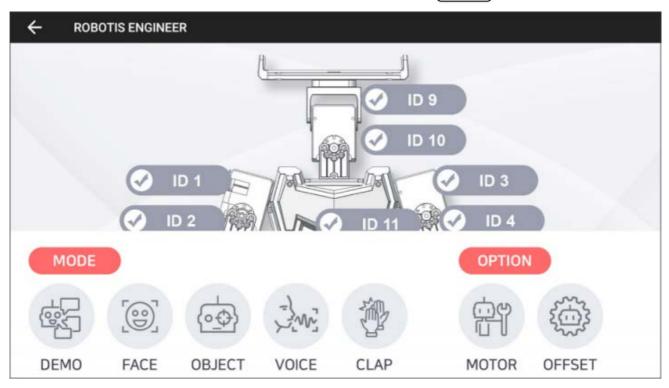
lcon	Mode Description
لے (+::::)	REMOTE : Use smart device as a remote controller.
57	MUSIC : SPI and smart device play music together.
	CLAP : The robot detects clapping sound and SPI will clap as many as perceived claps.

2. 5. Setting Up the Robot

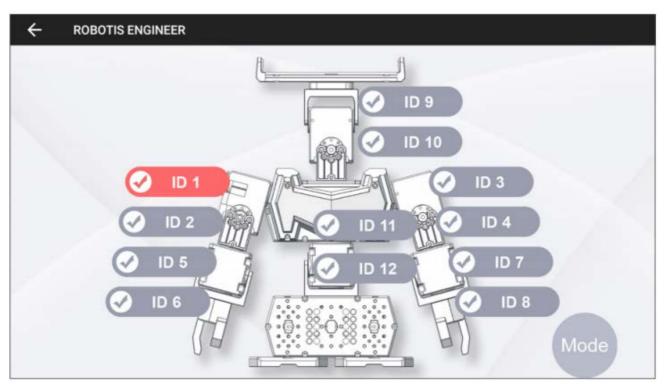
2. 5. 1. Check DYNAMIXEL Assembly

This function checks DYNAMIXEL ID and status of the ROBOTIS ENGINEER Kit.

1. Launch the robot example from the main screen, and select (MOTOR) from the option menu.



2. Select the joint ID from the screen. Check if the selected joint flinches while LED is turned on.

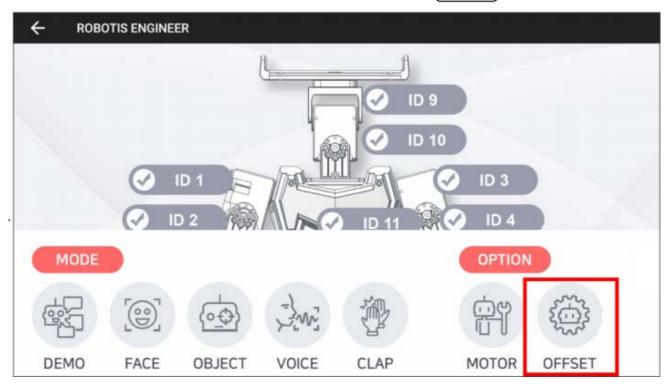


2. 5. 2. DYNAMIXEL Offset

This function is used to adjust the pose of robot by calibrating offset values of DYNAMIXEL used in the ROBOTIS ENGINEERING KIT. Configured offset value will be saved in each DYNAMIXEL's.

Please perform offset adjustment with a thorough understanding as it may cause unstable motions or hardware damages when improperly configured.

1. Launch the robot example from the main screen, and select (OFFSET) from the option menu.



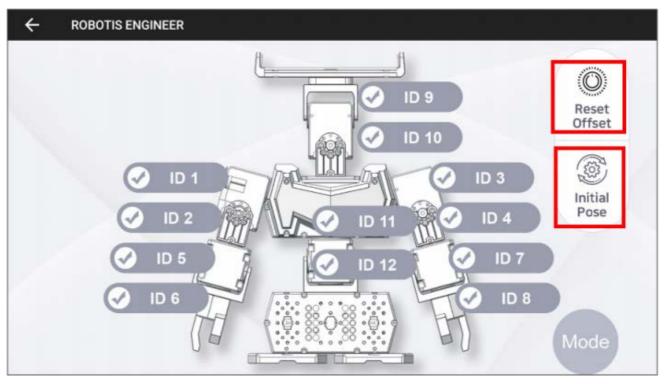
2. Select the joint ID to adjust offset from the screen and adjust menu will appear.

÷	ROBOTIS ENGINEER				
		Č.			Ø
		🗘 ID	2 OFFSET		Reset Offset
	 ID ID 2 ID 5 	0	Torque On	ID 3 ID 4 ID 7	Initial Pose
	✓ ID 6) ID 8	
		CANCEL	ОК	10	Mode

- \circ (+ / -): Increase / Decrease the offset value.
- Torque On / Off : Toggle the torque of the selected joint.
- OK / CANCEL : Save / Cancel the changes in offset value.
- Select OK to save the offset value. The confirmation message will appear.
 Select OK once again to save the offset value to robot.



4. Below buttons will reset or reload offset values of each joint.



- Reset Offset : When selected, the confirmation window will appear. Select [OK] to reset the offset value of all joint.
- Initial Pose : This button will reload the saved offset value. Incorrectly configured offset may be recovered with this button.

3. Tutorials

3. 1. [Machine Learning] Object Detection

Get started to learn a machine learning with **ROBOTIS ENGINNER** and Tensor Flow developed by Google Brain.

Tensor Flow is a machine learning application to ease the process of acquiring data and training models.

Once you finish this instruction, you will understand how to utilize the object detection which is one of the part of a machine learning. Explore following simple steps and train your robot to recognize your custom objects.

- Use a smart device with a camera to utilize the object detection.
- Install R+ ENGINEER in the smart device.

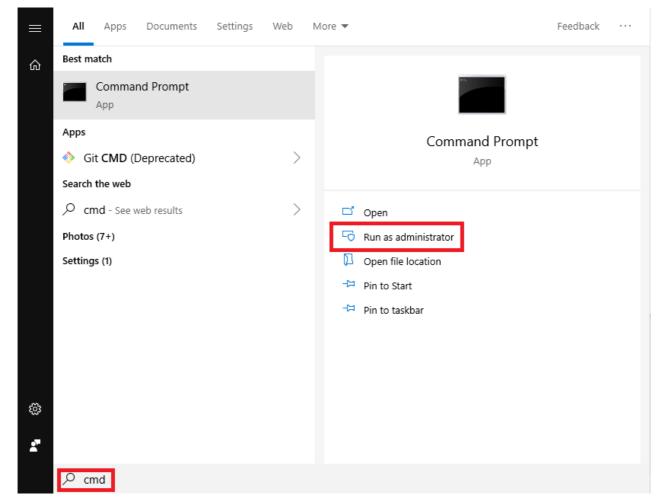
3. 1. 1. Windows

Anaconda is the easiest way to perform a machine learning and a large-scale data processing on Linux, Windows, and Mac OS X. To utilize an object detection with **ROBOTIS ENGINEER**, install Anaconda3 4.2.0 for Windows (64/32 bit) on your PC to build your own image classifier using Tensor Flow.

- Download Anaconda3-4.2.0 for Windows 64 bit
- Download Anaconda3-4.2.0 for Windows 32 bit

3. 1. 1. 1. Upgrade pip Packages

- 1. Open a Command Prompt as an administrator.
 - Press (WIN) + (s) on your keyboard to open a Windows search box.
 - Type **CMD** into the Windows search box and click the resulting "Command Prompt" as an administrator.



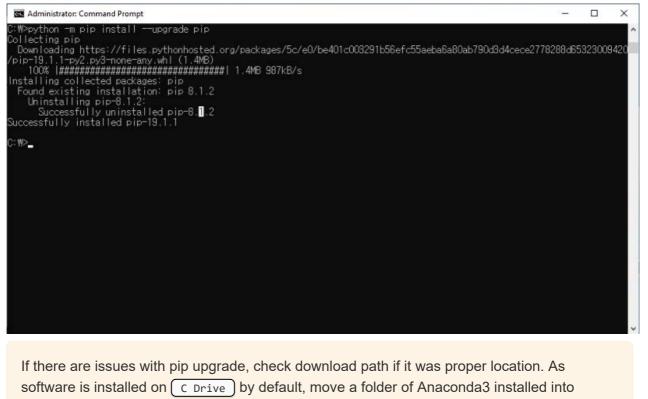
2. Command Prompt will be popped if you get access to CMD in the administrator mode.

Command Prompt	-	×
Microsoft Windows [Version 10.0.17763.437] (c) 2018 Microsoft Corporation. All rights reserved.		^
C:#WindowsWsystem32>		
		i i

3. Copy the following command and paste it into Command Prompt.

<pre>python -m pip installupgrade pip</pre>		
G Administrator: Command Prompt	-	×
Microsoft Windows [Version 10.0.17763.437] (c) 2018 Microsoft Corporation. All rights reserved.		
C:#Windows#system32 <mark>python -m pip installupgrade pip</mark>		
		~

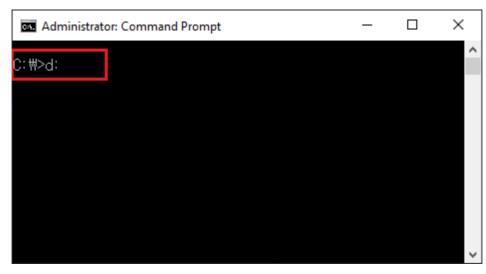
4. As shown in the picture below, new pip package will be installed.



C Drive then upgrade pip package.

3.1.1.2. Create Folder

- 1. Create Folder named [!R+Smart 🕳 | 📝 📙 🖛 | Partition (D:) \times Manage File Home Share 0 View Drive Tools 🛃 Open 👻 📑 Select all hew item -~ 4 X 🛋 | * M- Copy path Easy access 🔻 📝 Edit Pin to Quick Copy Paste Properties History Move Copy Delete Rename New folde Select Clipboard Organize New Open ← → ~ ↑ → This PC → Partition (D:) ✓ ♂ Search Partition (D:) Q 🗊 3D Objects Date modified Size Name Туре 🗾 Desktop 2019-08-27 오전 8:... File folder R+Smart 👮 Documents Downloads Music Pictures Videos 🏪 Local Disk (C:) Partition (D:) Network ::: 1 item
 - You can create the folder in any location on your PC, but make sure a path in Command Prompt must coincide with the location of its folder properly.
 - You can change a folder name, but make sure the name in Command Prompt must coincide with the actual folder name.
 - In this instruction, the folder name is [!R+Smart], and the path is C Drive
- 2. Change your path in Command Prompt into D Drive where PR+Smart folder exists as your current location in Command Prompt is C Drive.



3. Copy the following command and paste it in Commad Prompt to move into [!R+Smart] from D drive.

cd !R+Smart			
Administrator: Comn	nand Prompt	_	×
C:₩>d:			^
d:#>cd !R+Smart			
d:₩!R+Smart>			
			~

3. 1. 1. 3. Create Virtual Environment

1. Copy the following command and paste it in Command Prompt to create a virtual environment for your project.



a Administrator: Command Prompt	-	×
):\!R+Smart>conda create -n tensorlfow python=3.5		^

2. It will ask you if you want to proceed to the next step. Press y, and then press Enter key to install the Python version and new packages.

kage plan for installation in e	nvironment C:#Users	₩ROBOTIS_David₩Anaconda3₩en	ivs∰tensorflow:	
e following packages will be dow	n I oaded:			
package	build			
vs2015_runtime-14.0.25420 vc-14 python-3.5.4 certifi-2016.2.28 wincertstore-0.2 setuptools-36.4.0 pip-9.0.1	0 0 9y35_0 9y35_0 9y35_1 9y35_1 9y35_1	2.0 MB 703 B 30.3 MB 213 KB 14 KB 531 KB 1.7 MB		
	Total:	34.7 MB		
e following NEW packages will be	INSTALLED:			
certifi: 2016.2.28-py35 pip: 9.0.1-py35_1 python: 3.5.4-0 setuptools: 36.4.0-py35_1 vc: 14-0 vs2015_runtime: 14.0.25420-0 wheel: 0.29.0-py35_0	_0			

3. As shown in the picture, you can see all the packages are successfully installed.

Administrator: Command		 	 	 	
pip: python: setuptools: vc: vs2015_runtime: wheel:	2016.2.28-py35_0 9.0.1-py35_1 3.5.4-0 36.4.0-py35_1 14-0 14.0.25420-0 0.29.0-py35_0 0.2-py35_0				
roceed ([y]/n)? y					
etching packages s2015_runtime 100% c-14-0.tar.bz 100% ython-3.5.4-0 100% ertifi-2016.2 100% incertstore-0 100% etuptools-36. 100% xtracting packages COMPLETE inking packages COMPLETE		0:00:00 0:00:00 0:00:00 0:00:00 0:00:00 0:00:0	kB/s MB/s MB/s MB/s MB/s		
To activate this e > activate tensorf					
To deactivate this > deactivate tenso					
* for power-users	using bash, you must source				
:#!R+Smart>					

3. 1. 1. 4. Install Tensor Flow

Tensor Flow installation can be done in two simple steps.

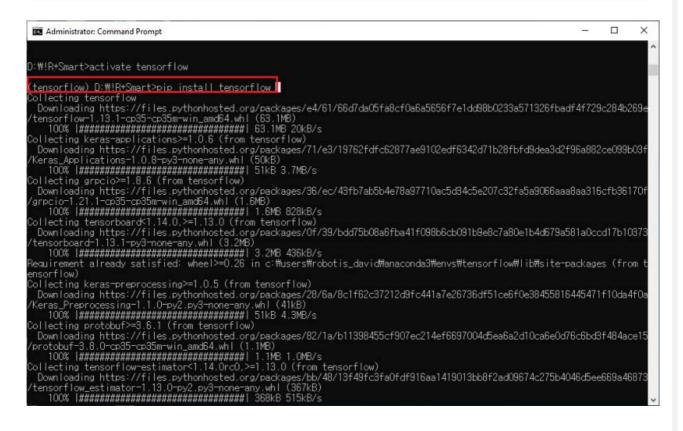
pip install tensorflow==1.13.1

1. Copy the following command and paste it in Command Prompt to activate newly created virtual environment of Tensor Flow.

Administrator: Comma	nd Prompt						-	×
python: setuptools: vc: vs2015_runtime: wheel: wincertstore:	3.5.4-0 36.4.0-py35_1 14-0 14.0.25420-0 0.29.0-py35_0 0.2-py35_0							
ceed ([y]/n)? y								
tching packages . 2015_runtime 100% 14-0.tar.bz 100% thon-3.5.4-0 100% tifi-2016.2 100% certstore-0 100% cuptools-36. 100% p-9.0.1-py35 100% tracting packages		Time:	0:00:00 0:00:00 0:00:00 0:00:00	68.27 19.84 3.62 36.36	MB/s kB/s MB/s MB/s MB/s MB/s MB/s			
COMPLETE king packages	_]]ининининининининининининин	*****	******	*****	100%			
COMPLETE	.] <i>###################################</i>	nnnnn	******	#####	100%			
lo activate this ∘ ≻ activate tensor								
fo deactivate thi: ≻ deactivate tens	s environment, use: orflow							
for power-users	using bash, you must source							

2. Lastly, Copy the following command and paste it in Command Prompt to install Tensor Flow.

WARNING: Be sure to install tensorflow 1.13.1. Otherwise, it may cause unexpected errors.



3. 1. 1. 5. Create a file and a folder

1. Go on the associated link to download a retrain.py file.

Download retrain.py

2. Move the downloaded file <u>retrain.py</u> in <u>IR+Smart</u> folder. Create a <u>photos</u> folder in <u>IR+Smart</u> to add images for an object detection.

☐ ☑ ☐ ╤ File Home Share	Search Tools IR+Sma	art				- 0	× ^ (3)
This PC Location	Image: Size → Date modified → Refine	Advanced options • Open file	Close search				
\leftarrow \rightarrow \checkmark \uparrow \square \Rightarrow This	PC > Partition (D:) > !R+Smart	>			5 ~		Q
💻 This PC	^ Name	^	Date modified	Туре	Size		
3D Objects Desktop		notos train.py	2019-06-19 오전 2: 2019-06-19 오전 1:		56 KB		
🔀 Documents 🖶 Downloads							
Music Fictures							
Videos							
🏪 Local Disk (C:)							
Partition (D:)	v						
2 items							

3. Create subfolders named (001 dummy), (002 banana) and (003 pineapple) or something like that, which contains images matching a detected object characteristic for an object detection.

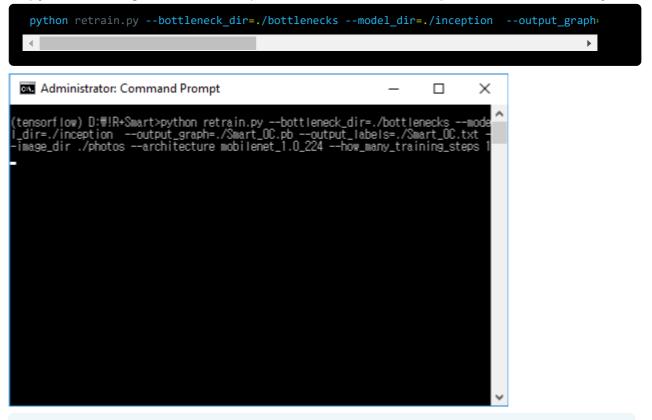
📕 🛃 🤿 🗸 photos						-	o x
File Home Share View File Home Share View Fin to Quick Copy Paste Copy Paste shortcut Clipboard	Move to * Copy to * Copy to * Copy to * Copy to *	New item •	Properties Open Open	Belect none			^ 🛛
\leftarrow \rightarrow \checkmark \uparrow \square \rightarrow This PC \rightarrow Partition (D:) > !R+Smart > photos >				~ ∂	Search photos	Ą
 This PC 3D Objects Desktop Documents Downloads Music Pictures Videos Local Disk (C:) Partition (D:) 	 Name 001 dummy 002 banana 003 pineapple 	2	Date modified Tyr 2019-06-19 오전 4: File 2019-06-19 오전 2: File 2019-06-19 오전 2: File	e folder e folder			
3 items	×						

NOTE :

- To reduce errors of recognizing objects, 001 dummy folder will be useful to scan unspecified objects.
- Train your **ROBOTIS ENGINEER** with sufficient images. The more it is, the better performance it is. (Collecting 100 images will be enough for recognizing objectes)
- To organize folders in order, specify them with a number 001, 002, etc..

3. 1. 1. 6. Train models

1. Copy the following command and paste it in Command Prompt to train models of objects.



In the command line, the option <u>how_many_training_steps</u> is the count of steps of training models. The enough steps for training models are 1000 times.

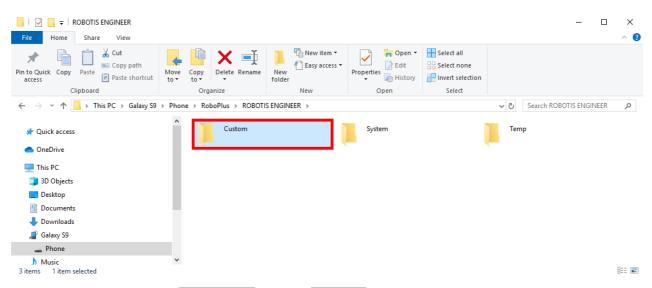
2. After completion of training, <u>Smart_OC.txt</u> and <u>Smart_OC.pb</u> files will be created in the [!R+Smart] folder.

☐ ☑ ☐ ╤ !R+Smart File Home Share View					-	□ × ^ (2)
Image: Pin to Quick access Copy ath Paste shortcut	Move Copy to * to *	New item •	Properties	Select all Select none		
Clipboard ← → ✓ ↑ → This PC → Partition (Organize	New	Open	Select	Search !R+Smart	م
This PC This PC Desktop Cournents Cownloads Music Pictures Videos	 Name bottlenecks inception photos retrain.py Smart_OC.pb Smart_OC.txt 	D 20 20 20 20 20 20 20	te modified Type 19-06-19 오전 4: File 1 19-06-19 오전 2: File 1 19-06-19 오전 2: File 1 19-06-19 오전 1: PY F 19-06-19 오전 4: Text	e Size folder folder ile 56 KB ile 16,727 KB		
Local Disk (C:) Partition (D:) 6 items	~					

3. 1. 1. 7. Apply training file to your prject

- 1. Connect your smart device in which R+ ENGINEER app installed to your PC.
- 2. Enter RoboPlus > ROBOTIS ENGINEER > CUSTOM of your device folder.

🕳 🛃 📙 🖛 Phone				– 🗆 ×
File Home Share View				^ (
★ 📄 📩 Cut © Copy path	📮 🛄 🗙 📑	New item ▼ F Easy access ▼ F Edit	Select all	
Pin to Quick Copy Paste access Paste Paste shortcut	Move Copy Delete Rename	New folder Properties	Invert selection	
Clipboard	Organize	New Open	Select	
← → ∽ ↑ 🖬 → This PC → Galaxy St	9 > Phone >		✓ O Search Pho	ne p
	^ !temp	Alarms	Android	^
📌 Quick access	· · · · · · · · · · · · · · · · · · ·			
OneDrive	DCIM	Download	Movies	
💻 This PC	1 L	<u> </u>	<u> </u>	
3D Objects	Music	Notifications	Pictures	
Desktop				
Documents	Playlists	Podcasts	Ringtones	
Downloads I Galaxy S9				
Phone Phone	RoboPlus	Samsung	tmp	
h Music	~	· · · · · · · · · · · · · · · · · · ·		~
15 items 1 item selected				
📙 🛃 📮 = RoboPlus				– 🗆 🗙
File Home Share View				~ 🔞
🖈 📄 📋 🔏 Cut	📕 🗐 🗙 🛋	🚹 New item 🔹 📄 Open 🔹	Select all	
Pin to Quick Copy Paste	Move Copy Delete Rename	New Easy access • Departures Easy access • Dep	Select none	
access Clipboard	t to + to + Organize	folder New Open	Select	
		New Open		DI
← → × ↑ <mark>·</mark> → This PC → Galaxy St	59 > Phone > RoboPlus >		✓ C Search Rob	oPlus 🔎
🖈 Quick access	Block	course	ROBOTIS ENGINE	ER
 OneDrive 				
📮 This PC	Smart3			
3D Objects				
Desktop				
Documents				
🚽 Downloads				
📲 Galaxy S9				
Phone				
h Music 4 items 1 item selected	v			877



3. Create a folder named Project 1 in the CUSTOM folder.

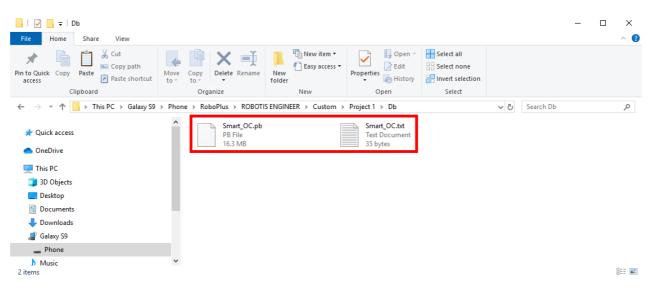
File Home Share View Pin to Quick Copy Paste Cipboard Organize New Open Pinot Quick access Cipboard Organize New Open Select all Properties Pinot Quick access OneDrive This PC 3D Objects Desktop Bostop Desktop Downloads	a 🖻 🚔 V Cut
✓ Quick access OneDrive I This PC 3D Objects Desktop B Documents	to Quick Copy Paste access Paste and Paste shortcut
 OneDrive OneDrive This PC 3D Objects Desktop Documents 	→ 👻 🛧 📙 → This PC → Galaxy S9
Galaxy 59	 OneDrive This PC 3D Objects Desktop Documents Downloads Galaxy S9 Phone
Music 1 item 1 item selected	

NOTE : If there is your own project, you can skip 3rd step of this instruction.

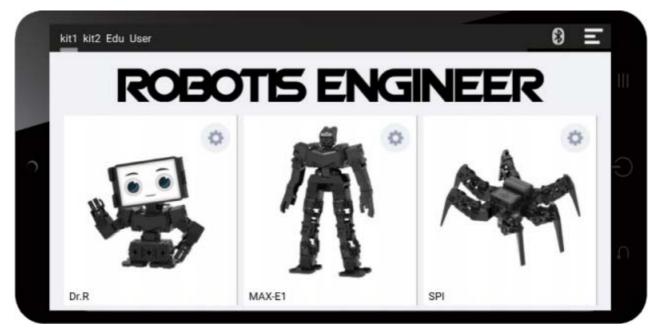
4. Create a Db folder to store training files.

File Home Share View							~ (
★ Cut ★ Copy path Copy path Copy path Paste Paste shortcut	Move Copy to *	New item •	Properties	Select all Select none			
Clipboard	Organize	New	Open	Select			
> -> 🕆 📙 > This PC > Galaxy S9 🕫	> Phone > RoboPlus > ROBOTI	S ENGINEER > Custom >	Project 1 >		v ē	Search Project 1	م
OneDrive							
 OneDrive This PC 30 Objects Desktop Documents Downloads Colume 50 							
 This PC 3D Objects Desktop Documents 							

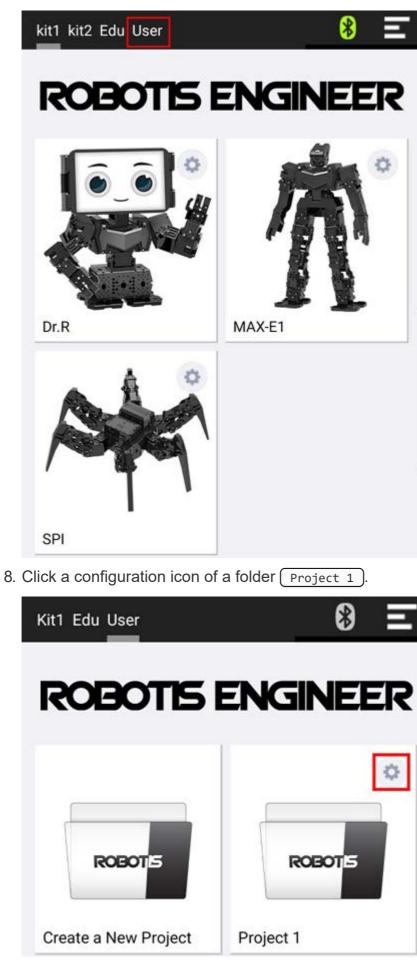
5. Copy <u>Smart_OC.txt</u> and <u>Smart_OC.pb</u> files from <u>!R+Smart</u> and then paste them into the <u>Db</u> folder.



6. Disconnect the smart device from the PC, and then launch the **ROBOTIS ENGINEER** app on your smart device.



7. Click User tab.



9. Select Object Classifier) at Vision Section.

← Pr	oject 1	Ξ
ROBOTIS	🕑 R+ m.Task	R+ m.Motion
	(b) Motion offset	
Vision	● Face Detection	Color Detection
	● Motion Detection	Line Detection
	Object Classifier	

10. To test object detection, select your custom object in the list.

←	Object Classifier
1	001 dummy
2	002 banana
3	003 pineapple

11. Detect objects in real time.



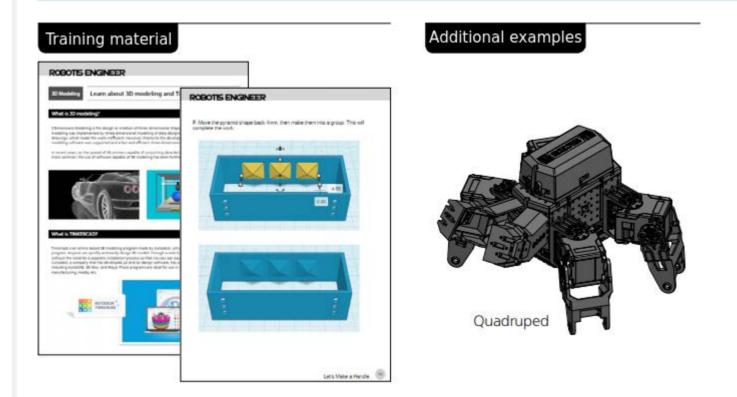
NOTE : It is not possible to add new object datas to <u>Smart_OC.txt</u> and <u>Smart_OC.pb</u>, which have been already configured. To add new data into them, please add a new object image to the subfolders created in (!R+Smart).

- Create a file and a folder
- Train models

4. Study Materials

Additional course materials can be downloaded from below link.

Request Additional Course Materials



3D Printing



5. Download Softwares

- ROBOTIS ENGINEER supports R+ Task 3.0.
- R+ Task 3.0 is an integrated software of R+ Task 2.0 and R+ Motion 2.0.
- Write the task code to operate the robot.

Create various motions to vitalize the robot.



R+ ENGINEER : Android App Download



R+ Task 3.0 : Android App Download R+ Task 3.0 : Windows Installer Download

6. References

6. 1. BLE Signal Setting

The Bluetooth communication could be unstable if the signal strength of BLE slave module in the CM-550 is weak or interfered.

The BLE signal strength can be adjusted by R+ Manager 2.0 in this case.

Please refer to the method to adjust CM-550 BLE signal strength for various situations.

My CM-550	Other CM-550	BLE Signal Strength
Unstable Link	Stable Link	Increase
Unstable Link	Unstable Link	Increase
Stable Link	Unstable Link	Decrease
Stable Link	Stable Link	No Change

- If communication is unstable when using one CM-550 controller in the room, the signal strength might be weak. **Increase the BLE signal strength**.
- If communication is unstable when using multiple CM-550 controllers in the room, BLE signals could interrupt each other. Increase the BLE signal strength of the unstable CM-550 or decrease the BLE signal strength of other stable CM-550.
- If all CM-550 in the room are stable, Maintain the BLE signal strength.

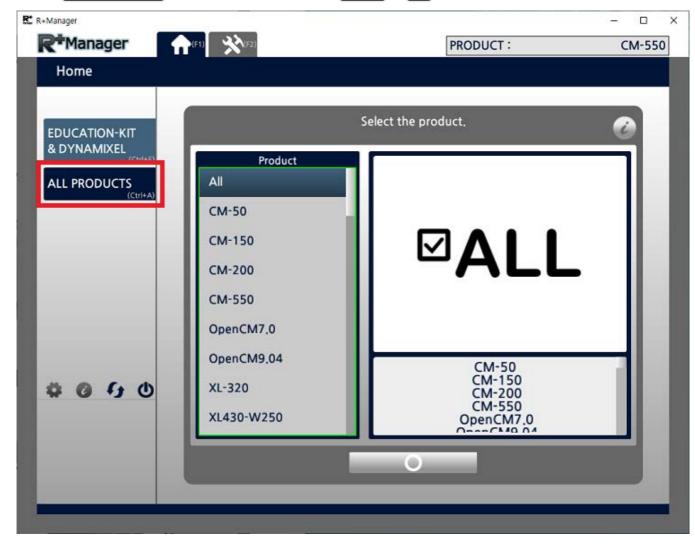
NOTE : The BLE signal strength and noise may differ by environment and the number of devices nearby.

- Turn off the BT-410 master or BT-410 Dongle that is paired to CM-550 BLE. (BLE signal strength cannot be configured while CM-550 BLE is connected to the paired device)
- 2. Connect the USB cable from PC to CM-550 (5V USB will automatically turn on the controller even if the power switch is off).
- 3. Wait until the MODE button of CM-550 flickers every second.
- 4. Run R+ Manager 2.0.

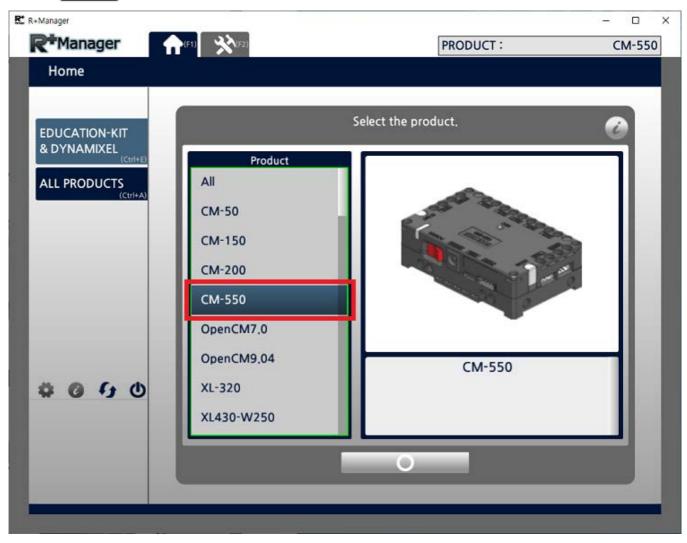
5. Click the Check for Updates button to install the latest updates.



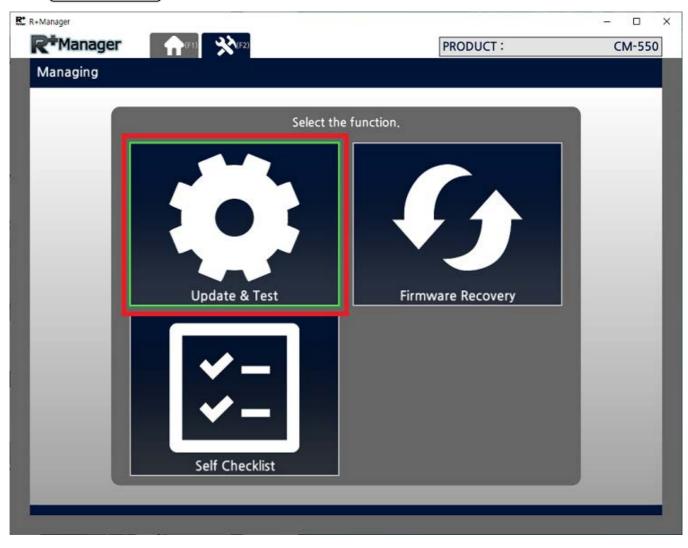
6. Go to ALL PRODUCTS tab or use shortcut key(Ctrl + A).



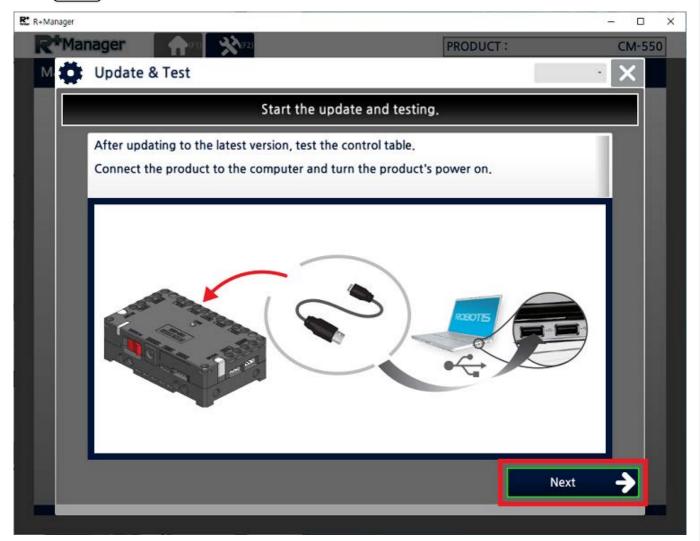
7. Select (CM-550) from the product list.



8. Click Update & Test button.



9. Click Next button.



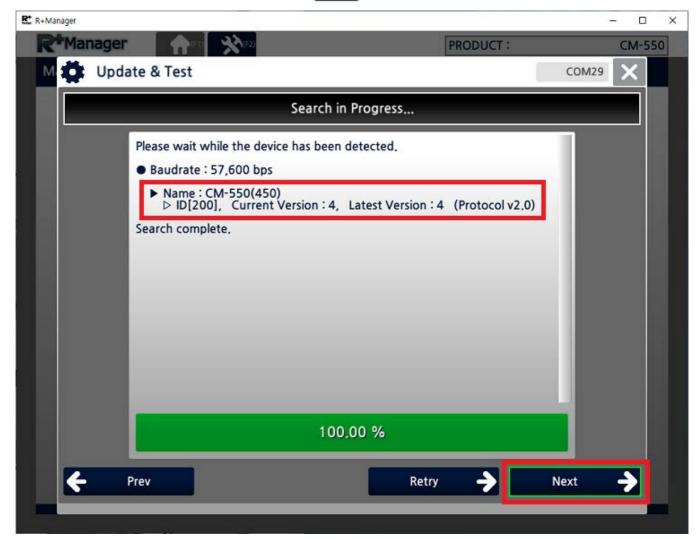
10. Select the port where the controller is connected to.

M D Upd	ate & Test	PRODUCT :	CM-550
	Select the o	communication port.	
	🖌 Auto	Search	0
	Port Type	Port Number	
	Recently connected devices	ROBOTIS Virtual COM Port COM29	
		Use USB Dongle	
	Prev		Next ->

11. Confirm the Baudrate (The default baudrate is fixed to 57600 bps).

Selec	t the baudrate for searching	ng.	
Basic Option	Advanced Option	Custom Option	
¥	Baudrate	Value	
	9600 bps	0	
✓	57600 bps	1	
	115200 bps	2	
	2M bps	:41	

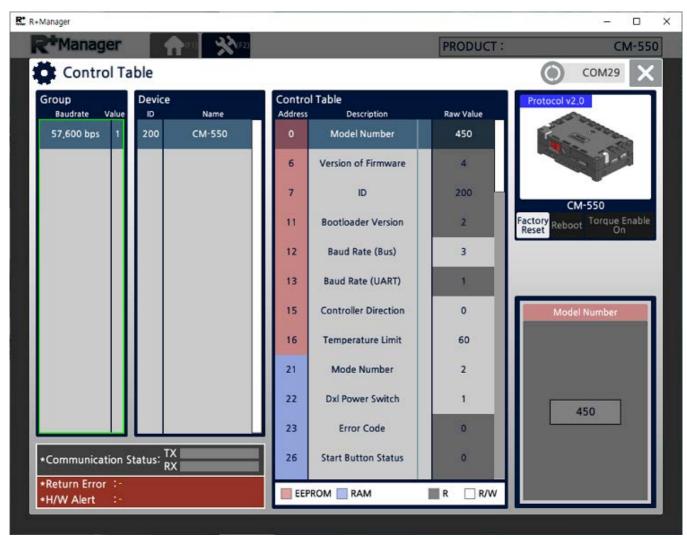
12. Once CM-550 controller is detected, click Next).



13. If the controller has the latest firmware, click Next, or else follow the update instruction on the screen to download the latest firmware.

R+Manager			- 🗆 X
R ⁺ Manage		PRODUCT :	CM-550
M 🛟 Upo	late & Test		сом29 🗙
	The firmware of all devices is the late	est version.	
	Click on [Next].		
			Next

14. Upon the successful connection, below control table will appear on the screen.



15. Scroll down until to find BLE Signal Power) in the address [139].

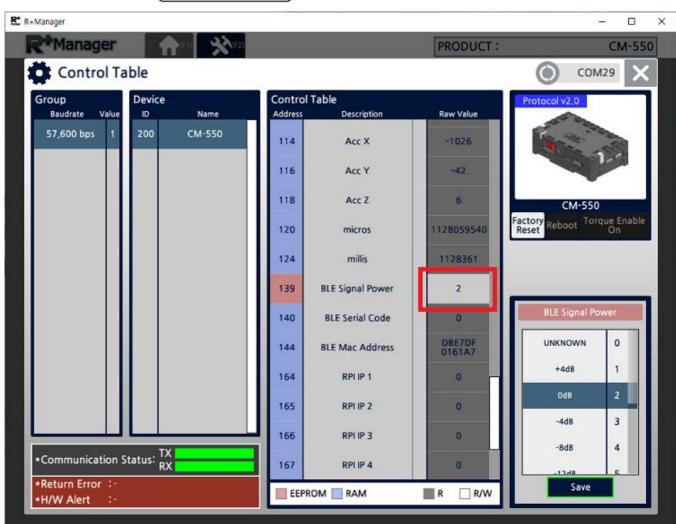
Manager		(FE)			PRODUCT :	CM-
Control Ta	ble					О сом29
Group Baudrate Value	Device	Name	Control Address	Table Description	Raw Value	Protocol v2.0
57,600 bps 1	200	CM-550	114	Acc X	-1020	Sector Sector
			116	Acc Y	-39	1-1
			118	Acc Z	2	CM-550
			120	micros	851779983	Factory Reset Reboot On
			124	millis	852082	
			139	BLE Signal Power	1	
			140	BLE Serial Code	0	BLE Signal Power
			144	BLE Mac Address	DBE7DF 0161A7	UNKNOWN 0
			164	RPI IP 1	0 -	+4dB 1
			165	RPI IP 2	0	OdB 2
			166	RPI IP 3	0	-4d8 3
Communication S	tatus: TX RX		167	RPI IP 4	0	-8d8 4
•Return Error :-				ROM 🔲 RAM	R R/W	Save

16. Select the BLE Signal Power on the right section of the control table and click Save button. The bigger value will increase the signal strength.



If the value of BLE Signal Power is marked on UNKNOWN(0), please go back to step 1 and check if BT-410 Master or BT-410 Dongle module is turned off.

17. Confirm the changed BLE Signal Power value.



6. 2. Self Checklist

1. Why the robot does not turn on?

Please check the battery level and connection.

2. How can I check the battery level?

Please refer to Battery Level Check section.

3. I keep hearing the alarm from the robot.

If the battery level is too low, battery warning alarm sounds. Please refer to **Charging Battery** section.

4. The robot motion seems awkward.

The robot may not assembled properly. Please check the robot assembly and **Check DYNAMIXEL Assembly** section.

5. The robot turns on with the adapter, but not with the battery.

Please check the Fuse on the bottom of CM-550 controller. Please refer to **Fuse** *Replacement* section.

6. 3. Charging Battery

CAUTION

- The provided battery must be charged with the provided charger(LBC-10) in the kit.
- Please power the charger before connecting the battery.
- Please fully charge the battery prior to first use.
- 1. Get the rechargeable battery in the kit.



2. Connect the battery to the charger as shown below.



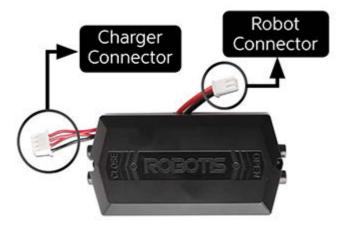
3. When fully charged, the LED will emit a solid green light.



4. The robot and controller can also be powered by the SMPS without the battery.



5. The battery has separate connectors for the charger and the robot. Please disconnect the **Robot Connector** from the robot when charging the battery.



6. 4. Battery Level Check



Current battery life can be verified by the color of the LED located on the CM-550.

- Blue : 70% ~ 100%
- Green : 30% ~ 70%
- Red : Under 30% (Low voltage alarm)

NOTE : The Power LED will blink when Bluetooth connection is disconnected.

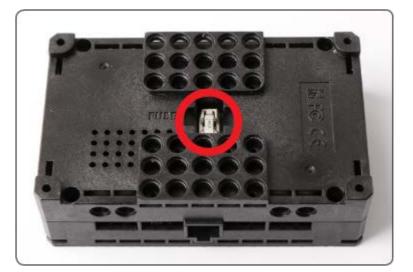
CAUTION : Please disconnect the battery from the charger when charging is completed. Please do not charge the battery while operating the robot.

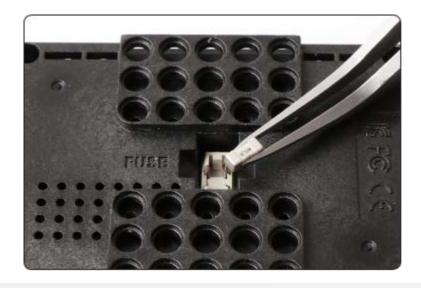
6. 5. Fuse Replacement

The fuse in CM-550 protects hardware from unexpected excessive current. If CM-550 can be turned on with the SMPS, but not with the battery, please check the fuse and replace it if necessary.

DANGER : Disconnect any power sources(SMPS, battery, USB) from CM-550 before replacing the fuse.

Disconnect power source from CM-550 and replace the fuse on the bottom of CM-550.





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