Teaching-aid Robot that Seamlessly Supports from Individual Learning to Collaborative Learning

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Presentation

- Background of the teaching-aid robot development

- Collaborative learning by integrating individual learning

- The robot and its features

- Introductory education on programming
  - University and National Institute of Technology use

- Program integration with the IoT platform

What are the requirements for learning programming

- Logical thinking ability. . . Not only
- Knowledge of computer usage
- Knowledge of using programming environment and knowledge of programming language
- Appropriate issues to raise interest and satisfy
  - Can imagine the goal of the task
  - Can feel a sense of accomplishment
  - Available anytime and anywhere

Teaching materials for acquiring programming knowledge

- **Understand intuitively**
  - Easy operation
  - Easy-to-understand instructions
- **Feel fulfilled**
  - Can leave the result
  - Can compare with others
- **Easy to use anytime**
  - Can be carried
 - Can use without PC

+
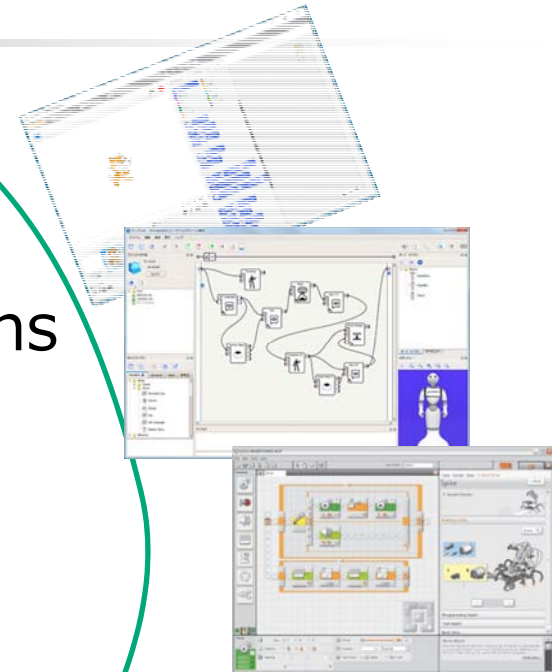
The knowledge acquired is versatile

Collaborative learning synthesizing individual learning

- Individualized learning is expected to lead to steady learning because individuals advance learning while solving problems
- Collaborative learning can expect deep learning from multiple perspectives while reducing the stalemate of individual learning
- It can be expected to eliminate the shortcomings of collaborative learning by synthesizing

Individualized learning and integration example

Cooperation between the line trace car and the traffic light
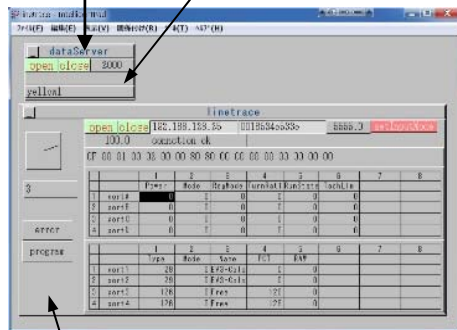
TCP/IP ClientPad
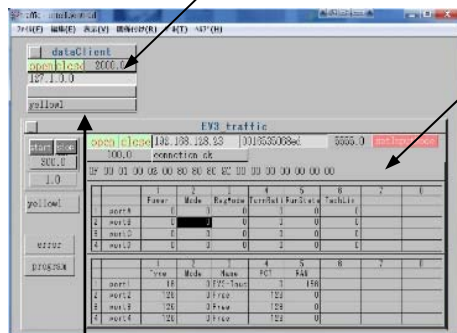
EV3ControllerPad

Break down into small tasks

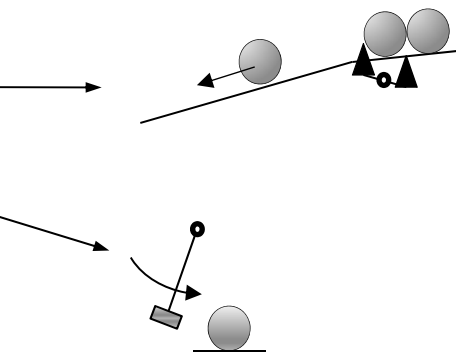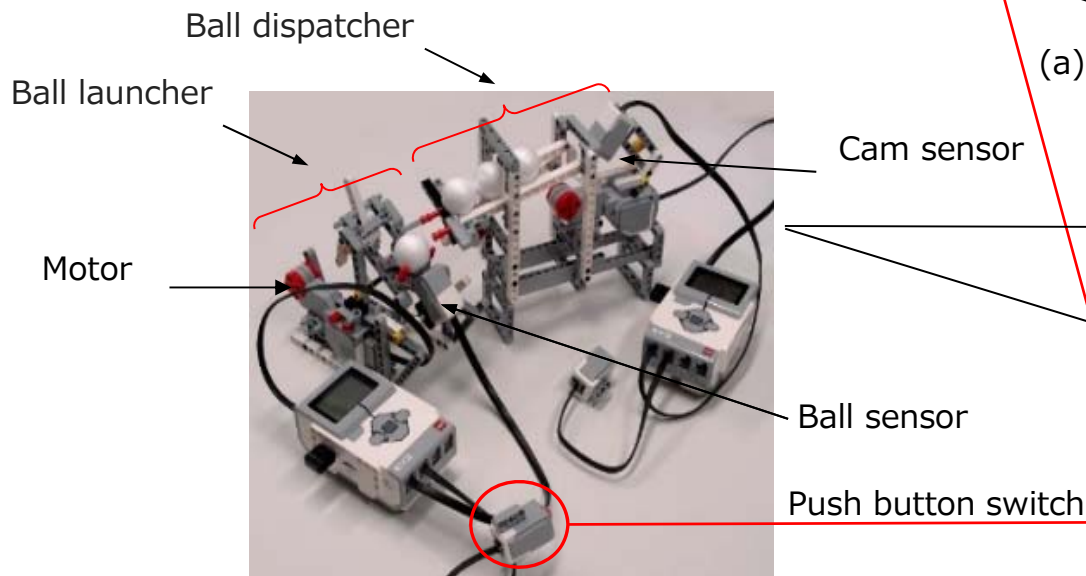TCI/IPcommunication

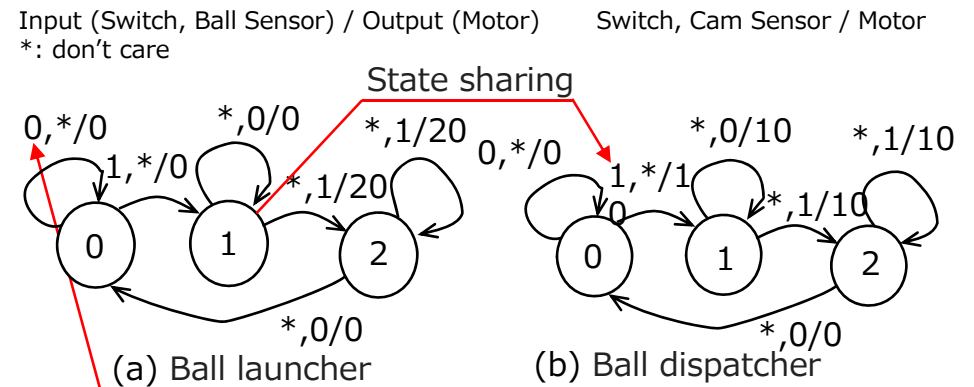(a) A traffic light

TCP/IP ServerPad

(c) Cooperation between devices

ProcedurePad   (b) A line trace car

Individualized learning and integration example

Collaboration of devices by state sharing
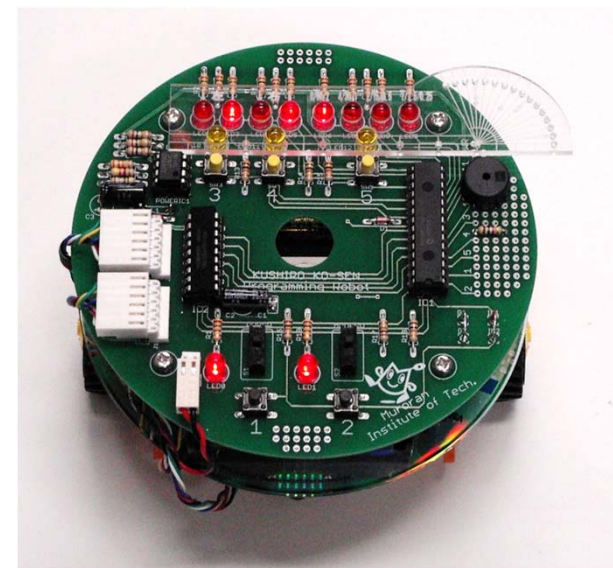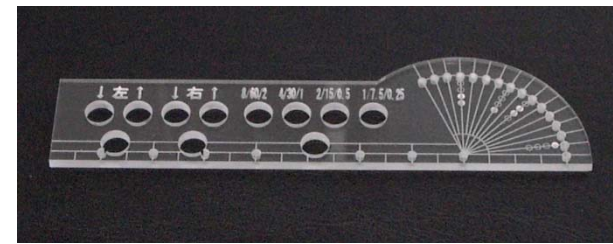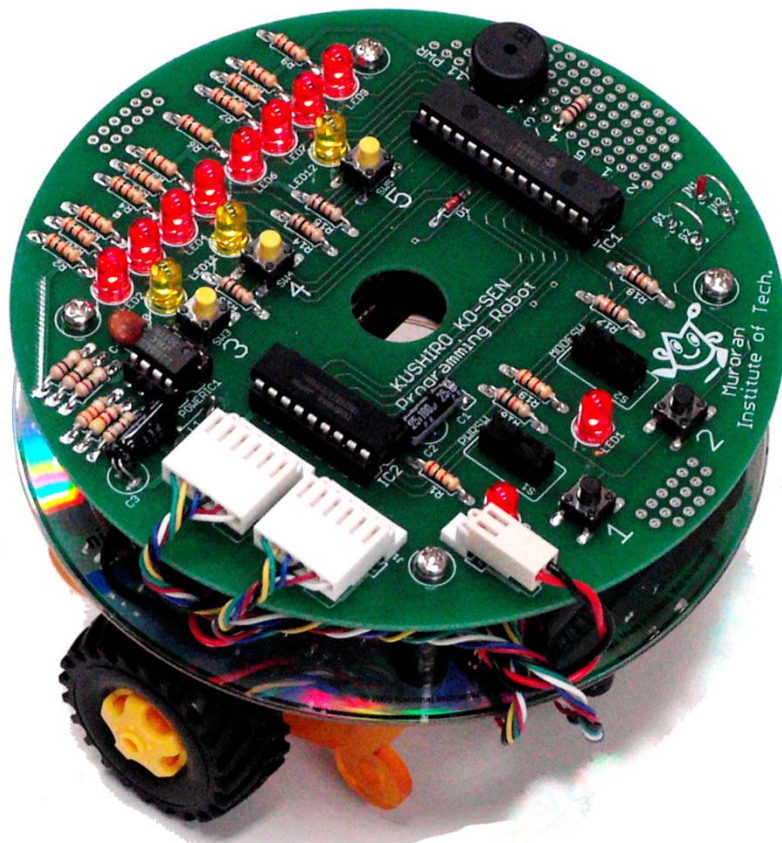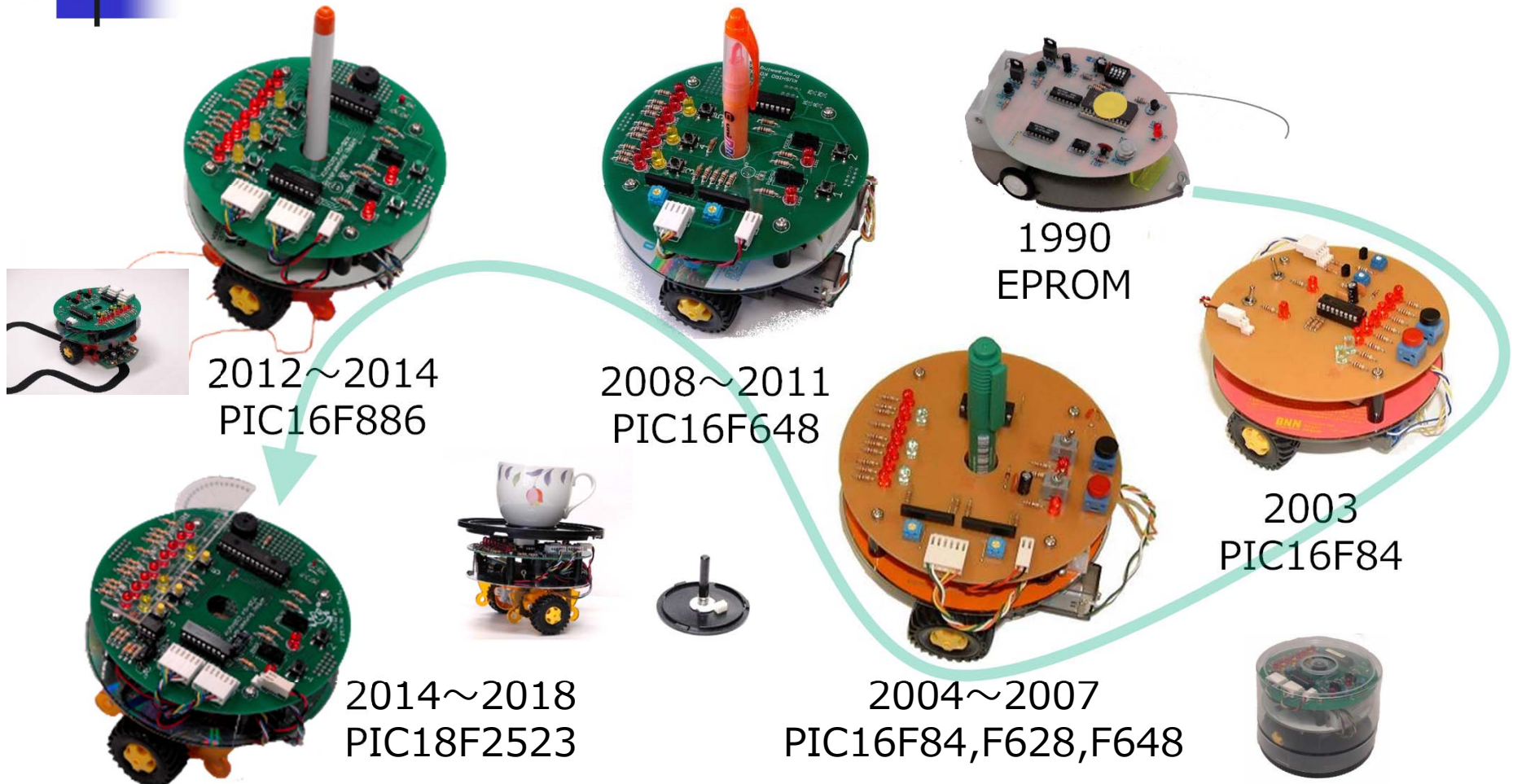
Input (Switch, Ball Sensor) / Output (Motor)
*: don't care

Switch, Cam Sensor / Motor

State sharing

(a) Ball launcher

0,*/0   *,0/0   *,1/20   0,*/0
1,*/0   *,1/20
(0) (1) (2)
*,0/0

(b) Ball dispatcher

*,0/10   *,1/10
1,*/10   *,1/10
0,*/0
(0) (1) (2)
*,0/0

Ball dispatcher

Ball launcher

Motor

Cam sensor

Ball sensor

Push button switch

Break down into small tasks

(c) Ball launcher with automatic ball supply

Teaching-aid robot

Trace the History of Teaching-aid Robot

2012〜2014
PIC16F886

2008〜2011
PIC16F648

1990
EPROM

2003
PIC16F84

2014〜2018
PIC18F2523

2004〜2007
PIC16F84,F628,F648

Demonstration
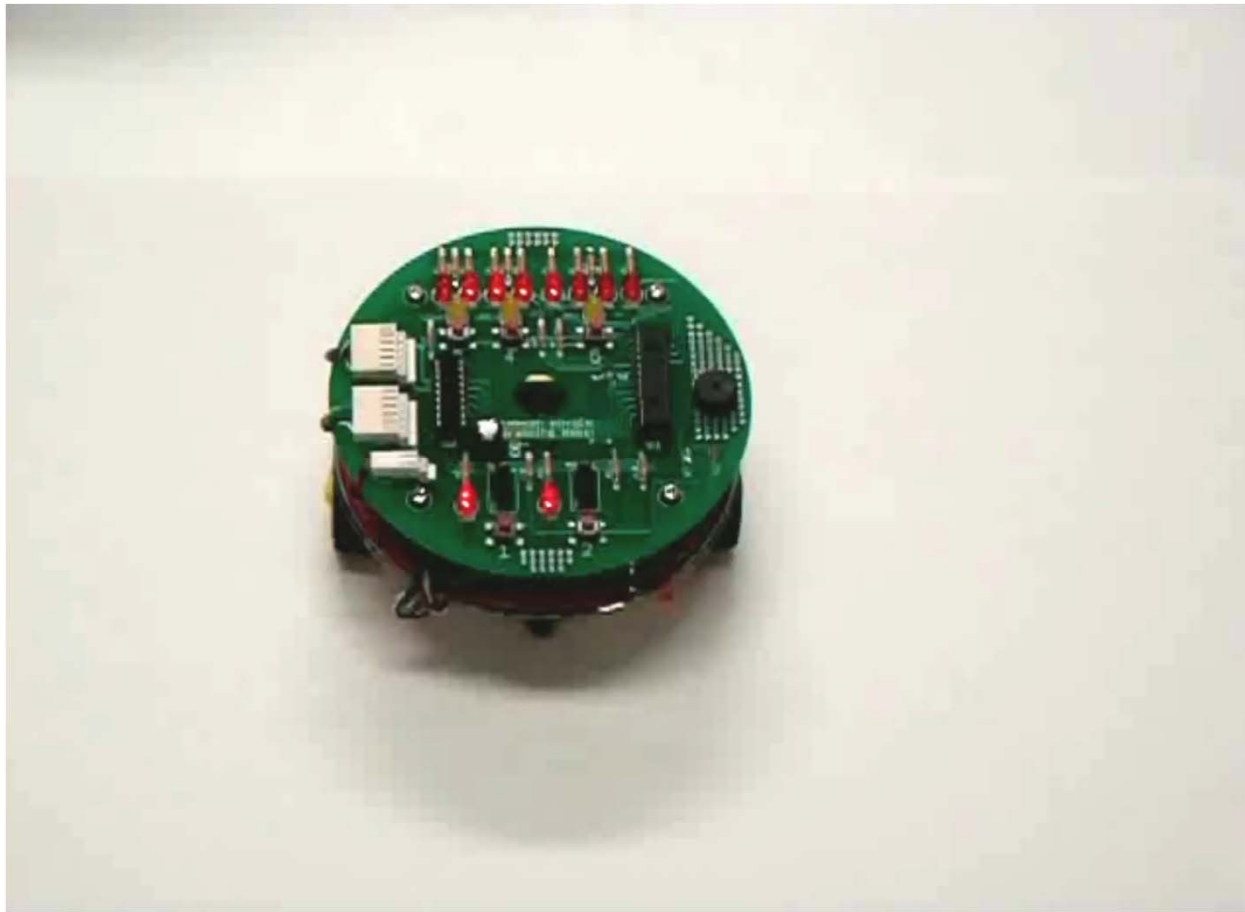
Features in programming

- Machine language instructions that can be understood intuitively
- Direct editing of machine instructions
- You can see the output result by the movement of the robot
- Step execution is possible
- Robot alone can run from program to execution
- You can record the track and compare with others
- Even elementary school students can use it
- You can learn how the computer works through programming
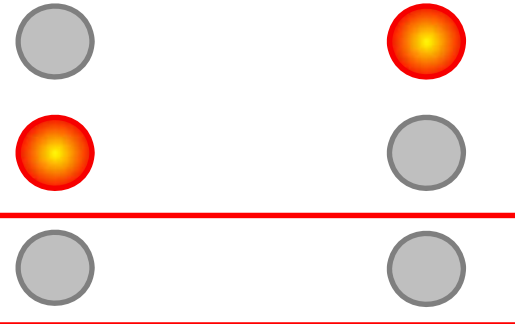
Advantages of using a robot for programming

- When the same instruction is combined, <u>the difference in the result</u> for <u>the difference in order</u> is easy to understand
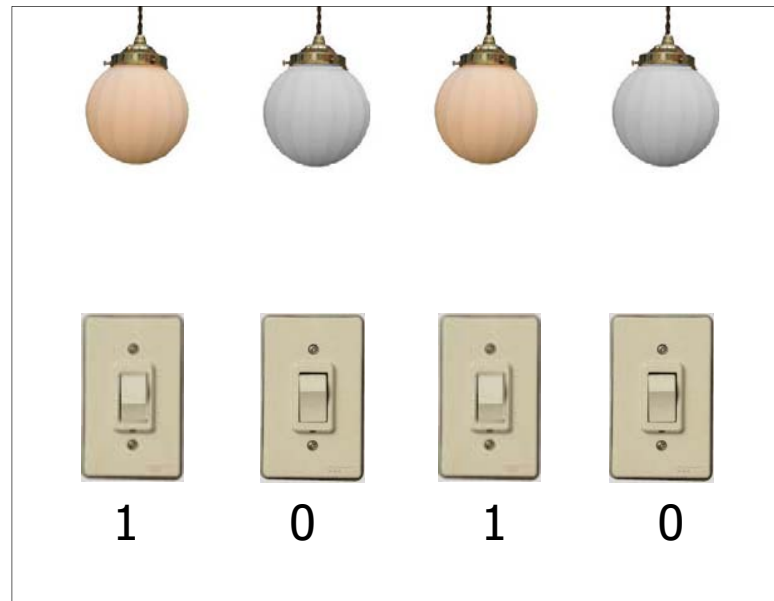
Robot

LED
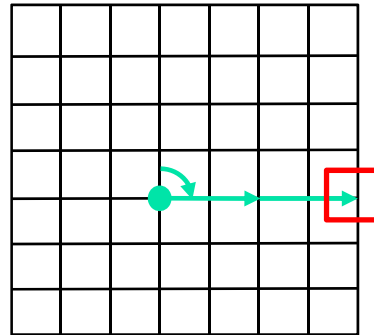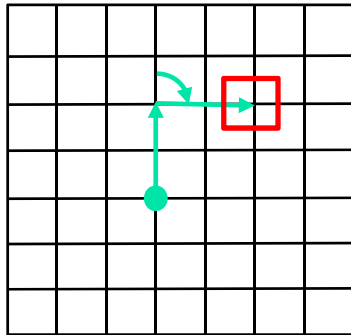
{Forward, Turn, Forward} {Turn, Forward, Forward}   {OFF, ON, OFF}   {ON, OFF, OFF}
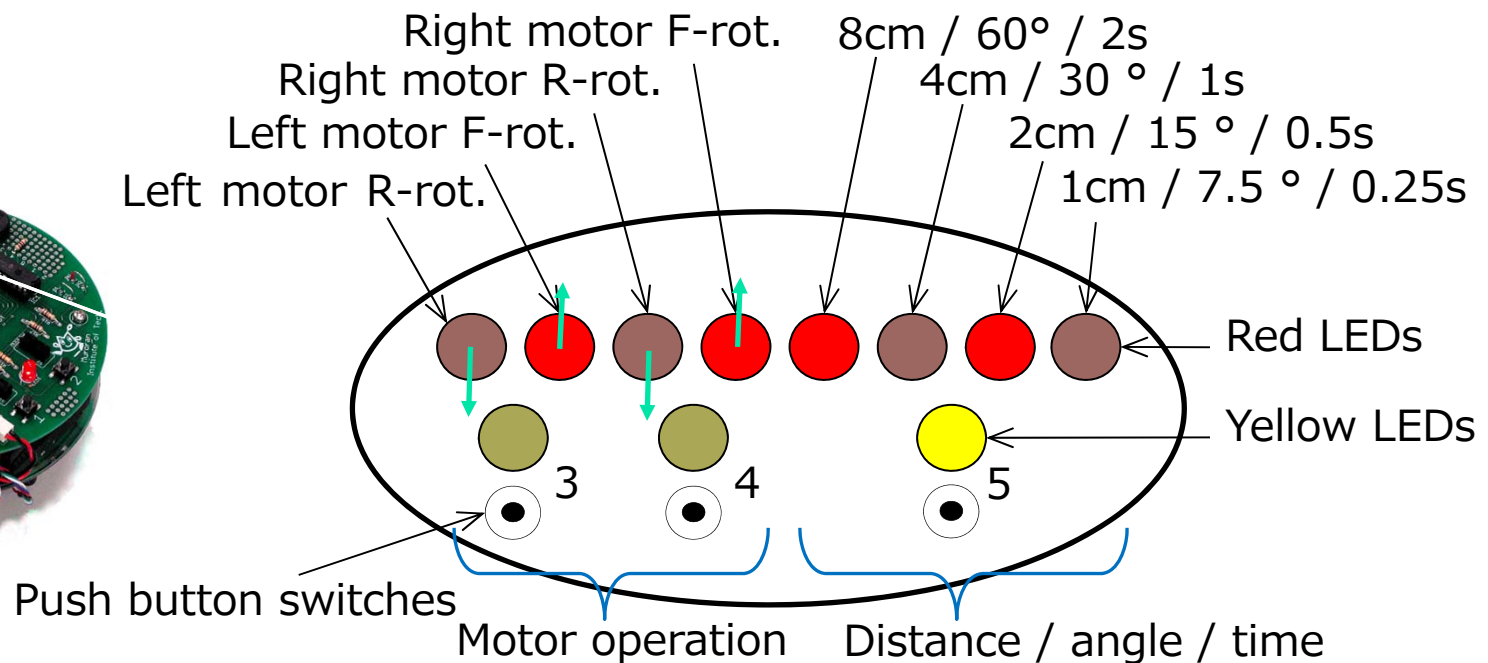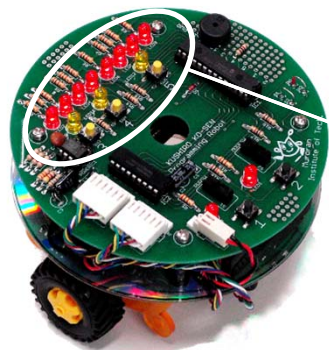
result

Intuitively understandable instructions
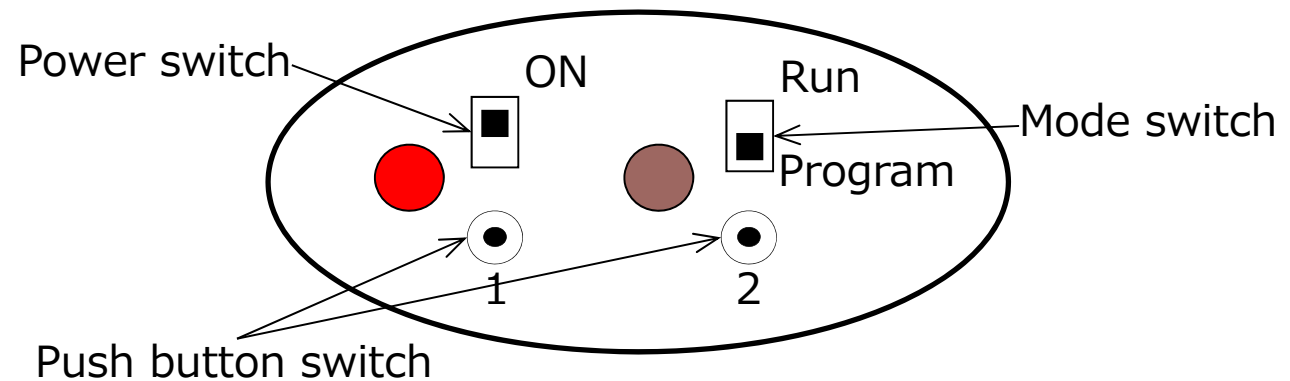
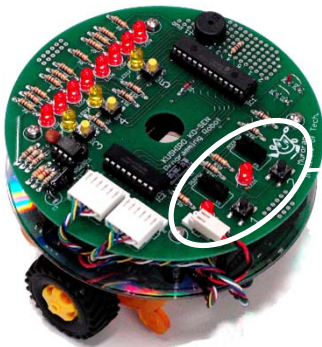- One-to-one correspondence
- Immediate response

| 1 | 0 | 1 | 0 |

Intuitively easy-to-understand mobile operation command and interface

- An instruction to the robot to advance 10 cm

Right motor F-rot.
Right motor R-rot.
Left motor F-rot.
Left motor R-rot.

8cm / 60° / 2s
4cm / 30 ° / 1s
2cm / 15 ° / 0.5s
1cm / 7.5 ° / 0.25s

Red LEDs

Yellow LEDs

3   4   5

Push button switches

Motor operation   Distance / angle / time

Operation interface

- Address is set to 0 at power on
- "Run／Program" switch by mode switch

Power switch

ON

Run

Mode switch

Program

1

2

Push button switch

Mode of the Robot

- Run mode
  - Run program with switch 1 and 2 on
  - Step run with switch 2 on
- Programming mode
  - Write data into EEPROM with switch 2 on
- Command mode (connect to PC)
  - Mode switch to Run
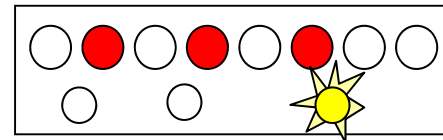 - Power on with switch 1 and 2 on

Relationship between easy-to-understand instructions and programs

- Move the robot → instruction
- Arrange the order of instructions → program
- Order → address
- 0,1,2…
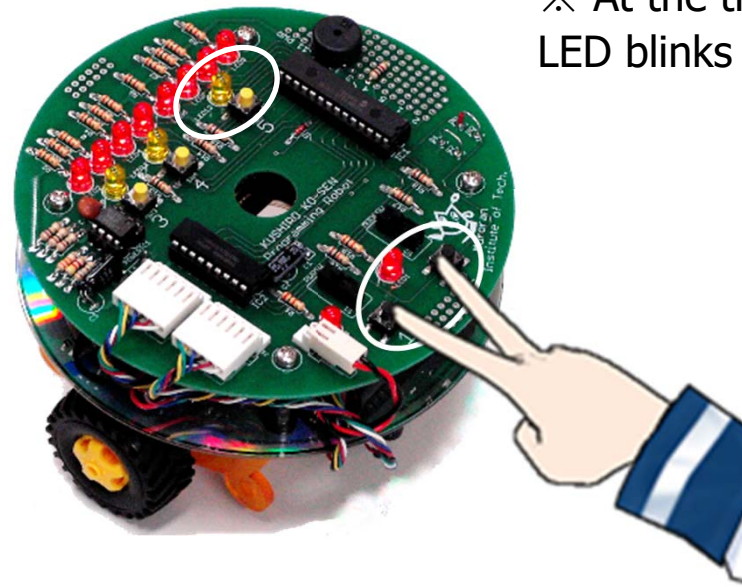
Forward 8cm

0 ○●○●●○○○

TurnLeft 90°

1 ●○○●●●○○
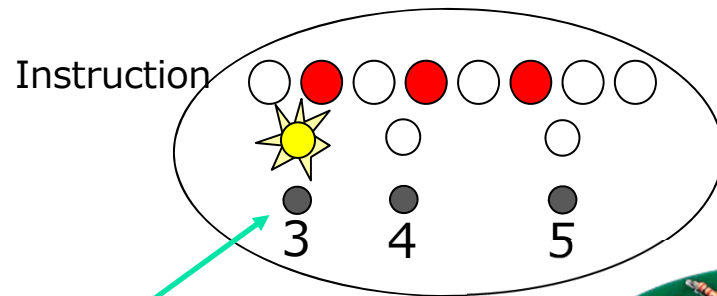
End

2 ●●●●●●●●
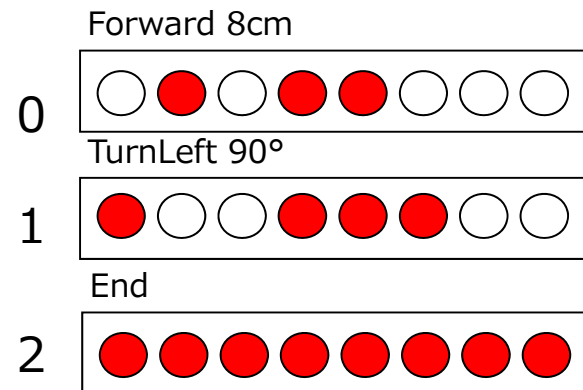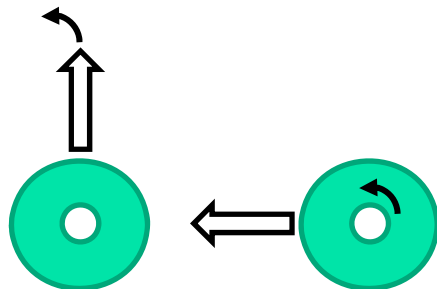
Run program with 2 button switches
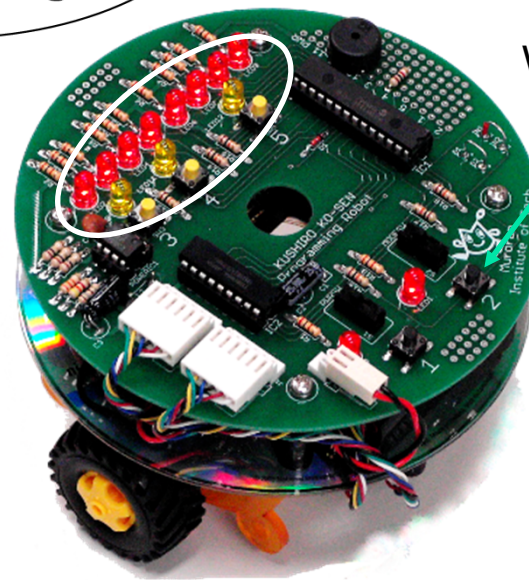
instruction

※ At the time of execution, the yellow LED blinks and displays the instruction

Program write and change

Instruction

3 4 5

Change button

Write button
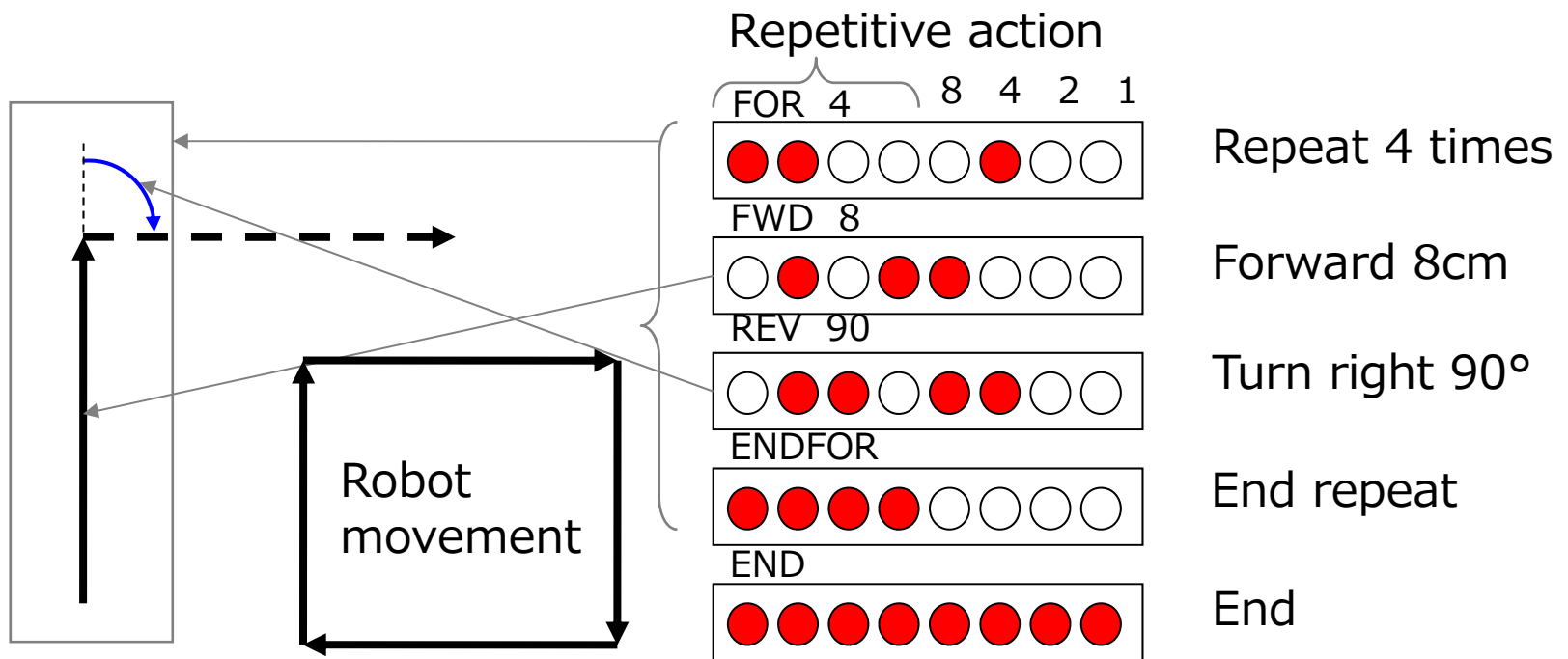
Example program

- Draw an arrow

Forward 8cm

○ ● ○ ● ● ○ ○ ○

Turn Left 90°

● ○ ○ ● ● ● ○ ○

Forward 4cm

○ ● ○ ● ○ ● ○ ○

Turn Right 90°

○ ● ● ○ ● ● ○ ○

Turn Right 45°

○ ● ● ○ ○ ● ● ○

Forward 8cm

○ ● ○ ● ● ○ ○ ○

End

● ● ● ● ● ● ● ●
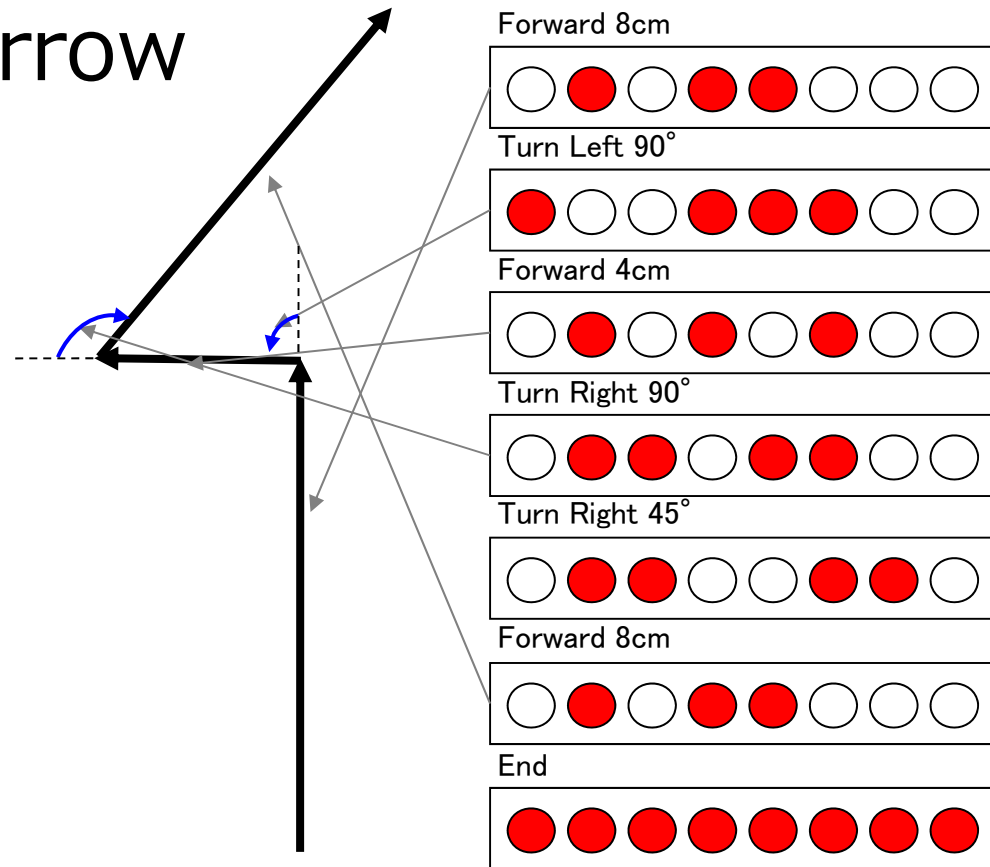
Virtual computer and its architecture

				Data bus buffer	

Bus width: 8

T register X	T register Y	Instraction register IR	Accumulator A	Flag resistor F	memory 0～255
			Stack pointer SP	Index resistor IX	
ALU		Control curcuit	Program counter PC		
			Address bus buffer		Input/output

Sensor
Actuator
Speaker
LED

8

⟷ Flow of data

→ Flow of control

Instruction set

命令	記述	機械語	プログラム例，説明
排他的論理和 EXOR		BF nn: 1011 1111	BF 0F，レジスタAとFの排他的論理和がAに代入
左シフト	SHI	B4: 1011 0100	レジスタAの値を1桁左に移動します．

命令	記述	機械語	プログラム例，説明
前進	FWD n	5n: 0101 $n_8n_4n_2n_1$	54，4cm前進します．
後退	REV n	An: 1010 $n_8n_4n_2n_1$	A4，4cm後退します．
右回転	RGT n	6n: 0110 $n_{60}n_{30}n_{15}n_{7.5}$	68，60度右へ回転します．
左回転	LFT n	9n: 1001 $n_{60}n_{30}n_{15}n_{7.5}$	9C，90度左へ回転します．
停止	STP n	0n: 0000 $n_2n_1n_{0.5}n_{0.25}$	04，1秒間停止します．
前進レジスタA	FWD A	50: 0101 0000	B7 08，(LDI 08) レジスタAに8を代入
後退レジスタA	REV A	A0: 1010 0000	50，(FWD A) 8cm前進
右回転レジスタA	RGT A	60: 0110 0000	レジスタAの値は8ビット有効です．大きな値を
左回転レジスタA	LFT A	90: 1001 0000	セットしたときには動作範囲が大きくなるので，
停止レジスタA	STP A	00: 1001 0000	机から落ちたりしないよう注意が必要です．
円弧	ARC nRm	8/4n 2/1m:0100 $n_8n_4n_2n_1$ 0001 $m_8m_4m_2m_1$	44 13，左車輪が4cm前進，右車輪が3cm前進し弧を描きます．(ARC: 8/4, R: 2/1)
不規則動作	IRG	30: 0011 0000	不規則にいろいろな動作をします
速度	SPD n	3n: 0011 nnnn	3C，低速(1)から高速(15)，高速はモータにより制限が有ります
サウンド	SND	7n: 0111 nnnn	70，サウンド停止，71～7F：ドC4～ドC6 238番地から252番地に音程データが有ります
乱数セット	RND	B0: 1011 0000	レジスタAに0～255の乱数をセット
表示オン	DSP ON	B1: 1011 0001	レジスタAの値をLEDに表示します．
1増し	INC	B2: 1011 0010	レジスタAの値を1増します．
1減	DEC	B3: 1011 0011	レジスタAの値を1減じます．

Loop instruction

- ## Program using repetition

Repetitive action

| FOR 4 | | | | 8 | 4 | 2 | 1 | Repeat 4 times |

FOR 4 — Repeat 4 times

FWD 8 — Forward 8cm

REV 90 — Turn right 90°

ENDFOR — End repeat
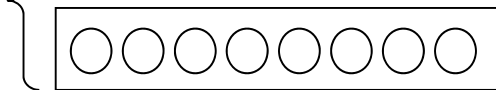
END — End

Robot movement

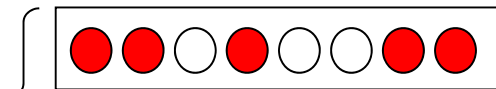# Conditional branching

- 2-byte instruction

JMP nn
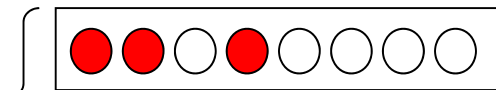
Unconditional jump

Destination address (address 0 is shown in the fig.)
※ Can be set from address 0 to address 255

$JMPsw_s$, nn   4 2 1

Conditional jump SWs（push button3 in the fig .)
※ Jump when switched on. Can be set from SW1 to SW5

Address number （ address 0 is shown in the fig ）
※ Can be set from address 0 to address 255

Robot assembly manual

Programming manual

Component part

コンピュータ基盤　　　　　ＣＤ

キャスター台

キャスター部品

電池ボックス　　　　ナット　　　電池　　　タイヤ

15mm　10mm　8mm　3mmネジ

平スペーサ

25mmスペーサ　タッピングネジ　モータ　台座

Introductory education in higher education institutions

- 2015 ～ Muroran Institute of Technology Information Electronics
  - 190 freshmen "Freshman PBL Seminar" 1 unit 3 times out of 15 classes
- 2016 ～ Muroran Institute of Technology Information Electronics Department Night Main Course
  - Seventeen out of 15 classes in 18 freshmen "Freshman Seminar"
- 2017 ～ Hokkaido University common subjects
  - About 100 first graders "Informatics II" 2 credits 2 times out of 15 classes (4 lecture hours) "Basic knowledge of algorithm and programming"
- 2018 Kushiro National College of Electrical Engineering
  - 35 third graders "Introduction to robot systems" 2 credits 15 out of 15 classes
- 2018 Hokkaido University General Education Exercise
  - 18 people (Freshman Seminar) "Introduction to Tangible Information Science" 2 credits 9 credits out of 15 classes

# How to realize collaborative learning synthesizing individual learning

- Synchronize multiple robots with start only
- Run the integrated program on a single robot
- Synchronize and operate multiple robots

Example of synchronize multiple robots with start only

- Muroran Institute of Technology, Night Course
  - Seven out of 15 classes in 18 freshmen "Freshman Seminar"
- National Institute of Technology, Kushiro College, Electrical Engineering
  - 35 third graders "Introduction to robot systems" 5 out of 15 classes

Muroran Institute of Technology
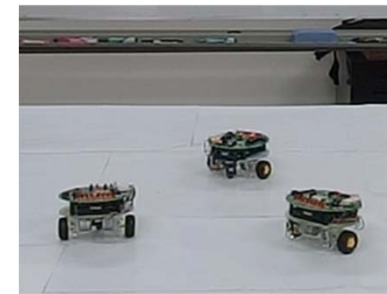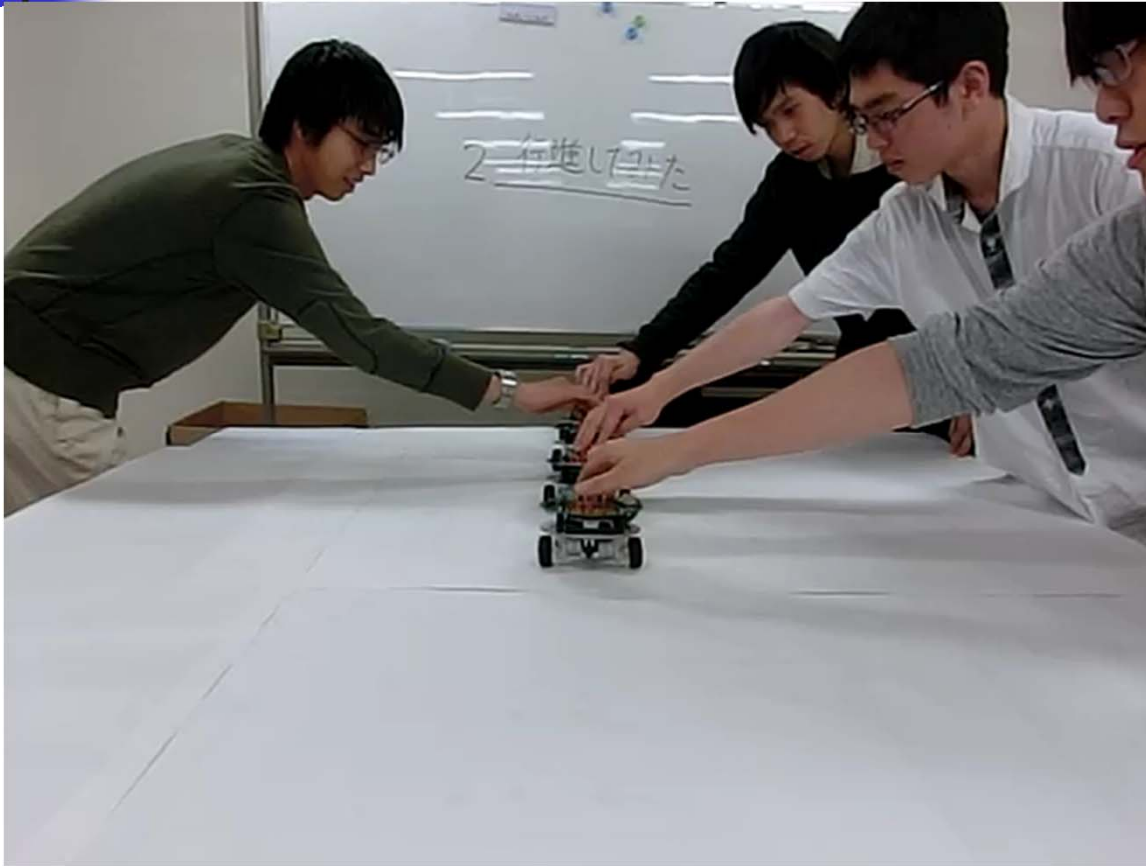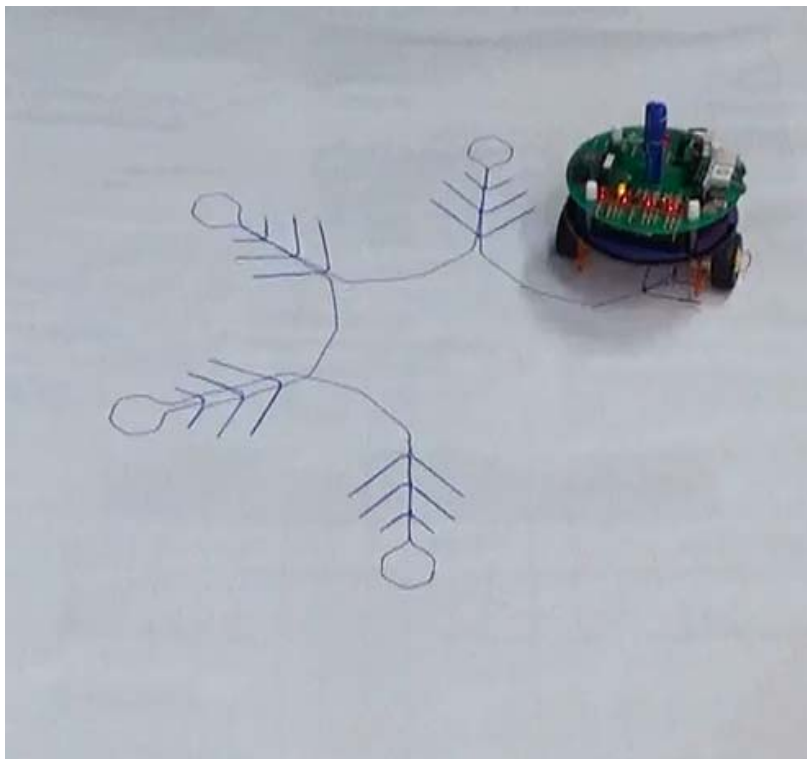
National Institute of Technology, Kushiro College

Example of executing integrated program on a single robot

- **Hokkaido University**
  - 18 students (Freshman Seminar) "Introduction to Tangible Information Science" 9 times out of 15 classes
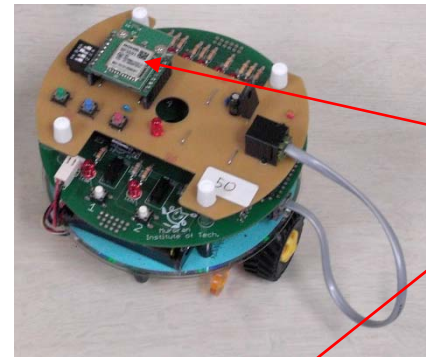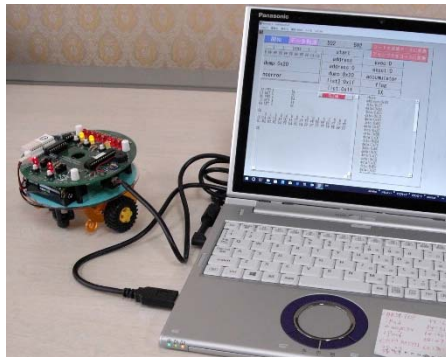
Program integration

CALL A
CALL B
CALL C

Write program

Append program

Program A
...
ret

Program B
...
ret

Robot's EEPROM

Program B
...
ret

Editing system
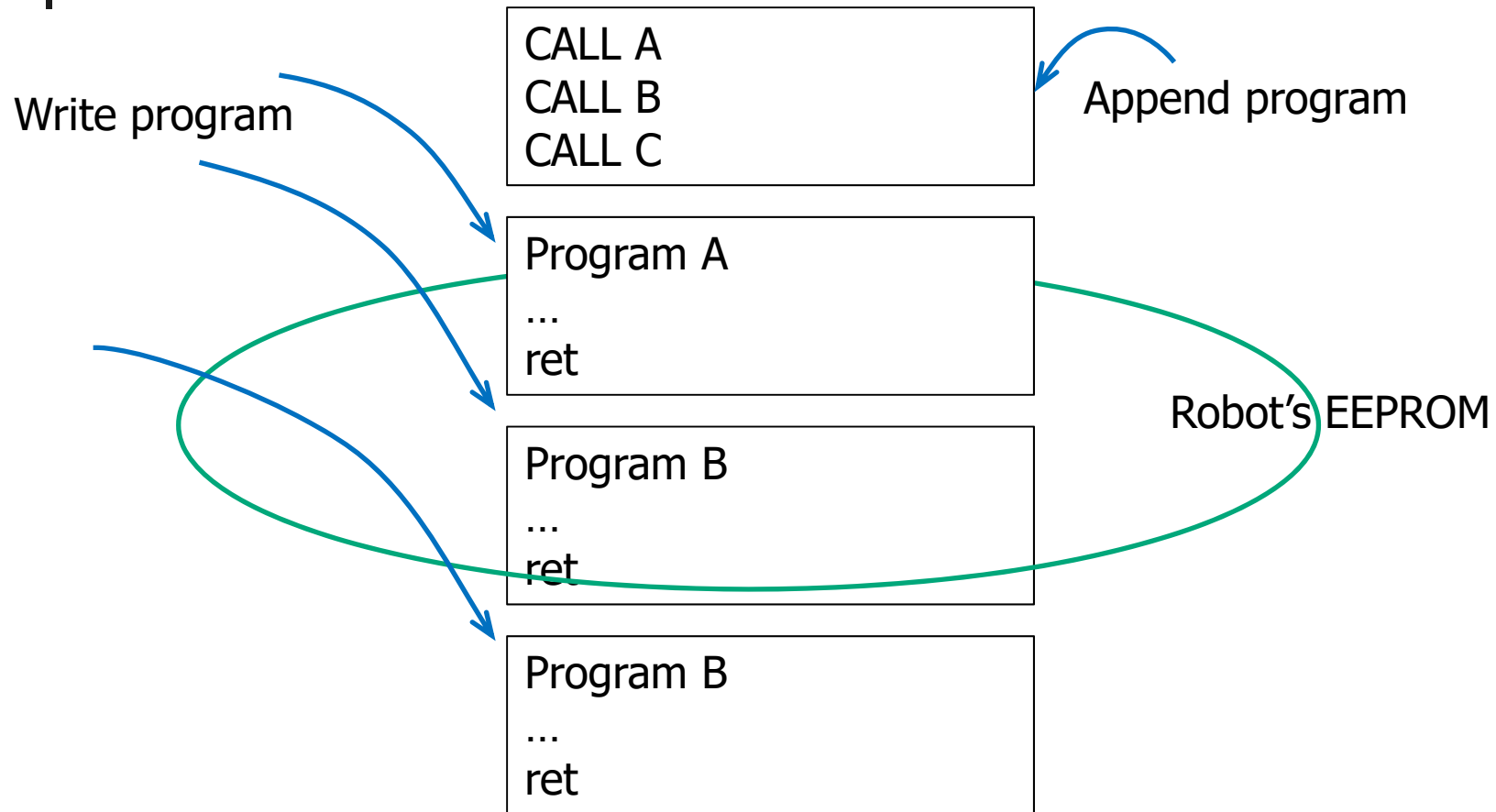
Hokkaido University

Synchronize and operate multiple robots

- ## IoT robot
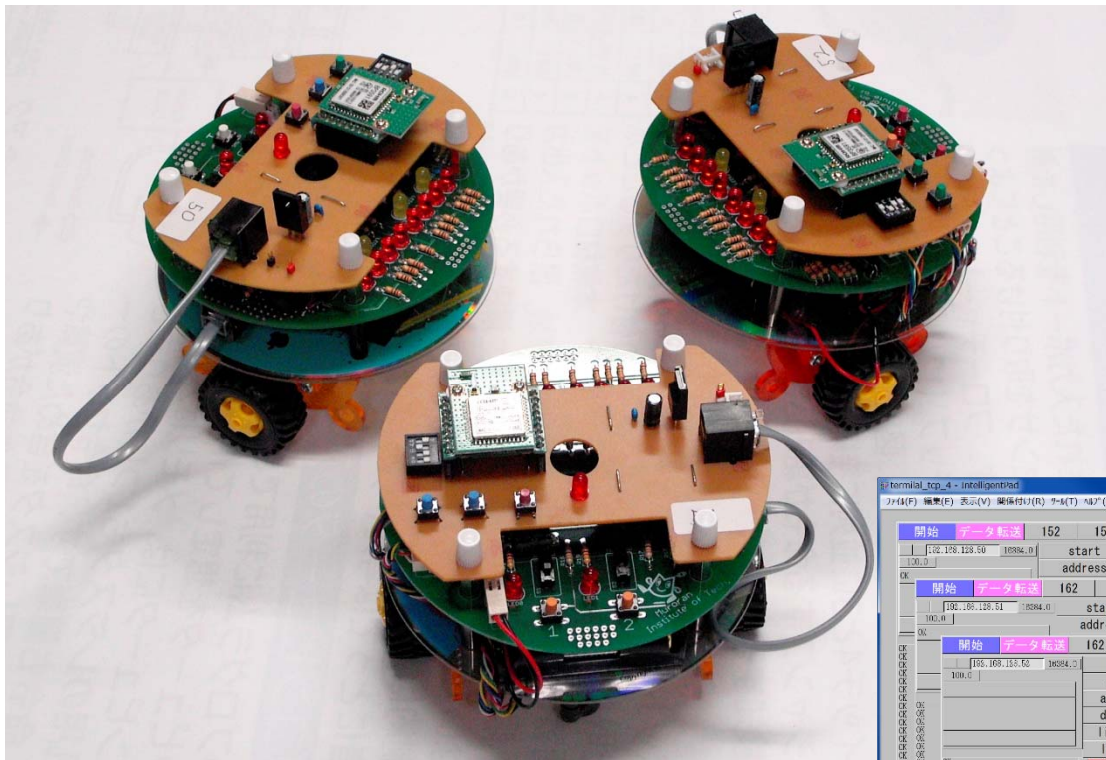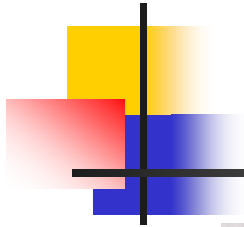

TCP/IP

- ## IoT platform

It can send plural
commands
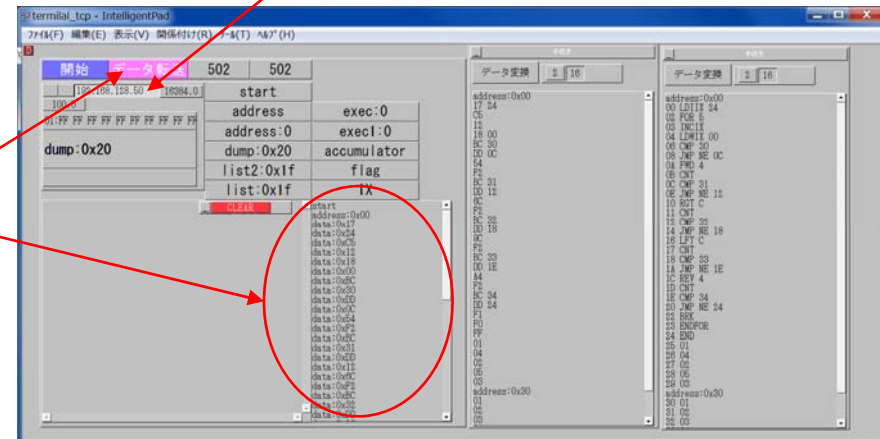
Command mode

Control command set

Command	Example	Explanation
start		Start command transfer mode
address		Output the value of address pointer
address	address:0x00	Set address pointer to 0
accumulator	accumulator	Output the value of accumulator
	accumulator:0xAB	Set the accumulator to 171
IX	IX	Output the value of index-register IX
	IX:0x10	Set the index-register IX to 16
flag		Output the value of flag-resister
data	data:0x54	Write 84 to EEPROM pointer address and increment it
exec	exec:0x00	Execute program at address 0
exec1	exec1:0x00	Execute an instruction at address 0
dump	dump:0x20	Dump 32 byte at pointer address
list	list:0x20	Output assembler program at address pointer address
list2	list2:0x20	Output 32 byte assembler program and hex data
stop		Exit command mode

Multiple controllers
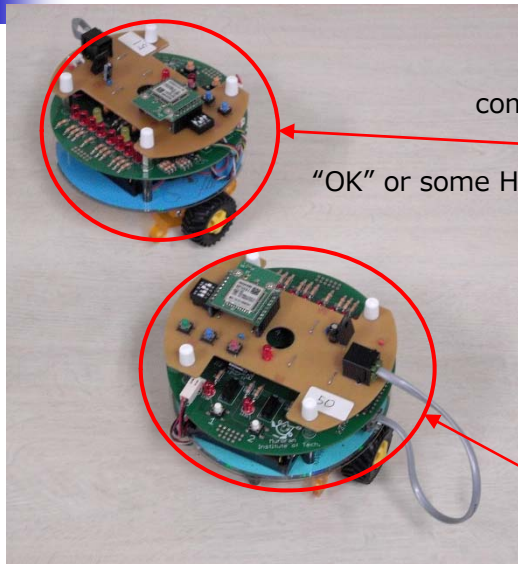can coexist and share
data and event

IoT Cooperation for Collaborative Learning
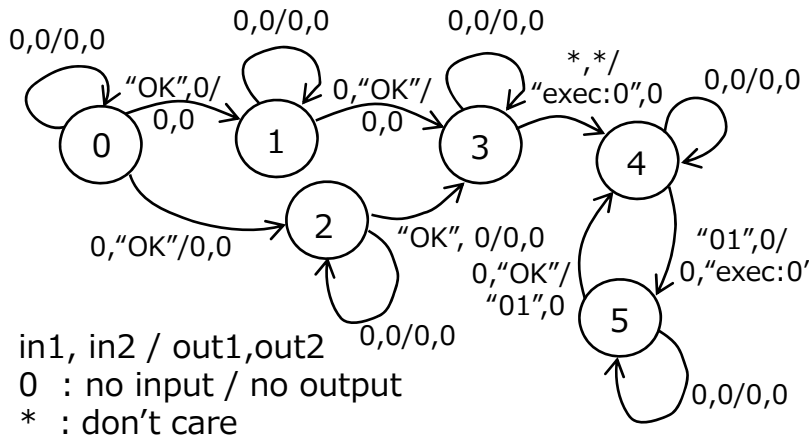
Execute the Script
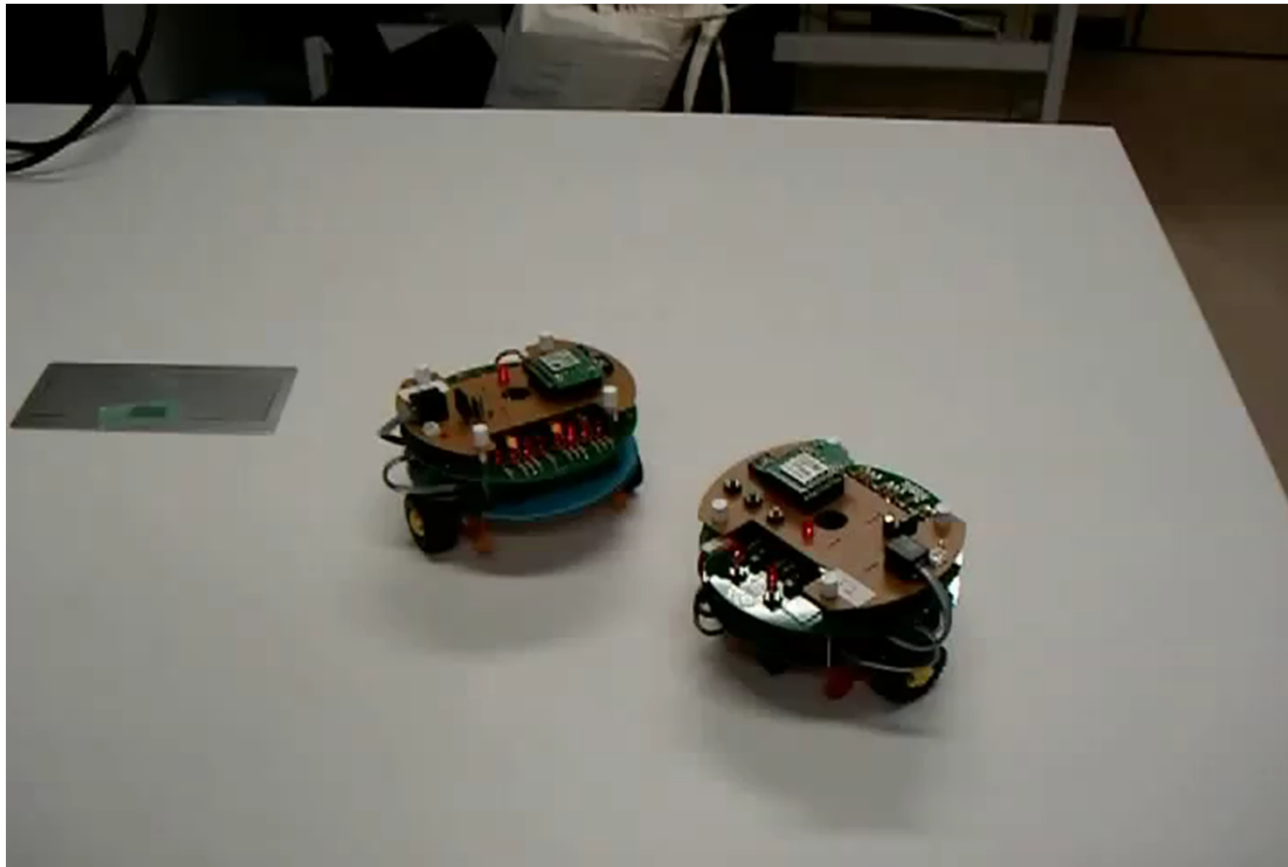
Dynamic combination of IoT platform

- It is easy to select and operate any combination of dozens of robots with our IoT platform

Summary

- We introduced teaching-aid robot and its use example and how to realize collaborative learning that integrates individual learning using the IoT platform

- A flexible collaborative learning environment can be realized by using the IoT platform

Acknowledgment