robotics/2012-12-15

Introduction to OpenEL (Embedded Library) for Robots

December 11, 2012

OMG Robotics Information Day

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Chairman of Applied Technology Research Committee
Chairman of Platform Research Group
Japan Embedded Systems Technology Association(JASA)

Agenda

■ Introduction of JASA

- Association profile, Main Activities, Organization, Embedded Technology Robot Software Design Contest, Platform Research Group etc.

■ Introduction of OpenEL

- Concept, Activities, API specification of Version 0.1.1, examples, video, Roadmap etc.

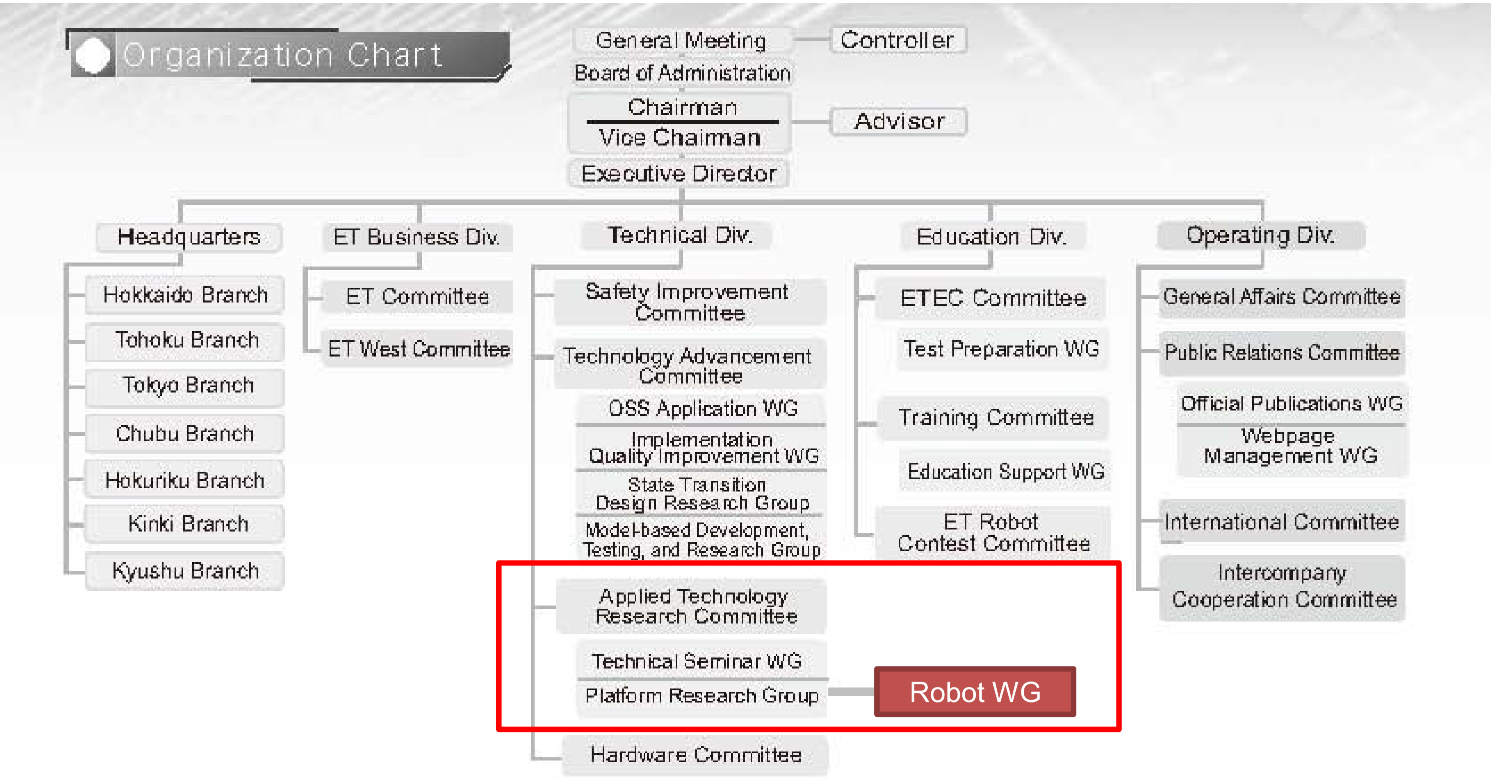
About JASA(Japan Embedded Systems Technology Association)

- Established in 1986.
- More than 200 embedded systems companies in Japan
  - ALPINE, CORE, dSPACE, Hitachi, Imagination, Microsoft, Mentor, MontaVista, Panasonic, RICOH, RENESAS, Toshiba etc.
- Main Activities
  - Embedded Technology, a Comprehensive Exhibit of Embedded Systems Technology(Yokohama and Osaka)
  - Implementation and Expansion of ETEC(Embedded Technology Engineer Certification)

Yokohama
(November)
Osaka
(June)

- Study and Research Activities for Technological Advancement
  - Case studies of safe design, surveying of techniques and methods recommended by safety standards, research and study into safety-related products, and support for IEC 61508 and ISO 26262.
  - Research and study on modeling and verification for the achievement of reliable embedded software development and public awareness activities and dissemination of case studies for the education of engineers.
- Embedded Technology Robot Software Design Contest

JASA Organization Chart



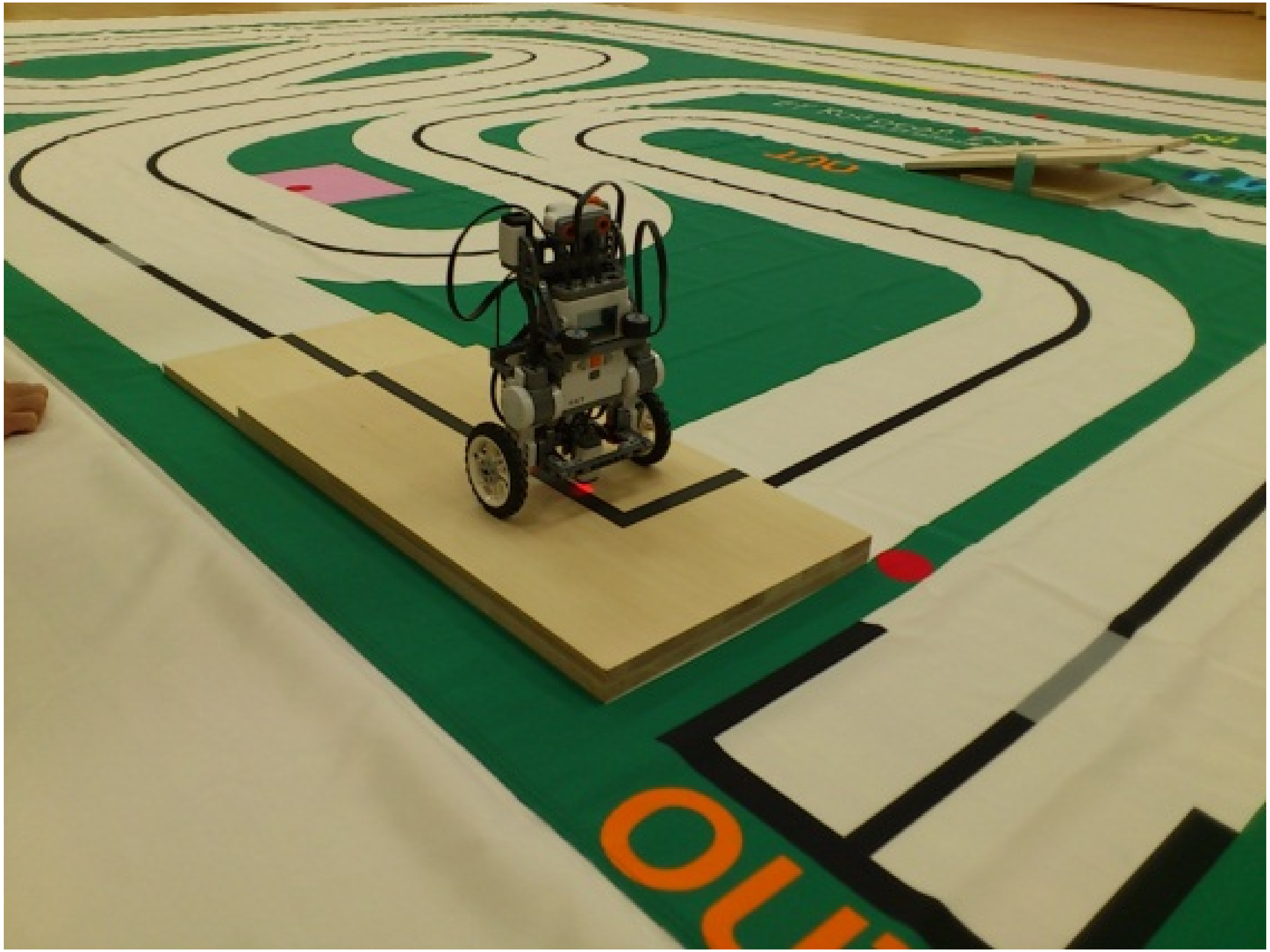
Platform Research Group

- Started to work in 2000.
- Members
  - CORE, NDD, CIC, ZUKEN ELMIC, Oriental Motor, Upwind Technology etc.
- Advisors
  - Tetsuo Kotoku Dr.Eng. The National Institute of Advanced Industrial Science and Technology (AIST)
  - Naoyuki Takesue, Associate Professor, Intelligent System Design, Tokyo Metroporitan University
  - Akihito Sano, Professor, Department of Mechanical Engineering, Department of Engineering Physics, Electronics and Mechanics, Nagoya Institute of Technology
  - Junji Furusho, Professor, Faculty of Engineering, Department of Management Information Science, Fukui University of Technology
- Activities
  - Research and study into technological and business trends in the platforms that serve as the common foundation for our business.
  - Drafting of the specifications of “OpenEL for Robots”, a software platform for robotics that is being proposed by JASA.

Embedded Technology Robot Software Design Contest

- In 2002, former OMG Japan started the contest named "UML Robot Contest".
- Since 2004, JASA has hosted the contest named “ET Robot Contest”.
- This is a software development contest that helps to educate embedded software engineers. Engineer training and competition are held in 11 areas within Japan. At the comprehensive exhibit of embedded systems technology, “Embedded Technology,” which is held in November, a championship tournament is held between winning teams from each area.
- Upwind Technology, Inc. is one of Bronze sponsor and provide a development environment.
  - GNUWing™ for ARM– Embedded system development toolchain
  - UTOS ® for LEGO NXT - Real-Time Operating System
    - NOTE:UTOS is a registered trademark of Upwind Technology, Inc..
  - OpenEL™ for LEGO NXT - Open Embedded Library for Robots
    - NOTE:OpenEL is a trademark of JASA.

Embedded Technology Robot Software Design Contest



What's OpenEL(Embedded Library)?

- OpenEL for Robots is an open platform to standardize the specifications of the software implementation of robotics and control systems.
- Currently, porting existing software on different systems, including the device driver in the development of embedded systems has been considerable effort required.
- For example, turning on the LED or just to operate the motor on different hardware, there may spend many days.
- Because an application program interface to control the output of the sensors and motors, were each uniquely defined by the device manufacturer, has been implemented since.

What's OpenEL(Embedded Library)?

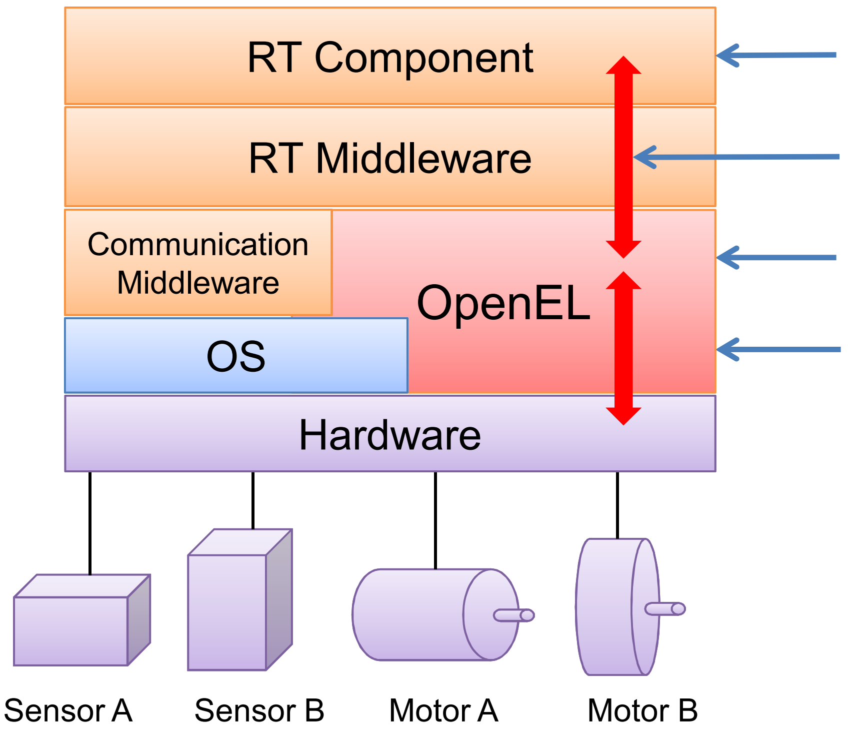
- Therefore, JASA propose to unify these interfaces which were different for each device manufacturer.
- JASA focus on robotics and control systems, has started drafting specifications OpenEL for Robots.
- In OpenEL for Robots, by the base portion of the software platform for robotics and control systems, and aims to enable applications running on different hardware too soon.
- This increases the portability and reusability of the software, resulting in improved quality, lower costs and lead to improved productivity is expected to improve convenience for users and developers.

Why OpenEL?

- Some Problems in ROS and RT Middleware
  - Limitation of Software Development Environment
    - OS, Languages etc.
  - No standard to use Sensors and Motors etc.
  - No standard to use A/D, D/A, DIO etc.
- In non-competitive areas, we often have a lot of trouble.
- OpenEL solves above problems.

Concept and Architecture of OpenEL platform

- Specifically, OpenEL is API (Application Program Interface) standardized on the layer below the middleware.
  - Naming Convention : el + Device + Command (ex. elMotorSetAngle())
- It is a mechanism for device control, such as the output to the motor, the input from the sensor and so on.
- We are targeting only implementation, the bottom of V-model.



If you use OpenEL , you can change the device anytime. No need to rewrite the application code.

elMotorPowerOn(), elMotorSetAngle(), elMotorPowerOff(), elMotorSetSpeed() etc.

OpenEL layer absorb the difference of devices such as sensors and motors.

The device vendors or we implement OpenEL layer.

Advantage of OpenEL

- OpenEL is new Application Programming Interface for Robots and Embedded Devices.
- OpenEL redefine embedded system programming.
- Very Easy Naming Convention for programmer.
- OpenEL standard to use Sensors and Motors etc.
- OpenEL standard to use A/D, D/A, DIO etc.
- In non-competitive areas, we will never have any trouble.
- OpenEL improves software portability, reusability and productivity.

Activities of OpenEL

- JASA Platform Research Group started work on the specification of OpenEL for Robots in April, 2011.
- JASA announced OpenEL on 16 November 2011.
- JASA released OpenEL version 0.1 in April, 2012.
  - The initial target robot is LEGO Mindstorms NXT.
  - Open Source Software(BSD License)
  - You can download from www.jasa.or.jp/top/activity/platform.html
- JASA Platform Research Group is working on the specification of OpenEL version 1.0.
- JASA Platform Research Group introduce OpenEL at OMG Technical meeting in December, 2012.

OpenEL API Version 0.1.1

■ Macros

```
#define   EL_TRUE   1
#define   EL_FALSE   0
#define   EL_NXT_PORT_A   0
#define   EL_NXT_PORT_B   1
#define   EL_NXT_PORT_C   2
#define   EL_NXT_PORT_S1   0
#define   EL_NXT_PORT_S2   1
#define   EL_NXT_PORT_S3   2
#define   EL_NXT_PORT_S4   3
#define   OPENEL_MAJOR   0
#define   OPENEL_MINOR   1
#define   OPENEL_VERSION   "OpenEL 0.1.1"
```

■ Typedefs

```
typedef signed char              ELChar
typedef unsigned char            ELUChar
typedef signed char              ELInt8
typedef signed short             ELInt16
typedef signed int               ELInt32
typedef signed long long         ELInt64
typedef unsigned char            ELUInt8
typedef unsigned short           ELUInt16
typedef unsigned int             ELUInt32
typedef unsigned long long       ELUInt64
typedef float                    ELFloat32
typedef double                   ELFloat64
typedef unsigned char            ELBool
```

OpenEL API Version 0.1.1

■ Functions for Motors

```
ELFloat64  elMotorGetAngle (ELUInt32 portid)
ELFloat64  elMotorSetAngle (ELUInt32 portid, ELFloat64 angle, ELInt32 speed)
void       elMotorResetEncoder (ELUInt32 portid)
ELInt32    elMotorGetSpeed (ELUInt32 portid)
void       elMotorSetSpeed (ELUInt32 portid, ELInt32 speed)
ELBool     elMotorGetBrake (ELUInt32 portid)
void       elMotorSetBrake (ELUInt32 portid, ELBool brake)
```

■ Functions for Sensors

```
ELUInt16  elGyroSensorGetValue (ELUInt32 portid)
ELUInt16  elGyroSensorGetOffset (ELUInt32 portid)
void      elGyroSensorSetOffset (ELUInt32 portid, ELUInt16 offset)
ELUInt16  elLightSensorGetValue (ELUInt32 portid)
ELBool    elLightSensorGetLED (ELUInt32 portid)
void      elLightSensorSetLED (ELUInt32 portid, ELBool light)
ELBool    elTouchSensorGetState (ELUInt32 portid)
ELUInt16  elBatteryGetVoltage (void)
ELBool    elSpeakerOutput (ELUInt32 freq, ELUInt32 ms, ELUInt32 vol)
void      elSonarSensorInitialize (ELUInt32 portid)
void      elSonarSensorTerminate (ELUInt32 portid)
ELInt32   elSonarSensorGetValue (ELUInt32 portid)
```

OpenEL API Version 0.1.1

■ Functions for Bluetooth

```
void      elBluetoothInitializeMaster (const ELUChar *addr, const char *pin)
void      elBluetoothInitializeSlave (const char *pin)
void      elBluetoothTerminate (void)
ELUInt32 elBluetoothSendData (const void *buf, ELUInt32 offset, ELUInt32 len)
ELUInt32 elBluetoothReceiveData (void *buf, ELUInt32 offset, ELUInt32 len)
ELBool    elBluetoothGetDeviceName (char *name)
ELBool    elBluetoothSetDeviceName (const char *name)
ELInt32   elBluetoothGetStatus (void)
ELInt16   elBluetoothGetSignalStrength (void)
```

Example of elMotorSetAngle()

```
ELFloat64 elMotorSetAngle ( ELUInt32       portid,
                            ELFloat64      angle,
                            ELInt32        speed
                          )
```

Rotates the motor to the specified angle.

If it is unable to do so, this function is finished.

A motor angle is defined as base angle(0radian) at the time of starting program or doing elMotorResetEncoder.

If This return value is difference between the parameter angle and the actual rotation angle.

Parameters:

[in]   portid   the port id of the motor.

[in]   angle   the angle specifies to the encoder. (unit: radian)

[in]   speed   the pwm value specifies to the motor. (range: [-100,100])

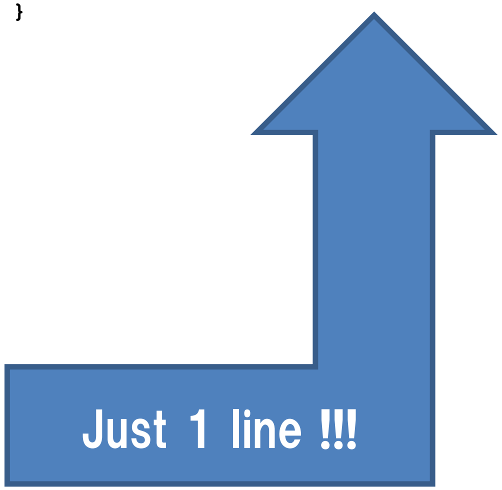
Returns:

the difference between the parameter angle and the actual rotation angle (unit: radian)

Example to use elMotorSetAngle()

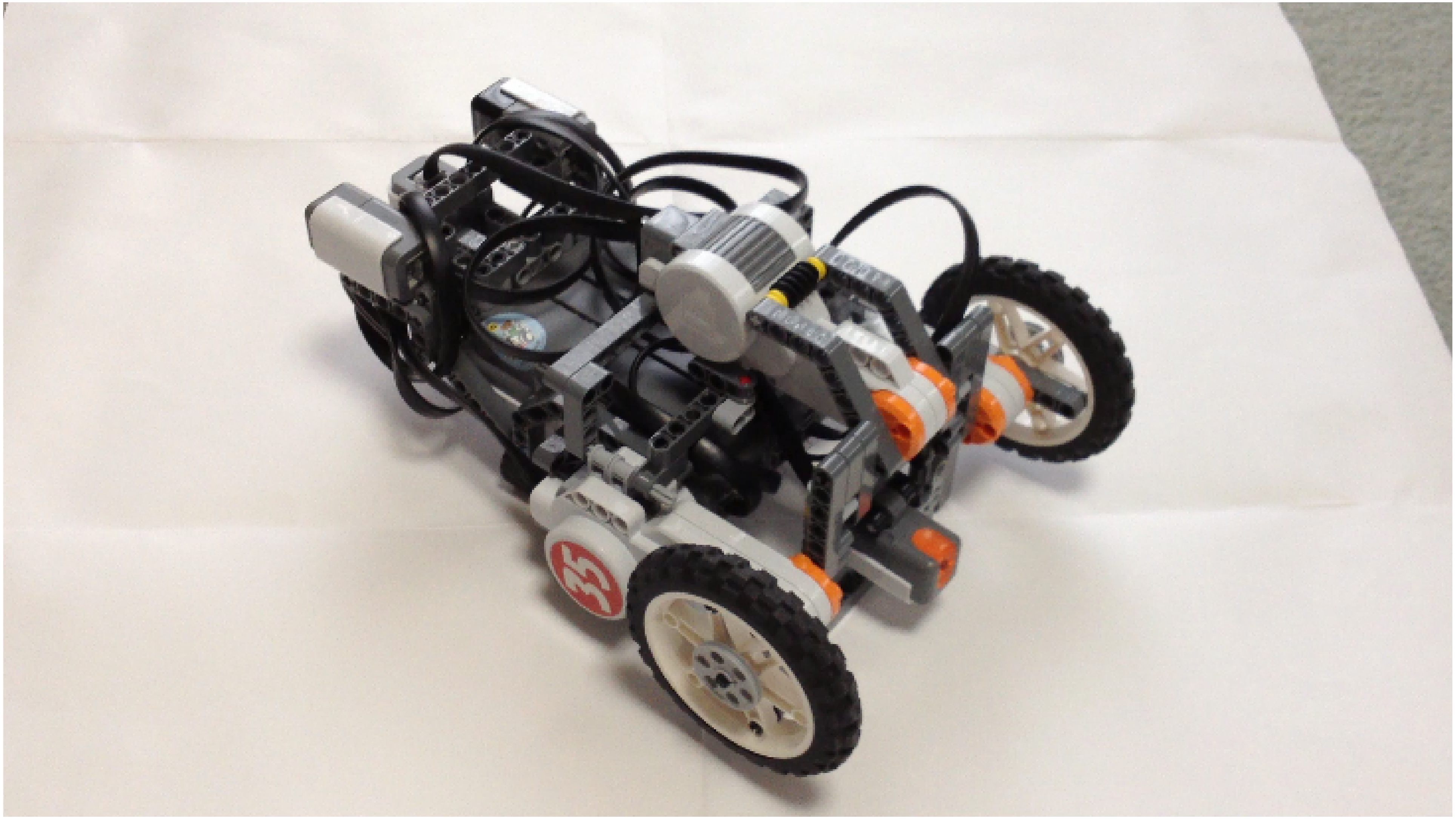
```
ELFloat64 elMotorSetAngle(ELUInt32 portid, ELFloat64
angle, ELInt32 speed)
{
  ELFloat64 pwm;
  ELInt32 loop_count=1, motor_count=0,
motor_count_prev=0;
  ELInt64 sum_motor_count_diff=0;

  motor_count = nxt_motor_get_count(portid);
  pwm = angle * 180.0 / PI - (ELFloat64)motor_count;
  while (fabs(pwm) > ANGLE_MARGIN) {
    if(loop_count == LOOP_MOTOR_COUNT){
      if(sum_motor_count_diff < 2)
        break;
      loop_count = 0;
      sum_motor_count_diff = 0;
    }
 pwm *= P_GAIN;
    if (pwm > speed)
      pwm = speed;
    else if (pwm < -speed)
      pwm = -speed;
    nxt_motor_set_speed(portid, pwm, 1);
    motor_count = nxt_motor_get_count(portid);
    sum_motor_count_diff += abs(motor_count -
motor_count_prev);
    pwm = angle * 180.0 / PI - (ELFloat64)motor_count;
    loop_count++;
    motor_count_prev = motor_count;
  }
  nxt_motor_set_speed(portid, 0, 1);
  return angle - (ELFloat64)motor_count / 180.0 * PI;
}
```

```
static void tail_control(signed int angle)
{
  double rad = (double)angle * PI / 180.0;
  elMotorSetAngle(EL_NXT_PORT_A, rad, 50);
}
```

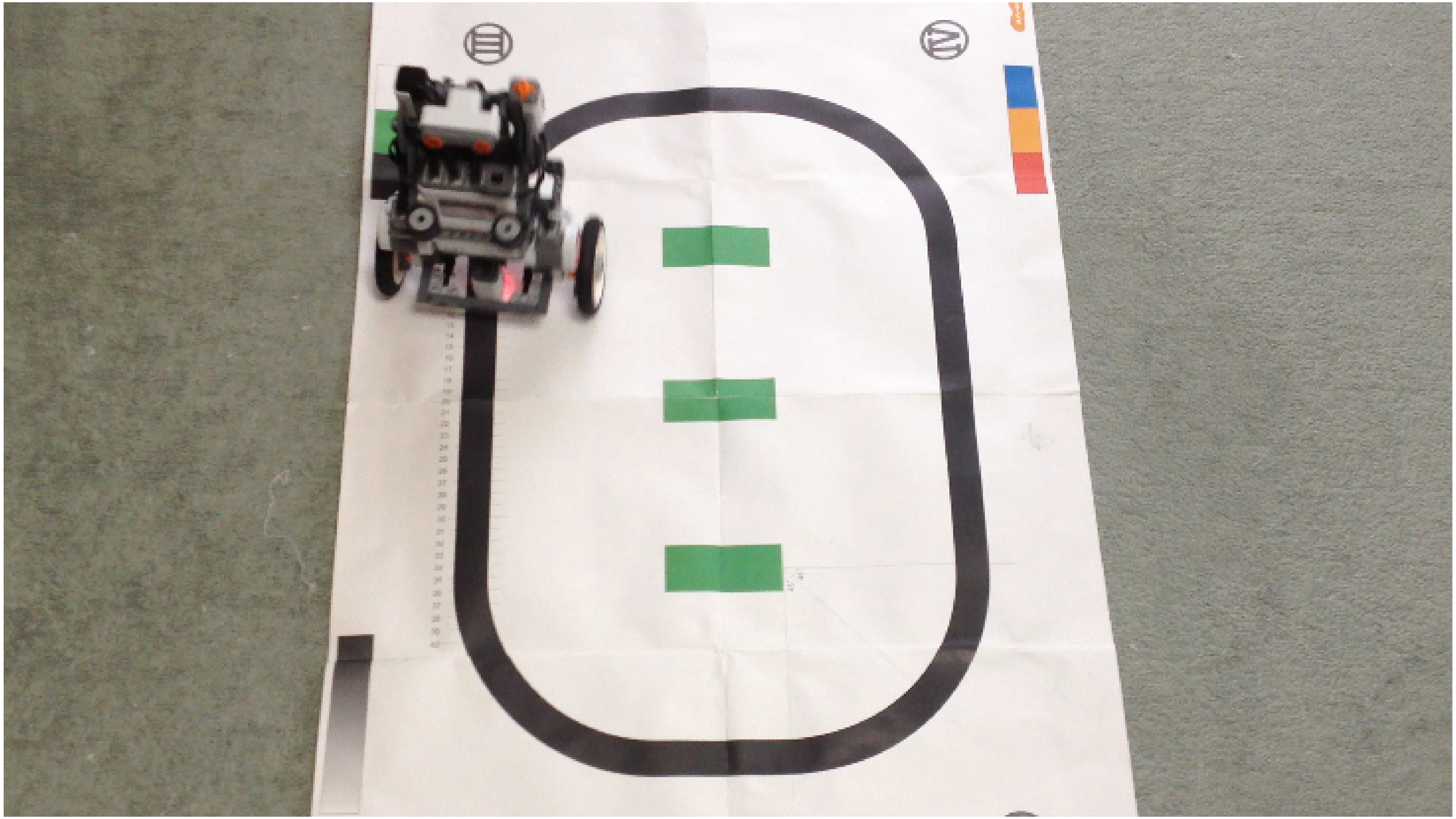


Just 1 line !!!

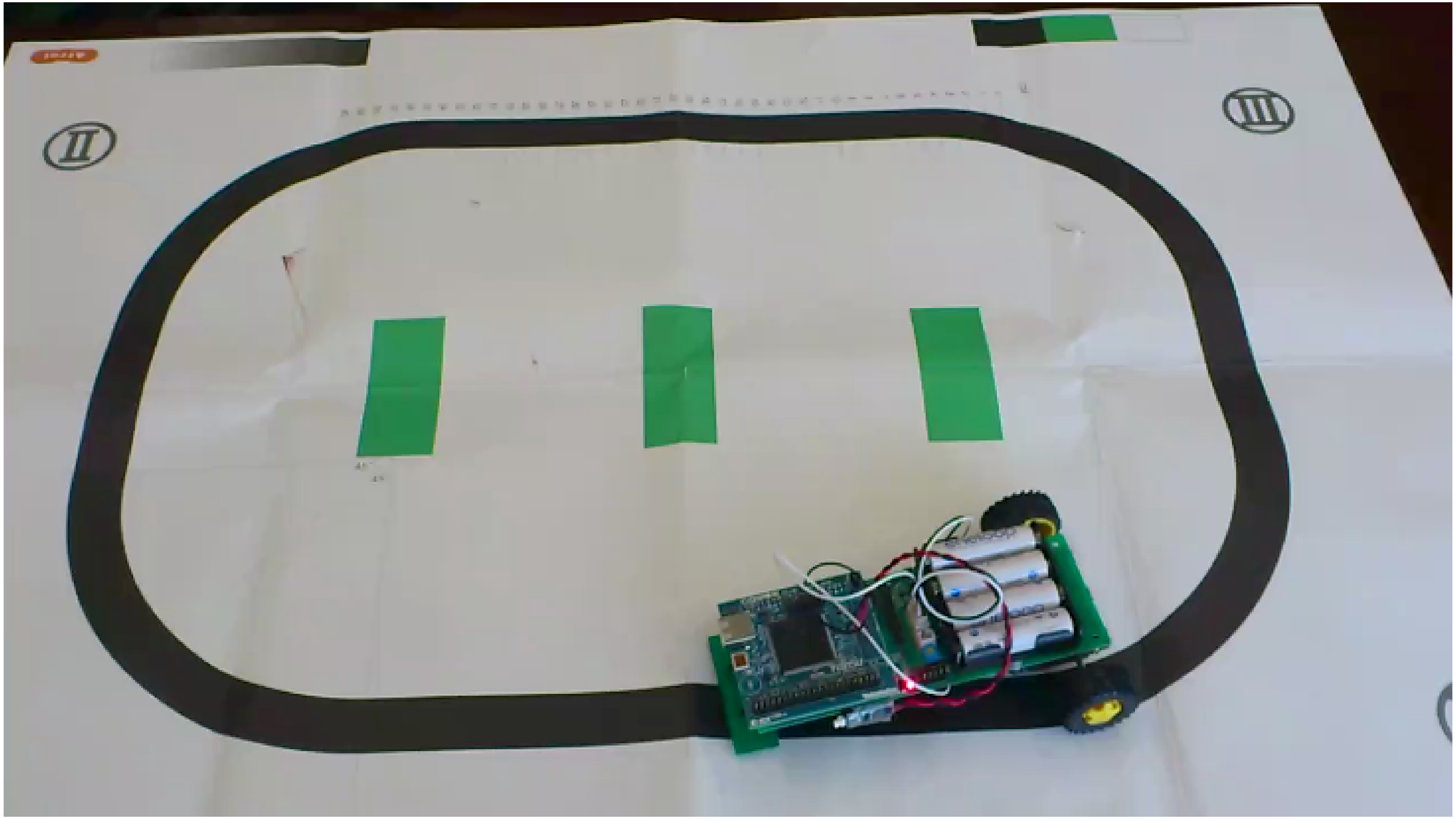
Demo video of tail_control() using elMotorSetAngle()



Demo video of OpenEL for LEGO Mindstorms NXT

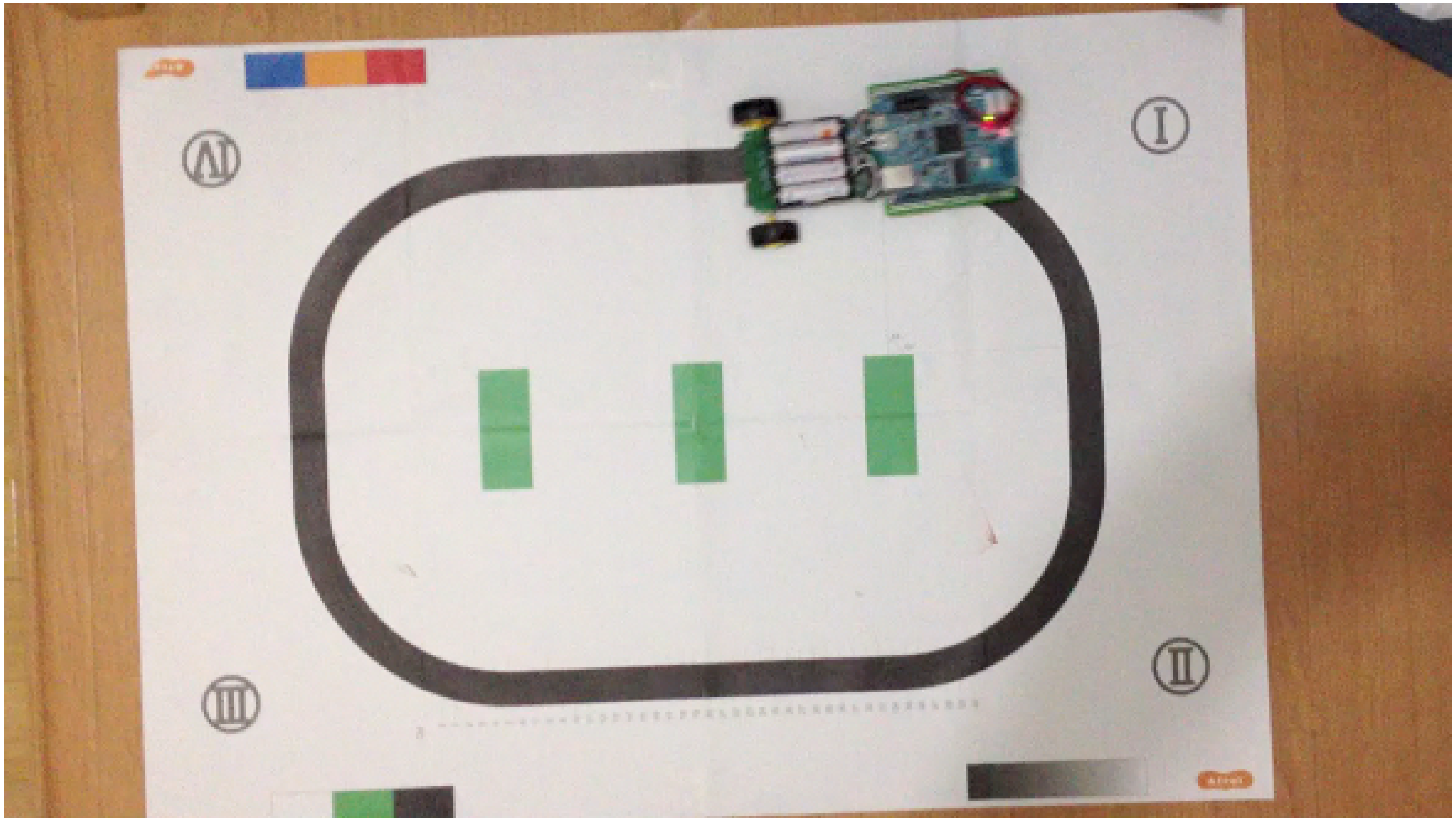


Demo video of OpenEL for FM3(Cortex-M3)



Demo video of OpenEL for Renesas RX63N

Same application runs on both FM3 and RX63N without any changes!



OpenEL Roadmap

- JASA will release OpenEL version 1.0 in March, 2013.
  - The target robots are Factory Automation robots etc..
  - The supported motors are Oriental motor etc..
  - The supported devices are A/D, D/A, DIO boards, etc.
  - The supported OS are UTOS, Linux, Windows 7.
- JASA will continue to update OpenEL.
  - More motors, sensors, devices and Robots
  - More OS like Android etc.
  - Support for safety standards, IEC 61508, ISO 13482 etc.
- JASA want to start standardization work at OMG next year.
- JASA are looking for people who agree with OpenEL in the world.

Conclusion

- OpenEL for Robots is an open platform to standardize the specifications of the software implementation of robotics and control systems.
- OpenEL is API (Application Program Interface) standardized on the layer below the middleware.
- OpenEL is a mechanism for device control, such as the output to the motor, the input from the sensor and so on.
- OpenEL increases the portability and reusability of the software, resulting in improved quality, lower costs and lead to improved productivity is expected to improve convenience for users and developers.
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Thank you!

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Date of publication : December 11, 2012

Publisher : Japan Embedded Systems Technology Association (JASA）
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