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Embedded Systems - Embodied Agents, Robot Programming in Java for the NXT Mindstorms

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LEGO Mindstorms


NXT

LEJOS
Java for LEGO Mindstorms

LEGO mindstorms

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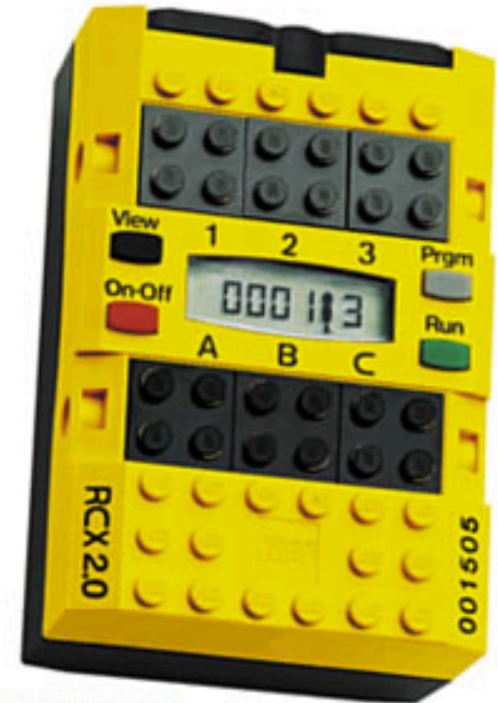
SOURCEFORGE.net

java.net MEMBER

JVM NXT Brick, Icommand technology, ...

GO >



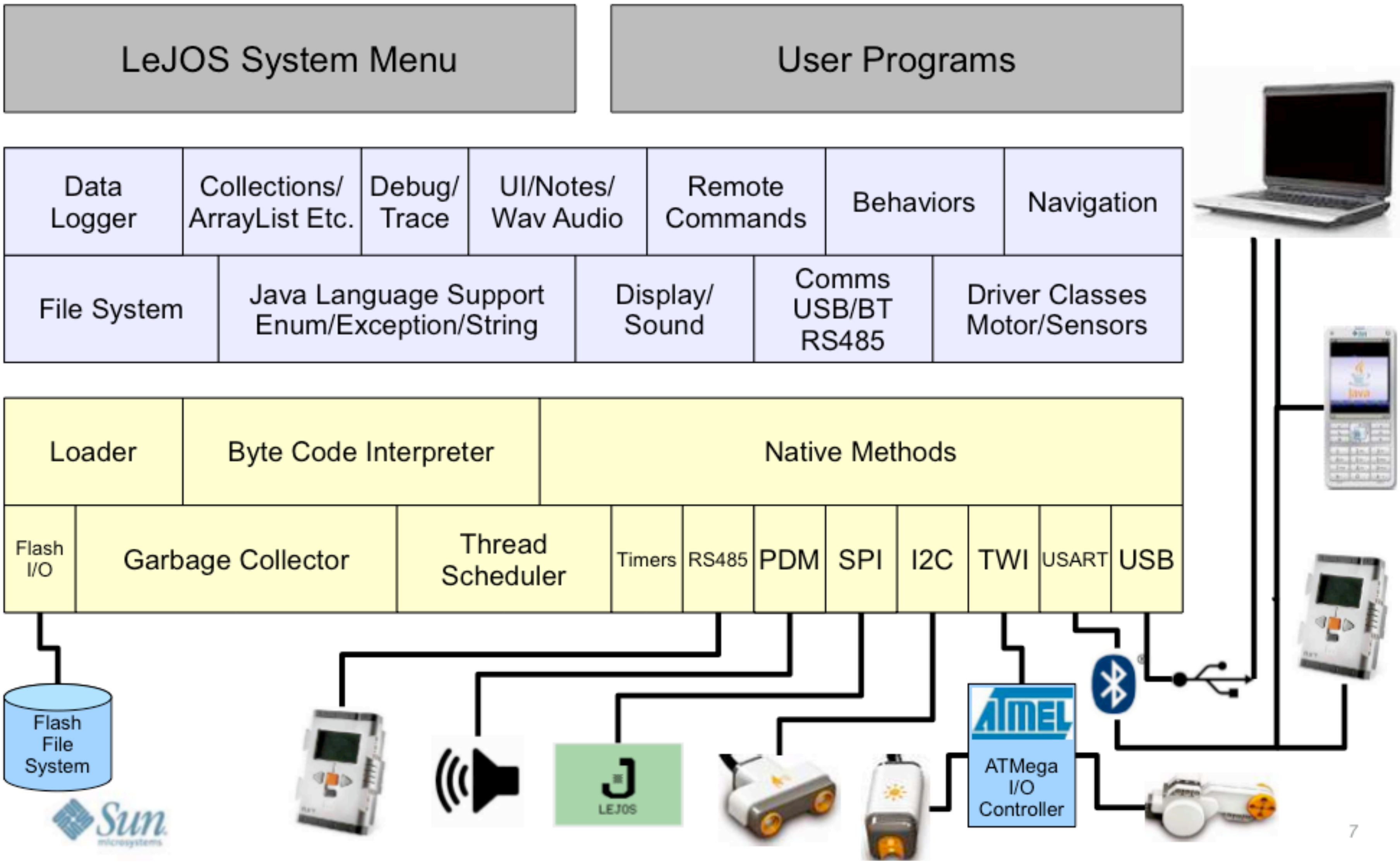
JVM RCX Brick

GO >

LEJOS News:

February 06, 2012 11:30 PM
leJOS NXJ 0.9.1 is available for download. Big thanks to all leJOS developer who made that happen. This release includes many bug fixes, new sensor drivers, and even new leJOS tools such as nxjchartinglogger and nxjmapcommand. Consult the release notes included with any release for a detailed list of changes.

LeJOS Architecture



lejos.nxt

Class LCD

java.lang.Object
  └ lejos.nxt.LCD

---

public class **LCD**
extends Object

Text and graphics output to the LCD display.

static void	drawInt(int i, int x, int y) Display an int on the LCD at specified x,y co-ordinate.
static void	drawInt(int i, int places, int x, int y) Display an in on the LCD at x,y with leading spaces to occupy at least the number of characters specified by the places parameter.
static void	drawString(String str, int x, int y) Display a string on the LCD at specified x,y co-ordinate.

Embedded Systems - Embodied Agents, Digital Control in an Physical World

Week 2

PID controllers and Embedded Java API

Articles

- PID Control.
  Chapter 5, pp. 179-190 of
  Fred G. Martin,
  Robotic Explorations: A Hands-on Introduction to Engineering,
  Prentice Hall, 2001.
- NXT LCD and Button.
- leJOS, Java API for LEGO Mindstorms NXT, especially the classes Battery, LCD and Button.

Further Reading

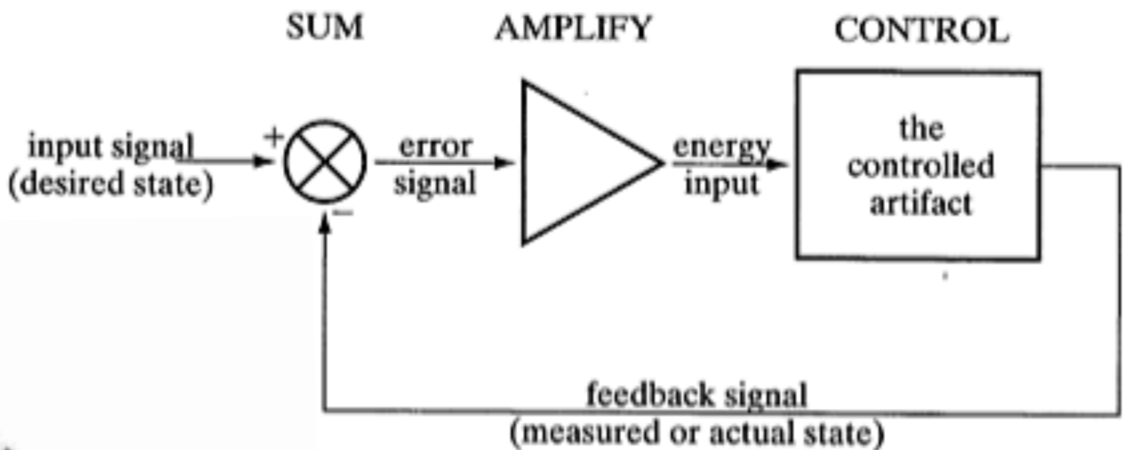
- Control System (Wikipedia).
- PID controller (Wikipedia).
- Vance J. VanDoren, Understanding PID Control.

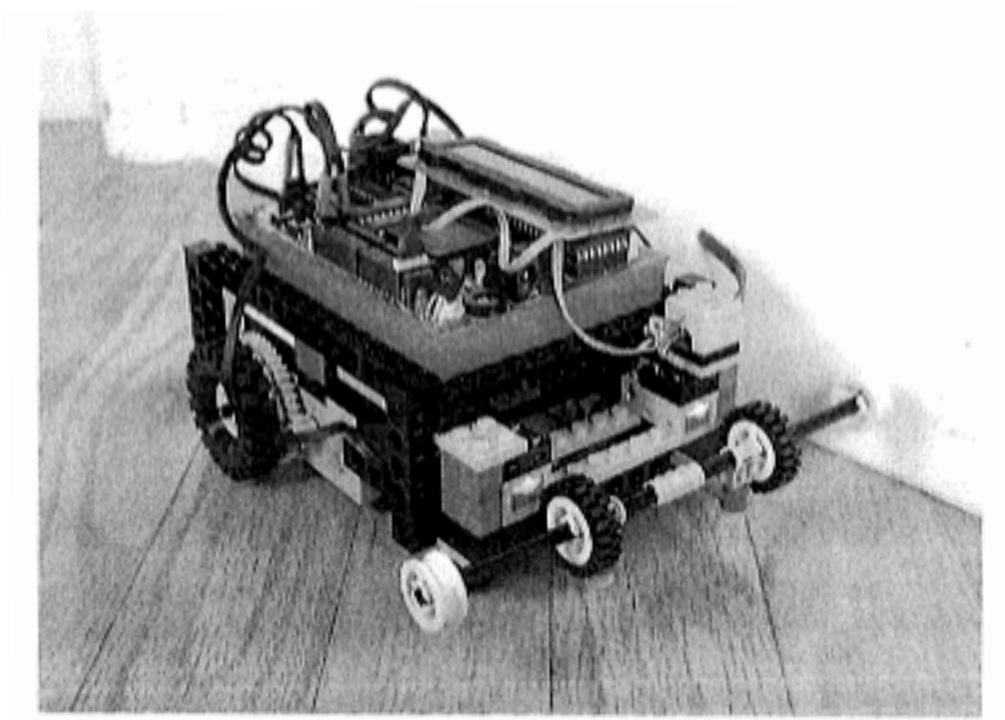
Lab Material

- NXT Programming, Lesson 1

- Compilation and upload of Java programs for the NXT is described in the leJOS NXJ installation guide.

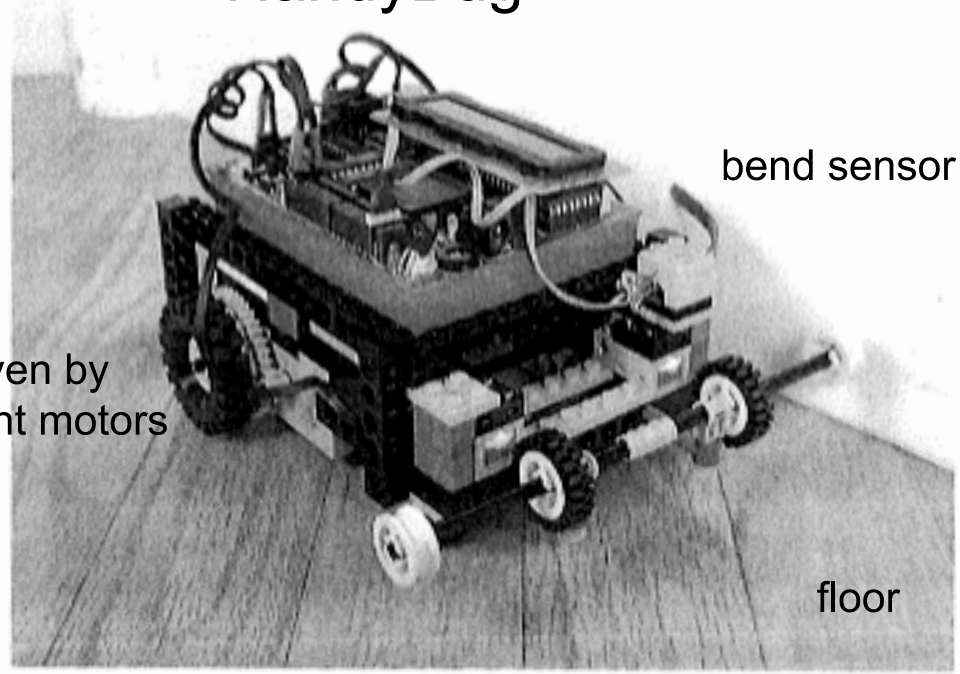
Control Systems





Fred Martin, Chapter 5

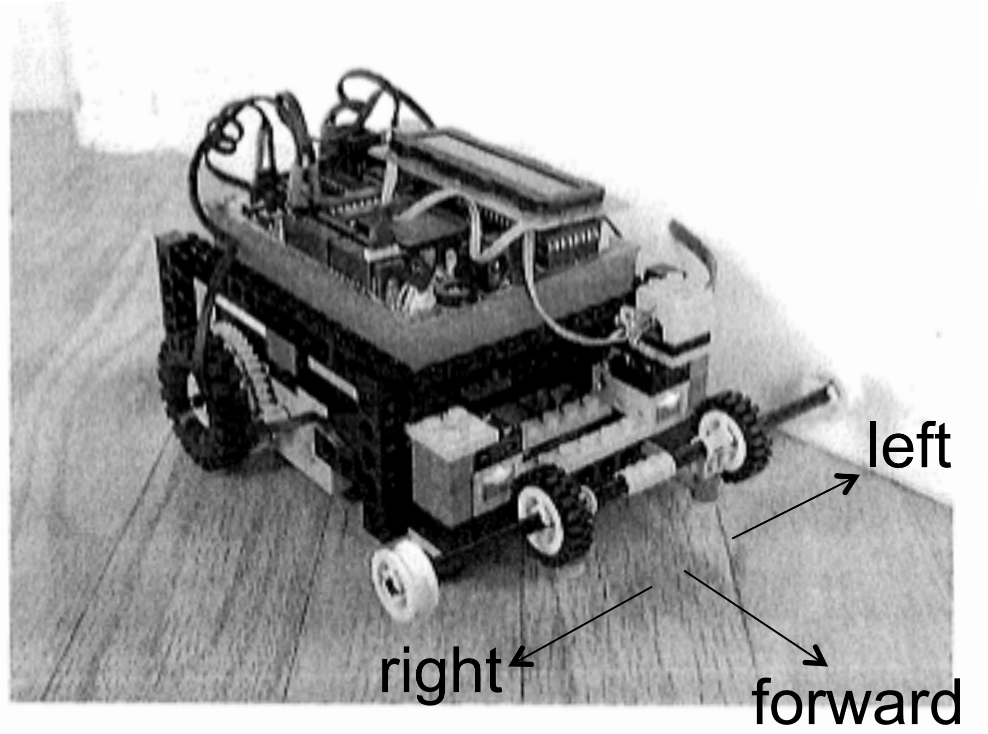
HandyBug



bend sensor value:

high value - close to wall

low value - away from wall




```
void main()
{
  calibrate();

  ix= 0;

  while (1) {
    int wall= analog(LEFT_WALL);
    printf("goal is %d; wall is %d\n", goal, wall);

    if (wall < goal) left();   /* too far from wall -- turn in */
    else right();              /* turn away from wall */

    data[ix++]= wall;          /* take data sample */

    msleep(100L);              /* 10 iterations per second */
  }
}
```

NXT Programming

Lesson 1

In this lesson we build a LEGO car to be controlled by the LEGO Mindstorms NXT. Then we **install the leJOS Java system**, [1], and use this to **compile and upload** a Java program to the NXT. The program will make the car follow a black line on a white surface.

The 9797 LEGO car

In the LEGO Mindstorms Education NXT Base Set 9797 there is a building instruction for a car, page 8 to page 22. Page 32 to page 34 shows how a light sensor can be added to the car. Build this car with a light sensor added.

Figure 1 The 9797 LEGO car with two motors.

A Java Control Program: LineFollower

The first Java program that we are going to execute on the NXT is the following Java program that makes the LEGO car follow a black line on a white surface: (`LineFollower.java`):

```
LightSensor light = new LightSensor(SensorPort.S3);
final int blackWhiteThreshold = 45;

// Use the light sensor as a reflection sensor
light.setFloodlight(true);

LCD.drawInt(light.readValue(), 3, 9, 0);

if (light.readValue() > blackWhiteThreshold){
```

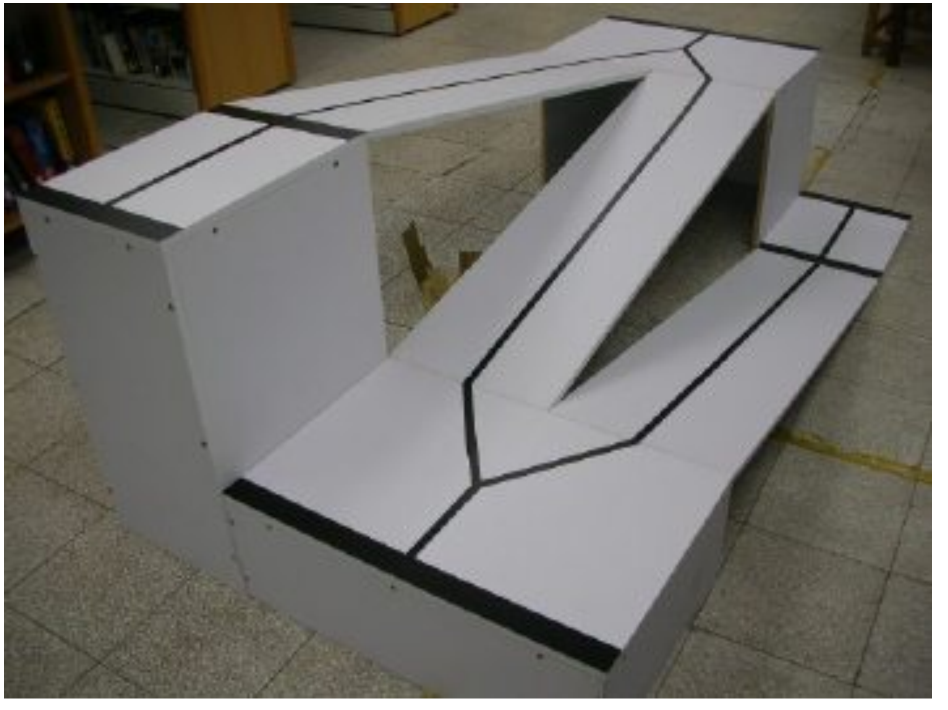
```
MotorPort.B.controlMotor(0,stop);
MotorPort.C.controlMotor(power, forward);
```

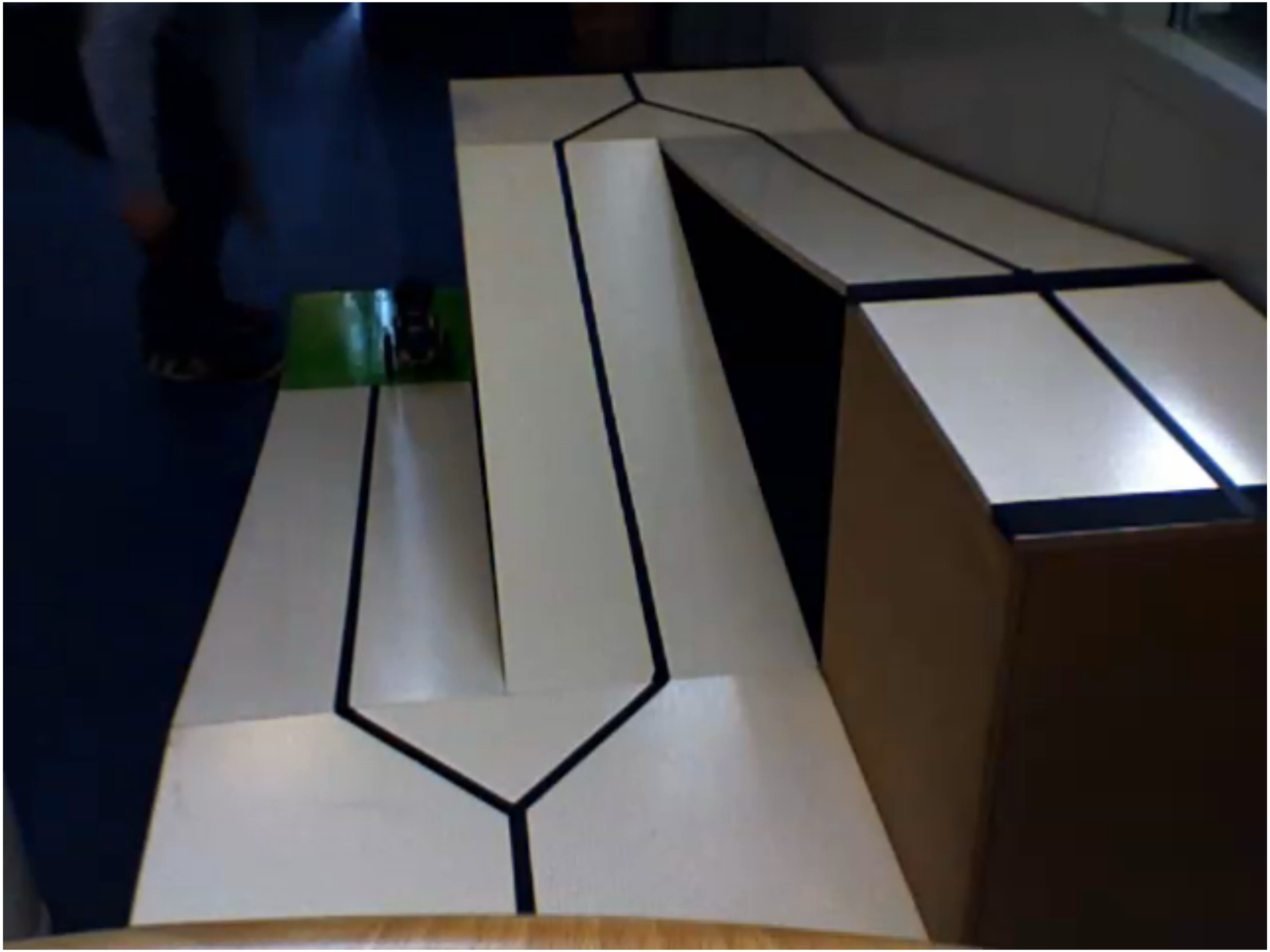
```
MotorPort.B.controlMotor(power, forward);
MotorPort.C.controlMotor(0,stop);
```

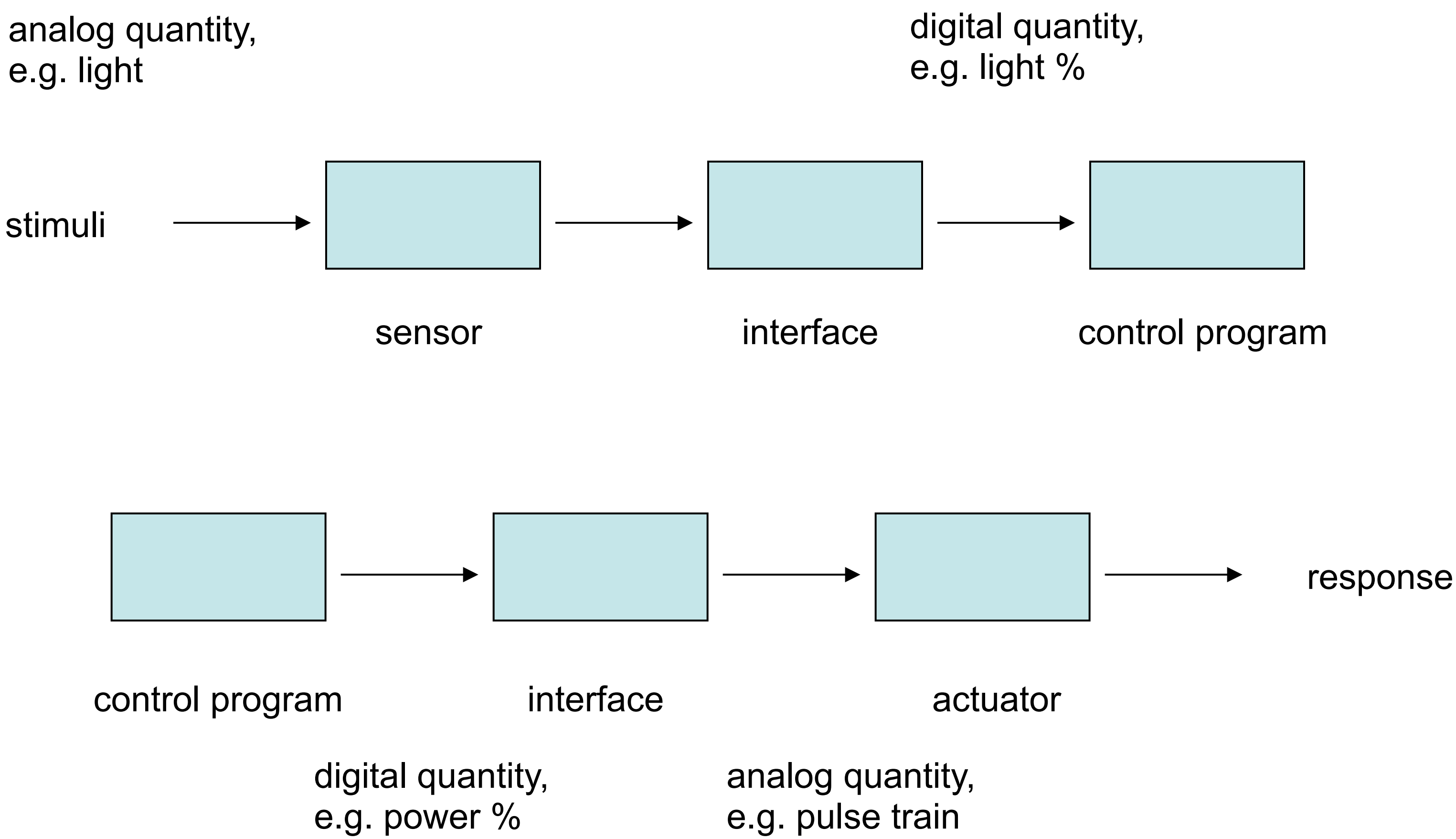
```
// Follow line until ESCAPE is pressed
while (! Button.ESCAPE.isPressed()){

        if (light.readValue() > blackWhiteThreshold){
                // On white, turn right
                LCD.drawString(right, 0, 1);
                MotorPort.B.controlMotor(0,stop);
                MotorPort.C.controlMotor(power, forward);
        }
        else{
                // On black, turn left
                LCD.drawString(left, 0, 1);
                MotorPort.B.controlMotor(power, forward);
                MotorPort.C.controlMotor(0,stop);
        }
        LCD.drawInt(light.readValue(), 3, 9, 0);
        LCD.refresh();
        Thread.sleep(100);

}
```


```
public void pidControl() {
    while (!Button.ESCAPE.isPressed()) {
        int normVal = ls.readNormalizedValue();

        // Proportional Error:
        int error = normVal - offset;
        // Adjust far and near light readings:
        if (error < 0) error = (int)(error * 1.8F);

        // Integral Error:
        int_error = ((int_error + error) * 2)/3;

        // Derivative Error:
        int deriv_error = error - prev_error;
        prev_error = error;

        int pid_val = (int)(KP * error + KI * int_error + KD * deriv_error)

        if (pid_val > 100)
            pid_val = 100;
        if (pid_val < -100)
            pid_val = -100;

        // Power derived from PID value:
        int power = Math.abs(pid_val);
        power = 55 + (power * 45) / 100; // NORMALIZE POWER
        Motor.B.setPower(power);
        Motor.C.setPower(power);

        if (pid_val > 0) {
            Motor.B.forward();
            Motor.C.forward();
        } else {
            Motor.B.backward();
            Motor.C.backward();
        }
    }
}
```

Alishan train track

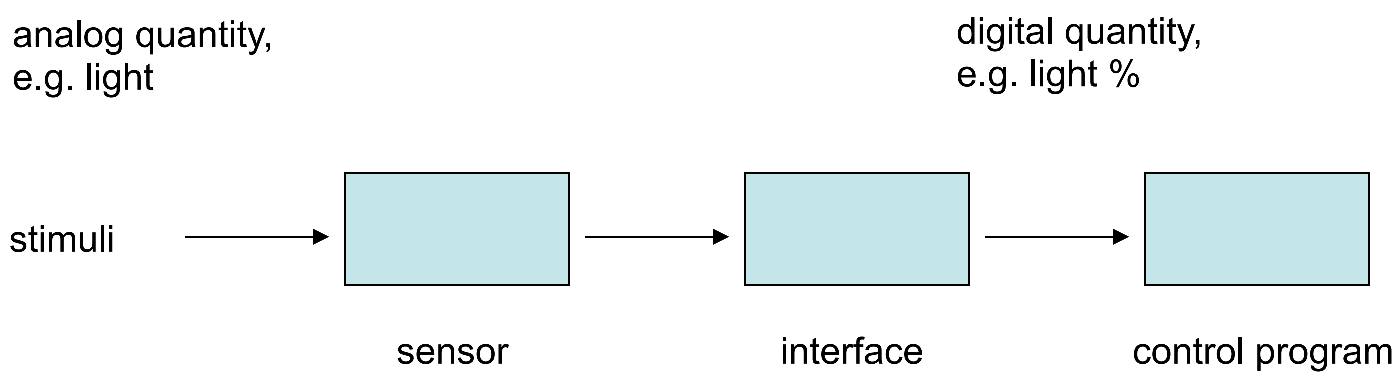


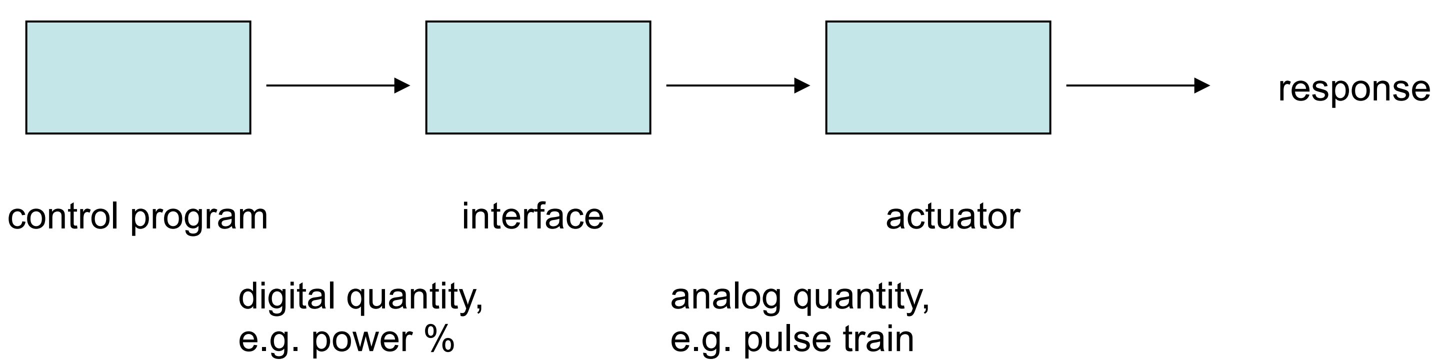



analog quantity,
e.g. light
digital quantity,
e.g. light %
stimuli
sensor
interface
control program
control program
interface
actuator
response
digital quantity,
e.g. power %
analog quantity,
e.g. pulse train

Behavior of a robot depends on

1. Environment
2. Physical robot
3. Control program





Embedded Systems - Embodied Agents, Digital Control in an Physical World

Embodied Agents

Articles

- P. Maes, Modeling Adaptive Autonomous Agents,
  Artificial Life Journal, C. Langton, ed., Vol. 1, No. 1 & 2, MIT Press, 1994.

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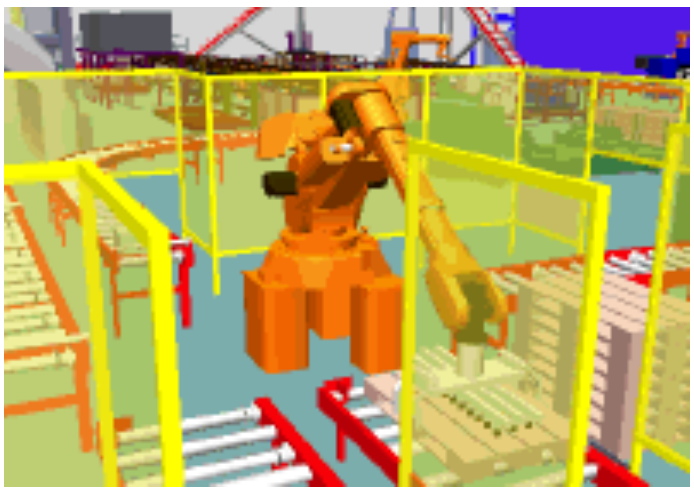
Embodied Agents

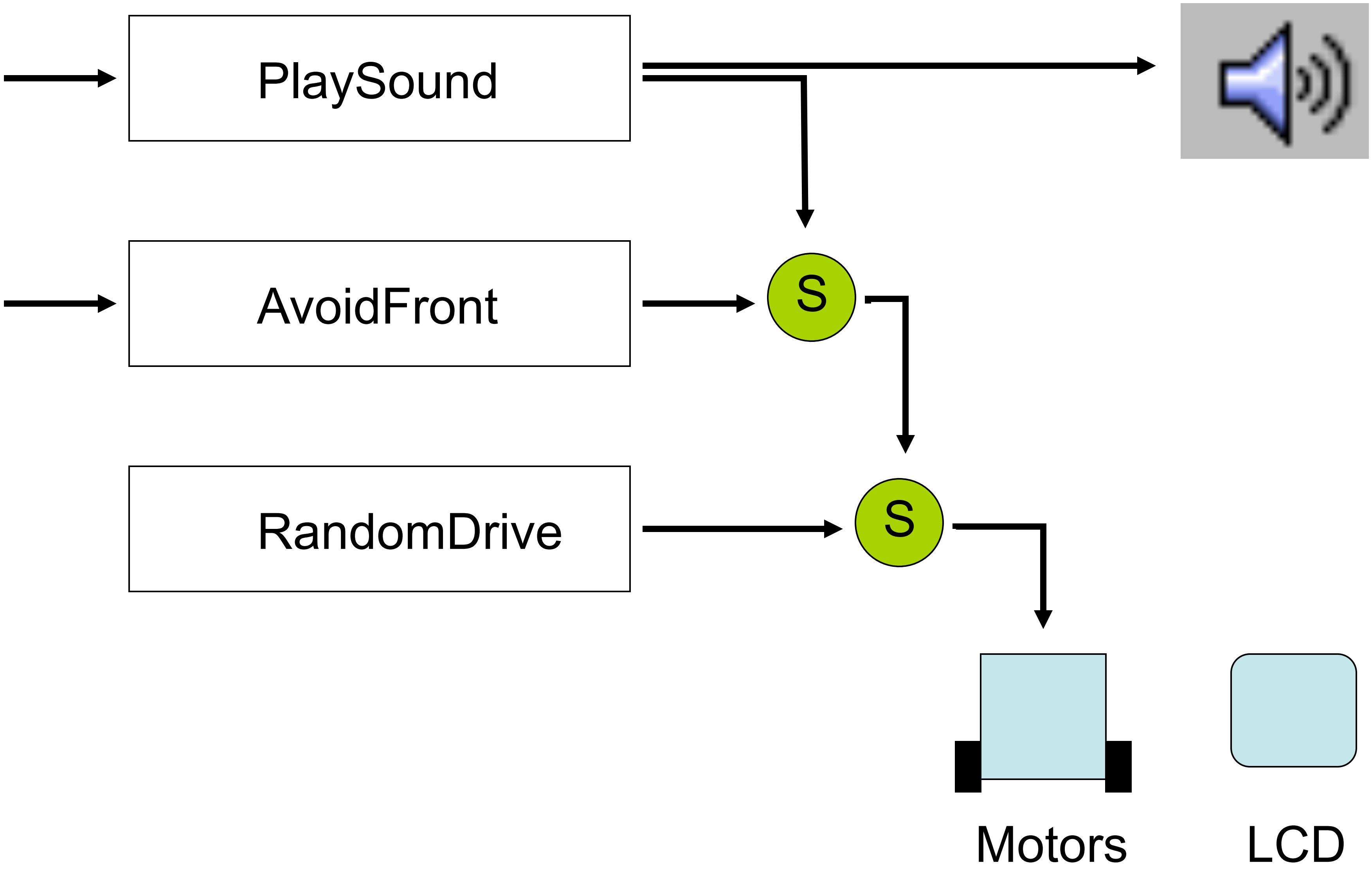
Industrial robot



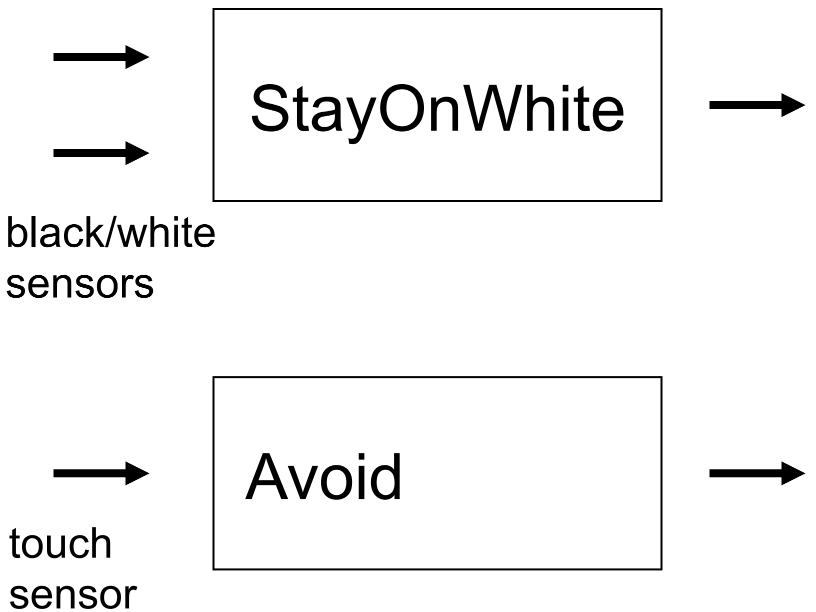
Sequential strategy

Robot baby seal Paro

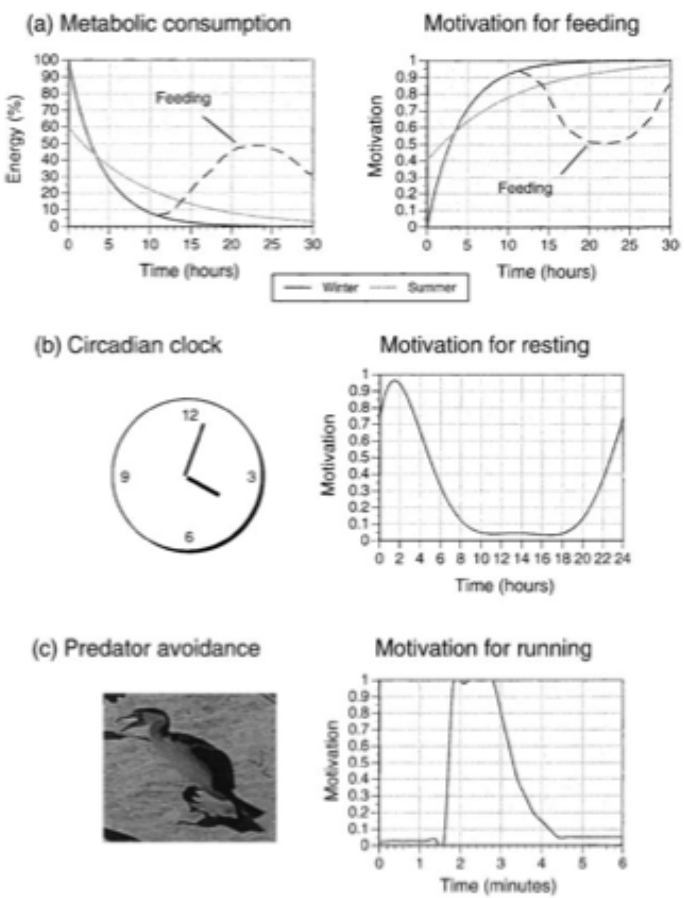
Reactive strategy

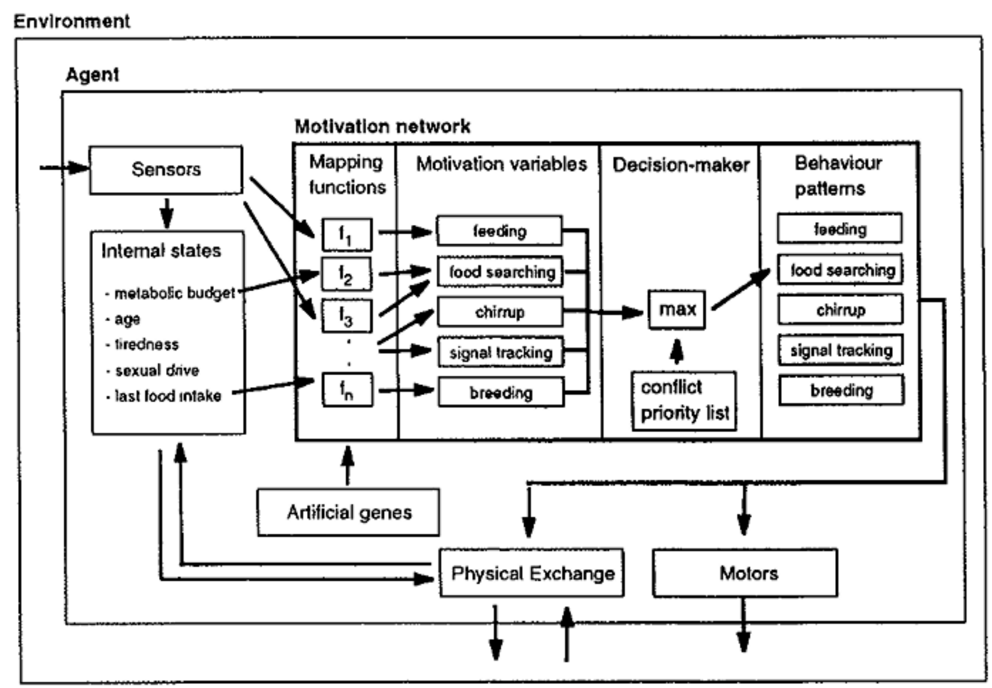

PlaySound
AvoidFront
RandomDrive
S
S
Motors
LCD

Ghost control program

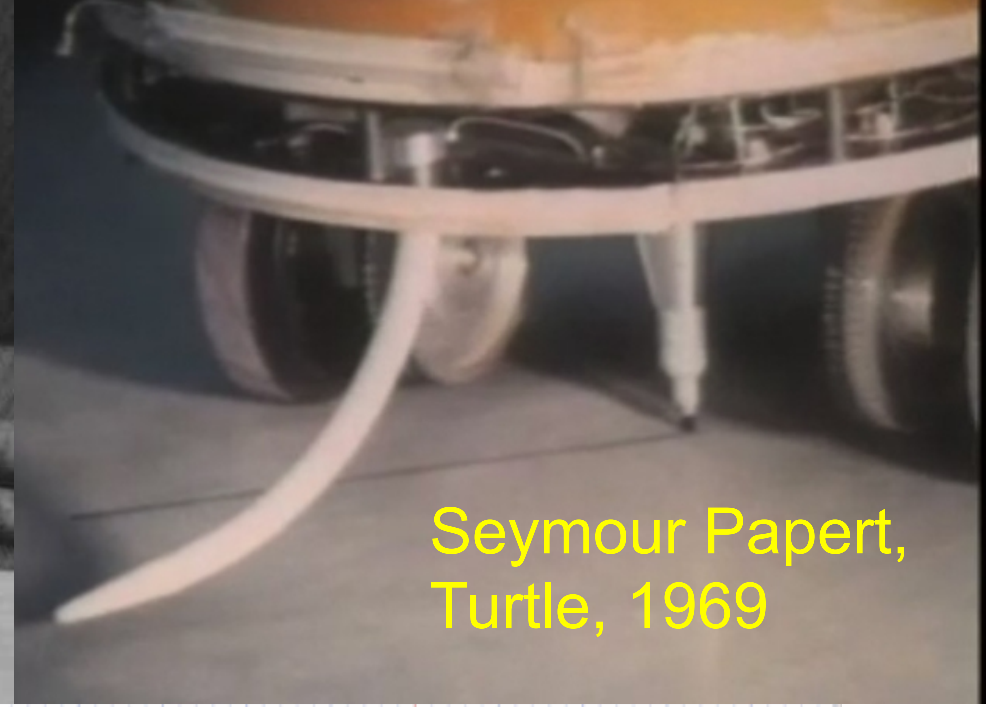


Motivation Networks – A Biological Model for Autonomous Agent Control





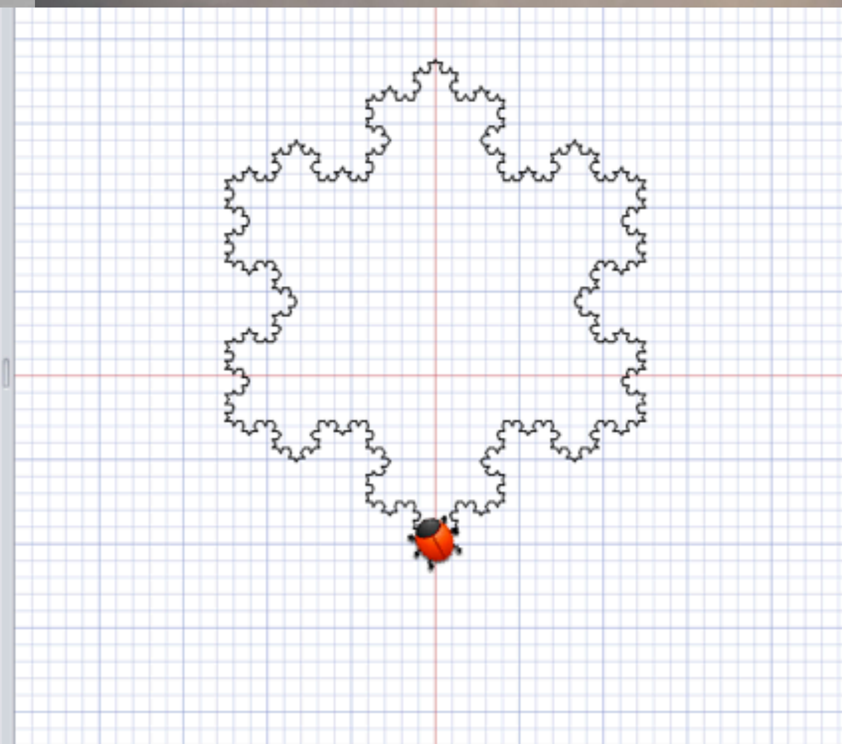
End course projects

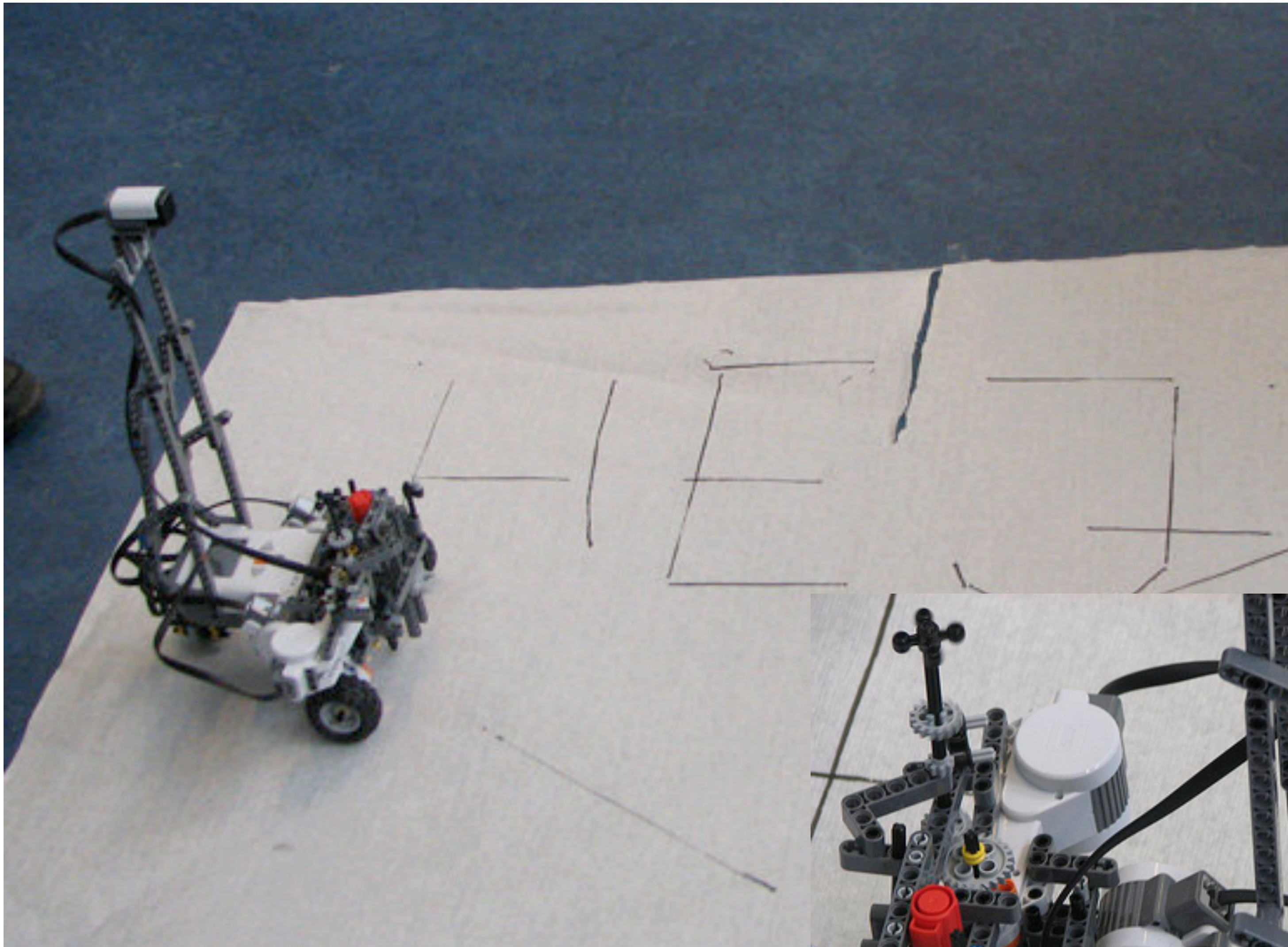


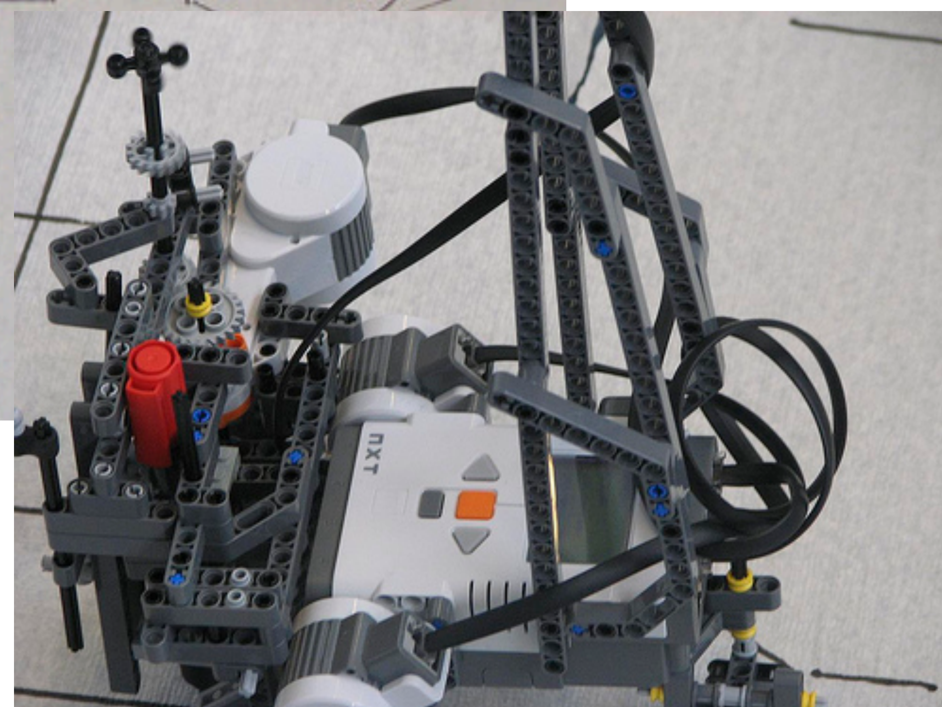

```
def snowflake(size, level)
{
    3.times {
        side(size, level)
        rt 120
    }
}

def side(size, level)
{
    if (level==0)
    {
        fd size
        return
    }
    side(size/3, level-1)
    lt 60
    side(size/3, level-1)
    rt 120
    side(size/3, level-1)
    lt 60
    side(size/3, level-1)
}

clean()
lt 30
setpos(0,-100)
snowflake(250, 4)
```







IDEAL AND REAL SYSTEMS: A Study of Notions of Control in Undergraduates Who Design Robots

FRED G. MARTIN

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Teaching powerful ideas with autonomous mobile robots

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