

Chapter 1

HTTP API

EiT API

Device status

Resource for storing and fetching the status of a device with a given id.

Get device status

0.1 GET /status/{device}

REQUEST

raw

RESPONSE

200 (OK)
Content-Type: application/json

```
{
  "timestamp": "Timestamp in milliseconds when the server received the last status
update",
  "_id": "Database id, not needed for anything",
  "device_id": "The same as the {device}-part of the request",
  "data1": "3.141529",
  "data_2": "2.71828",
  "and so on...": "any data the device has sent to the server",
  ...
}
```

Set device status

0.2 POST /status/{device}

REQUEST

raw

Content-Type: application/json

```
{
  "data1": "3.141529",
  "data_2": "2.71828",
```

```
"and so on...": "any data here will be stored by the server",
...
}
```

RESPONSE

200 (OK)
Content-Type: application/json

Will return the same as a GET request to [/command/{device}]

Manage sensor data for a single sensor

Resource for storing and fetching sensor data for a given sensor for a given device.

Get sensor data

0.3 GET /data/{device}/{sensor}

REQUEST

raw

RESPONSE

200 (OK)
Content-Type: application/json

```
{
  "timestamp": "Timestamp in milliseconds when the server received the last status
update",
  "_id": "Database id, not needed for anything",
  "device_id": "The same as the {device}-part of the request",
  "sensor": "The same as the {sensor}-part of the request",
  "any_key": "data specified by the device when updating the sensor data",
  ...
}
```

Set sensor data

0.4 POST /data/{device}/{sensor}

REQUEST

raw

Content-Type: application/json

```
{
  "any_key": "data specified by the device when updating the sensor data",
  ...
}
```

RESPONSE

200 (OK)
Content-Type: application/json

Will return the same as a GET request to [/command/{device}]

Manage sensor data for multiple sensors

Resource for storing and fetching sensor data for all sensors for a given device.

Get the data from all the device's sensors

0.5 GET /data/{device}

REQUEST

raw

RESPONSE

200 (OK)
Content-Type: application/json

```
[
  {
    update",
    "timestamp": "Timestamp in milliseconds when the server received the last status
    "_id": "Database id, not needed for anything",
    "device_id": "The same as the {device}-part of the request",
    "sensor": "The id of this sensor",
    "any_key": "data specified by the device when updating the sensor data",
    ...
  },
  {
    update",
    "timestamp": "Timestamp in milliseconds when the server received the last status
    "_id": "Database id, not needed for anything",
    "device_id": "The same as the {device}-part of the request",
    "sensor": "The id of this sensor",
    "any_key": "data specified by the device when updating the sensor data",
    ...
  },
  ...
]
```

Set the data for several of the device's sensors

0.6 POST /data/{device}

REQUEST

raw

Content-Type: application/json

```
[
  {
    "sensor": "The id of this sensor",
    ...
  },
  {
    "sensor": "The id of this sensor",
    ...
  },
  ...
]
```

RESPONSE

200 (OK)

Content-Type: application/json

Will return the same as a GET request to [/command/{device}]

Manage a device's command queue

Resource for adding commands to a device's command queue and retrieving the command queue.

Get the device's command queue and flush it

0.7 GET /command/{device}

REQUEST

raw

RESPONSE

200 (OK)

Content-Type: application/json

```
[
  {
    "timestamp": "Timestamp in milliseconds when the server received the last status
update",
    "any_key": "Any data can go here",
    ...
  },
  ...
]
```

Add a command to the device's command queue

0.8 POST /command/{device}

REQUEST

raw

Content-Type: application/json

```
{
  "any_key": "Any data can go here",
  ...
}
```

RESPONSE

200 (OK)
Content-Type: application/json

```
{}
```

Chapter 2

Agent code

2.1 car.h

```
1 #ifndef CAR_H
2 #define CAR_H
3
4 #include "motor.h"
5 #include <pthread.h>
6
7 #define NO_TURN 0
8 #define LEFT_TURN 1
9 #define RIGHT_TURN 2
10
11 #define TURN_MAGNITUDE 0.5 f
12
13 class Car{
14
15 public:
16     Car(int FR,int FL,int BR,int BL) : frontRightWheel(FR, WHEELMODE), frontLeftWheel(
        FL, WHEELMODE),
17     backRightWheel(BR, WHEELMODE), backLeftWheel(BL, WHEELMODE){turn = NO_TURN; speed
        = 0; direction = 0; mode = IDLE_MODE;};
18     void setSpeed(int, bool);
19     int getSpeed();
20     void turnCar(int);
21     void setMode(int);
22     int getMode();
23     void startPing();
24 private:
25     int direction;
26     int speed;
27     int turn;
28     int mode;
29     Motor frontRightWheel;
30     Motor frontLeftWheel;
31     Motor backRightWheel;
32     Motor backLeftWheel;
33     pthread_t thread_car;
34     static void * staticEntryPoint(void * c);
35     void ping();
36 };
37
38 #endif
```

include/car.h

2.2 car.cpp

```
1 #include "car.h"
2 #include <stdio.h>
3 #include <unistd.h>
```

```

4 pthread_mutex_t mutex_car = PTHREAD_MUTEX_INITIALIZER;
5
6
7 void Car::setSpeed(int theSpeed, bool dir){
8
9     if(getMode() == FAILSAFE.MODE)
10         return;
11
12     try{
13         switch(turn)
14         {
15             case NO_TURN:
16                 //set all wheels same speed
17                 frontLeftWheel.setSpeed(theSpeed, !dir);
18                 backLeftWheel.setSpeed(theSpeed, !dir);
19                 frontRightWheel.setSpeed(theSpeed, dir);
20                 backRightWheel.setSpeed(theSpeed, dir);
21                 break;
22             case LEFT_TURN:
23                 //set left wheels TURN_MAGNITUDE of right wheels
24                 frontLeftWheel.setSpeed(theSpeed*TURN_MAGNITUDE, !dir);
25                 backLeftWheel.setSpeed(theSpeed*TURN_MAGNITUDE, !dir);
26                 frontRightWheel.setSpeed(theSpeed, dir);
27                 backRightWheel.setSpeed(theSpeed, dir);
28                 break;
29             case RIGHT_TURN:
30                 //set right wheels TURN_MAGNITUDE of left wheels
31                 frontLeftWheel.setSpeed(theSpeed, !dir);
32                 backLeftWheel.setSpeed(theSpeed, !dir);
33                 frontRightWheel.setSpeed(theSpeed*TURN_MAGNITUDE, dir);
34                 backRightWheel.setSpeed(theSpeed*TURN_MAGNITUDE, dir);
35                 break;
36         }
37         speed = theSpeed;
38         direction = dir;
39     }
40     catch(MotorException e) {
41         printf("ID: %d lost\n", e.ID);
42         printError(e.status);
43         setMode(FAILSAFE.MODE);
44         printf("Wheels lost!\n");
45         startPing();
46     }
47 }
48
49
50 void Car::turnCar(int theTurn){
51
52     if(getMode() == FAILSAFE.MODE)
53         return;
54
55     try{
56         turn = theTurn;
57         if(speed != 0){
58             setSpeed(speed, direction);
59             return;
60         }
61         if(turn == NO_TURN){
62             setSpeed(0,1);
63             return;
64         }
65         bool dir;
66         if(turn == LEFT_TURN)
67             dir = 1;
68         if(turn == RIGHT_TURN)
69             dir = 0;
70
71         printf("direction %d\n", direction);
72         frontLeftWheel.setSpeed(1023*TURN_MAGNITUDE, dir);
73         backLeftWheel.setSpeed(1023*TURN_MAGNITUDE, dir);
74         frontRightWheel.setSpeed(1023*TURN_MAGNITUDE, dir);
75         backRightWheel.setSpeed(1023*TURN_MAGNITUDE, dir);
76     }
77     catch(MotorException e) {
78         printf("ID: %d lost\n", e.ID);
79         printError(e.status);
80         setMode(FAILSAFE.MODE);
81         printf("Wheels lost!\n");
82         startPing();
83     }
84 }
85
86
87 void Car::setMode(int theMode){
88     pthread_mutex_lock( &mutex_car );
89     mode = theMode;
90     pthread_mutex_unlock( &mutex_car );
91 }
92
93 int Car::getMode(){
94     pthread_mutex_lock( &mutex_car );

```


2.3. MOTOR.H

9

```
95 | int temp = mode;
96 | pthread_mutex_unlock( &mutex_car );
97 | return temp;
98 | }
99 |
100 | void Car::ping(){
101 |     printf("Ping Car\n");
102 |     while(1){
103 |         int count = 0;
104 |         count += frontLeftWheel.ping();
105 |         count += backLeftWheel.ping();
106 |         count += frontRightWheel.ping();
107 |         count += backRightWheel.ping();
108 |
109 |         if(count == 4){
110 |             printf("All wheels active!\n");
111 |             setMode(IDLE.MODE);
112 |             return;
113 |         }
114 |     }
115 | }
116 |
117 | void Car::startPing(){
118 |     pthread_create(&thread_car, NULL, Car::staticEntryPoint, this);
119 | }
120 |
121 | void * Car::staticEntryPoint(void * c)
122 | {
123 |     ((Car *) c)->ping();
124 |     return NULL;
125 | }
```

src/car.cpp

2.3 motor.h

```
1 | #ifndef MOTOR_H
2 | #define MOTOR_H
3 |
4 | #include <dynamixel.h>
5 | #include <pthread.h>
6 |
7 | // Control table address
8 | #define CW_ANGLE_LIMIT_L 6
9 | #define CW_ANGLE_LIMIT_H 7
10 | #define CCW_ANGLE_LIMIT_L 8
11 | #define CCW_ANGLE_LIMIT_H 9
12 | #define MAX_TORQUE_L 14
13 | #define MAX_TORQUE_H 15
14 | #define HIGH_LIMIT_VOLTAGE 13
15 | #define GOAL_POSITION_L 30
16 | #define GOAL_POSITION_H 31
17 | #define MOVING_SPEED_L 32
18 | #define MOVING_SPEED_H 33
19 | #define PRESENT_POSITION_L 36
20 | #define PRESENT_POSITION_H 37
21 | #define PRESENT_SPEED_L 38
22 | #define PRESENT_SPEED_H 39
23 | #define MOVING 46
24 |
25 | #define WHEELMODE 0
26 | #define SERVOMODE 1
27 |
28 | #define CW 1
29 | #define CCW 0
30 |
31 | #define IDLE_MODE 0
32 | #define FAILSAFE_MODE 1
33 |
34 |
35 | class MotorException{
36 | public:
37 |     MotorException(int theID, int theStatus) : ID(theID), status(theStatus){};
38 |     int ID;
39 |     int status;
40 | };
41 |
42 | class Motor{
43 | public:
44 |     Motor(int, int);
45 |     int getMode();
46 |     int getPosition();
47 |     int getSpeed();
```

```

48 void setGoalPosition(int);
49 void setSpeed(int, bool);
50 void setMode(int);
51 void setRotateDirection(int);
52 void printErrorCode(void);
53 void checkStatus();
54 int ping();
55 private:
56 int position;
57 int speed;
58 int mode;
59 int ID;
60 int commStatus;
61 int rotateDirection;
62 };
63
64 void pingAll();
65 void printError(int status);
66
67 #endif

```

include/motor.h

2.4 motor.cpp

```

1  #include "motor.h"
2  #include "dynamixel.h"
3  #include "stdio.h"
4  #include "communication.h"
5
6  Motor::Motor(int theID, int theMode){
7      ID = theID;
8      mode = theMode;
9      commStatus = COMM_RXSUCCESS;
10     setMode(mode);
11 }
12
13 int Motor::getMode(){
14     return mode;
15 }
16
17 int Motor::getPosition(){
18
19     int temp = readWord( ID, PRESENT_POSITION_L );
20     commStatus = getResult();
21     if(commStatus != COMM_RXSUCCESS)
22         throw MotorException(ID, commStatus);
23     printErrorCode();
24     position = temp;
25     return position;
26 }
27
28 int Motor::getSpeed(){
29
30     unsigned short temp = readWord( ID, PRESENT_SPEED_L );
31     commStatus = getResult();
32     if(commStatus != COMM_RXSUCCESS)
33         throw MotorException(ID, commStatus);
34     printErrorCode();
35     speed = temp & 1023;
36     return speed;
37 }
38
39 void Motor::setGoalPosition(int thePosition){
40
41     writeWord( ID, GOAL_POSITION_L, thePosition );
42     commStatus = getResult();
43     if(commStatus != COMM_RXSUCCESS)
44         throw MotorException(ID, commStatus);
45     printErrorCode();
46 }
47
48
49 void Motor::setMode(int theMode){
50
51     switch (theMode)
52     {
53     case WHEELMODE:
54         writeWord( ID, CW_ANGLE_LIMIT_L, 0 );
55         writeWord( ID, CCW_ANGLE_LIMIT_L, 0 );
56         break;
57     case SERVOMODE:
58         writeWord( ID, CW_ANGLE_LIMIT_L, 0 );

```

```

59 |     writeWord( ID, CCW_ANGLE_LIMIT_L, 1023 );
60 |     break;
61 | default:
62 |     printf("unknown mode: %d\n", theMode);
63 |     return;
64 | }
65 | mode = theMode;
66 | }
67 |
68 | void Motor::setSpeed( int theSpeed, bool theDirection ){
69 |
70 |     writeWord( ID, MOVING_SPEED_L, theSpeed | (theDirection << 10) );
71 |     commStatus = getResult();
72 |     if( commStatus != COMM_RXSUCCESS )
73 |         throw MotorException( ID, commStatus );
74 |     printErrorCode();
75 | }
76 |
77 | void Motor::setRotateDirection( int direction ){
78 |
79 |     switch( direction )
80 |     {
81 |     case CW:
82 |         writeWord( ID, MOVING_SPEED_L, 1024 );
83 |         break;
84 |     case CCW:
85 |         writeWord( ID, MOVING_SPEED_L, 0 );
86 |         break;
87 |     default:
88 |         printf("invalid input: %d\n", direction);
89 |         return;
90 |     }
91 |     commStatus = getResult();
92 |     if( commStatus != COMM_RXSUCCESS )
93 |         throw MotorException( ID, commStatus );
94 |     printErrorCode();
95 |
96 |     rotateDirection = direction;
97 | }
98 |
99 | // Print error bit of status packet
100 | void Motor::printErrorCode()
101 | {
102 |     if( getRXpacketError( ERRBIT_VOLTAGE ) == 1 )
103 |         printf("Input voltage error!\n");
104 |
105 |     if( getRXpacketError( ERRBIT_ANGLE ) == 1 )
106 |         printf("Angle limit error!\n");
107 |
108 |     if( getRXpacketError( ERRBIT_OVERHEAT ) == 1 )
109 |         printf("Overheat error!\n");
110 |
111 |     if( getRXpacketError( ERRBIT_RANGE ) == 1 )
112 |         printf("Out of range error!\n");
113 |
114 |     if( getRXpacketError( ERRBIT_CHECKSUM ) == 1 )
115 |         printf("Checksum error!\n");
116 |
117 |     if( getRXpacketError( ERRBIT_OVERLOAD ) == 1 )
118 |         printf("Overload error!\n");
119 |
120 |     if( getRXpacketError( ERRBIT_INSTRUCTION ) == 1 )
121 |         printf("Instruction code error!\n");
122 | }
123 |
124 | void Motor::checkStatus() {
125 |
126 |     unsigned char temp;
127 |     for( int i = 0; i < 50; i++ )
128 |     {
129 |         if( i == 10 || i == 45 )
130 |             continue;
131 |         temp = readByte( ID, i );
132 |         printf("%d:\t%d\t%d\n", ID, i, temp);
133 |     }
134 |     printf("\n");
135 | }
136 |
137 | int Motor::ping() {
138 |     pingID( ID );
139 |     commStatus = getResult();
140 |     if( commStatus == COMM_RXSUCCESS )
141 |     {
142 |         //printf("Motor ID: %d active!\n", ID);
143 |         return 1;
144 |     }
145 |     //printf("Motor ID: %d NOT active!\n", ID);
146 |     return 0;
147 | }
148 |
149 | void pingAll() {

```

```

150   for(int i = 0; i<254; i++){
151       dxi_ping(i);
152       if( dxi_get_result( ) == COMM_RXSUCCESS )
153       {
154           printf("ID: %d active!\n",i);
155       }
156   }
157 }
158
159 void printError(int status){
160     switch(status)
161     {
162     case COMM_TXFAIL:
163
164         printf("COMM_TXFAIL: Failed transmit instruction packet!\n");
165         break;
166
167     case COMM_TXERROR:
168         printf("COMM_TXERROR: Incorrect instruction packet!\n");
169         break;
170
171     case COMM_RXFAIL:
172         printf("COMM_RXFAIL: Failed get status packet from device!\n");
173         break;
174
175     case COMM_RXWAITING:
176         printf("COMM_RXWAITING: Now recieving status packet!\n");
177         break;
178
179     case COMM_RXTIMEOUT:
180         printf("COMM_RXTIMEOUT: There is no status packet!\n");
181         break;
182
183     case COMM_RXCORRUPT:
184         printf("COMM_RXCORRUPT: Incorrect status packet!\n");
185         break;
186
187     default:
188         printf("This is unknown error code!\n");
189         break;
190     }
191 }

```

src/motor.cpp

2.5 manipulator.h

```

1  #ifndef MANIPULATOR_H
2  #define MANIPULATOR_H
3
4  #include "motor.h"
5  #include <pthread.h>
6
7  #define PI 3.14159265
8
9  #define XSTART 0
10 #define YSTART 155
11 #define ZSTART 77
12
13 class Manipulator{
14 public:
15     Manipulator(int IDOne ,int IDTwo,int IDThree, int IDGrip-left, int IDGrip-right )
16     {
17         one(IDOne, SERVOMODE), two(IDTwo, SERVOMODE), three(IDThree, SERVOMODE),
18         grip-left(IDGrip-left, SERVOMODE), grip-right(IDGrip-right, SERVOMODE) {theta1 =
19         0; theta2 = 0; theta3 = 0; mode = IDLE_MODE;};
20     void goToPosition(int, int, int);
21     void setAngles(float, float, float);
22     void setGripper(bool);
23     void drawLine(int, int, int, int, int);
24     void drawCircle(int, int, int, int, float, float);
25     void setMode(int);
26     int getMode();
27     void startPing();
28 private:
29     float theta1;
30     float theta2;
31     float theta3;
32     int mode;
33     Motor one;
34     Motor two;
35     Motor three;
36     Motor grip-left;

```

```

35 | Motor grip_right;
36 | pthread_t thread;
37 | static void * staticEntryPoint(void * c);
38 | void ping();
39 | };
40 |
41 | #endif

```

include/manipulator.h

2.6 manipulator.cpp

```

1 | #include <stdio.h>
2 | #include <unistd.h>
3 | #include <math.h>
4 | #include "manipulator.h"
5 |
6 | using namespace std;
7 |
8 | #define D2 77 //length of first arm in mm
9 | #define D3 155 //length of second arm in mm
10 |
11 | #define ANGLE_TO_VALUE (float)511*6/(5*PI)
12 |
13 | #define GRIPPER_LEFT_ZERO 511-140
14 | #define GRIPPER_RIGHT_ZERO 511+140
15 | #define MAX_COUNT 5
16 |
17 | pthread_mutex_t mutex_man = PTHREAD_MUTEX_INITIALIZER;
18 |
19 | void Manipulator::goToPosition(int x, int y, int z){
20 |
21 |     //return error if beyond max
22 |     // if ((x*x+y*y+z*z) > (D2+D3)*(D2+D3))
23 |     // {
24 |     //     printf("invalid position!\n");
25 |     //     return;
26 |     // }
27 |
28 |     if(getMode() == FAILSAFE_MODE)
29 |         return;
30 |
31 |     float s3, c3, l;
32 |
33 |     l = sqrt(x*x+y*y);
34 |     c3 = (z*z + l*l - D2*D2 - D3*D3)/(2*D2*D3);
35 |     s3 = sqrt(1-c3*c3);
36 |
37 |     theta3 = atan2(s3,c3);
38 |     theta2 = PI/2 - atan2(D3*s3, D2+D3*c3)-atan2(z,l);
39 |     theta1 = atan2(x,y);
40 |
41 |     setAngles(theta1, theta2, theta3);
42 | }
43 |
44 | void Manipulator::setAngles(float t1, float t2, float t3){
45 |
46 |     if(getMode() == FAILSAFE_MODE)
47 |         return;
48 |
49 |     try{
50 |         int dummy;
51 |
52 |         if(t1 != t1)
53 |             printf("nan theta 1\n");
54 |         else if(t1 > 5*PI/6){
55 |             one.setGoalPosition(1023);
56 |             printf("Theta 1 too high\n");
57 |         }
58 |         else if(t1 < -5*PI/6){
59 |             one.setGoalPosition(0);
60 |             printf("Theta 1 too low\n");
61 |         }
62 |         else{
63 |             dummy = (float)(t1*ANGLE_TO_VALUE+511);
64 |             one.setGoalPosition(dummy);
65 |             //printf("one: %d\n",dummy);
66 |         }
67 |
68 |         if(t2 != t2)
69 |             printf("nan theta 2\n");
70 |         else if(t2 > 5*PI/6){
71 |             two.setGoalPosition(1023);

```

```

72     printf("Theta 2 too high\n");
73 }
74 else if(t2 < 0){
75     two.setGoalPosition(511);
76     printf("Theta 2 too low\n");
77 }
78 else{
79     dummy = (float)(t2*ANGLE_TO_VALUE+511);
80     two.setGoalPosition(dummy);
81     //printf("two: %d\n",dummy);
82 }
83
84 if(t3 != t3)
85     printf("nan theta 3\n");
86 else if(t3 > 0.78*PI){
87     three.setGoalPosition(989);
88     printf("Theta 3 too high\n");
89 }
90 else if(t3 < -0.5*PI){
91     three.setGoalPosition(51);
92     printf("Theta 3 too low\n");
93 }
94 else{
95     dummy = (float)(t3*ANGLE_TO_VALUE+511);
96     three.setGoalPosition(dummy);
97     //printf("three: %d\n",dummy);
98 }
99 }
100 catch(MotorException e) {
101     printf("ID: %d lost\n",e.ID);
102     printError(e.status);
103     setMode(FAILSAFE.MODE);
104     printf("Manipulator lost!\n");
105     startPing();
106 }
107 }
108
109 void Manipulator::setGripper(bool on){
110
111     if(getMode() == FAILSAFE.MODE)
112         return;
113
114     try{
115         if(!on){
116             grip_left.setGoalPosition(511-50);
117             grip_right.setGoalPosition(511+50);
118             return;
119         }
120
121         int positionL, positionR, lastPositionL, lastPositionR;
122         int counter = 0;
123         //put servo set point to zero degrees
124         grip_left.setGoalPosition(GRIPPER.LEFT.ZERO);
125         grip_right.setGoalPosition(GRIPPER.RIGHT.ZERO);
126         lastPositionR = grip_right.getPosition();
127         lastPositionL = grip_left.getPosition();
128         while(1){
129             positionL = grip_left.getPosition();
130             positionR = grip_right.getPosition();
131             printf("left: %d\tright: %d\n",positionL,positionR);
132
133             if(lastPositionL == positionL || lastPositionR == positionR)
134                 counter++;
135             else
136                 counter = 0;
137             if(counter == MAX.COUNT)
138                 return;
139             lastPositionL = positionL;
140             lastPositionR = positionR;
141             usleep(10000);
142         }
143     }
144     catch(MotorException e) {
145         printf("ID: %d lost\n",e.ID);
146         printError(e.status);
147         setMode(FAILSAFE.MODE);
148         printf("Manipulator lost!\n");
149         startPing();
150     }
151 }
152
153 void Manipulator::drawLine(int xstart, int ystart, int xend, int yend, int z){
154
155     if(getMode() == FAILSAFE.MODE)
156         return;
157
158     try{
159         goToPosition(xstart, ystart, z+50);
160         sleep(1);
161         goToPosition(xstart, ystart, z);
162         usleep(100000);

```

```

163     int x = xend-xstart;
164     int y = yend-ystart;
165     int length = sqrt(x*x+y*y);
166     x /= length; //normalize
167     y /= length; //normalize
168     for(int i = 0; i<length; i++){
169         printf("x: %d\ty: %d\n",xstart+i*x, ystart+i*y);
170         goToPosition(xstart+i*x, ystart+i*y, z);
171         usleep(10000);
172     }
173 }
174 catch(MotorException e) {
175     printf("ID: %d lost\n",e.ID);
176     printError(e.status);
177     setMode(FAILSAFE.MODE);
178     printf("Manipulator lost!\n");
179     startPing();
180 }
181 }
182
183 void Manipulator::drawCircle(int xcenter, int ycenter, int z, int radius, float
    startAngle, float endAngle){
184
185     if(getMode() == FAILSAFE.MODE)
186         return;
187
188     try{
189         float t = startAngle;
190         float stepSize = 0.01;
191         while(t <= endAngle){
192             goToPosition(radius*sin(t) + xcenter, radius*cos(t) + ycenter, z);
193             t += stepSize;
194             usleep(10000);
195         }
196     }
197     catch(MotorException e) {
198         printf("ID: %d lost\n",e.ID);
199         printError(e.status);
200         setMode(FAILSAFE.MODE);
201         printf("Manipulator lost!\n");
202         startPing();
203     }
204 }
205
206 void Manipulator::setMode(int theMode){
207     pthread_mutex_lock( &mutex_man );
208     mode = theMode;
209     pthread_mutex_unlock( &mutex_man );
210 }
211
212 int Manipulator::getMode(){
213     pthread_mutex_lock( &mutex_man );
214     int temp = mode;
215     pthread_mutex_unlock( &mutex_man );
216     return temp;
217 }
218
219 void Manipulator::ping(){
220     printf("Ping Manipulators\n");
221     while(1){
222         int count = 0;
223         count += one.ping();
224         count += two.ping();
225         count += three.ping();
226         count += grip_left.ping();
227         count += grip_right.ping();
228
229         if(count == 5){
230             printf("All manipulator motors active!\n");
231             setMode(IDLE.MODE);
232             //printf("Returning to start position\n");
233             //goToPosition(XSTART,YSTART,ZSTART);
234             //setGripper(0);
235             return;
236         }
237     }
238 }
239
240 void Manipulator::startPing(){
241     pthread_create(&thread, NULL, Manipulator::staticEntryPoint, this);
242 }
243
244 void * Manipulator::staticEntryPoint(void * c)
245 {
246     ((Manipulator *) c)->ping();
247     return NULL;
248 }
249

```

 src/manipulator.cpp

2.7 sensor.h

```

1  #ifndef SENSOR_H_
2  #define SENSOR_H_
3
4  #include <dynamixel.h>
5
6  //control table address
7  #define IR_LEFT_FIRE_DATA 26
8  #define IR_CENTER_FIRE_DATA 27
9  #define IR_RIGHT_FIRE_DATA 28
10 #define LIGHT_LEFT_DATA 29
11 #define LIGHT_CENTER_DATA 30
12 #define LIGHT_RIGHT_DATA 31
13 #define IR_OBSTACLE_DETECTED 32
14 #define LIGHT_DETECTED 33
15 #define SOUND_DATA 35
16 #define BUZZER_DATA_NOTE 40
17 #define BUZZER_DATA_TIME 41
18
19 #define LEFT 0
20 #define CENTER 1
21 #define RIGHT 2
22
23 /*melody:
24 0: Rising
25 1: Falling
26 2: Fight
27 4: Fail
28 5: sad
29 6: bip bip
30 7: sad 2
31 10: whistle rise
32 11: bip bop
33 15: bip bip 2
34 16: phone
35 21: whistle
36 24: rtrtrtrrt
37 */
38
39 class Sensor{
40 public:
41   Sensor(int);
42   int getIR(int);
43   int getLight(int); //only infrared light
44   void playMelody(int); //input range 0-26
45   void playMelody(unsigned char*, int); //play from arrays in songs.h
46   void ping();
47   void setMode(int);
48   int getMode();
49 private:
50   int ID;
51   int commStatus;
52   int mode;
53 };
54
55 #endif

```

include/sensor.h

2.8 sensor.cpp

```

1  #include "motor.h"
2  #include "sensor.h"
3  #include "stdio.h"
4  #include <unistd.h>
5  #include "communication.h"
6
7  Sensor::Sensor(int theID){
8    ID = theID;
9    commStatus = COMM_RXSUCCESS;

```



```

10 |     mode = IDLE_MODE;
11 | }
12 |
13 | int Sensor::getLight(int pos){
14 |
15 |     int data = readByte( ID, LIGHT_LEFT.DATA + pos );
16 |     commStatus = getResult();
17 |     if(commStatus != COMM_RXSUCCESS)
18 |     {
19 |         mode = FAILSAFE_MODE;
20 |         printf("sensor lost\n");
21 |     }
22 |     return data;
23 | }
24 |
25 | int Sensor::getIR(int pos){
26 |
27 |     int data = readByte( ID, IR_LEFT.FIRE.DATA + pos );
28 |     commStatus = getResult();
29 |     if(commStatus != COMM_RXSUCCESS)
30 |     {
31 |         mode = FAILSAFE_MODE;
32 |         printf("sensor lost\n");
33 |     }
34 |
35 |     return data;
36 | }
37 |
38 |
39 | void Sensor::playMelody(int song){
40 |
41 |     if(song < 0 || song > 26){
42 |         printf("invalid input\n");
43 |         return;
44 |     }
45 |     writeByte(ID, BUZZER.DATA.TIME, 255);
46 |     commStatus = getResult();
47 |     if(commStatus != COMM_RXSUCCESS)
48 |     {
49 |         mode = FAILSAFE_MODE;
50 |         printf("sensor lost\n");
51 |     }
52 |     writeByte(ID, BUZZER.DATA.NOTE, song);
53 |     commStatus = getResult();
54 |     if(commStatus != COMM_RXSUCCESS)
55 |     {
56 |         mode = FAILSAFE_MODE;
57 |         printf("sensor lost\n");
58 |     }
59 | }
60 |
61 | void Sensor::playMelody(unsigned char* song, int length){
62 |
63 |
64 |     for(int i = 0; i<length; i+=2)
65 |     {
66 |
67 |         if(song[i+1] != 100)
68 |         {
69 |             writeByte(ID, BUZZER.DATA.TIME, 254);
70 |             writeByte(ID, BUZZER.DATA.NOTE, song[i+1]);
71 |             usleep(40000*song[i]);
72 |         }
73 |         else
74 |         {
75 |             writeByte(ID, BUZZER.DATA.TIME, 0);
76 |             usleep(40000*song[i]);
77 |         }
78 |     }
79 |
80 | }
81 | writeByte(ID, BUZZER.DATA.TIME, 0);
82 |
83 | }
84 |
85 |
86 | void Sensor::ping(){
87 |     pingID(ID);
88 |     commStatus = getResult();
89 |     if( commStatus == COMM_RXSUCCESS )
90 |     {
91 |         printf("Sensor ID: %d active!\n",ID);
92 |         setMode(IDLE_MODE);
93 |     }
94 |     else{
95 |         setMode(FAILSAFE_MODE);
96 |     }
97 | }
98 |
99 | void Sensor::setMode(int theMode){
100 |     mode = theMode;

```

```

101 }
102
103 int Sensor::getMode() {
104     return mode;
105 }

```

src/sensor.cpp

2.9 interface.h

```

1 #ifndef INTERFACE_H_
2 #define INTERFACE_H_
3
4 #include "manipulator.h"
5 #include "car.h"
6
7 void windowInit();
8 void checkEvent(Manipulator *, Car *);
9
10 #endif

```

include/interface.h

2.10 interface.cpp

```

1 #include <X11/Xlib.h>
2 #include <X11/Xutil.h>
3 #include <stdio.h>
4 #include <stdlib.h>
5 #include "interface.h"
6 #include "manipulator.h"
7
8 #define KEYMASK ButtonPressMask | KeyPressMask | KeyReleaseMask | ButtonReleaseMask
9 | PointerMotionMask
10
11 #define FORWARD 25
12 #define BACKWARD 39
13 #define LEFT 38
14 #define RIGHT 40
15
16 #define LEFT_MOUSE_BUTTON 1
17 #define RIGHT_MOUSE_BUTTON 3
18 #define MOUSE_WHEEL 2
19 #define MOUSE_WHEEL_FORWARD 4
20 #define MOUSE_WHEEL_BACKWARD 5
21
22 Display *display;
23 Window window;
24 XEvent event;
25 bool button = 0;
26 bool buttonR = 0;
27 int xpos = XSTART;
28 int ypos = YSTART;
29 int zpos = ZSTART;
30 int xzero = 0;
31 int yzero = 0;
32
33 void windowInit()
34 {
35     int s;
36     /* open connection with the server */
37     display = XOpenDisplay(NULL);
38     if (display == NULL)
39     {
40         fprintf(stderr, "Cannot open display\n");
41         exit(1);
42     }
43     s = DefaultScreen(display);
44
45     /* create window */
46     window = XCreateSimpleWindow(display, RootWindow(display, s), 10, 10, 500, 500,
47         1,
48         BlackPixel(display, s), WhitePixel(display, s));

```

```

49  /* select kind of events we are interested in */
50  XSelectInput(display, window, KEYMASK);
51
52  /* map (show) the window */
53  XMapWindow(display, window);
54
55  //do not detect autorepeating events from keyboard
56  XAutoRepeatOff(display);
57  printf("Display open\n");
58 }
59 void checkEvent(Manipulator *man, Car *car){
60     XNextEvent(display, & event);
61     switch(event.type){
62     case MotionNotify:
63         if (button){
64             xpos = event.xmotion.x - xzero;
65             ypos = event.xmotion.y - yzero;
66             xzero = event.xmotion.x;
67             yzero = event.xmotion.y;
68             //printf("xpos: %d\t ypos: %d\n", xpos, ypos);
69             man->goToPosition(xpos, ypos, zpos);
70         }
71         break;
72     case ButtonPress:
73         if (event.xkey.keycode == LEFT_MOUSE_BUTTON)
74         {
75             button = 1;
76             xzero = event.xbutton.x;
77             yzero = event.xbutton.y;
78         }
79         if (event.xkey.keycode == RIGHT_MOUSE_BUTTON)
80         {
81             buttonR ^= 1;
82             man->setGripper(buttonR);
83         }
84         if (event.xkey.keycode == MOUSE_WHEEL_FORWARD)
85         {
86             zpos -= 10;
87             man->goToPosition(xpos, ypos, zpos);
88         }
89         if (event.xkey.keycode == MOUSE_WHEEL_BACKWARD)
90         {
91             zpos += 10;
92             man->goToPosition(xpos, ypos, zpos);
93         }
94
95         printf("KeyPress: %d\n", event.xkey.keycode);
96         break;
97     case ButtonRelease:
98         if (event.xkey.keycode == LEFT_MOUSE_BUTTON)
99             button = 0;
100         break;
101     case KeyPress:
102         //printf("KeyPress: %d\n", e.xkey.keycode);
103         switch(event.xkey.keycode){
104             case FORWARD:
105                 printf("forward\n");
106                 car->setSpeed(1023, 1);
107                 break;
108             case BACKWARD:
109                 car->setSpeed(1023, 0);
110                 printf("backward\n");
111                 break;
112             case RIGHT:
113                 car->turnCar(RIGHT_TURN);
114                 printf("right\n");
115                 break;
116             case LEFT:
117                 car->turnCar(LEFT_TURN);
118                 printf("left\n");
119                 break;
120             default:
121                 printf("unknown:%d\n", event.xkey.keycode);
122         }
123         break;
124     case KeyRelease:
125         //printf("KeyRelease: %d\n", e.xkey.keycode);
126         switch(event.xkey.keycode){
127             case FORWARD:
128                 car->setSpeed(0, 1);
129                 printf("forward released\n");
130                 break;
131             case BACKWARD:
132                 car->setSpeed(0, 1);
133                 printf("backward released\n");
134                 break;
135             case RIGHT:
136                 car->turnCar(NO_TURN);
137                 printf("right released\n");
138                 break;
139             case LEFT:

```

src/interface.cpp

2.11 dynamixel.h

[illegible]

```

70 int dxl_read_byte(int id, int address);
71 void dxl_write_byte(int id, int address, int value);
72 int dxl_read_word(int id, int address);
73 void dxl_write_word(int id, int address, int value);
74
75 #ifdef __cplusplus
76 }
77 #endif
78
79
80 #endif

```

include/dynamixel.h

2.12 dynamixel.c

```

1  #include "dxl_hal.h"
2  #include "dynamixel.h"
3
4  #define ID (2)
5  #define LENGTH (3)
6  #define INSTRUCTION (4)
7  #define ERBIT (4)
8  #define PARAMETER (5)
9  #define DEFAULT_BAUDNUMBER (1)
10
11 unsigned char gbInstructionPacket[MAXNUM_TXPARAM+10] = {0};
12 unsigned char gbStatusPacket[MAXNUM_RXPARAM+10] = {0};
13 unsigned char gbRxPacketLength = 0;
14 unsigned char gbRxGetLength = 0;
15 int gbCommStatus = COMM_RXSUCCESS;
16 int giBusUsing = 0;
17
18
19 int dxl_initialize(int deviceIndex, int baudnum)
20 {
21     float baudrate;
22     baudrate = 2000000.0f / (float)(baudnum + 1);
23
24     if (dxl_hal_open(deviceIndex, baudrate) == 0)
25         return 0;
26
27     gbCommStatus = COMM_RXSUCCESS;
28     giBusUsing = 0;
29     return 1;
30 }
31
32 void dxl_terminate(void)
33 {
34     dxl_hal_close();
35 }
36
37 void dxl_tx_packet(void)
38 {
39     unsigned char i;
40     unsigned char TxNumByte, RealTxNumByte;
41     unsigned char checksum = 0;
42
43     if (giBusUsing == 1)
44         return;
45
46     giBusUsing = 1;
47
48     if (gbInstructionPacket[LENGTH] > (MAXNUM_TXPARAM+2))
49     {
50         gbCommStatus = COMM_TXERROR;
51         giBusUsing = 0;
52         return;
53     }
54
55     if (gbInstructionPacket[INSTRUCTION] != INST_PING
56         && gbInstructionPacket[INSTRUCTION] != INST_READ
57         && gbInstructionPacket[INSTRUCTION] != INST_WRITE
58         && gbInstructionPacket[INSTRUCTION] != INST_REG_WRITE
59         && gbInstructionPacket[INSTRUCTION] != INST_ACTION
60         && gbInstructionPacket[INSTRUCTION] != INST_RESET
61         && gbInstructionPacket[INSTRUCTION] != INST_SYNC_WRITE )
62     {
63         gbCommStatus = COMM_TXERROR;
64         giBusUsing = 0;
65         return;
66     }
67

```

```

68 | gbInstructionPacket[0] = 0xff;
69 | gbInstructionPacket[1] = 0xff;
70 | for( i=0; i<(gbInstructionPacket[LENGTH]+1); i++ )
71 |     checksum += gbInstructionPacket[i+2];
72 | gbInstructionPacket[gbInstructionPacket[LENGTH]+3] = ~checksum;
73 |
74 | if( gbCommStatus == COMM_RXTIMEOUT || gbCommStatus == COMM_RXCORRUPT )
75 |     dxl_hal_clear();
76 |
77 | TxNumByte = gbInstructionPacket[LENGTH] + 4;
78 | RealTxNumByte = dxl_hal_tx( (unsigned char*)gbInstructionPacket, TxNumByte );
79 |
80 | if( TxNumByte != RealTxNumByte )
81 | {
82 |     gbCommStatus = COMM_TXFAIL;
83 |     giBusUsing = 0;
84 |     return;
85 | }
86 |
87 | if( gbInstructionPacket[INSTRUCTION] == INST_READ )
88 |     dxl_hal_set_timeout( gbInstructionPacket[PARAMETER+1] + 6 );
89 | else
90 |     dxl_hal_set_timeout( 6 );
91 |
92 | gbCommStatus = COMM_TXSUCCESS;
93 | }
94 |
95 | void dxl_rx_packet(void)
96 | {
97 |     unsigned char i, j, nRead;
98 |     unsigned char checksum = 0;
99 |
100 |    if( giBusUsing == 0 )
101 |        return;
102 |
103 |    if( gbInstructionPacket[ID] == BROADCAST_ID )
104 |    {
105 |        gbCommStatus = COMM_RXSUCCESS;
106 |        giBusUsing = 0;
107 |        return;
108 |    }
109 |
110 |    if( gbCommStatus == COMM_TXSUCCESS )
111 |    {
112 |        gbRxGetLength = 0;
113 |        gbRxPacketLength = 6;
114 |    }
115 |
116 |    nRead = dxl_hal_rx( (unsigned char*)&gbStatusPacket[gbRxGetLength],
117 |                      gbRxPacketLength - gbRxGetLength );
118 |    gbRxGetLength += nRead;
119 |    if( gbRxGetLength < gbRxPacketLength )
120 |    {
121 |        if( dxl_hal_timeout() == 1 )
122 |        {
123 |            if( gbRxGetLength == 0 )
124 |                gbCommStatus = COMM_RXTIMEOUT;
125 |            else
126 |                gbCommStatus = COMM_RXCORRUPT;
127 |            giBusUsing = 0;
128 |            return;
129 |        }
130 |    }
131 |
132 |    // Find packet header
133 |    for( i=0; i<(gbRxGetLength-1); i++ )
134 |    {
135 |        if( gbStatusPacket[i] == 0xff && gbStatusPacket[i+1] == 0xff )
136 |        {
137 |            break;
138 |        }
139 |        else if( i == gbRxGetLength-2 && gbStatusPacket[gbRxGetLength-1] == 0xff )
140 |        {
141 |            break;
142 |        }
143 |    }
144 |    if( i > 0 )
145 |    {
146 |        for( j=0; j<(gbRxGetLength-i); j++ )
147 |            gbStatusPacket[j] = gbStatusPacket[j + i];
148 |        gbRxGetLength -= i;
149 |    }
150 |
151 |    if( gbRxGetLength < gbRxPacketLength )
152 |    {
153 |        gbCommStatus = COMM_RXWAITING;
154 |        return;
155 |    }
156 |
157 |    // Check id pairing

```

```

158 | if( gbInstructionPacket[ID] != gbStatusPacket[ID])
159 | {
160 |     gbCommStatus = COMMLRXCORRUPT;
161 |     giBusUsing = 0;
162 |     return;
163 | }
164 |
165 | gbRxPacketLength = gbStatusPacket[LENGTH] + 4;
166 | if( gbRxGetLength < gbRxPacketLength )
167 | {
168 |     nRead = dxl_hal_rx( (unsigned char*)&gbStatusPacket[gbRxGetLength],
169 |         gbRxPacketLength - gbRxGetLength );
170 |     gbRxGetLength += nRead;
171 |     if( gbRxGetLength < gbRxPacketLength )
172 |     {
173 |         gbCommStatus = COMMLRXWAITING;
174 |         return;
175 |     }
176 | }
177 | // Check checksum
178 | for( i=0; i<(gbStatusPacket[LENGTH]+1); i++ )
179 |     checksum += gbStatusPacket[i+2];
180 | checksum = ~checksum;
181 |
182 | if( gbStatusPacket[gbStatusPacket[LENGTH]+3] != checksum )
183 | {
184 |     gbCommStatus = COMMLRXCORRUPT;
185 |     giBusUsing = 0;
186 |     return;
187 | }
188 |
189 | gbCommStatus = COMMLRXSUCCESS;
190 | giBusUsing = 0;
191 | }
192 |
193 | void dxl_txrx_packet(void)
194 | {
195 |     dxl_tx_packet();
196 |
197 |     if( gbCommStatus != COMM_TXSUCCESS )
198 |         return;
199 |
200 |     do{
201 |         dxl_rx_packet();
202 |     }while( gbCommStatus == COMMLRXWAITING );
203 | }
204 |
205 | int dxl_get_result(void)
206 | {
207 |     return gbCommStatus;
208 | }
209 |
210 | void dxl_set_txpacket_id( int id )
211 | {
212 |     gbInstructionPacket[ID] = (unsigned char)id;
213 | }
214 |
215 | void dxl_set_txpacket_instruction( int instruction )
216 | {
217 |     gbInstructionPacket[INSTRUCTION] = (unsigned char)instruction;
218 | }
219 |
220 | void dxl_set_txpacket_parameter( int index, int value )
221 | {
222 |     gbInstructionPacket[PARAMETER+index] = (unsigned char)value;
223 | }
224 |
225 | void dxl_set_txpacket_length( int length )
226 | {
227 |     gbInstructionPacket[LENGTH] = (unsigned char)length;
228 | }
229 |
230 | int dxl_get_rxpacket_error( int errbit )
231 | {
232 |     if( gbStatusPacket[ERRBIT] & (unsigned char)errbit )
233 |         return 1;
234 |
235 |     return 0;
236 | }
237 |
238 | int dxl_get_rxpacket_length(void)
239 | {
240 |     return (int)gbStatusPacket[LENGTH];
241 | }
242 |
243 | int dxl_get_rxpacket_parameter( int index )
244 | {
245 |     return (int)gbStatusPacket[PARAMETER+index];
246 | }
247 |

```

```

248 int dxl_makeword( int lowbyte, int highbyte )
249 {
250     unsigned short word;
251
252     word = highbyte;
253     word = word << 8;
254     word = word + lowbyte;
255     return (int)word;
256 }
257
258 int dxl_get_lowbyte( int word )
259 {
260     unsigned short temp;
261
262     temp = word & 0xff;
263     return (int)temp;
264 }
265
266 int dxl_get_highbyte( int word )
267 {
268     unsigned short temp;
269
270     temp = word & 0xff00;
271     temp = temp >> 8;
272     return (int)temp;
273 }
274
275 void dxl_ping( int id )
276 {
277     while(giBusUsing);
278
279     gbInstructionPacket[ID] = (unsigned char)id;
280     gbInstructionPacket[INSTRUCTION] = INST_PING;
281     gbInstructionPacket[LENGTH] = 2;
282
283     dxl_txrx_packet();
284 }
285
286 int dxl_read_byte( int id, int address )
287 {
288     while(giBusUsing);
289
290     gbInstructionPacket[ID] = (unsigned char)id;
291     gbInstructionPacket[INSTRUCTION] = INST_READ;
292     gbInstructionPacket[PARAMETER] = (unsigned char)address;
293     gbInstructionPacket[PARAMETER+1] = 1;
294     gbInstructionPacket[LENGTH] = 4;
295
296     dxl_txrx_packet();
297
298     return (int)gbStatusPacket[PARAMETER];
299 }
300
301 void dxl_write_byte( int id, int address, int value )
302 {
303     while(giBusUsing);
304
305     gbInstructionPacket[ID] = (unsigned char)id;
306     gbInstructionPacket[INSTRUCTION] = INST_WRITE;
307     gbInstructionPacket[PARAMETER] = (unsigned char)address;
308     gbInstructionPacket[PARAMETER+1] = (unsigned char)value;
309     gbInstructionPacket[LENGTH] = 4;
310
311     dxl_txrx_packet();
312 }
313
314 int dxl_read_word( int id, int address )
315 {
316     while(giBusUsing);
317
318     gbInstructionPacket[ID] = (unsigned char)id;
319     gbInstructionPacket[INSTRUCTION] = INST_READ;
320     gbInstructionPacket[PARAMETER] = (unsigned char)address;
321     gbInstructionPacket[PARAMETER+1] = 2;
322     gbInstructionPacket[LENGTH] = 4;
323
324     dxl_txrx_packet();
325
326     return dxl_makeword((int)gbStatusPacket[PARAMETER], (int)gbStatusPacket[PARAMETER
327         +1]);
328 }
329
330 void dxl_write_word( int id, int address, int value )
331 {
332     while(giBusUsing);
333
334     gbInstructionPacket[ID] = (unsigned char)id;
335     gbInstructionPacket[INSTRUCTION] = INST_WRITE;
336     gbInstructionPacket[PARAMETER] = (unsigned char)address;
337     gbInstructionPacket[PARAMETER+1] = (unsigned char)dxl_get_lowbyte(value);
338     gbInstructionPacket[PARAMETER+2] = (unsigned char)dxl_get_highbyte(value);

```



```

338 |     gbInstructionPacket[LENGTH] = 5;
339 |
340 |     dxl_txrx_packet();
341 | }

```

src/dynamixel.c

2.13 dxl_hal.h

```

1  #ifndef _DYNAMIXEL_HAL_HEADER
2  #define _DYNAMIXEL_HAL_HEADER
3
4
5  #ifdef __cplusplus
6  extern "C" {
7  #endif
8
9
10 int dxl_hal_open(int deviceIndex, float baudrate);
11 void dxl_hal_close();
12 int dxl_hal_set_baud(float baudrate);
13 void dxl_hal_clear();
14 int dxl_hal_tx(unsigned char *pPacket, int numPacket);
15 int dxl_hal_rx(unsigned char *pPacket, int numPacket);
16 void dxl_hal_set_timeout(int NumRcvByte);
17 int dxl_hal_timeout();
18
19
20
21 #ifdef __cplusplus
22 }
23 #endif
24
25 #endif

```

src/dxl_hal.h

2.14 dxl_hal.c

```

1  #include <stdio.h>
2  #include <string.h>
3  #include <unistd.h>
4  #include <fcntl.h>
5  #include <termios.h>
6  #include <linux/serial.h>
7  #include <sys/ioctl.h>
8  #include <sys/time.h>
9
10 #include "dxl_hal.h"
11
12 int gSocket_fd = -1;
13 long glStartTime = 0;
14 float gfRcvWaitTime = 0.0f;
15 float gfByteTransTime = 0.0f;
16
17 char gDeviceName[20];
18
19 int dxl_hal_open(int deviceIndex, float baudrate)
20 {
21     struct termios newtio;
22     struct serial_struct serinfo;
23     char dev_name[100] = {0, };
24
25     sprintf(dev_name, "/dev/ttyUSB%d", deviceIndex);
26
27     strcpy(gDeviceName, dev_name);
28     memset(&newtio, 0, sizeof(newtio));
29     dxl_hal_close();
30
31     if((gSocket_fd = open(gDeviceName, O_RDWR|O_NOCTTY|O_NONBLOCK)) < 0) {
32         fprintf(stderr, "device open error: %s\n", dev_name);
33         goto DXL_HAL_OPEN_ERROR;
34     }
35
36     newtio.c_cflag = B38400|CS8|CLOCAL|CREAD;

```

```

37 newtio.c_iflag = IGNPAR;
38 newtio.c_oflag = 0;
39 newtio.c_lflag = 0;
40 newtio.c_cc[VTIME] = 0; // time-out (TIME * 0.1 ) 0 : disable
41 newtio.c_cc[VMIN] = 0; // MIN read return

42
43 tcflush(gSocket_fd, TCIFLUSH);
44 tcsetattr(gSocket_fd, TCSANOW, &newtio);
45
46 if(gSocket_fd == -1)
47     return 0;
48
49 if(ioctl(gSocket_fd, TIOCGSERIAL, &serinfo) < 0) {
50     fprintf(stderr, "Cannot get serial info\n");
51     return 0;
52 }
53
54 serinfo.flags &= ~ASYNC_SPD_MASK;
55 serinfo.flags |= ASYNC_SPD_CUST;
56 serinfo.custom_divisor = serinfo.baud_base / baudrate;
57
58 if(ioctl(gSocket_fd, TIOCSSERIAL, &serinfo) < 0) {
59     fprintf(stderr, "Cannot set serial info\n");
60     return 0;
61 }
62
63 dxl_hal_close();
64
65 gfByteTransTime = (float)((1000.0f / baudrate) * 12.0f);
66
67 strcpy(gDeviceName, dev_name);
68 memset(&newtio, 0, sizeof(newtio));
69 dxl_hal_close();
70
71 if((gSocket_fd = open(gDeviceName, O_RDWR|O_NOCTTY|O_NONBLOCK)) < 0) {
72     fprintf(stderr, "device open error: %s\n", dev_name);
73     goto DXL_HAL_OPEN_ERROR;
74 }
75
76 newtio.c_cflag = B38400|CS8|CLOCAL|CREAD;
77 newtio.c_iflag = IGNPAR;
78 newtio.c_oflag = 0;
79 newtio.c_lflag = 0;
80 newtio.c_cc[VTIME] = 0; // time-out (TIME * 0.1 ) 0 : disable
81 newtio.c_cc[VMIN] = 0; // MIN read return

82
83 tcflush(gSocket_fd, TCIFLUSH);
84 tcsetattr(gSocket_fd, TCSANOW, &newtio);
85
86 return 1;
87
88 DXL_HAL_OPEN_ERROR:
89 dxl_hal_close();
90 return 0;
91 }
92
93 void dxl_hal_close()
94 {
95     if(gSocket_fd != -1)
96         close(gSocket_fd);
97     gSocket_fd = -1;
98 }
99
100 int dxl_hal_set_baud( float baudrate )
101 {
102     struct serial_struct serinfo;
103
104     if(gSocket_fd == -1)
105         return 0;
106
107     if(ioctl(gSocket_fd, TIOCGSERIAL, &serinfo) < 0) {
108         fprintf(stderr, "Cannot get serial info\n");
109         return 0;
110     }
111
112     serinfo.flags &= ~ASYNC_SPD_MASK;
113     serinfo.flags |= ASYNC_SPD_CUST;
114     serinfo.custom_divisor = serinfo.baud_base / baudrate;
115
116     if(ioctl(gSocket_fd, TIOCSSERIAL, &serinfo) < 0) {
117         fprintf(stderr, "Cannot set serial info\n");
118         return 0;
119     }
120
121     //dxl_hal_close();
122     //dxl_hal_open(gDeviceName, baudrate);
123
124     gfByteTransTime = (float)((1000.0f / baudrate) * 12.0f);
125     return 1;

```

```

126 }
127
128 void dxl_hal_clear(void)
129 {
130     tcflush(gSocket_fd, TCIFLUSH);
131 }
132
133 int dxl_hal_tx( unsigned char *pPacket, int numPacket )
134 {
135     return write(gSocket_fd, pPacket, numPacket);
136 }
137
138 int dxl_hal_rx( unsigned char *pPacket, int numPacket )
139 {
140     memset(pPacket, 0, numPacket);
141     return read(gSocket_fd, pPacket, numPacket);
142 }
143
144 static inline long myclock()
145 {
146     struct timeval tv;
147     gettimeofday(&tv, NULL);
148     return (tv.tv-sec * 1000 + tv.tv-usec / 1000);
149 }
150
151 void dxl_hal_set_timeout( int NumRcvByte )
152 {
153     glStartTime = myclock();
154     gfRcvWaitTime = (float)(gfByteTransTime*(float)NumRcvByte + 5.0f);
155 }
156
157 int dxl_hal_timeout(void)
158 {
159     long time;
160
161     time = myclock() - glStartTime;
162
163     if(time > gfRcvWaitTime)
164         return 1;
165     else if(time < 0)
166         glStartTime = myclock();
167     return 0;
168 }
169

```

src/dxl_hal.c

2.15 communication.h

```

1 #ifndef COMMUNICATION_H_
2 #define COMMUNICATION_H_
3
4 int readWord(int, int);
5 int readByte(int, int);
6 int getResult();
7 int getRXpacketError(int);
8 void writeWord(int,int,int);
9 void writeByte(int,int,int);
10 void pingID(int);
11
12 #endif

```

include/communication.h

2.16 communication.cpp

```

1 #include <dynamixel.h>
2 #include <pthread.h>
3
4 //Mutex is used for multiple access from threads
5 //Best way would be to make communication atomic
6 //such that the communication would finish without
7 //being interrupted. That way would could avoid timeout error
8 pthread_mutex_t mutex_comm = PTHREAD_MUTEX_INITIALIZER;
9

```

```

10 int readWord(int id, int address){
11     pthread_mutex_lock( &mutex_comm );
12     int temp = dxl_read_word(id, address);
13     pthread_mutex_unlock( &mutex_comm );
14     return temp;
15 }
16
17 int readByte(int id, int address){
18     pthread_mutex_lock( &mutex_comm );
19     int temp = dxl_read_byte(id, address);
20     pthread_mutex_unlock( &mutex_comm );
21     return temp;
22 }
23
24 int getResult(){
25     pthread_mutex_lock( &mutex_comm );
26     int temp = dxl_get_result();
27     pthread_mutex_unlock( &mutex_comm );
28     return temp;
29 }
30
31 int getRXpacketError(int errbit){
32     pthread_mutex_lock( &mutex_comm );
33     int temp = dxl_get_rxpacket_error(errbit);
34     pthread_mutex_unlock( &mutex_comm );
35     return temp;
36 }
37
38 void writeWord(int id, int address, int value){
39     pthread_mutex_lock( &mutex_comm );
40     dxl_write_word(id, address, value);
41     pthread_mutex_unlock( &mutex_comm );
42 }
43
44 void writeByte(int id, int address, int value){
45     pthread_mutex_lock( &mutex_comm );
46     dxl_write_byte(id, address, value);
47     pthread_mutex_unlock( &mutex_comm );
48 }
49
50 void pingID(int id){
51     pthread_mutex_lock( &mutex_comm );
52     dxl_ping(id);
53     pthread_mutex_unlock( &mutex_comm );
54 }

```

src/communication.cpp

2.17 json_ processing.h

```

1
2 //defines
3 #define BUFFER_SIZE (256 * 1024) /* 256 KB */
4 #define URLFORMAT "https://wodinaz.com/%s"
5 #define URL_SIZE 256
6
7 //includes
8 #include <stdlib.h>
9 #include <string.h>
10 #include <stdio.h>
11 #include <string>
12 #include <vector>
13 #include <map>
14
15 using namespace std;
16
17 //functions
18 void json_test_function();
19 //example code that uses the four basic functions to communicate with the server
20
21 void debug_print_map(map<string, double> mymap);
22 // a debug function used to print maps received from the server
23
24 void debug_print_vector(vector<string> myvector);
25 //debug function used to print vectors
26
27
28 void json_send_data(map<string, double> mymap);
29 // Uploads the provided map of sensor values to the server
30
31 map<string, double> json_get_data(int id);
32 // Downloads sensor data from the server. The user must choose which agent (id) to
   receive from

```

```

33 |
34 | void json_send_command(string cmd,int id);
35 | // Uploads a command to the server.
36 | //The agent with the corresponding id will download this command
37 |
38 | vector<string> json_get_commands(int id);
39 | //Download commands from the server.

```

include/json_processing.h

2.18 json_processing.cpp

```

1 | /*
2 | * Copyright (c) 2009–2013 Petri Lehtinen <petri@digip.org>
3 | *
4 | * Jansson is free software; you can redistribute it and/or modify
5 | * it under the terms of the MIT license. See LICENSE for details.
6 | */
7 |
8 | #include <stdlib.h>
9 | #include <string.h>
10 | #include <stdio.h>
11 |
12 | #include <jansson.h>
13 |
14 | #include "http-functions.h"
15 |
16 | #define BUFFER_SIZE (256 * 1024) /* 256 KB */
17 |
18 | #define URLFORMAT "https://wodinaz.com/%s"
19 | #define URL_SIZE 256
20 | int i=0;
21 |
22 | //URL's
23 | #define PATH.CONNECT "connect"
24 | #define PATH.DATA "data/"
25 | #define PATH.COMMAND "command/"
26 |
27 | //C++ stuff
28 | #include <string>
29 | #include <iostream>
30 | #include <ostream>
31 | #include <sstream>
32 | #include <vector>
33 | #include <map>
34 | using namespace std;
35 |
36 | int myID=0;
37 | int testID=0;
38 |
39 | //functions
40 |
41 |
42 |
43 | void debug_print_map(map<string,double> mymap){
44 |     for (map<string,double>::iterator it=mymap.begin(); it!=mymap.end(); ++it)
45 |     {
46 |         string key = it->first;
47 |         double value = it->second;
48 |         printf ("sensor %s has value %f\n",key.c_str(),value);
49 |     }
50 | }
51 |
52 | void debug_print_vector(vector<string> myvector){
53 |     for (vector<string>::iterator it=myvector.begin(); it!=myvector.end(); ++it)
54 |     {
55 |         string command = *it;
56 |         printf ("command: %s\n",command.c_str());
57 |     }
58 | }
59 |
60 | string convertIntToString(int number)
61 | {
62 |     if (number == 0)
63 |         return "0";
64 |     string temp="";
65 |     string returnvalue="";
66 |     while (number>0)
67 |     {
68 |         temp+=number%10+48;
69 |         number/=10;
70 |     }
71 |     for (int i=0;i<temp.length();i++)

```

```

72         returnvalue+=temp[temp.length()-i-1];
73     return returnvalue;
74 }
75 int convertStringToInt(string inputString){
76     return atoi(inputString.c_str());
77 }
78 double convertStringToDouble(string inputString){
79     stringstream ss(inputString);
80     double result;
81     return ss >> result ? result : 0;
82 }
83
84 string convertDoubleToString(double number){
85     stringstream convert; // stream used for the conversion
86
87     convert << number; // insert the textual representation of 'Number' in the
88                         // characters in the stream
89
90     return convert.str(); // set 'Result' to the contents of the stream
91 }
92
93 map<string, double> json-get-data(int id){
94     printf("starting get-data\n");
95     map<string, double> data_map;
96     int root_length=0;
97     char *text_response;
98     char url[URL_SIZE];
99     string id_path=PATHDATA;
100
101     string id_string = "client_"+convertIntToString(id);
102     id_path.append(id_string);
103     snprintf(url, URL_SIZE, URLFORMAT, id_path.c_str());
104     printf("url:%s\n", url);
105
106     text_response = http-request(url);
107     printf("response:%s\n", text_response);
108     json_t *root;
109     json_error_t error;
110     root = json_loads(text_response, 0, &error);
111     free(text_response);
112
113     if(!root)
114     {
115         fprintf(stderr, "error: on line %d: %s\n", error.line, error.text);
116         throw 202;
117     }
118
119     if(!json_is_array(root))
120     {
121         fprintf(stderr, "error: root is not an object\n");
122         json_decref(root);
123         root_length=1;
124     }
125
126     root_length=json_array_size(root);
127     printf("root_length:%d\n", root_length);
128     //getting the actual data
129     json_t *data, *time_stamp, *entry_id, *sensor, *sensor_value, *device_id;
130     double timeStamp, entryID, sensorValue, deviceID;
131     string sensor_name;
132     for (i=0; i<root_length; i++){ //DEBUG i<root_length
133         data = json_array_get(root, i);
134         if(!json_is_object(data))
135         {
136             fprintf(stderr, "error: commit data %d is not an object\n", i + 1);
137             json_decref(root);
138             throw 202;
139         }
140
141         time_stamp = json_object_get(data, "timestamp");
142         if (!json_is_string(time_stamp)){
143             printf("throwing jsonException\n");
144             throw 202;
145         }
146         else {
147             timeStamp = convertStringToDouble(json_string_value(time_stamp));
148             printf("timeStamp:%f\n", timeStamp);
149         }
150
151         entry_id = json_object_get(data, "id");
152         if (!json_is_string(entry_id)){
153             printf("throwing jsonException\n");
154             throw 202;
155         }
156         else {
157             entryID =convertStringToDouble(json_string_value(entry_id));
158         }
159
160         sensor= json_object_get(data, "sensor");

```

```

162 |         if (!json_is_string(sensor)){
163 |             printf("throwing jsonException\n");
164 |             throw 202;
165 |         }
166 |         else {
167 |             sensor_name = json_string_value(sensor);
168 |             printf("sensor_name:%s\n",sensor_name.c_str() );
169 |         }
170 |
171 |         const char* snsr_name = sensor_name.c_str();
172 |         sensor_value = json_object_get(data,snr_name);
173 |         if (!json_is_string(sensor_value)){
174 |             printf("throwing jsonException at sensor-value\n");
175 |             throw 202;
176 |         }
177 |         else {
178 |             sensorValue= convertStringToDouble(json_string_value(sensor_value));
179 |             printf("sensor_value:%f\n",sensorValue);
180 |         }
181 |
182 |         device_id = json_object_get(data,"device_id");
183 |         if (!json_is_string(device_id)){
184 |             printf("throwing jsonException at device id\n");
185 |             throw 202;
186 |         }
187 |         else {
188 |             deviceID = convertStringToDouble(json_string_value(device_id));
189 |             printf("deviceID:%f\n",deviceID);
190 |         }
191 |         //put stuff in returning map
192 |         data_map[sensor_name]=sensorValue;
193 |     }
194 |     return data_map;
195 | }
196 |
197 | void json_send_data(map<string,double> mymap){
198 |     //printf("starting send_data\n");
199 |
200 |     char url[URL_SIZE];
201 |
202 |
203 |     string id_string = convertIntToString(myID);
204 |     string http_path=PATH_DATA;
205 |     http_path.append("client_"+id_string);
206 |     string sensor_name;
207 |     string key;
208 |     double value;
209 |     string value_string;
210 |     string json_string;
211 |     for (map<string,double>::iterator it=mymap.begin(); it!=mymap.end(); ++it)
212 |     {
213 |         key = it->first;
214 |         value = it->second;
215 |         value_string=convertDoubleToString(value);
216 |         sensor_name=key;
217 |
218 |         string http_path=PATH_DATA;
219 |         http_path.append("client_"+id_string);
220 |         http_path.append("/");
221 |         http_path.append(sensor_name);
222 |         json_string="{ ";
223 |         json_string.append("\n");
224 |
225 |         json_string.append(sensor_name);
226 |         json_string.append("\n");
227 |         json_string.append(": ");
228 |         json_string.append(" ");
229 |         json_string.append("\n"+value_string+"\n"+"}");
230 |         snprintf(url, URL_SIZE, URL_FORMAT, http_path.c_str());
231 |         //printf("url:%s\n",url);
232 |         //printf("json_string:%s\n",json_string.c_str());
233 |
234 |         char *json_cstring = new char[json_string.length() + 1];
235 |         strcpy(json_cstring, json_string.c_str());
236 |         // do stuff
237 |
238 |         http_post(url,json_cstring);
239 |         free(json_cstring);
240 |     }
241 | }
242 |
243 | void json_send_command(string cmd,int id){
244 |     printf("starting send_commands\n");
245 |
246 |     char url[URL_SIZE];
247 |     string command=cmd;
248 |     string http_path=PATH_COMMAND;
249 |     string id_string = convertIntToString(id);
250 |     http_path.append("client_"+id_string);
251 |     string json_string;
252 |     http_path=PATH_COMMAND;

```

```

253     http_path.append("client_"+id_string);
254     json_string="{ ";
255     json_string.append("\n");
256
257     json_string.append("command");
258     json_string.append("\n");
259     json_string.append(":");
260     json_string.append(" ");
261     json_string.append("\n"+command+"\n"+"}");
262     snprintf(url, URL_SIZE, URLFORMAT, http_path.c_str());
263     printf("url:%s\n", url);
264     printf("json_string:%s\n", json_string.c_str());
265
266     char *json_cstring = new char[json_string.length() + 1];
267     strcpy(json_cstring, json_string.c_str());
268     // do stuff
269
270     http_post(url, json_cstring);
271     free(json_cstring);
272 }
273
274 vector<string> json_get_commands(int id){
275     //printf("starting get_commands\n");
276     vector<string> commands_vector;
277     int root_length=0;
278     char *text_response;
279     char url[URL_SIZE];
280     string id_path=PATHCOMMAND;
281
282     string id_string = "client_"+convertIntToString(id);
283     id_path.append(id_string);
284     snprintf(url, URL_SIZE, URLFORMAT, id_path.c_str());
285     //printf("url:%s\n", url);
286
287     text_response = http_request(url);
288     //printf("response:%s\n", text_response);
289     json_t *root;
290     json_error_t error;
291     root = json_loads(text_response, 0, &error);
292     free(text_response);
293
294     if(!root)
295     {
296         fprintf(stderr, "error: on line %d: %s\n", error.line, error.text);
297         throw 202;
298     }
299
300     if(!json_is_array(root))
301     {
302         fprintf(stderr, "error: root is not an array\n");
303         json_decref(root);
304         root_length=1;
305     }
306
307     root_length=json_array_size(root);
308     //printf("root_length:%d\n", root_length );
309     //getting the actual data
310     json_t *data, *time_stamp, *iterator;
311     double timeStamp;
312     string command="";
313     for (i=0;i<root_length;i++){ //DEBUG i<root_length
314         data = json_array_get(root, i);
315         if(!json_is_object(data))
316         {
317             fprintf(stderr, "error: commit data %d is not an object\n", i + 1);
318             json_decref(root);
319             throw 202;
320         }
321
322         time_stamp = json_object_get(data, "timestamp");
323         if (!json_is_string(time_stamp)){
324             printf("throwing jsonException\n");
325             throw 202;
326         }
327         else {
328             timeStamp = convertStringToDouble(json_string_value(time_stamp));
329             printf("timeStamp:%f\n", timeStamp );
330         }
331         iterator = json_object_get(data, "command");
332         if (!json_is_string(iterator)){
333             printf("throwing jsonException\n");
334             throw 202;
335         }
336         else {
337             command = json_string_value(iterator);
338             //printf("command:%s\n", command.c_str());
339         }
340         commands_vector.push_back(command);
341     }
342 }
343 return commands_vector;

```



```

344 }
345
346
347 void json_test_function () {
348     map<string, double> debug_map;
349     debug_map["test1"] = 8.9;
350     debug_map["test2"] = 5678.456;
351     printf("Sending data\n");
352     json_send_data(debug_map);
353     printf("printing data\n");
354     debug_print_map(json_get_data(testID));
355
356     string command1="command one";
357     string command2="command two";
358     printf("sending commands\n");
359     json_send_command(command1, testID);
360     json_send_command(command2, testID);
361     printf("printing commands\n");
362     debug_print_vector(json_get_commands(testID));
363 }
364

```

src/json-processing.cpp

2.19 http_functions.h

```

1 #ifndef HTTP_FUNCTIONS
2 #include <stdlib.h>
3 #include <string.h>
4 #include <stdio.h>
5
6 // make HTTP request to url
7 char* http_request(char *url);
8
9 //make a HTTP post to url
10 void http_post(char* url, char* json_string);
11 #endif

```

include/http-functions.h

2.20 http_functions.cpp

```

1
2 #include <stdlib.h>
3 #include <string.h>
4 #include <stdio.h>
5 #include <curl/curl.h>
6 using namespace std;
7
8 #define BUFFER_SIZE (256 * 1024) /* 256 KB */
9
10 #define URLFORMAT "https://wodinaz.com/%s"
11 #define URL_SIZE 256
12
13 struct write_result
14 {
15     char *data;
16     int pos;
17 };
18
19 static size_t write_response(void *ptr, size_t size, size_t nmemb, void *stream)
20 {
21     struct write_result *result = (struct write_result *)stream;
22
23     if(result->pos + size * nmemb >= BUFFER_SIZE - 1)
24     {
25         fprintf(stderr, "error: too small buffer\n");
26         return 0;
27     }
28
29     memcpy(result->data + result->pos, ptr, size * nmemb);
30     result->pos += size * nmemb;
31
32     return size * nmemb;
33 }

```

```

34 // make HTTP request to url
35 char* http_request(char *url)
36 {
37     CURL *curl = NULL;
38     CURLcode status;
39     struct curl_slist *headers = NULL;
40     char *data = NULL;
41     long code;
42
43     curl_global_init(CURL_GLOBAL_ALL);
44     curl = curl_easy_init();
45     if(!curl)
46         goto error;
47
48     data = (char*) malloc(BUFFER_SIZE);
49     if(!data)
50         goto error;
51
52     struct write_result write_result;
53     write_result.data=data;
54     write_result.pos=0;
55
56     curl_easy_setopt(curl, CURLOPT_URL, url);
57     curl_easy_setopt(curl, CURLOPT_HTTPHEADER, headers);
58
59     curl_easy_setopt(curl, CURLOPT_WRITEFUNCTION, write_response);
60     curl_easy_setopt(curl, CURLOPT_WRITEDATA, &write_result);
61
62     status = curl_easy_perform(curl);
63     if(status != 0)
64     {
65         fprintf(stderr, "error: unable to request data from %s:\n", url);
66         fprintf(stderr, "%s\n", curl_easy_strerror(status));
67         goto error;
68     }
69
70     curl_easy_getinfo(curl, CURLINFO_RESPONSE_CODE, &code);
71     if(code != 200)
72     {
73         fprintf(stderr, "error: server responded with code %ld\n", code);
74         goto error;
75     }
76
77     curl_easy_cleanup(curl);
78     curl_slist_free_all(headers);
79     curl_global_cleanup();
80
81     /* zero-terminate the result */
82     data[write_result.pos] = '\0';
83
84     return data;
85
86 error:
87     if(data)
88         free(data);
89     if(curl)
90         curl_easy_cleanup(curl);
91     if(headers)
92         curl_slist_free_all(headers);
93     curl_global_cleanup();
94     return NULL;
95 }
96
97 //post to server
98 void http_post(char* url, char* json_string){
99     CURL *curl;
100     CURLcode res;
101
102     /* In windows, this will init the winsock stuff */
103     curl_global_init(CURL_GLOBAL_ALL);
104     /* get a curl handle */
105     curl = curl_easy_init();
106     if(curl) {
107         /* First set the URL that is about to receive our POST. This URL can
108            just as well be a https:// URL if that is what should receive the
109            data. */
110         curl_easy_setopt(curl, CURLOPT_URL, url);
111
112         /* Now specify the POST data */
113         curl_easy_setopt(curl, CURLOPT_POSTFIELDS, json_string);
114
115         /* Perform the request, res will get the return code */
116         res = curl_easy_perform(curl);
117
118         /* Check for errors */
119         if(res != CURLE_OK)
120             fprintf(stderr, "curl_easy_perform() failed: %s\n",
121                 curl_easy_strerror(res));
122     }
123 }
124

```

```
125 |  
126 |     // printf("return code:%d\n",res );  
127 |     /* always cleanup */  
128 |     curl_easy_cleanup(curl);  
129 | }  
130 | curl_global_cleanup();  
131 | }
```

src/http_functions.cpp

Chapter 3

Example code

3.1 Car

```
1 #include <stdio.h>
2 #include <termio.h>
3 #include <unistd.h>
4 #include <dynamixel.h>
5 #include <time.h>
6 #include "car.h"
7
8 using namespace std;
9
10 //put ID of the wheels here
11 #define FRONT_RIGHT_WHEEL 1
12 #define BACK_RIGHT_WHEEL 3
13 #define FRONT_LEFT_WHEEL 0
14 #define BACK_LEFT_WHEEL 2
15
16
17 int main(){
18
19     int deviceIndex = 0;
20     int baudnum = 1;
21
22     printf("-----CAR TEST PROGRAM-----\n");
23
24     ////////// Open USB2Dynamixel //////////
25     if( dxl_initialize(deviceIndex, baudnum) == 0 )
26     {
27         printf( "Failed to open USB2Dynamixel!\n" );
28         printf( "Press Enter key to terminate...\n" );
29         getchar();
30         return 0;
31     }
32     else
33         printf( "Succeed to open USB2Dynamixel!\n" );
34
35     Car car1(FRONT_RIGHT_WHEEL, FRONT_LEFT_WHEEL, BACK_RIGHT_WHEEL, BACK_LEFT_WHEEL);
36     sleep(1);
37
38     car1.setSpeed(1023,1);
39     sleep(2);
40     car1.setSpeed(1023,0);
41     sleep(2);
42     car1.setSpeed(0,1);
43
44     while(1)
45     {
46
47
48     }
49
50     // Close device
51     car1.setSpeed(0,1);
52     dxl_terminate();
53     return 0;
54 }
55 }
```

 example/Car/src/main.cpp

3.2 Interface

```

1  #include <stdio.h>
2  #include <termio.h>
3  #include <unistd.h>
4  #include <dynamixel.h>
5  #include <time.h>
6  #include "car.h"
7  #include "manipulator.h"
8  #include "interface.h"
9
10 using namespace std;
11
12 //put ID of the wheels here
13 #define FRONT_RIGHT_WHEEL 1
14 #define BACK_RIGHT_WHEEL 3
15 #define FRONT_LEFT_WHEEL 0
16 #define BACK_LEFT_WHEEL 2
17
18 #define MAN_ONE 4 //zero at 511
19 #define MAN_TWO 7 //zero at 511, not allowed to go under
20 #define MAN_THREE 5 //zero at 511
21
22 #define GRIPPER_LEFT 12
23 #define GRIPPER_RIGHT 6
24
25 int main() {
26
27     int deviceIndex = 0;
28     int baudnum = 1;
29
30     printf("-----LOCAL INTERFACE TEST PROGRAM-----\n");
31
32     ////////// Open USB2Dynamixel //////////
33     if( dxl_initialize(deviceIndex, baudnum) == 0 )
34     {
35         printf( "Failed to open USB2Dynamixel!\n" );
36         printf( "Press Enter key to terminate...\n" );
37         getchar();
38         return 0;
39     }
40     else
41         printf( "Succeed to open USB2Dynamixel!\n" );
42
43     windowInit();
44     Car car1(FRONT_RIGHT_WHEEL, FRONT_LEFT_WHEEL, BACK_RIGHT_WHEEL, BACK_LEFT_WHEEL);
45     Manipulator manipulator1(MAN_ONE, MAN_TWO, MAN_THREE, GRIPPER_LEFT, GRIPPER_RIGHT)
46     ;
47     sleep(1);
48     manipulator1.goToPosition(XSTART, YSTART, ZSTART);
49     manipulator1.setGripper(0);
50
51     while(1)
52     {
53         checkEvent(&manipulator1, &car1);
54     }
55
56
57
58
59
60     // Close device
61     car1.setSpeed(0,1);
62     dxl_terminate();
63     return 0;
64 }

```

example/Interface/src/main.cpp

3.3 Main

```

1 #include <stdio.h>
2 #include <termio.h>
3 #include <unistd.h>
4 #include <dynamixel.h>
5 #include <pthread.h>
6 #include <vector>
7 #include <string>
8 #include <time.h>
9 #include "car.h"
10 #include "manipulator.h"
11 #include "json_processing.h"
12 #include "sensor.h"
13
14 using namespace std;
15
16 //ID of wheels
17 #define FRONT_RIGHT_WHEEL 1
18 #define BACK_RIGHT_WHEEL 3
19 #define FRONT_LEFT_WHEEL 0
20 #define BACK_LEFT_WHEEL 2
21
22 //ID of manipulator arm
23 #define MAN_ONE 4 //zero at 511
24 #define MAN_TWO 7 //zero at 511, not allowed to go under
25 #define MAN_THREE 5 //zero at 511
26
27 //ID of gripper
28 #define GRIPPER_LEFT 12
29 #define GRIPPER_RIGHT 6
30
31 //ID of sensor
32 #define SENSOR 100
33
34 void *sendSensorData(void *ptr);
35
36 int main(){
37
38     pthread_t thread1;
39     int deviceIndex = 0;
40     int baudnum = 1;
41     string command;
42     vector<string> commands;
43     string strCheck = "position";
44
45     printf("-----MAIN PROGRAM-----\n");
46
47     ////////// Open USB2Dynamixel //////////
48     if( dxl_initialize(deviceIndex, baudnum) == 0 )
49     {
50         printf( "Failed to open USB2Dynamixel!\n" );
51         printf( "Press Enter key to terminate...\n" );
52         getchar();
53         return 0;
54     }
55     else
56         printf( "Succeed to open USB2Dynamixel!\n" );
57
58     Car car1(FRONT_RIGHT_WHEEL, FRONT_LEFT_WHEEL, BACK_RIGHT_WHEEL, BACK_LEFT_WHEEL);
59     Manipulator manipulator1(MAN_ONE, MAN_TWO, MAN_THREE, GRIPPER_LEFT, GRIPPER_RIGHT);
60
61     Sensor sensor1(SENSOR);
62     sleep(1);
63
64     sensor1.playMelody(6);
65     manipulator1.goToPosition(XSTART,YSTART,ZSTART);
66     manipulator1.setGripper(0);
67
68     //get old commands from server and disregard them
69     vector<string> dummy = json_get_commands(0);
70
71     //create thread for sending sensor data
72     pthread_create( &thread1, NULL, sendSensorData, &sensor1 );
73
74     while(1)
75     {
76         //get commands
77         while(commands.empty())
78         {
79             commands = json_get_commands(0);
80         }
81
82         //execute commands
83         while(!commands.empty())
84         {
85             command = commands.front();
86             commands.erase(commands.begin());
87             if(command == "forward")
88                 car1.setSpeed(1023,1);
89

```

```

90         else if (command == "backward")
91             car1.setSpeed(1023,0);
92
93         else if (command == "stop")
94             car1.setSpeed(0,1);
95
96         else if (command == "leftTurn")
97             car1.turnCar(LEFT_TURN);
98
99         else if (command == "rightTurn")
100             car1.turnCar(RIGHT_TURN);
101
102         else if (command == "noTurn")
103             car1.turnCar(NO_TURN);
104
105         else if (command == "gripClose")
106             manipulator1.setGripper(1);
107
108         else if (command == "gripOpen")
109             manipulator1.setGripper(0);
110
111         else if (command.find(strCheck) != string::npos){
112             size_t found1 = command.find(" ");
113             size_t found2 = command.find(" ", found1+1);
114             size_t found3 = command.find(" ", found2+1);
115             string nr1 = command.substr(found1+1, found2-found1);
116             string nr2 = command.substr(found2+1, found3-found2);
117             string nr3 = command.substr(found3+1);
118
119             int x = atoi(nr1.c_str());
120             int y = atoi(nr2.c_str());
121             int z = atoi(nr3.c_str());
122             manipulator1.goToPosition(x, y, z);
123         }
124
125         else
126             printf("Unknown command\n");
127
128         printf("command: %s\n", command.c_str());
129     }
130
131 }
132
133
134
135
136 // Close device
137 car1.setSpeed(0,1);
138 dxl_terminate();
139 return 0;
140 }
141
142 //thread function for continuously sending data
143 void *sendSensorData(void *ptr){
144
145     //initialize sensor here?
146     Sensor* p = (Sensor*)ptr;
147     int data;
148     map<string,double> sensorData;
149     while(1){
150         //sleep for 100ms
151         sleep(1);
152
153         if(p->getMode() == FAILSAFE_MODE)
154         {
155             p->ping();
156             continue;
157         }
158         //get data and put it in the map
159         data = p->getIR(CENTER);
160         printf("\nIR center: %d\n",data);
161         sensorData["IR center"] = data;
162
163         data = p->getIR(LEFT);
164         printf("IR left: %d\n",data);
165         sensorData["IR left"] = data;
166
167         data = p->getIR(RIGHT);
168         printf("IR right: %d\n",data);
169         sensorData["IR right"] = data;
170         //send data
171         json_send_data(sensorData);
172         //clear map
173         sensorData.clear();
174     }
175     return NULL;
176 }

```

example/Main/src/main.cpp

3.4 Manipulator

```

1 #include <stdio.h>
2 #include <termio.h>
3 #include <unistd.h>
4 #include <dynamixel.h>
5 #include <time.h>
6 #include "manipulator.h"
7
8 using namespace std;
9
10 #define MAN_ONE 4 //zero at 511
11 #define MAN_TWO 7 //zero at 511, not allowed to go under
12 #define MAN_THREE 5 //zero at 511
13
14 #define GRIPPER_LEFT 12
15 #define GRIPPER_RIGHT 6
16
17 int main(){
18
19     int deviceIndex = 0;
20     int baudnum = 1;
21
22     printf("-----MANIPULATOR TEST PROGRAM-----\n");
23
24     ////////// Open USB2Dynamixel //////////
25     if( dxl_initialize(deviceIndex, baudnum) == 0 )
26     {
27         printf( " Failed to open USB2Dynamixel!\n" );
28         printf( " Press Enter key to terminate...\n" );
29         getchar();
30         return 0;
31     }
32     else
33     {
34         printf( "Succeed to open USB2Dynamixel!\n" );
35
36         Manipulator manipulator1(MAN_ONE, MAN_TWO, MAN_THREE, GRIPPER_LEFT, GRIPPER_RIGHT)
37         ;
38         sleep(1);
39
40         manipulator1.setGripper(0);
41
42         //test drawing
43         manipulator1.setGripper(1);
44         manipulator1.drawLine(50,200,50,150,0);
45         manipulator1.drawLine(50,175,25,175,0);
46         manipulator1.drawLine(25,200,25,150,0);
47
48         while(1)
49         {
50             for(int i = 0; i < 130; i+=1)
51             {
52                 manipulator1.goToPosition(0,170,i);
53                 usleep(5000);
54             }
55             for(int i = 130; i > 0; i-=1)
56             {
57                 manipulator1.goToPosition(0,170,i);
58                 usleep(5000);
59             }
60             for(int i = 0; i < 100; i+=1)
61             {
62                 manipulator1.goToPosition(i,170,0);
63                 usleep(5000);
64             }
65             for(int i = 100; i > -100; i-=1)
66             {
67                 manipulator1.goToPosition(i,170,0);
68                 usleep(5000);
69             }
70             for(int i = -100; i < 0; i+=1)
71             {
72                 manipulator1.goToPosition(i,170,0);
73                 usleep(5000);
74             }
75         }
76     }
77
78
79     // Close device
80     dxl_terminate();
81     return 0;
82 }

```

example/Manipulator/src/main.cpp

3.5 Motor

```

1  #include <stdio.h>
2  #include <termio.h>
3  #include <unistd.h>
4  #include <dynamixel.h>
5  #include "motor.h"
6
7  using namespace std;
8
9  #define MOTOR_ID    1
10
11 int main(){
12
13     bool b = 0;
14     int deviceIndex = 0;
15     int baudnum = 1;
16
17     printf("-----MOTOR TEST PROGRAM-----\n");
18
19     ////////// Open USB2Dynamixel //////////
20     if( dxl_initialize(deviceIndex, baudnum) == 0 )
21     {
22         printf( " Failed to open USB2Dynamixel!\n" );
23         printf( " Press Enter key to terminate...\n" );
24         getchar();
25         return 0;
26     }
27     else
28         printf( " Succeed to open USB2Dynamixel!\n" );
29
30     Motor motor1(MOTOR_ID, SERVOMODE);
31
32     while(1)
33     {
34         try{
35             printf( " Press Enter key to continue!(press ESC and Enter to quit)\n" );
36             if(getchar() == 0x1b)
37                 break;
38
39             if(b){
40                 printf("motor1 to 300 degrees\n");
41                 motor1.setGoalPosition(1023);
42             }
43
44             else{
45                 printf("motor1 to 30 degrees\n");
46                 motor1.setGoalPosition(0);
47             }
48
49             b ^= 1; //change b
50         }
51         catch(MotorException e) {
52             printf("ID: %d lost\n",e.ID);
53             printError(e.status);
54             break;
55         }
56     }
57
58     // Close device
59     dxl_terminate();
60     return 0;
61 }

```

example/Motor/src/main.cpp

3.6 ReadWrite

```

1  //#####
2  ///#          R O B O T I S          ##
3  ///#          ReadWrite Example code for Dynamixel.      ##
4  ///#                                     2009.11.10 ##
5  //#####
6  #include <stdio.h>
7  #include <termio.h>
8  #include <unistd.h>
9  #include <dynamixel.h>
10
11 // Control table address
12 #define P_GOAL_POSITION_L 30
13 #define P_GOAL_POSITION_H 31
14 #define P_PRESENT_POSITION_L 36
15 #define P_PRESENT_POSITION_H 37
16 #define P_MOVING 46
17
18 // Defulat setting
19 #define DEFAULT_BAUDNUM 1 // 1Mbps
20 #define DEFAULT_ID 1
21
22 void PrintCommStatus(int CommStatus);
23 void PrintErrorCode(void);
24
25 int main()
26 {
27     int baudnum = 1;
28     int GoalPos[2] = {0, 1023};
29     //int GoalPos[2] = {0, 4095}; // for Ex series
30     int index = 0;
31     int deviceIndex = 0;
32     int Moving, PresentPos;
33     int CommStatus;
34
35     printf( "\n\nRead/Write example for Linux\n\n" );
36     ////////////// Open USB2Dynamixel ///////////////////
37     if( dxl_initialize( deviceIndex, baudnum ) == 0 )
38     {
39         printf( "Failed to open USB2Dynamixel!\n" );
40         printf( "Press Enter key to terminate...\n" );
41         getchar();
42         return 0;
43     }
44     else
45         printf( "Succeed to open USB2Dynamixel!\n" );
46
47     while(1)
48     {
49         printf( "Press Enter key to continue!(press ESC and Enter to quit)\n" );
50         if( getchar() == 0xb )
51             break;
52
53         // Write goal position
54         dxl_write_word( DEFAULT_ID, P_GOAL_POSITION_L, GoalPos[index] );
55         do
56         {
57             // Read present position
58             PresentPos = dxl_read_word( DEFAULT_ID, P_PRESENT_POSITION_L );
59             CommStatus = dxl_get_result();
60
61             if( CommStatus == COMMLRXSUCCESS )
62             {
63                 printf( "%d %d\n", GoalPos[index], PresentPos );
64                 PrintErrorCode();
65             }
66             else
67             {
68                 PrintCommStatus( CommStatus );
69                 break;
70             }
71
72             // Check moving done
73             Moving = dxl_read_byte( DEFAULT_ID, P_MOVING );
74             CommStatus = dxl_get_result();
75             if( CommStatus == COMMLRXSUCCESS )
76             {
77                 if( Moving == 0 )
78                 {
79                     // Change goal position
80                     if( index == 0 )
81                         index = 1;
82                     else
83                         index = 0;
84                 }
85
86                 PrintErrorCode();
87             }
88             else
89             {
90                 PrintCommStatus( CommStatus );

```

```

91         break;
92     }
93     } while (Moving == 1);
94 }
95
96 // Close device
97 dxl_terminate();
98 printf("Press Enter key to terminate...\n");
99 getchar();
100 return 0;
101 }
102 // Print communication result
103 void PrintCommStatus(int CommStatus)
104 {
105     switch (CommStatus)
106     {
107     case COMM.TXFAIL:
108         printf("COMM.TXFAIL: Failed transmit instruction packet!\n");
109         break;
110
111     case COMM.TXERROR:
112         printf("COMM.TXERROR: Incorrect instruction packet!\n");
113         break;
114
115     case COMM.RXFAIL:
116         printf("COMM.RXFAIL: Failed get status packet from device!\n");
117         break;
118
119     case COMM.RXWAITING:
120         printf("COMM.RXWAITING: Now receiving status packet!\n");
121         break;
122
123     case COMM.RXTIMEOUT:
124         printf("COMM.RXTIMEOUT: There is no status packet!\n");
125         break;
126
127     case COMM.RXCORRUPT:
128         printf("COMM.RXCORRUPT: Incorrect status packet!\n");
129         break;
130
131     default:
132         printf("This is unknown error code!\n");
133         break;
134     }
135 }
136
137 // Print error bit of status packet
138 void PrintErrorCode()
139 {
140     if (dxl_get_rxp_packet_error(ERRBIT.VOLTAGE) == 1)
141         printf("Input voltage error!\n");
142
143     if (dxl_get_rxp_packet_error(ERRBIT.ANGLE) == 1)
144         printf("Angle limit error!\n");
145
146     if (dxl_get_rxp_packet_error(ERRBIT.OVERHEAT) == 1)
147         printf("Overheat error!\n");
148
149     if (dxl_get_rxp_packet_error(ERRBIT.RANGE) == 1)
150         printf("Out of range error!\n");
151
152     if (dxl_get_rxp_packet_error(ERRBIT.CHECKSUM) == 1)
153         printf("Checksum error!\n");
154
155     if (dxl_get_rxp_packet_error(ERRBIT.OVERLOAD) == 1)
156         printf("Overload error!\n");
157
158     if (dxl_get_rxp_packet_error(ERRBIT.INSTRUCTION) == 1)
159         printf("Instruction code error!\n");
160 }

```

example/ReadWrite/ReadWrite.c

3.7 Sensor

```

1 #include <stdio.h>
2 #include <termio.h>
3 #include <unistd.h>
4 #include <dynamixel.h>
5 #include "sensor.h"
6 #include "songs.h"
7
8

```

```

9 using namespace std;
10
11 #define SENSOR 100
12
13 int main() {
14
15     int deviceIndex = 0;
16     int baudnum = 1;
17
18     printf("-----Sensor TEST PROGRAM-----\n");
19
20     ////////// Open USB2Dynamixel //////////
21     if( dxl_initialize(deviceIndex, baudnum) == 0 )
22     {
23         printf( "Failed to open USB2Dynamixel!\n" );
24         printf( "Press Enter key to terminate...\n" );
25         getchar();
26         return 0;
27     }
28     else
29         printf( "Succeed to open USB2Dynamixel!\n" );
30
31
32     Sensor sensor1(SENSOR);
33     sensor1.playMelody(FurElise, sizeof(FurElise));
34     //sensor1.playMelody(Sirene, sizeof(Sirene));
35     //sensor1.playMelody(6);
36
37     while(1)
38     {
39
40     }
41
42     // Close device
43     dxl_terminate();
44     return 0;
45 }

```

example/Sensor/src/main.cpp

3.8 SyncWrite

```

1  #####
2  ##### R O B O T I S #####
3  ##### SyncWrite Example code for Dynamixel. #####
4  ##### 2009.11.10 #####
5  #####
6  #include <stdio.h>
7  #include <unistd.h>
8  #include <math.h>
9  #include <termio.h>
10
11 #include <dynamixel.h>
12
13 #define PI 3.141592f
14 #define NUMACTUATOR 3
15
16 // Control table address
17 #define P_GOAL_POSITION_L 30
18 #define P_GOAL_POSITION_H 31
19 #define P_GOAL_SPEED_L 32
20 #define P_GOAL_SPEED_H 33
21
22 // Defulat setting
23 #define DEFAULT_BAUDNUM 1 // 1Mbps
24 #define NUMACTUATOR 3 // Number of actuator
25 #define STEP_THETA (PI / 100.0f) // Large value is more fast
26 #define CONTROL_PERIOD (10000) // usec (Large value is more slow)
27
28 void PrintCommStatus(int CommStatus);
29 void PrintErrorCode(void);
30
31 int main()
32 {
33     int id[NUMACTUATOR];
34     int baudnum = 1;
35     int deviceIndex = 0;
36     float phase[NUMACTUATOR];
37     float theta = 0;
38     int AmpPos = 512;
39     //int AmpPos = 2048; // for EX series
40     int GoalPos;
41     int i;

```

```

42 | int CommStatus;
43 | printf( "\n\nSyncWrite example for Linux\n\n" );
44 |
45 | // Initialize id and phase
46 | for( i=0; i<NUMACTUATOR; i++ )
47 | {
48 |     id[i] = i+1;
49 |     phase[i] = 2*PI * (float)i / (float)NUMACTUATOR;
50 | }
51 |
52 | // Open USB2Dynamixel //
53 | if( dxl_initialize(deviceIndex, baudnum) == 0 )
54 | {
55 |     printf( "Failed to open USB2Dynamixel!\n" );
56 |     printf( "Press Enter key to terminate...\n" );
57 |     getchar();
58 |     return 0;
59 | }
60 | else
61 |     printf( "Succeed to open USB2Dynamixel!\n" );
62 |
63 | // Set goal speed
64 | dxl_write_word( BROADCAST_ID, P_GOAL_SPEED_L, 0 );
65 | // Set goal position
66 | dxl_write_word( BROADCAST_ID, P_GOAL_POSITION_L, AmpPos );
67 |
68 | while(1)
69 | {
70 |     printf( "Press Enter key to continue!(press ESC and Enter to quit)\n" );
71 |     if( getchar() == 0x1b )
72 |         break;
73 |
74 |     theta = 0;
75 |     do
76 |     {
77 |         // Make syncwrite packet
78 |         dxl_set_txpacket_id(BROADCAST_ID);
79 |         dxl_set_txpacket_instruction(INST_SYNC_WRITE);
80 |         dxl_set_txpacket_parameter(0, P_GOAL_POSITION_L);
81 |         dxl_set_txpacket_parameter(1, 2);
82 |         for( i=0; i<NUMACTUATOR; i++ )
83 |         {
84 |             dxl_set_txpacket_parameter(2+3*i, id[i]);
85 |             GoalPos = (int)((sin(theta+phase[i]) + 1.0) * (double)AmpPos);
86 |             printf( "%d ", GoalPos );
87 |             dxl_set_txpacket_parameter(2+3*i+1, dxl_get_lowbyte(GoalPos));
88 |             dxl_set_txpacket_parameter(2+3*i+2, dxl_get_highbyte(GoalPos));
89 |         }
90 |         dxl_set_txpacket_length((2+1)*NUMACTUATOR+4);
91 |
92 |
93 |         printf( "\n" );
94 |
95 |         dxl_txrx_packet();
96 |         CommStatus = dxl_get_result();
97 |         if( CommStatus == COMM_RXSUCCESS )
98 |         {
99 |             PrintErrorCode();
100 |         }
101 |         else
102 |         {
103 |             PrintCommStatus(CommStatus);
104 |             break;
105 |         }
106 |
107 |         theta += STEP_THETA;
108 |         usleep(CONTROL_PERIOD);
109 |     } while(theta < 2*PI);
110 | }
111 |
112 | dxl_terminate();
113 | printf( "Press Enter key to terminate...\n" );
114 | getchar();
115 |
116 | return 0;
117 | }
118 |
119 | // Print communication result
120 | void PrintCommStatus(int CommStatus)
121 | {
122 |     switch(CommStatus)
123 |     {
124 |     case COMM_TXFAIL:
125 |         printf("COMM_TXFAIL: Failed transmit instruction packet!\n");
126 |         break;
127 |
128 |     case COMM_TXERROR:
129 |         printf("COMM_TXERROR: Incorrect instruction packet!\n");
130 |         break;
131 |
132 |

```

```

133 | case COMM_RXFAIL:
134 |     printf("COMM_RXFAIL: Failed get status packet from device!\n");
135 |     break;
136 |
137 | case COMM_RXWAITING:
138 |     printf("COMM_RXWAITING: Now receiving status packet!\n");
139 |     break;
140 |
141 | case COMM_RXTIMEOUT:
142 |     printf("COMM_RXTIMEOUT: There is no status packet!\n");
143 |     break;
144 |
145 | case COMM_RXCORRUPT:
146 |     printf("COMM_RXCORRUPT: Incorrect status packet!\n");
147 |     break;
148 |
149 | default:
150 |     printf("This is unknown error code!\n");
151 |     break;
152 | }
153 | }
154 |
155 | // Print error bit of status packet
156 | void PrintErrorCode()
157 | {
158 |     if (dxl_get_rxpacket_error(ERRBIT_VOLTAGE) == 1)
159 |         printf("Input voltage error!\n");
160 |
161 |     if (dxl_get_rxpacket_error(ERRBIT_ANGLE) == 1)
162 |         printf("Angle limit error!\n");
163 |
164 |     if (dxl_get_rxpacket_error(ERRBIT_OVERHEAT) == 1)
165 |         printf("Overheat error!\n");
166 |
167 |     if (dxl_get_rxpacket_error(ERRBIT_RANGE) == 1)
168 |         printf("Out of range error!\n");
169 |
170 |     if (dxl_get_rxpacket_error(ERRBIT_CHECKSUM) == 1)
171 |         printf("Checksum error!\n");
172 |
173 |     if (dxl_get_rxpacket_error(ERRBIT_OVERLOAD) == 1)
174 |         printf("Overload error!\n");
175 |
176 |     if (dxl_get_rxpacket_error(ERRBIT_INSTRUCTION) == 1)
177 |         printf("Instruction code error!\n");
178 | }

```

example/SyncWrite/SyncWrite.c