FTC Programming with Android Studio

Patrick R. Michaud
University of Texas at Dallas
Jonsson School of Engineering
patrick.michaud@utdallas.edu

Goals

Introduce FTC robot controller apps

Learn programming basics for FTC robots

Topics

Setup basics

Autonomous and teleop templates

Motor and servo control

Driving logic

Joystick buttons

IR sensor basics

Robot control system overview

Smartphone based

- ZTE Speed
- Motorola Moto G 2nd gen
- Motorola Moto G 3rd gen
- Motorola G Play
- Nexus 5

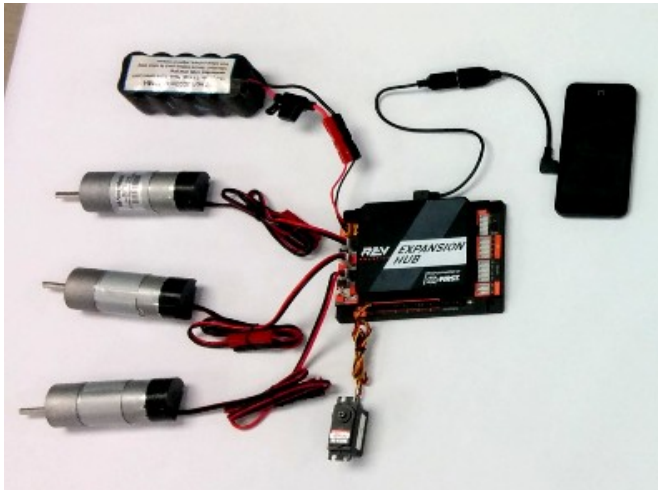
Controllers for motors, servos, sensors

Programming in Android Studio (Java)

Robot control system basics

Two phones:

- Driver Station
- Robot Controller



Gamepads connect to Driver Station via USB OTG cable

Robot Controller phone connects to REV Expansion Hub via USB OTG cable

Motors, servos, and sensors connect to REV Expansion Hub

Setup: Android Studio and ftc_app SDK

(Detailed instructions available on Roboplex.)

1. Install Java SE Development Kit 8
2. Install Android Studio (latest version)
3. Unpack ftc_app downloaded from GitHub
4. Import ftc_app into Android Studio

Setup: Configure phone

(Detailed instructions for ZTE speed on Roboplex)

1. Remove SIM card
2. Enable WiFi and Airplane Mode
3. Enable Developer Options
4. Install ZTE Drivers via USB
5. Configure WiFi Direct with team number followed by “-ds” or “-rc”

Programming process basics

All teams start with the same basic app framework, called “FtcRobotController”

Teams customize the app with “opmodes” for their robot's specific functionality

OpModes

Driver Station can place the Robot Controller app into one of several operational modes (“opmodes”)

Examples:

- TeleOp
- Autonomous 1
- Autonomous 2
- Stop Robot

Each “opmode” is a separate *class* instance in the Robot Controller App

Driver Station Demo

Robot Configuration Demo

Basic OpMode Java code

```
@TeleOp(name="MyTeleOp", group="Iterative Opmode")
// @Disabled
public class MyTeleOp extends OpMode {

    /* variables common to all methods */

    public void init() {
        /* code to run when opmode entered */
        /* set hardware variables */
    }

    public void loop() {
        /* code run repeatedly during operation
         * once every 25 milliseconds (nominal) */
    }

    public void stop() {
        /* cleanup to run when opmode disabled */
    }
}
```

Programming - motors

In variables section, declare a variable for each motor configured on the robot

```
private DcMotor leftMotor = null;
private DcMotor rightMotor = null;
```

Variable type

Variable name

In Java, type names normally begin with uppercase letters; variables, functions, and method calls start with lowercase letters.

In init() method, lookup components by name from controller configuration file

```
leftMotor = hardwareMap.dcMotor.get("leftmotor");
rightMotor = hardwareMap.dcMotor.get("rightmotor");
```

Can reverse motor direction if desired

```
leftMotor.setDirection(DcMotor.Direction.REVERSE);
```

Java method calls

Java is an *object-oriented language*

Many operations are performed by making *method calls* using the dot notation

```
leftMotor.setDirection(DcMotor.Direction.REVERSE);
```

Which object we're working with

What we want it to do or get

Method calls can return a result

```
leftMotor = hardwareMap.dcMotor.get("lmotor");
```

Programming - motors

To make a motor move, set its power to be between -1.0 and +1.0 in the loop() method:

```
leftMotor.setPower(0);      /* turn off motor */
rightMotor.setPower(1.0);   /* full power forward */
leftMotor.setPower(-0.5);   /* 50% power reverse */
```

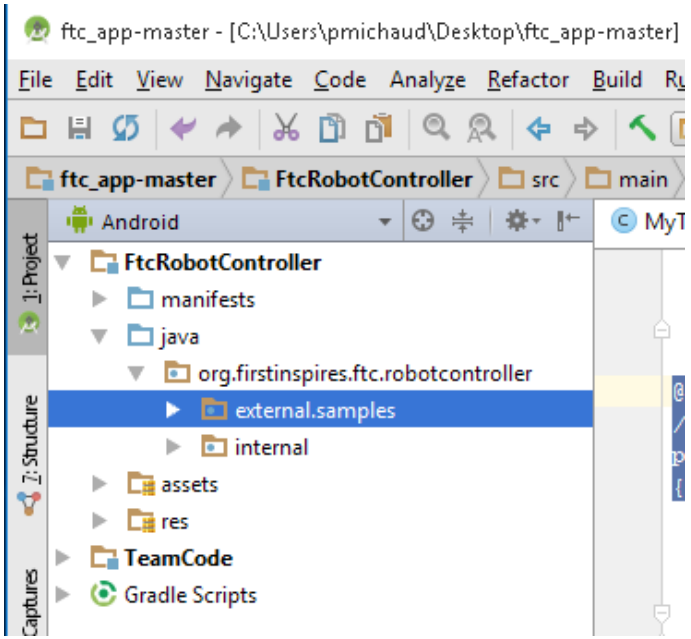
The motor will continue running at its last commanded speed until given a new setPower value or the OpMode is cancelled

A simple “move forward” program

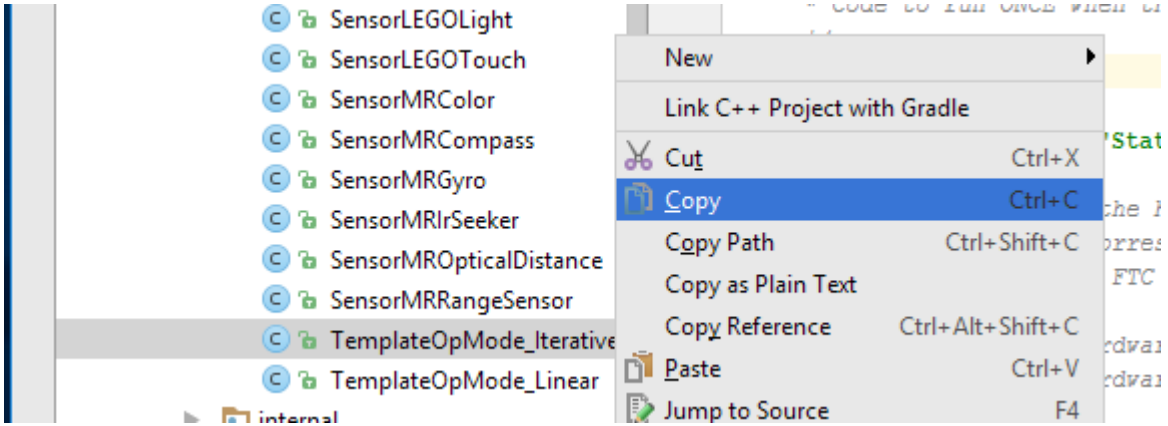
```
@TeleOp(name=”MyTeleOp”, group=”Iterative Opmode”)
// @Disabled
public class MyTeleOp extends OpMode {

    private DcMotor leftMotor = null;
    private DcMotor rightMotor = null;

    public MyTeleOp() { }

    public void init() {
        leftMotor = hardware.dcmotor.get(“leftmotor”);
        rightMotor = hardware.dcmotor.get(“rightmotor”);
        leftMotor.setDirection(DcMotor.Direction.REVERSE);
    }

    public void loop() {
        leftMotor.setPower(0.5);
        rightMotor.setPower(0.5);
    }

}
```

How to create a new OpMode

Locate
“TemplateOpMode_Iterative” or
“TemplateOpMode_Linear”
in the external.samples folder

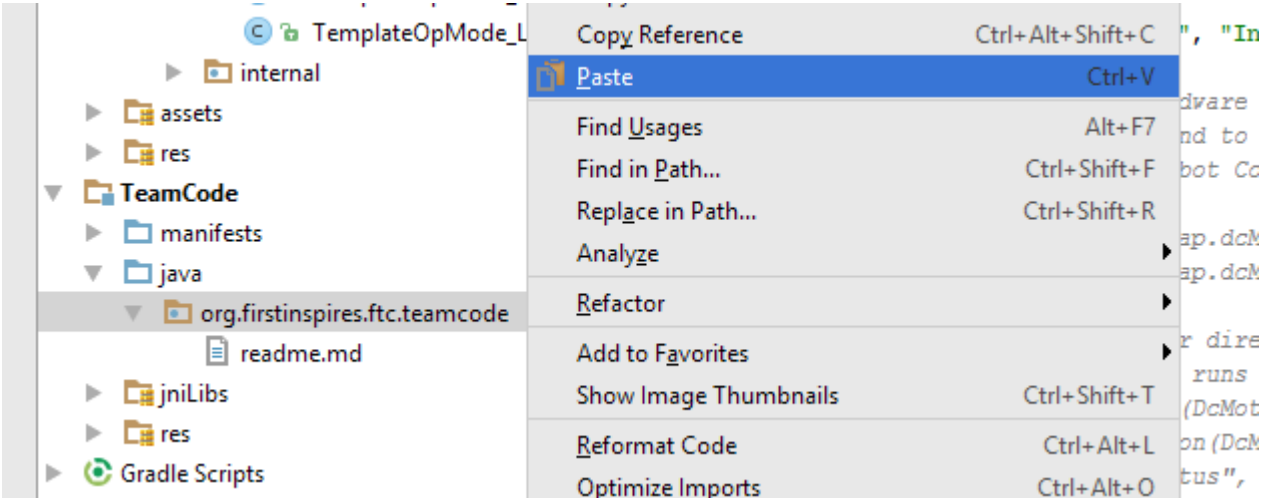


Right click and select “Copy”

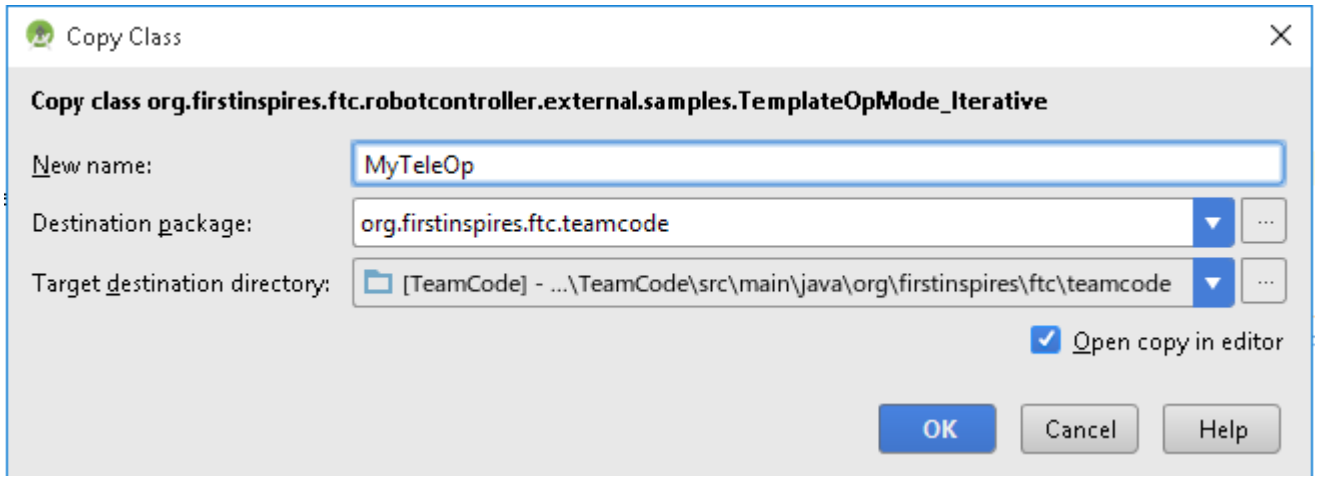


How to create a new OpMode

In the TeamCode folder, right click and select “Paste”



In the “Copy Class” dialog box, enter a name for the new OpMode



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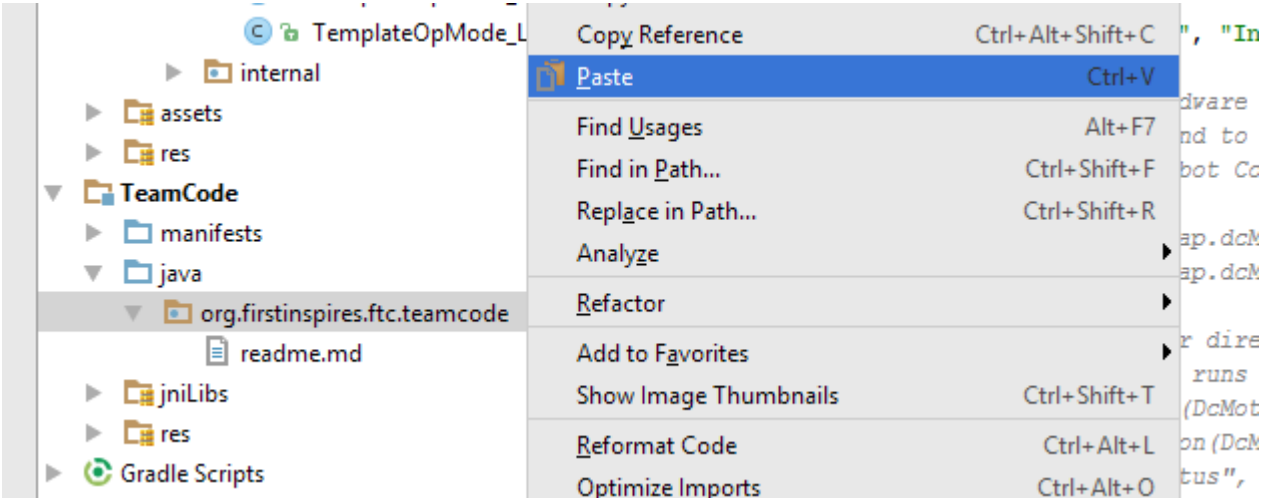

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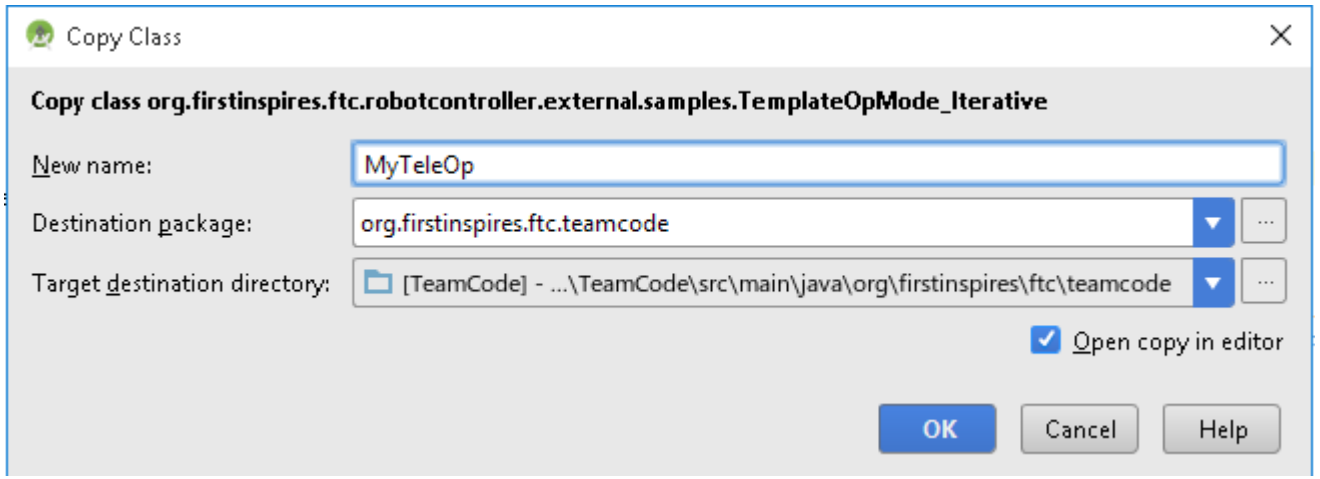


How to create a new OpMode

The new OpMode is created:

```
@TeleOp(name="Template: Iterative OpMode", group="Iterative Opmode")
@Disabled
public class MyTeleOp extends OpMode
{
    /* Declare OpMode members. */
    private ElapsedTime runtime = new ElapsedTime();

    // private DcMotor leftMotor = null;
    // private DcMotor rightMotor = null;

    /*
```

Comment this line (add two slashes in front)
to enable the OpMode in the Driver Station menu

A simple “move forward” program

```
@TeleOp(name=”MyTeleOp”, group=”Iterative Opmode”)
// @Disabled
public class MyTeleOp extends OpMode {

    private DcMotor leftMotor = null;
    private DcMotor rightMotor = null;

    public MyTeleOp() { }

    public void init() {
        leftMotor = hardware.dcmotor.get(“leftmotor”);
        rightMotor = hardware.dcmotor.get(“rightmotor”);
        leftMotor.setDirection(DcMotor.Direction.REVERSE);
    }

    public void loop() {
        leftMotor.setPower(0.5);
        rightMotor.setPower(0.5);
    }

}
```

Teleop – joystick controls

During the “teleop” phase, drivers use gamepad controllers to command the robot

Driver 1

Driver 2

Teleop driving – tank controls

"Tank controls" allow each driving motor to be independently controlled

Driver 1

gamepad1.left_stick_y
(Left wheel)

gamepad1.right_stick_y
(Right wheel)

```
public void loop() {

    leftMotor.setPower( gamepad1.left_stick_y );
    rightMotor.setPower( gamepad1.right_stick_y );

}
```

Teleop driving – steering controls

Steering control uses just one stick

Driver 1

gamepad1.left_stick_x
gamepad1.left_stick_y

```
public void loop() {

    double throttle = gamepad1.left_stick_y;
    double turn     = gamepad1.left_stick_x;

    double leftspeed  = throttle – turn;
    double rightspeed = throttle + turn;

    leftMotor.setPower(leftspeed);
    rightMotor.setPower(rightspeed);

}
```

Teleop driving – steering controls

```
public void loop() {

    double throttle = gamepad1.left_stick_y;
    double turn     = gamepad1.left_stick_x;

    double leftspeed  = throttle – turn;
    double rightspeed = throttle + turn;

    leftMotor.setPower(leftspeed);
    rightMotor.setPower(rightspeed);

}
```

Robot will turn when left/right wheels are moving at different speeds

Y-axis is setting forward/backward speed of robot

X-axis is setting the difference between the two motors

Using joystick buttons

Each gamepad has 10 buttons available

Button can be read with “gamepad1.” and the name of the button

Using joystick buttons

Can use `if` statements to perform actions based on button setting:

```
private DcMotor armMotor = null;

public void init() {
    // ...
    armMotor = hardwareMap.dcMotor.get(“armmotor”);
}

public void loop() {
   // ...
   if (gamepad1.y) {
       armMotor.setPower(0.1);
   }
   else {
       armMotor.setPower(0);
   }
}
```

Q: What happens if the `else` part is missing?

Coding style

Always keep opening and closing braces aligned

Indent + align code inside braces

Dualing joysticks

Each robot is given two driver controllers

Many teams use one controller for driving, another for attachment control

Team 7172 prefers to duplicate all controls on both joysticks

Servo control

Servos are motors that can be told to move (and hold) a specific position

Servo positions are given as a number from 0 (fully counter-clockwise) to 1 (fully clockwise)

Servo control

To tell the servo to move to a position, use the `setPosition(...)` method:

```
claw.setPosition(0);    // fully counter-clockwise
claw.setPosition(1);    // fully clockwise
claw.setPosition(0.5);  // move to middle position
```

The servo will attempt to hold the requested position until told to move to a different one

General pattern for hardware devices

1. Name the device on the robot controller phone

2. Declare a variable in the OpMode

```
private Servo claw;
```

3. Look up the device via `hardwareMap` in `init()`

```
claw = hardwareMap.servo.get("claw");
```

4. Read/write values to the device in `loop()`

```
claw.setPosition(0.5);
```

Gamepad servo control

Make the servo controllable from the gamepad:

In the variables section, add a Servo variable:

```
Servo claw = null;
```

In the `init()` method, initialize from the hardware map:

```
claw = hardwareMap.servo.get("claw");
```

In the `loop()` method, control the arm from button A:

```
if (gamepad1.a) {
    claw.setPosition(0);
}
else {
    claw.setPosition(1);
}
```

Autonomous (Linear) OpModes

Autonomous programming

In the Autonomous portion of the game, there is no driver control (beyond pressing the stop button)

So, how do we get the robot to follow a sequence of commands?

Basic LinearOpMode Java code

```
@Autonomous(name="MyAutoOp", group="Autonomous")
// @Disabled
public class MyAutoOp extends OpMode {

    /* variables common to all methods */

    public void runOpMode() throws InterruptedException {
        /* set hardware variables */

        waitForStart();

        /* turn on motors */
        sleep(1000);   // drive for 1 second
        /* turn off motors */

    }

}
```

A simple “move forward” program autonomous

```
@Autonomous(name="MyAutoOp", group="Linear Opmode")
// @Disabled
public class MyAutoOp extends LinearOpMode {

    private DcMotor leftMotor = null;
    private DcMotor rightMotor = null;

    @Override
    public void runOpMode() throws InterruptedException {
        telemetry.addData("Status", "Initialized");
        telemetry.update();

        leftMotor  = hardwareMap.dcMotor.get("leftmotor");
        rightMotor = hardwareMap.dcMotor.get("rightmotor");
        rightMotor.setDirection(DcMotor.Direction.REVERSE);

        // Wait for the game to start (driver presses PLAY)
        waitForStart();

        if (opModeIsActive()) {
            leftMotor.setPower(0.5);
            rightMotor.setPower(0.5);
            sleep(2000);     // wait for two seconds
            leftMotor.setPower(0);
            rightMotor.setPower(0);
        }
    }
}
```

Multiple movements

```
public void runOpMode() throws InterruptedException {

    leftMotor  = hardwareMap.dcMotor.get("leftmotor");
    rightMotor = hardwareMap.dcMotor.get("rightmotor");
    rightMotor.setDirection(DcMotor.Direction.REVERSE);

    // Wait for the game to start (driver presses PLAY)
    waitForStart();

    // move forward for two seconds
    if (opModeIsActive()) {
        leftMotor.setPower(0.5);
        rightMotor.setPower(0.5);
        sleep(2000);     // wait for two seconds
        leftMotor.setPower(0);
        rightMotor.setPower(0);
    }

    // move backwards for one second
    if (opModeIsActive()) {
        leftMotor.setPower(-0.5);
        rightMotor.setPower(-0.5);
        sleep(1000);     // wait for one second
        leftMotor.setPower(0);
        rightMotor.setPower(0);
    }
}
```

Breaking code into functions

```
public void move(double lpower, double rpower, int msec)
        throws InterruptedException {
    if (opModeIsActive()) {
        leftMotor.setPower(lpower);
        rightMotor.setPower(rpower);
        sleep(msec);
        leftMotor.setPower(0);
        rightMotor.setPower(0);
    }
}


public void runOpMode() throws InterruptedException {
    leftMotor  = hardwareMap.dcMotor.get("leftmotor");
    rightMotor = hardwareMap.dcMotor.get("rightmotor");
    rightMotor.setDirection(DcMotor.Direction.REVERSE);

    // Wait for the game to start (driver presses PLAY)
    waitForStart();

    move(0.5, 0.5, 2000);    // move forward for two seconds
    move(-0.5, -0.5, 1000);  // move backwards for one second
    move(0.5, 0, 1500);      // turn to right for 1.5 seconds
}
```

Sensors

Hardware and Sensor types

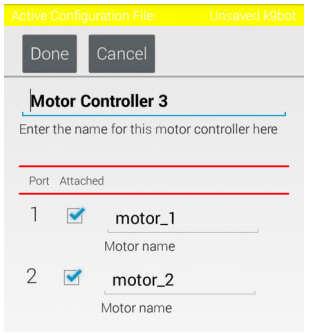
In general, everything we put on a robot has a corresponding class for programming in Java:

```
DcMotor
Servo


TouchSensor
GyroSensor
ColorSensor
UltrasonicSensor
```

General pattern for hardware devices

1. Name the device on the robot controller phone



2. Declare a variable in the OpMode

```
private DcMotor motor_1;
```

3. Look up the device via `hardwareMap` in `init()`

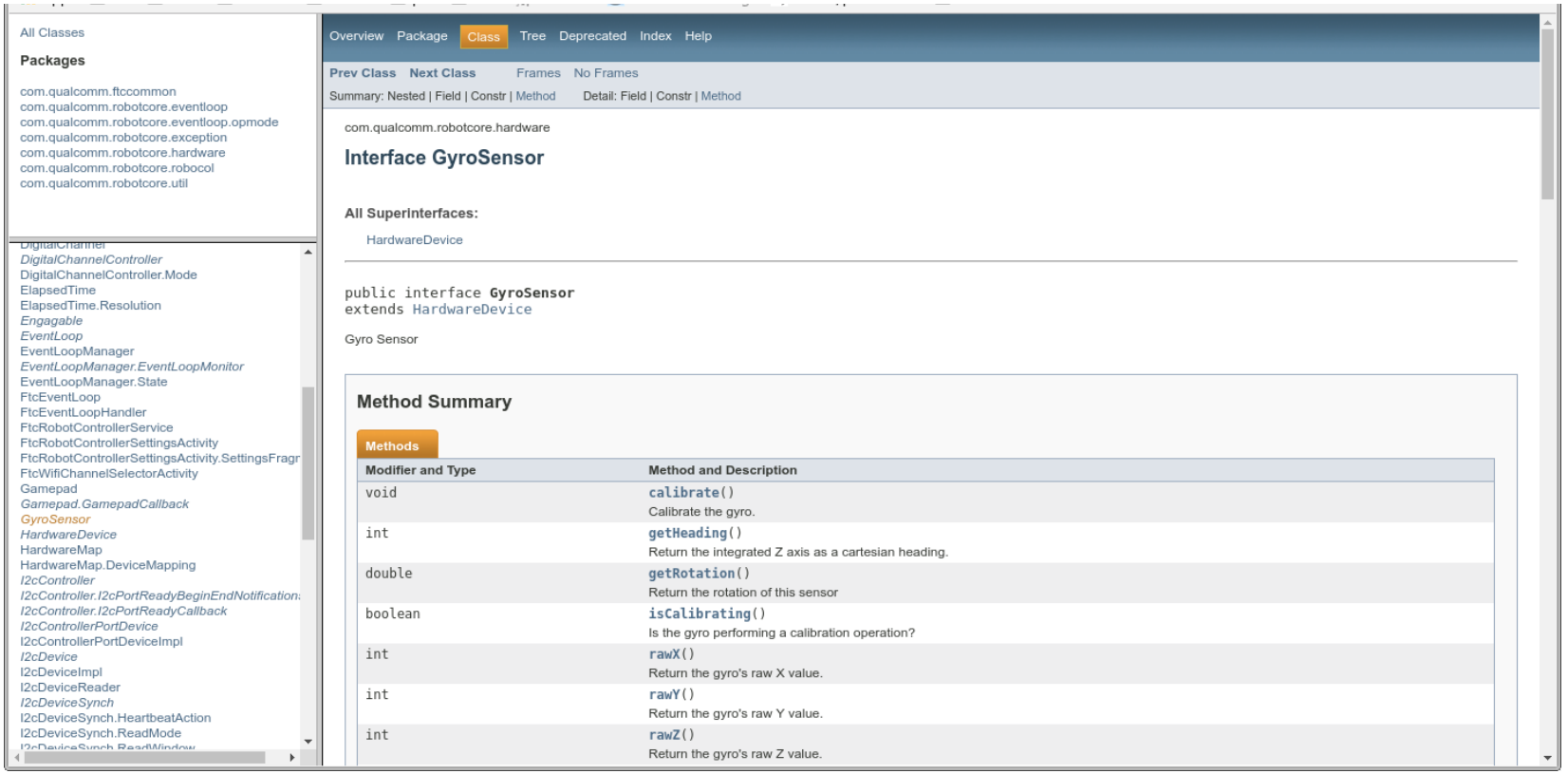
```
motor_1 = hardwareMap.dcMotor.get("motor_1");
```

4. Read/write values to the device in `loop()`

```
motor_1.setPower(0.5);
```

ftc_app Documentation

All of the sensor and hardware types are documented in *doc/javadoc/index.html* in the ftc_app directory.



Touch Sensor

The touch sensor detects presses on its button. It's ideally used as a limit switch or bumper switch.

OpMode variables:

```
TouchSensor bumper;
```

init method:

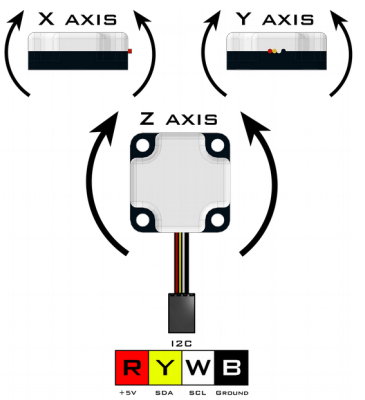
```
bumper = hardwareMap.touchSensor.get('bumper');
```

loop method:

```
if (bumper.isPressed()) {
    servo.setPosition(1);
}
else {
    servo.setPosition(0);
}
```

Gyro Sensor

The gyro sensor reports how quickly the robot is turning about an axis.



On the z-axis, the gyro sensor will also keep track of *how far* the robot has turned ("integrating gyro").