Arduino Programming Part 3

EAS 199A
Fall 2011

Overview

Part I

- Circuits and code to control the speed of a small DC motor.
- Use potentiometer for dynamic user input.
- Use PWM output from Arduino to control a transistor.
- Transistor acts as variable voltage switch for the DC motor.

Part II

- Consolidate code into reusable functions.
- One function maps 10-bit analog input to 8-bit PWM output.
- Another function controls the motor speed.
- Using functions provides modular features that are useful for more complex control tasks, e.g. the desktop fan project.

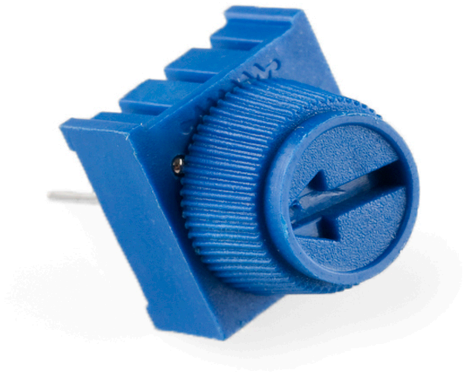
Part 1: Control motor speed with a pot

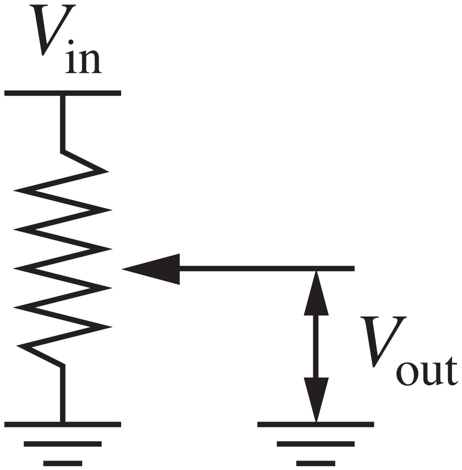
Increase complexity gradually

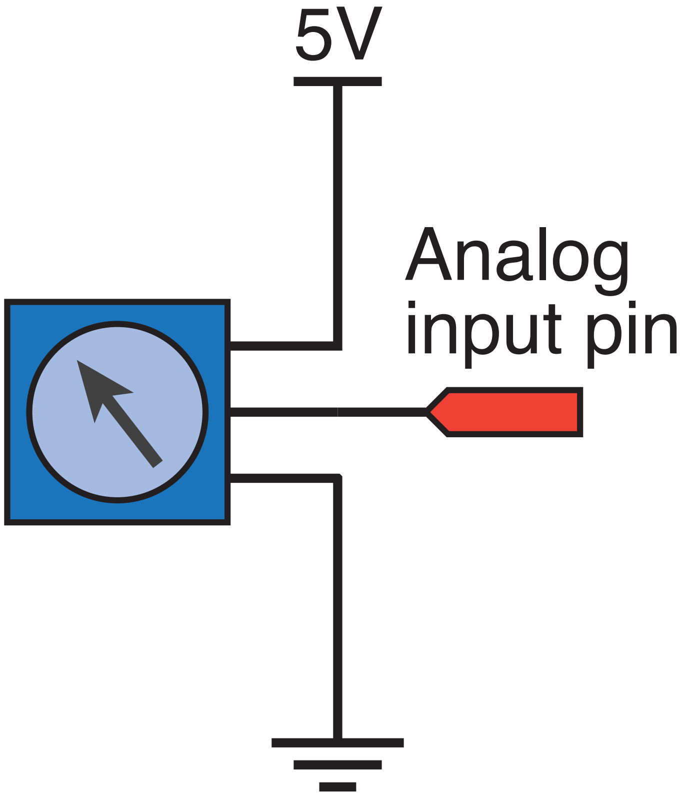
1. Use a pot to generate a voltage signal
   (a) Read voltage with analog input
   (b) Print voltage to serial monitor to verify
2. Convert 10-bit voltage scale to 8-bit PWM scale
   (a) Voltage input is in range 0 to 1023
   (b) PWM output needs to be in the range 0 to 255
   (c) Print voltage to serial monitor to verify
3. Write PWM data to DC motor
4. Write a function to linearly scale the data
5. Write a function to update the motor

Potentiometer Circuit

Use the potentiometer from the Arduino Inventor's Kit







Code to print potentiometer reading

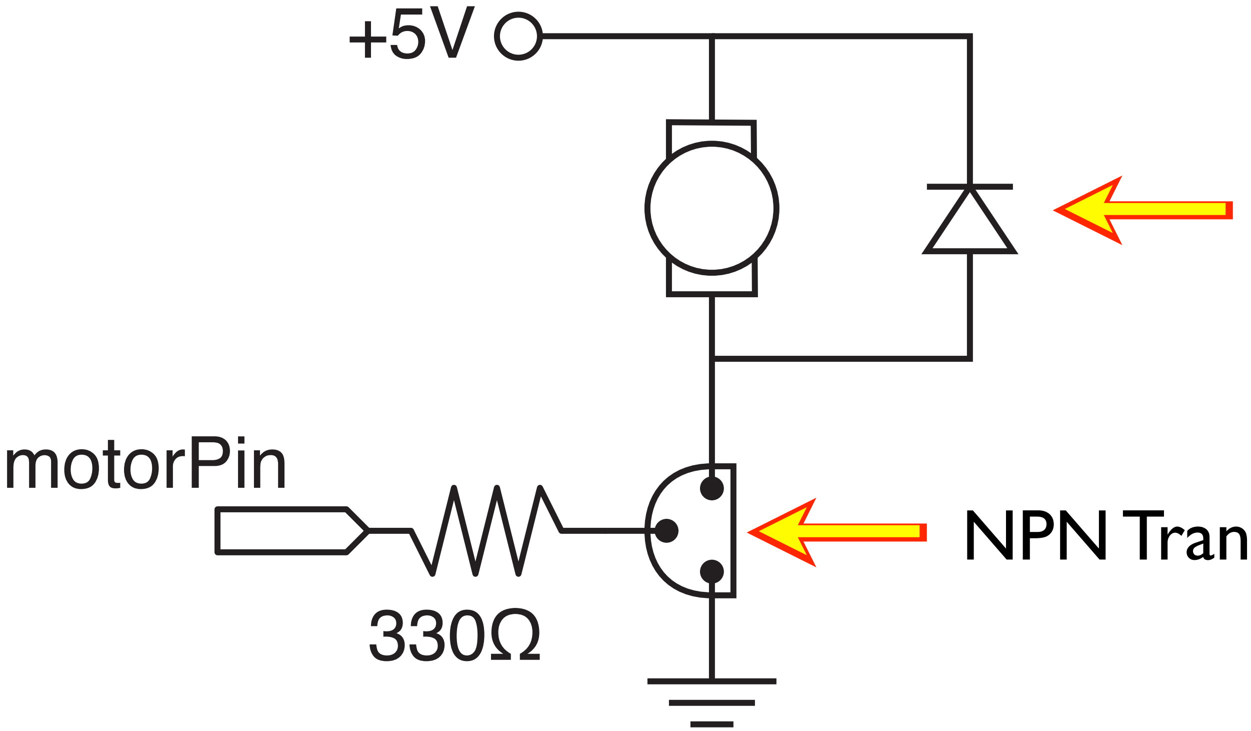
```
//  Function:  read_potentiometer
//
//  Read a potentiometer and print the reading

int  sensor_pin = 3;    //  Wire sweeper of pot to
                        //  analog input pin 3
void setup()
{
  Serial.begin(9600);
}

void loop()
{
  int  val;

  val = analogRead( sensor_pin );
  Serial.print("reading = ");
  Serial.println( val );
}
```

DC Motor Control Circuit

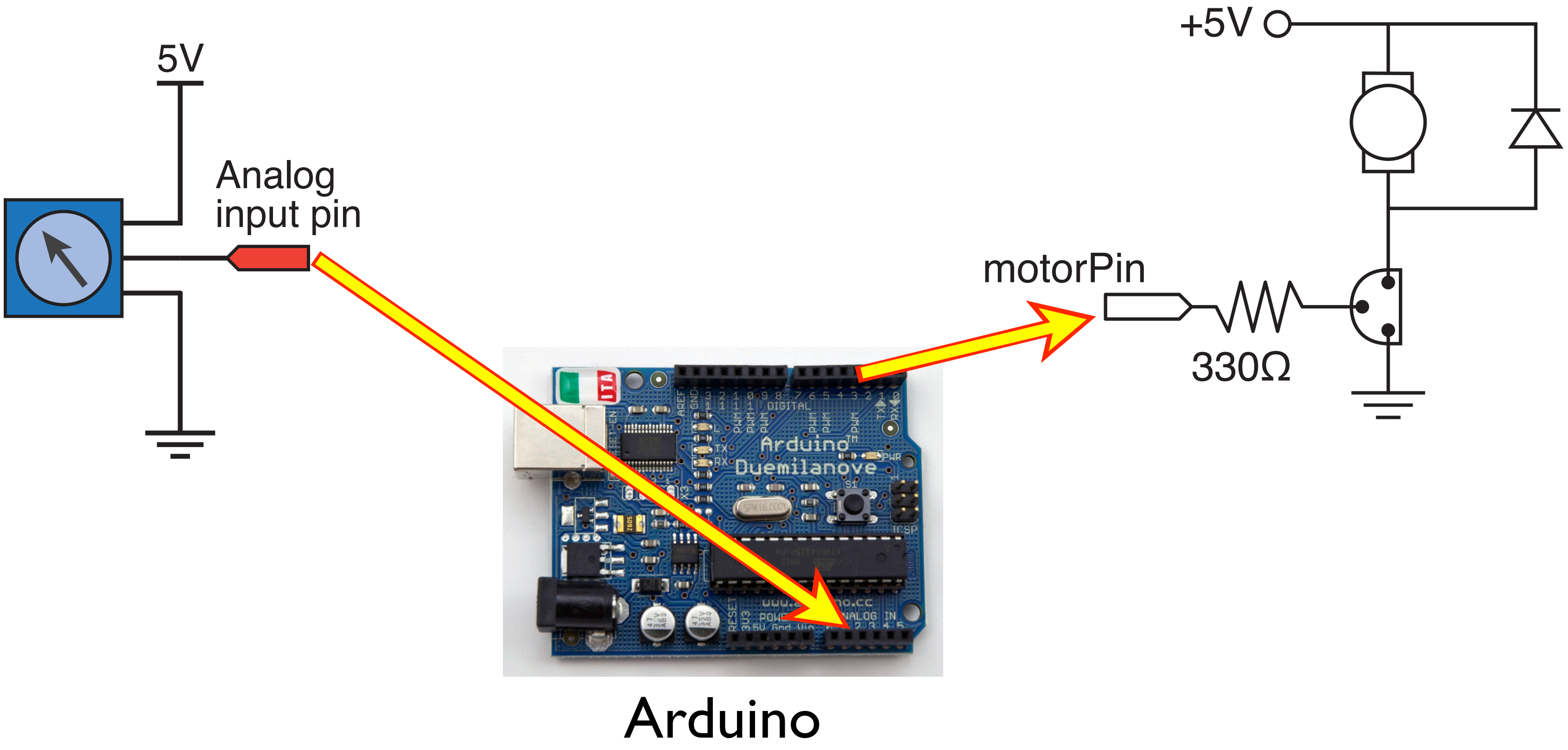


Snubber Diode

NPN Transistor

Add this to the breadboard with the potentiometer circuit

DC Motor Control Circuit



Control the DC motor with PWM Output

```
//  Function:  DC_motor_control_pot
//
//  Use a potentiometer to control a DC motor

int  sensor_pin = 3;
int  motor_pin = 5;       // must be a PWM digital output

void setup()
{
  Serial.begin(9600);
  pinMode(motor_pin,  OUTPUT)
}

void loop()
{
  int  pot_val, motor_speed;

  pot_val = analogRead( sensor_pin );
  motor_speed = pot_val*255.0/1023.0;    // Include decimal
  analogWrite( motor_pin, motor_speed);
}
```

Subtle: Don’t use integer values of 255 and 1023 here. Aggressive compilers pre-compute the integer division of 255/1023 as zero.

Take Stock

You now have a working solution

- Potentiometer creates a variable voltage input that is read by the Arduino (analogRead)
- Motor speed is controlled via PWM

Next step: Use functions to encapsulate code

- Reuse code
- Organize code: Isolated activities happen inside a function.

Part II: Create functions for reusable code

```
//  Function:  DC_motor_control_pot
//
//  Use a potentiometer to control a DC motor

int  sensor_pin = 3;
int  motor_pin = 5;       // must be a PWM digital output

void setup()
{
  Serial.begin(9600);
  pinMode(motor_pin,  OUTPUT)
}

void loop()
{
  int  pot_val, motor_speed;

  pot_val = analogRead( sensor_pin );
  motor_speed = pot_val*255.0/1023.0;    // Include decimal
  analogWrite( motor_pin, motor_speed);
}
```

Adjust motor speed

Map input values to output scale

Final version of the loop() function

```
//   Function:  DC_motor_control_pot
//
//   Use a potentiometer to control a DC motor

int  sensor_pin = 3;
int  motor_pin = 5;        // must be a PWM digital output

void setup()
{
  Serial.begin(9600);
  pinMode(motor_pin,  OUTPUT)
}

void loop()
{
  adjust_motor_speed( sensor_pin, motor_pin);

  ... // do other useful stuff
}
```

adjust_motor_speed takes care of the two main tasks: reading the potentiometer output sand setting the PWM signal to the transistor

Using and Writing Functions

Arduino web site

- http://www.arduino.cc/en/Reference/FunctionDeclaration

Functions are reusable code modules:

- Functions encapsulate details of tasks into larger building blocks
- Well-written functions can be reused
- Functions can accept input (or not) and return output (or not)
- All Arduino sketches have at least two functions
  - setup: runs once to configure the system
  - loop: runs repeatedly after start-up is complete
- Users can add functions in the main sketch file, or in separate files

The setup() Function

Consider the simple blink sketch

“void” means Returns nothing

No inputs

```
//  Blink.pde:  turn on an LED for one second, then
//              off for one second.  Repeat continuously.

void setup() {
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH);    // set the LED on
  delay(1000);               // wait for a second
  digitalWrite(13, LOW);     // set the LED off
  delay(1000);               // wait for a second
}
```

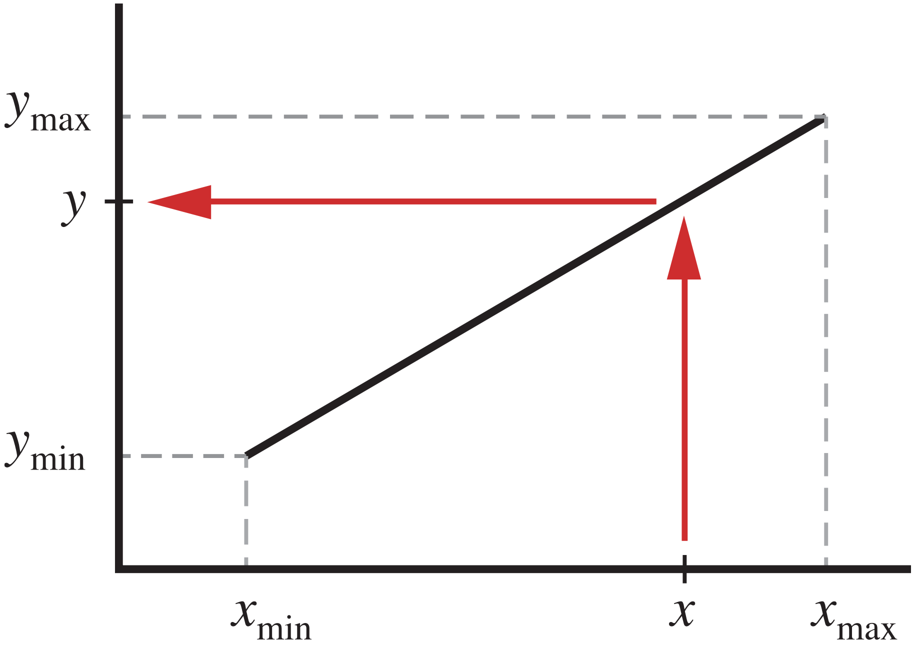
“setup” is the name of the function

A Function to Translate Linear Scales

Linear scaling from x values to y values:

$$y = f(x)$$

where f is a linear mapping



$$\frac{y - y_{\min}}{y_{\max} - y_{\min}} = \frac{x - x_{\min}}{x_{\max} - x_{\min}}$$

$$\Longrightarrow \quad y = y_{\min} + (y_{\max} - y_{\min}) \frac{x - x_{\min}}{x_{\max} - x_{\min}}$$

In words: Given x, $x_{\min}$, $x_{\max}$, $y_{\min}$, and $y_{\max}$, compute y

A Function to Translate Linear Scales

Enter the code at the bottom into your sketch

- The code is *not* inside any other program block (like setup or void)

How would you test that this function is working?

```
int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  int y;

  y = ymin + float(ymax - ymin)*float( x - xmin )/float(xmax - xmin);
  return(y);
}
```

N.B. This code is essentially a reimplementation of the built-in map function.
See http://arduino.cc/en/Reference/Map

A Function to Translate Linear Scales

```
int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  int y;

  y = ymin + float(ymax - ymin)*float( x - xmin )/float(xmax - xmin);
  return(y);
}
```

returns an int

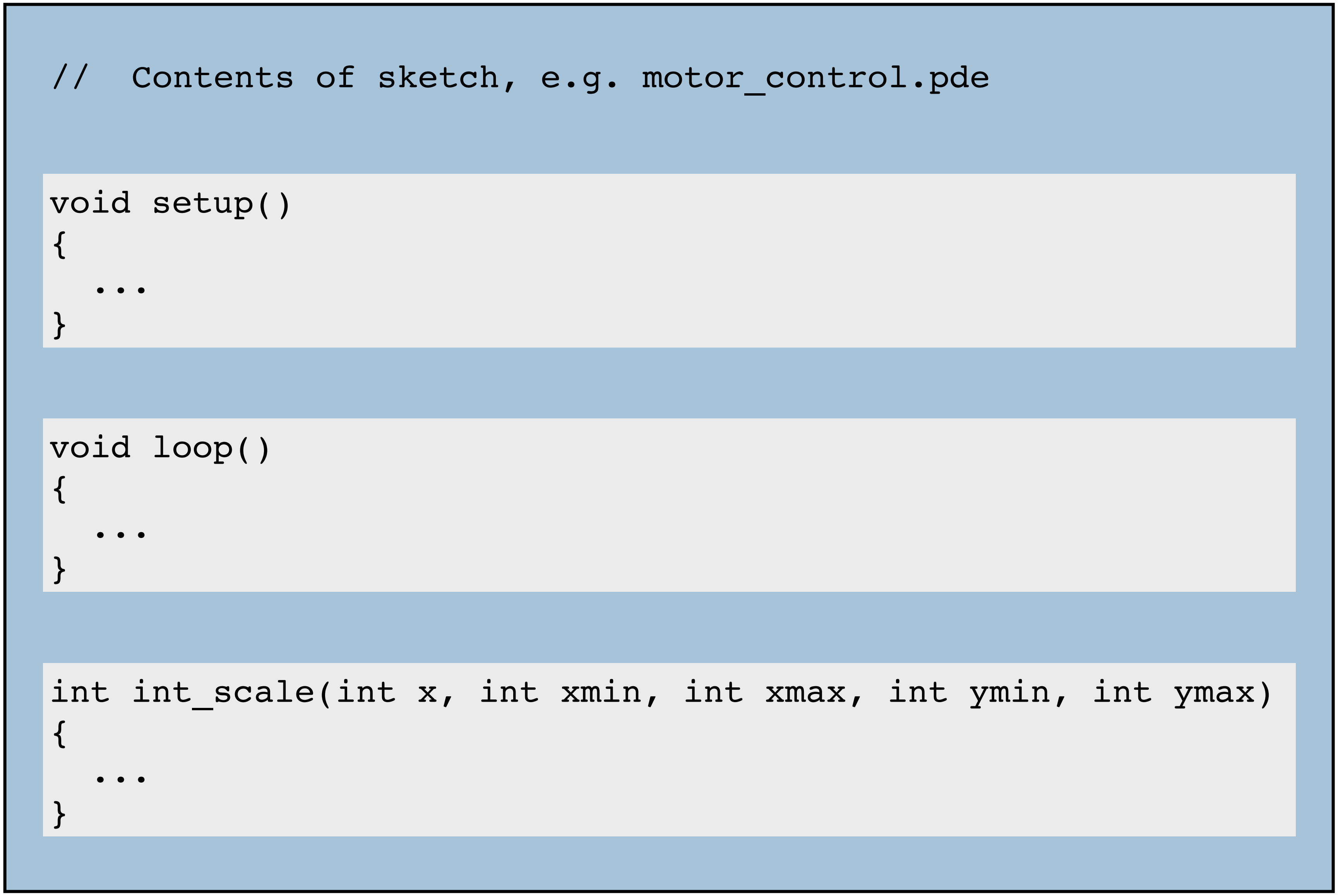
name is int_scale

first input is an int named “x”

Use float for better precision

return the value stored in “y”

Functions are not nested



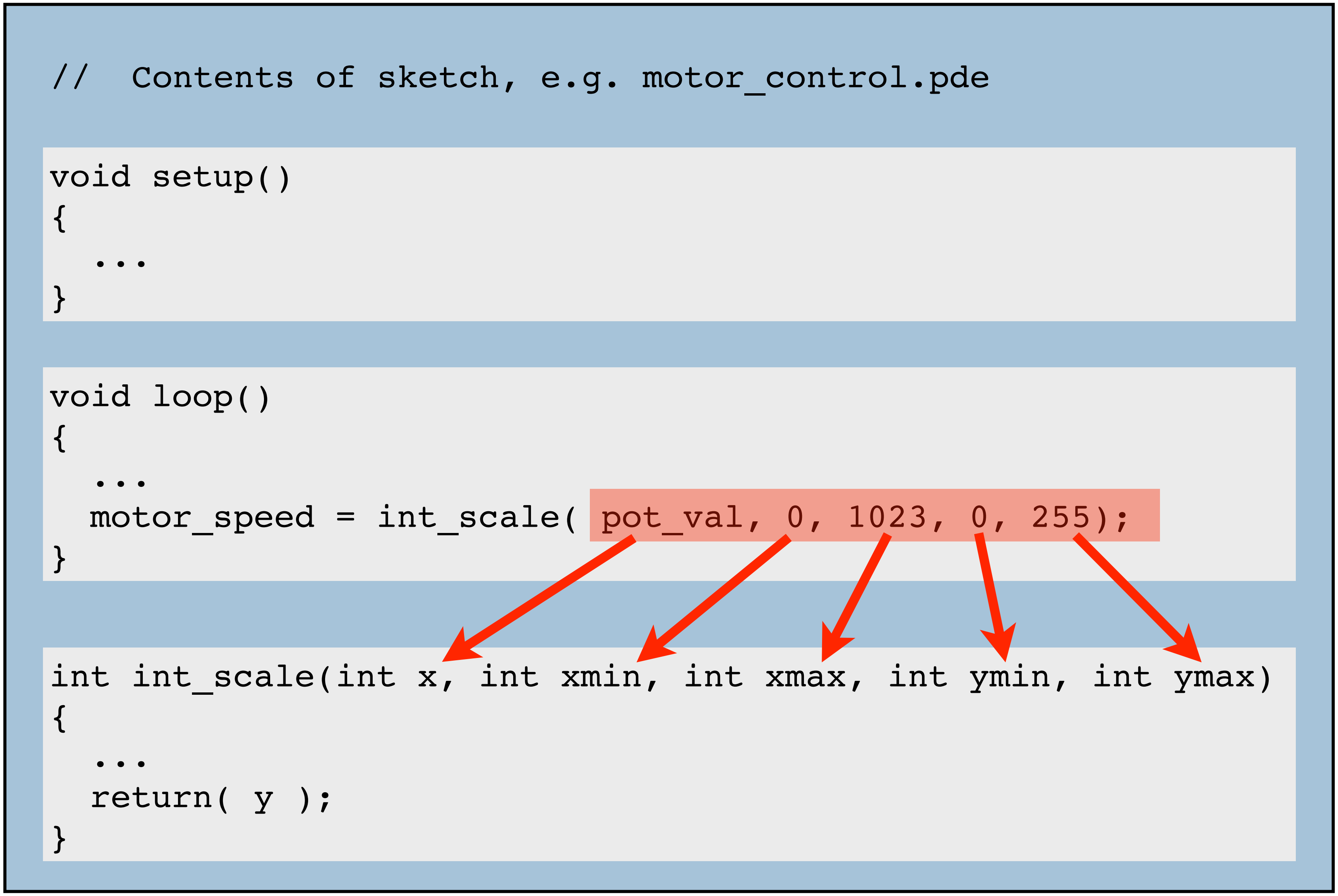
```
//  Contents of sketch, e.g. motor_control.pde

void setup()
{
  ...
}

void loop()
{
  ...
}

int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  ...
}
```

Functions call other functions



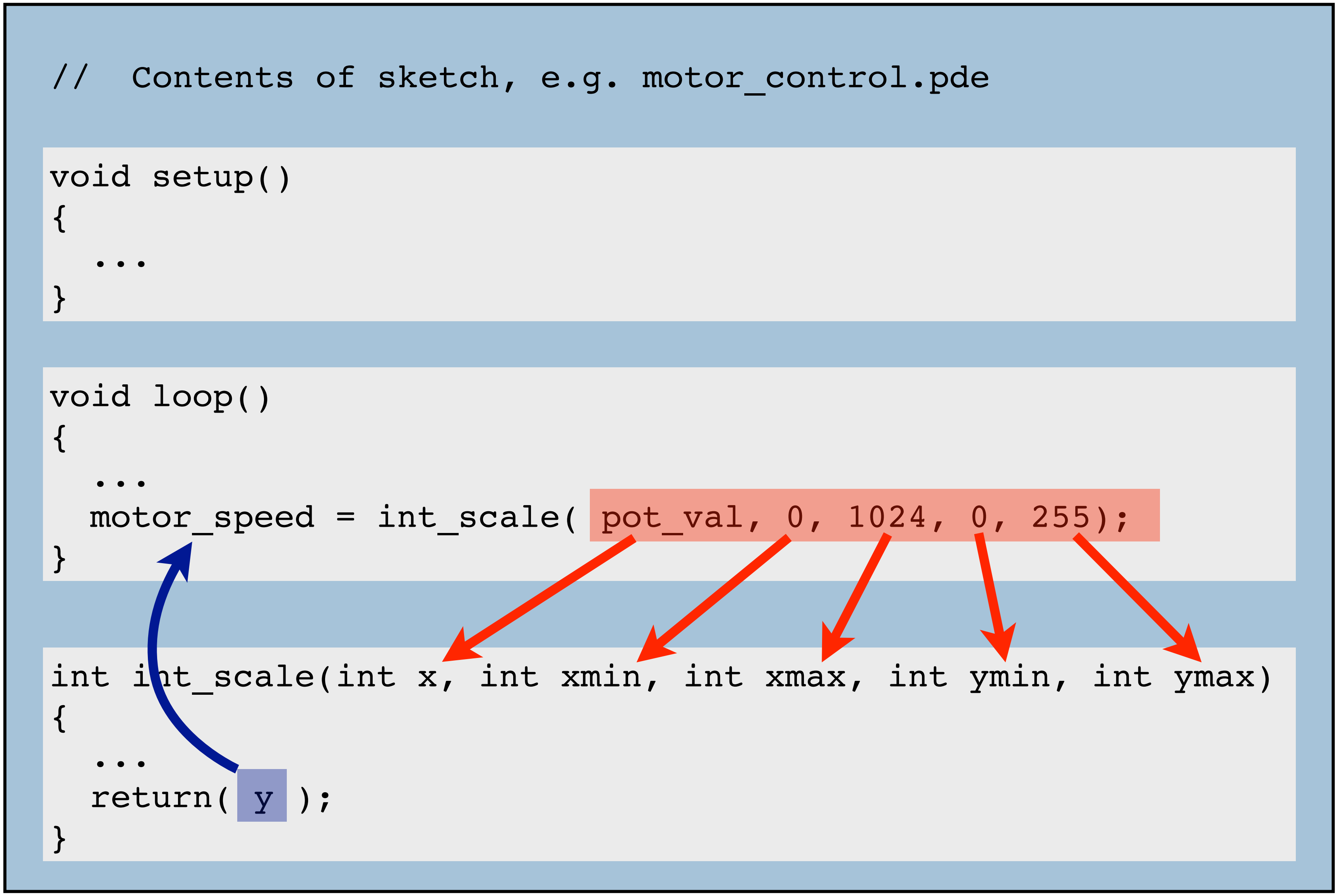
```
//  Contents of sketch, e.g. motor_control.pde
```

```
void setup()
{
  ...
}
```

```
void loop()
{
  ...
  motor_speed = int_scale( pot_val, 0, 1023, 0, 255);
}
```

```
int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  ...
  return( y );
}
```

Functions call other functions



```
//  Contents of sketch, e.g. motor_control.pde

void setup()
{
  ...
}

void loop()
{
  ...
  motor_speed = int_scale( pot_val, 0, 1024, 0, 255);
}

int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  ...
  return( y );
}
```

Use the int_scale function

```
//  Function:  DC_motor_control_pot
//
//  Use a potentiometer to control a DC motor

int  sensor_pin = 3;
int  motor_pin = 5;       // must be a PWM digital output

void setup()
{
  Serial.begin(9600);
  pinMode(motor_pin,  OUTPUT)
}

void loop()
{
  int  pot_val, motor_speed;

  pot_val = analogRead( sensor_pin );
  motor_speed = int_scale( pot_val, 0, 1023, 0, 255;
  analogWrite( motor_pin, motor_speed);
}

int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  int y;

  y = ymin + float(ymax - ymin)*float( x - xmin )/float(xmax - xmin);
  return(y);
}
```

A Function to update motor speed

Inputs

- sensor pin
- motor output pin

Tasks:

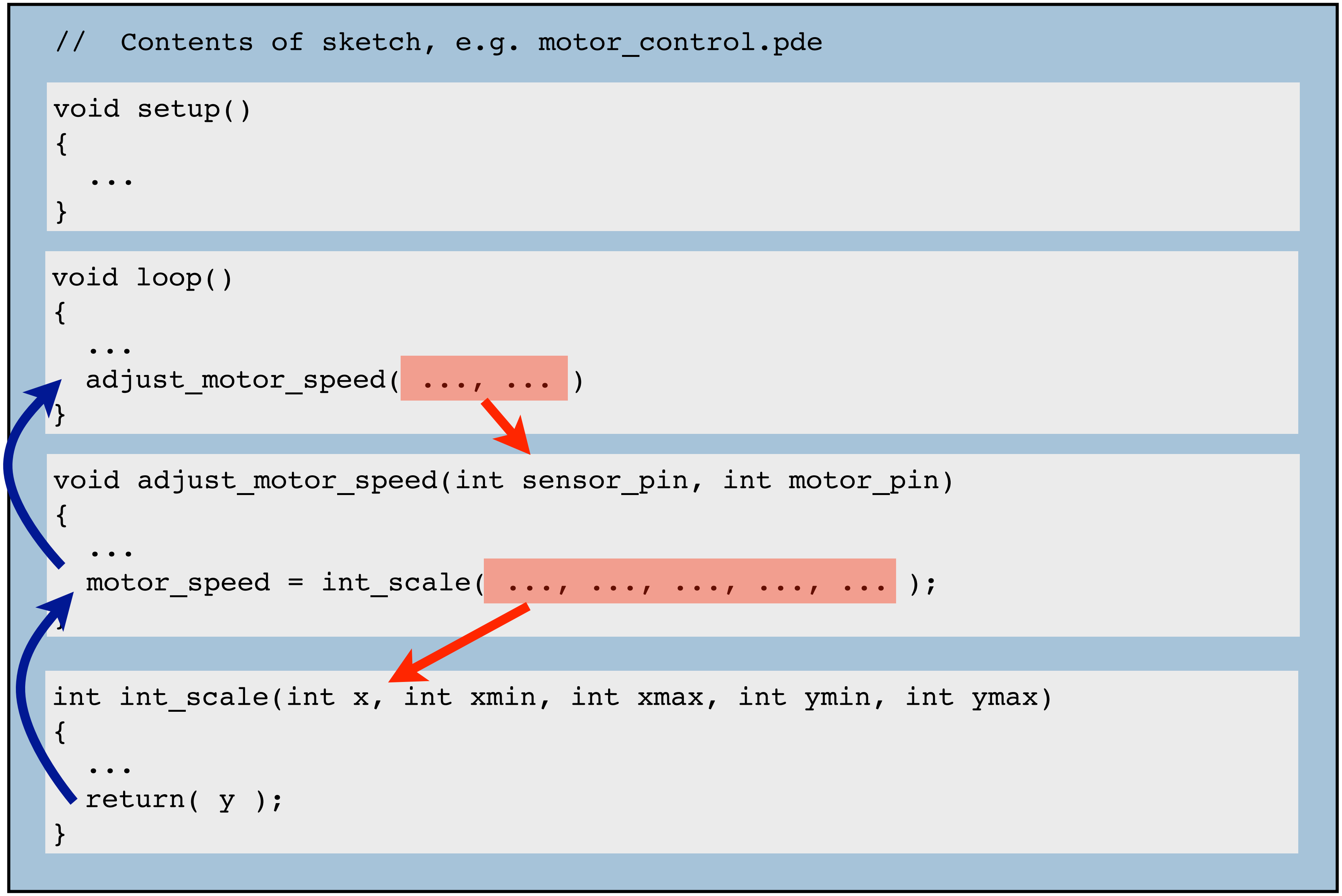
- Read potentiometer voltage
- Convert voltage from 10 bit to 8 bit scales
- Change motor speed

```
void adjust_motor_speed(int sensor_pin, int motor_pin)
{
  int  motor_speed, sensor_value;

  sensor_value = analogRead(sensor_pin);
  motor_speed = int_scale(sensor_value, 0, 1023, 0, 255);
  analogWrite( motor_pin, motor_speed);

  Serial.print("Pot input, motor output = ");
  Serial.print(sensor_value);
  Serial.print(" ");  Serial.println(motor_speed);
}
```

Functions call functions, call functions, ...



```
//  Contents of sketch, e.g. motor_control.pde

void setup()
{
  ...
}

void loop()
{
  ...
  adjust_motor_speed( ..., ... )
}

void adjust_motor_speed(int sensor_pin, int motor_pin)
{
  ...
  motor_speed = int_scale( ..., ..., ..., ..., ... );
}

int int_scale(int x, int xmin, int xmax, int ymin, int ymax)
{
  ...
  return( y );
}
```