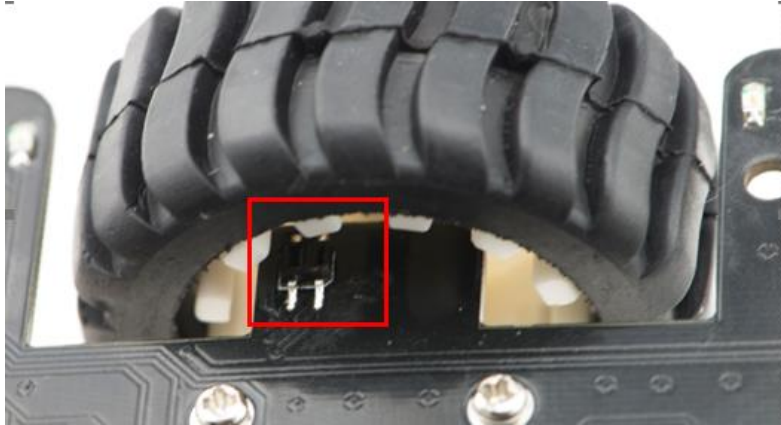


Lesson 7. Encoder



Key Point

You have got to know how to control the speed of motors, but the speed is just depend on the power you give. When the load or your battery or something else change, the speed will change at the same time. So if we want to control the speed accurately, we need to know the real speed of motors, thus we need a new device: encoder.

You should:

1. Learn how to use the encoder and review how to use interrupt function
2. Know how an encoder work
3. Get the speed of motors and control it
4. Equipment needed: Micro USB cable, miniQ

Down Sample Code

- Open the sample code: speed.ino

```

speed | Arduino 1.0.4
File Edit Sketch Tools Help

speed
#define R 2 //right encoder interrupt num
#define L 3 //left encoder interrupt num
#define EN1 6//pin for run the right motor
#define IN1 7//pin for control right motor direction
#define EN2 5//pin for run the left motor
#define IN2 12//pin for control left motor direction
float time_step= 500; //delay time
volatile int r_val=0; //store right wheel num
volatile int l_val=0; //store left wheel num
volatile int r_speed=255; //right speed
volatile int l_speed=255; //left speed
float l_speed_reality; //reality right speed
float r_speed_reality; //reality left speed

#define FORW 0
#define BACK 1

```

1) Sample code

- Download the code and open the serial monitor, you will see:

```

COM1
r_val:0 r_speed_reality:0.00 l_val:0 l_speed_reality:0.00
r_val:0 r_speed_reality:0.00 l_val:0 l_speed_reality:0.00
r_val:0 r_speed_reality:0.00 l_val:0 l_speed_reality:0.00
r_val:0 r_speed_reality:0.00 l_val:0 l_speed_reality:0.00

```

2) The data when motors stop

```

r_val:38 r_speed_reality:76.00 l_val:0 l_speed_reality:0.00
r_val:37 r_speed_reality:74.00 l_val:0 l_speed_reality:0.00
r_val:37 r_speed_reality:74.00 l_val:0 l_speed_reality:0.00
r_val:37 r_speed_reality:74.00 l_val:0 l_speed_reality:0.00
r_val:38 r_speed_reality:76.00 l_val:0 l_speed_reality:0.00
r_val:38 r_speed_reality:76.00 l_val:0 l_speed_reality:0.00

```

3) Data when right motor runs

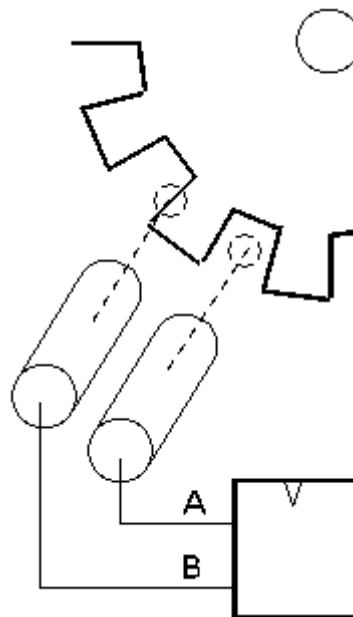
- ✚ You can change the speed(PWM) of motors in the code(this is not the real speed), thus to measure the real speed in different PWM. For example: calculate the number of times which the voltage change in 100ms, if 100 times changing, it means in 1s it will change

1000 times, and if the gear has 50 teeth, it will be run $1000/50=20$ circle in 1 second, just get the diameter of the wheel and you will know the real speed.

Principle

1. Encoder

It is easy to understand that two motors will run differently through they have the same power and the same parameter, takes your robot for example, if you make both of the motors run at the same PWM, the robot can not run exactly straightly. So we need to know the real speed of motors. Thus encoder comes here.



4) Encoder Principal

The principle of encoder is the same as the infrared line tracking sensor, it just output the state of whether it has gear teeth in front. And for, MCU, just calculate these data.

1. Interrupt

We have learned about interrupt, and the picture below shows which pin can be used as interrupt input of the number of interrupt in different kinds of Arduino boards.

Pin 2 in Uno or Mega2560 can be used as number 0 interrupt but in Leonardo it is Pin 3.

Board	int.0	int.1	int.2	int.3	int.4	int.5
Uno, Ethernet	2	3				
Mega2560	2	3	21	20	19	18
Leonardo	3	2	0	1	7	

5) Interrupt number and Pin number of different boards

Interrupt helps us do something in time, and it also receives several kinds of input for trigger:

LOW: when it has low input, trigger the interrupt

CHANGE: when the input change its voltage

RISING: when the input changes from low voltage to high voltage

FALLING: when the input changes from high voltage to low voltage

Interrupt function:

`attachInterrupt(interrupt, function, mode)`

interrupt: number of interrupt

function: the name of your function when interrupt was triggered, this function can't return or receive any parameters.

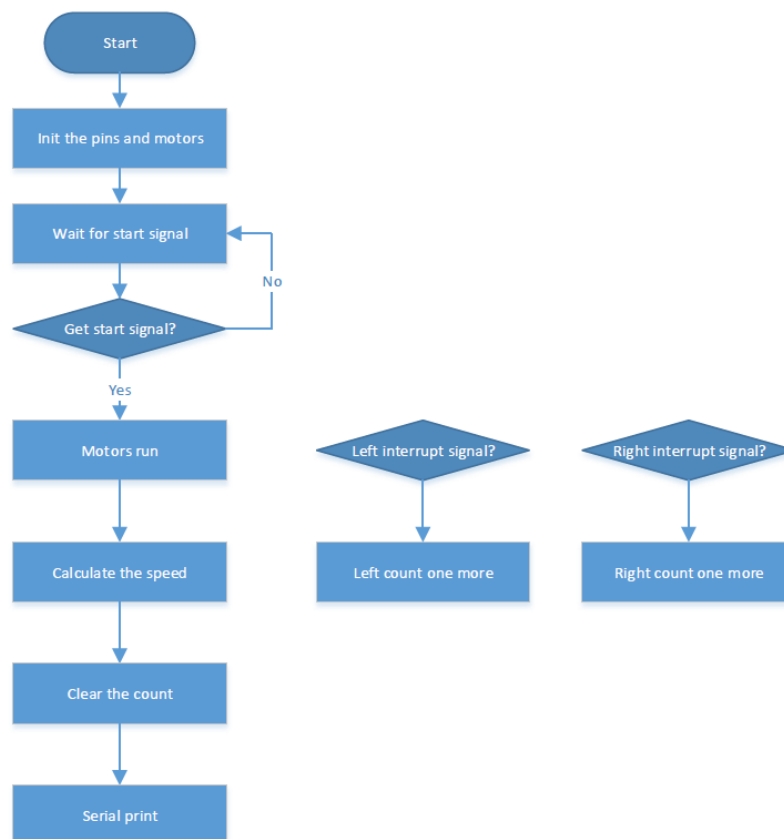
mode: Which kind of input can trigger the interrupt

For example:

`attachInterrupt(R, right_count , CHANGE);` //attach isr function

R=2, right_count is the function, CHANGE is the kind of trigger.

And notice that when interrupt function runs, the program in the loop will stop.



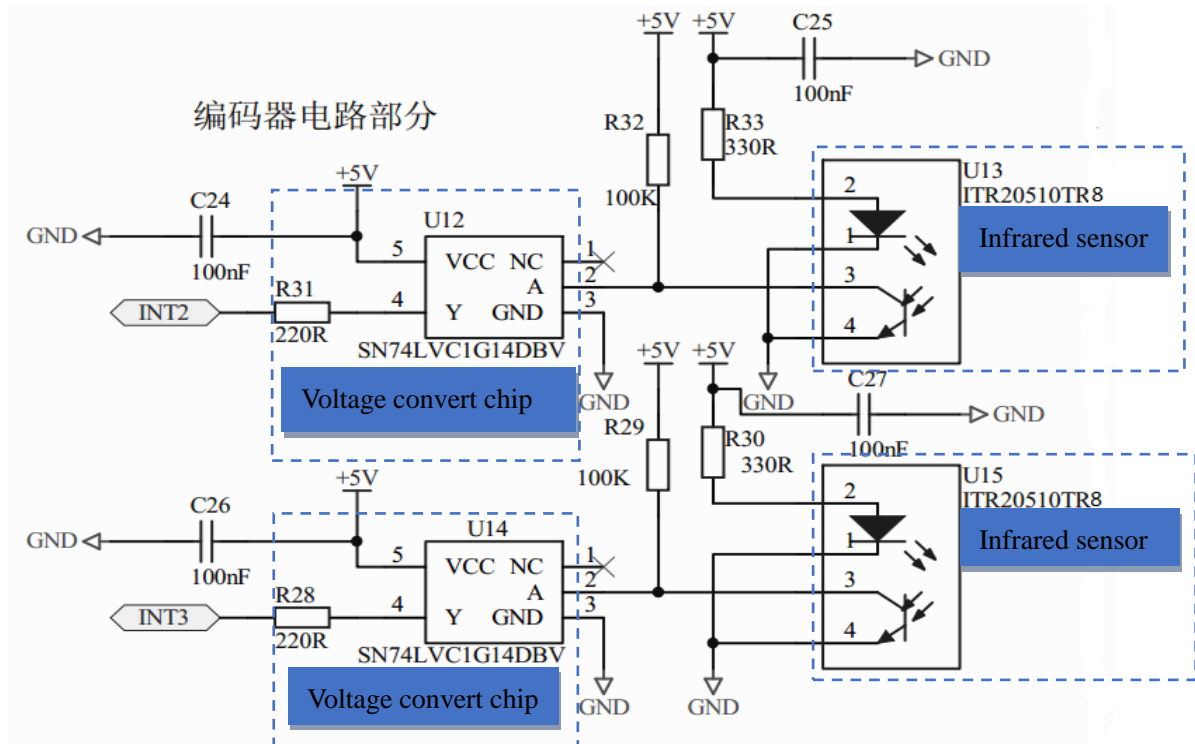
6) How does an encoder work

Encoder is widely used in many place, if you want to control your speed well, you can learn more about the arithmetic about PID or fuzzy.

Code Analysis

- Define the data about the interrupt
 - `attachInterrupt(R,right_count , CHANGE); //attach isr function`
 - `attachInterrupt(L,left_count, CHANGE); //attach isl function`
- Print the speed of right motor
 - `r_speed_reality=r_val/(time_step/1000);`
 - `Serial.print("r_val:");`
 - `Serial.print(r_val);`
 - `Serial.print("\t r_speed_reality:");`
 - `Serial.print(r_speed_reality);`
 - `// calculate speed`
- The interrupt function of the right motor
 - `void right_count()`
 - `{`
 - `//Serial.println("r");`
 - `r_val++;`
 - `}`

Circuit Design



7) Encoder circuit

The circuit is just use a chip SN74LVC1G14DBV to deal with the signal that infrared sensor gives, and transmit to Arduino. The chip can make the signal received from infrared sensor more stable.

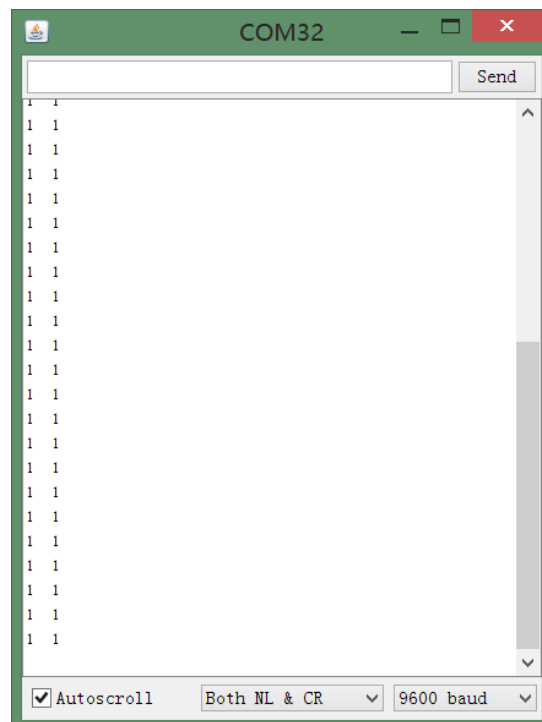
You may face these questions:

- ✚ The speed is always showing 0,
 - ◆ First, check the program, if someone changed your code, you need to get your precious one back.
 - ◆ If the first step didn't work, it is usually because of the location of the wheel, they didn't fit the infrared sensors well by transport or any other reasons. Now let's try to solve this problem.
 - ◆ Upload the code below to for print the value in computer:

```
void setup()
{
  pinMode(0,INPUT);//right encoder
  pinMode(1,INPUT);//left encoder
  Serial.begin(9600);//Serial initiation
}

void loop()
{
  int x=digitalRead(0);//Read the value of right encoder
  int y=digitalRead(1);//Read the value of left encoder
  Serial.print(x);//print the value through computer
  Serial.print(" ");
  Serial.println(y);
  delay(500);
}
```

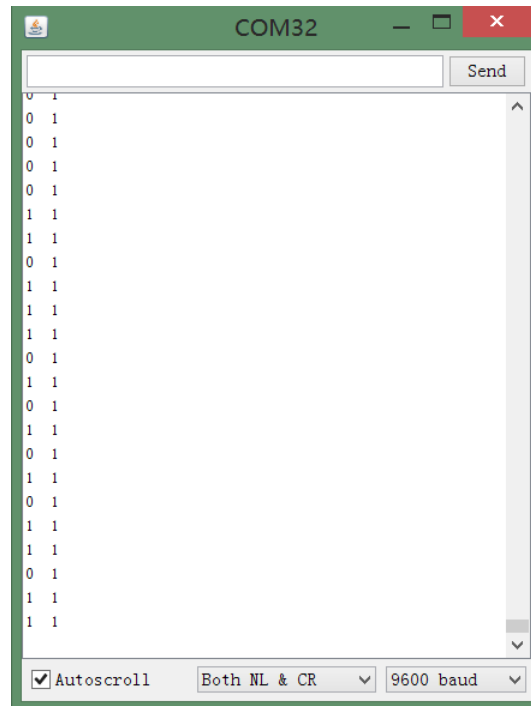
- ◆ Open the serial monitor and you will see:



8) Unchanged value

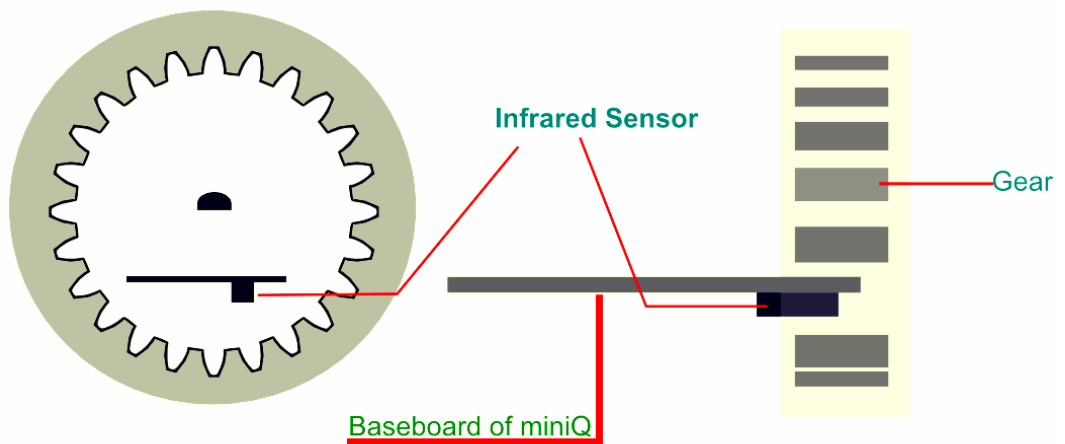
◆ Adjust the location of wheel

Pull out or push into the wheel a little, then turn the wheel, if you see the value changes, the situation is OK:



9) The left side is OK

Generally the location is where the wheel starts to meet the sensor:



10) The location of IR sensor

When value is always 1, it means the sensor can always detect a body, you should pull the wheel out a little.

◆ Now download speed.ino, and try to understand it!

Extension

PID controller:

<http://www.google.com.hk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&ved=0>

[CDUQFjAB&url=%68%74%74%70%3a%2f%2f%65%6e%2e%77%69%6b%69%70%65%64%69%61%2e%6f%72%67%2f%77%69%6b%69%2f%50%49%44%5f%63%6f%6e%74%72%6f%6c%6c%65%72&ei=oTWIU_-KNcfd8AW2tIGgBg&usg=AFQjCNGE0CT5nT-S7CLC-LuvB4iawq5TlIQ&bvm=bv.67720277,d.dGc&cad=rjt](http://www.google.com.hk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CCoQFjAA&url=%2F68%74%70%3a%2F65%6e%2e%77%69%6b%69%70%65%64%69%61%2e%6f%72%67%2f77%69%6b%69%2f50%49%44%5f%63%6f%6e%74%72%6f%6c%6c%65%72&ei=oTWIU_-KNcfd8AW2tIGgBg&usg=AFQjCNGE0CT5nT-S7CLC-LuvB4iawq5TlIQ&bvm=bv.67720277,d.dGc&cad=rjt)

Fuzzy control:

[http://www.google.com.hk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CCoQFjAA&url=%68%74%74%70%3a%2f%2f%65%6e%2e%77%69%6b%69%70%65%64%69%61%2e%6f%72%67%2f%77%69%6b%69%2f%46%75%7a%7a%79%5f%63%6f%6e%74%72%6f%6c%5f%73%79%73%74%65%6d&ei=xjWlU5ioL8-58gW4wYGwDA&usg=AFQjCNFFoUY-3ym1h1JSNW70rCxHaDIuWg&bvm=bv.67720277,d.dGc&cad=rjt](http://www.google.com.hk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CCoQFjAA&url=%2F68%74%74%70%3a%2f%2f%65%6e%2e%77%69%6b%69%70%65%64%69%61%2e%6f%72%67%2f%77%69%6b%69%2f%46%75%7a%7a%79%5f%63%6f%6e%74%72%6f%6c%5f%73%79%73%74%65%6d&ei=xjWlU5ioL8-58gW4wYGwDA&usg=AFQjCNFFoUY-3ym1h1JSNW70rCxHaDIuWg&bvm=bv.67720277,d.dGc&cad=rjt)