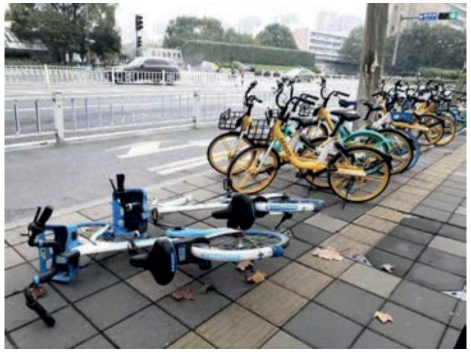
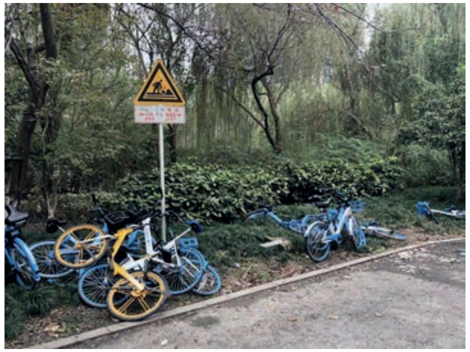
December 2020

IoT Product Solution to Solve the Problem of Shared Bicycles Falling Down

Research & Problem

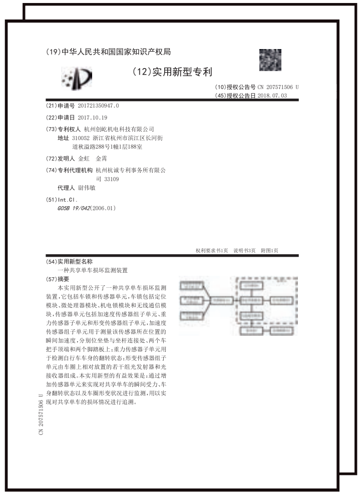
Primary Research





Secondary Research

Patent



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(12)实用新型专利

(10)授权公告号 CN 207571506 U
(45)授权公告日 2018.07.03

(21)申请号 201721350947.0

(22)申请日 2017.10.19

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(51)Int.Cl.
G05B 19/042(2006.01)

权利要求书1页 说明书3页 附图1页

(54)实用新型名称
一种共享单车损坏监测装置

(57)摘要
本实用新型公开了一种共享单车损坏监测装置，它包括车锁和传感器单元，车锁包括定位模块、微处理器模块、机电锁模块和无线通信模块，传感器单元包括加速度传感器组子单元、重力传感器子单元和形变传感器组子单元，加速度传感器组子单元用于测量该传感器所在位置的瞬间加速度，分别位坐垫与坐杆连接处、两个车把手顶端和两个脚踏板上；重力传感器子单元用于检测自行车车身的翻转状态；形变传感器组子单元由车圈上相对放置的若干组光发射器和光接收器组成。本实用新型的有益效果是：通过增加传感器单元来实现对共享单车的瞬间受力、车身翻转状态以及车圈形变状况进行监测，用以实现对共享单车的损坏情况进行追溯。

CN 207571506 U

A shared bicycle damage detection device

Date: 2017.10.19
Author: Hong Jin, Xiao Jin

3 sensors:
Accelerometer, Gravity sensor, Deformation sensor
Flow chart:
Sensors detect changes && CPU determines abnormal state → Obtain time, loction by GPS/BDS → Server retrieves time, location, abnormal bike image → Trace bike damage, retain evidence.

Problem statement

The fallen shared-bikes are in the corner of the city. People are coming and going. But they are still on the ground no matter they are broken or not. Some are lying in a remote corner of the city, some shared-bikes are hidden in the grass. The reasons for this phenomenon may be human factors or natural factors. Some people throw bike sharing into the corner for their own benefit. Of course, natural factors such as strong winds can also cause bicycle fallen.

Sensors

Detect whether the shared bicycle has fallen down

Accelerometer

AC-response

DC-response

Gyroscope

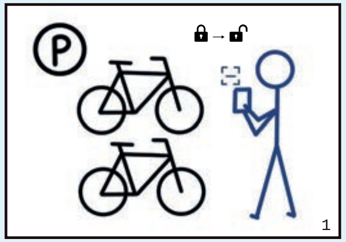
Rotary type
big, hard to get

Vibrating type
small, MEMS device

Optical type
big, expensive,
more acurrate,

Proposal

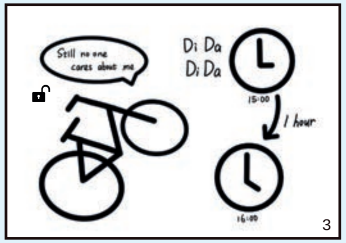
Unlocked Bike



User unlocked the shared bike

I fall down!
2

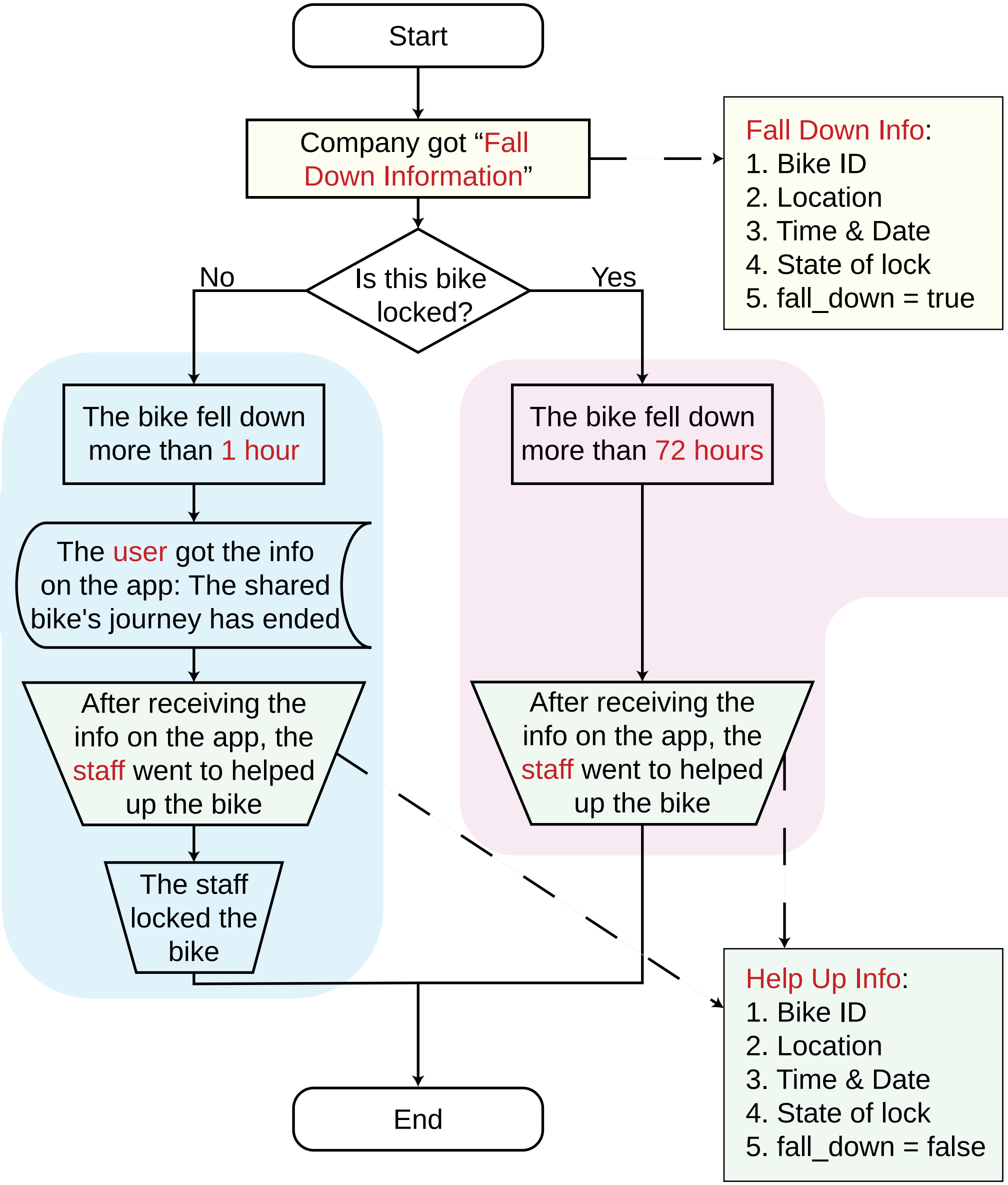
The bike sent info to sever



After an hour

I was helped up
4

Staff helped bike up



Start

Company got "Fall Down Information"

Fall Down Info:
1. Bike ID
2. Location
3. Time & Date
4. State of lock
5. fall_down = true

Is this bike locked?

No

The bike fell down more than 1 hour

The user got the info on the app: The shared bike's journey has ended

After receiving the info on the app, the staff went to helped up the bike

The staff locked the bike

Yes

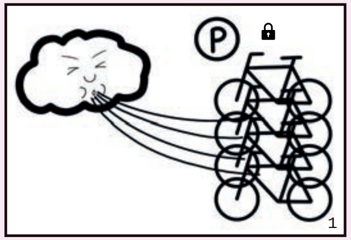
The bike fell down more than 72 hours

After receiving the info on the app, the staff went to helped up the bike

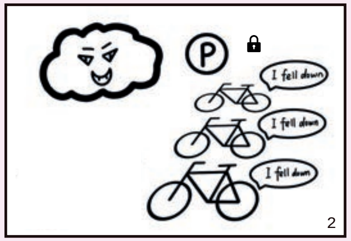
Help Up Info:
1. Bike ID
2. Location
3. Time & Date
4. State of lock
5. fall_down = false

End

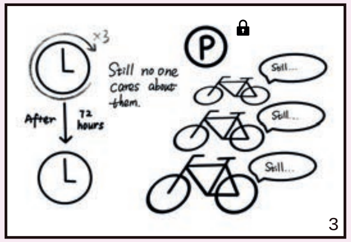
Locked Bike



Shared bikes were blown down



Bikes sent messages to sever

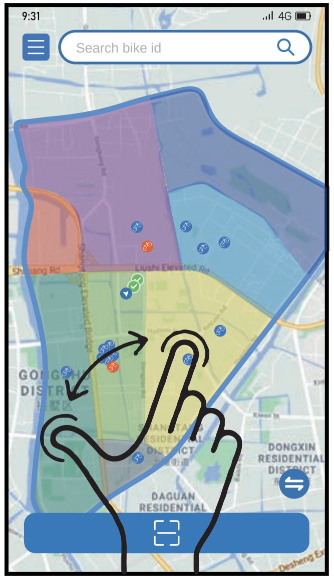


After 72 hours

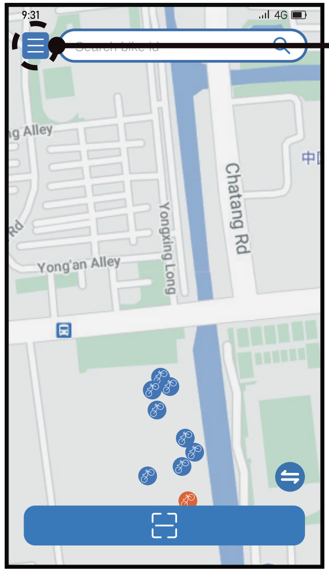
I was helped up
4

The staff propped bike up

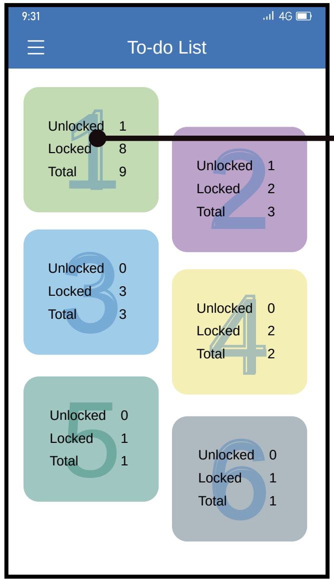
Interface Design for Staff



Responsible area interface



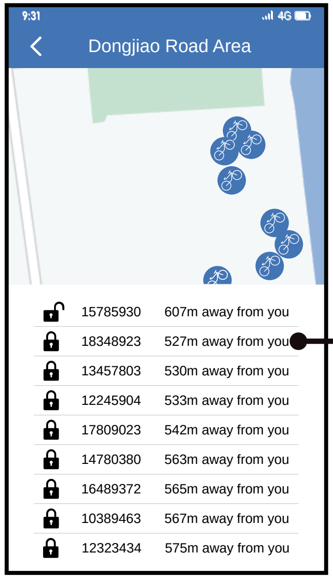
Zoom interface



To-do List

	Unlocked	Locked	Total
1	1	8	9
2	1	2	3
3	0	3	3
4	0	2	2
5	0	1	1
6	0	1	1

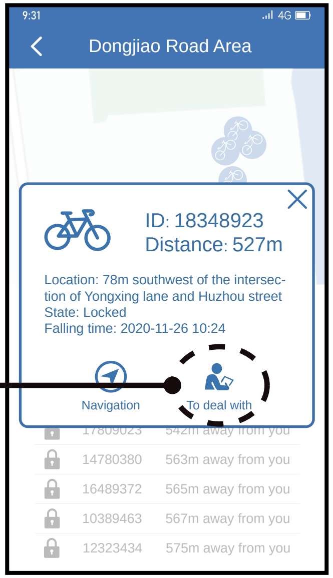
To-do List interface



Dongjiao Road Area

🔓	15785930	607m away from you
🔒	18348923	527m away from you
🔒	13457803	530m away from you
🔒	12245904	533m away from you
🔒	17809023	542m away from you
🔒	14780380	563m away from you
🔒	16489372	565m away from you
🔒	10389463	567m away from you
🔒	12323434	575m away from you

Area details



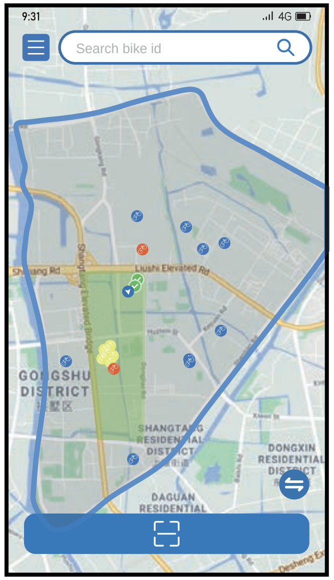
Dongjiao Road Area

ID: 18348923
Distance: 527m

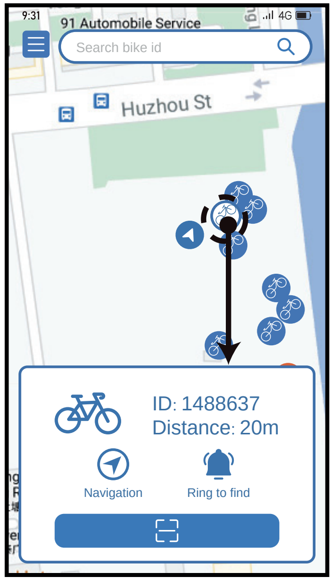
Location: 78m southwest of the intersection of Yongxing lane and Huzhou street
State: Locked
Falling time: 2020-11-26 10:24

🔒	17809023	542m away from you
🔒	14780380	563m away from you
🔒	16489372	565m away from you
🔒	10389463	567m away from you
🔒	12323434	575m away from you

Bike state details



Working area



ID: 1488637
Distance: 20m

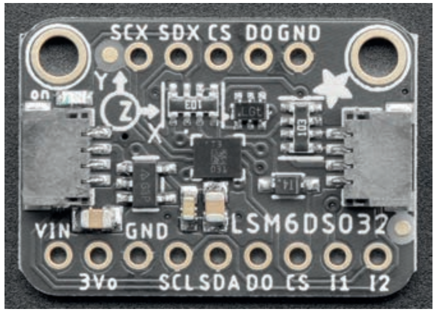
Pop up after clicking on one bike

Interpretations of Icon

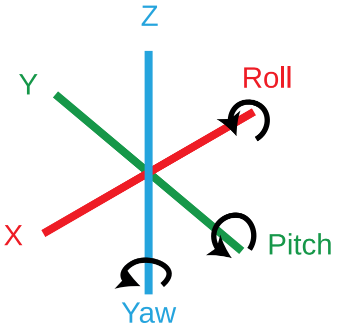
- Responsible area of staff
- Locked fallen shared-bike
- Unlocked fallen shared-bike
- Shared-bike being processed by staff
- Staff's location
- Processed shared bicycles
- Switch to display only unprocessed shared bicycles

Solution feasibility

6-DoF motion tracking module ≈ $11

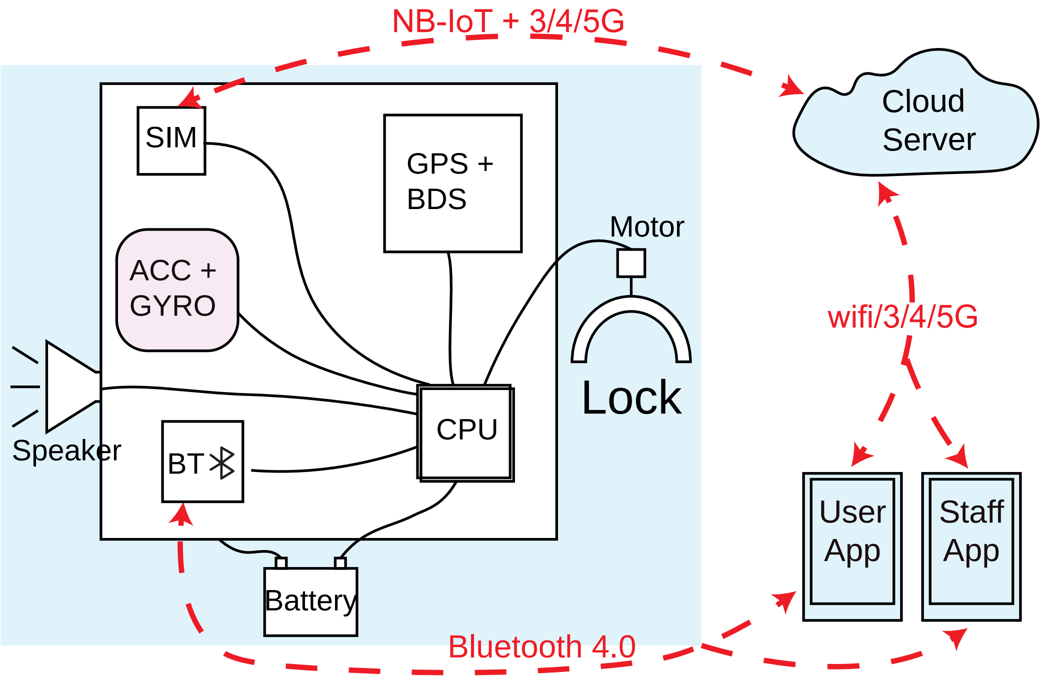


3 axis capacitive Accelerometer
3 axis vibrating Gyroscope



Detect changes:
motion, orientation, angles

Lock structure and IoT connection



NB-IoT + 3/4/5G

SIM

GPS + BDS

ACC + GYRO

Motor

Lock

CPU

Speaker

BT

Battery

Cloud Server

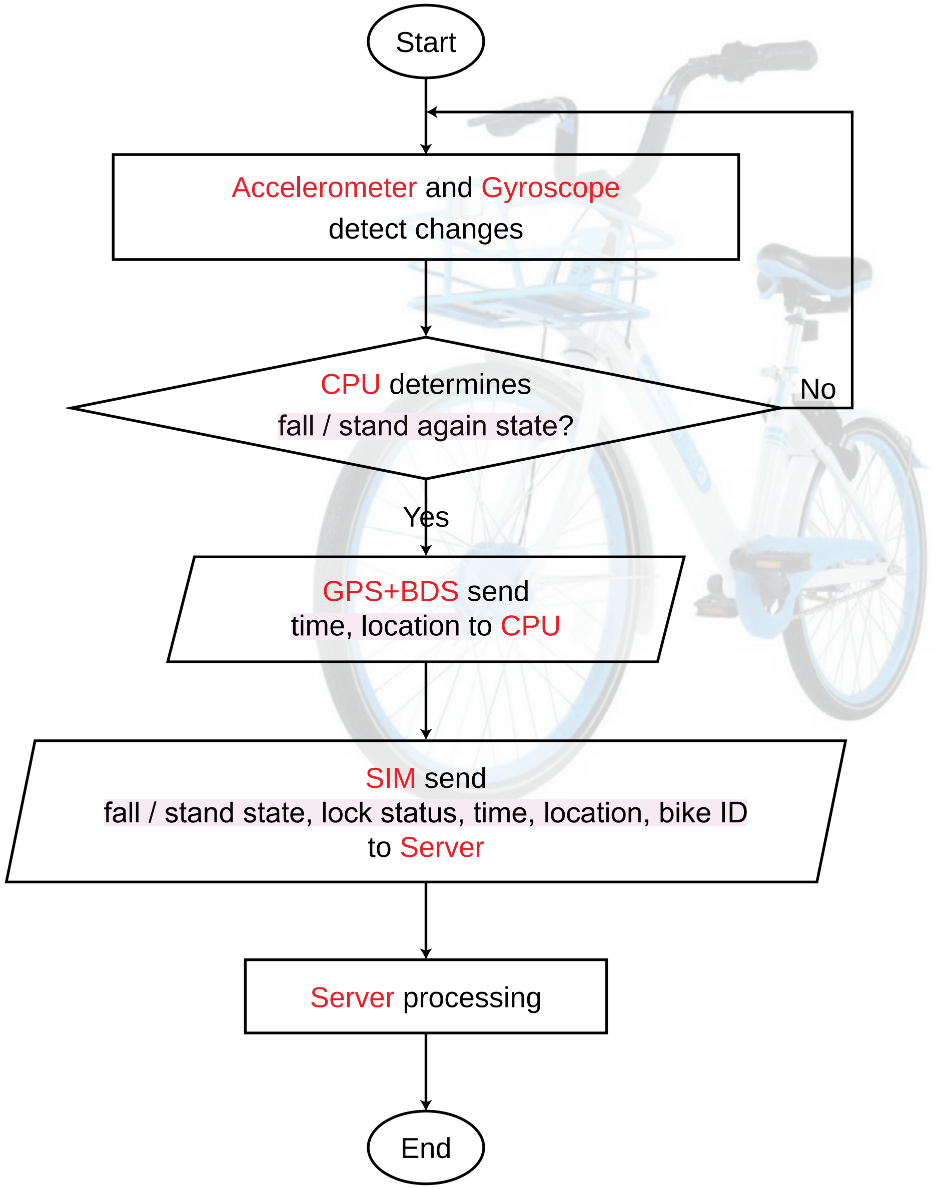
wifi/3/4/5G

User App

Staff App

Bluetooth 4.0

Detection and transmission of bike status



Start

Accelerometer and Gyroscope detect changes

CPU determines fall / stand again state?

No

Yes

GPS+BDS send time, location to CPU

SIM send fall / stand state, lock status, time, location, bike ID to Server

Server processing

End

Experiment and Tools

Sensor

Triple Axis Acceleromter

Actuator

Red LED Light:

Light on simulate that server has received bike falling down information.

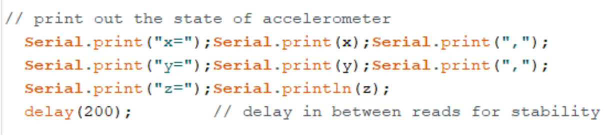
Processor

DFRobot UNO R3 (Arduino board)
Adobe I/O Expansion Shield

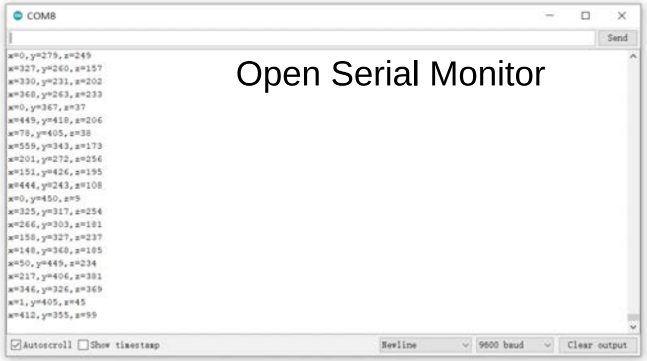
Other

USB data cable
PH2.0 Jumper Wire

Experiment and Arduino Code



```
// print out the state of accelerometer
  Serial.print("x=");Serial.print(x);Serial.print(",");
  Serial.print("y=");Serial.print(y);Serial.print(",");
  Serial.print("z=");Serial.println(z);
  delay(200);         // delay in between reads for stability
```



```
x=0,y=279,z=249
x=327,y=260,z=157
x=330,y=231,z=202
x=368,y=263,z=233
x=0,y=367,z=37
x=449,y=418,z=206
x=78,y=405,z=38
x=559,y=343,z=173
x=201,y=272,z=256
x=151,y=426,z=195
x=444,y=243,z=108
x=0,y=450,z=9
x=325,y=317,z=254
x=266,y=303,z=181
x=158,y=327,z=237
x=148,y=368,z=185
x=50,y=449,z=234
x=217,y=406,z=381
x=346,y=326,z=369
x=1,y=405,z=45
x=412,y=355,z=99
```

☑ Autoscroll □ Show timestamp

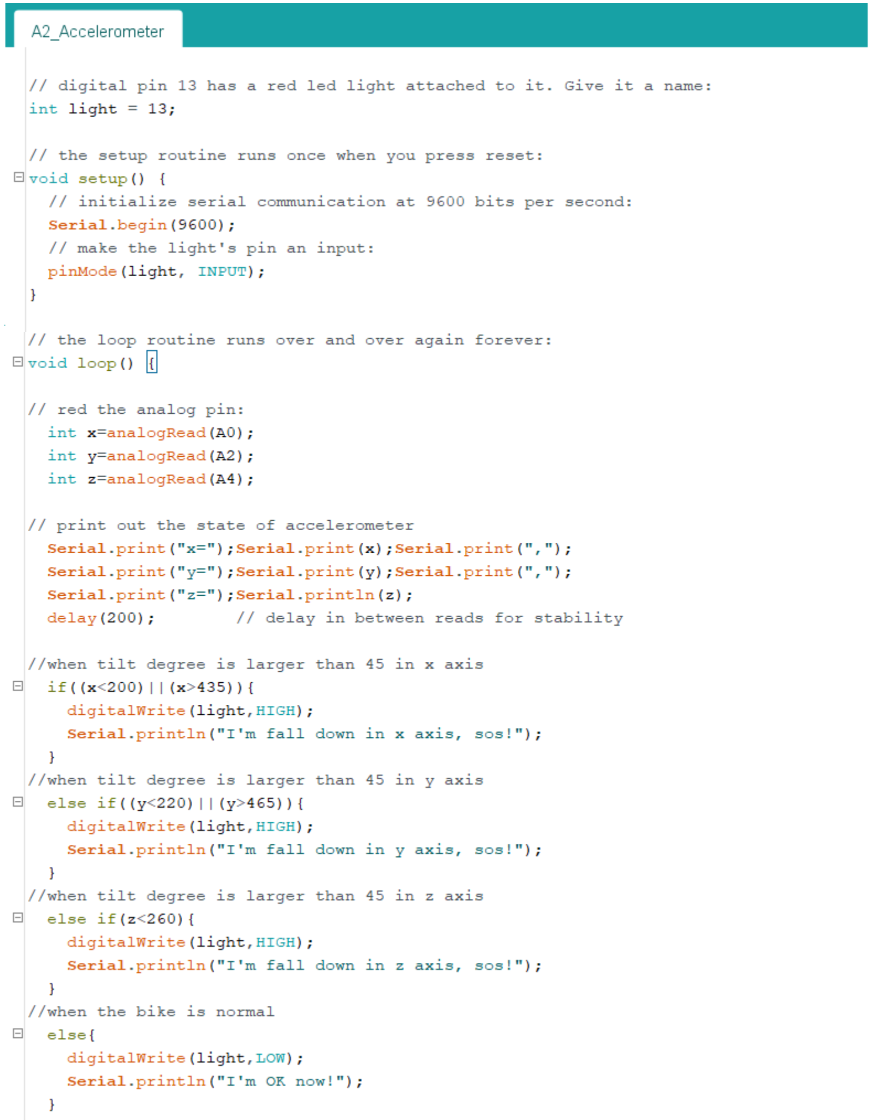
Open Serial Monitor

When accelerometer detects that bicycle tilt angle **> 45 degrees**, the system judges it fell down.

Annotate:

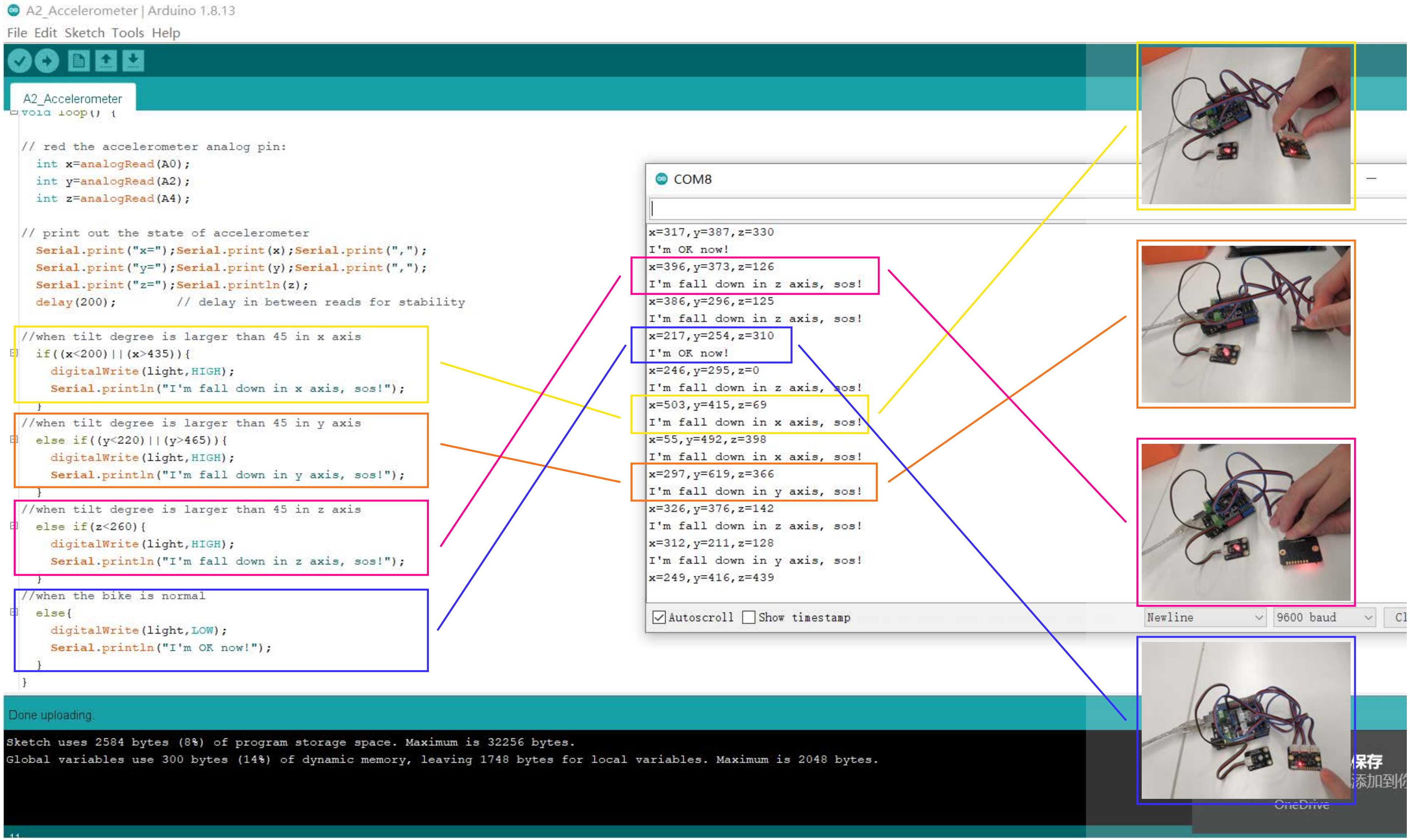
//normal x≈330, y≈345, z≈420
//x -90°≈165; 90°≈490; -45°≈200; 45°≈435
//y -90°≈185; 90°≈505; -45°≈220; 45°≈465
//z ±180°≈100; ±90°≈260; ±45°≈360

Entire Code



```
// digital pin 13 has a red led light attached to it. Give it a name:
int light = 13;

// the setup routine runs once when you press reset:
void setup() {
  // initialize serial communication at 9600 bits per second:
  Serial.begin(9600);
  // make the light's pin an input:
  pinMode(light, INPUT);
}

// the loop routine runs over and over again forever:
void loop() {

// red the analog pin:
  int x=analogRead(A0);
  int y=analogRead(A2);
  int z=analogRead(A4);

// print out the state of accelerometer
  Serial.print("x=");Serial.print(x);Serial.print(",");
  Serial.print("y=");Serial.print(y);Serial.print(",");
  Serial.print("z=");Serial.println(z);
  delay(200);         // delay in between reads for stability

//when tilt degree is larger than 45 in x axis
  if((x<200)||(x>435)){
    digitalWrite(light,HIGH);
    Serial.println("I'm fall down in x axis, sos!");
  }
//when tilt degree is larger than 45 in y axis
  else if((y<220)||(y>465)){
    digitalWrite(light,HIGH);
    Serial.println("I'm fall down in y axis, sos!");
  }
//when tilt degree is larger than 45 in z axis
  else if(z<260){
    digitalWrite(light,HIGH);
    Serial.println("I'm fall down in z axis, sos!");
  }
//when the bike is normal
  else{
    digitalWrite(light,LOW);
    Serial.println("I'm OK now!");
  }
```

Experiment and Proof


A2_Accelerometer | Arduino 1.8.13
File Edit Sketch Tools Help
A2_Accelerometer
COM8
☑ Autoscroll ☐ Show timestamp
Cl
保存
添加到你
OneDrive

```
void loop() {

 // red the accelerometer analog pin:
   int x=analogRead(A0);
   int y=analogRead(A2);
   int z=analogRead(A4);

 // print out the state of accelerometer
   Serial.print("x=");Serial.print(x);Serial.print(",");
   Serial.print("y=");Serial.print(y);Serial.print(",");
   Serial.print("z=");Serial.println(z);
   delay(200);          // delay in between reads for stability

 //when tilt degree is larger than 45 in x axis
   if((x<200)||(x>435)){
     digitalWrite(light,HIGH);
     Serial.println("I'm fall down in x axis, sos!");
   }
 //when tilt degree is larger than 45 in y axis
   else if((y<220)||(y>465)){
     digitalWrite(light,HIGH);
     Serial.println("I'm fall down in y axis, sos!");
   }
 //when tilt degree is larger than 45 in z axis
   else if(z<260){
     digitalWrite(light,HIGH);
     Serial.println("I'm fall down in z axis, sos!");
   }
 //when the bike is normal
   else{
     digitalWrite(light,LOW);
     Serial.println("I'm OK now!");
   }
}
```

```
x=317,y=387,z=330
I'm OK now!
x=396,y=373,z=126
I'm fall down in z axis, sos!
x=386,y=296,z=125
I'm fall down in z axis, sos!
x=217,y=254,z=310
I'm OK now!
x=246,y=295,z=0
I'm fall down in z axis, sos!
x=503,y=415,z=69
I'm fall down in x axis, sos!
x=55,y=492,z=398
I'm fall down in x axis, sos!
x=297,y=619,z=366
I'm fall down in y axis, sos!
x=326,y=376,z=142
I'm fall down in z axis, sos!
x=312,y=211,z=128
I'm fall down in y axis, sos!
x=249,y=416,z=439
```

Newline 9600 baud

Done uploading.

```
Sketch uses 2584 bytes (8%) of program storage space. Maximum is 32256 bytes.
Global variables use 300 bytes (14%) of dynamic memory, leaving 1748 bytes for local variables. Maximum is 2048 bytes.
```