

密级状态: 绝密() 秘密() 内部() 公开(√)

RK3399 VR Sensor 开发指南

(系统产品二部)

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版本历史

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V0.1	lyx	2016-10-24	V0.1	



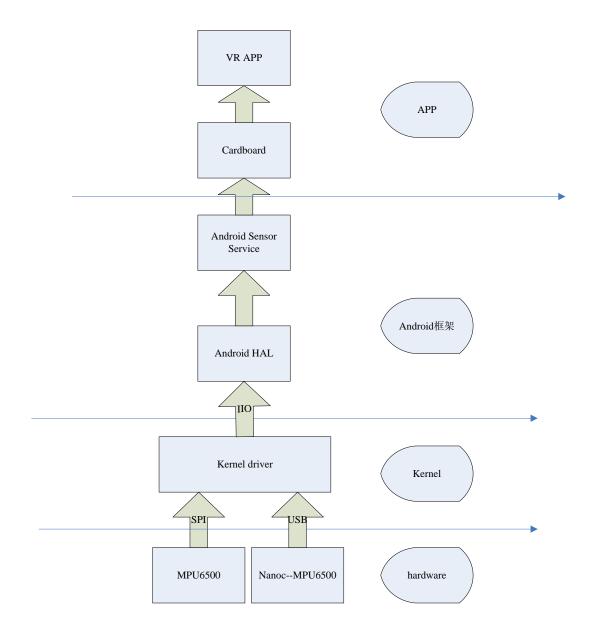
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1 代码架构:

RK VR sensor 目前只支持 MPU6500 这颗陀螺仪; 代码架构也是基于 mpu6500 的。





2 Sensor 代码配置:

```
1) Dts
   一体机配置:
   使用 SPI 接口:
   &spi1 {
        status = "okay";
        max-freq = <50000000>;
         pinctrl-names = "default", "sleep";
         pinctrl-1 = <&spi1 gpio>;
        mpu6500@0 {
             status = "okay";
             compatible = "inv-spi,mpu6500";
             pinctrl-names = "default";
             pinctrl-0 = <&mpu6500_irq_gpio>;
             irq-gpio = <&gpio1 4 IRQ_TYPE_EDGE_RISING>;
             reg = <0>;
             spi-max-frequency = <1000000>;
             spi-cpha;
             spi-cpol;
             mpu-int_config = <0x00>;
             mpu-level shifter = <0>;
             mpu-orientation = <1 0 0 0 1 0 0 0 1>;
             orientation-x= <1>;
             orientation-y= <0>;
             orientation-z= <1>;
             support-hw-poweroff = <1>;
             mpu-debug = <1>;
        };
   };
   使用 I2C 接口:
   &i2c4 {
        status = "okay";
        i2c-scl-rising-time-ns = <345>;
        i2c-scl-falling-time-ns = <11>;
        clock-frequency = <400000>;
```



};

```
mpu6500@68 {
         status = "okay";
         compatible = "invensense,mpu6500";
         pinctrl-names = "default";
         pinctrl-0 = <&mpu6500 irq gpio>;
         reg = <0x68>;
         irq-gpio = <&gpio2 27 IRQ TYPE EDGE RISING>;
         mpu-int config = <0x10>;
         mpu-level shifter = <0>;
         mpu-orientation = <1 0 0 0 1 0 0 0 1>;
         orientation-x= <1>;
         orientation-y= <1>;
         orientation-z= <0>;
         support-hw-poweroff = <1>;
         mpu-debug = <1>;
     };
     sensor@0d { //compass 目前都是使用 i2c 接口
         status = "okay";
         compatible = "ak8963";
         pinctrl-names = "default";
         pinctrl-0 = <&ak8963 irq gpio>;
         reg = <0x0d>;
         type = <SENSOR_TYPE_COMPASS>;
         irq-gpio = <&gpio2 28 IRQ TYPE EDGE RISING>;
         irq_enable = <0>;
         poll delay ms = <30>;
         layout = <3>;
     };
&pinctrl {
     mpu6500 {
         mpu6500_irq_gpio: mpu6500-irq-gpio {
             rockchip,pins = <1 4 RK FUNC GPIO &pcfg pull none>;
         };
     };
     ak8963 {
         ak8963_irq_gpio: ak8963-irq-gpio {
             rockchip,pins = <2 28 RK FUNC GPIO &pcfg pull none>;
```

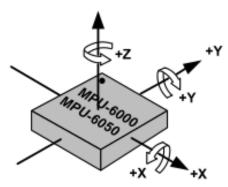


```
};
};
}
分体机配置:
mpu6500_hid {
status = "okay";
compatible = "inv-hid,mpu6500";
};
```

2) 方向配置说明:

mpu-orientation = <1 0 0 0 1 0 0 0 1>; //3x3 的矩阵,用于表示 x,y,z 轴的交换。

```
orientation-x= <1>; //代表取反 orientation-y= <0>; orientation-z= <1>; 请根据实际的 layout 配置。
```



Orientation of Axes of Sensitivity and Polarity of Rotation



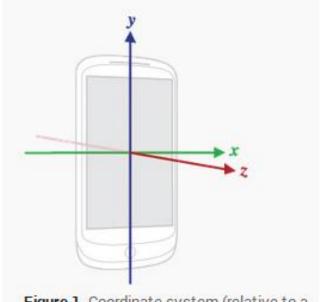
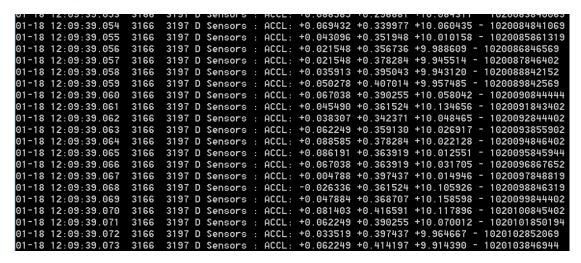


Figure 1. Coordinate system (relative to a device) that's used by the Sensor API.

如果你的 sensor 已经工作,可以正常上报数据,也可以通过数据来确定这个方向。依据是:某个轴的正方向与重力方向相反时,该轴的 gsensor 数据为+9.81 m/s²⁻ 其他轴为 0。

如下是屏幕向上,水平放置时的 gsensor 数据,此时 Z 轴为+9.81 左右,其他轴接近 0。



3 Sensor 功能确认

1) mpu6500 驱动是否加载 OK。

开机 log 打印:

成功的 log:[3.183472] inv_mpu_iio_spi spi32766.0: mpu6500 is ready to go! 失败的话会有相应错误 log 提示,可能是 gpio 申请失败,中断申请失败,spi/i2c 通信错误等。

5



设备节点:

Is -I /sys/bus/iio/devices/iio:device0

```
ls -1
rw-rw---- system
                       sustem
                                      4096 2013-01-18 11:52 accl_enable
 rw-rw---- system
                                     4096 2013-01-18 11:52 accl_matrix
                       system
drwxr-xr-x root
                       root
                                           2013-01-18 11:52 buffer
                                      4096 2013-01-18 11:53 dev
   -r--r-- root
                       root
                       system
                                     4096 2013-01-18 11:52 display_orientation_on
            system
                                     4096 2013-01-18 11:52 dmp_event_int_on
4096 2013-01-18 11:52 dmp_firmware
4096 2013-01-18 11:52 dmp_int_on
rw-rw---- system
                      system
 rw-rw---- system
                       system
 rw-rw---- system
                      system
 rw-rw---- system
                                     4096 2013-01-18 11:52 dmp_on
                       system
 rw-rw---- system
                       system
                                      4096 2013-01-18 11:52 dmp_output_rate
   -r--r-- root
                                      4096 2013-01-18 11:53 event_accel_motion
                       root
 rw-rw---- system
                       system
                                     4096 2013-01-18 11:52 event_display_orientation
                                      4096 2013-01-18 11:52 event_smd
 rw-rw---- system
                      system
                                     4096 2013-01-18 11:52 firmware_loaded
 rw-rw---- system
                       system
 rw-rw---- system
                                     4096 2013-01-18 11:52 gyro_enable
                       system
 rw-rw---- system
                                     4096 2013-01-18 11:52 gyro_matrix
                       system
                                     4096 2013-01-18 11:52 in_accel_scale
4096 2013-01-18 11:53 in_accel_x_calibbias
 rw-rw---- system
                       system
 rw-r--r-- root
                       root
            system
                       system
                                     4096 2013-01-18 11:52 in_accel_x_offset
                                     4096 2013-01-18 11:53 in_accel_y_calibbias
4096 2013-01-18 11:52 in_accel_y_offset
     --r-- root
                       root
            system
                       system
                                      4096 2013-01-18 11:53 in_accel_z_calibbias
            root
                       root
                                     4096 2013-01-18 11:52 in_accel_z_offset
4096 2013-01-18 11:52 in_angluel_scale
4096 2013-01-18 11:53 in_angluel_x_calibbias
                      system
            system
            system
                       system
           root
                       root
                                      4096 2013-01-18 11:53 in_anglvel_y_calibbias
            root
                       root
                                      TUGE
```

如果没有加载成功,请确认 dts 配置和开机 log 确认问题点。

2) Hal 层是否正常工作:

logcat -s Sensors, 正常 log 如下:

```
int open_sensors(const hw_module_tx, const charx, hw_device_txx)

Sensor HAL version: 1.18

dev_name=(null), data_name=(null), data_fd=-1

path open /dev/compass, data_name=compass, data_fd=48

couldn't find 'lightsensor-level' input device

dev_name=/dev/lightsensor, data_name=lightsensor-level, data_fd=-1

couldn't find 'proximity' input device

dev_name=/dev/psensor, data_name=proximity, data_fd=-1

Couldn't open /dev/psensor (No such file or directory)

dev_name=(null), data_name=(null), data_fd=-1

HAL:Could not open or load MPL calibration file (46)

Entered : handle = 0x3, en = 0x0.

newState = 0x0, what = 0x0, mEnabled = 0x0.

to exit : mEnabled = 0x0.

compass poll fd=48

int sensors_poll_context_t::activate(int, int)

int sensors_poll_context_t::activate(int, int)
  91-18 11:52:47.429
91-18 11:52:47.429
91-18 11:52:47.429
                                                                                                                                                                                                                           int open_sensors(const hw_module_t*, const char*, hw_device_t**)
                                                                                                          486
                                                                                                                                        486 D
                                                                                                                                                                      Sensors
01-18 11:52:47.429
01-18 11:52:47.429
01-18 11:52:47.429
01-18 11:52:47.429
01-18 11:52:47.429
01-18 11:52:47.429
01-18 11:52:47.429
01-18 11:52:47.429
01-18 11:52:47.429
01-18 11:52:47.429
01-18 11:52:47.595
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
01-18 11:52:47.596
                                                                                                                                         486 D Sensors
                                                                                                          486
                                                                                                                                       486 I Sensors
486 D Sensors
                                                                                                          486
                                                                                                                                        486 E Sensors
486 D Sensors
                                                                                                          486
                                                                                                                                       486 E Sensors
486 D Sensors
486 E Sensors
                                                                                                          486
                                                                                                          486
                                                                                                          486
                                                                                                          486
                                                                                                                                         486 D Sensors
                                                                                                                                        486 E Sensors :
                                                                                                          486
                                                                                                                                        486 D Sensors
486 I Sensors
                                                                                                          486
                                                                                                          486
                                                                                                                                       486 D Sensors :
486 D Sensors :
486 D Sensors :
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                                                                                                          486
                                                                                                          486
                                                                                                          486
                                                                                                                                         486 D Sensors
                                                                                                                                       486 D Sensors
486 D Sensors
                                                                                                          486
                                                                                                          486
                                                                                                                                         486 D Sensors
                                                                                                          486
                                                                                                                                       486 D Sensors
486 D Sensors
      1-18
                           11:52:47.596
                                                                                                          486
   01-18 11:52:47.596
01-18 11:52:47.596
                                                                                                         486
486
                                                                                                                                         486 D Sensors
     1-18 11:52:47.596
                                                                                                          486
                                                                                                                                         486
                                                                                                                                                                       Sensors
  91-18 11:52:50.302
91-18 11:52:50.417
91-18 11:52:50.417
                                                                                                          486
                                                                                                                                       625 D Sensors
                                                                                                                                       625 D
625 D
                                                                                                          486
                                                                                                                                                                       Sensors
                                                                                                                                                                       Sensors
                                                                                                          486
                            11:52:50.534
11:52:50.685
                                                                                                                                                                                                                          int sensors_poll_context_t::activate(int, int)
int sensors_poll_context_t::setDelay(int, int64_t)
                                                                                                          486
```

如果 hal 层工作不正常,请确认 sensor 驱动是否正常加载,设备节点权限是否足够。



4 数据正确性判断

1) Gsensor

某个轴的正方向与重力方向相反时,该轴的 gsensor 数据为+9.81 m/s² 其他轴为 0。如机器水平放置在桌面上,一般是 Z 轴的数据为+9.81。

```
01-18 12:09:39.054
                               3197 D Sensors :
                                                   ACCL: +0.069432 +0.339977
                                                                                                  1020084841069
01-18 12:09:39.055
01-18 12:09:39.056
                                                   ACCL: +0.043096 +0.351948 +10.010158
                        3166
                               3197 D Sensors
                                                                                                  1020085861319
                        3166
                              3197 D Sensors
                                                   ACCL: +0.021548 +0.356736 +9.988609
                                                                                                 1020086846569
                               3197 D Sensors
                                                   ACCL: +0.021548 +0.378284 +9.945514
01-18 12:09:39.057
                       3166
                                                                                                 1020087846402
                                                   ACCL: +0.035913 +0.395043 +9.943120
ACCL: +0.050278 +0.407014 +9.957485
01-18 12:09:39.058
01-18 12:09:39.059
                                                                                                 1020088842152
                       3166
                               3197 D Sensors
                                                                                                 1020089842569
                               3197 D Sensors
                        3166
                                                   ACCL: +0.067038 +0.390255 +10.058042
ACCL: +0.045490 +0.361524 +10.134656
01-18 12:09:39.060
                               3197 D Sensors
                                                                                                  1020090844444
                        3166
                               3197 D Sensors
01-18 12:09:39.061
                                                                                                  1020091843402
                        3166
                                                   ACCL: +0.038307 +0.342371 +10.048465
ACCL: +0.062249 +0.359130 +10.026917
                               3197 D Sensors
01-18 12:09:39.062
                        3166
                                                                                                  1020092844402
01-18 12:09:39.063
                        3166
                               3197 D Sensors
                                                                                                  1020093855902
01-18 12:09:39.064
                        3166
                               3197 D Sensors
                                                   ACCL: +0.088585 +0.378284 +10.022128
                                                                                                  1020094846402
01-18 12:09:39.065
                               3197 D Sensors
                                                   ACCL: +0.086191 +0.363919 +10.012551
                                                                                                  1020095845944
                        3166
01-18 12:09:39.066
                        3166
                               3197 D Sensors
                                                   ACCL: +0.067038 +0.363919 +10.031705
                                                                                                  1020096867652
01-18 12:09:39.067
                        3166
                               3197 D Sensors
                                                   ACCL: +0.004788 +0.397437 +10.014946
                                                                                                  1020097848819
                               3197 D Sensors
                                                   ACCL: -0.026336 +0.361524 +10.105926
                                                                                                  1020098846319
01-18 12:09:39.068
                        3166
                                                   ACCL: +0.047884 +0.368707 +10.158598
ACCL: +0.081403 +0.416591 +10.117896
01-18 12:09:39.069
                        3166
                               3197 D Sensors
                                                                                                  1020099844402
01-18 12:09:39.070
                                                                                                  1020100845402
                        3166
                               3197 D Sensors
                                                   ACCL: +0.062249 +0.390255 +10.070012 - 102010185019
ACCL: +0.033519 +0.397437 +9.964667 - 1020102852069
01-18 12:09:39.071
                               3197 D Sensors
                                                                                                  1020101850194
                       3166
01-18 12:09:39.072
                                       Sensors
                        3166
                               3197 D
                                                          +0.062249 +0.414197 +9.914390
                                                                                              - 1020103846944
01-18 12:09:39.073
                        3166
                               3197 D Sensors
                                                   ACCL:
```

Gyro

陀螺仪数据主要看零漂是否严重,也就是机器静止放置的时候,陀螺仪数据应该为 0。

```
91-18 12:09:24.536

91-18 12:09:24.536

91-18 12:09:24.537

91-18 12:09:24.538

91-18 12:09:24.549

91-18 12:09:24.540

91-18 12:09:24.541
                                                                        RAW GYRO: -0.000383 +0.003961 +0.001198
RAW GYRO: +0.001748 +0.005027 +0.000133
                                                                                                                                                 1005567249103
                                 3166
                                            3197 D Sensors
                                 3166
                                            3197 D Sensors
                                                                                                                                                 1005568245728
                                 3166
                                                                         RAW GYRO: +0.002813 +0.003961 +0.001198
                                                                                                                                                 1005569245562
                                            3197 D Sensors
                                                                        RAW GYRO: +0.002813 +0.003961 +0.001198
RAW GYRO: +0.003878 +0.001831 +0.004394
RAW GYRO: +0.001748 +0.001831 +0.002264
RAW GYRO: -0.001448 +0.002896 -0.000932
RAW GYRO: -0.002513 +0.002896 -0.001997
RAW GYRO: -0.001448 +0.002896 -0.000932
RAW GYRO: -0.003579 +0.002896 +0.002264
RAW GYRO: -0.006775 +0.005027 +0.004394
RAW GYRO: -0.004644 +0.005027 +0.004394
RAW GYRO: -0.00383 +0.003961 +0.003329
RAW GYRO: +0.001748 +0.000766 +0.001198
                                 3166
                                            3197 D Sensors
                                                                                                                                                 1005570250062
                                                                                                                                                 1005571246395
                                            3197 D Sensors
                                 3166
                                            3197 D Sensors
                                 3166
                                                                                                                                                 1005572245937
 01-18 12:09:24.542
01-18 12:09:24.543
                                            3197 D Sensors
                                                                                                                                                 1005573248395
                                 3166
                                 3166
                                            3197 D Sensors
                                                                                                                                                 1005574245312
 01-18 12:09:24.544
01-18 12:09:24.545
                                 3166
                                            3197 D Sensors
                                                                                                                                                 1005575245728
                                            3197 D Sensors
                                 3166
                                                                                                                                                 1005576247895
 01-18 12:09:24.546
01-18 12:09:24.547
                                            3197 D Sensors
                                                                                                                                                 100557725093
                                 3166
                                 3166
                                            3197 D Sensors
                                                                                                                                                 1005578248437
 01-18 12:09:24.548
01-18 12:09:24.549
                                                                         RAW GYRO: +0.001748 +0.000766 +0.001198
                                                                                                                                                 1005579249145
                                 3166
                                            3197 D Sensors
                                                                         RAW GYRO: -0.000383 -0.000300 -0.000932
                                 3166
                                            3197 D Sensors
                                                                                                                                                 1005580248687
91-18 12:09:24.550
                                                                         RAW GYRO: -0.001448 +0.000766 +0.001198
                                 3166
                                            3197 D Sensors
                                                                                                                                                 1005581249687
                                                                        RAW GYRO: +0.000682 +0.002896 +0.002264 -
RAW GYRO: +0.000682 +0.002896 +0.001198 -
 01-18 12:09:24.551
01-18 12:09:24.552
                                 3166
                                            3197 D Sensors
                                                                                                                                                 1005582250978
                                 3166
                                            3197 D Sensors
                                                                                                                                                 1005583252853
01-18 12:09:24.553
                                 3166
                                            3197 D Sensors
                                                                        RAW GYRO:
                                                                                         -0.003579 +0.001831 -0.001997
                                                                                                                                                100558426639
```

以上数据如果偏差较大的话,就说明数据有问题。

5 Sensor debug 开关

1) sensor log 查看命令: logcat -s Sensors



2) sensor raw data 查看命令:

setprop invn.hal.data.input 1;

stop; start;

logcat -s Sensors

```
HAL:inv_build_accel
                                                                                                           4817086627045
18 10:54:01.129
18 10:54:01.129
                                               HAL:inv_build_gyro:
HAL:inv_build_accel:
                                                                             -14
+120
                           2547 U Sensors
                                                                                                   +7 - 4817087628337
                           2547 U Sensors
                                                                                                 -16808
                                                                                                         - 4817087628337
                    2515
                    2515
2515
                                               HAL:inv_build_gyro:
HAL:inv_build_accel:
18 10:54:01.130
                                                                                                   +7 - 4817088632837
                           2547 U Sensors
18 10:54:01.130
                                                                             +120
                           2547 U Sensors
                                                                                                 -16836 - 4817088632837
                    2515
18 10:54:01.131
                           2547 U Sensors
                                               HAL:inv_build_gyro:
                                                                                                    +9 - 4817089632379
   10:54:01.131
                    2515
                           2547 U Sensors
                                               HAL:inv_build_accel:
                                                                             +104
18 10:54:01.132
                    2515
                           2547 U Sensors
                                               HAL:inv_build_gyro:
                                                                                                    +9 - 4817090629879
18 10:54:01.132
18 10:54:01.133
                    2515
2515
                                               HAL:inv_build_accel:
HAL:inv_build_gyro:
                                                                             +112
                           2547 U Sensors
                                                                                                  16804 - 4817090629879
                           2547 U Sensors
                                                                              -15
                                                                                                     +7 - 4817091630295
   10:54:01.133
                    2515
                           2547 U Sensors
                                               HAL:inv_build_accel
                                                                             +116
                                                                                                 -16788 - 4817091630295
```

3) Hal 层处理后的数据查看(上报给 android 系统)命令:

setprop invn.hal.data.handler 1;

stop; start;

logcat -s Sensors

```
01-18 11:01:04.307 5116 5147 U Sensors : HAL:gyro data : -0.002197 +0.003995 +0.001215 -- 5240265268289 - 1
01-18 11:01:04.308 7 5116 5147 U Sensors : HAL:gyro data : -0.005067 +0.263362 +10.055647 - 5240265268289 - 1
01-18 11:01:04.308 5116 5147 U Sensors : HAL:gyro data : -0.000067 +0.003995 +0.000150 -- 5240266230497 - 1
01-18 11:01:04.309 5116 5147 U Sensors : HAL:gyro data : -0.033307 +0.237026 +10.043676 -- 5240266230497 - 1
01-18 11:01:04.309 5116 5147 U Sensors : HAL:gyro data : +0.00264 +0.001664 +0.000150 -- 5240266230914 - 1
01-18 11:01:04.309 5116 5147 U Sensors : HAL:gyro data : +0.002197 +0.210690 +10.074800 -- 5240267230914 - 1
01-18 11:01:04.310 5116 5147 U Sensors : HAL:gyro data : +0.004194 -0.000266 +0.000150 -- 5240268229581 - 1
01-18 11:01:04.311 5116 5147 U Sensors : HAL:gyro data : +0.004194 -0.000277 +10.149021 -- 5240268229581 - 1
01-18 11:01:04.311 5116 5147 U Sensors : HAL:gyro data : +0.003129 +0.000799 +0.000150 -- 5240269231164 - 1
01-18 11:01:04.312 5116 5147 U Sensors : HAL:accel data : -0.045996 +0.02597 +10.149021 -- 5240269231164 - 1
01-18 11:01:04.312 5116 5147 U Sensors : HAL:accel data : -0.045999 +0.000799 +0.000150 -- 5240269231164 - 1
01-18 11:01:04.312 5116 5147 U Sensors : HAL:accel data : -0.045999 +0.025949 +0.005501 -- 5240269231164 - 1
01-18 11:01:04.312 5116 5147 U Sensors : HAL:accel data : -0.045999 +0.025949 +0.005501 -- 5240269231164 - 1
01-18 11:01:04.312 5116 5147 U Sensors : HAL:accel data : -0.002394 +0.229843 +10.046070 -- 5240270230414 - 1
```

4) 其他开关: sensor.debug.level, 查看 hal 处理后的上报给 android 的

数据 , 功能与 invn.hal.data.handler 有些重复。

sensor.debug.level 值定义如下:

```
/*
```

- 0 0000 no debug
- 1 0001 gyro data
- 2 0010 accl data
- 4 0100 mag data
- 8 1000 raw gyro data with uncalib and bias

*/



6 Sensor 校准

工厂 PCBA 测试时,会对 sensor 做校准,目前是做 gsensor 校准,可以纠正由于外界环境导致的 gsensor 固定偏差。

7 常见问题

图像漂移:

现象一:头盔转动时图像飘移严重,静止放置一会儿后图像会停止下来。可能的原因是:

- 1) 坐标方向配置错误, sensor 坐标系需要与机器的坐标系定义一致。
- 2) Gsensor 数据偏差太大,加速度计、陀螺仪属于 MEMS Sensor,全称 Micro Electro Mechanical Systems 微机械电子系统。是采用微电子和微机械加工技术制造出来的新型传感器。硬件上的应力对其内部结构会有影响,从而影响数据的准确性。在我们的板子上就出现过超声波洗板导致 sensor 损坏,数据偏差大的问题。

现象二:静止放置时一直在飘移,可能是轻微的 飘移,但是不会停止下来;这种现象一般是陀螺仪零漂大导致的,陀螺仪零漂是指机器静止放置时,陀螺仪的数据不为零。陀螺仪的零漂取决于 sensor 本身和外接干扰,温度、电源纹波、运动状态对其都有影响,需要系统每段时间对其做矫正;

画面歪:

一般是因为 Gsensor 数据有一些偏差。

Gsensor 数据正确性判断:

加速度传感器的工作原理是通过测量施加在传感器上的应力(F)来计算设备所产生的的加速度(A),重力作为常量始终作用在物体上,所以当物体静止放置的时候,Sensor 的数据应等于重力加速度 9.81 m/s²。



某个轴的正方向与重力方向相反时,该轴的 gsensor 数据为 $+9.81 \text{ m/s}^2$ 其他轴为 0。

当数据有偏差是需要做校准,一般 gsensor 的偏差都是固定偏差,所以只需要减去偏置值即可。