

夸父 3.5 传感器时间同步测试报告



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1 测试目的

夸父 3.5 中传感器 imu、gnss、激光雷达、相机通过 SSU 模块时间同步

2 测试内容

- 1、测试单个传感器驱动层面的数据链路延迟；
- 2、五个激光雷达间的时间同步；
- 3、激光雷达与相机的时间同步；
- 4、顶雷达与 imu、encoder 的时间同步；

3 测试环境

夸父 3.5 实车测试

4 测试说明

针对通过 SSU 同步方案中传感器及其相关硬件模块时间来源进行以下说明：

- 1、**SSU 时间来源**分为 gnss 搜星前和搜星后，gnss 搜星前 SSU 时间戳来源是 SSU 内部晶振时钟源（2020-09-29 08：00）；gnss 搜星后时间来源是 UTC 时间，SSU 只同步更新 UTC 中的年月日时分秒，毫秒数据来自于 imu 的 pps 数据信号触发。
- 2、**激光雷达时间来源**年月日时分秒是来自于 SSU 时间，毫秒是来自于 SSU 的 pps 数据信号触发；



- 3、**相机时间来源**年月日时分秒是来自于工控机系统时间，毫秒是来自于 SSU 的 PPS 数据信号触发；
- 4、**imu 时间来源**是 SSU 的年月日时分秒及其毫秒数据；
- 5、**encoder 时间来源**是 VCU 中的年月日时分秒及其毫秒，而 **VCU 时间来源**是 SSU 年月日时分秒，毫秒来自于 SSU 的 pps 数据信号触发；
- 6、**工控机时间来源**是 SSU 通过 NTP 传给工控机的年月日时分秒,毫秒以下目前还没有同步获取；

5 测试过程

5.1 测试单个传感器驱动层面的数据链路延迟

(1) imu 驱动代码中添加时间戳信息，计算从端口接收数据到 publisher 发出数据延迟情况为 1ms 以内；

```
timestamp: 1658892253.621034, current time: 1658892253.621039.
timestamp: 1658892253.631039, current time: 1658892253.631042.
timestamp: 1658892253.644709, current time: 1658892253.644711.
timestamp: 1658892253.650907, current time: 1658892253.650909.
timestamp: 1658892253.660809, current time: 1658892253.660812.
timestamp: 1658892253.670850, current time: 1658892253.670852.
timestamp: 1658892253.680993, current time: 1658892253.680999.
timestamp: 1658892253.691298, current time: 1658892253.691304.
timestamp: 1658892253.700856, current time: 1658892253.700859.
timestamp: 1658892253.710904, current time: 1658892253.710906.
```

(2) 激光雷达驱动代码中添加时间戳信息，计算从端口接收数据到 publisher 发出数据延迟 1~9ms 之间。

```
timestamp: 1658827621.291365, point size: 48444, current time: 1658827621.300376.
timestamp: 1658827621.299087, point size: 63480, current time: 1658827621.300851.
timestamp: 1658827621.300015, point size: 61308, current time: 1658827621.301239.
timestamp: 1658827621.294650, point size: 49226, current time: 1658827621.301817.
timestamp: 1658827621.302009, point size: 46618, current time: 1658827621.302670.
```

(3) odom 驱动代码中添加时间戳信息，计算从端口接收数据到 publisher 发出数据延迟为 1ms 以内；

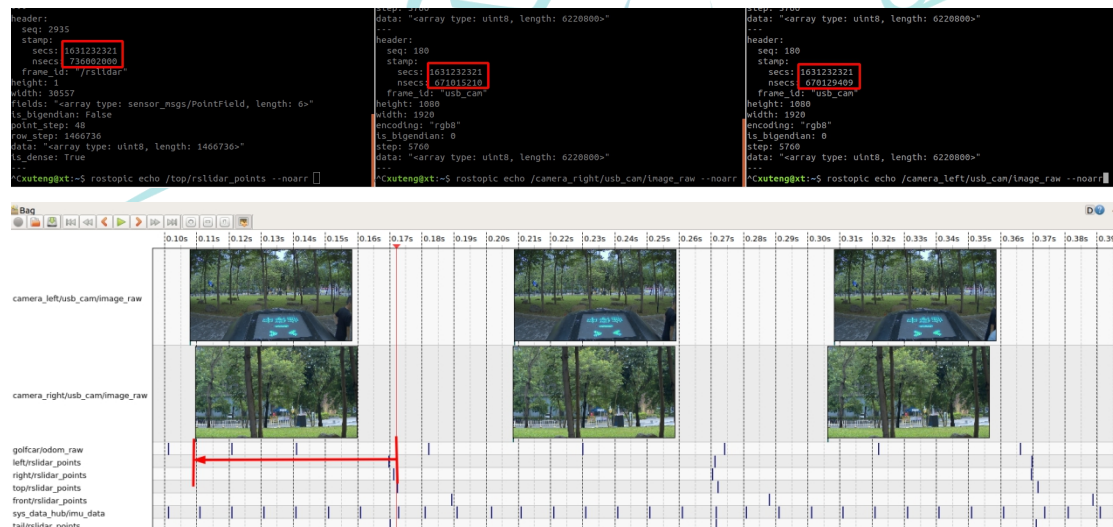
```
timestamp: 0.000000, current time: 1658901643.808140.
once!
1658901643.828000751
timestamp: 0.000000, current time: 1658901643.828127.
once!
```

5.2 五个激光雷达间的时间同步

同一时刻输出 5 个激光雷达时间戳，比较其时间戳差异为 1~8ms 之间；

```
data: "array type: uint8, length: 233184"
is_dense: True
header:
  seq: 54195
  stamp:
    secs: 1659670714
    nsecs: 152198000
  frame_id: "/rsllidar"
height: 1
width: 48618
fields: "array type: sensor_msgs/PointField, length: 6"
is_bigendian: False
point_step: 48
row_step: 2333664
data: "array type: uint8, length: 2333664"
is_dense: True
---
data: "array type: uint8, length: 2351328"
is_dense: True
header:
  seq: 54195
  stamp:
    secs: 1659670714
    nsecs: 144320000
  frame_id: "/rsllidar"
height: 1
width: 48904
fields: "array type: sensor_msgs/PointField, length: 6"
is_bigendian: False
point_step: 48
row_step: 2347392
data: "array type: uint8, length: 2347392"
is_dense: True
---
is_bigendian: False
point_step: 48
row_step: 3035136
data: "array type: uint8, length: 3035136"
is_dense: True
header:
  seq: 54195
  stamp:
    secs: 1659670714
    nsecs: 152142000
  frame_id: "/rsllidar"
height: 1
width: 63210
fields: "array type: sensor_msgs/PointField, length: 6"
is_bigendian: False
point_step: 48
row_step: 3034080
data: "array type: uint8, length: 3034080"
is_dense: True
---
secs: 1659670714
nsecs: 149221000
frame_id: "/rsllidar"
height: 1
width: 48212
fields: "array type: sensor_msgs/PointField, length: 6"
is_bigendian: False
point_step: 48
row_step: 2314176
data: "array type: uint8, length: 2314176"
is_dense: True
---
secs: 1659670714
nsecs: 152199000
frame_id: "/rsllidar"
height: 1
width: 61964
fields: "array type: sensor_msgs/PointField, length: 6"
is_bigendian: False
point_step: 48
row_step: 2974272
data: "array type: uint8, length: 2974272"
is_dense: True
---
```

5.3 激光雷达与相机的时间同步



测试相机与顶雷达时间戳差在 65ms 左右；

5.4 顶雷达与 imu、encoder 的时间同步



imu 与 encoder 会存在丢帧或者黏包现象导致时间戳始终不能进行对齐，还有一个因素是 encoder 和 imu 毫秒以下时间戳信息无法保证与雷达的 pps 同步触发。

```

covariance: "array type: float64[36, length: 36]"
seq: 12562
stamp:
  secs: 1631232306
  nsecs: 231530195
frame_id: "odom"
child_frame_id: "base_link"
pose:
  position:
    x: 0.0
    y: 0.0
    z: 0.0
  orientation:
    x: 0.0
    y: 0.0
    z: 0.0
    w: 1.0
covariance: "array type: float64[36, length: 36]"
twist:
  linear:
    x: 0.0
    y: 0.0
    z: 0.0
  angular:
    x: 0.0
    y: 0.0
    z: 0.0
covariance: "array type: float64[36, length: 36]"
row_step: 1466256
data: "array type: uint8, length: 1466256"
is_dense: True
header:
  seq: 2778
  stamp:
    secs: 1631232306
    nsecs: 170754800
  frame_id: "/rslidar"
height: 1
width: 30549
fields: "array type: sensor_msgs/PointField, length: 6"
is_bigendian: False
point_step: 40
row_step: 1466352
data: "array type: uint8, length: 1466352"
is_dense: True
header:
  seq: 2779
  stamp:
    secs: 1631232306
    nsecs: 276772000
  frame_id: "/rslidar"
height: 1
width: 30539
fields: "array type: sensor_msgs/PointField, length: 6"
is_bigendian: False
point_step: 40
row_step: 1465872
data: "array type: uint8, length: 1465872"
is_dense: True
w: 0.673840541406
orientation_covariance: "array type: float64[9, length: 9]"
angular_velocity:
  x: -0.0014420861844
  y: -0.000480340619108
  z: 0.000103588543425
angular_velocity_covariance: "array type: float64[9, length: 9]"
linear_acceleration:
  x: -0.69527810812
  y: 0.0643780604005
  z: 9.78356170654
linear_acceleration_covariance: "array type: float64[9, length: 9]"
header:
  seq: 26648
  stamp:
    secs: 1631232306
    nsecs: 894000005
  frame_id: "/rton/yaw"
orientation:
  x: 2.29500714426e-41
  y: 0.0
  z: 0.0
  w: 1.0
orientation_covariance: "array type: float64[9, length: 9]"
angular_velocity:
  x: -0.00138022494502
  y: -0.000299001520034
  z: -3.22756022797e-05
angular_velocity_covariance: "array type: float64[9, length: 9]"
linear_acceleration:
  x: -0.696594655514
  y: 0.0573214553297
  z: 9.78723621368
linear_acceleration_covariance: "array type: float64[9, length: 9]"

covariance: "array type: float64[36, length: 36]"
seq: 12802
stamp:
  secs: 1631232311
  nsecs: 216807184
frame_id: "odom"
child_frame_id: "base_link"
pose:
  position:
    x: 0.0
    y: 0.0
    z: 0.0
  orientation:
    x: 0.0
    y: 0.0
    z: 0.0
    w: 1.0
covariance: "array type: float64[36, length: 36]"
twist:
  linear:
    x: 0.0
    y: 0.0
    z: 0.0
  angular:
    x: 0.0
    y: 0.0
    z: 0.0
covariance: "array type: float64[36, length: 36]"
row_step: 1465104
data: "array type: uint8, length: 1465104"
is_dense: True
header:
  seq: 2827
  stamp:
    secs: 1631232311
    nsecs: 31672000
  frame_id: "/rslidar"
height: 1
width: 30490
fields: "array type: sensor_msgs/PointField, length: 6"
is_bigendian: False
point_step: 40
row_step: 1463520
data: "array type: uint8, length: 1463520"
is_dense: True
header:
  seq: 2828
  stamp:
    secs: 1631232311
    nsecs: 131700000
  frame_id: "/rslidar"
height: 1
width: 30504
fields: "array type: sensor_msgs/PointField, length: 6"
is_bigendian: False
point_step: 40
row_step: 1464192
data: "array type: uint8, length: 1464192"
is_dense: True
w: 0.673840541406
orientation_covariance: "array type: float64[9, length: 9]"
angular_velocity:
  x: -7.81080371505e-05
  y: 0.00014236633871
  z: 0.000641497899778
angular_velocity_covariance: "array type: float64[9, length: 9]"
linear_acceleration:
  x: -0.699517660303
  y: 0.067768066525
  z: 9.78852558136
linear_acceleration_covariance: "array type: float64[9, length: 9]"
header:
  seq: 27143
  stamp:
    secs: 1631232311
    nsecs: 684000015
  frame_id: "/rton/yaw"
orientation:
  x: 2.29500714426e-41
  y: 0.0
  z: 0.0
  w: 1.0
orientation_covariance: "array type: float64[9, length: 9]"
angular_velocity:
  x: -7.79039764893e-05
  y: 0.00023495653295
  z: 0.00075501581426
angular_velocity_covariance: "array type: float64[9, length: 9]"
linear_acceleration:
  x: -0.697815358639
  y: 0.0609502971411
  z: 9.78987709154
linear_acceleration_covariance: "array type: float64[9, length: 9]"

```


5.5 NTP 时间同步数据链路验证

```
--> 192.168.3.226

time1 : 2022-08-31_17-14-47.300
time2 : 2022-08-31_17-14-47.000
time3 : 2022-08-31_17-14-47.000
time4 : 2022-08-31_17-14-47.309
timev : 2022-08-31_17-14-47.004
timec : 2022-08-31_17-14-47.309
Wed Aug 31 17:14:47 CST 2022
=====
--> 192.168.3.226

time1 : 2022-08-31_17-14-48.401
time2 : 2022-08-31_17-14-48.000
time3 : 2022-08-31_17-14-48.000
time4 : 2022-08-31_17-14-48.411
timev : 2022-08-31_17-14-48.005
timec : 2022-08-31_17-14-48.411
Wed Aug 31 17:14:48 CST 2022
=====
--> 192.168.3.226

time1 : 2022-08-31_17-14-49.500
time2 : 2022-08-31_17-14-49.000
time3 : 2022-08-31_17-14-49.000
time4 : 2022-08-31_17-14-49.511
timev : 2022-08-31_17-14-49.005
timec : 2022-08-31_17-14-49.511
Wed Aug 31 17:14:49 CST 2022
```

SSU 时间

工控机时间

NTP 同步数据链路延迟大概是在 300ms、400ms、500ms 三个值之间进行跳动，由此导致 encoder 与 imu 数据始终无法真正意义上与雷达进行数据对齐。

5.6 夸父 3.5 自动驾驶测试

传感器数据时间戳来自于 SSU，启动 NTP 脚本，针对 NTP 时间同步验证了 1s、3s、10s、30s、60s 不同更新时间状态下车辆运行情况；

目前 NTP 时间刷新频率为 1s 时容易出现卡顿情况，3s、10s 偶尔卡顿（更新频率越快卡顿越明显）报错信息如下图所示；

故障码	故障码
C0037:左后轮速传感器故障	C0037:左后轮速传感器故障
C003A:右后轮速传感器故障	C003A:右后轮速传感器故障
E0233:局部规划感知输入检查失败	E3009:定位匹配失败或误匹配
C1174:左前轮胎欠压提示	E5000:guardian保护指令话题接收超时
C1175:右前轮胎欠压提示	E5100:自动模式下运动控制话题接收超时
C1176:左后轮胎欠压提示	C1174:左前轮胎欠压提示
C1177:右后轮胎欠压提示	C1175:右前轮胎欠压提示
	C1176:左后轮胎欠压提示
	C1177:右后轮胎欠压提示
	W3003:定位score分数在0.3-5之间(较高)
	W5101:自动模式下附件控制(灯光及喇叭)话题接收超时

NTP 同步时间频率换成 30s、60s 运行很流畅，不会出现以上情况。

综合以上各个传感器数据时间来源、NTP 时间同步跳变及其延迟情况，可以初步判断 NTP 更新太快会不断刷新各个传感器时间戳信息，导致传感器时间戳会出现回拉现象。目前比较好的方案就是 NTP 给定一个比较长的更新时间。

