**README NGAP**

**Overview**

Tram 1013 operating in revenue service in Florence tramway system is equipped with a set of sensors (RADAR, IMU, GNSS) and collects datasets from relevant measurements.

The first and second dataset associated to NGAP system is made of the all sensors’ outputs.

* RADAR: used in Doppler mode to provide information on vehicle velocity
* IMU: inertial unit to measure acceleration components
* GNSS: Global Navigation Satellite System to measure position

NGAP system processes data from sensor with Sensor Fusion Algorithms and determines the relevant tram position.

**Dataset Contents/Dataset Description**

The first dataset is composed of the following files

\_slash\_imu.csv

\_slash\_RadarContinentalDataMsgPod.csv

\_slash\_UbxNavPvtMsgPod.csv

The fields description is reported in the following tables

Table 1 - File \_slash\_imu.csv fields description (IMU sensor)

|  |  |  |
| --- | --- | --- |
| **Item** | **Type** | **Description** |
| Epoch\_rosbag | float64 | Epoch timestamp in ns. |
| Epoch | float64 | Epoch timestamp in ms. |
| AccX | float64 | Acceleration along X axis expressed in m/s^2. |
| AccY | float64 | Acceleration along Y axis expressed in m/s^2. |
| AccZ | float64 | Acceleration along Z axis expressed in m/s^2. |
| AngX | float64 | Measures the rate of rotation around the device's X-axis in degrees per second, tracking angular velocity. |
| AngY | float64 | Measures the rate of rotation around the device’s Y-axis in degrees per second, tracking angular velocity. |
| AngZ | float64 | Measures the rate of rotation around the device’s Z-axis in degrees per second, tracking angular velocity. |
| Seq | uint16 | Sequence number used to count the received IMU messages. |
| T | uint16 | Temperature in °C detected by the sensor. |

Table 2 - \_slash\_RadarContinentalDataMsgPod.csv fields (RADAR)

|  |  |  |
| --- | --- | --- |
| **Item** | **Type** | **Description** |
| Epoch\_bag | float64 | Epoch expressed in ns. |
| Epoch | Float64 | Epoch expressed in ms. |
| Speed | float64 | Longitudinal speed expressed in m/s (this speed is a speed provided by a Kalman Filter). |
| Sigma | float64 | Sigma associated with the speed provided by the Kalman Filter. |
| Raw Speed | Float64 | Raw speed that feeds the Kalman Filter (which is the mean of the speed of the clusters speed that are inside the hitbox). |
| Innovation value |  | Innovation value provided by the Kalman Filter. |
| Innovation failure | bool | Flag which indicates if the measurement (speed) provided to the Kalman Filter has been accepted (1) or refused (0). |
| Hitbox number | uint8 | Number of elements that are . |

Table 3 - \_slash\_UbxNavPvtMsgPod.csv fields (GNSS)

|  |  |  |
| --- | --- | --- |
| **Item** | **Type** | **Description** |
| epoch\_s | float64 | Epoch expressed in ms. |
| iTOW\_ms | uint32 | Integer time of week in milliseconds, indicating the specifc time within the week measured from the start of the GPS week. |
| yearUTC | uint16 | Represents the year part of the Coordinated Universal Time (UTC) timestamp, indicating the current year during which the IMU data is collected. |
| monthUTC | uint8 | Represents the month part of the Coordinated Universal Time (UTC) timestamp, indicating the current year during which the IMU data is collected. |
| dayUTC | uint8 | Represents the day part of the Coordinated Universal Time (UTC) timestamp, indicating the current year during which the IMU data is collected. |
| hourUTC | uint8 | Represents the hour part of the Coordinated Universal Time (UTC) timestamp, indicating the current year during which the IMU data is collected. |
| minUTC | uint8 | Represents the minutes part of the Coordinated Universal Time (UTC) timestamp, indicating the current year during which the IMU data is collected. |
| secUTC | uint8 | Represents the seconds part of the Coordinated Universal Time (UTC) timestamp, indicating the current year during which the IMU data is collected. |
| valid | uint8 | Flag which indicates in the Navigation message is valid or not. |
| tAccUTC\_s | float64 | Refers to the accuracy of the Coordinated Universal Time (UTC) timestamp in seconds, indicating the precision of the time measurement associated with the IMU data. |
| nano\_ns | int32 | Refers to the nanosecond prt of the timestamp, indicating the fractional second precision of the time measurement associated with the IMU data. |
| fixTypeGNSS | uint8 | Refers to the type of positioning fix determined by the GNSS, indicating the level of accuracy and reliability of the location (e.g., no fix, 2D fix, 3 fix). |
| flags | uint8 | Refers specific Ublox configuration flags. |
| reserved | uint8 | Reserved flag. |
| numSV | uint8 | Number of satellities received signals. |
| longitude\_rad | float64 | Acquired longitude in radians. |
| latitude\_rad | float64 | Acquired latitude in radians. |
| heightEllipsoid\_m | float64 | Refers to the height above the ellipsoid model of the Earth in meters, indicating the vertical position relative to a mathematical model rather than mean sea level. |
| heightMSL\_m | float64 | Refers to the altitude in meters of the device relative to the Earth's ellipsoid, a mathematical figure approximating the shape of the Earth. |
| hAcc\_m | float64 | Refers to the horizontal accuracy in meters, indicating the estimated precision of the horizontal position measurements provided by IMU. |
| vAcc\_m | float64 | Refers to the vertical accuracy in meters, indicating the estimated precision of the vertical position measurements provided by IMU. |
| velN\_m\_s | float64 | Refers to the velocity North direction measured in meters per second, indicating the northward component of the velocity vector captured by the IMU. |
| velE\_m\_s | float64 | Refers to the velocity in the East direction measured in meters per second, indicating the eastward component of the velocity vector captured by the IMU. |
| velD\_m\_s | float64 | Refers to the velocity in the Down direction measured in meters per second, indicating the downward component of the velocity vector captured by the IMU. |
| groundSpeed\_m\_s | float64 | Ground speed calculate by the received expressed in m/s. |
| heading\_rad | float64 | Orientation angle in radians relative to the North, indicating the direction in which the device is facing. |
| speedAcc\_m\_s | float64 | Ground speed accuracy in m/s. |
| headingAcc\_rad | float64 | Orientation angle accuracy expressed in radians. |
| positionDOP | float64 | Refers to the Position Dilution of Precision, a measure of the error in position due to the geometric positions of the satellites being tracked. |
| reserved16 | uint16 | Reserved. |
| reserved32 | uint32 | Reserved. |
| headVeh\_deg | int32 | Refers to the vehicle's heading in degrees, indicating the direction in which the vehicle is moving, relative to true North. |
| magDec\_deg | int16 | Refers to the magnetic declination in degrees, indicating the angle between magnetic North and the true North at the location of the IMU. |
| magAcc\_deg | uint16 | Refers to the accuracy of the magnetic heading measurement in degrees, indicating the expected error range in the magnetic declination reading. |

The second dataset is composed of the following files *output.csv.* The fields description is reported in the following tables.

Table 4 Output.csv field description

|  |  |  |
| --- | --- | --- |
| **Item** | **Type** | **Description** |
| **EPOCH** |  | Epoch of when the message has been received by the SFA (by the listener module) |
| **SENSOR** |  | Identifier of the received message:   * + 1: Acceleration and angular velocity coming from IMU   + 3: Speed message coming from RADAR   + 9: Initialization message   + 12: Balise position message coming from the GNSS Navigation message |
| **ImuCnt** |  | Sequence counter of the IMU message. Important in order to check if we are missing some IMU messages. |
| **Dropped** |  | Flag which indicates if IMU message have been dropped (1) or not (0). |
| **GT\_cnt** |  | Not Applicable |
| **GT\_Edge** |  | Identification of the spline where the SFA is running. |
| **GT\_Position** |  | Initial position in [m] specified by the initialization message. |
| **GT\_Speed** |  | Initial speed in [m/s] specified by the initialization message. |
| **GT\_Dir** |  | Direction of the vehicle on the spline. 0 means forward direction, 1 means backward direction. |
| **FU\_cnt** |  | Counter which is used the number of predictions processed by the SFA. |
| **FU\_Edge** |  | Identifier of the spline used by the SFA. |
| **FU\_Arc** |  | Position, starting from the origin of the spline, in [m] of the vehicle on the used spline |
| **FU\_Arc\_var** |  | Variance of the position, calculated by the SFA, expressed in  . |
| **FU\_Arc\_norm** |  | Position, starting from the end of the spline, in [m] of the vehicle on the used spline |
| **FU\_Protection\_Limit\_speed** |  | Speed Protection Limit value exiting the SFA, expressed in m/s. |
| **FU\_Protection\_Limit\_position** |  | Position Protection Limit value exiting the SFA, expressed in m. |
| **FU\_Speed** |  | Speed, expressed in m/s, calculated by the SFA. |
| **FU\_SpeedVar** |  | Variance of the speed, expressed in   calculated by the SFA. |
| **FU\_Epoch** |  | Epoch of the Sensor Fusion Algorithm. |
| **FU\_ecef\_x** |  | ECEF X coordinate, associated to the position calculated by the SFA on the selected spline. |
| **FU\_ecef\_y** |  | ECEF Y coordinate, associated to the position calculated by the SFA on the selected spline. |
| **FU\_ecef\_z** |  | ECEF Z coordinate, associated to the position calculated by the SFA on the selected spline. |
| **FU\_vel\_x** |  | Speed along X axis, expressed in [m/s], calculated by the SFA. |
| **FU\_vel\_y** |  | Speed along Y axis, expressed in [m/s], calculated by the SFA. |
| **FU\_vel\_z** |  | Speed along Z axis, expressed in [m/s], calculated by the SFA. |
| **FU\_dir\_x** |  | Direction along X axis, calculated by the SFA: 0-forward, 1-backward. |
| **FU\_dir\_y** |  | Direction along Y axis, calculated by the SFA: 0-forward, 1-backward. |
| **FU\_dir\_z** |  | Direction along Z axis, calculated by the SFA: 0-forward, 1-backward. |
| **Sigma** |  | Speed sigma value, expressed in [m/s], provided by the RADAR. |
| **Speed** |  | Speed value, expressed in [m/s], provided by the RADAR. |
| **SequenceNum** |  | Incremental number which from 1 to 32767 which is used to identify if we are missing an IMU packet or not, |
| **BitStatus** |  | Flag which is used to identify if the IMU it has been correctly processing IMU information 0 or there was a problem 0. |
| **X1SpecForce** |  | Acceleration along x expressed in , provided by the IMU. |
| **X2SpecForce** |  | Acceleration along y expressed in , provided by the IMU. |
| **X3SpecForce** |  | Acceleration along z expressed in , provided by the IMU |
| **X1AngVel** |  | Angular velocity along x expressed in , provided by the IMU. |
| **X2AngVel** |  | Angular velocity along x expressed in , provided by the IMU. |
| **X3AngVel** |  | Angular velocity along x expressed in , provided by the IMU |
| **X1MagField** |  | Magnetometer force along x expressed in Gauss, provided by the IMU. |
| **X2MagField**: |  | Magnetometer force along y expressed in Gauss, provided by the IMU. |
| **mX3MagField** |  | Magnetometer force along z expressed in Gauss, provided by the IMU. |
| **GPSLatitude** |  | Latitude calculated by the GNSS receiver, expressed in m. This information is received when the GNSS NAV message is provided |
| **GPSLongitude** |  | Longitude calculated by the GNSS receiver, expressed in m. This information is received when the GNSS NAV message is provided. |
| **GPSAltitude** |  | Altitude calculated by the GNSS receiver, expressed in m. This information is received when the GNSS NAV message is provided. |
| **GPSSpeed** |  | Speed calculated by the GNSS receiver, expressed in m/s. This information is received when the GNSS NAV message is provided. |
| **HAccuracy** |  | Horizontal accuracy expressed in m of the position provided as latitude, longitude, altitude. This information is received when the GNSS NAV message is provided. |
| **VAccuracy** |  | Vertical accuracy expressed in m of the position provided as latitude, longitude, altitude. This information is received when the GNSS NAV message is provided. |
| **ArcLengthGNSS** |  | Arclength value (spline distance from origin) of the projected GNSS coordinates. |
| **Pos**\_**accuracy** |  | Horizontal accuracy, expressed in [m] provided by the GNSS receiver. |
| **NumSatellities** |  | Number of satellites of the received position message. This information is received when the GNSS NAV message is provided. |

Instead, the dataset related to velocity contains the following file

*profilo\_velocità.csv*. The following table describes the field meaning

Table - File profilo\_velocità.csv fields description

|  |  |  |
| --- | --- | --- |
| **Item** | **Type** | **Description** |
| ArcLenght |  | Length of arc of spline which approximates the railway line (m). The difference between two adjacent samples is very short, usually of a magnitude of 10-4 m. The first sample start around 16 meters (approximately half of the length of tram) and ends at 11.15 km which is the length of Line T1. |
| FU\_Speed |  | Velocity (m/s) |
| ECEF\_X |  | Coordinate ECEF X (m) |
| ECEF\_Y |  | Coordinate ECEF Y (m) |
| ECEF\_Z |  | Coordinate ECEF Z (m) |
| FU\_Speed\_X |  | Velocity X (m/s) |
| FU\_Speed\_Y |  | Velocity Y (m/s) |
| FU\_Speed\_Z |  | Velocity Z (m/s) |

**Getting Started**

The dataset is provided in .csv format, so no special software or prerequisites are required to access or use it.

**Download & Usage**

* git clone https://github.com/VERGE-PROJECT/GTSI-HITACHI-NGAP-dataset

The files are zipped, divided per folder and, because github limitation (file size less than 25MB), splitted in several files.

**Citation**

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