Stream

The stream estimated maximum latency is about 0.5 msec.

Calculated features

Navigation data is in ECEF coordinate system.

Vehicle state vector at time t_k

$$\vec{s}_k = [\vec{r}_k, \vec{v}_k]^T$$
$$\vec{r}_k \equiv [x, y, z]_k^T$$
$$\vec{v}_k \equiv [v_x, v_y, v_z]_k^T$$

Equation 1 Vehicle state vector

Navigation errors:

$$\vec{\delta} = \vec{r}_k - (\vec{r}_{k-1} + T(\vec{v}_k + \vec{v}_{k-1})/2)$$
$$T = t_k - t_{k-1}$$
$$\delta_x = x_k - x_{k-1} - T(v_{x,k} + v_{x,k-1})/2$$
$$\delta_y = y_k - y_{k-1} - T(v_{y,k} + v_{y,k-1})/2$$
$$\delta_z = z_k - z_{k-1} - T(v_{z,k} + v_{z,k-1})/2$$

Equation 2 Nav errors Nav_x, Nav_y, Nav_z

For each of the Nav errors compute histogram:

Histogram bin resolution is 1 meter and a span [-20, 20] meters. Each time new Nav_x,y,z values obtained they are truncated and added to histogram array to appropriate bin. Histogram is updated by taking histogram from previous batch and adding new values to bins according to data in the current batch

Equation 3 Update histogram for each of Nav errors Nav_x_hist, Nav_y_hist, Nav_z_hist

Based on histogram compute std by

$$Nav\_\delta_x^2 = \left[\sum_{bin}^{N} \delta_{x,bin}^2 \cdot Nav\_x\_hist_{bin}\right] \Big/ \sum_{bin}^{N} Nav\_x\_hist_{bin}$$
$$Nav\_\delta_y^2 = \left[\sum_{bin}^{N} \delta_{y,bin}^2 \cdot Nav\_y\_hist_{bin}\right] \Big/ \sum_{bin}^{N} Nav\_y\_hist_{bin}$$
$$Nav\_\delta_z^2 = \left[\sum_{bin}^{N} \delta_{z,bin}^2 \cdot Nav\_z\_hist_{bin}\right] \Big/ \sum_{bin}^{N} Nav\_z\_hist_{bin}$$

Equation 4 Compute standard deviations: Nav_std_x,y,z

Compute maneuver angle

$$\alpha = A\cos\left(\vec{v}_{k-1} \cdot \vec{v}_k \,/\, |\vec{v}_{k-1}||\vec{v}_k|\right)$$

Equation 5 Compute maneuvering angle: Nav_alfa

Compute navigation total error by:

$$Nav\_Error = \sqrt{Nav\_\delta_x^2 + Nav\_\delta_y^2 + Nav\_\delta_z^2}$$

Equation 6 Nav Total error

Compute maximum navigation error over last 10 sec .

$$Nav\_Max\_Error\_10\text{sec}$$

Compute navigation average error over last 5 samples.

$$Nav\_Mean\_Error\_5\_samples$$

Compute navigation error discrepancy:

$$Nav\_Error\_disc = Nav\_Error\_5\_samples - Nav\_Error\_10\text{sec}$$

Build Nav Data enrichment Data Frame that will contain all fields that are in avro message plus new fields

Nav_x,
Nav_y,
Nav_z,
Nav_x_hist,
Nav_y_hist,
Nav_z_hist,
Nav_std_x,
Nav_std_y,
Nav_std_z
Nav_alfa,
Nav_Error,
Nav_Max_Error_10sec
Nav_Mean_Error_5_samples
Nav_Error_disc