The DJH INS ROS Package Documentation

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Abstract

The purpose of this article is to document the approach to the DJH inertial navigation system (INS) ROS package. This package, we anticipate, will be used in a variety of other navigation systems. For example, we design this so that it can be easily used in a visual-inertial odometry system or a magnetic positioning system.

1 Introduction

The DJH INS ROS package is designed to provide several potentially useful computations to a user as IMU data is received. These include:

- IMU data aggregated into sets of Eigen matrices
- blah blah blah

2 The IMU Aggregator

One of the functions of the DJH INS is that an INS solution is only computed when requested by the `comp_sol` topic. This topic is a message created for this package that includes:

- `Header header`
- `float64 time_desired`
- `bool stop_agg`

The `time_desired` variable is the time for which an INS solution is desired. The `stop_agg` variable is switched to `true` when it is desired to stop aggregating the data (presumably to then compute an INS solution at `time_desired`). As the system is running if IMU data is collected with a timestamp at or after `time_desired`, then that data is saved for use in a matrix with a later `time_desired`. The aggregated matrix is published on a topic called `aggregate_imu`. This aggregated IMU data is published as Float64 vector standard message in ROS. The following C++ code shows how to convert that message into a regular n-by-7 Eigen matrix.

```
/*------- Receive and reform aggregated IMU Matrix -------*/
// Define a temporary std vector for the aggregated IMU
// message data
vector<double> vec = msg->data;
// Compute the number of rows in the aggregated matrix
int sz = vec.size()/7;
// Create pointer and store memory address of first vector
   element
double* ptr = &vec[0];
```

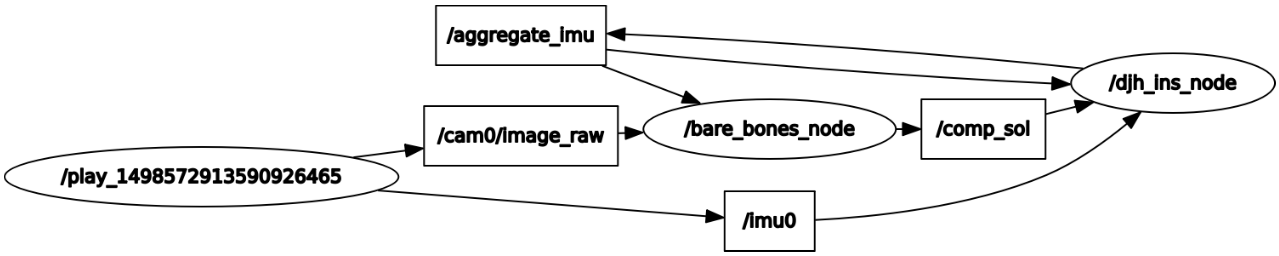

Figure 1: The DJH INS package receives IMU data and a flag to stop aggregating that IMU data in a matrix. That aggregated data is then published and can be used by both the `djh_ins_node` for computing an INS solution or by some other node (in this case `bare_bones_node`) for some other reason.

```
// Note: MatrixX7d is defined in aggregator.h
Map<MatrixX7d>agg_mat(ptr,sz,7);
/*----- End receive and reform aggregated IMU Matrix -----*/

// Print Results
cout << "--------------------------------------------------------\n";
cout << agg_mat << endl;
cout << "--------------------------------------------------------\n";
```

The structure of the resulting aggregated matrix is as follows:

$$\begin{bmatrix} timestamp_1 & accel_{x1} & accel_{y1} & accel_{z1} & gyro_{x1} & gyro_{y1} & gyro_{z1} \\ timestamp_2 & accel_{x2} & accel_{y2} & accel_{z2} & gyro_{x2} & gyro_{y2} & gyro_{z2} \\ ... & ... & ... & ... & ... & ... & ... \end{bmatrix} \tag{1}$$

Since the DJH INS package is a ROS node, it can interface with some navigation algorithm through ROS topics. Using `bare_bones_node` as an example navigation node (such as a visual-inertial odometry code), the aggregated IMU data can interface with it as shown in Figure 1.

3 The IMU Model and Corrector

The elements of the aggregated matrix are corrected for fixed scale factors (S_g and S_a), cross-coupling effects (M_g and M_a), and biases (B_{fg} and B_{fa}). These parameters (since they are fixed) are set in a parameter file called `IMUmodel.yaml`. We also assume that the navigation algorithm can potentially estimate some bias online (B_g for the gyroscopes and B_a for the accelerometers). Therefore, we have set up a subscriber to a ROS topic called `bias_est` which contains a `std_msgs::Float64MultiArray` message. The first three elements of the message are assumed to correspond to the x, y, and z-axis accelerometer biases respectively. The second three elements of the message are assumed to correspond to the x, y, and z-axis gyroscope biases respectively. Equations 2 and 3 show how we use measurements from the gyroscopes, ω, and accelerometers, a_{sf}, to compute corrected gyroscope, $\tilde{\omega}$, and accelerometer, $\tilde{a}_{sf}$, data. Figure 2 shows the same information as Figure 3. However, now ROS topics relevant for IMU error correction is also included.

$$\tilde{\omega} = (1 + S_g)\omega + M_g\omega + B_{fg} + B_g \tag{2}$$

$$\tilde{a}_{sf} = (1 + S_a)a_{sf} + M_a a_{sf} + B_{fa} + B_a \tag{3}$$

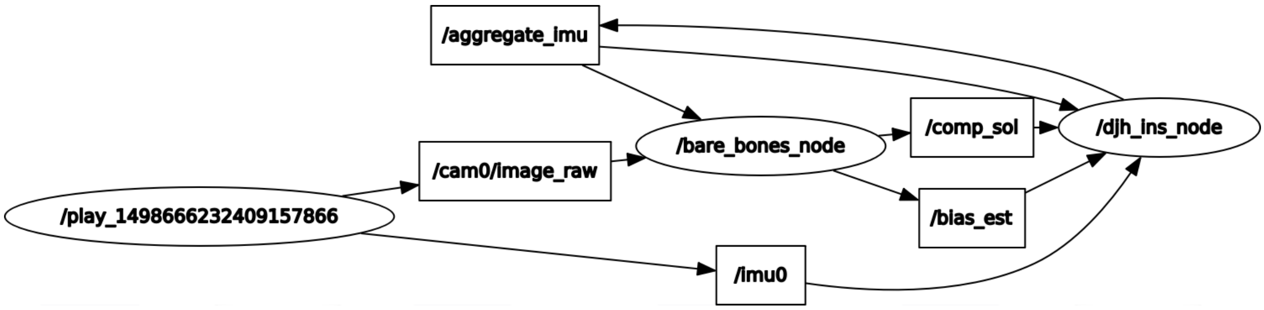

Figure 2: This ROS graph shows all the ROS topics associated with aggregating IMU data and with correcting IMU measurements.

4 Integration Algorithms and Implementation

5 Conclusion

blah blah blah [1–4]

References

[1] N. Trawny and S. I. Roumeliotis, "Indirect Kalman Filter for 3D Attitude Estimation: A Tutorial for Quaternion Algebra," University of Minnesota Department of Computer Science and Engineering, Tech. Rep. 2005-002 Rev. 57, March 2005.

[2] C. Forster, L. Carlone, F. Dellaert, and D. Scaramuzza, "On-Manifold Preintegration for Real-Time Visual-Inertial Odometry," *IEEE Transactions on Robotics*, vol. 33, no. 1, pp. 1–19, February 2017.

[3] ——, "IMU Preintegration on Manifold for Efficient Visual-Inertial Maximum-a-Posteriori Estimation," in *Proceedings of the Robotics: Science and Systems (RSS)*, Sapienza University of Rome, July 2015.

[4] K. Eckenhoff, P. Geneva, and G. Huang, "High-Accuracy Preintegration for Visual-Inertial Navigation," in *Proceedings of the Workshop on the Algorithmic Foundations of Robotics (WAFR)*, San Francisco, CA, December 2016.