Gyro-Encoder Hybrid Localization

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1 Introduction

Using encoder data for localization is prone to positioning errors due to compounding of small angle errors. During a mapping task correct position knowledge is important and such errors can cause poor results; however, techniques such as registration and probabilistic positioning have been developed to cope with imperfect encoders. Improved low-level localization would relieve the robot of these expensive calculations, leaving more time for other tasks.

Encoders produce a fairly accurate measure of translation but poor measure of angle; gyroscopes measure angle highly accurately. Combining the devices by using the encoders for measuring distance and the gyro for measuring angle creates a more accurate and useful device.

Presented are results comparing position calculations using solely encoders and combining encoders with a gyro. Test runs were carried out using a Active Media Pioneer II mobile robot and a KVH E-Core RD1100 rate gyro.

2 Integration of Gyro

The robots motor controller calculates position and orientation $(x_{encoder}, y_{encoder}, \theta_{encoder})$ from encoder ticks and sends the data to to a software controller on the on-board computer. The mounted rate gyro communicates with a gyro driver which integrates the rate values into an absolute angle (θ_{gyro}). Global position (x_{robot}, y_{robot}) is found by transforming the translation vector from encoder space to gyro space. Global angle (θ_{robot}) is the gyro angle (θ_{gyro}). The following describes the computation:

$$dx = x^t_{encoder} - x^{t-1}_{encoder} \tag{1}$$

$$dy = y^t_{encoder} - y^{t-1}_{encoder} \tag{2}$$

$$d\theta = \theta^t_{gyro} - \theta^t_{encoder} \tag{3}$$

$$x^t_{robot} = x^{t-1}_{robot} + cos(d\theta)dx - sin(d\theta)dy \tag{4}$$

$$y^t_{robot} = y^{t-1}_{robot} + sin(d\theta)dx + cos(d\theta)dy \tag{5}$$

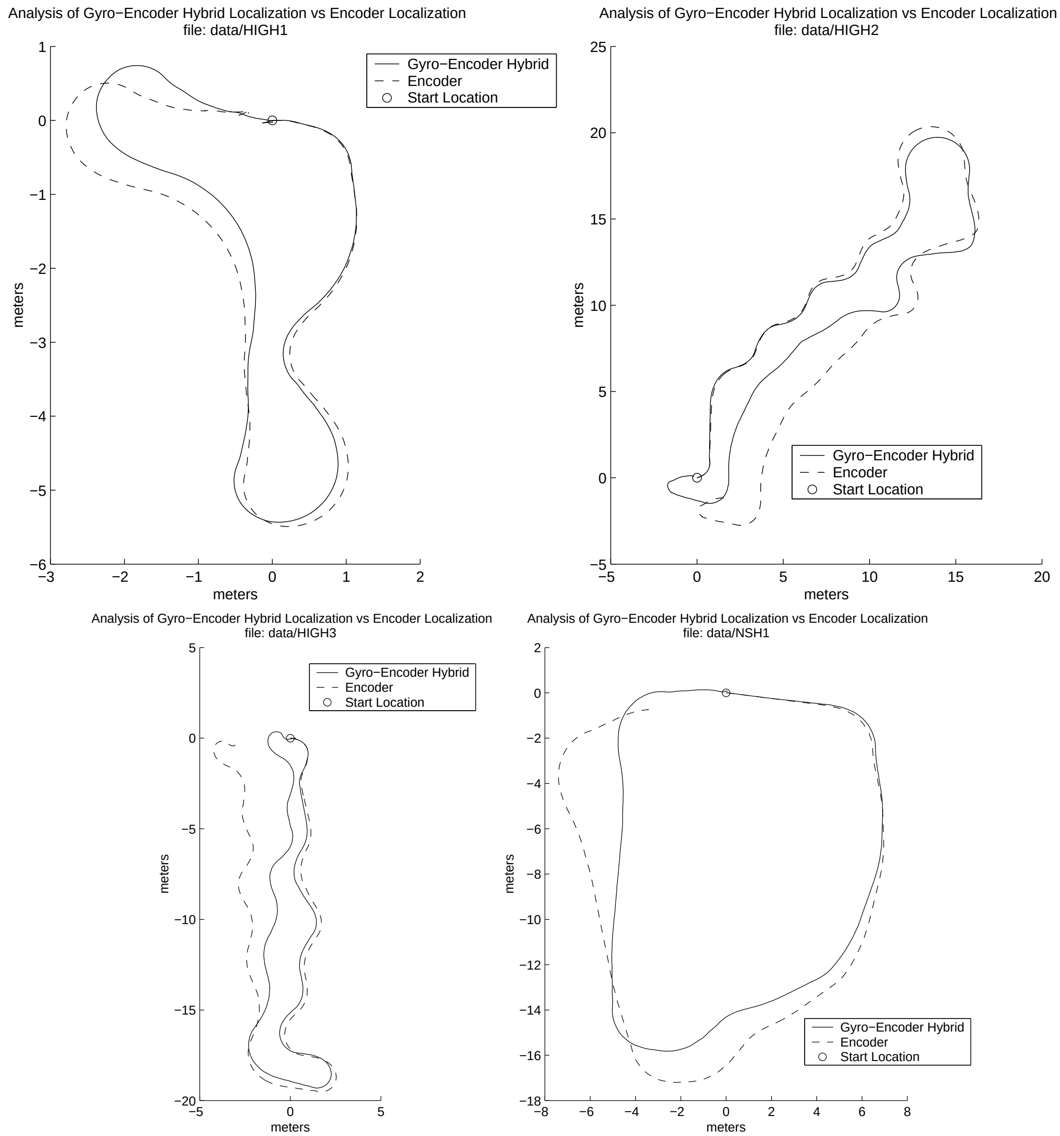
$$\theta^t_{robot} = \theta^t_{gyro} \tag{6}$$

3 Testing Procedure

An interactive program allows the robot to be maneuvered through keyboard input in real time while the controller logs both the gyro corrected position information $(x_{robot}, y_{robot}, \theta_{robot})$ and the raw motor controller data $(x_{encoder}, y_{encoder}, \theta_{encoder})$. Starting the robot in a marked location, a human operator navigates the robot around the environment and finishes at the start location.

4 Test Run Data

Figure 1: Closed loop tours in the FRC high bay and Newell Simon Hall



5 Conclusion

Gyro-encoder hybrid positioning results have vastly greater accuracy in positioning over encoder calculations. On closed loop paths, hybrid localization is several orders of magnitude more accurate then encoders alone. However, hybrid localization is limited due to rate gyros having a limit on the speed at which they can rotate while maintaining valid results. The KVH E-Core RD1100 rate gyro used to gather these these results is limited to $100 degres/sec$ where as the encoders can register rotations of much higher speeds. One solution would be to use the hybrid when rotations are less then the gyros maximum, and use the encoders when the rotation rate exceeded the maximum. Presumably, this would yield less accurate results then using the hybrid and operating at lower speeds, however robustness to faster turns and unexpected movements

such as being forced in a direction or bumped would be gained.

Figure 2: Closed loop tours in the FRC