TrackPlot Enhancements: Support for Multiple Animal Tracks and Gyros

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LONG-TERM GOALS

To make it easier for researchers to interpret data obtained from archival recording tags attached to marine mammals. Specifically: 1) to take advantage of low-cost tags containing gyroscopes as well as accelerometers to determing animal accelerations, 2) to understand animal foraging behaviors, and 3) to understand behaviors of multiple animals within groups.

OBJECTIVES

Add capabilities to TrackPlot software to improve kinematic analysis and simplify the analysis of data from multiple tags simultaneously deployed.

1) Support for the analysis of gyroscopes data in combination with accelerometer and magnetometer data.
2) the extraction and frequency analysis of accelerations and rotation in animal coordinates, providing support for the analysis of kinematic patterns from tag data;
3) support for the visualization and kinematic analysis of foraging groups
4) support for longer tag deployments,
5) enhanced support for the presentation of results

APPROACH

The appoach has the following elements.

1) Participation in tagging cruises with collaborators to obtain representative data
2) Algorithm and software development
3) Testing of algorithms and tag hardware

All work is carried out by the PI

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WORK COMPLETED

Two open tags, with floatation, VHF beacons, suction cups and burn wires were obtained from Loggerhead instruments just in time for the July Stellwagen project lead by David Wiley. There were three successful attachments ranging from 2 to 4 hours durationn (see Figures 1 and 2). Both of the longer de-ployments remained attached as planned and released at the preset time. The data from these deployments has been processed into pseudo tracks.

Figure 1. Tag mounted on pole using a modified DTAG "robot"

Figure 2. Tag attached to a humpback whale on Stellwagen Bank. Summer, 2014

A method has been developed for combining acceleromenter and gyro data to produce more detailed accelerations.

Calculating dynamic linear tag acceleration (d) is as simple as subtracting the gravity vector from the measured acceleration vector if gravity can be estimated independently from accelerometer signals:

$$d = a - g$$

In principle, this is easily accomplished by starting with the sensing system static, in which case the accelerometers register a pure gravity vector signal (a=g). The average of a over some inter-val can then be used to establish the starting point for a virtual gravity vector g'. From this point forward, the gravity estimation vector g' is counter rotated according to the signals from the gy-roscopes at each time step. This method is detailed in a paper submitted to PLOS ONE (Ware et al, submitted)

Bench test calibrations of this method
For an end to end test of the method developed to process gyro data we mounted the tag on a crank arm attached to the chuck of a large industrial lathe as shown in Figure 3. provided a situation where the actual accelerations are known, being the sum of *g* and the centripetal accel-eration. For this simple case we could determine how accurately dynamic acceleration could be separated from static acceleration. Centripetal acceleration (*d*) is given by

$$d = \omega^2 r$$

where ω is the angular speed in radians/s and r is the radius.

Using the circuit board diagram provided by the manufacturer we determined the location of the accelerometer chip within the tag and mounted, the tag on a crank arm so that the accelerometers were placed at 9 and 18 cm eccentricities to the lathe axis of rotation.

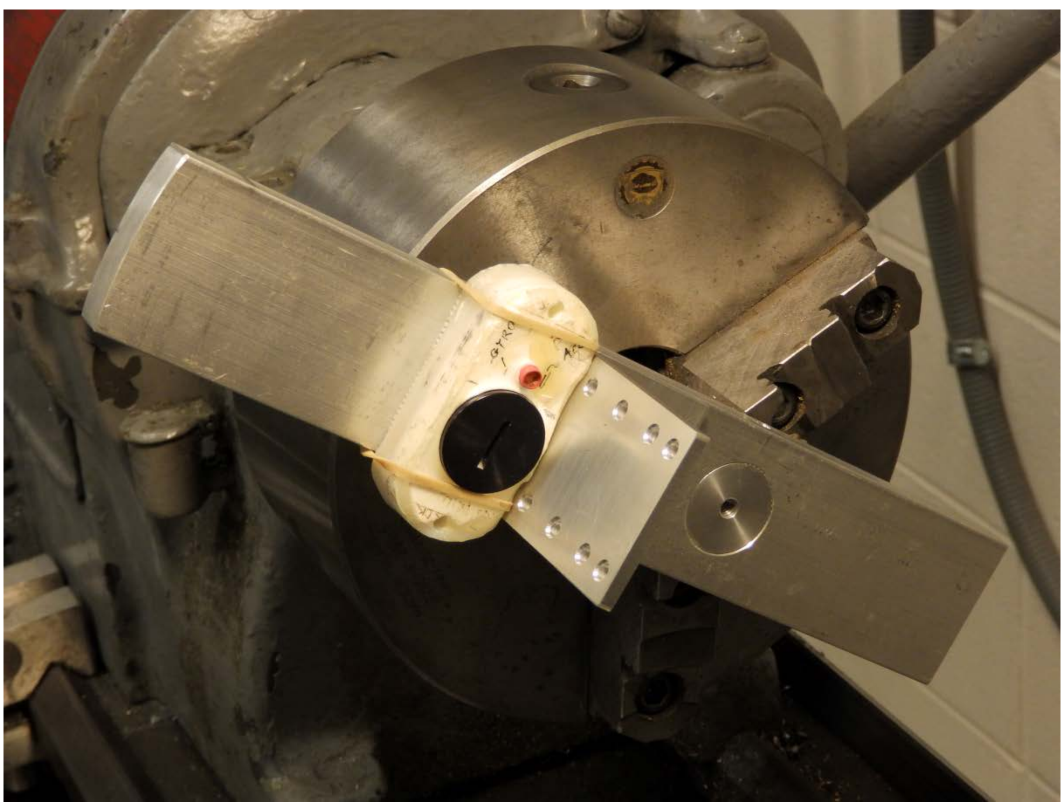

Figure 3. OpenTag mounted on a lathe to test processing method.

RESULTS

Implications of results obtained so far: It should be possible to measure actual dynamic accelerations to within about 0.5 m/s^2. This is far better than the widely *used overall dynamic body acceleration* (ODBA) method which greatly overestimates dynamic accelerations. Results suggest that from smaller marine mammals, such as dolphins, pinnipeds or turtles it may be possible to estimate energy expended due to locomotion.

The only formal result obtained so far are from bench tests of OpenTag. We set the lathe rotating with nominal speeds of 30 and 60 rpm in both clockwise and counter clockwise directions. To measure the actual speed of rotation we determined the period for 10 cycles using the accelerometer measurements. Table 1 shows the calculated centripetal accelerations. Since the acceleration is always towards the axis of rotation we took dynamic acceleration to be the axis of the tag pointing in that direction. We also calculated estimated dynamic body acceleraion EDBA (the vector sum of all estimated dynamic accelerations) using the method in Ware et al (submitted).

We processed the data using the method described in Ware et al (submitted) and the results are given in Table 1. As can be seen EPBA overestimates the larger dynamic accelerations and under estimates them the smaller dynamic accelerations. The absolute size of the estimation error increases with the acceleration.

Table 1: The rotation speeds obtained with the test rig with calculated centripetal accelerations. Average values for 16 seconds of steady rotation.

Rotation speed (rad/s)	Radius (m)	Centripetal m/s^2	EPBA m/s^2	EPBA error m/s2
0.0	-	0.0	0.133 (0.02)	0.133
-2.605	0.09	0.611	0.467 (0.21)	-0.144
	0.18	0.618	0.488 (0.33)	-0.155
2.618	0.09	1.222	1.051 (0.39)	-0.169
	0.18	1.234	1.073 (0.19)	-0.161
-6.163	0.09	3.440	3.693 (0.55)	0.253
	0.18	3.343	3.647 (0.66)	0.309
6.094	0.09	6.881	7.334 (0.59)	0.453
	0.18	6.861	7.257 (0.81)	0.396

IMPACT/APPLICATIONS

The benefits of this research will be more accurate and complete analysis of the behavior of tagged marine mammals, including better estimates of energy expenditures.

RELATED PROJECTS

Additional funding for this project is being provided by NOAA grant (NA05NOS4001153) to the center for coastal and Ocean mapping. This includes work with Pinnipeds in collaboration with Andrew Trites of UBC.

REFERENCES

Ware, C., Trites, A., and Rosen, D. (submitted) Relating propulsive body acceleration to swim-ming speed and hydrodynamic drag for Steller sea lions using tags incorporating gyroscopes and accelerometers

PUBLICATIONS

Ware, C., Trites, A., and Rosen, D. (2014) New and Improved Ways to Estimate Propulsive Body Acceleration of Marine Mammals. Poster presentation. Biologging Conference