MICROBOTICS, INC.

MIDG Series INS/GPS Application Note

AN002 - Calculating Ground Track

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1. MIDG Series INS/GPS. The MIDG Series INS/GPS is well suited to work with ground track of a vehicle. The "Ground Track" refers to the direction of motion of the vehicle with respect to the local map. Most of the time, the direction of motion is analogous to heading; however, the MIDG Series INS/GPS can be used to track both the direction of motion as well as the direction of pointing. This application note demonstrates how to calculate ground track using messages from the MIDG Series INS/GPS. Ground track is calculated from vehicle velocity. If the vehicle velocity is known in the local Earth reference frame, then ground track is:

GT = arctan Veast Vnorth 2( ),

Where "arctan2" is the standard C math library atan2 function, which computes the arc tangent of y/x, using the signs of both arguments to determine the quadrant of the result. The Veast and Vnorth are the east and north velocities, respectively.

2 MIDG Series INS/GPS Messages. The MIDG Series INS/GPS messages, GPS_PV and NAV_PV both provide velocities. The GPS_PV velocity is computed directly from the internal GPS receiver at a rate up to 4Hz. The GPS velocity update is only provided when a GPS is solution is available. The NAV_PV velocity is a result of the Kalman filter and is available at rates up to 50Hz. The NAV_PV velocity is estimated even when during GPS dropouts. In both cases, the reference datum is WGS-84.

The default for the MIDG Series INS.GPS is to provides velocities in East, North, Up (ENU) coordinates. However, Earth-Centered, Earth-Fixed coordinates (ECEF) may be specified for velocities using the MIDG Series INS/GPS output format configuration option.

If ECEF coordinates are required for velocity output, east and north velocities can still be calculated as shown in Figure 1. The conversion of ECEF velocities to ENU velocities requires knowledge of the location on the Earth where the conversion will take place.

In the example in Figure 1, the location is defined by:

Latitude = 30 degrees

Longitude = 0 degrees.

Only after the ENU velocity has been calculated, can the ground track can be calculated using the equation presented above.

Conversion of ECEF velocity to ENU coordinates for the purpose of determining ground track. The velocity to be converted (in ECEF) is:

$$Vx = 0 * \frac{m}{sec} \qquad Vy = 10 * \frac{m}{sec} \qquad Vz = 10 * \frac{m}{sec}$$

Conversion from degrees to radians (for convenience):

$$D2R = \frac{\pi * rad}{180}$$

Define the location where the conversion will take place.

$\emptyset = 30\ Deg\ D2R$ Latitude

$\lambda = 0\ Deg\ D2R$ Longitude

$h = 0\ m$ Altitude above the ellipsoid

Convert ECEF velocity at the reference point to ENU coordinates:

$$\begin{pmatrix} Ve \\ Vn \\ Vu \end{pmatrix} = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix} * \begin{bmatrix} \cos(-\emptyset) & 0 & -\sin(-\emptyset) \\ 0 & 1 & 0 \\ \sin(-\emptyset) & 0 & \cos(-\emptyset) \end{bmatrix} * \begin{bmatrix} \cos(\lambda) & \sin(\lambda) & 0 \\ -\sin(\lambda) & \cos(\lambda) & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{pmatrix} Vx \\ Vy \\ Vz \end{pmatrix}$$

$$\begin{pmatrix} Ve \\ Vn \\ Vu \end{pmatrix} = \begin{bmatrix} -\sin(\lambda) * Vx + \cos(\lambda) * Vy \\ -\sin(\emptyset) * \cos(\lambda) * Vx - \sin(\emptyset) * \sin(\lambda) * Vy + \cos(\emptyset) * Vz \\ \cos(\emptyset) * \cos(\lambda) * Vx + \cos(\emptyset) * \sin(\lambda) * Vy + \sin(\emptyset) * Vz \end{bmatrix}$$

$$\begin{pmatrix} Ve \\ Vn \\ Vu \end{pmatrix} = \begin{pmatrix} 10 \\ 8.66 \\ 5 \end{pmatrix} * \frac{m}{sec}$$

Figure 1. MathCad Example