Documentation of the Coordinate Transformation C-Code

1.1 Summary

The file "coord_transformer.c" contains the C-code required to convert from GIS to Radar coordinates and vice-versa. The file is designed to be built as an executable which takes a command line argument flag to designate whether to convert from GIS to Radar (-g) or Radar to GIS (-r). The initial and final locations are currently hard coded as Wallops Island (37N, 75W) and Puerto Rico (18N, 66W), respectively.

Example usage on Windows:

- Build: "gcc coord_transformer.c -o coord_trans"
- Radar to GIS: "coord_trans.exe -r"
- GIS to Radar: "coord_trans.exe -g"

Example output:

- Radar to GIS:
  Final Longitude: -66.000000
  Final Latitude: 18.000000
- GIS to Radar:
  Range: 2288.66 km
  Bearing: 154.96 degrees

2.1 GIS to Radar

The function for converting from GIS coordinates to Radar coordinates is handled by the "GIS2Radar" and requires the initial and final latitude and longitude coordinates. This function is a C implementation of the following mathematical formulas. To calculate the range and bearing, the following intermediate equations are useful.

$$
\begin{aligned}
a &= \sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1)\cdot\cos(\phi_2)\cdot\sin^2\left(\frac{\Delta\lambda}{2}\right) \\
c &= 2\cdot\operatorname{atan2}\left(\sqrt{a}, \sqrt{1-a}\right) \\
x &= \cos(\phi_1)\cdot\sin(\phi_2) - \sin(\phi_1)\cdot\cos(\phi_2)\cdot\cos(\Delta\lambda) \\
y &= \sin(\Delta\lambda)\cdot\cos(\phi_2)
\end{aligned}
$$

where ϕ_1 and ϕ_2 represent the initial and final latitude coordinate, respectively, $\Delta\phi$ is the difference in latitudes, and $\Delta\lambda$ is the difference in longitudes. The range and bearing are then calculated via the following formulas.

$$\text{Range} = R \cdot c$$
$$\text{Bearing} = \text{atan2}(y, x) \cdot \frac{180}{\pi}$$

where R is the radius of Earth in kilometers, range is in km, and bearing is in degrees.

3.1 Radar to GIS

The function for converting from Radar coordinates to GIS coordinates is handled by the "R2G" and requires the initial latitude and longitude coordinates, as well as a range and bearing. This function is a C implementation of the following mathematical formulas. To calculate the range and bearing, the following intermediate equations are useful for documentation clarity, though are not required in implementation.

$$\alpha = \sin(\phi_1) \cdot \cos\left(\frac{\text{Range}}{R}\right)$$
$$\beta = \cos(\phi_1) \cdot \sin\left(\frac{\text{Range}}{R}\right) \cdot \cos(\text{Bearing})$$
$$\gamma = \sin(\text{Bearing}) \cdot \sin\left(\frac{\text{Range}}{R}\right) \cdot \cos(\phi_1)$$
$$\delta = \cos\left(\frac{\text{Range}}{R}\right) \cdot \sin(\phi_1) \cdot \sin(\phi_2)$$

The final latitude and longitude coordinates are then calculated via the following formulas.

$$\phi_2 = \sin^{-1}(\alpha + \beta)$$
$$\lambda_2 = \lambda_1 + \text{atan2}(\gamma, \delta)$$

where ϕ_1 and ϕ_2 represent the initial and final latitude coordinates, respectively, λ_1 and λ_2 represent the initial and final longitude coordinates, respectively, and R is the Earth's radius in kilometers.