

Geoid Determination for Effective Integration of GPS-Derived Data into Ghana National Coordinate System

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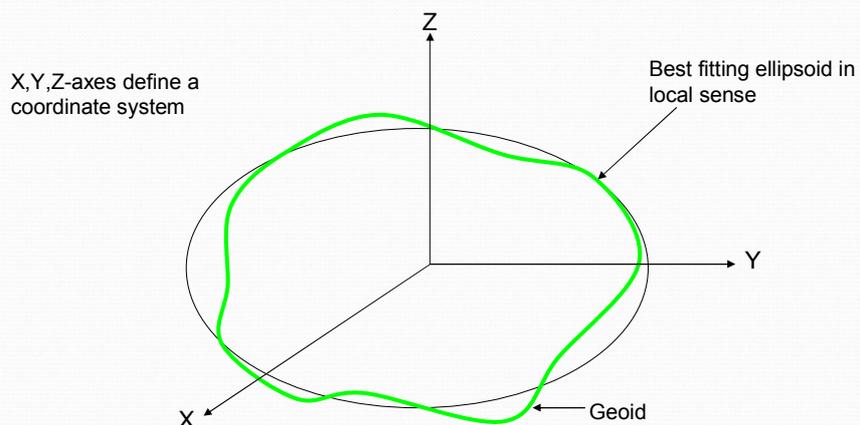
Outline

- **Introduction**
- **Datums and Transformations**
- **Coordinate Conversions**
- **Geoid Determination**
- **Conclusion**

Geodetic Datum

- A specific ellipsoid in a specific position and orientation with respect to the Earth, and on which a coordinate system is based for mapping purposes
- Minimum of 5 elements required to define a geodetic datum:
 - position of the origin, 2 parameters (Φ_0, λ_0);
 - orientation of the network, 1 parameter (initial azimuth, α_0);
 - size and shape of the reference ellipsoid, 2 parameters (a,b or a,f).

Geodetic Datum



Types of Geodetic Datums

- Local Geodetic Datum:

- A datum which best approximates the size and shape of a particular part of the Earth's mean sea level surface

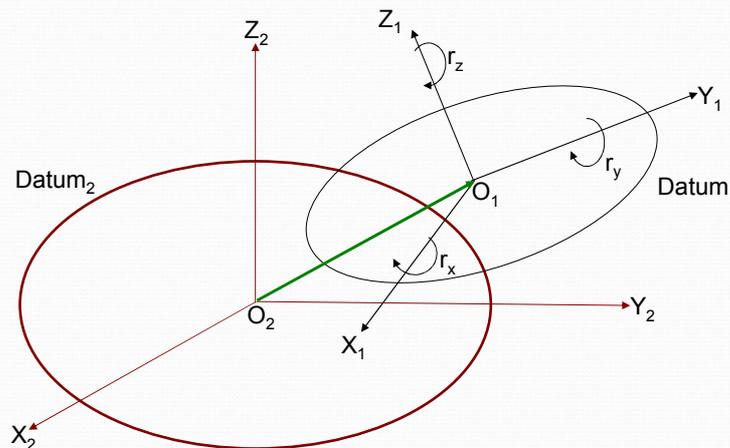
E.g. Accra datum based on War Office Ellipsoid: Legon datum based on Clake 1880 (Modified) Ellipsoid

- Geocentric Datum

- A datum which best approximates the size and shape of the whole Earth
E.g. WGS84 datum

Datum Transformation Models

- 3-D Transformation



Bursa-Wolf 7-Parameter Transformation Model

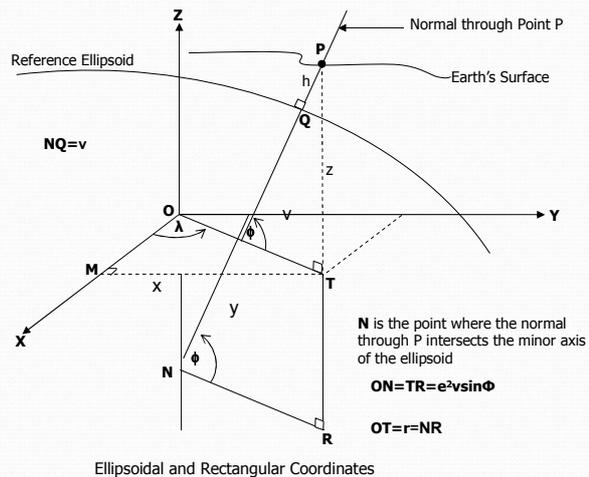
- Datum transformation from Cartesian Coordinate System 1 to System 2

$$\begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + (1 + \delta_s) \begin{bmatrix} 1 & r_z & -r_y \\ -r_z & 1 & r_x \\ r_y & -r_x & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix}$$

System 1 – Accra Datum based on War Office Ellipsoid or Legon Datum based on Clarke 1880 (Modified) Ellipsoid

System 2 – WGS84 Datum based on WGS84 Ellipsoid

Ellipsoidal & Cartesian Coordinates



Converting Ellipsoidal coordinates to Cartesian coordinates

$$x = r \cos \lambda = (v + h) \cos \phi \cos \lambda$$

$$y = r \sin \lambda = (v + h) \cos \phi \sin \lambda$$

$$z = (v + h) \sin \phi - e^2 v \sin \phi = [v(1 - e^2) + h] \sin \phi$$

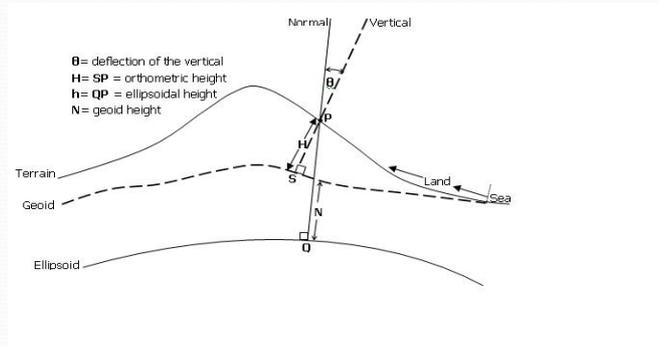
$$\text{But } h = H \pm N$$

Ellipsoid-Geoid Fitting

- Local Geoid:- Geoid undulation with respect to an ellipsoid adopted by a country, e.g War Office Ellipsoid
- Global Geoid:- Geoid undulation with respect to a globally adopted ellipsoid, e.g. WGS84 Ellipsoid



Basic Definition of Geoid



Equipotential surface of the Earth's gravity field that best approximates the mean sea level in the open oceans, ignoring oceanographic effects (Listing, 1873).

Geoid Determination (I)

- When is the geoid said to be determined?

The geoid is said to be determined for a given area or country if for points in that area at reasonable intervals, its separation or undulation from a selected reference ellipsoid is known or can be estimated geometrically (Dadzie, 2005).

Geoid Determination (II)

- What is the way forward?

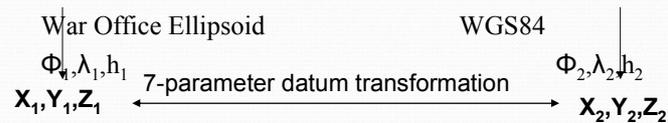
To model the geoid undulation (N) with respect to War Office Ellipsoid for accurate computation of ellipsoidal height (h) with respect to War Office Ellipsoid required for determination of accurate transformation parameters

Implementation Strategies (I)

- How can we do that?
 1. Acquisition, reduction, plotting and analysis of all available gravity data
 2. Computation of geoid undulation with respect to War Office Ellipsoid using Stokes' Formula evaluated through both 1D- and 2D-FFT techniques and by employing the remove-restore approach with EGM96 as the reference global geopotential model

Implementation Strategies (II)

Computation and testing of transformation parameters



Conclusion

From the theoretical developments, it is shown that determination of the geoid undulation with respect to the War Office Ellipsoid is required for computation of accurate transformation parameters for effective use of GPS as a tool for acquiring positional data.



THANK YOU FOR YOUR TIME