Research Article

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Direct bearing angles determination on globe

Abstract

In this paper, we will see that the determination of direct bearing angles. As it is known, in bearing angles are often computed used formulas with arctan function. The arctan function gives an angle values between -90º and +90º. However, the bearing angle is by definition 0º to 360º. Consequently, it is inevitable to examine the process of obtaining the azimuth angle. Classic formulas only work correctly if the edge is in the 1st quarter. If the edge is located in the other quarters, the angles of the bearing should be examined. In this work we proposed new formulas for direct bearing angles on globe (sphere). Using the formula that we propose will save execution time in codes with intensive geodesic calculations.

Keywords: bearing angles, globe, sphere, geographical coordinates, direct bearing angles, classic formulas, arctan function, geodesic calculations, azimuth angle, ellipsoid surface

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Introduction

For example, First Geodetic Basic problem; $P_1(\varphi_1,\lambda_1)$ the geographic coordinates of a point P_1 are given in latitude longitude values, S_{12} the geodetic curve length from point P_1 to point P_2, A_{12} the bearing angle (azimuth angle) of the length and desired $P_2(\varphi_2,\lambda_2)$ the geographic coordinates of a point P_2. The azimuth A_{21} is desirable which corresponding A_{12} azimuth angle is because there are approximately 180º difference between A_{12} and A_{21}. Thus, the region of A_{21} is easily predicted. If the two points are on the same meridian or on the same parallel circle the difference between A_{12} and A_{21} is exactly 180º.[1,2]

However, in the 2nd Geodetic basic problem; the geographic coordinates latitude and longitude values of the two points are given ; $P_1(\varphi_1,\lambda_1), P_2(\varphi_2,\lambda_2)$ and required the geodesic curve length between the two points is S_{12} and the corresponding azimuths A_{12} and A_{21} between the two points. The azimuth calculation is not as easy as in the 1st geodetic basic problem assignment. If the A_{12} azimuth is calculated incorrectly, the A_{21} azimuth will also be incorrect by itself. In this proposed method, formulas are given for how to obtain the azimuth angle directly without any examination. The given method can calculate azimuth without reducing the sphere and ellipsoid surface.

Material and methods

Calculation of between the two points S_{12} and the corresponding azimuths A_{12} and A_{21} from known P_1, P_2 point's geographical coordinates is also called as geodetic 2nd basic problem solution (Figure 1). Problem is solved classically with below formulas (Equation 1).[3–5]

Classic method

$$\text{ó} = \arccos(\sin\phi_1\ \sin\phi_2 + \cos\phi_1\cos\phi_2\ \cos\text{Ä}\lambda$$

$$A_{12} = \arctan\left(\frac{\sin\Delta\lambda}{\tan\phi_2 \cos\phi_1 - \sin\phi_1 \cos\Delta\lambda}\right)$$

$$A_{21} = \arctan\left(\frac{\sin\Delta\lambda}{\cos\Delta\lambda\ \ \sin\phi_2 - \cos\phi_2\ \ \tan\phi_1}\right) + \pi$$

Here σ is the angular equivalent of the edge.

If you want to find the metric of the edge:

$$S = s / r.R$$

$$r = 180^o / \pi$$

R= radius of the earth

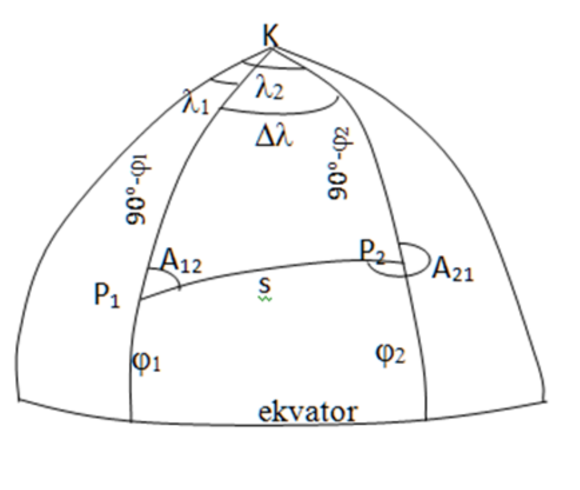

Figure 1 The two points S_{12} and the corresponding azimuths A_{12} and A_{21} from known P_1, P_2 points geographical coordinates is also called as geodetic 2nd basic problem solution.

It is important to remember that these classic formulas only work correctly if the edge is in the 1st quarter. If the edge is located in the other quarters, the angles of the bearing angle should be examined. For correct angles, the necessary additions should be made according to the Table 1 below.

Direct determination of azimuth by geographic coordinates

For direct calculations we give below formulas. In this proposed method, formulas are given for how to obtain the azimuth angle directly without any examination. The proposed method can calculate direct azimuth angles on the sphere and ellipsoid surface, (Equation 2).[6]

Proposed method

$$I = \sin \Delta\lambda$$

$$II = \tan\phi_2 \cos\phi_1 - \sin\phi_1 \cos\Delta\lambda$$

$$A_{12} = 2.\arctan\left(\frac{I}{II - \sqrt{I^2 + II^2}}\right) + 180^o$$

$$III = \tan\phi_1 \cos\phi_2 - \sin\phi_2 \cos\Delta\lambda$$

$$A_{21} = 2.\arctan\left(\frac{I}{-III + \sqrt{I^2 + III^2}}\right) + 180^o$$

Table 1 Fixed value to add for bearing angles

Quadrant	Fixed value to add for A_{12}	Fixed value to add for A_{21}
1.Quadrant	-	-
2.Quadrant	+180°	+180°
3.Quadrant	+180°	-180°
4.Quadrant	+360°	-

Numerical example

To compare direct formula and classical formula results, From the point P_1 to the point P_2 which is located in different quarters each time, the second basic problem solutions were made and the bearing angles calculations were made.

$P_1(\varphi_1, \lambda_1)$, the geographic coordinates of a point P1 are given in latitude longitude values:

$$\varphi_1 = 30^o, \lambda_1 = 30^o$$

$$R = 6370000m$$

Required: s, A_{12}, A_{21}

If we use the above equations (Equation 1) and (Equation 2) for the solution, for results please see Table 2

Table 2 Direct formula and classical formula results

				Classic formula (Equation 1)		Direct formula (Equation 2)	
Quadrant	φ_2	λ_2	S	A_{12}	A_{21}	A_{12}	A_{21}
1	32	31	241911.948	22.9432	203.45833	22.9432	203.45833
2	29	32	223183.087	-60.6189	120.36606	119.3811	300.36606
3	28	29	242683.026	23.86428	203.37939	203.86428	23.37939
4	32	29	241911.948	-22.9432	156.54167	337.0568	156.54167

Results and discussion

In this proposed method, formulas are given for how to obtain the azimuth angle directly without any examination. The given method can calculate azimuth without reducing the sphere and ellipsoid surface. The numerical example that we have given shows the accuracy of the method we propose. The advantage of the method is that no examination is required. In computer calculations, if..end blocks are not used when direct formulas are used. The if..end blocks reduce the execution speed in computer calculations.

For future studies, researchers are advised to try to find more simple direct formulas.

Conclusion

In this proposed method, formulas are given for how to obtain the azimuth angle directly without any examination. The given method can calculate azimuth without reducing the sphere and ellipsoid surface. Using the formula that we propose will save execution time in codes with intensive geodesic calculations

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Conflicts of interest

The author declares that there are no conflicts of interest.

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