USE OF GREAT - CIRCLE DISTANCE FOR AERIAL ROUTE GUIDING IN HILLY AREAS

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ABSTRACT

Path planning always remains hot issue in every era of civilization. It plays vital roles in all aspects of daily life. However, this issue becomes crucial during emergency like situations for example hazards. It is evident from history that most portion of losses, either in the form of human lives, or in the form of economic occur because of late arrival of relief work, and selection of optimal path plays key role. Here, in this research, authors focuses on the addition of elevation difference function for more accuracy while path planning particularly mountainous areas. This research is the part of research carried out by author while working on the use of advanced computer technology for hazard mitigation.

Key Words: Hazard Mitigation, Path Planning, Great Circle.

1. INTRODUCTION

On 8th October 2005 at 8:50 AM, an earthquake of 7.6 on the Richter scale struck through the mountainous region of northern Pakistan [1]. The most devastating destruction was struck in northern parts of Pakistan. The northern region of Pakistan is comprised of mountains and hilly areas, where after this destructing disaster the ordinary means of transportations and routes were destroyed severely (80% wiped off) most of casualties were resulted because of late arrival of relief work and relief goods. There were 10800 plus villages in that mountainous region which were suffered by that earthquake [1], as shown in figures 1,2 and 3.

The earthquake struck zone consists of 10835 villages that were badly affected by earthquake. The plots in figures are sketched from latitudinal and longitudinal values of places from Excel file Shown in figure 4.

The problem in these earthquake affected regions was that these villages were located at different heights shown in figure 5, and most of the roads were destroyed. This kind of resource constrained shortest path problem asks for the computation of a least cost path that obeys set of resource constraints [4]. Here computing of shortest paths is a fundamental issue and can be resolved by different techniques [5]. However, for immediate relief in those areas aerial route was most suitable by mean of using choppers. For this problem a great circle distance formula can be used.

2. THE GREAT- CIRCLE DISTANCE

The great-circle distance is considered as the shortest distance between any two points on the earth when measured along the surface of earth. It can be concluded from literature that this is commonly used for distances between two points on sea [6]. The distance between two points in Euclidean space is the length of a straight line from one point to another. Where as it is evident from literature that there is no straight line on spherical surface

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of earth. Therefore for measurement of distance between two points on earth, straight lines are replaced with geodesics. Geodesics on the sphere are the great circles.

Let X1,Y1; X2,Y2 be the longitude and latitude in degrees of two points, respectively, ΔX the longitude difference and Δσ the angular distance between two points measured in radians.
Then:

$$\Delta\sigma = \arccos\{\sin y_1 \sin y_2 + \cos y_1 \cos y_2 \cos \Delta x\}$$

Where: $x_1 = X_1 * \pi/180$,

Similarly x_2, y_1 and y_2 can be computed in the same way in radians.

Δσ is the angle made by those two points X1,Y1 and X2,Y2 on the surface of earth. Thus the angular distance between two points is say D, then
D= Δσ *radius of earth (kilometers, miles or nautical miles)

3. ELEVATION DIFFERENCE FUNCTION

Earth surface is not pure round (or flat) and different points have different respective heights or elevations. If we incorporate the elevation of those locations, this can supplement more accuracy in distance computation [2]. It is evident from literature that consideration of two dimensional path is insufficient in case of hilly areas[3]. In straight line distance matrix if the elevation difference between two points is 20% of their horizontal distances it will contribute approximately 2% addition in minimum distance so we can add a supplementary function in our path calculating function, that if elevation difference between two points is 20 % or higher of measured distance then it must be incorporated.

4. CONCLUSIONS

In this paper importance of elevation while computing the distance between two points is presented. The main focus of this research aimed for contribution of supplemented function that may be helpful for computation of shortest paths between those two points whose elevation has much differences as compared to their two dimensional distance in the perspectives of Great Circles. It is clearly evident from the computations done by Elevation Difference function that if elevation difference between two points is equal to 20% of total computed distance, then it will add supplementary distance of 2%. So in the opinion of author if elevation difference between two points is higher then 20 percent then this may supplement the accuracy by 2 percent or more accordingly.

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Figure 1: Global map of Pakistan depicting the affected region

Figure 2: Map of Pakistan with major cities and earthquake affected region

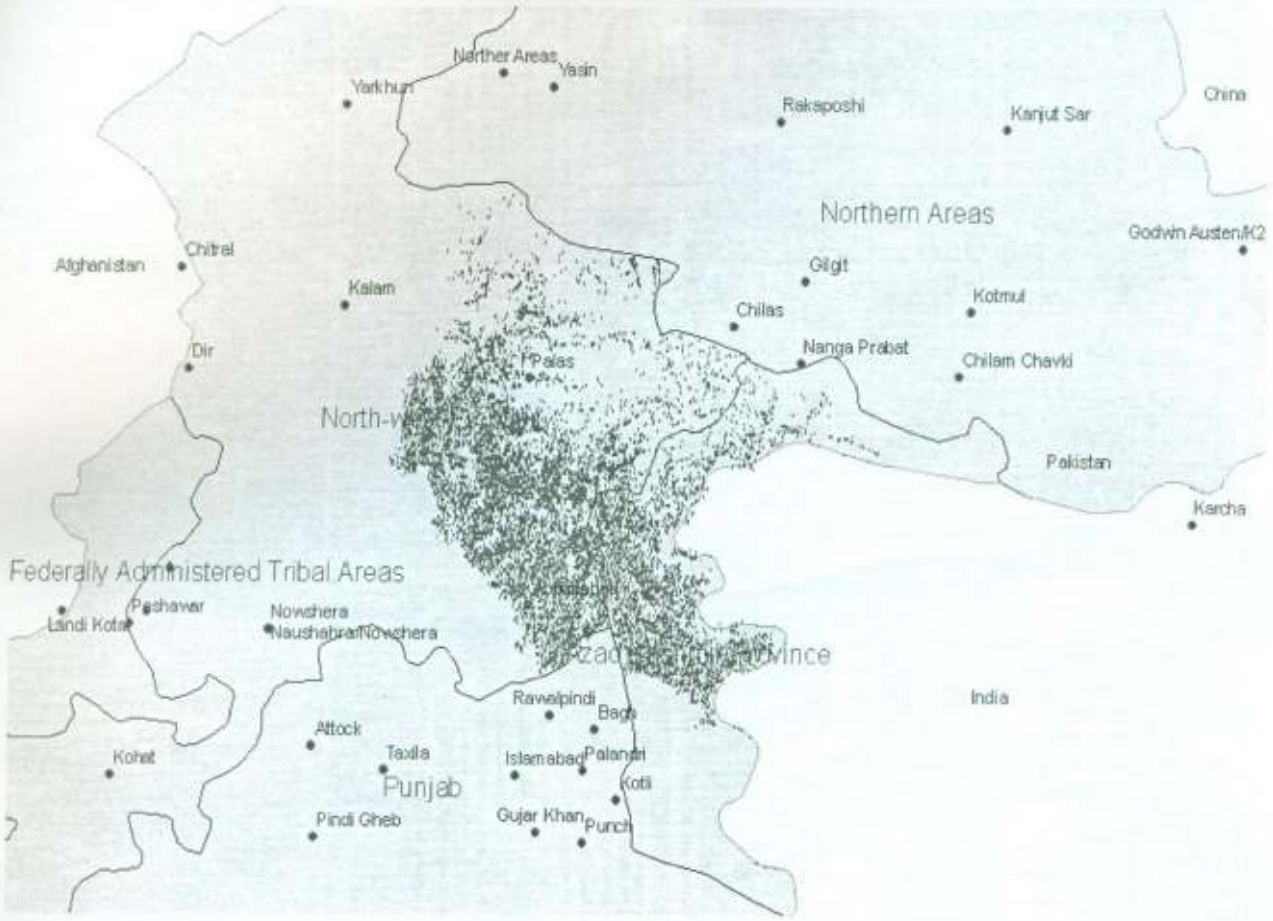
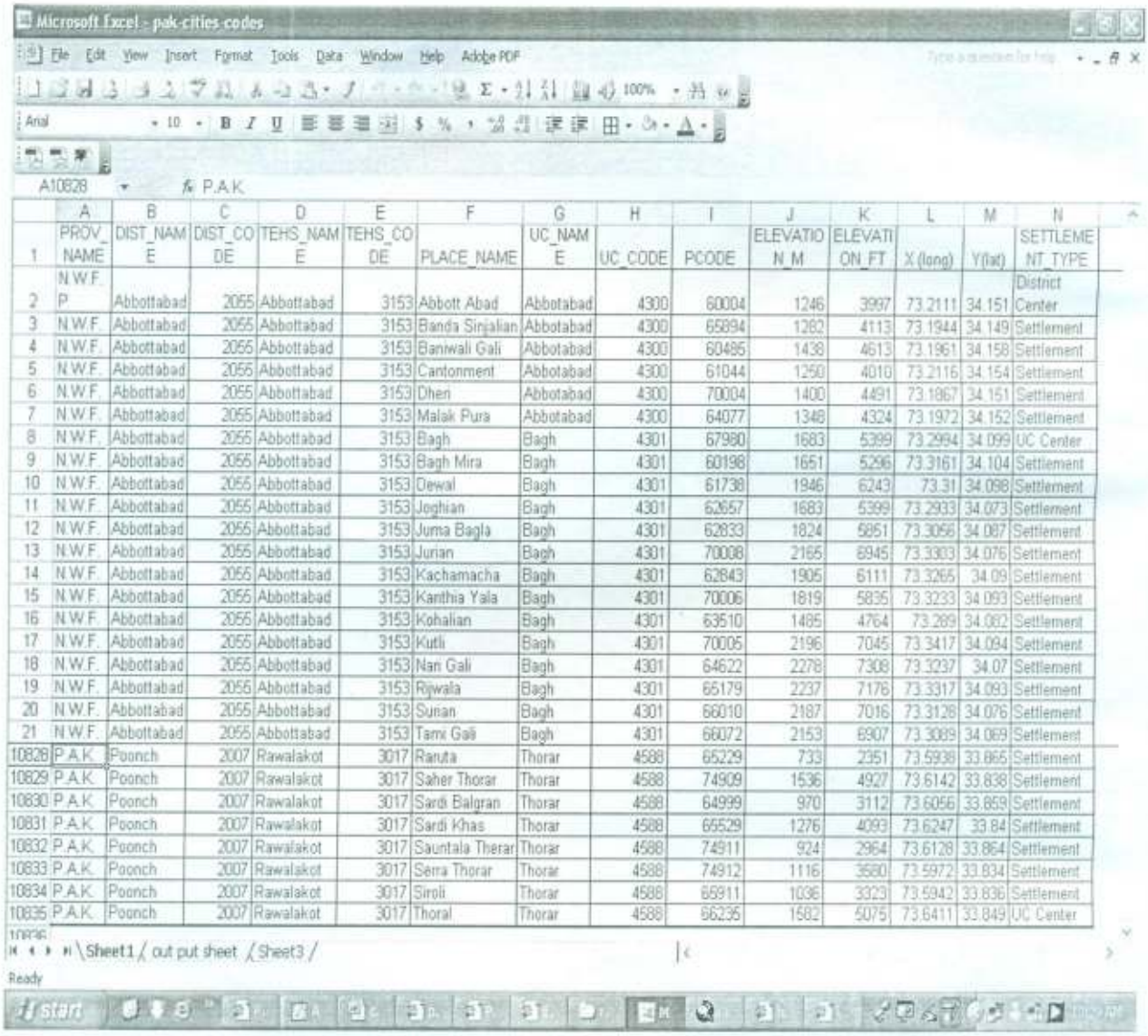


Figure 3: Earthquake affected zone.



Microsoft Excel - pak-cities codes

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	PROV_NAME	DIST_NAME	DIST_CODE	TEHS_NAME	TEHS_CODE	PLACE_NAME	UC_NAME	UC_CODE	PCODE	ELEVATION_M	ELEVATION_FT	X (long)	Y(lat)	SETTLEMENT_TYPE
2	N.W.F.P	Abbottabad	2055	Abbottabad	3153	Abbott Abad	Abbotabad	4300	60004	1246	3997	73.2111	34.151	District Center
3	N.W.F.	Abbottabad	2055	Abbottabad	3153	Banda Sirjalian	Abbotabad	4300	65894	1282	4113	73.1944	34.149	Settlement
4	N.W.F.	Abbottabad	2055	Abbottabad	3153	Baniwali Gali	Abbotabad	4300	60485	1438	4613	73.1961	34.158	Settlement
5	N.W.F.	Abbottabad	2055	Abbottabad	3153	Cantonment	Abbotabad	4300	61044	1250	4010	73.2116	34.154	Settlement
6	N.W.F.	Abbottabad	2055	Abbottabad	3153	Dheri	Abbotabad	4300	70004	1400	4491	73.1867	34.151	Settlement
7	N.W.F.	Abbottabad	2055	Abbottabad	3153	Malak Pura	Abbotabad	4300	64077	1346	4324	73.1972	34.152	Settlement
8	N.W.F.	Abbottabad	2055	Abbottabad	3153	Bagh	Bagh	4301	67980	1683	5399	73.2994	34.099	UC Center
9	N.W.F.	Abbottabad	2055	Abbottabad	3153	Bagh Mira	Bagh	4301	60198	1651	5296	73.3161	34.104	Settlement
10	N.W.F.	Abbottabad	2055	Abbottabad	3153	Dewal	Bagh	4301	61738	1946	6243	73.31	34.098	Settlement
11	N.W.F.	Abbottabad	2055	Abbottabad	3153	Joghian	Bagh	4301	62657	1683	5399	73.2933	34.073	Settlement
12	N.W.F.	Abbottabad	2055	Abbottabad	3153	Juma Bagla	Bagh	4301	62833	1824	5851	73.3056	34.087	Settlement
13	N.W.F.	Abbottabad	2055	Abbottabad	3153	Jurian	Bagh	4301	70008	2165	6945	73.3303	34.076	Settlement
14	N.W.F.	Abbottabad	2055	Abbottabad	3153	Kachamacha	Bagh	4301	62843	1905	6111	73.3265	34.09	Settlement
15	N.W.F.	Abbottabad	2055	Abbottabad	3153	Kanthia Yala	Bagh	4301	70006	1819	5835	73.3233	34.093	Settlement
16	N.W.F.	Abbottabad	2055	Abbottabad	3153	Kohalian	Bagh	4301	63510	1485	4764	73.269	34.082	Settlement
17	N.W.F.	Abbottabad	2055	Abbottabad	3153	Kutli	Bagh	4301	70005	2196	7045	73.3417	34.094	Settlement
18	N.W.F.	Abbottabad	2055	Abbottabad	3153	Nan Gali	Bagh	4301	64622	2278	7308	73.3237	34.07	Settlement
19	N.W.F.	Abbottabad	2055	Abbottabad	3153	Rijwala	Bagh	4301	65179	2237	7176	73.3317	34.093	Settlement
20	N.W.F.	Abbottabad	2055	Abbottabad	3153	Surian	Bagh	4301	66010	2187	7016	73.3128	34.076	Settlement
21	N.W.F.	Abbottabad	2055	Abbottabad	3153	Tarni Gali	Bagh	4301	66072	2153	6907	73.3089	34.069	Settlement
10828	P.A.K.	Poonch	2007	Rawalakot	3017	Raruta	Thorar	4588	65229	733	2351	73.5938	33.865	Settlement
10829	P.A.K.	Poonch	2007	Rawalakot	3017	Saher Thorar	Thorar	4588	74909	1536	4927	73.6142	33.838	Settlement
10830	P.A.K.	Poonch	2007	Rawalakot	3017	Sardi Balgran	Thorar	4588	64999	970	3112	73.6056	33.859	Settlement
10831	P.A.K.	Poonch	2007	Rawalakot	3017	Sardi Khas	Thorar	4588	66529	1276	4093	73.6247	33.84	Settlement
10832	P.A.K.	Poonch	2007	Rawalakot	3017	Sauntala Therar	Thorar	4588	74911	924	2964	73.6128	33.864	Settlement
10833	P.A.K.	Poonch	2007	Rawalakot	3017	Serra Thorar	Thorar	4588	74912	1116	3580	73.5972	33.834	Settlement
10834	P.A.K.	Poonch	2007	Rawalakot	3017	Siroli	Thorar	4588	65911	1036	3323	73.5942	33.836	Settlement
10835	P.A.K.	Poonch	2007	Rawalakot	3017	Thoral	Thorar	4588	66236	1582	5075	73.6411	33.849	UC Center

Sheet1 / out put sheet / Sheet3 /

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Figure 4: Excel file showing 10835 villages with different heights.

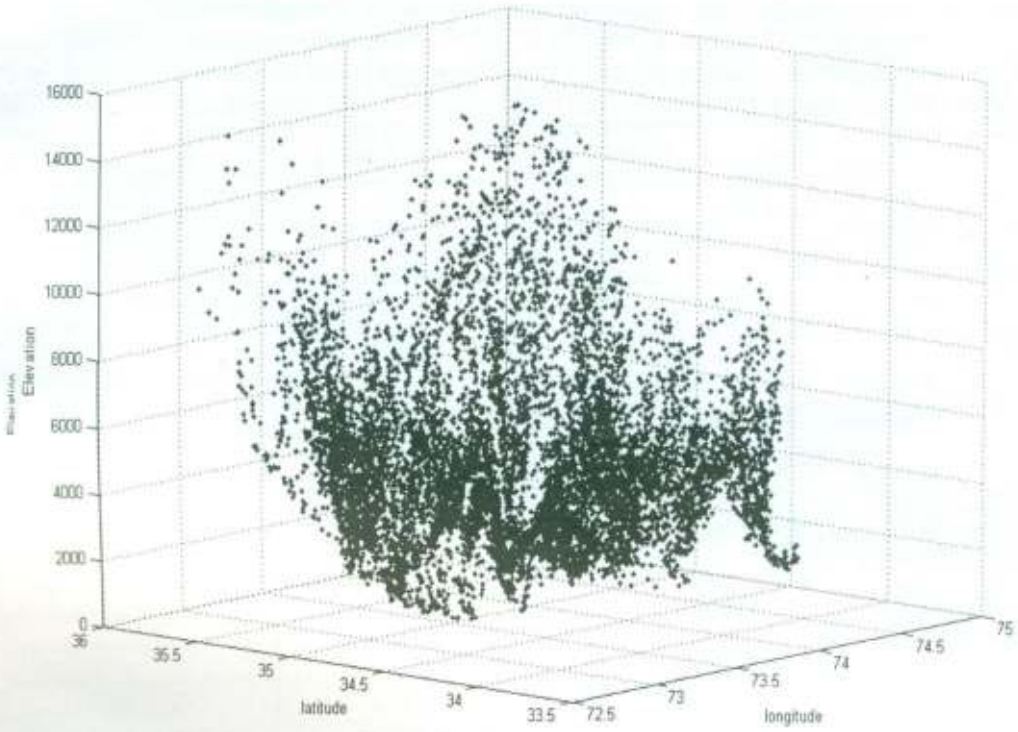

Figure 5: Village points in earthquake effected zone

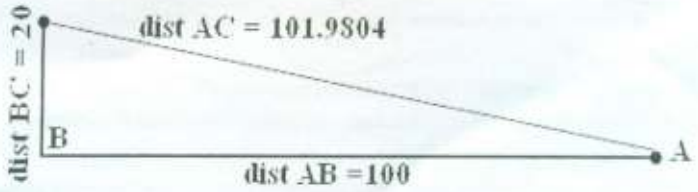

Figure 6: Elevation difference model

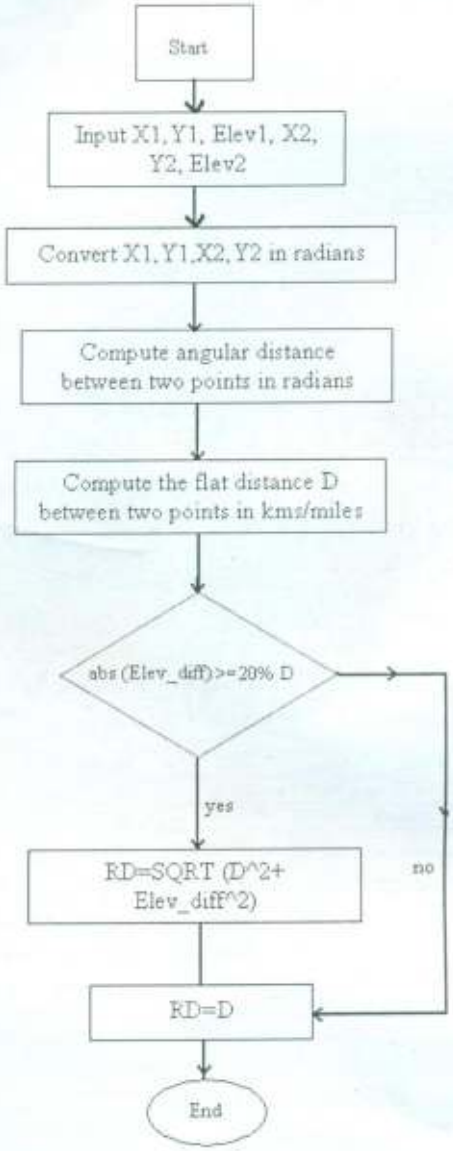

Figure 7: Program routine for the great-circle distance computation.