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Short comunication

GIS-Based Proximity Analysis of Schools, An E-Governance Initiative

Vinod Jain & Animesh Pant

Scientist-D & Scientific Officer,National Informatics Centre, Rajasthan state Unit.Jaipur,India

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PROJECT OBJECTIVES

1. To create effective algorithm for finding such settlements which do not have schools within 'n' KM of region.
2. To create effective algorithm for finding such settlements which have 'k' number of schools within 'n' KM of region where k>1.
3. To apply above concepts in Rajasthan School GIS System. A G2G application for School education department of Rajasthan, India.

Abstract: Given shape files of a particular region along with shape file of schools, it is possible to get statistical information regarding such regions which might be suitable for opening new schools based on given geographical criterion of school opening planning committee. GNS (Get Nearest School) function can be used in determining such settlements which either do not have schools within 'n' KM of region or which have 'k' number of schools within 'n' KM of region where k>=1. Such type of proximity analysis requires more attention.

INTRODUCTION TO THE PROBLEM

The process of Proximity analysis of schools can we divided in some number of steps:

Step 1 : Mark school and settlement point in map, shapefile containing settlement points and school points is mandatory.

Step 2: GNS (Get Nearest School) algorithm is required to find nearest school to a given settlement polygon.

Step 3: Use Modified GNS algorithm to find settlements which do not have schools according to criterion of school opening planning committee.

Assumptions:

1. While calculating distance between school and settlement it is assumed that distance is Rectilinear.
2. Centroid of settlement polygon is takes as base point for distance calculation.
3. Physical hindrance like drain /river etc is ignored with calculating school to settlement distance.

Concept:

The shortest distance (the geodesic) between two given points P1= (lat1, lon1) and P2= (lat2, lon2) on the surface of a sphere with radius R is the great circle distance. It can be calculated using the formula:

$$Dist = \arccos(\sin(lat1) \cdot \sin(lat2) + \cos(lat1) \cdot \cos(lat2) \cdot \cos(lon1 - lon2)) \cdot R$$

Proof:

Given a unit sphere, a "spherical triangle" on the surface of the sphere is defined by the great circles connecting three points u, v, and w on the sphere. If the lengths of these three sides are *a* (from u to v), *b* (from u to w), and *c* (from v to w), and the angle of the corner opposite *c* is *C*, then according to the spherical law of cosines:

$$\cos(c) = \cos(a)\cos(b) + \sin(a)\sin(b)\cos(c)$$

Since this is a unit sphere, the lengths *a*, *b*, and *c* are simply equal to the angles (in radians) subtended by those sides from the center of the sphere (for a non-unit sphere, they are the distances divided by the radius). As a special case, for c=(pi)/2 , then cos(c)=0 and one obtains the spherical analogue of the Pythagorean theorem:

$$\cos(c)=\cos(a)\cos(b)$$

A variation on the law of cosines, the second spherical law of cosines, (also called the **cosine rule for angles**) states:

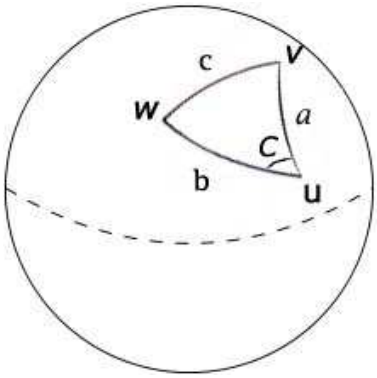
$$\cos(A) = -\cos(B)\cos(c) + \sin(B)\mathrm{Sin}(C)\cos(a)$$

A proof of the law of cosines can be constructed as follows. Let **u**, **v**, and **w** denote the unit vectors from the center of the sphere to those corners of the triangle. Then, the lengths (angles) of the sides are given by the dot products:

$$\cos(a) = u.v$$

cos(b) = u.w

cos(c) = v.w



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To get the angle *C*, we need the tangent vectors **t***a* and **t***b* at **u** along the directions of sides *a* and *b*, respectively. For example, the tangent vector **t***a* is the unit vector perpendicular to **u** in the **u**-**v** plane, whose direction is given by the component of **v** perpendicular to **u**. This means:

ta = (v-u(u.v)) / |v - u(u.v)| = (v - u cos(a)) / sin(a)

Where for the denominator we have used the Pythagorean identity sin2(*a*) = 1 − cos2(*a*). Similarly,

tb = (w - ucos(b))/ sin(b)

Then, the angle *C* is given by:

cos(c) = ta*tb = ((cos(c) - cos(a)cos(b))/sin(a)sin(b))

Suppose we want to find places within a distance *d*=2 km from *M*=(*lat*, *lon*)=(1.3963, -0.6981) in a database. Given that we have a table named Places with columns Lat and Lon that hold the coordinates *in radians*, then we could use this SQL query:

SELECT * FROM Places WHERE acos(sin(1.3963) * sin(Lat) + cos(1.3963) * cos(Lat) * cos(Lon - (-0.6981))) * 6371 <= 2

Algorithm:

1. GNS algorithm.

In order to synthesis GNS algorithm, the shapefiles are imported in SQL.

fnGNS(SetLat , SetLon ,distance)

{

SELECT Top acos(sin(SetLat) * sin(Lat) + cos(SetLat) * cos(Lat) * cos(Lon - (SetLon))) * 6371 as NDistance,SchoolName,

Lat, Lon FROM Places WHERE acos(sin(SetLat) * sin(Lat) + cos(SetLat) * cos(Lat) * cos(Lon - (SetLon))) * 6371 <=

distance ORDER BY acos(sin(SetLat) * sin(Lat) + cos(SetLat) * cos(Lat) * cos(Lon - (SetLon))) * 6371 asc

return NDistance,SchoolName, Lat, Lon

}

The above algorithm takes SetLat , SetLon as input which are settlements latitude and longitude, the output is in form of return (NDistance,SchoolName, Lat, Lon) from sql function.

NDistance = Distance of settlement from nearest school.

distance = length upto which school has to be searched.

SchoolName = Name of School.

Lat = Latitude of School.

Lon = Longitude of School.

2. Modified GNS algorithm (find such settlements which do not have schools within 'n' KM of region.)

```
fnNoSchool()
{
foreach( settlement , distance )
        {
         if(fnGNS(SetLat , SetLon ,distance ) == false)
            {
              arraySetNoSchool[]  <- (SetLat , SetLon, SelName)
            }
         }
return arraySetNoSchool;
}
```

The algorithm starts with selection of settlements points one by one , each settlement is passed through GNS function , if GNS returns "false" it indicates that is no school within N Km distance. Such settlement points are stored in an array.

3. Algorithm to find settlements which have 'k' number of schools within 'n' KM of region where k>=1.

fnMoreSchool(SetLat, SetLon, distance)

```
{
  SELECT count (*) as SchoolCount FROM Places WHERE acos(sin(SetLat) * sin(Lat) + cos(SetLat) *
cos(Lat) * cos(Lon -
 (SetLon))) * 6371 <= distance
 return SchoolCount ;
}
fnMoreSchoolArary()
{
foreach( settlement , distance )
        {
        if(fnMoreSchool(SetLat, SetLon,  distance ) >=1)
            {
              arraySetMoreSchool[]  <- (SetLat , SetLon, SelName)
            }
          }
return arraySetMoreSchool;
}
```

The algorithm starts with finding such settlements which have more than one school in a region. Followed by creating array of such settlement points.

APPLICATIONS

Rajasthan School GIS system is a unique statistical tool of its kind, the objective behind its development is proximity analysis, which is primarily concerned with the proximity of schools with respect to Habitations/Villages. Hence in School GIS System *proximity* is defined as the ability to identify any school that is near a habitation/ village, or in other words the ability to identify any habitation/village that is not having school based on attribute value, or a specific distance.

Fairly appreciable results were obtained on running the above technique on GIS data of Jawaja block of Rajasthan.

Criticism:

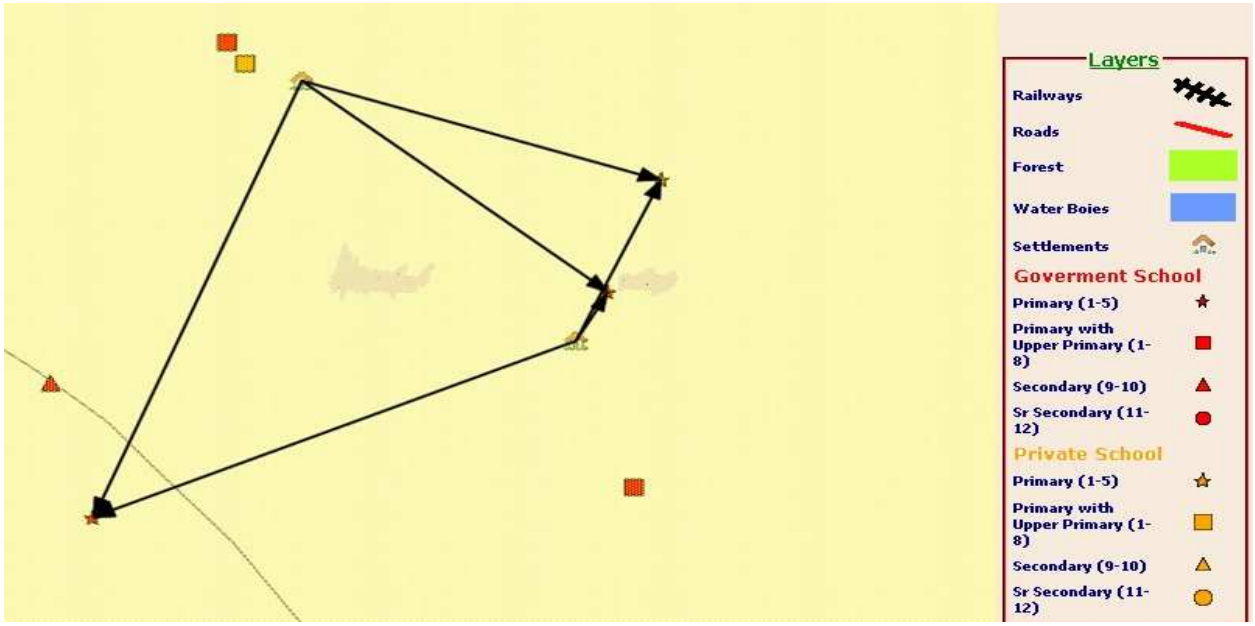
1.Settlements are considered as points leading to small percentage of approximation error.

2.Physical boundaries like rivers, drain are not takes into account

CONCLUSIONS AND FUTURE WORK

School GIS System is being used as a tool by Rajasthan council of Education for planning to open new schools. Efficient algorithms with low complexity allowed us to generate realtime reports used for

planning. The future work includes taking into account physical boundaries like rivers , drain while generating required reports.



Above print from Rajasthan school GIS System Shows habitation point (image as hut) having more than one primary school within 2 KM radius.

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*Correspondence Author: **Animesh Pant;** Scientific Officer; National Informatics Centre, Rajasthan state Unit;**Vinod Jain;** Scientist-D ; National Informatics Centre, Rajasthan state Unit
Email : vinod.jain@nic.in; animesh.pant@nic.in