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Urban population estimation using remote sensing data (sample Birjand)

Photograph of Presenter

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Abstract

One of the main obstacles to urban studies is the lack of data and up- to- date information. Since population censuses are done every ten years, urban Planners and researchers are usually confronted with the problem of insufficient information. Naturally then, searching for proper techniques of determining the population of urban areas will be of great help to careful studies and planning there. Actually, a variety of methods and techniques to estimate the population of both urban and rural areas have been developed. Each of these methods has their own advantages and disadvantages. These methods nevertheless, are still used by a number of experts. Though just about of the methods which seems to be enjoying a higher credibility than the others is estimation the population of urban areas using remote sensing data. In general, the methods used in this field are divided into two categories: surface interpolation methods and /or statistical modeling methods. Depending on whether they make use of marginal information the former are themselves subdivided into two further groups. Statistical modeling , too, is divided into five categories , basing itself on a number of factors such as the relationship between the population and the relationship between the population and the area of a city, land functional use , descriptive as well as extender units , pixel specifications of a given picture and finally physical, economic and /or social chrematistics. This paper aims to put to test the efficiency of the surface interpolation methods in order to estimate the population of Iran's urban areas. For this purpose, Birjand as city in the south khorasan Province was selected as sample for the pilot study to be conducted using aerial photos and satellite ones available- to manipulate statistical estimate and censuses of the city population. Finally comparing and contrasting the results with those of 1996 and 2006, respectively. The results obtained were indicative of an acceptable level of accuracy, with the possibility of the final results to replace full census or population sampling which are both time and cost consuming.

Key words: Urban planning, Population, Remote Sensing, Birjand.

1. Introduction

Access to updated and accurate information is one the main tools for developing programs and urban projects. In many cases, the lack of up – to minute and accurate information not only has a negative effect on the results of the studied performed as well as planning , but also consumes or rather wastes plenty of the time and expenses with the people involved in the

field. The dynamicity and the mobility of urban domains seems to raise the necessity of conducting population censuses on a rather shorter term bases , In most countries including Iran are conducted on an almost ten- year – long basis , with the results virtually having no doubt lost freshness. Leaving the expert with hardly any feeling of recently and /or updateness, whatsoever, which, luckily enough has been for long diverting the attention of the authorities and the researcher to more indirect methods of determining the population. By now different methods have been proposed and employed for determining and estimating the population of urban areas, each of which have their own advantages and disadvantages. This paper aims to investigate and measure the potentialities of population estimation methods using remote sensing data.

2. Data and Material

One model to determine the density is referred to as simple gravity. As a matter of fact, Nowadays even the laymen can readily figure out how significantly has the population density decreased in the inner-city in suburban areas. Clark (1951) was the first to focus on the topic in terms of mathematical concepts (Liu, 2003).

Another model which is closely connected to the issue is Cramer's model. This model shows how interrelated are the various models of urban forms having in common certain other researchers have introduced other mathematical functions to throw some light on the connection between population density and location. Satun(1977), for example, Satvn presented and Gvsni forms. These models are well demonstrated in different parts of their efficiency and capabilities however, the negative exponential function has been criticized by many, fore example, Betty and Long mentioned that exponential population experimental data, having been taken in to consideration simply because of its comfort and elegance. For this reason Parr (1985) said the function reverse was more for the suburbs and the land behind the beach to describe the density of the city in the region. In this regard, in borders to improve methods used in borders towns, Tabler (1999) changed Martin's population interpolation algorithm, according to Tabler, although the loss of power function intervals is considered a good estimate for the whole area, its use in areas further downtown, does not seem very reasonable since the surrounding environment and away from the center the density gradient is more linear (1995: 85).to rectify this problem, Tabler proposed lease function. In this model every unit of census are divided into triangles with vertices of a geometric center of gravity, population in the triangle is determined according to this method by vertices of the coordinates and the population.

If In order to use the models of population estimation in lran, a region of Birjand city has been selected as a sample. The main reason for this selection was that the population studies which were conducted at this level can be used for other cities of Iran which are of average extent.

Birjand city, which was studied in this research, is 1480 m above the sea-level and is located on the south of Mashhad city. This is the most important city of south Khorasan province and the center of this province socially and economically. The maximum and minimum temperature is 40c in the summer and -10c in the winter. The average annual rainfall of the city is about 220ml.

By the year 1921, it was considered as a small village with a low population. The first report about the population dates back to 1875. There were 3000 houses in this city. But the first official census was conducted in 1956 in Iran with 13934 people in the city, there were 84000 people in 1986 (Zanjani, 1989: 3) and there were more than 166000 people in 2006.

The development of the city was accelerated after 1320 and the highway that was built by the occupiers during the Second World War between Mashhad and Zahedan affected the development of this city too.
In addition to this, this development was forced by the immigration of Afghans and villagers and Birjand city was pushed to the fifth city of the province.
In order to study the accuracy and validity of the estimations obtained from the long-distance evaluations the divisions which were presented by the Census Center of Iran in 1375 were used According to the report there were 127607 people in this city which were numbered in 46 districts.
For this reason special attention is paid to these districts as a basis of population calculations.
But it should be mentioned that the population information of each of these sub-districts. And the information obtained from the census was gathered and the average density of each district was calculated based on the available sampling of the 46 districts.
This information shows that basically the districts under study can be categorized into four density groups with regard to construction. The first group is those districts with little construction and the density is up to 60 percent and the average density is between 76 to 89 percent and high density of 90 percent and more. Considering the above mentioned data the structure of the bulling is mainly related to the type of the buildings, 1-1/5 storey and the rest three –storey buildings which are mainly prevalent in high density cites

3. Research Methodology

One model to determine the density is referred to as simple gravity In spite of frequent use of this model in urban geography; it is originally associated with social sciences so that it has been called the heart of social physics. As a matter of fact, Nowadays even the laymen can readily figure out how significantly has the population density decreased in the inner-city in suburban areas. Clark (1951) was the first to focus on the topic in terms of mathematical concepts (Liu, 2003).
Another model which is closely connected to the issue is Cramer's model. This model shows how interrelated are the various models of urban forms having in common certain other researchers have introduced other mathematical functions to throw some light on the connection between population density and location. Satun (1977), for example, Satvn presented and Gvsni forms. These models are well demonstrated in different parts of their efficiency and capabilities however, the negative exponential function has been criticized by many, fore example, Betty and Long mentioned that exponential population experimental data, having been taken in to consideration simply because of its comfort and elegance. For this reason Parr(1985)said the function reverse was more for the suburbs and the land behind the beach to describe the density of the city in the region. In this regard, in borders to improve methods used in borders towns, Tabler(1999) changed Martin's population interpolation algorithm , according to Tabler, although the loss of power function intervals is considered a good estimate for the whole area, its use in areas further downtown, does not seem very reasonable since the surrounding environment and away from the center the density gradient is more linear, (1995 p.85).to rectify this problem, Tabler proposed lease function. In this model every unit of census are divided into triangles with vertices of a geometric center of gravity, population in the triangle is determined according to this method by vertices of the coordinates and the population.

Negative exponential functions are used only for local and small cases since this function indicates how most population is distributed in urban areas. Therefore, this function is less used in studies which intend to accurately estimate the population and give priority to precision and accuracy. Consequently, most studies of this type, surface interpolation or statistical modeling is used more, for example changes from a spatial format to others types. In fact, these two sets of spatial units are both of the same source and destination. (Lam, 1983).

Since the surface interpolation which determines the density is often associated with errors quality estimates obtained from interpolation to the exact definition depends on the source and destination areas. Meanwhile, the degree of generalization in the interpolation that process and classify surface features are ineffective in this process (lam,1983) whoever, due to the above conditions, the surface interpolation method based on whether using supplementary information or not, are divided into two groups.

Interpolation Surface without auxiliary information when we are supposed to use the method of interpolation without using supplementary information two approaches can be adopted: point –oriented and surface –oriented (Lam, 1983).

In point-oriented approach, a control point of origin to view each region is allocated and a network map with raster values estimated from control points is produced. In contrast, area-based interpolation instead of control points which are selectively allocated the area of origin is used as their unit of operation. Also, surface – based interpolation with higher levels of volume are used to maintain volume. That is, in collecting the sums of population data, sub-units are considered once again as a whole. Limited experimental and theoretical evidence from previous studies show that an overall volume is a prerequisite to accurate estimation of interpolation.

So far many methods of point orientation have been compiled and introduced. Some researchers have divided such methods into two main groups global and local. This classification is done in a manner to maintain the quantities of the main sample point. Another division is in relation with overall surface function. In fact, in the analysis, some such methods keep the resulted surface but some others do not (Lam, 1983)

As opposed to point _oriented methods, methods based on the level are ones which pay especial attention to overall volume. The simplest methods in this category are covering operations of origin and target. In these methods, the target area is placed on the source regions share in the target/destination area. When the share is determined, the weight amount and its value are converted into linear function on the basis of which the remaining stages of the procedure are carried out. The main problem with the covering methods is that source areas are assumed to be homogeneous where in the real world source areas that are homogeneously distributed rarely occur. This might be true of some phenomena such as might be true of some phenomena such as rate of rainfall or the quantity of agricultural produce but for human phenomena such as population it is rarely accessible. What is more, most often the origin areas are devoted to some other purposes, again probably not containing any important distribution in form for the target areas.

Dissymmetric is one of the best known methods among these methods. This method was introduced by Wright (1936); his aim was to correct the corplot maps which failed to provide a valid presentation of population distribution. Using this method and geographic information, he tried to identify the regions in the areas which have different population density. So he managed to correct the symmetrical distribution (Fisher and Langford, 1995). To prepare the

population density map Wright made dual parts repeatedly and using the method he managed to divide the general areas into smaller areas and by finding the population density in these areas he got his final goal, and he realized that the total population is equal to the original population of the area. In this way making dissymmetric maps which was a difficult job before became easy.

To find the population density of the minor regions, the dissymmetric method is very dependant on local information. Flowerdem and Gveen (1989) suggested the statistical regression analysis for estimating the density of minor regions. Meanwhile Lang Ford used the multi-variable regression technique for estimating the population density of minor regions for the first time in 1991.

Since the total population is clear the real density of each region can be used by increase or decrease in the density of minor regions. Although the using the dissymmetric method is easy, it faces the problem of equal distribution of population assumption. In fact although the differences between the minor regions are clear, these differences are ignored with regard to the density of population in minor regions. For example with regard to basic differences between the type of land use of single family residential units, a researcher should pay attention to more detailed classification of land use and relate each use to special density of population.

Although this method can increase the accuracy of population estimation, more effective methods should be used for classification of land use and estimation of population and density. The easiest method of using asymmetric technique by data obtained from double division method in which the regions are divided into populated and deserted regions and in the end the census is limited only to populated regions.

Many researchers such as Halt et al (2004) Fisher and Langford (1996) have done studies on this. In addition to this a special kind of dissymmetric method has been used to classify the lands and specifying population census to these regions in some studies.

Menis (2003), Eicher and Brewer (2001),Yuan et al (1997) and Langford et al. (1991)have done such researches in the last studies, methods were investigated based on which the proportion of population density should be calculated with regard to the levels of land use. In some of the studies the simple experimental sampling (Menis, 2003) was used to find some of the census of population density, (Eicher and Brewer, 2001). While regression analysis has been used in some of the studies (Yuan et al.1997) and (Langford et al.1991) it seems that the regression jis more practical than the other methods because it pays special attention to the accuracy of experimental model with regard to meaningful tests.

Harvey (2000&2000)suggested an accurate method to show the symmetry assumption in minor regions using density population estimation with the accuracy of Pixels.

We have divided the internal surface methods into tow groups based on the fact that whether it has used supplementary information or not. The methods which use supplementary information usually provide better results of the population.

4. Results and Analysis

In order to estimate the population in each of the sample districts the photograph of the two groups which are taken by plane are studied. As we know there weren't any photographs available in 1375, so there was no way but combining the old and new photographs According to the studies conducted during this period, About 585 avers (28 percent of the city) was allotted to construction in Birjand city.

Based On this, the main attention was given to this small part. In order to prevent possible mistakes in the estimation of population, general condition of the parts was specified to have a more accurate estimation of each district.
The study showed that about 2.2 percent of each district was allotted to educational functions, 31 percent to services and 21 percent to desert, Under construction and dilapidated and evacuated grounds respectively 4 percent of each district was allotted to gardens and farms Among the factors that could affect the accuracy brooks and floodways which was allotted to photographs consisted about0.5 percent of the obtained functions and the available data the accuracy of these findings.
A study of the experimental samples (for years under study) shows that the dimension of family in districts under study is about 4.2 people which distributed according to table 1.

Explanation	Population number	Number of families	Family average	Percent
One person families	4	4	1	1/5
Two persons families	60	30	2	11/1
Three persons families	114	38	3	14
Four persons families	248	62	4	22/9
Five persons families	270	54	5	19/9
Six persons families	222	37	6	13/7
Seven persons families	196	28	7	10/3

Table 1. The average of families of the experimental cases from 1991 to 1999.

This information and the condition of residential units helped positively to the accurate estimation of population According to experimental samples, 77.2 percent of families have an independent residential unit 21.5 percent of families have a residential unit and more than 1.3 percent of families live in building where four or five families live while one unit Two or more in the Experimental samples were 79.8, 17.8, and 2.4 percent respectively (field studies). The samples for each of the districts were selected using the photographs and the type of density and constructional structure.

5. Conclusions

According to this data, the estimated overlap with the real statistics obtained from the 44, 45 and 46 was more than others. The reason is that the buildings are new and the combination is lower in this part. This overlap is lower for the 1 and 2 most of whose development happened in 1335 and before that. Generally thy obtained estimations have been most that the real level. So the accuracy of the estimation obtained from the photographs taken by airplanes is about 73 percent.

The satellite photographs which are used in the studies of France and Russia and now available in Iran were used in this study. To do this the educational regions were identified and an estimation of the population in the related districts was conducted after a study using field information. According to these data the average overlap of total data in this district is about %68.[1]

References

Eicher, C. L. and Brewer, C. A. (2001). Dasymetric Mapping and Areal Interpolation: Implementation and Evalution, Cartography and Geographic Information Science, 28(2): 125-138.

Fisher, P. F. and Langford, M. (1995). Modeling the Errors in Areal Interpolation between Zonal Systems by Monte Carlo Simulation, Environment and Planning A, 27: 211-224.

Flowerdew, R. and Green, M. (1989). *Statistical Methods for Inference Between Incompatible Zonal systems*, London, UK: Taylor and Francis.

Harvey, J. T. (2000). Small Area Population Estimation Using Satellite Imagery, Statistics in Transition, 4(4): 611-633.

Harvey, J. T. (2000a). Estimation Census District Populations from Satellite Imagery: Some Approaches and Limitations, International Journal of Remote Sensing, 23(10)2071-2095.

Harvey, J. T.,(2000b). Population Estimation Models Base on Individual TM Pixels, Photogrammetric Engineering and Remote Sensing, 68(11)1181-1192.

Holt, J. B., Lo, C.P. and Hodler, T. W. (2004). Dasymetric Estimation of Population Density and Areal Interpolation of Census Data, Cartographic and Geographic Information Science, 31(2): 103-121.

Lam, N. S., (1983). Spatial Interpolation Methods: A Review, The American Cartographer, 10(2): 129-149.

Langford, M., Maguire, D. J., and Unwin, D. J. (1991). The Areal Interpolation Problem: Estimating Population Using Remote Sensing in a GIS Framework, in Masser, New York, NY: Wiley, 55-77.

Liu, X., (2003). *Estimation of the Spatial Distribution of Urban Population Using High Spatial Resolution Satellite Imagery*, PH. D. Thesis, University of California, Santa Barbara.

Mennis, J. (2003). Generating Surface Models of Population Using Dasymetric Mapping, Professional Geographer, 55(1): 31- 42.

Parr, J. B. (1985). A Population – Density Approach to Regional Spatial Structure, Urban Studies, 22(4): 289-303.

SCI (different years 1959 to 2006). *Population and Housing Census,* Statistical analysis of Birjand.

Iranian Remote Sensing Center (various years 1961 to 2002), *Aerial photos and satellite images*, Birjand in Khorasan Province.

Architecture and Urban Planning Consultants Zysta (2004), *comprehensive plan of Birjand*. Teheran, Zysta.

Clark, C.(1951). Urban Population Densities, Journal of the Royal Statistical Society, 114: 490-496.

[1]An estimation of overlap level shows that there is a meaningful difference between internal and lateral districts.

Sutton, P., Roberts, C., Elvidge, C., and Mej, H. (1997). A Comparison of Nighttime Satellite Imagery and Population Density for the Continental United States, Photogrammetric Engineering and Remote Sensing, 63(11): 1303-1313.

Tobler, W. R., (1999). Linear Pycnophylactic Reallocation- Comment on a Paper by D.

Wright, J. K. (1936). A Method of Mapping Densities of Population, The Geographical Review, 26(1) 103-110.

Yuan, Y., Smith, R. M. and Limp, W. F. (1977). Remodeling Census Population with Spatial Information from LandSat TM Imagery, Computers, Environment and Urban Systems, 21(3-4): 245-258.