A GIS Tool for Building Population Analysis

建物人口データを分析する GIS ツールの開発

Ko Ko Lwin and Yuji MURAYAMA

Abstract

Recently, increasing numbers of researches in micro-spatial analysis due to the emergence of high spatial resolution satellite images and GIS data available at finer scale with better attribute information. Under the GIS analysis functions, population data is always assumed as a homogeneous plane (i.e. census tracts or townships or prefectures). Moreover, most census boundaries do not coincide with geographical features such as flood plains or watersheds. This may lead the problems in population analysis related to geographical features. To overcome these problems, we have implemented a GIS Tool or stand alone program named as PopShapeGIS (Population Shape GIS) which can generate building population data based on census tracts and building footprints dataset for micro-spatial analysis users. Building population data is required for public facility management, disaster and emergency preparedness, market analysis and other micro-spatial analyses in urban development processes.

Keywords: building population, micro-spatial analysis, PopShape GIS

1. Introduction

Population data at smallest geographical unit is ever wanted for demographers, urban planners and public facility managers for a long time ago. A GIS plays critical roles in population studies and analyses by means of mapping spatial extents and analyzing along with other GIS dataset. Moreover, population data at smallest geographical unit is required for micro-spatial analysis such as evacuation planning and emergency preparedness to minimize the lost of human life and property from the natural hazards, planning of social and educational services, public facility management in urban planning, consumer and retail market analysis, environment and public health, and other demographic studies. One important thing to acquire building population data is improving accuracy in cost estimation of foods and shelters in emergency preparedness and other humanitarian assistances.

However, most population data used in GIS analyses are always assumed as a homogeneous plane known as “Choropleths map” (i.e. census tract or township or prefecture level). Any spatial analysis functions performing within the census

Ko Ko Lwin, 1-1-1 Tennodai, Tsukuba,
Ibaraki 305-8572 Japan.
Division of Spatial Information Science,
Graduate School of Life and Environmental Sciences,
University of Tsukuba
Email: kokolwin@geoenv.tsukuba.ac.jp

tract or block do not acquire any significant changes of population amount. Current population estimation and dataset are not suitable to use in micro-spatial analysis due to the nature of coarse grains (i.e. raster interpolation) and distributed unpopulated areas as well. Although, the development of "aerial interpolation" and "dasymetric mapping" in cartography improve the spatial distribution patterns of population in GIS analyses, these data are not suitable to use in micro-spatial analysis due to the nature of raster formats.

This paper proposes two methods (Aerial and Volumetric methods) to estimate the building population data based on building footprints and census data which available from the market. We also explain about a PopShape GIS tool which can generate a new ESRI shape file with estimated building population attribute field.

2. Estimation of building population

Here we introduce two estimation methods, name as Areametric (which does not require number of floors attribute information) and Volumetric (which requires number of floors attribute information). To improve the accuracy, we filter or omitted by such un-appropriate criteria such as footprints area less than 20 m^2 and other building use types such as commercial, industrial, educational, and others which do not occupy by people in the night time. The calculation can be expressed as following mathematical expressions.

This algorithm has already tested and evaluated with actual building population dataset (obtained from fire department for study purpose) in terms of visually, statistically and spatially (using Morhan's Index and performing spatial correlation analysis). We have obtained the best result in volumetric method applied by $20m^2$ footprints filtering category.

Areametric Method

$$BP_i = \left(\frac{CP}{\sum_{i=1}^{n} BA_i}\right) BA_i \qquad \text{……. equation (1)}$$

Volumetric Method

$$BP_i = \left(\frac{CP}{\sum_{i=1}^{n} BA_i.BF_i}\right) BA_i.BF_i \qquad \text{……. equation (2)}$$

Where:

BP_i : Population of building i

CP : Census tract population

BA_i : Footprint area of building i

BF_i : Number of floors of building i

i : Index (increasement)

n : Number of buildings which meet user defined criteria and fall inside the polygon of CP.

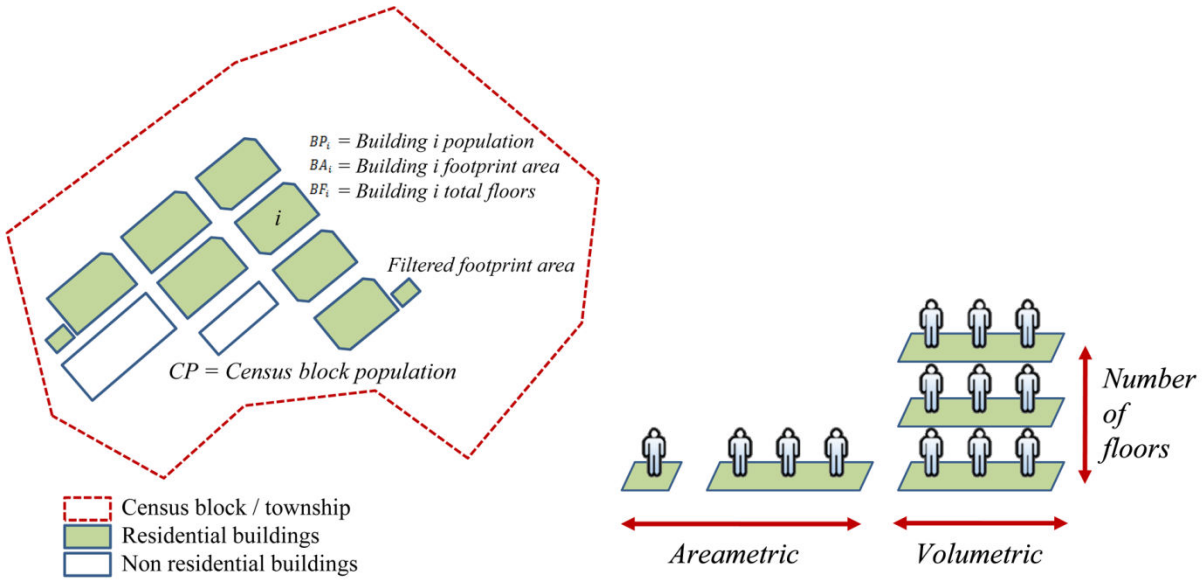

Figure 1: Graphical illustration of equation (1) and (2)

3. Implementation of a PopShapeGIS tool

To achieve our goal, we have implemented a GIS tool or standalone program using Visual Basic programming language and TatukGIS DK (Development Kit). This tool is name as a PopShape GIS program (Population Shape GIS) and available to use for any interested users at following URL (http://giswin.geo.tsukuba.ac.jp/sis/en/software.html).

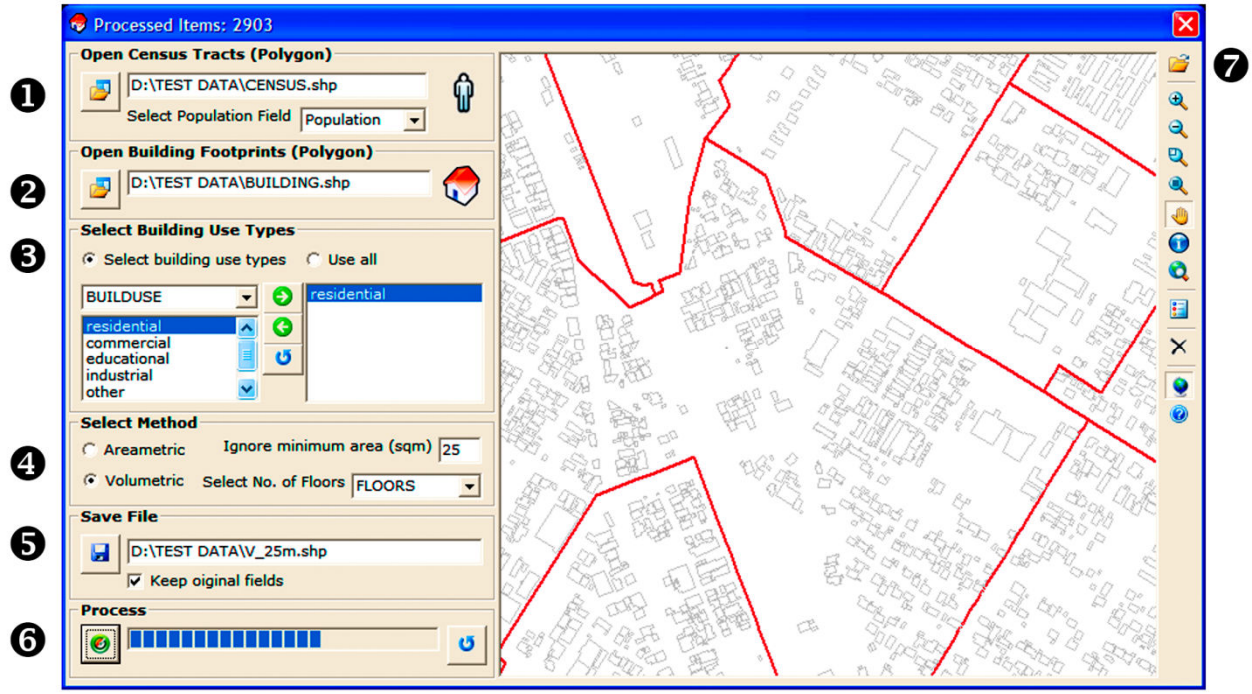

Figure 2: PopShape GIS program user interface. (1) Insert Census file; (2) Insert Building footprints file; (3) Select building use types; (4) Select method; (5) Set up output file nae; (6) Start to process; (7) Map controls.

The input data and output data are based on ESRI Shape file format which is an industrial standard vector format and widely used in Geographical Information System. This program requires two input data name as census tract and building footprints. User can select building use types based on desire population activities such as population in daytime and population in night time. Estimation method can choose either Areametric or Volumetric method based on number of floors data availability. Moreover, this program allows user to filter by minimum footprint area which does not take account of calculation, because of all building footprints are not occupied by people.

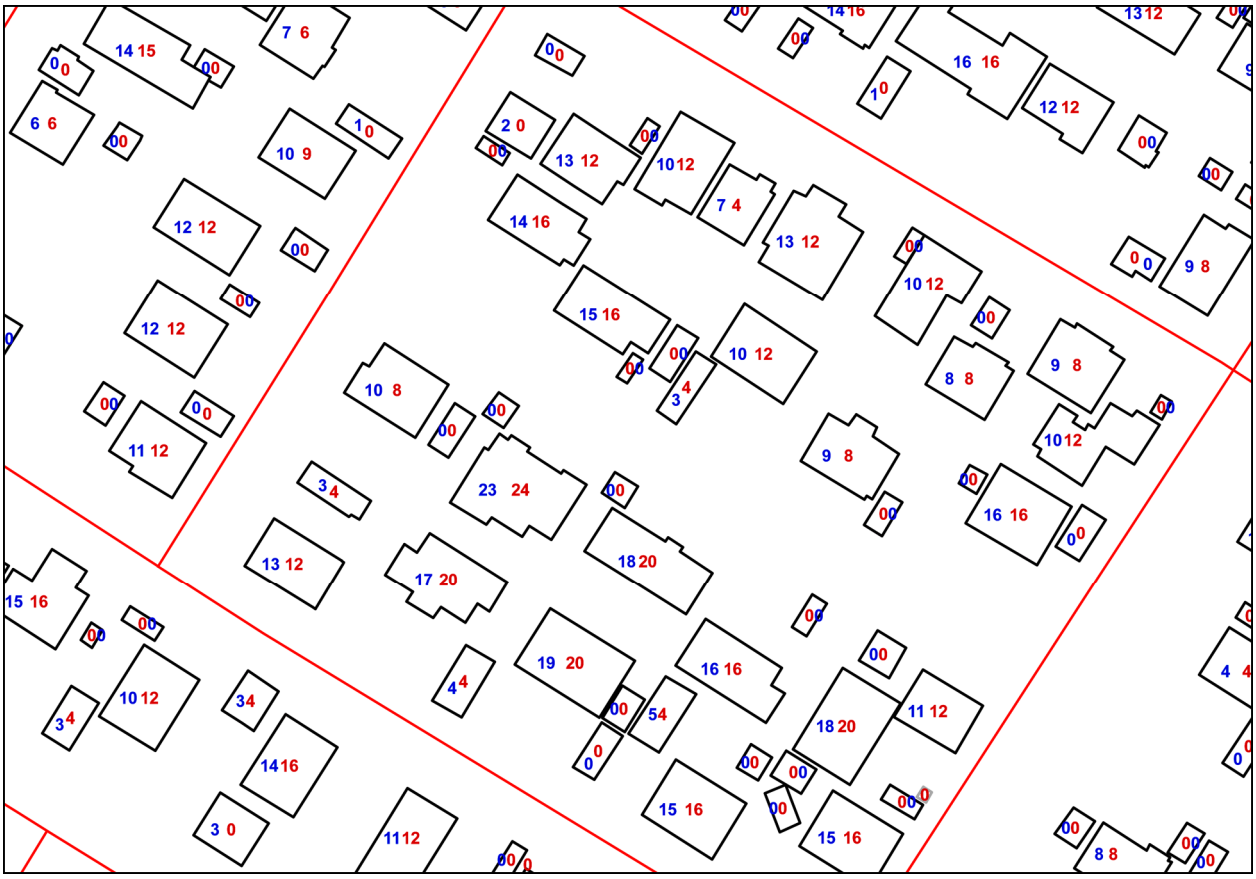

Figure 3 Estimated populations vs. actual populations in low rise building area (Filtered area 20 m^2, Volumetric Method applied to residential building); Left value is estimated value and right value is actual value.

4. Workflow

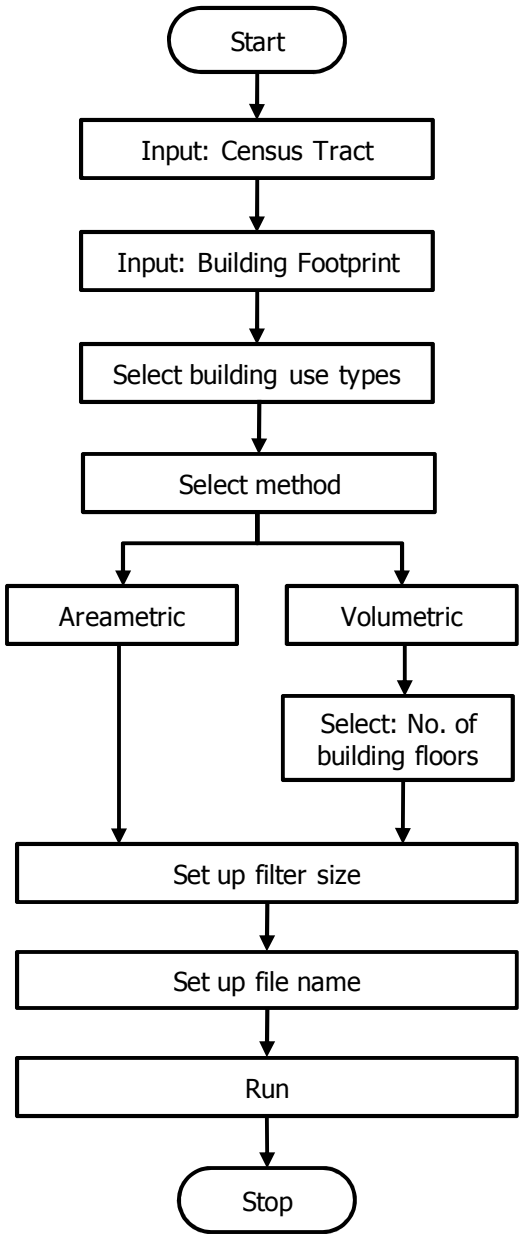

Figure 4: PopShapeGIS workflow

5. Conclusion

The estimating or quantitative mapping of building population is essential for micro-spatial analysis especially in emergency management and marketing analysis. The efficient disaster preparedness requires quantitative spatial distribution pattern of population in order to locate emergency response centers and preparation of foods and shelters in the case of disaster occurred. City and urban planners want to know how many local residents will benefit to a new constructed public facility such as bus center, railway station, hospital, etc. Hydrologists want to estimate how many people

will be effected inside of the floodplain. Potential business owners can define their business location and perform a public accessibility analysis. Quantitative building population data can be used as a weighted factor in some spatial statistical analysis such as finding mean center and standard distance. This is important to make a decision which related to population such as voting place selection, building a new public facility, etc. The application of quantitative building population data is unlimited and we hope to increase accuracy in various spatial decision making processes at micro-scale level.

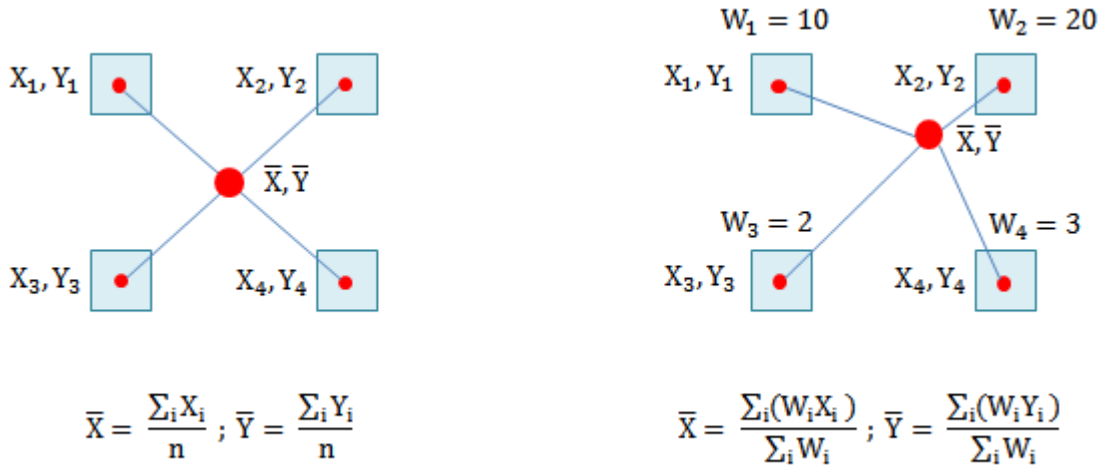

Figure 5 Example of finding a mean center (a) Mean center without weighted factor (b) Mean center using building population as a weighted factor.

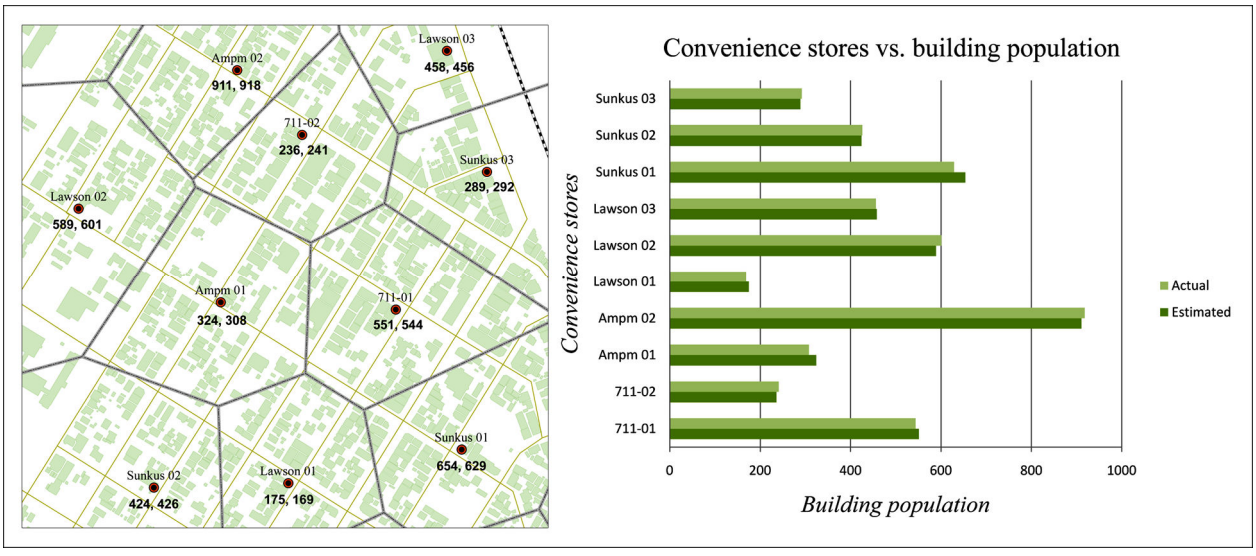

Figure 6 Use of building population in market competition analysis (24 hours convenience stores (mini stores) vs. neighboring population)