Validation & Verification of GIS-Based Population Data Conversion Program (POPCON)

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1. Introduction

Preparing population data adjacent to a nuclear power plant (NPP) site is one of the important procedures to perform a radiological consequence analysis. When preparing population data, it is necessary to convert raw data into appropriate format as well as obtain proper raw population data. In addition, interfacing between different coordinate systems should be conducted precisely in this process. Korea Atomic Energy Research Institute (KAERI) developed GIS-based population data conversion program (POPCON: POPulation data CONverter) [1, 2] which converts shape-formatted population data (.shp) downloaded from the National Geographic Information Institute (NGII) into user-specified text format regarding coordinate system. For example, if a user wants to have 100m×100m point-wise population data, text format might be composed of the center point of a location (X and Y) consistence with user-specified coordinate system, the number of population, the name of district, and etc.

In order to guarantee the quality of a developed software, validation and verification (V&V) are fundamental procedures. Software testing as a dynamic V&V method was performed to confirm whether POPCON is built in accordance with the design requirements and whether it can be well linked with KOSCA-POP [3, 4] which is a preprocessor to convert population data into MACCS [5] site input fitted to the polar coordinate system.

2. Methods and Results

Software testing conducted in this study is comprised of verification testing and application testing. As aforementioned, the former is testing the consistency of POPCON with requirement specification and the latter is checking the compatibility of POPCON with another application software. The hardware requirement to run the software is a computer installing Windows 7 (or higher) operating system and a PC installing Windows 10 is used for the testing.

2.1 Verification Testing

Execution procedures to perform the verification testing are:

- receiving data,
- selecting a coordinate system to be converted, and
- setting the order and separator of fields (columns) to be created.

For the verification testing, 100m×100m population data of Seoul was received from NGII website.

Acceptance criteria of the verification testing with regard to the requirement specification of POPCON are as follows:

1. whether the user-specified field order and separator are applied to the result file,
2. whether the number of grids in input data matches the number of rows in output file,
3. whether the total population of input and output is identical, and
4. whether the coordinate system of the result image overlays with background map.

To check the first acceptance criterion, the order of the columns of X, Y, total population (male), and total population (female) were changed to be located after the name of district. And the separator was changed from comma (,) to pipe (|). As the execution result shown in Figure 1, it was confirmed that the order of fields and the separator are applied as user specified.

Fig. 1. POPCON result by changing the order and separator of fields

In order to confirm the second criterion, the number of 100m×100m grids in the raw data downloaded from NGII was compared with the number of point locations (the number of rows) handled by POPCON.

In addition, for the purpose to evaluate with the third acceptance criteria, the total population of each district of input data and POPCON result were compared.

Table I shows the comparison results of above two verification tests. It was confirmed that the number of grids and the number of population in the input file are exactly matched with the results converted by the POPCON. It can be concluded that POPCON runs in accordance with the second and third criteria.

Table I: Comparison of the number of grids and population between input file and POPCON result

Administrative district	No. of grids in input	No. of point locations in POPCON result	Total population of input	Sum of population in POPCON result
Gangnam	4,170	4,170	543,593	543,593
Gangdong	2,596	2,596	434,448	434,448
Gangbuk	2,528	2,528	312,526	312,526
Gangseo	4,382	4,382	588,345	588,345
Gwanak	3,130	3,130	498,720	498,720
Gwangjin	1,812	1,812	349,688	349,688
Guro	2,211	2,211	403,609	403,609
Geuncheon	1,424	1,424	232,044	232,044
Nowon	3,743	3,743	530,225	530,225
Dobong	2,226	2,226	330,764	330,764
Dongdaemun	1,539	1,539	344,337	344,337
Dongjak	1,773	1,773	393,606	393,606
Mapo	2,570	2,570	371,536	371,536
Serdaemun	1,916	1,916	305,871	305,871
Seocho	4,963	4,963	428,455	428,455
Seongdong	1,794	1,794	297,969	297,969
Sungbuk	2,654	2,654	441,085	441,085
Songpa	3,578	3,578	672,661	672,661
Yangcheon	1,926	1,926	453,811	453,811
Yeongdeungpo	2,605	2,605	362,077	362,077
Yongsan	2,325	2,325	228,402	228,402
Eunpyeong	3,170	3,170	476,634	476,634
Jongro	2,563	2,563	150,662	150,662
Jung	1,107	1,107	125,435	125,435
Jungrang	1,972	1,972	394,952	394,952
Total	**64,677**	**64,677**	**9,671,455**	**9,671,455**

Point locations of POPCON results were printed over the maps with relevant coordinate systems:

- Bessel TM central origin (EPSG: 5174),
- GRS80 UTMK (EPSG: 5179),
- GRS80 TM central origin (EPSG: 5181, old),
- GRS80 TM central origin (EPSG: 5186, new), and
- WGS84 longitude and latitude (EPSG: 4326).

The Bessel TM case was verified using the background map of KOSCA-POP, and public map data was used for the other coordinate systems. The POPCON execution result is depicted as a symbol with a different color for each district in order to check the overlap with the background map. Figure 2 describes how the test was carried out.

It was confirmed that the image result of conversion to each coordinate system option overlaps well with the background map having the corresponding coordinate system. It means POPCON meets the fourth acceptance criterion. Figure 3 describes the test example for the Bessel TM central origin (EPSG: 5174).

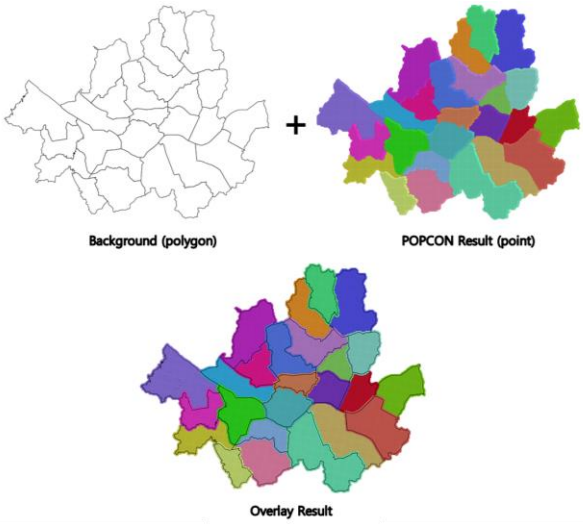

Fig. 2 Overlay testing to a background map in order to verify the compatibility of POPCON with various coordinate systems

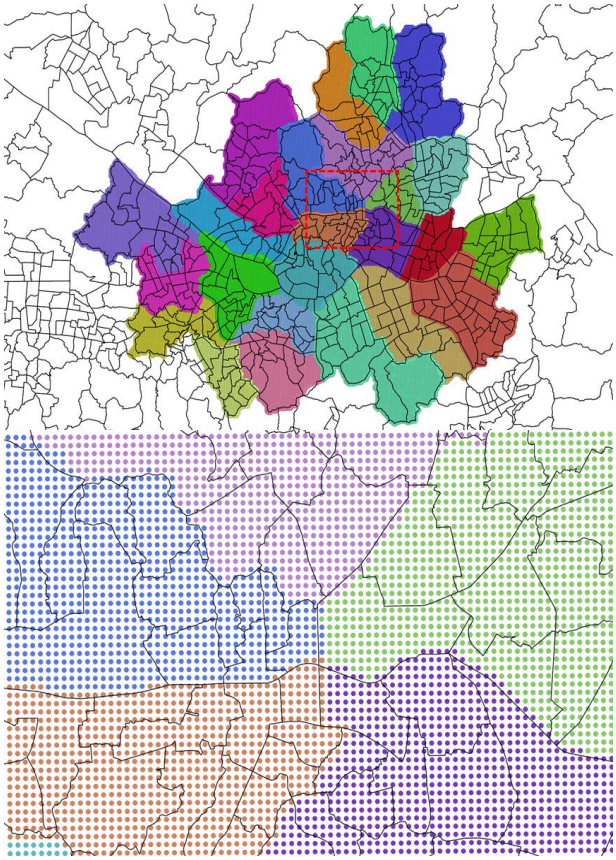

Fig. 3 Background map overlapping of Bessel TM central origin (EPSG: 5174)

By performing verification testing with four acceptance criteria, it was confirmed that POPCON is well developed and runs accurately pursuant to the initial design requirements.

2.2 Application Testing

While the verification testing is a self-test for the POPCON program itself, the application testing is a test and verification in connection with KOSCA-POP and interfacing between POPCON and KOSCA-POP is one of the primary goals to develop POPCON.

Testing employs population data with different resolutions. The original data of the NGII was extracted by setting the resolutions of 1km, 500m, 250m, and 100m, then was converted using POPCON. Figure 4 shows the results of KOSCA-POP using the data from POPCON with various resolutions. It should be noted that it is not changing the spatial grid of KOSCA-POP in polar coordinate, but changing the resolution of point-wise population data converted by POPCON.

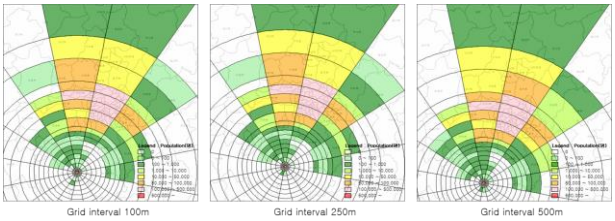

Fig. 4 KOSCA-POP calculation results using POPCON results in a variety of spatial resolutions

It was ascertained that KOSCA-POP runs well with the text output converted by POPCON, regardless of the resolution of population data. However, population differences could exist at population-changeable area such as the boundaries of administrative districts and the area between mountains and flat lands. It is due to the change of resolution and center point of the population data which belongs to the spatial grids of KOSCA-POP. It is apparent that using population data with higher resolution allows greater fidelity to produce site input used for a consequence analysis.

As an additional application testing, it was checked whether the output of the sectors with no resident population is calculated correctly. In this testing, two kinds of population data were used:

- Daejeon, where KAERI is located, to check the mountainous and lake area, and
- Busan close to the sea.

Figure 5 and Figure 6 show the calculation results of KOSCA-POP using the population data of Daejeon and Busan, respectively. As described in Figure 5, population of the mountains, lakes, and rivers in Daejeon, where a resident population does not exist, is calculated as zero. In addition, Figure 6 indicates that population calculation using POPCON and KOSCA-POP can recognize the sea area and land area including islands in Busan.

Accordingly, no significant error was found to interfacing the population files between POPCON and KOSCA-POP.

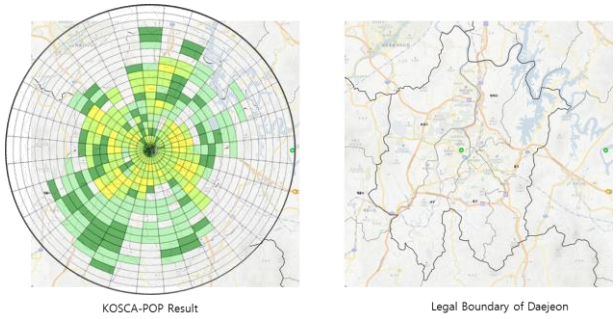

Fig. 5 Result of KOSCA-POP for Daejeon (resolution: 100m)

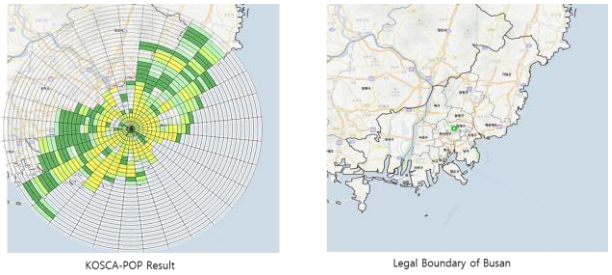

Fig. 6 Result of KOSCA-POP for Busan (resolution: 100m)

3. Conclusions

POPCON, a GIS-based population data conversion program, was developed to provide population data with appropriate format and coordinate system to a pre-processor in order to prepare the site data of a nuclear power plant.

Verification testing was conducted to confirm that POPCON operates without any pronounced error, in conformance with the design requirements. Application testing was also carried out to validate its applicability to the preprocessing of KOSCA-POP. As a result of the testing, it was confirmed that POPCON software runs appropriately without a glaring error in order to perform the designed functions such as file conversion, coordinate conversion, and compatibility with KOSCA-POP.

Acknowledgements

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