

Development of the MSPAR-SITE Code for Estimating Multi-Unit MACCS Site

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1. Introduction

After the Fukushima accident, the Multi-Unit Probabilistic Risk Analysis (MU-PSA) has gained much attention around the world, which evaluates comprehensive risks considering the sharing and the linkage characteristics in the sites. Especially in Korea, more than 5 units are operating at all sites. Therefore, there is a high interest in MU-PSA and many researches related to that have been carried out.

In terms of MU-PSA, it is important to assess the off-site consequence from the radionuclide released to the environment in a level 3 PSA. MELCOR Accident Consequence Code System (MACCS) is a computational code for level 3 PSA and widely used in USA, Korea and other countries. In MACCS, all the calculations are conducted and saved in a polar-coordinated grid centered on a point location. Also, Site information such as population and land fraction for each spatial grid element needs in form of the site file. Therefore, the method to determine a single location representing multi units and site data reflecting domestic situations are required to implement MU-PSA.

Calculation and generation of these site information requires a lot of manpower when working with hand. The MSPAR (Multi-unit Standardized Plant Analysis Risk) SITE can reduce manpower greatly because it makes computer to process calculation of site data, and this is the number one reason the MSPAR-SITE has been developed.

In this study, The MSPAR-SITE was developed as a pre-processor of MACCS. It finds a simple or weighted location point for various locations and makes site information for specified points into a MACCS input file. Also, to verify the MSPAR-SITE, a preliminary evaluation of the multi-unit accident was conducted using MACCS with the MSPAR-SITE output.

2. The MSPAR-SITE Code

The MSPAR-SITE was made by using WPF and JavaScript for applying Google Map API. Input data uses the KML format and contains information about many administrative districts. Each district information consists of name, population, area, and coordinates for drawing a polygon on the map. The KML format used by several map-related programs, including this program, is equivalent to XML. To use KML extension file, the MSPAR-SITE include 'ogr2ogr' which is the program can convert a map file of another format (e.g. GeoJSON, SHP) into KML [1][2].

2.1 A method of calculating Population and Land Fraction of a sector

This program allows for a drawing of a polar grid around a designated accident occurrence location. Sectors are generated by intersections of several axes and concentric circles on a polar grid, and administrative district information can be used for each sector to provide population per sector. The sector is saved as polygon form which is 'google.Maps.Polygon'.

More specifically, one sector had four vertices, and this program finds a district where each vertex belongs. Next, it calculates population using the following Eq. (1), and the same calculation can be performed on the remaining vertices and then added together, so total population of one sector can be calculated.

$$P = \frac{D \times A}{4} \quad (1)$$

P: Total population of the sector

D: The population density of the district to which the point belongs

A: The area of the sector

Each actual area of different administrative districts included in one sector are less accurate, since they are not exactly matched off in four divisions. Therefore, to increase accuracy of calculation, a sector requires to be divided into smaller sectors and each of segments needs to be calculated. This program used the algorithm used to be known as Divide and Conquer method as a method of dividing one sector. If one sector contains different administrative districts, the sector will be divided into four small sectors and the same calculation will be applied. Conversely, if one sector is within just one administrative district, there is no need to have to be separated more and population of the sector will be calculated at that time.

If a result of finding an administrative district of a vertex isn't district, the vertex is considered as sea area. In this way, land fraction can be calculated. For example, if only one of four vertices of a certain sector don't have district, the land fraction of the sector will become 0.75. Divide and Conquer method can also be applied to this calculation sequence. If a result of calculating land fraction in a sector where divided once is 0.75, the result will be changed into $0.75 * 0.25$ and added to the whole result.

The problem is that when boundaries of administrative districts are drawn in detail, a sector will be divided into

near infinity and cause to increase the process time exponentially.

Therefore, if a sector is divided repeatedly as a specific number of times (depth), by setting the depth of Divide and Conquer method, population of a sector will be calculated directly at that stage, even if the sector contains different administrative districts.

A result of calculating population is stored as information in a sector. Also, a sector is numbered by axes and concentric circles on a grid, users can create text files that match the site file form using this number.

This program can configure the number of axes, an interval and the number of concentric circles, and a starting degree of an axis of a first sector, which denotes the left side of the green line in the Fig. 1., to produce information that match the site file form.

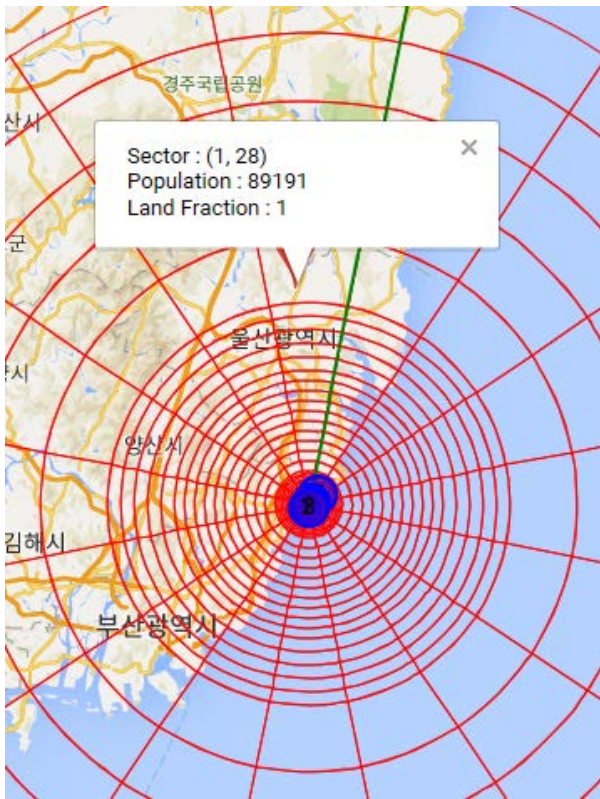


Fig. 1. Segmentation Process of the MSPAR-SITE.

2.2 A method of finding location of Multi-Unit Accident

To select a center of sectors, the MSPAR-SITE has the function to register coordinates as a location at which an accident may occur. Also, it can register a new location for multi-unit PSA by applying the center of mass formula following the Eq. (2) on a weight of each location.

$$p_m = \frac{\sum_{i=1}^n p_i w_i}{W} \quad (2)$$

p : The coordinate (x, y) at location

w : The weight of the location

W : The sum of weight of all the locations

In this example, the basis for a weight of each location to make a new location is power capacity. From the TABLE I and the Fig. 2., The new location shows up the result of calculating a center of mass and can be located.

Table I: The Location Example

Number	Name	Weight
1	Location 1	700
2	Location 2	1000
3	Location 3	1500
10	New Location	0

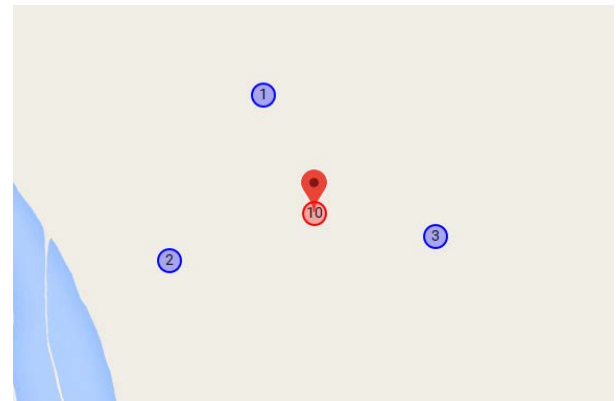


Fig. 2. Calculation new coordinate between the three points.

2.3 Application of site data for MACCS process

Sectors generated with parameters of SPATIAL INTERVALS and WIND DIRECTIONS set centered on the new location have population and land ratio information. and it can generate site files. SPATIAL INTERVALS allow the user to specify the distance, and WIND DIRECTIONS is divided by the uniform angle. This input data is used as the emission point of the radiation source when deriving the risk of the multi-unit accident, and the radiation material of each unit is calculated to be overlapped at this point by using the MACCS MULTI SOURCE TERM function.

3. Conclusions

In this study, the MSPAR-SITE was developed to create site information for level 3 MU-PSA. It can find a simple or user-specified weighted average of various locations, derive domestic site information for user-specified grid elements using Divide and Conquer method, and create MACCS input file.

Also, a preliminary evaluation of the two units in the reference site was performed by placing the release location on the electric power-weighted average of their locations.

The MSPAR-SITE, the results of this study, will be expected to contribute domestic level 3 MU-PSA modeling in the future. For further work, it is planned to add modules which can visually show MACCS output

such as a concentration of radionuclide by grid elements to the MSPAR-SITE.

4. Acknowledgements

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