Individual tree information
Using the high-resolution satellite photograph

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Abstract: The acquisition of individual tree information using the high-resolution satellite photograph was tried. In the image classification by conventional cluster analysis, the classification class differs from the delicately brightness value for reasons of the high resolution. Especially, the effect of the lower vegetation and the difference of tree crown angle, are strong. In order to solve such problem, the method using proposing degree of assignment in the cluster analysis and/or membership function (MS) of fuzzy cluster analysis was examined. The degree of assignment is calculated from the statistic of classification distance in result of cluster analysis. The value is 1, if the classification distance is smaller than the average. The value is 0, if the distance is over the threshold. In the other case, the value is interpolated in the decrease function. MS is the relative index, of which the sum is 1, but the degree of assignment is an absolute index. In the analysis for the class estimated with the specific tree, using degree of assignment or/and MS as an index data, the circle in which the total of the product of index and distance to the center becomes the minimum is searched. Largest and smallest radius of the tree crown is designated as the parameter as the divided threshold and the integrated threshold. These circles are correspondent to the tree crown, and they are base of the acquisition of individual tree information. By this method, the application experiment for park and street tree and flatland forest is reported.
Keywords: NDVI, IKONOS, forest, tree, Cluster analysis

1. Introduction

In the natural environment problem of the earth, it is important to accurately grasp the land cover. Especially, the forest gives large effect in the natural environment, and a grasp of the resources information is important. The remote sensing technique is one of the useful means for obtaining environment and resources information of the forest. The much research that grasps forest resources using middle resolution satellite photograph such as Landsat is ever reported. In the remote sensing using the middle resolution satellite photograph, it was possible to obtain land use and vegetation information. It is possible to get the rough forest stand information as conifer or broad-leaved tree. In the meantime, it is possible to grasp more detailed information in high-resolution satellite photograph which becomes recently available, and the usefulness is expected. It seems to be possible to grasp information as an individual tree in the high-resolution satellite photograph. It is expected that tree species division and individual tree information extraction are possible. However, there are various problems in the analysis by the high-resolution satellite photograph. For example on analysis of one tree, the luminance value is different by the angle of the tree crown that faces the sun. By the high resolution, the difference of the partial luminance becomes a problem of the analysis. That is to say, the pixel to be classified into the equal class as individual tree may be classified into the different class in the image classification by cluster analysis. In the high-resolution satellite photograph, the continuity of the pure-pixel becomes a problem, while mixcel was a problem in the middle resolution satellite photograph. As a method for recognizing the individual tree using the high-resolution satellite photograph, approximate colors circle retrieval method, etc. are reported [1,2,3]. However, they have not yet been established as a technique using the enough result. Then, the extracting method of the more useful individual tree information is examined. In this paper, the counting method of individual tree using the certainty of class separation as a result of cluster analysis is reported.

2. Data and Methodology

IKONOS satellite image for high-resolution satellite photograph was used in the examination of this method. As flatland forest that did not receive the geomorphologic constraint, two regions were set for object areas. One is a suburban zone in the Kyoto City that contains park and forest site. Other is flatland forest area that contains conifer and broad-leaved forest and the pastureland in Hokkaido research forest of Kyoto Univ. Field Educational Research Center. Data of IKONOS satellite image is the 4 bands of RGB and near infrared. As a pretreatment, normalized DN values that divided each band by the total of the 4 bands DN value were calculated. Three normalization vegetation indexes (NDVI) were calculated from RGB and near infrared DN value. And, the result of texture analysis for RGB, Nir and NDVI value,

Average, contrast, dispersion, energy and entropy were calculated for texture index. Size of the subject area of texture analysis is 3*3 and 5*5 pixels, and the shape is rectangle and diamond. As individual tree information, whether the measurement of crown size and the number of the tree was possible was examined. Then, un-supervisor cluster analysis was carried out using the pre-calculated variable for the individual tree classification. In this cluster analysis, the simple Euclidean distance was used. In the many cases, the identical individual is classified into some classes by the difference reflection luminance under influence of shade and sunshine etc. In usual cluster analysis, the distance (it is called the following classification distance) between variable value of each pixel and variable value of each class center is a classification index. Each pixel is classified into the class in which the classification distance is the shortest. Therefore, when classification distance to some classes is little difference, classified class is different by the cases. Then, the index classified into the specific class is proposed. In this paper, this index is called the degree of assignment. The degree of assignment is calculated using average and standard deviation of classification distance of the pixel classified into the class. If classification distance is under the mean value of the class, the degree of assignment is 100. If classification distance is over the value that added mean value and double of standard deviation, the degree of assignment is 0. The value of the interval is complemented in the decrease function as Fig.1. The degree of assignment is 0-100. There is the high possibility of belonging to the class, as the value is bigger. The possibility of belonging to the class rises, as the value is bigger. However, it is not always classified into the class, as the degree of assignment to the class is big. That is to say, the classification class is not decided according to the amount of the degree of assignment. And, the fuzzy cluster analysis was also examined with usual cluster analysis. In the fuzzy cluster analysis, membership value that shows the belonging degree of the class and the classification class are calculated. In the fuzzy cluster analysis, it is classified by the value of the membership value. The membership value is calculated on all classes, and the total value is 1. In this paper, the membership value was transformed in linearity so that the total may become 100 for the comparison degree of the assignment. The degree of assignment has shown the expectation value in which individual pixel belongs to the individual class. Therefore, the total degree of the assignment of the pixels to each class may greatly exceed 100, and it becomes not always 100. Like the above, assignment and membership value are different in some points.

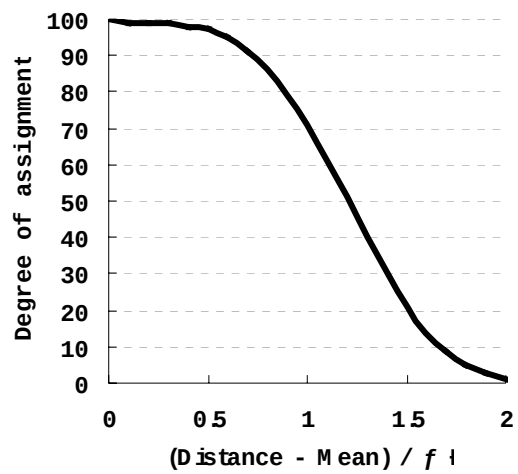

Fig.1 Relationship between assignment and classification distance

The following method shows the discrimination of the individual tree. First, the class estimated with the specific tree is extracted. There are many cases in which an individual tree is classified into multiple classes, because, the difference of the reflection luminance is occurred by the incidence angle of the sun. Next, the maximum value of the degree of assignment or the sum of membership value was calculated for the multiple classes belonging the same tree. At present these values will be called index-values. The pixel in which the index-value is over constant value is selected, and using these plane coordinate values and index-value, the circle that corresponds to the tree crown is searched. First in the search of the circle, the central coordinate is given on the assumption of some circles. Next, the object pixel is divided in each circle so that the product of index-value and distance between object pixel and center of the circle may become a minimum. The radius and new center coordinate of each circle is calculated by the pixel coordinate included the circle. The radius of each circle is compared with the largest and smallest radius of the tree crown set as a parameter. The circle is divided, when the radius exceeded the largest radius. And, The circle is integrated with neighboring circle, when the radius is under the smallest radius. By repeating this calculation, it is possible to obtain the circle that corresponds to the tree crown. It was considered that number and size of searched circles could be utilized as individual tree information.

3. Result and discussion

The discrimination of the tree in the garden was tried using this method. Variables for the cluster analysis are luminance value of RGB and Nir band and NDVI. Figure 2 shows result of analysis for the street and garden in the Kyoto city. In this technique, some parameters can be set in order to search the circle that corresponds to tree crown. In this analysis, initial tree crown radius was set at 5m. Divided largest tree crown radius was set at 5m, and integrated

smallest tree crown radius was set at 1m. The result was appropriate, when the tree is clearly different from the background like large street tree. Especially, it is useful, when the size of the tree crown as a target can be guessed. However, it became bad on the discriminated accuracy, when there were shrub and grassland under the tree. It is considered that the over tree and under vegetation are classified into same class as the plant. As the solution, the improvement in some accuracy was observed by increasing classification class number of the cluster analysis. However, the problem remained in the analysis in continued tree band, when the boundary of tree crown is not clear like the broad-leaved tree. Future, it is necessary to examine the appropriate classification number and the integration of the similar classification class.

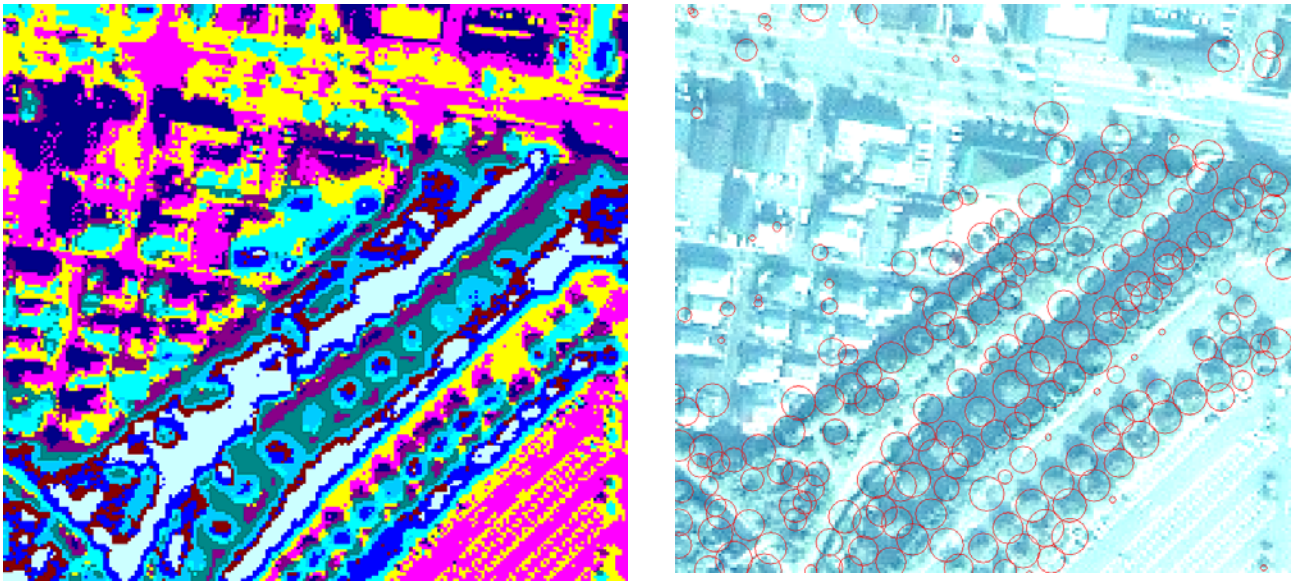

Fig. 2 Result of classification and individual tree crown circle

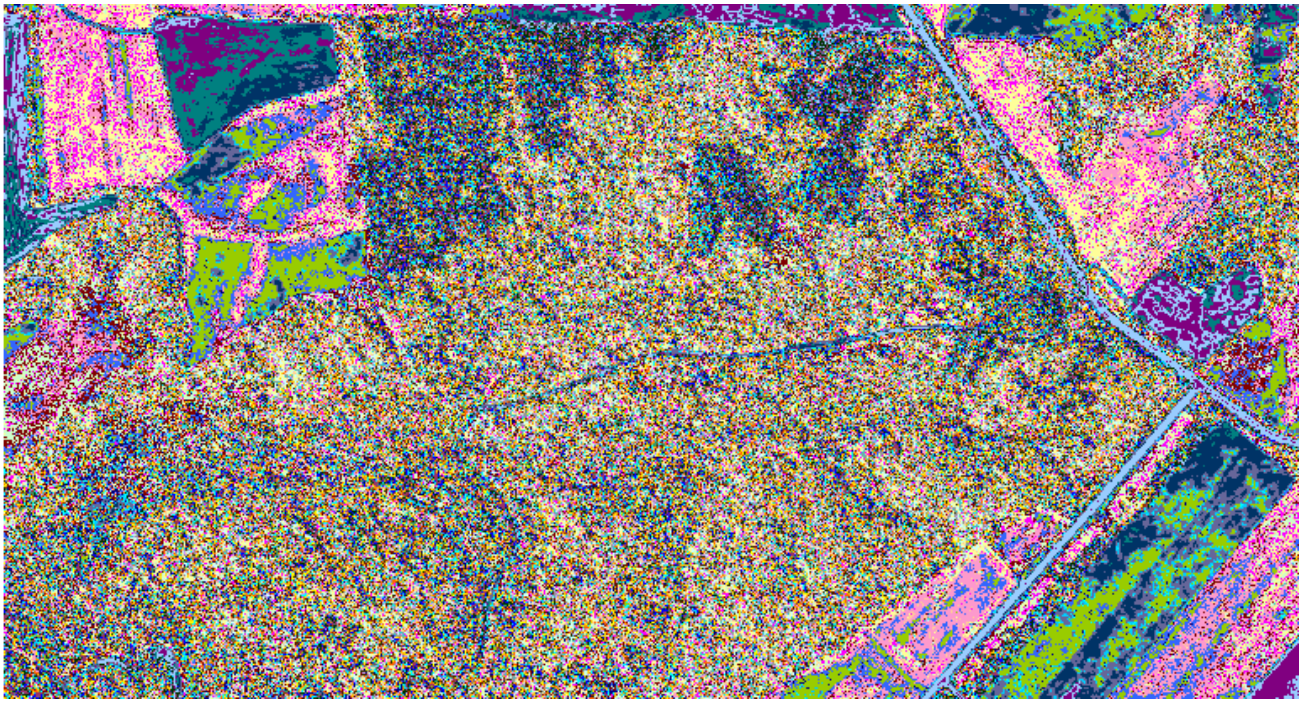

Fig.3 Result of cluster analysis

And, the counting method of number of tree at the plantation forest was examined as individual tree information. Figure 3 shows the result of the cluster analysis (2000*1000 pixels) by the K-Mean method for the flatland forest in Hokkaido. Used variables are RGBNIR bands, NDVI and entropy and energy of NDVI texture. The coniferous forest based on Japanese larch has been divided. 9-sample areas were selected from the larch forest, and the number of tree was counted by this technique. From the analysis of the sample area, the following are obtained: Number of circle that corresponds to tree crown, number of pixels classified as larch forest and numerical value of membership function or degree of the assignment in each pixel. The density degree of the classification of the object area was calculated from numerical value of membership function or degree of the assignment and the number of pixels. In the meantime, the density (tree number/ha) of each larch forest is obtained by referring to forest investigation notebook based on the field study. Figure 4 and 5 show the relationship between density of the forest investigation notebook and density degree of the classification got from the analysis of sample areas. These figures show that there is a little strong correlation. The tree number density of the Japanese larch is lower, as the density degree of the classification is higher. That is to say, it is shown that the maturity of the larch forest rises, as the density degree of the classification is higher. Generally, the tree number density is higher in yang forest, and that is lower in old forest. From these facts, the density degree of the classification seems to be useful for the estimation of the tree number density.

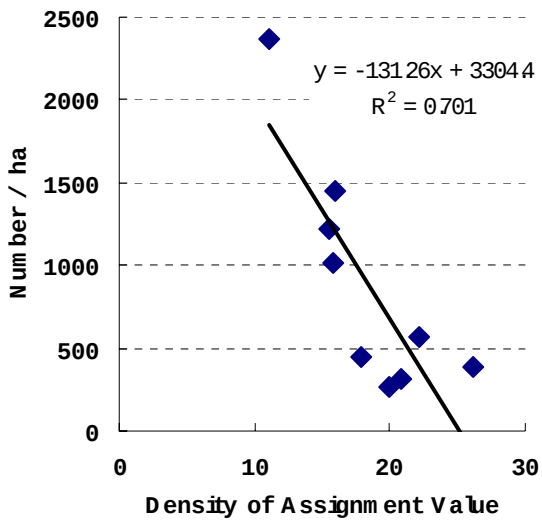

Fig.4 Relation of tree-number and Assignment value

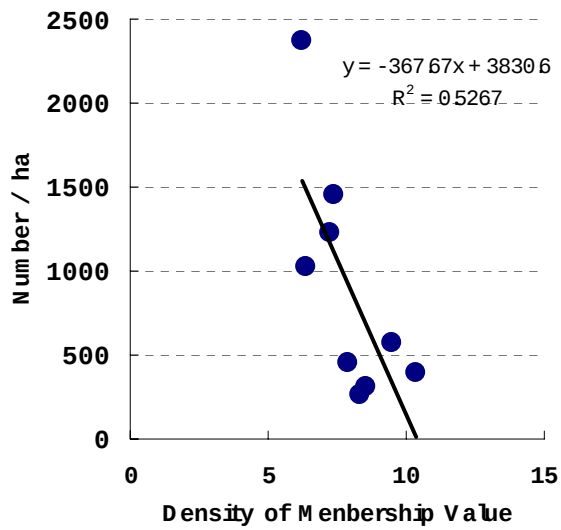

Fig5 Relation of tree number and membership value

Figures 6 shows the result of individual tree information of the sample area using this method. The shade of color shows the value of degree of assignment in each pixel. The degree of assignment is higher, as the color is darker. The circle in the figure is correspondent to the tree crown. The parameter of this analysis are set as that the largest radius is 3m and smallest radius is 1m. There is partially an overlap of the circle, but it is approximately regarded as a good. In this example, the number of circle that seemed tree crown is 960, and the number of circle that average density of degree of the assignment against circle area over 60% is 651. There are many circles of a radius around 2m, and the number is 683. Like this, the parameter was changed for the each sample area, and the analysis was done. By such procedure, the parameter is changed for the each sample area, and the analysis is done. The relation between class separation and the value of membership function or/and degree of the assignment was examined in the same region. Figure 7 and 8 show the frequency distribution of the value of membership function or/and degree of the assignment of classified pixels and not classified pixels got as a result of the cluster classification by K-means and fuzzy method. In usual k-means cluster analysis, the degree of the assignment of boundary between classification and non-classification is over 80-90. And in the fuzzy cluster analysis, the membership value of them is about 20-30. In both cases, it is clear that there are many pixels classified another class (non-classified), even if their value of membership function and degree of the assignment is high. As a means for obtaining the continuity of the classification of pixels, possibility and usefulness of using these index values are shown. In this method, the index of search circle is the value of membership function degree or assignment, but not classification class. So, this means that this method is new and appropriate.

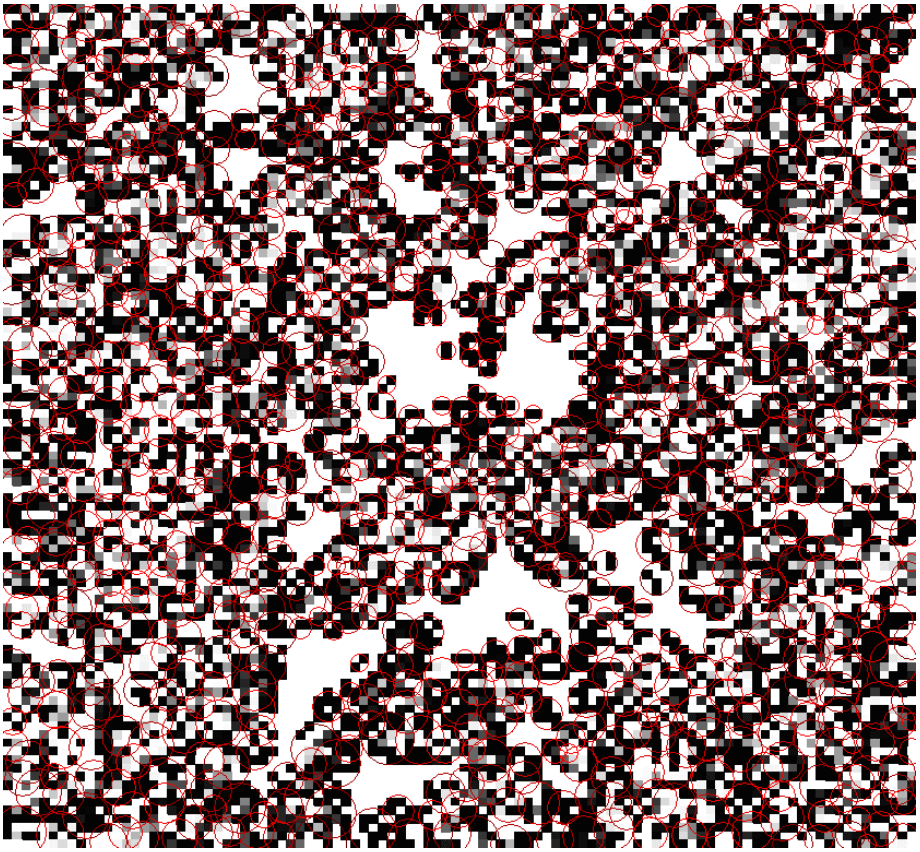

Fig.6 Result of individual tree crown in sample area-6 (100*100 pixels)

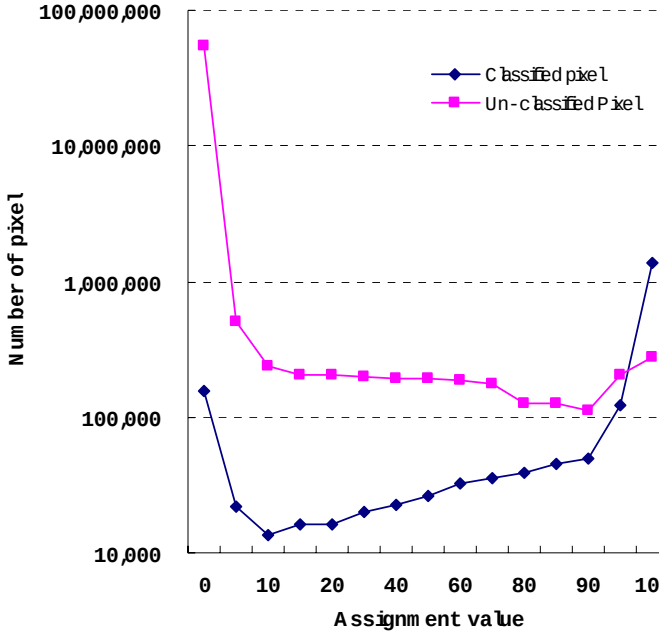

Fig.7 Distribution of assignment value

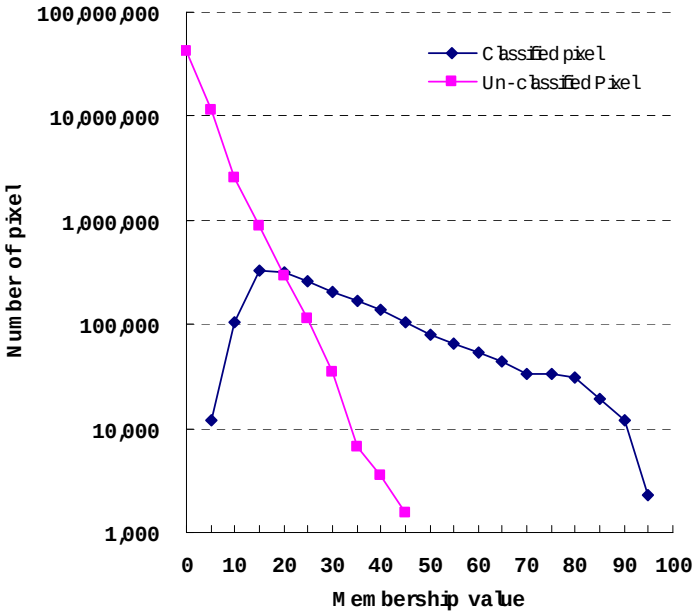

Fig.8 Distribution of memberships value

In this technique, tree crown radiuses of division or integration are the most important parameter. What kind of effect these values gave for the analysis was examined. Figure 9 shows the result of searching by each same radius at 1-5m. It is clear that the number of the tree crown equivalent circle increases, as the radius is smaller, and that the numbers of the tree crown equivalent circle decreases, as the radius is bigger. It is meant that the relation between the number of tree and tree the number of searched circle differs by the value of the parameters. That is to say, the clear correlation to both in the simplicity cannot be expected. The calculation of the tree number is possible, when the tree crown radius can be estimated. But it is difficult, when the radius cannot be estimated. Future examination subject is the tree number estimation method by combination of integration object tree crown radius and division object tree crown radius

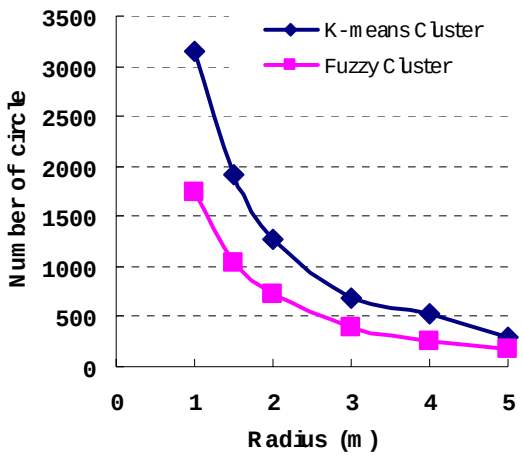

Fig.9Relation of radius and number of circle

4. Conclusion

The classification technique using high-resolution satellite photographs as an index of assignment/membership value was proposed. These indexes were useful for the continuity classification of neighboring pixels and the acquisition of individual tree information. However, some problems have also been left. In the future, the research is done for the establishment of this technique. And, we want to examine the classification technique by the multi- agents using the continuity classification of neighboring pixels.

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