A Leader and Media Spot Estimation Method Using Location Information

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Abstract. This research aims to characterize the system of local resident-based regional activations using ICT. It verifies the hypothesis that an individual participates aggressively in the local community planning only when the main activity does not take place in the home and workplace. Verification was conducted by employing a proposed leader estimation method that uses kernel density estimation (KDE) and evaluated questionnaire results. This method was applied to location information gathered between August 1 and 31 in 2015. This research finds that KDE can serve as a visualization method to promote awareness.

1 Introduction

After the Tohoku Earthquake, the structure of regional communities in Japan was challenged. Japan is the first country to have a super-aging society, first noted in 2007. Having strong leaders who would lead the community for the locals' regional activation was deemed necessary. Non-profit organizations and municipalities provided leadership training courses to train the regional leaders. According to the latest Annual Health, Labour and Welfare Report, the number of people who want to help in the community increased despite an observed weakening of the connections among members of the communities [1].

Over the past few years, information and communications technology (ICT) has become more familiar to people, owing to the spread of smartphones. The Cyber Physical System (CPS) has become an active area of research in the field of computer science. CPS is a system that collects data on both inanimate objects and humans and then integrates and analyzes them for application in the community. In its Strategy Proposal for 2012, the Japan Science and Technology Agency proposed the usage of CPS to promote community involvement among the elderly [2].

The research on "constructing" the system has been successful, but that on its "usage" is in the developing stage. Moreover, the introduction of the system does not always guarantee regional activation, which always depends on the locals who will notice their problems and act to solve them. As such, the present research aimed to characterize the system of local resident-based regional activations using ICT.

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In this research, the hypothesis that an individual participates aggressively in local community planning only when the main activity does not take place in the home or workplace was verified. A leader estimation method using kernel density estimation (KDE) and evaluated questionnaire results was proposed to be the method of verification. Such method was applied to location information gathered between August 1 and 31 in 2015. The appropriateness of the estimation method was evaluated by comparing estimation and questionnaire results using a name generator form.

2 Research Concept and Related Research

2.1 Resident-Centered Vitalization of the Local Community

Ushino's research (1982) on local resident-based regional development explained the importance of such concept and proposed a system called "Kande System" [3]. Ushino said that after the industrialization and urbanization in the 1950s, the village communities in the rural areas were divided by the agricultural policy and then re-integrated in the 1970s to create a new regional system. The importance of local resident-based regional development has already been a significant research topic since the 1980s.

Meanwhile, Yoshizumi's case study (2013) analyzed the way for locals to develop regions sustainably and suggested the "Eco Card System" [4]. In this system, the locals are given a stamp card called "Eco Card" that promotes environmental activities, thereby creating a setup for the locals to be involved in the region. This system highlights the importance of visualizing or making the locals notice the problems for them to manage local resident-based regional development.

2.2 Importance of Regional Leaders

Hayashi (2007) focused on the importance of regional leaders [5]. In particular, he looked into one of the leaders who made a huge success at a village by promoting green tourism. He analyzed why the program worked and how the leader became one. He concluded that the leader's huge success was attributed to the vast human network between the farmers and the government.

The Handbook of Training Regional Development Leaders issued by the Statistical Research and Training Institute in 2014 [6] says that a leader needs to meet the following criteria:

- Be passionate and have belief of improving the region
- Be able to develop and harmonize many kinds of opinions from the locals

The handbook also says that the organization needs to do the following to keep the leader at a sustained position:

- Excavate and develop
- Develop a successor and division of roles

Hence, having a big human network and sophisticated communication skill are needed to become a regional leader. The organization also needs to develop a successor at an early stage to attain a sustained village development.

2.3 Research Concept

The above discussion explained how local resident-based regional development is tightly connected with the presence of a leader; developing a successor at an early stage is important for a sustained village development. Visualizing or making the locals notice the problem for them to be able to manage local resident-based regional development has also been emphasized. The research examples and the government's approaches, such as that of the Statistical Research and Training Institute, indicate a society that aspires to promote local resident-based regional developments.

All these analyses on successful cases and proposals to the regions have existed independently. However, the following three steps must be done continuously to be able to achieve successful village developments:

– A proposal for a better region
– A practice of the proposal
– An analysis on the practice

A region will most likely not practice a proposed plan that has never been tried or has failed. A successful village development plan does not always work in different regions. Hence, attention has been given to "community designers" or "facilitators" who make the three-step sequence into a cycle and help in regional activations [7].

This type of social situation has prompted the development of several approaches from the computer science field, including the Strategy Proposal of 2012 mentioned above. The person-watching system for the elderly and smart city system are examples of these approaches. Despite the need for these approaches in many regions, most regions lack the system that allows them to work on regional activation. Having a facilitator to extract the region's problem and solve it with the locals is how a community design works.

However, it is difficult at times to solve a new problem as a facilitator cannot do the problem extraction at the same region all the time. At the same time, the computer science field has no available research on ways to solve regional problems, only proposals for the usage of such systems. In terms of connections in regions, most research works focus on virtual connections, such as regional social networking services.

Hence, more studies that are directly related with real-world connections are needed. As such, the present research focuses on residents and the promotion of ICT-aided visualization, or making the locals notice their community's problems using ICT. ICT was used as a tool to help the locals, who are the subject of problem solving. The visualization of a new leader was selected as the first step to help the locals.

3 Experiment Method

This section presents the hypothesis on a local leader, inspection method, and demonstration experiment conducted for the inspection.

The researchers performed KDE using location information acquired from the smartphones given to experiment cooperators. By deriving the local maximums, the researchers extracted the place where each person was usually found. The extracted locations were compared with the hypothesis and then analyzed.

3.1 Hypothesis and Inspection Method

The hypothesis was that "an individual participates aggressively in local community planning only when the local activity does not take place in the home or workplace." The first step was an estimation of "the place where the person was usually found" to inspect this hypothesis. The researchers used KDE, a nonparametric technique to estimate probability density function. It is not necessary to set a boundary. The estimated kernel probability density function is expressed as follows.

$$\widehat{f}_h(x) = \frac{1}{Nh} \sum_{i=1}^{N} K\left(\frac{x - x_i}{h}\right) \tag{1}$$

$K(x)$ is a kernel function and h is a bandwidth. The researchers used (2) Gaussian kernel for a kernel function.

$$K(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2} \tag{2}$$

In addition, the researchers applied Scott's Rule expressed in (3) to the bandwidth.

$$h = \frac{1.06\sigma}{n^{0.2}} \tag{3}$$

$$\sigma = min\left\{S.D., \frac{q(0.75) - q(0.25)}{1.34}\right\} \tag{4}$$

where n is the number of dimensions, $S.D.$ is standard deviation, and $q(0.75) - q(0.25)$ is four-quantiles acquired by subtracting first four-quantiles from third four-quantiles.

The two-dimensional (2D) location information (the point showing a position) consisted of latitude and longitude that recorded a person's action at a specific time. The point that showed many positions at the spot where the person stayed in will be plotted, and then density would become higher. The part that is high in density appears as the maximum value. Subsequently, the researchers derived the probability density function of this location information using KDE and then estimated the place where each person was usually found by counting

the number of maximum value locations. The inspection of the hypothesis followed. A media spot was defined as the place where communication is active in an area. "Active communication" refers to the place where many residents gather in an area. The media spot estimation method entailed the following steps:

- Find the local maximums using KDE from each person's location information.
- The local maximums show places who was usually found as it shows density of location information.
- Delete location information around the global maximums, which are expected main activity places such as the home and workplace.
- Collect the dataset with deleted information on the home and workplace.
- Apply KDE to the collected dataset and then find the local maximums as media spots.

The researchers also used Numpy and Scipy, which are libraries for high-level scientific calculations of Python for the inspection.

3.2 Summary of the Proof Experiment

The field experiments were conducted in the Makishima area in Uji City, Kyoto Prefecture, Japan, in cooperation with members of the non-profit corporation Makishima Kizuna-no-Kai. Through the experiments, information related to community activities was collected using the smartphones provided to the participants. Table 1 presents the data on experiment cooperators. Tables 2 and 3 present the data on experimental installation. The activity data included "location information," "email exchanges," and "passing information using Bluetooth."

The action data were analyzed using location information. The location information was acquired every minute, except for the following situations:

- The researchers announced that "the experiment cooperator can switch off the smartphone when he/she does not want to inform his/her location information."
- The smartphone has run out of battery/the experiment cooperator forgets to carry the smartphone.
- The smartphone cannot transmit location information as it is out of range.
- The timing when the Android finishes to acquire location information is not determined exactly.

3.3 Evaluation of the Appropriateness of the Estimation Method

The researchers designed a questionnaire using a name generator form and conducted a survey before the field experiment. The name generator form is a method for identifying a respondent's relationship with the names of persons in the questionnaire entries. The questionnaire included an item that asks for the name of the person who is thought to be the leader in an area. The questionnaire results were evaluated. The proposed method was applied to location information between August 1 and 31 in 2015.

Table 1. Field experiment data

Area	Makishima, Uji, Kyoto, Japan
Number of experiment cooperators	20–50 persons
Age	30–70yo
First period	November 11 to December 10, 2013
Second period	February 11 to March 27, 2015
Third period	July 11, 2015 to January 11, 2016

Table 2. Experimental installation (first period)

Network career	NTT docomo
Manufacturer of smartphone	Fujitsu
Model number of smartphone	ARROWS Kiss F-03E
OS	Android 4.0.4

4 Results of the Analysis and Discussion

4.1 Leader Estimation

Figure 1 shows a portion of the results of applying KDE to location information (left) and leader estimation (right). The upper side shows 2D figures. The vertical and horizontal axes represent latitude and longitude, respectively. The blue part is the place of the point's high density. Meanwhile, the bottom side shows three-dimensional (3D) figures. The left and right axes represent latitude and longitude, respectively. The upper axis represents density. The red part means the place of the point's high density.

Figure 2 presents a scatter diagram for the comparison of peaks of leader estimation method and the total number of points for the question "Who do you think is the leader?" The correlation coefficient ($r = 0.0046$) does not show a correlation peaks of leader estimation method and the total number of that question. The following are reasons for such low correlation:

The following are reasons for such low correlation:

– The experiment cooperators comments:
  - The person who does community involvement in his/her home

Table 3. Experimental installation (second & third periods)

Network career	IIJ mobile
Manufacturer of smartphone	ASUS
Model number of smartphone	ZenFone 5 A500KL
OS	Android 4.4.2

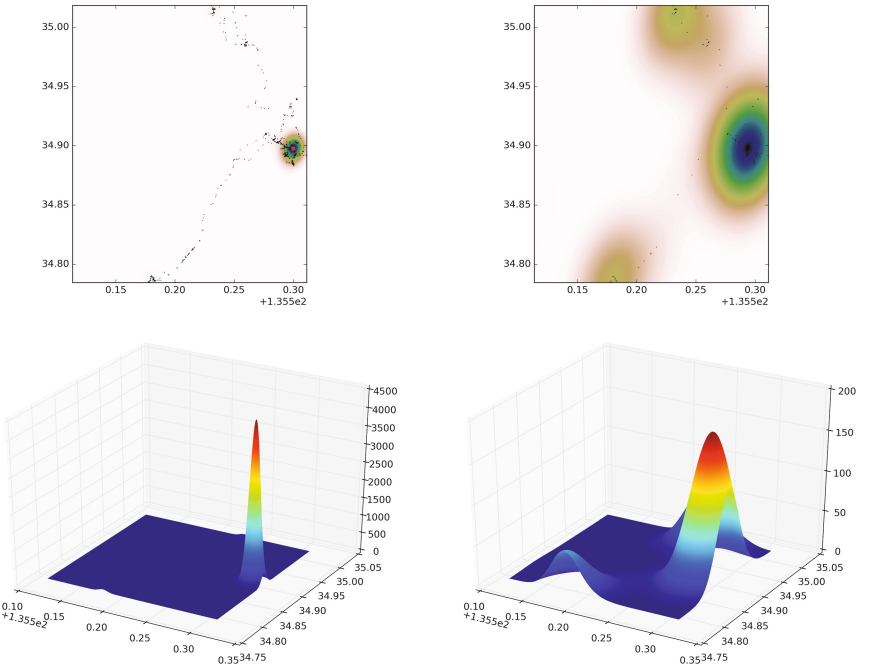

Fig. 1. Left: The results of applying kernel density estimation (KDE) to location information; right: the results of leader estimation (a portion). (Color figure online)

  - The person who works at the place where he/she has become active in the local community such as hosting an event

– Analysis algorithms
  - From computational resource, the researchers used the reduced data.
  - The location information was not accurate.
  - The time information of location information was not collected.

As regards the comments of experiment cooperators, it is necessary to judge whether location information shows local community activation. A versatile data analysis method that accounts for the use of information sent to other participants via Bluetooth needs to be developed.

Analysis algorithm is a prototype and must be optimized. The kernel function and bandwidth in KDE are fixed in a given datum. When considering the accuracy of the individual location information, the estimated result can be improved by applying accuracy as the bandwidth. Moreover, the present research did not take into account the time when the location information; it was assumed that the local community would not be active in the middle of the night. Thus, an analysis technique that considers the time information would provide improved estimation results.

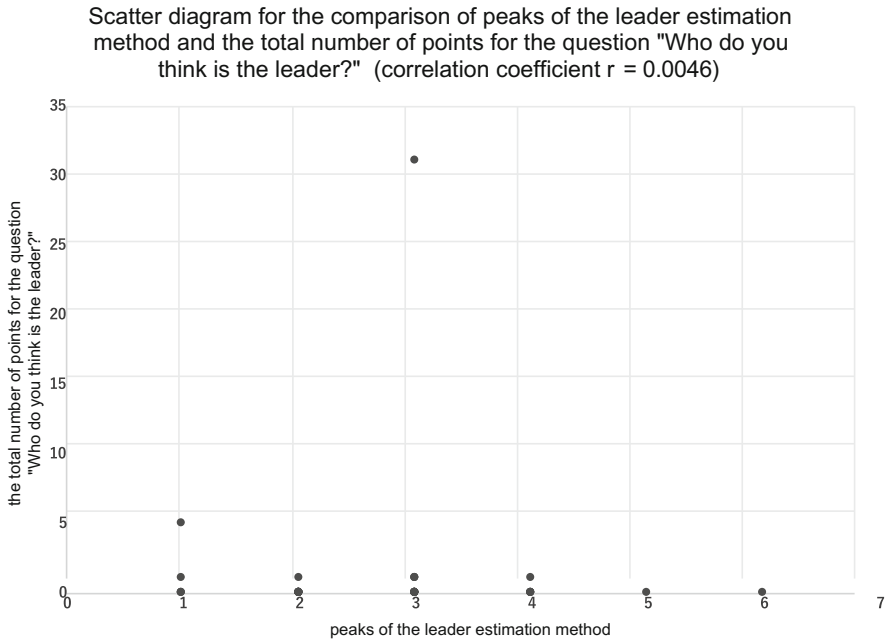

Fig. 2. Scatter diagram for comparison of peaks of the leader estimation method and the total number of points for the question "Who do you think is the leader?"

4.2 Media Spot Estimation

Figure 3 presents the results of executing the media-spot estimation. The upper side shows a 2D figure. The vertical and horizontal axes represent the latitude and longitude, respectively. The blue part is the place of the point's high density. Meanwhile, the lower side is a 3D diagram. The left and right axes represent latitude and longitude, respectively. The upper shaft indicates the density, whereas the red part means the place of the point's high density.

The longitude and latitude of the highest density place are below:

$$(latitude, longitude) = (34.9015292, 135.7827344)$$

This point is close to a meeting place and community center. Hence, an activity place could take place here.

However, this might not be the only place where communication is active in the region. As such, estimating the next media spot is possible by removing location information in the periphery of the densest part of this dataset and then performing the KDE again. However, developing a mechanism to verify the validity of the media spot is necessary as meaningless location information might be visualized as portions having high density.

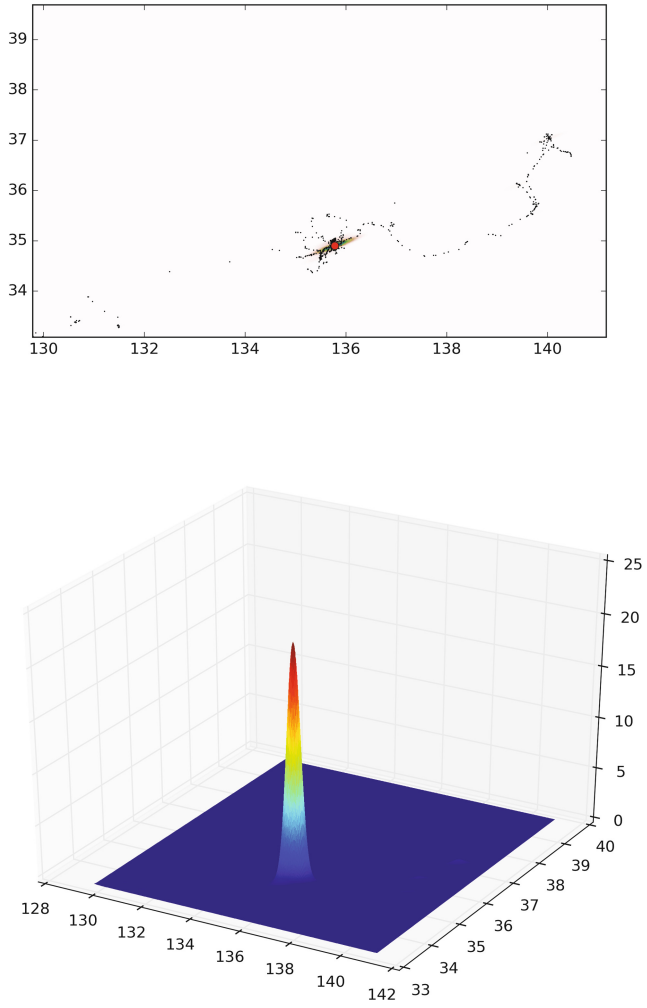

Fig. 3. Results of the media spot estimation (Color figure online)

5 Conclusion

The present research verified the hypothesis that an individual participates aggressively in the local community planning only when the main activity does not place in the home or workplace. Previous studies suggested that this idea is dependent on the importance of the leader who leads the local community. It also promoted resident-centered vitalization of local communities by visualizing the leader and being realized states of local community.

The leader estimation method using KDE and evaluated questionnaire results was proposed to verify the hypothesis. This method was applied to location information between August 1 and 31, 2015, involving the following steps:

- Find the local maximums using KDE from each person's location information.
- The local maximums show places who was usually found as it shows the density of location information.
- Delete location information around the global maximum points, which are assumed main activity places such as the home and workplace.
- Apply KDE to the dataset with deleted location information around the main activity place and then find the local maximums. Compare each person's local maximums and estimate the leader of the local community as the one who has the most local maximum

The research defined a media spot as the place where communication is active in an area. It estimated media spots through the following steps:

- Find the local maximums using KDE from each person's location information.
- The local maximums show places who was usually found as they show the density of location information.
- Delete location information around the global maximums, which are assumed main activity places, such as the home and workplace.
- Collect the dataset with deleted information on the home and workplace.
- Apply KDE to the collected dataset and then identify the local maximums as media spots.

The estimation did not yield good comparative result but KDE was found to be a valid visualization method to promote awareness. From a viewpoint of resident-centered design, data that seem insignificant should be important for residents. As such, the researchers propose that the visualization method of location information by nonparametric method is significant.

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