A Study on the Estimation Method of the Resident's Location using the Plant Bioelectric Potential

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Abstract. In Japan, an aging society is progressing rapidly, and thenumber of aged single-person households are also increasing. Therefore, to keep safety life of human and to report any emergencyies occured in single-person households immediately, a demand of monitoring is increasing. Generally, microphones or cameras are used for monitoring, however, it is hardly accepted to residents because they are afraid that their privacy might be violated by such devices.
In this paper, we focused a living plant as a monitoring device. Living plants are easily accepted to residents. Therefore, we have studied to develop a method to use living plants for monitoring, because the living plants never violate resident's privacy comparing with devices generally used for monitoring. However, we have found our method has problems of an accuracy and a measuring distance.
In this paper, we introduce a deep learning method to improve an accuracy of estimation. And then, we report a result of experiment to confirm an accuracy of the method.
Keywords: plant bioelectric potential, monitoring, welfare, safe and comfortable life

1. INTRODUCTION

In Japan, it is said that an aging society has been extremely progressed. For this reason, single-aged-person households are increasing. Further, not only for aged person, there are many people who live in single-person households away from their family. Therefore, the demand to monitor resident's behaviors for their safety, security, and so on, is high. Generally, cameras or microphones are used to monitoring. However, these instruments will violate resident's privacy, and it will be a mental burden on resident. In this study, we focus the plant bioelectric potential as a device to monitor resident's behaviors. It has been investigated in previous study that the plant bioelectric potential is affected by human's behaviors or activities. Therefore, we expect that we can monitor resident's behaviors by measuring them. Further, the plant bioelectric potential changes depending on the distance from human to the plant. In this paper, we propose the method to estimate a location of the resident in the room that many living plant are placed.

2. PREVIOUS STUDIES

Hirobayashi *et al.* (2007) researched that the plant bioelectric potential is affected by human's behaviors. For example, when human is stepping near the plant, the potential changes interlinking with the step. Furthermore, Nomura *et al.* (2014) shows that human behaviors, such as stepping, walking, opening doors and so on, can be distinguished by the difference of the plant electronic potential. However, these studies don't show that the relationship between the change of potential and a distance from the plant to human.

Jing *et al.* (2014) proposed a method to estimate the distance from the plant to human with machine learning method using the change of the plant electric potential.

In this study, based on Jing *et al.* (2014), we propose the method to estimate a location of resident in a room where 2 or more plants are placed.

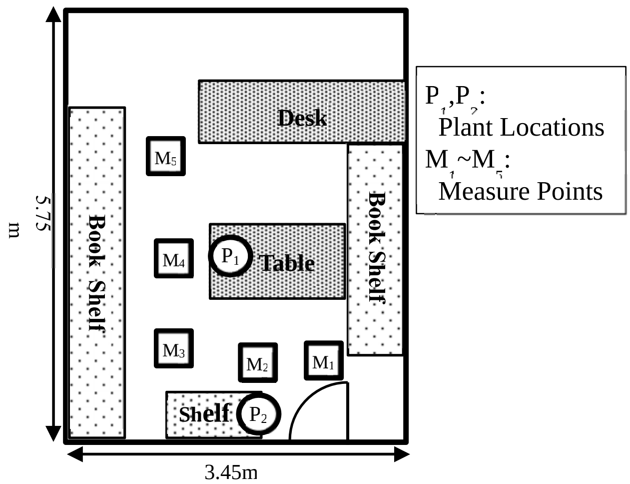

Figure 1: Experimental Environment

3. EXPERIMENTAL ENVIRONMENT

In this study, all measurement is done under the environment shown in Fig.1. Two plants, P1 and P2, a re located in the room that size is 5.75m height and 3. 45m width. And, five measure points are set up, they are shown as M1 to M5 in the figure. Their distance from two plants are shown in Table.1.

To measure bioelectric potential, we use GL900-4 by GRAPHTEC Corporation (Fig.2). All data in this study is measured at a sampling rate 500Hz.

Table 1: Distances of M_x from P_1 or P_2.

	M_1	M_2	M_3	M_4	M_5
Distance from P_1 (cm)	170	140	90	40	100
Distance from P_2 (cm)	85	40	120	210	280

4. ESTIMATION METHOD

In this chapter, a detail of the proposed method is described. The method consists from 3 parts, which are parameter extraction, learning and estimation. Each part is described in 4.1, 4.2 and 4.3 respectively.

Figure 2: The instrument for measuring, GRAPHTEC GL900-4.

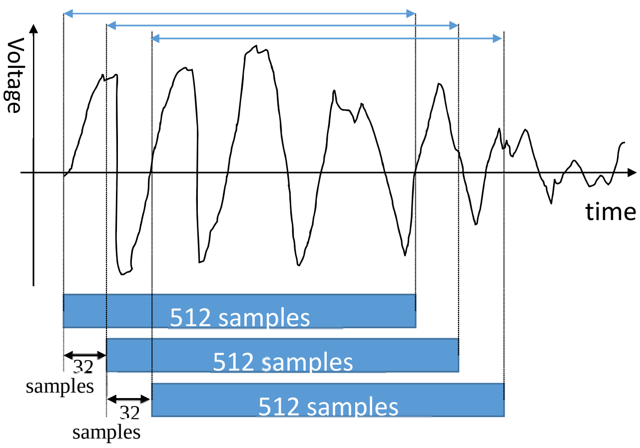

Figure 3: Sampled data and block of analysis.

4.1 Parameter extraction

All bioelectric potential are measured at sampling rate 500Hz and transmitted to PC by GL900-4. Each data is time sequence data of a voltage. 512 sample data are regarded as 1 unit of analysis data. When PC receive 512 sample data, each data is processed every 32 sample points (Fig.3). This 512 sample data is regarded as a block for analysis.

Each block is decomposed to smaller size for precise analysis. Fig.4 shows an original block and smaller blocks. In our method, not only smaller blocks but also an original block are target of analysis. The reason that we use various length of blocks is we expect to obtain various changes. When user stays near the plant for long time, the potential of the plant is affected for long time. On the other hand, when user stays for short time, just like passing by, the potential is affected for just a short time. Therefore, we have to observe various length of the potential. In our configuration of measurement, sampling rate is 500Hz. In short, 500 sampling points represent for 1 second change. We use 512 points as a block because we expect the potential change is within 1 second at most. For all original and decomposed blocks, cepstrum coefficients, maximum value, minimum value and average value are calculated. Cepstrum coefficients represents an envelope of frequency spectrum of the signal. It is extracted by the following procedures.

1. Let S(t) as the signal of potential.
2. Obtain frequency components S(ω) from FFT of S(t).
3. Calculate log (S(ω)).
4. Obtain cepstrum coefficients by Inverse FFT of

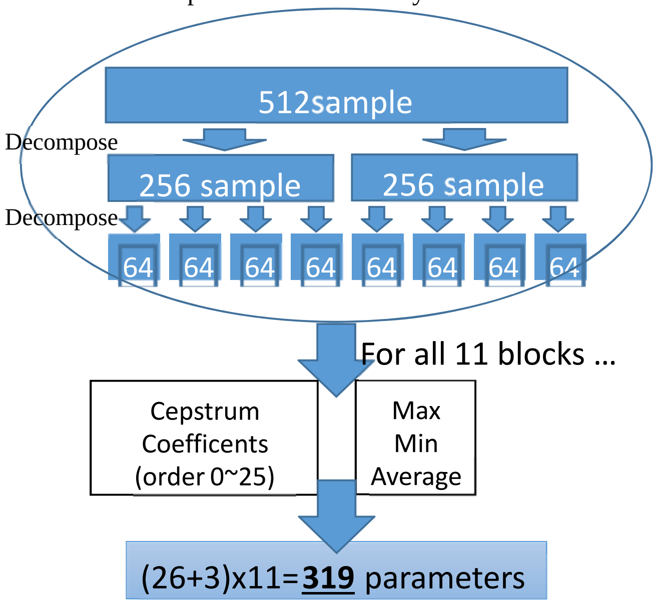

Figure 4: Decomposition of a unit and obtaining log(S(ω)).

In this paper, we calculate 26 cepstrum coefficients (order from 0 to 25).

For each block, 29 parameters, they are 26 cepstrum coefficients, max value, min value and average, are obtained. Totally, 319 parameters are obtained from a unit of analysis, because 11 blocks are obtained including an original block. We regard these parameters as one instance of the unit.

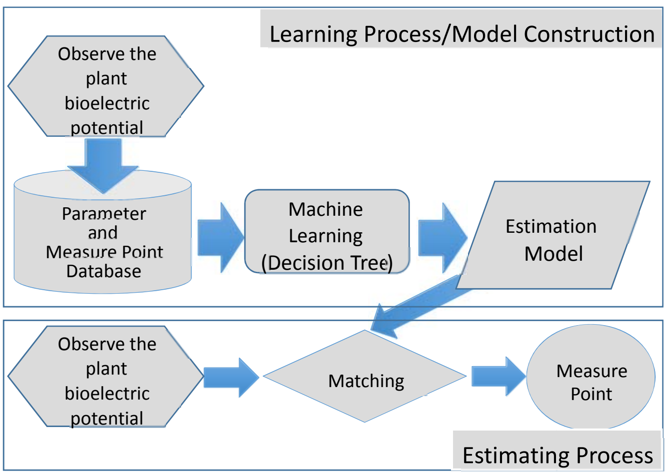

Figure 5: A process flow of the proposed method.

4.2 Learning method

In this study, we use decision tree and deep learning as a learning method. We collect various potential signals and analyze them. Then, we obtain an instance for a unit; each instance consists from extracted 319 parameters as dependent variables, and measured point M_x as target variables. They are input data of a learning method. We use J48 algorithm on Weka version 3.7.12. As a result, we obtain a model to estimate a measured point from a unit of potential signals. We use tensorflow for deep learning.

4.3 Estimation method

When estimating a measure point, measured potential signal is imputed to a model obtained by learning method. Then, the model outputs an estimated measure point.

A process flow of the proposed method is shown in Figure.5.

5. EXPERIMENTS

Under the environment described in Chapter.3, we observed the plant bioelectric potential when a resident moves in the room.

Table 3: Cross summary of estimation for P2.

Output / Input	M1	M2	M3	M4	M5	None
M1	2854	49	265	2	0	1
M2	90	3078	3	0	0	0
M3	232	1	2897	14	10	17
M4	1	0	16	2654	407	93
M5	3	0	8	430	2408	322
None	3	0	11	88	330	2739

5.1 Obtaining data and model

At first, when a resident steps at a point M1 ~ M5, we observe the potential of P1 and P2 for 30 seconds. Furthermore, we observed when no resident is in the room.

These observation are repeated for 7 times. Totally, 210 seconds potential signal is obtained for each measure point and each plant by this observation. In the same way, same length signal is obtained for each plant when there is no resident. All obtained data are analyzed and parameters are extracted from them. Finally, 3171 instances that includes 319 parameters for each are obtained for each measure point and each plant. There are 6 measure points (including no resident) and 2 plants, and then we obtained 19026 instances. At last, an estimation model is constructed using these instances. Using J48 algorithm on Weka, we obtain the model.

Table 2 and 3 shows the result of model evaluation. The model is constructed for each plant, and they are evaluated by 10 fold cross validation method. These table represent an input instance's measured point and an estimated point. In the table "None" represents there are no resident in the room. According to these result, these are some errors, they are misclassification between neighbor point, such as M1 and M2. However, classification accuracy is high, their F-measure are 0.877 for P1 and 0.874 for P2. Here, F-measure is a harmonic mean of precision and recall.

Table 2: Cross summary of estimation for P1.

Input \ Output	M1	M2	M3	M4	M5	None
M1	2608	507	2	0	14	40
M2	505	2560	21	0	76	9
M3	1	12	2685	6	467	0
M4	0	0	5	3161	5	0
M5	32	73	494	4	2561	7
None	38	14	0	0	3	3116

Samples

Figure 6: The estimation point for moving pattern 1.

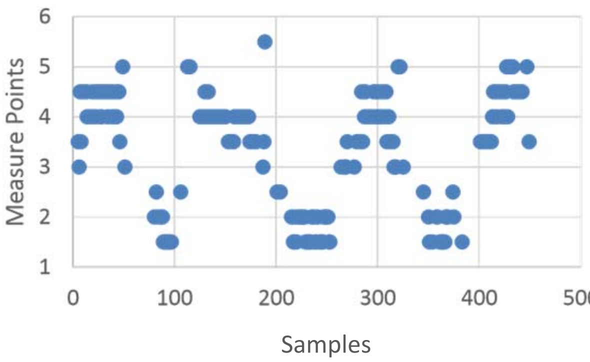

Figure 7: The estimation point for moving pattern 1.

5.2 Location Estimation

Next, we conducted location estimation experiments using the model obtained in primer section. The plant bioelectric potential of P1 and P2 are observed when user moves in the room. We tested for 2 moving patterns. First pattern is following. At first, resident waits at side of the desk for 10 seconds, then he moves to M5 and walks to M1 at slow speed. After arriving at M1, he moves toward M4 again at slow speed. These move is done in about 20 seconds. Second pattern is following. At first, resident stands by P2 at M4, then he moves to M2 and returns to M4. He repeats this go and returns 3 times in 30 seconds.

For each pattern, the potential of P1 and P2 are observed for 30 seconds. Then, observed signals are analyzed and instances are obtained. Applying estimation models, we get an estimated measure point for each instances.

Estimation results are obtained for P1 and P2, in short, two estimation results are obtained. We should aggregate two result to get an estimated measure point. In this paper, we apply the method followings.

1. If two estimation results are same, the estimated measure point is the estimation result.
2. If two estimation results are neighbor, the estimated measure point is the average of them. In short, the middle point of them are accepted.
3. If two estimation result are different, not neighbor, the estimated measure point is not obtained.

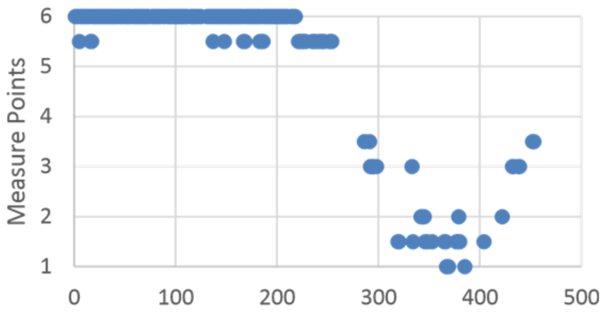

Figure 6 shows the estimated measure point for moving pattern 1. Figure 7 shows the estimated point for moving pattern 2. In these figure, vertical axis represents measure points, and value of 6 means no residents in the room.

According to the figure 6 and 7, moving pattern is roughly obtained.

6. SUMMARY

In this paper, we propose the method to estimate the location of the resident in the room. Placing multi plants and using the plant bioelectric potential, our method make an estimation model by J48 algorithm that is one of the machine learning method, and utilize the model. According to an evaluation experiment, the model made by J48 is able to estimate the measure point in high accuracy. Further, we conduct an experiment to trace moving resident. As the result, our method is able to recognize the location of resident roughly. In future works, we should estimate distance. In this study, our method estimates the measure point. It is a classification, not a regression. To estimate any location in the room, it is need to get distance from plants. In that case, we need more plants in the room and we have to observe more signals for machine learning.

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