Family Communication Support Tool Using Time-Series Visualization of Individual Ambient Temperature

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Abstract—**Face-to-face conversation is important for communication within a family. We focused on a serial record of individual ambient temperature for initiation of conversation. The ambient temperature data are recorded automatically as a time-series during the user's activity. We developed and evaluated the family communication support tool using time-series visualization of individual ambient temperature. The user and other members of the family can review and compare the visualized time-series, and they can call to mind or imagine the mutual past activity of the day. Common tendency or different feature of time-series might induce their conversation. The system consists of two parts. One part is a sensor device to measure and record ambient temperature of each user. The other part is application software to visualize and display the temperature. It receives the data from the devices, and then it processes, analyzes, and visualizes the data.**

Keywords-family communication tool; sensor; visualization and ambient temperature;

I. INTRODUCTION

Face-to-face conversation is important for communication within a family. According to goo research [1], ninety-six percent of parents think that face-to-face conversation is the most important means of communication with their children. Thus, we consider that increasing occasion of face-to-face conversation is useful to increase a quality of communication within the family. Face-to-face conversation needs common space and occasion of conversation. There are common spaces such as a living room and a dining room in a house. Therefore, if a family get occasion of conversation there, the family can get talking. Speculating about family member's activity leads to conversation, and imaging the mutual past activity by seeing information implying each activity promote conversation. For example, if a child who is covered with mud gets home, his mother will imagine that he played outside. She will talk to him about that. If someone gets a cold and one of others know it, he or she will say the someone "Do you feel all right?" In this day and age, we can get many kinds of information to see individual activity by using sensors and cameras. However, too concrete information does not have a family started conversation. Additionally, it has concerns of privacy. Therefore, it is better to use abstract information for conversation.

Our purpose is development of a family communication support tool. A system of the tool is making occasion of conversation by visualizing and showing information implying user's activity. Users can review and compare the information, and they can call to mind or imagine the mutual past activity of the day. We focused on serial records of individual ambient temperature for initiation of conversation. We developed and evaluated the family communication support tool using time-series visualization of individual ambient temperature.

II. RELATED RESEARCH

Wii® is included as family communication tools. Its concept is public space of a family. It is used by everyone including persons not usually playing TV games. Context Aware Messaging Service [2] is included as research about information of personal life. Users know where other users are now by using the system, and they communicate each other. Raison D'etre Object [3] is included as research about making occasion to get into conversation. It makes occasion users by providing a space for conversation. pHotOluck [4] is a system for vitalizing mealtime communication by projecting photos taken by family members. Digital family portrait [5] provides qualitative visualizations of a family member's daily life to support older adults who want to continue living independently. Portable personal memory for communication [6] is a small portable photo editor/viewer. The authors focused on the roll of such personal memories and named such communication as "memoir based communication".

III. AMBIENT TEMPERATURE

Ambient temperature is air temperature around a person. Ambient temperature is familiar. Such as clothes and weather forecast, its topics are often spoken. If a person speaks to someone, he or she will not go direct his or her topic, but speak

about light topic such as weather and temperature. In addition, showing temperature with color is intuitive such as a thermograph. Comparing to other ambient information such as humidity and light, temperature information is appropriate for representation with full color. Besides, we can imagine about activity such as moving from a room to outside by seeing time-series of individual temperature. If temperature variation is large, it indicates that the person moved to different place from there. If temperature variation is small, it indicates that he or she does not moved there. But it doesn't show where he or she is. Therefore, we think that ambient temperature is not concrete. Probably, we don't remember ambient temperature in a day. However, we will remember the activity in a day by finding our time-series ambient temperature. And, we don't find other person's activity by ever seeing his or her time-series ambient temperature. We consider that it becomes an initiation of conversations that we imagine other person's activity by seeing it.

IV. SYSTEM

The system we proposed supports communication within family by measuring, visualizing, and showing serial records of individual ambient temperature (Figure 1).

The system consists of two parts. One part is a sensor device to measure and record ambient temperature of user. User carries around it. The other part is application software to visualize and display the temperature. It receives the data from the devices, and then it processes, analyzes, and visualizes the data. User can see the output screen at home. Because censer device is small and light, carrying it is easy. And, User only use remote controller to see the display.

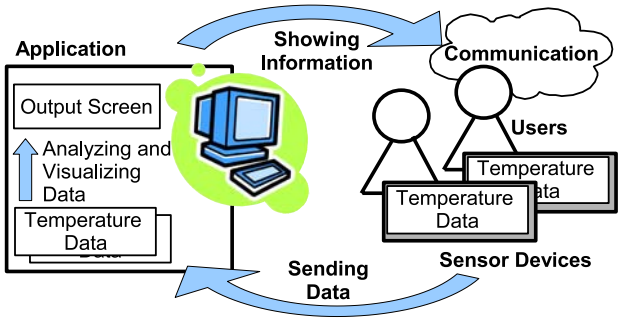

Figure 1. Structure of our system.

V. IMPLEMENTATION

A. Sensor Device

The circuit of the device is 3.4cm long, 3.4cm wide and about 1.0cm in thickness (Figure 2). When user carries around it, it is put in a case. The temperature sensor of the circuit is a thermistor 103AT-2. The device works with powers from a dry cell or a personal computer through USB. The data of ambient temperature are measured and recorded every 10 seconds.

Figure 2. Circuit.

B. Application

We implemented the application with Borland C++ Builder 6.0. A personal computer receives user's temperature data from sensor device, and analyzes the data and makes the image. Its OS is Windows XP. The application's display is a digital photo flame(Figure 3). User sees the photo flame and user can operate the screen by using remote controller.

Figure 3. Application.

1) Output to Screen

User's temperature data are visualized and displayed to the screen. Main functions of outputs are a display of user's temperature with color and a display of a similar part of two user's temperature. The outputs consist of a main window and some sub windows.

2) Color and Temperature

Temperature is associated with color. We have a feeling of sensuous temperature to colors. We feel that red is hot, blue is cold, and green is between red and blue. When temperature change higher or lower, the color changes like Figure 4. We use RGB space to display color. Values of R, G, and B are from 0 to 255. Values are defined as follows:

$$(R,G,B)=\begin{cases}(0,x,255) & \dfrac{4t}{T_{MAX}-T_{MIN}}<1\\ (0,255,255-x) & 1\le\dfrac{4t}{T_{MAX}-T_{MIN}}<2\\ (x,255,0) & 2\le\dfrac{4t}{T_{MAX}-T_{MIN}}<3\\ (255,255-x,0) & 3\le\dfrac{4t}{T_{MAX}-T_{MIN}}\end{cases} \quad (1)$$

$$x = \frac{255 \times 4t}{T_{MAX} - T_{MIN}} \bmod \frac{4t}{T_{MAX} - T_{MIN}} \quad (2)$$

Where t is the temperature, T_{MAX} is the upper limit, and T_{MIN} is the lower limit. The hue is changed with temperature. However, chroma saturation and brightness are fixed.

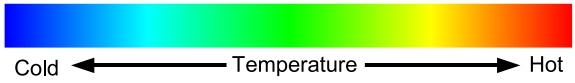

Figure 4. Color alteration.

3) Output of Ambient Temperature Using Color

The output shows time-series temperature of a day using color (Figure 5). The horizontal axis is time. Because width of screen is limited, all of data are not displayed. The data of 24 hours are displayed with scroll function and they can be enlarged by a remote controller's operations. A part represented with gray color is blank. It is such a time that user is sleeping.

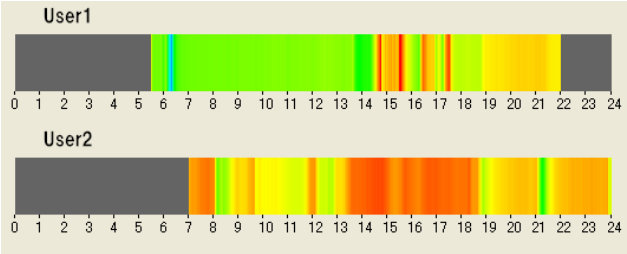

Figure 5. Main screen.

4) Output of Similar Temperature Part of Two Users

The output shows Similar Temperature Part of Two Users by color (figure 6). User finds each user's time of two user's similar temperature part, and temperature with color. By comparing the data of each other, feeling relation with the other might induce conversation. For example, imagine that users have lunch at a restaurant on a hot day. It is cool in there. In contrast, it is hot out of there. Even if lunchtime of user A and lunchtime of user B are different, both transition of temperature are similar. Showing temperature in such time might have users feel relation between users. We use a multiresolution analysis which based on discrete wavelet transform to extract similar part of two users from the data.

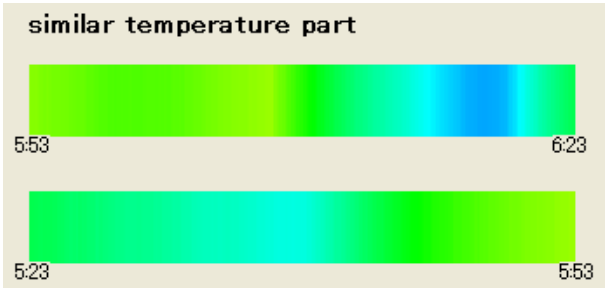

Figure 6. Similar temperature part.

5) Other Output

The system has output of temperature variation and output of temperature line plot. The temperature variation is indicated by black-and-white (figure 7). User can see when he or she had rapid change in temperature. Output of temperature line plot shows temperature with time-series line plot (figure 8). When user wants to see degree of temperature, user sees the screen of temperature line plot.

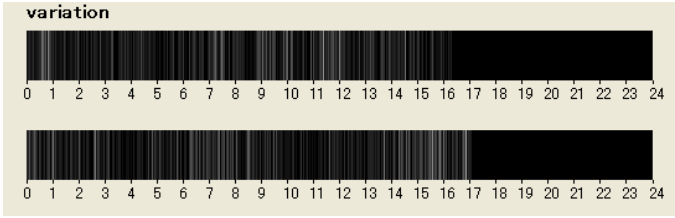

Figure 7. Temperature variation.

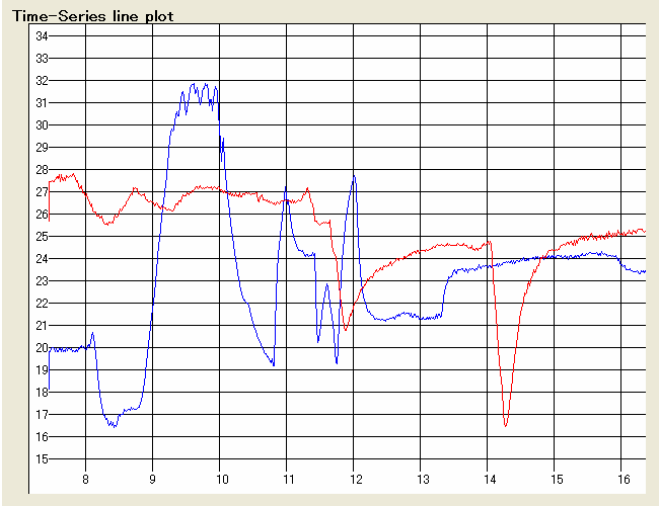

Figure 8. Temperature line plot.

C. *Analysis Method to Find Similar Temperature Part of Two Users*

We employ multiresolution analysis based on discrete wavelet transform to extract from the data. We use the wavelet functions and the scaling functions. Let

$$v_{A,j}(t) = \frac{v_{A,j-1}(t) + v_{A,j-1}(t - 2^{j-1})}{2} \quad (3)$$

represent User A's wavelet function of level j. And let

$$w_{A,j}(t) = \frac{v_{A,j-1}(t) - v_{A,j-1}(t - 2^{j-1})}{2} \quad (4)$$

represent User A's scaling function of level j. Where $v_{A,0}(t)$ is User A's raw data, the number of the time is T. We set

$t = t - T$ if $t > T$. We set a time range of the wavelength from about ten minutes to about six hour. We use two methods for analyzing to find similar temperature part.

1) Method Using Maximum of Wavelet Function

In this method, we assume similar temperature part as the time two users wavelets product $w_{A,j}(t)w_{B,j}(t+\tau)$ $(0 \le \tau \le T)$ are maximum. τ represents time lag of the two users's data.

The similar time of User A is from $t - 2^{j-1}$ to $t + 2^{j-1}$, and the similar time of User B is from $t + \tau - 2^{j-1}$ to $t + \tau + 2^{j-1}$.

2) Method Using Cross-Correlation Function

In this method, we use Cross-Correlation function. Cross-correlation value indicates correlation between two data. If cross-correlation function of two data is large, the correlation of two data is high. We calculate cross-correlation function between user A's wavelet function and user B's wavelet function. The cross-corretion function $C_{w_{A,j}w_{B,j}}(\tau)$ with time lag τ is define as follows:

$$C_{w_{A,j}w_{B,j}(\tau)} = \sum_{t=0}^{T} w_{A,j}(t)w_{B,j}(t+\tau) \quad (5)$$

The similar time of A is from $t - 2^{j-1}$ to $t + 2^{j-1}$, and the similar time of B is from $t + \tau - 2^{j-1}$ to $t + \tau + 2^{j-1}$.

VI. PRELIMINARY EXPERIMENT

A married couple was employed as the subjects of the evaluation experiment. They are in a husband-wife household, and they have been married for about ten years. When we conducted the preliminary experiment, the application's display is not digital photo flame, but a personal computer display. In August, they had used the system for two weeks in Sapporo, Japan. He uses a personal computer in office only. She doesn't use a personal computer since she became a full-time housewife. They usually use mobile phone. He uses its functions such as mail forwarding, telephone function, alarm, electronic compass and GPS system. She uses mainly telephone function, and uses mail functions for emergencies.

There were following descriptions in the questionnaire that had been written after the experiment:

The husband:

1. It is interesting to remember my past activity by seeing my ambient temperature.
2. It is more interesting to compare with other. We had a talk naturally.
3. Without this system, my wife often talk about her activities in a day. But, I am sometimes distracted then. When I listened to her talk as I look the display, I am not distracted.
4. I found a different temperature part. It is while we had a shopping together. After we talked about the time, we found that we were different sections such as a food section and a notions corner. We had initiation with not only similar temperature parts, but also different temperature parts.

The wife:

5. Using the tool, I feel that it is easy to talk about my activity in a day. Moreover, the conversation is not one-sided.
6. The system is conducive to talk about user's activity.
7. While my husband is away on business, if I watch a weather forecast, I care about a weather and high temperature in a city he is in. I feel it is better for someone who usually uses mobile phone that the tool has a function to communicate each other with e-mail.
8. I feel that it is better to be a joyous display.

VII. CONCLUSION AND FUTURE WORK

We developed and evaluated the family communication support tool using time-series visualization of individual ambient temperature. By a preliminary experiment, we were convinced of this system effective as the initiation of conversation. Now we are designing more practical experiments assuming various cases of family structures. Moreover, the tool used the preliminary experiment was not using digital photo flame, but a personal computer display. Therefore, we must have experiments for the tool using digital photo flame. From the experiment, we should think about the interface of the tool for user to use more happily. For example, the tool shows weather forecast using picture with ambient temperature.

VIII. REFERENCE

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