

# Creating A User's Impression Map Based on Heart Rate Data

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**Abstract:** Some existing guide systems reflect user's impression and feeling. However, these systems based on questionnaire and do not deal with user's emotion directly. Meanwhile, existing study proposed that the user's strong impression is related to the decreasing of heart rate. Therefore, we develop a system that obtains user's impression by detecting his/her heart rate using a smart watch and map the detected impression on a map using Android API. We implemented the system with Android smart watch, a Android tablet, and Google Map API. We evaluated the system by showing the emotional arousal image to a subject in our university's campus, and user's impressed places were confirmed to be mapped with our method. However, in the smart watch that was used, that there is a problem with the accuracy of the heart rate data was found.

**Keywords:** Heart Rate , Impression Map , Smart Watch , Emotion Recognition

## 1. Introduction

In recent years, tourist attractions, zoos and aquariums, in a variety of places, events, such as museums and libraries, guide application to support the people who visited there are many. If the aquarium called "Hakkejima Sea Paradise" is, for example, tourist facilities, or creatures of the information is delivered automatically to the smartphone, along with the site map, or presents an easy-to-understand what kind of creature can be seen at that location , or tell the time of day, location as long as there is an event. Application has also been used in educational facilities, for example, if a library has been used experimentally in the "Nagoya University Library". Find the Purpose of this in the database, or presents a place where there is the book, or go to navigate to that location (Fig1).



Fig. 1 Actually used guide application example

Although this is also of a type to be installed on site and implementing as mobile applications, it has been an increasing number of the type that can be seen in the mobile terminal of the user himself. Thus, the user regardless of the current position of the own, it becomes available for the system on the move. In addition, from the feedback, such as a mobile information of the user obtained by the mobile terminal, a new guide features and, and the like can display the exact current position by the display of the map information, it has become to allow strengthening of existing functions. This guide the function, and the vicinity of-site map, for example, to perform a geographic information provided by displaying the content at the same time and, to display a list of content, by simply indexing their popularity is, the user there is such as to recommend the place to visit in [1].

However, they and the position and movement information of the user, are those provided from the feedback of the

questionnaire, etc., it is not considered "Emotion" when the user actually visited the content. Content is less out evaluation and, although are often evaluated as scores, because converting the feelings own number is not easy, is considered in the judgment in which takes time. Further, when a user feedback to determine them, it is necessary to enter information, would be sandwiched one cushion, leave the evaluation that the user feels at the time of visiting the content, falling the accuracy also it includes the possibility to put away.

In this study, the "Impression" felt when the user is visiting the content and estimated from fluctuation of the heart rate, it is proposed to map it on the map. This realizes be obtained user feedback without going through a questionnaire. Also, by visualizing it as an index for the content of other users considered can be a useful information.

Configuration of Page Layout

## 2. Materials and Methods

### 2.1 Feelings

- Emotion is expressed by the two techniques primarily as "classification approach" "Dimension approach". Classification approach, whereas the expression using a plurality of categories of minimum unit emotions, dimension approach, the emotion "emotional valence (valence)", direct dimension of the two values of "alertness (arousal)" It expressed using the system. Emotional valence is positive of the emotions, is a value that represents the negativity, comfort, discomfort, and it can be classified into either not even neutral, free - can be explained by the one-dimensional with a discomfort to both poles. For example, pleasant feelings Upon such as "joy", "happiness", "surprise", unpleasant feelings hits such as "sadness," "melancholy," "boring". Arousal indicates the degree of physical and cognitive arousal caused by emotion. This is a high arousal and low arousal, and it can be classified in awakening in the meantime, high-arousal - can be explained by the one-dimensional with a low arousal to both poles. Feelings of a high arousal Upon such as "excitement", "wake up", "awakening manner", feelings of low-arousal hits such as

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"relax", "sleepy", "inactive" [2]. The combination of these two dimensions, is to express the emotion, is the dimension approach.

- This study deals with emotion on the basis of this approach, looking for more information about primarily arousal.

## 2.2 Observation sensors of physiological signals

- How to obtain the physiological reaction of the user are discussed many methods are manifold. That is used in many studies, a sensor mounted on the body of the user, a method of obtaining a physiological signal. Thus, electroencephalogram (EEG), skin conductance, electrocardiogram, etc. eye movement, it is possible to observe the various signals. The shape of the sensor may vary, and those wrapped around a body part with a band-shaped, the electrode using a sticky pad, those pasted on the body, a video camera, and the like.
- With the development of technology, small of the device, cost reduction is progressing, but still, the restricted each having, there is a possibility that inhibits the user interaction. When using a physiological signal of a user, the restraint property causes some influence to the user, which may produce problems. In this study, when estimating the impression is, the user is not the same as ever, to be able to turn the content was considered important. Because discomfort caused by mounting the sensor, the effect would given to emotion, to those as small as possible.
- In this study, many users will utilize the everyday a "wristwatch", using a wearable device "Smart Watch", it was decided to perform the measurement of the heart rate.
- This, in addition to the clock, a terminal that also functions smart devices, such as arithmetic processing and communication, are installed many sensors. For example, such as an acceleration or a gyro sensor, and those using such as orientation and tilt of the terminal itself, heart rate sensor, such as sensor relative to that exerted from the outside, and the like to the terminal such as an optical sensor.
- The advantage of this device is, (1) in fact that it can be mounted in a sense that does not change with the watch is used in everyday life, (2) cost is small, have been released many off-the-shelf in that the share is growing, (3) a field that may be future developments, such as the performance improvement of sensors include that there is a future.

## 2.3 Estimation of emotion based on heart rate

- Heart rate is the number of times the heart beats within a certain period of time, usually the dynamic number of beats per minute (BPM, Beats Per Minute) is expressed as. When performing the emotion estimation is one of the easily obtained physiological signals, are already widely used in the emotion estimation. Smart Watch since those to be attached to the wrist, can be heart rate gain can not be obtained electrocardiogram. Electrocardiograph occurs when the repeated expansion and contraction trying to

circulate the heart blood to the whole body, is weak activities current. Therefore, in the mounting position of the wrist, it is not possible to measure it. Therefore, this time measurement of ECG is not performed, by using only the heart rate as the data at the time of emotion estimation.

- As do the feelings estimation using the heart rate, In a related study, combined with the heart rate when you are watching the video, and the facial expressions, should be from the video to highlight those to estimate the (attention to) place [3]. Intended to estimate the feeling of when you are watching the video [4], from a physiological signal obtained or developers in software development, to estimate the stress and comfort, or recommend the interruption of the task, the code of proposal. Things or perform [5], and the like. In [8], after presenting visual and auditory stimuli to the user, from the pattern of variation and heartbeat, it was carried out the classification of evoked emotion.
- Also Toyosawa et al. [6], from the user's heart rate when you are watching the video, the user can be estimated at the time that felt the impression is, have proposed a summary method of the video.
- In the present study, a technique the same techniques on the same paper, the estimation of impression of which will be described later.

## 2.4 Changing heart rate by stimulus.

- Toyosawa et al, as a method of generating a "impressive" digest video utilizes to estimate the time when I thought impressive from lowering of the heart rate. "The higher the degree of awakening by to watch a particular video section, reduces the heart rate of the viewer (HR), parasympathetic activity is activated." To A, it has already been presented to human stimulus when, resulting effect on the heart rate, it is because that is already clear that.
- "I feel and impressive, Which refers to the degree of awakening of the place, which is defined in the emotional motivational model is in a high state", that is, the heart rate continuously acquired, the detection of deterioration in the If it is, the user received awakening stimulation at that time, the user at that time felt impression is, to a performs estimation is this technique. Toyosawa et al., Has been selected and the lowering of heart beat, the parasympathetic nervous activity, Toyosawa using two indicators of increased HF is a high-frequency component of HRV, the video section, which I thought is impressive audience. Because Smart Watch cannot be obtained electrocardiogram data, it is impossible to observe the HRV from the time interval between heartbeats (RRI). Thus, not mention the increase in the HF component this time, as an index, the only decrease of HR, using the techniques on existing research, to observe the impression of the user.
- Within existing research papers, the result of adaptation rates that were obtained in the experiments, and was "adaptation rate comparable emotional classification

means using other psychophysiological index" , " heartbeat and heart rate variability RF even if the components were each used alone , if unrestrained data collection is possible to consider the merit , degree of practicality has said that high " .

### 3. System Implementation

Here, we describe a system that assumed in this study.

User is the Smart Watch is mounted on the arm to get the heart rate, when around the content of the event in the facility, you always get the heart rate. Acquired heart rate is sent as a message to the Android devices that are separately possession. Android terminal, to get the current position information, the time by using at the same time position information API of Android gets a message from the Smart Watch, continue to save in the terminal wearing heart rate and string. When you have finished around the content, to end the acquisition of heart rate, we estimate the time-point felt impression is, the mapping on the map. Shows a representation of the outline of the system is shown in Fig.2.

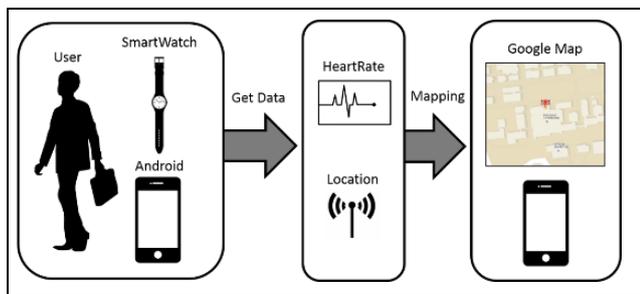


Fig. 2 System Overview

After the pre-processing on the obtained heart rate, detection is performed decrease. Corresponding to the detected point in time, the acquired position in the Android API, the mapping on the map. Mapping using the Google Android API, the mapping as a heart map. Pre-processing, detection of degradation, with respect to the mapping will be described later.

#### 3.1 Processing for estimating the impression of time

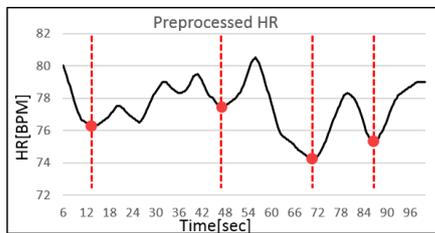
- Estimation of felt impression of time is greater, "the acquisition of heart rate," "pre-processing", processing in the three phases of the "detection of heart rate lowering" is made. The last time points of the heart rate sensed to have decreased by the "detection of the heart rate lowering", is estimated as the time a user feels impression of.
- I. Acquiring of heart rate
- Heart rate is measured by the heart rate sensor on the front panel display back surface in moto360 (Fig. 3).



Fig.3 Sensor mounted to moto360

- Measurement is carried out at a frequency of approximately 5 [Hz] in the shortest time interval of measurement can be set freely using the method.
  - This sensor is an optical type, it is necessary sensor is in close contact with the wrist portion thereof. Or empty little space, if you like or shaken vigorously arms, is not acquired successfully heart rate, or constant values may sometimes continue to be sent as a message. Because for this is a part that depends on the performance of the sensor of the hardware itself, there is no way to prevent in this terminal, walking heart rate measurement at the time had become a poor accuracy. This will be described later. Acquired heart rate is Smart Watch as a message is transmitted to the Android terminal that is paired set, transmission frequency of the time message is set to 1 [Hz]. This one is easy point should the data for each [sec] when performing the pretreatment Thereafter, also the greater the number of acquisitions of heart rate sensor, becomes many acquisition number, acquisition failure number of times also because it believed that many.
- II. Preprocessing
- Pretreatment is carried out in three stages. The first is the elimination of artifacts.
  - Here, the removal of outliers occurring when obtaining the heart rate. The contents are merely very simple, the difference between the value of the currently acquired, and the previous value, if it is  $\pm 50\%$  or more, to replace the intermediate value of the two values as a current obtained value.
  - Thus, the performs correction when the measured too large, a small value due malfunction of the sensor. The second is a linear interpolation by spline interpolation. Thus, the heart rate acquired by 1 [sec] intervals, are interpolated to 0.2 [sec] intervals. The third is a moving average filter, this filter is based on the value from the previous 6 [sec] up to now, to determine the current value. Smoothed by the filter is performed, there is no unevenness of the degree of fine waveform, a smooth curve. This facilitates detection of the decrease in heart rate. Time that this 6 [sec] is due to the fact pattern of heart rate reduction due to emotional valence described above, the variation in all it is time to approximately the end.
- III. Detecting a decrease in heart rate
- In the detection of the lowering of the heart rate, it makes a

determination of the unevenness of the waveform, peak detection, determination of the degree of subduction by the threshold. After acquired heart rate subjected to the above-mentioned pre-treatment, continue to check from the beginning of the data. Compared to the current value, to determine the next value is decreasing or increasing, it confirms the positive and negative slope. If there is positive if, looking for the peak of the convex, keep the value at that time. Then, the slope because that serves as a negative, go looking for the concave peak. In this case, concave peaks, while sinking heart rate, in the case were below a certain threshold from the peak of the convex, which is not to detect a decrease in the heart rate. Thus, it left be subjected to smoothing by the moving average filter, unnecessary to detect the shaking of the fine waveform. An example of detecting a decrease in the waveform shown in Figure 5. Is a value which is detected points on the broken line, the time period corresponding is estimated.



● Fig. 5 Detect a decrease from the heart rate waveform

### 3.2 Processing of mapping

- Mapping is performed using the Google Android API. After describing the process of displaying the Google Map, that superimposing the layout of the heat map on as an overlay.

## 4. Experiment

Evaluation experiments were performed in two. First, as the first one was carried out to confirm the accuracy of a stationary state. As two eyes, actually a situation where users around the content, virtually to prepare, get the heart rate, were mapping.

When the evaluation experiment for impression of induction, not must be considered, when the user around the content, is that either produce and to how the situation in which I think the "impressive" virtually. This time, using the "emotional arousal image", it was decided to perform the evoked arousal level of the user. Emotional arousal image, show the image to the number of users, felt emotional valence of pleasure - discomfort, arousal of high - have a low statistical evaluation [7].

This time, emotional arousal image was the use of those selected from GAPED dataset. GAPED dataset, in all 791 sheets, with six categories. In the experiment, when it is assumed strong stimulate wakefulness, after sorting the values of wakefulness all the images, using from what is best, the case of a weak, were used from the lowest ones. However, so as not to all categories are the same, were selected from multiple categories.

### 4.1 Experiment 1 : Confirmation of the accuracy of

#### stationary state

- First, the detection of heart rate drop in static state, performed using this system, and confirmed their accuracy. The participant, in order to get the heart rate on the arm, equipped with moto360 described above, other to have a K014. Participants five people, for 20-22-year-old students (all male), the experimenter by two things strong ones, weak evocation of arousal, was presented a total of four. Presentation is strong ones, weak ones, were conducted alternately. Image presented before, in order to calm the emotions, for 10 seconds, (not to show the image) give anything not the stimulus time provided, and then presented the image for 20 seconds. Further, since also see variations in heart rate after the presentation completion, nothing 10 seconds even after presentation provided time without stimulation.

### 4.2 Experiment 2: Confirmation of the mapping process at the time of root movement

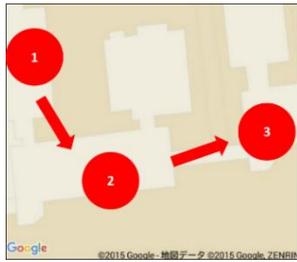
- Same as the present experiment also Experiment1, participant equipped with moto360 in the arm, the other to have a K014. It was induced stimulate arousal by using the emotional arousal image. Participants, three locations of the premises of the (Fig. 6, 1 ~ 3) to move on foot Toyohashi University of Technology, is presented an image from 20 seconds experimenter in each location. Participants by one person, twice the same route, at different times, were carried out a trial of the mapping using a different emotional arousal image (six from among those used in the Experiment1).

## 5. Experiment

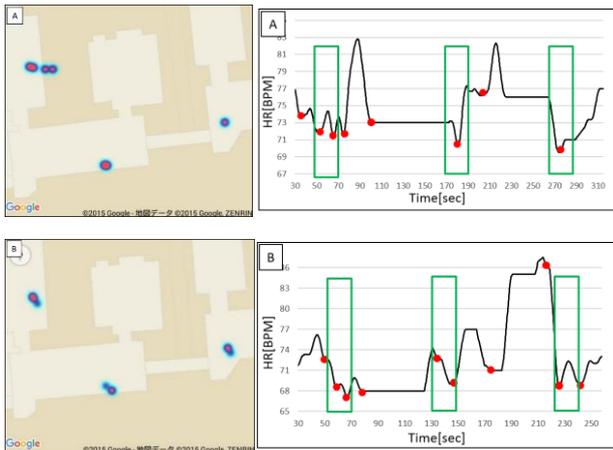
### 5.1 Experiment 1

- Shown here is the results of the Experiment 1 .
- When the TRUE-Positive has showed what a strong evocation of arousal , what was the detection of degradation in the image presentation time . When FALSE-Positive has showed what a strong evocation of the arousal level , there is a sense of decline in the outside of the image presentation time , or when the evocation of awakening level showed a weak , there is a sense of deterioration in the image presentation time those that have been . When the TRUE-Negative has showed what is weak evocation of arousal, those were not the detection of degradation in the image presentation time . When FALSE-Negative has showed what a strong evocation of arousal, those were not the detection of degradation in the image presentation time . In this case , adaptation rate is 42.9% , recall became 75.0 % . Positive-FALSE ( false positives ) was often seen with 40.0% .

5.2 Experiment 2



● Fig. 6 Root for the user to move



● Fig. 73 Mapping the result (left) and the corresponding heart rate of the waveform (right)

- (In waveform, round point where the heart rate lowering detection point, image presentation period in the rectangular frame)
- Mapping results showing the results of Experiment 2, shows the resulting map, the time acquired heart rate waveform in Figure 7. Result, it was confirmed that the mapping was performed in place and close that present the image.
- However, from the waveform, the existence of a place where it has been estimated that the "impressive" is also on a non-image presentation time (travel time, image preparation time, etc.) could be confirmed. During this time the experiment, because you did not perform the shooting of the experimental video, whether the subjects were looking at what, what kind of facial expression was that of one, there is no information like that. Therefore, the estimated point in time other than the image presented is, or saw something like actually feel something impression is, or is not without false positives to look for, was not able to confirm the fact.
- In addition there is also a long time constant value is followed by point, because the actual difficult this way stable that continue to think, think there is also a period of time have failed to measure the heart rate. This phenomenon since the often seen during movement, does not perform the detection of the decrease in heart rate while walking, it was confirmed that there may not be able to impression of estimation.

6. Experiment

In this study, using a mobile terminal, get the heart rate of the user, the user has performed the development of a system for mapping impression of you feel the association on the map and location information. Using less Smart Watch and Android terminal-binding property as a mobile terminal, get the position information and time information at the same time as the heart rate, an implementation of the process of saving in association string in the terminal.

Also, two cases at rest during root move using the system for the experiment, was estimated and mapping impression of.

In Experiment1, fit rate at rest is 42.9%, the false positive rate was confirmed that the 40 percent. In fact when thinking that the system is utilized, if the data from many users is obtained, by superimposing it is believed that it is possible to reduce the weight of the erroneous detection. Is a hypothetical, whereas think users impressive is the fixed location for a location of the content, the false detection would be performed is not fixed location. As the number of data increases, mapped more strongly about the content to give a really impression is, it should stand out from the false detection. Therefore, even if many erroneous detection as now the problem seems not. The system seems more sensitive to perform detection, it is necessary to not overlook point felt impressive.

In experiment2, prepared contents of virtually three places, asked to patrol the subject, it was confirmed that mapped to near position at each location. In addition, from the actual measured heart rate of the waveform, decrease in the walking time of measurement accuracy is hear about. However, from the fact that it is mapped to the close location to the content, museum and zoo, etc., as long as facilities such as stop the leg when viewing the content, to get the impression of the content in the current system, the mapping It seems to be carried out.

For information on how to mapping, a number of methods are considered. For example, a method of representation using the color as a heat map that is currently assumed, in its also using something symbol to the outside, and a method to display it there. We will also consider those more visually easily recognized, it is necessary to obtain actual evaluation of when the user uses.

In the future, in order to correspond to heart rate detection at the time of walking, consider the use of more reliable sensor device. In moto360 was used in this experiment, it has been released a new version that was considered for use in the sport at the time. If vigorous motion sensor on the assumption seems to do not more of accurate data can be obtained.

In [8], if you make the emotional identification from the heart only in five categories, accuracy is as much as 25%, albeit at chance level or more, that they are not high, also feelings estimates from the index of one-dimensional it is difficult, similarly with an accuracy improvement of by combining the electrical skin and brain waves have been proposed. this system is believed to be essential to combine multiple physiological signals.

In addition, sympathetic, parasympathetic, etc., also a combination of other indicators other than the heart rate by

performing an ECG measurement, to the improvement of the accuracy, the mapping of a variety of emotions and goals. Smart watch is that of a watch, and user information can be obtained from the sensors other than the heart rate sensor mounted on .smart watch is excellent point when you actually use, for example, outside of voice information, use the acceleration, etc. for even if can not, I want to consider.

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## Errata

**Title:** “Creating A User’s Impression Map Based on Heart Rate Data”

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- (1) Page 4, right column, line 30, Change “5. Experiment” to “5. Results”
- (2) Page 5, right column, line 1, Change “6. Experiment” to “6. Discussion & Conclusion”
- (3) Page 6, left column, “References”

I wrote some references in Japanese,by mistake.

Please see the following for the correct references.

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