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A Cloud System for Extraction of Autonomic Nervous System Indices and Blood Pressure Variabilities from Video Images

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ABSTRACT

To cope with the new life style of With-After COVID-19, we have developed a prototype of non-contact and remote health monitoring cloud system on the basis of video images shot by ordinary video cameras of clients' personal computers around the world in the Internet without installing any applications or programs.

1 INTRODUCTION

The corona crisis poses a threat to people's physical and mental health all over the world. In order to minimize the risk of infection, it is important to promote telemedicine.

In this study, we have developed a prototype of non-contact and remote health monitoring cloud system on the basis of video images shot by ordinary video cameras of clients' personal computers. In the cloud system, we can measure and accumulate health-related information such as blood circulation, autonomic nervous system indices, and relative blood pressure by simply uploading video images of the face or hands to the system through Web browsers without using any special sensors. As shown in Fig.1, our final goal is to develop a cloud system that has a loop circulating personal health records on a world map representing human circulatory sates to utilize for health monitoring all over the world.

This paper will introduce the functions of the system such as automatic multivariate analysis and describe the problems to be solved.

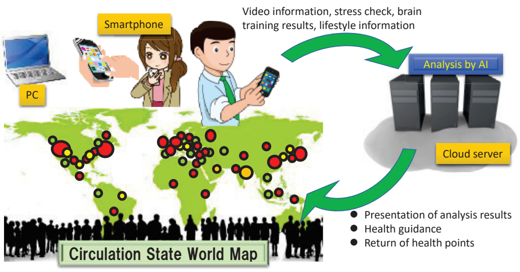

Fig. 1 Final goal of the cloud-type health monitoring.

2 METHODS

As shown in Fig.2, the system named "*The Mirror Magical*" performs in https://mirror-magical.net and was developed with Visual C++, OpenCV, php with javascript, and R-language for statistical analyses in Windows OS in a cloud server and consists of the following procedures.

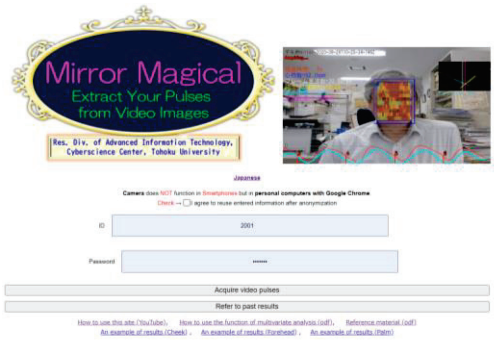

Fig. 2 Opening page of the cloud system (https://mirror-magical.net).

2.1 Upload of Video images from Clients' Cameras or Video Files through Browsers

In the system, a video image with time length less than 180s shot by a built-in camera or an externally connected Web camera of a computer or an already existing video file shot by another external video camera can be used through browsers connecting with the Internet. By using the Google Chrome browser, the video image is shot at the frame rate of 30 fps and at the size of 640×480 pixels or wider with the color gradation of 8 bits. The already existing video file must be non-compressed, compressed by lossless compression or the MJPG compression to extract a video plethysmogram (VPG), i.e. pulse wave. If the ambient light is dark, the frame rate may become too low to extract the VPG because the exposure time may become longer by the automatic exposure adjustment.

2.2 Automatic Detection and Stabilization of Region of Interest (ROI)

After uploading the video file to the cloud server, the Viola-Jones algorithm is used to detect the position of the face and eyes, and the Lucas-Kanade method is used to be stabilized against the movement of the face. The area of the cheek is automatically set as an area under the

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eyes to extract the corresponding VPG as shown in Fig.3c). If you want to extract the pulse wave from any place on the skin such as palm, the region of interest (ROI) is manually assigned with a mouse.

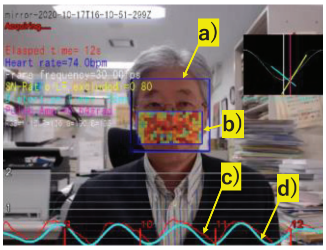

Fig.3 Detection and stabilization of the ROI. (https://mirror-magical.net/English/Demo.webm)

2.3 Extraction of VPGs and Mosaic Display of Blood Perfusion

Since hemoglobin in blood absorbs the green component of ambient light well, the VPGs can be extracted from the video images by averaging the intensity of the green component of each pixel over the skin area. Several techniques of signal processing are used to suppress noise included in the VPG signals caused by body movement or change in illuminance.

The signal is filtered with a band-pass filter with a pass-band of 0.5-2 Hz (cardiac frequency components), as shown in Fig.3d).

As shown in Fig. 3b), the mosaic images are displayed according to the corresponding intensity of the VPG signal of many small segments after the above same band-pass filtering.

2.4 Autonomic Nervous System Indices and Distortion Time

Foot-to-foot intervals (FFI [ms]) are determined based on the time point giving the local minimum of the VPG is to obtain the heart rate variability, and its frequency components are calculated to obtain autonomic nervous system indices such as $CVRR$ [%] of FFI , LF/HF , μ_{PA} and so on [1,2]. As the blood pressure-related index, distortion time (DT [ms]) defined as the difference between two negative peak time points of the raw wave and its fundamental wave is calculated [3]. In addition, the autonomic nervous age, Age [2] defined as

$$Age = 72.6 - 5.37 \cdot CVRR - 7.29\mu_{PA} \qquad (1)$$

2.5 Automatic Multivariate Analysis

The number of the above data is 22 in total. These data are accumulated for each ID number. Multivariate analyses such as multiple regression analysis, principal component analysis, and factor analysis are automatically performed on these data, using R-language: *rscript*.

3 RESULTS AND DISCUSSION

It took about 25s to upload, analyze, and download a 30s long data with the size of 46MB in our Wi-Fi environment of 50Mbps. The time consuming for upload and download is only a few seconds. It is no doubt that the speed of analysis will be shorten much more if the performance of the cloud server becomes higher.

A typical example of a summary of many analyzed results is shown in Fig.4 as a radar chart and a $CVRR$ - μ_{PA} plane. In this case, heart rate, mean value of pulsatile amplitude(PA [grad.]), its standard deviation, SN-ratio of the VPG signal, LF/HF , μ_{PA} , $CVRR$, DT , autonomic nervous age: Age are shown.

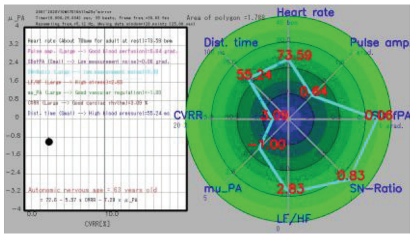

Fig. 4 Radar chart and CVRR- μ_{PA} plane display.

Figure 5 shows an example of results of multiple regression analysis, estimating moving averaged DT from HR, PA, LF/HF, $CVRR(FFI)$, $CVRR(PA)$, and μ_{PA} with the multiple correlation coefficient of 0.736. The other analyses, principal component analysis and factor analysis could work automatically as expected.

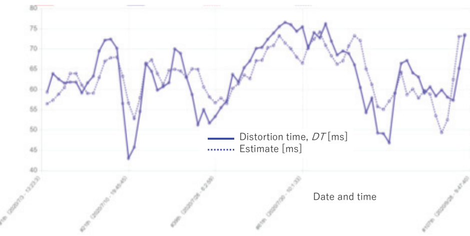

Fig. 5 Example of multivariate analysis.

4 CONCLUSIONS

We have developed a non-contact and remote health monitoring cloud system based on video images only accessing a Web browser for big-data analyses. In the case of almost all smartphones, however, the video images are automatically compressed at too high compression rete to reproduce the pulse waves. This problem will easily be solved by preinstalling some application to record low compression rate video image.

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