

# To Make a Flexible Patch Type Photoelectric Pulse Wave Sensor Highly Sensitivity

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## ABSTRACT

Recently, research about emotion estimation by using vital data was developed actively. In current type sensor, emotion estimation could be carried out slightly in motion-condition due to a gap between the skin and the device. A flexible patch type sensor could be acquired large amount of data even motion-condition.

## 1 INTRODUCTION

In modern Japan, it is social problem that the disorder of physical and mental condition caused by long working hours due to labor shortage with the declining birthrate and aging population. So Japanese companies promote "work style reform" and "Health and Productivity Management". Under these circumstances, NEC Corporation provide "Emotion Estimation Solution" which is the service of visualization monitoring labor condition in real-time.

Our company aim to solve social problem, for example 1) safety driving support by drowsiness detection for a driver in traffic and logistics industry 2) prevention mental disorder by digitization stress of nurse and carer 3) health management by production management (work time / quality) of manufacturing and factory worker.

Especially we focus on applied the solution for aging people. The case in hospital, it apply the people who can't express oneself well because of dementia etc. The case at home, it prevent a frail.

NEC provide the emotion estimation solution by using a commercial wrist-band type device.

This solution can categorize emotion based on circumplex model of Russell[1,2] by a measurement pulse wave, analysis heart rate variability and using original algorithm[3,4]. If we obtain the data from photoelectric pulse wave sensor in a wrist band type, there are two problem; 1) the contact with the wrist or arm is important for this device. If there is a gap between the skin and the device, the effective of the disturbance light. So when we move, it is difficult to gain the data, 2) an arm of elderly people is too thin to turn on commercial device.

In order to solve these problems, we develop the flexible patch type device and obtain the data of pulse wave. A patch type device miniaturize and use by flexible substrate, it is expected that increase the contact with the skin (Fig.1).

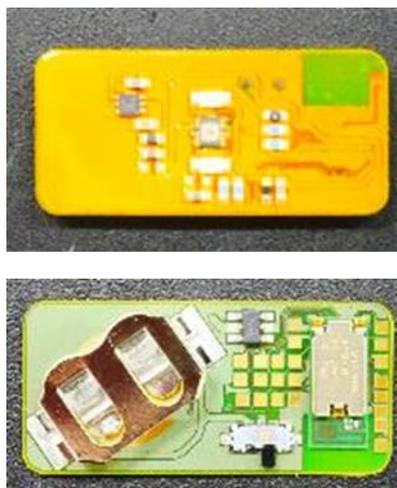


Fig. 1 Pulse measurement module

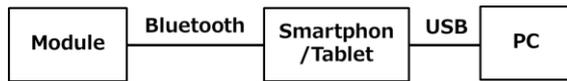
And it can put on anywhere in the body, we can choose a position which is hard to generate body motion noise.

We acquire the data from various parts of the body and compare the signal different wavelength in light source and photodiode. Finally, we aim to develop the device which optimize for photoelectric pulse wave measurement.

## 2 EXPERIMENT

So as to compare the data from the device between patch type and wrist-band type, we experimented two different condition, stationary-condition and motion-condition. Patch type device was put on left forefinger and wrist type devices were put on left wrist and right arm. First, we kept still for 20 minutes from the start of measurement. This is a data of stationary-condition. Second, in order to examine the effective of body motion, we went up and down the stairs started measurement at the same then walked for 20 minutes. This is a data of motion-condition.

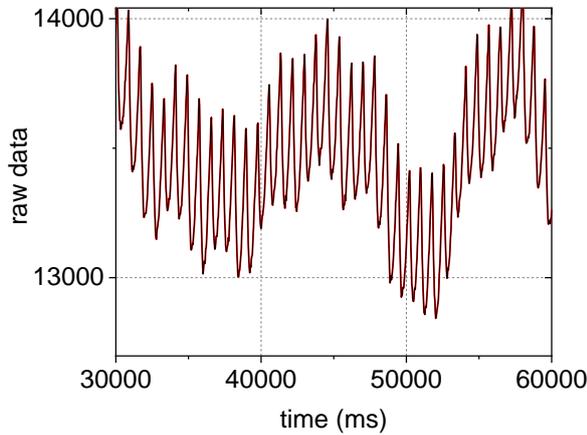
In patch type sensor, the data were sent to smartphone via Bluetooth and smartphone stored it. After that, the data were sent to PC via USB cable then emotion estimation started for raw data (Fig.2).



**Fig.2 System configuration**

### 3 RESULTS

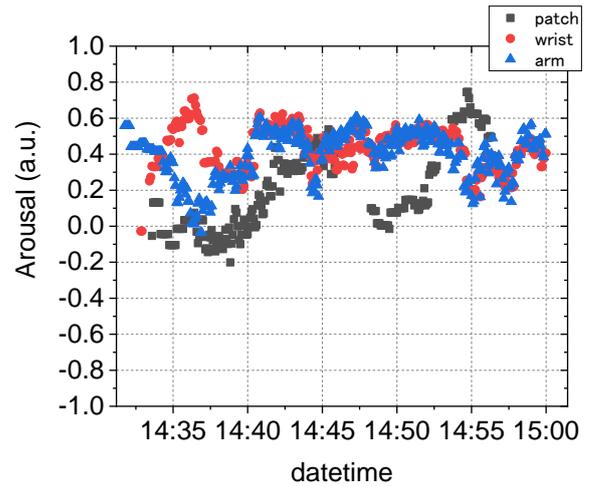
The result of pulse wave signal from patch type sensor in motion-condition shows Fig.3.



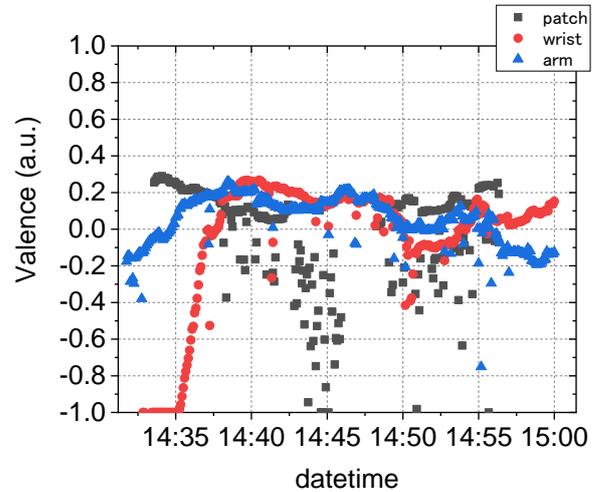
**Fig. 3 Raw data of pulse wave signal from patch type sensor in motion-condition**

However base line fluctuated because of body motion noise, pulse wave could be measured.

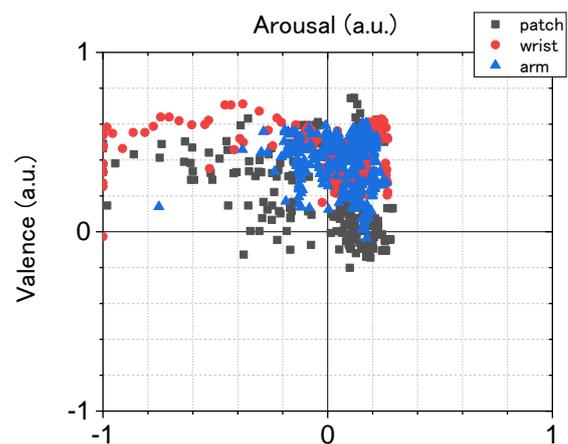
The result of emotion estimation, time change of "Arousal" and "Valence" which are the components of a Russell circumplex model show Fig.4 (arousal, stationary-condition), Fig.5 (valence, stationary-condition), Fig.7 (arousal, motion-condition), Fig.8 (valence, motion-condition). And emotion confirm Russell circumplex (Fig.6: stationary-condition, Fig.9: motion-condition). From results in stationary-condition, three data from patch and wrist band type sensors are almost the same. It means that these sensors are not difference in function. On the other hand, in motion-condition, emotion estimation could carried out with the patch type sensor at fingertip, but slightly with wrist band type in arm and almost no signal with wrist band type in wrist.



**Fig. 4 Time change of arousal in stationary-condition**



**Fig. 5 Time change of valence in stationary-condition**



**Fig.6 Valence-arousal dimensional model in stationary-condition**

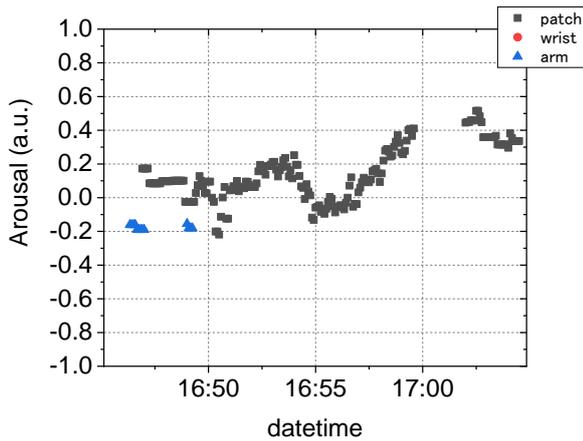


Fig. 7 Time change of arousal in motion-condition

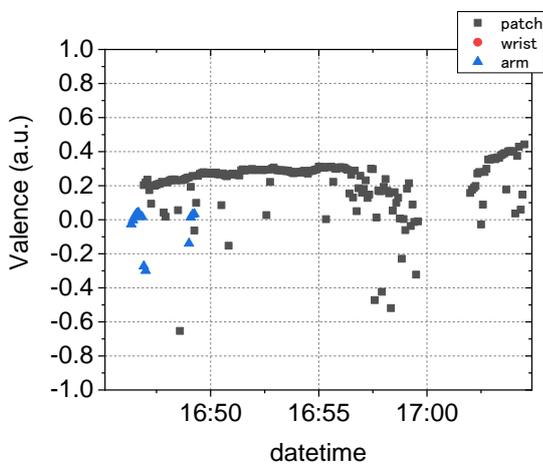


Fig. 8 Time change of valence in motion-condition

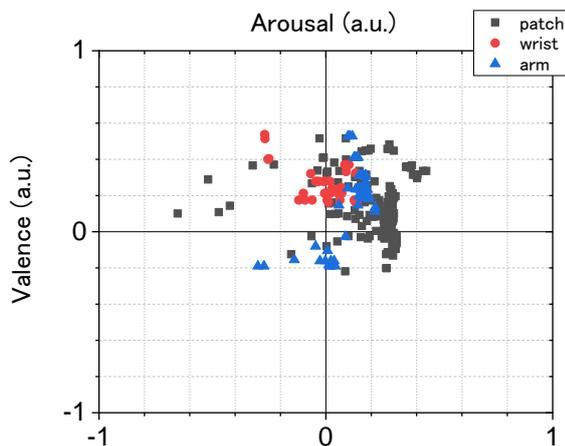


Fig.9 Valence-arousal dimensional model in motion-condition

#### 4 DISCUSSION

In stationary-condition, signal from patch type and wrist-band type are the same. This result means that the performance as photoelectric pulse wave sensor are the

equivalent in between patch-type and wrist-band type. On the other hand, in motion-condition, patch type could obtain the data but wrist-band type obtained only a little. In the case of the wristband-type, if it put on wrist, we could not obtain enough data for emotion estimation owing to disturbance light due to swinging of the arm during stairs up and down walking. If it was put on arm, the amount of data was larger than wrist. It is because that the influence of swinging of the arm is less than wrist. In contrast, patch-type sensor can be acquired continuously even if the influence of body motion. A patch type sensor can be pasted even in thin position like fingertip, so it adheres forefinger and is not much affected. From the above results, it is revealed that the suppression effect is very large against body motion noise in patch type sensor.

#### 5 CONCLUSIONS

From this experiment, patch type sensor could put on fingertip and it was acquired large amount of data even motion-condition. In addition to this result, we will discuss the data from various parts of the body and compare the signal different wavelength in light source and photodiode in detail.

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