Compact-Sizing of Optical Topography Technology (NIRS)

Kiyoshi Hasegawa
Hitachi Ltd. Business Incubation Division, Tokyo 101-8608 Japan
kiyoshi.hasegawa.yp@hitachi.com

ABSTRACT

There are several neuro-imaging methods, however, most of them need specialized facilities and high maintenance cost. Recently the need for measuring in the daily-life-like environment is increasing, and Hitachi succeeded to develop compact-sized Optical Topography (OT) units. Compact-sized units will realize the measurement in the various environment efficiently and economically .In this symposium, I will explain the basic technology of NIRS and potential future expansive usage.

1. Introduction

21st century is so called as neurotechnology era, while 20th century is called as physics era. Since the world faces globalization, there is an increasing need to know human itself better. In many case in the past, the way to know how people are feeling and thinking, are the subjective evaluation methods, such as questionnaire sheet or group interview. But recently many noticed that subjective evaluation methods have certain limitation, because it needs a verbal interpretation between the questioner and respondent. For knowing how people feels and think, there are some new solutions created, such as behavior measurements, brain function measurements, and etc.

In the past, in order to measure brain function, it is first necessary to prepare a specialized measuring room which needs a large initial investment as well as maintenance fee. Some measurement tools must fix the examinee's body tight.

What is highly required in the market is the tool measureable in the daily-life-like environment. Hitachi believe that OT technology would be one of the closest and best applicable solution, compared with other brain measurement tools.

2. Method

1) Background of development

OT Technology was developed by Hitachi's Central Research Lab. in 1995, and in 2001, the first medical grade product was introduced by Hitachi Medical Corporation.

Compact-sized product was developed and introduced from 2010, and there are several types of products available now.

2) Basic Principle of OT

OT technology is based on very weak near-infrared light around 800nm, and it can be used safely from neonates to seniors. Measurement system consists of the combination of irradiation sensor and detection sensor. The sensors are designed to be positioned at 3cm distance in square. The irradiated light from the surface of head skin goes inside of the brain and scatters, and a portion of light path, going up to 2 to 2.5cm depth and then come back to the surface of the head (Fig. 1).

The light around 800nm is known as a very good wavelength to measure human body, which goes through the skin, bone, and human tissue, but is absorbed by hemoglobin.

When a part of brain becomes active, it needs more oxygen and glucose. Oxygen is carried by hemoglobin, and when the brain activity becomes higher, the increase in hemoglobin also occurs. The brain activity refers as an increase or decrease of the returned light intensity. When the brain activity becomes higher, the increase in hemoglobin occurs and the decrease of returning light intensity occurs. On contrary, when the brain activity becomes lower, the decrease of hemoglobin occurs and the increase of returning light intensity occurs[1].

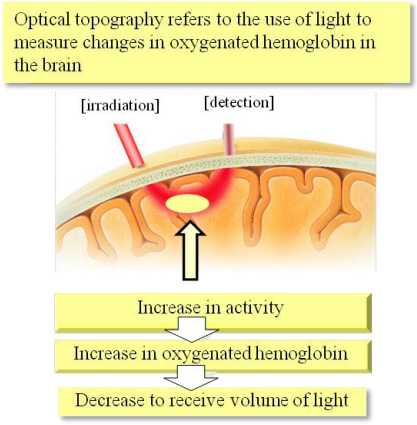

Fig.1 Mechanism of measurement

3) Comparison of measurement technologies

Compared with other measurement technologies, OT has certain merits to be usable in the daily-life-like environment. First, it can be designable as transportable and also wearable. Secondary, it is not affected by the outside radio noises, since the measurement is not electric wave, but near infrared light. The drawback of OT is that it is not possible to measure the deep portion of brain, but the surface of the brain (cerebral cortex part). And also spatial resolution is 3cm, which is wider than fMRI. Nevertheless OT is best fit to measure human's brain activity in cerebral cortex in the daily-life-like environment (Fig.2).

	Signal	Measurable in daily life like condition	Compact Sizing	Simultanous measurement	Realtime measurement	Easiness to wear
EEG	nerve	△	◎	◎	○	○
MEG	nerve	X	×	△	×	×
fMRI	Blood Volume Change(deoxy)	X	×	×	△	×
Optical Topography NIRS	Blood Volume Change	○	◎	◎	○	○

Fig. 2 Comparison of measurement technology

3. Development of Compact-Sized OT

Hitachi has developed 2 types of Compact-Sized OT, which are available commercially in research field. Those 2 models are specialized for forehead measurement.

1) Wearable Optical Topography (WOT series)

WOT's design target is that the unit should be measureable in the daily-life-like environment, so mobility is one of the most important design concept. It employs non-fiber optics ergonomic design, newly developed 2-wave-length built-in laser capsule, rechargeable built-in battery, and wireless LAN for non-cable connection to the host control computer. In addition, new probe design was adopted and soft touch style probe was realized (Fig. 3) [2].

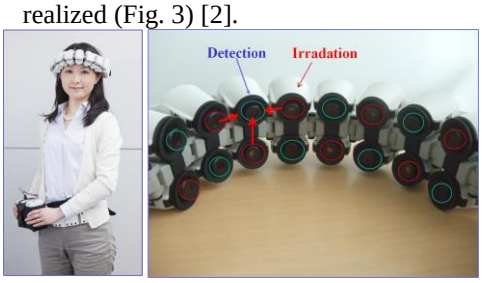

Fig. 3 Wearable form factor and new probe design

Since it employs wireless LAN, Wearable OT's another merit is to measure multiple persons simultaneously. Currently, up to 4 persons measurement becomes possible (Fig. 4), and it is effective to measure people's communications (Fig. 5), interactions, and mass data collection at one time[3].

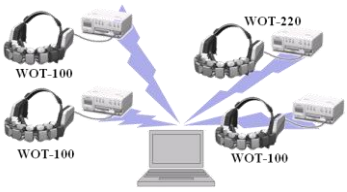

Fig. 4 Wireless System

Fig. 5 Scene of Communication measurement

2) 2 Channel NIRS(HOT121)

Furthermore, the smaller form factor HOT121 was developed to be able to wear headset by examinee itself and start measurement in the very short time. HOT121 measures 2 points of forehead, targeting working memory area (Fig. 6).

Fig. 6 Design of HOT121

Later than HOT121, by the joint research effort with Tohoku University and Hitachi, 1-channel Wireless Proto-Type System was developed (Fig.7). This Proto-Type System enabled up to 20 persons measurement simultaneously at one time.

Fig. 7 Proto-Type System of 1-channel

4. Concluding remarks

By Compact-sized OT hardware, the measurement scene will expand wider.

In the future, by the wireless communication technology, measurement scheme may lead to collect more data and do analysis in almost realtime (Fig. 8).

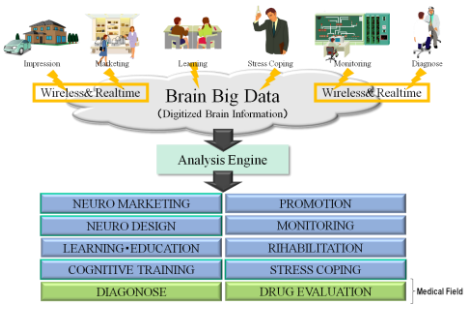

Fig. 8 Future Image

References

[1] A. Maki, Y. Yamashita, Y. Ito, E. Watanabe, Y. Mayanagi, H. Koizumi, *Med. Phys.*, Vol. 22(No. 12), pp. 1997-2005, 1995.

[2] Atsumori H, Kiguchi, M., Obata A, Sato H, Katura T, Funane T, Maki A, Rev Sci Instrum. 80, 043704 (2009).

[3] Kiguchi, M., Atsumori H, Fukasaku I, Kumagai Y, Funane T, Maki A, Kasai Y, Ninomiya A, Rev Sci Instrum. 83, 056101 (2012).