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## Development of Safety Device Utilizing Brain Machine Interface(BMI) for Educational Practice of Machine Tool

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### Abstract

National Institute of technology (N.I.T.) of Japan is consist of 55 colleges, and each college provides practical knowledge and skill about engineering to relatively young student who is from 15 years to 22 years old. Ariake college of N.I.T. to which authors belong, had ever experienced one serious incident of a students in machine-tool practice. As for this incident, a drop of the student's concentration by the accumulation his fatigue is regarded as a cause. In this case, if the concentration-drop of each student can be detected during machine-tool practice automatically, it will help to prevent occur of incident and keep safe environment of study in college. Lately Toy-based head-set type of a simple brain machine interface (B.M.I.) is developed and provided on the market with reasonable price. This interface can measure brain-waves, such as alpha, beta, and theta waves. Also application programing interface (A.P.I.) for Microsoft Windows is provided to produce original application programing. Thus the use of this simple B.M.I. is considered to realize active-safety system for student to practice machine-tool. The active safety system consists of the B.M.I. to sense brain-waves, a personal computer (P.C.) to analyze the detected brain wave and control machine-tool, an original-made interface to connect P.C. and machine-tool. The B.M.I. and P.C. are connected with Bluetooth, and the combination of them provide application, that is named as "algorithmic eSense", that can display a concentration or relaxation of subject with the score that is from 0 to 100. The P.C. monitors concentration of subject from B.M.I. output. If the level of the concentration goes under a preset level, the P.C. transfer the signal, such as emergency stop, to machine-tool through the originally developed P.C.-machine-tool interface. The developed active-safety system based on brain wave of subject is finally examined. In this experiment, subject is of 20 years old selected, his brain wave is analyzed with the system. The system distinguishes whether the subject concentrate on machine-tool practice with his brain wave, the system demonstrates emergency stop of machine-tool spindle when his concentration is below preset threshold. Those experimental results show that the developed active-safety system employing B.M.I. is effective and feasible.

**Keywords:** Brain Machine Interface, Education system, Safety, Brain-waves, Machine-tool

### 1. Introduction

National Institute of technology (N.I.T.) of Japan is consist of 55 colleges, and each college provides practical knowledge and skill about engineering to relatively young student who is from 15 years to 22 years old. Ariake college of N.I.T. to which authors belong, had ever experienced one serious incident of a students in machine-tool practice. As for this incident, a drop of the student's concentration by the accumulation his fatigue is regarded as a cause. In this case, if the concentration-drop of each student can be detected during machine-tool practice automatically, it will help to prevent occur of incident and keep safe environment of study in college. Objectively estimate human fatigue conditon, concentratiom degree not only an expression and response but but also blood pressure, heartbeat, breath and brainwave vital sign (body signal) such as will be necessary to arrest an always relative change. Toy-based head-set type of a simple brain machine interface (B.M.I.) is developed and provided on the market with reasonable price lately. SDK (Software Development Kit) is shown so that application to original game development is possible in this commercial interface. Therefore,

authors paid attention to commercial based simple brain-wave-measurement-headset and decided to develop the safety device. In this study, assuming a machine-tool practice in college or school or etc., emergency stop system which could stop a machine safely while monitoring concentration-drop of student.

### 2. Development of the security stop system using brain-wave

Fig.1 is illustration of the developed system to be utilized for an electroencephalograph surveying instrument in this study. The system employs commercial based electroencephalographic measurement interface ((Mindset) made by Neurosky) and a lathe as a machine-tool to be used in machine-tool practice, PC to analyze electroencephalographs with original programed application, and originally developed machine tool control interface, a machine tool. The system mechanism of emergency stop is that PC monitor the brain-wave value which is transferred from Mindset, emergency-stop works if the value gets over pre-programed threshold.

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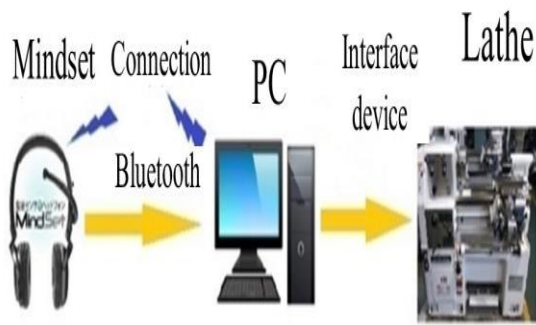


Fig.1 Illustration of the system

### 2.1 Simple brain machine interface

Mindset which is electroencephalographic measurement interface, as shown in Fig.2, is connected with a PC through wireless connection of Bluetooth. The head set has two ear pad and arm. The left ear pad and the arm are equipped with electrodes to measure voltage difference of surface of a face [1-2]. Mind set provide Application Programing Interface (API) to analyze concentration degree and relaxation degree of the subject. This can output each degree in the range of a reading of 0-100. In this study, the value of the concentration is utilized for emergency stop. The system works when the concentration degree is less than preset value before experiment.



Fig.2 Head-set to obtain brain-wave

### 2.2 Machine-tool-control-interface

In order to control the machine tool (lathe) by PC easily, machine-tool-control-interface using a microcomputer board has been developed. The interface is consist of microcomputer board, relay circuit, and circuit breaker to stop spindle motor. The installed interface shut down the power supply of the machine tool until concentration of a subject is recovered. In this study, a conventional lathe (TSL-550 made by TAKISAWA co. ltd) is selected for demonstration of the developed system. This product is used for the machine tool training in high school, college, university, and vocational training facility, etc. This lathe has electric wirings from a power supply to a spindle motor which is comprised of a main breaker

and three breakers, as shown in Fig. 3. The developed interface is installed between the main breaker and the spindle motor. The interface switches existing circuit and additional circuit with relay circuits, as shown in Fig.4.

At first, for a movement sequence of the whole system, concentration degree is calculated by the analyzing application of the PC after the electroencephalographic change is obtained from the headset and it is transmitted to PC. Emergency stop signal is sent to the developed interface, and spindle is stopped if concentration degree of the subject is judged less than the threshold level that this is set subject before his operation.

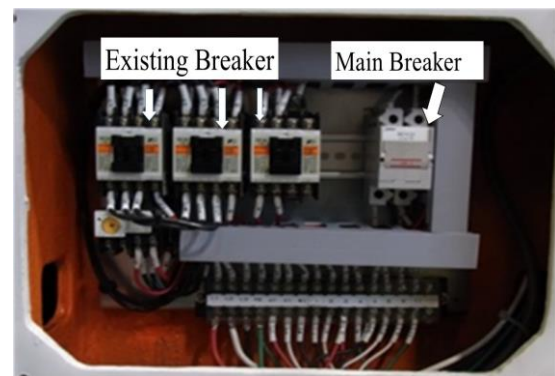


Fig.3 Power control unit of lathe

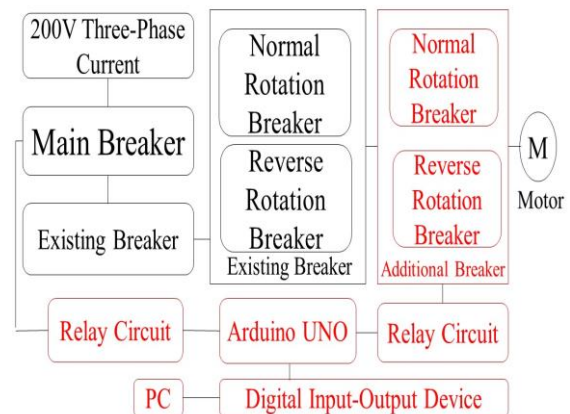
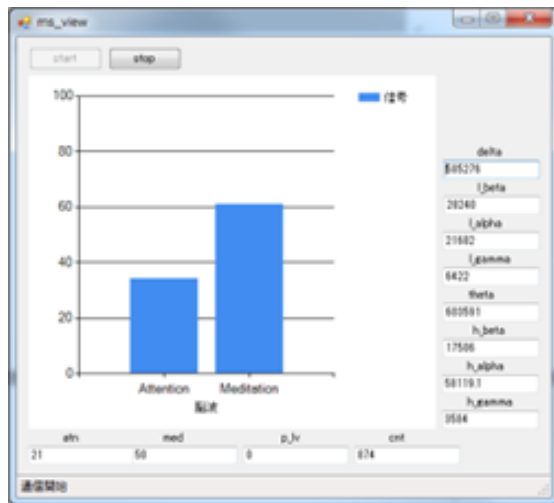


Fig.4 Illustration of system component

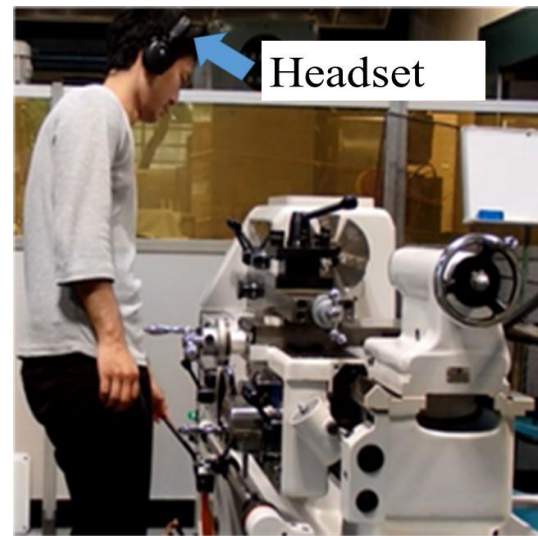
### 2.3 Brain-wave-measuring-application on PC

Fig.5 is a screen shot of developed PC application that display histogram of the calculated brain-wave value from Mindset. When concentration degrees that acquired from Mindset become less than the threshold, this application also outputs a signal to machine-tool-control-interface. After application is started, API that is called "eSense", collects the brain-wave information from Mindset, "eSense" calculates concentration degree and meditation degree which expresses relaxation of subject. The calculated degrees are displayed as histogram on monitor of the PC. This application is as fast to provide real time monitoring of brain wave. Therefore, emergency stop by monitoring brain-wave is realized by those software environments.

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**Fig.5 Concentration degree of subject on display**



**Fig.6 Photo of verification experiment**

### 3. Verification experiment of developed system

In order to verify whether the developed the emergency stop system works by means of monitoring brain-wave, student of age 20 is selected as a subject, and verification experiment is executed as shown in Fig.6.

Before the experiment, brain wave of the subject is measured when he is ordinal by using the developed system. Based on this measured data, the threshold level of his concentration degree is decided at 40. If his concentration degree goes under threshold level of 40 when he operates the lathe, the system understands that the subject lost his concentration, emergency stop mode must run.

At the beginning of experiment, his concentration degree is around 60. After couples of minutes, his concentration degree occasionally goes down. At last, his concentration degree becomes under 40, it is confirmed that the function of emergency stop of spindle runs immediately. This proved that the developed system can stop machine tool emergently by means of monitoring brain-wave.

Meanwhile further subjects are as follows,  
1) Commercial toy based brain-wave interface, "Mind set", use their original algorism to calculate concentration degree. Our developed system basically depends on the algorism. Therefore, further investigation is needed in whether the concentration degree which system detects is precise.  
2) The way for us to determine appropriate threshold level of subject that is programed for PC is also the further subject.  
3) Electro-magnetic compatibility(EMC). Generally, machine tool is used in factory where many machines work. Not to be affected by the outside noise is important for practical use.

### 4. Conclusion

In this study, assuming a machine-tool practice in college or school or etc., emergency stop system by means of monitoring brain-waves of student is developed. The system employs simple toy based Brain Machin Interface that is called "Mind set". Using provided API system of it and application program to monitor and distinguish brain-wave, and to control spindle of machine tool. Also in order to connect the developed system to machine tool, machine-tool control-interface which is consist of microcomputer and breaker circuit is developed. In order to verify whether the design concept of the system is accomplished, a student subject of age 20 is selected, verification experiment is carried out. The experiment demonstrates the developed emergency system work by means of monitoring brain-wave of subject, it is proved the developed system is feasible.

### 5. References

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