The Second ENRI International Workshop on ATM/CNS

Development of "cereameter"

--- Cerebral Resource and Activity Measurement Equipment ---

Kakuichi Shiomi (shiomi@enri.go.jp)
8 Channels Projection System

6 m Height

15 m φ Screen

8 m Octagonal Stage

Facility of Virtual Reality Simulation
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On 26 April 1994, China Airlines Flight 140 was crashed at Nagoya Airport. A human error attracted attention as a cause of the accident.

China Airlines Flight 140 was a route from Taipei, Taiwan to Nagoya, Japan. On April 26, 1994, the Airbus A300 on the route was due to land at Nagoya Airport. The Airbus A300 was completing a routine flight and approach, however just before landing, the First Officer pressed the Takeoff/Go-around button (also known as a TO/GA) which raises the throttle position to the same as take offs and go-arounds. Pilot Wang Lo-chi and copilot Chuang Meng-jung attempted to correct the situation by manually reducing the throttles and pushing the yoke downwards. The autopilot then acted against these inputs (as it is programmed to do when the TO/GA button is activated), causing the plane to have a very nose-high attitude. This nose-high attitude, combined with decreasing airspeed due to insufficient thrust, resulted in an aerodynamic stall of the aircraft. With insufficient altitude to recover from this condition, the subsequent crash killed 264 (15 crew and 249 passengers) of the 271 (15 crew and 256 passengers) people aboard. All passengers who survived the incident were seated at the starboard side of the aircraft in coach class. The crash which destroyed the aircraft (delivered less than 3 years earlier in 1991) was attributed to crew error for their failure to correct the controls as well as the airspeed. It is the second highest death toll of any incident involving an Airbus A300 anywhere in the world after Iran Air Flight 655. (from WIKIPEDIA)

In 1994, the author started to develop software to discriminate human voices from mechanical noises in order to extract pilots’ voices from recordings re-treived from aircraft cockpit voice recorders.
In 1998, the author and Mr. Shozo Hirose discovered that the time-averaged value of the first Lyapunov exponent calculated from a human voice signal changes according to the speaker’s psychosomatic condition.
The strange attractors are reconstructed in phase space according to Takens’ embedding theorem.
Figures 1 and 2 each show a “strange attractor” generated from a vocalized “o” sound. Each “strange attractor” is generated from the last 80ms of the vocalized “o” sound of call-out made by railway drivers immediately before departure, “Shu-ppatsu Shinkoooo!”
In 1998, the author and Mr. Shozo Hirose had found that the first Lyapunov exponent calculated from a human voice changed according to the speaker's increase of tiredness.
The time-averaged value of the first Lyapunov exponent calculated from a reading voice changed according to the speaker’s mental condition.
As seen in the right picture, the test subject wore a head-set, and his reading voice could be able to give as feedback. The author thought that the feedback voice would give some kind of stress to the test subject.
The average value of the first Lyapunov exponent (FLE) was increased from about 500 to 540. Increase of the FLE means that voice feedback gave stress to the test subject. Cerebral activity level of the test subject was changed to higher.
CRAY-MTA2 System (2002)

10,000kg-100kVA → 3kg-100W

CENTE Ver.8 (2010)
運転の疲労を声で測定

TODAY'S LIVE
Measurement (CFF: Critical Flicker Frequency, SSE: Subjective Symptom Examination, Uttered Voice Recording)

Measurement
Driving Exercise (1 sequence)

18:00 18:10 18:20 18:30 18:40 18:50 19:00 19:10 19:20 19:30 19:40 19:50 20:00

(CFF, SSE, Uttered Voice Recording + Repose Brain Wave, POMS, Lactic Acid Value in Blood)

Driving Exercise (1 set)
Short Rest

Driving Training

2nd / 3rd day

00:00 06:00 12:00 18:00 24:00

Driving Training

Learning Driving

00:00 06:00 12:00 18:00 24:00

Driving Exercise

Ergometer Exercise

00:00 06:00 12:00 18:00 24:00 06:00 12:00 18:00 24:00

Driving Exercises

Sleep

00:00 06:00 12:00 18:00 24:00

1st day

2nd day

3rd day

4th day

5th day
The Second ENRI International Workshop on ATM/CNS
Development of "cicreameter"
Change of CEM values calculated from call-out voice

Experimental Result in Hokkaido, Japan

Date & Time: July 2, '06

The driver must have been very sleepy.
Mental workload was provided by **simple mental arithmetic calculations:** two one or two-digit numbers were presented aurally, and the subjects were required to speak the sum of the numbers within five seconds, or before the presentation of the next pair of numbers.

Each single exercise required the subject to perform **60 calculations in 10 minutes.**
Before and after each exercise, a subject’s CFF value was measured, and he read aloud from a text to obtain a “Reading-CEM” value.
The subject also made “check mark” indications to record his subjective sleepiness level on a VAS-SL scale, and his subjective fatigue level was on a VAS-FL scale according to how sleepy and tired he felt as shown in this Figure.
### Development of "cereameter"

<table>
<thead>
<tr>
<th>Index</th>
<th>Workload</th>
<th>Light</th>
<th>Medium</th>
<th>Heavy</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Avege</td>
<td>StdDev.</td>
<td>Avege</td>
</tr>
<tr>
<td>Ratio of Wrong Answers (%)</td>
<td></td>
<td>0.7</td>
<td>1.0</td>
<td>3.3</td>
</tr>
<tr>
<td>Calling CEM</td>
<td></td>
<td>271.7</td>
<td>32.4</td>
<td>317.9</td>
</tr>
<tr>
<td>Heart Pulse Rate (pulses/min)</td>
<td></td>
<td>65.7</td>
<td>9.6</td>
<td>68.7</td>
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</table>

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</thead>
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<tr>
<td></td>
<td></td>
<td>Avege</td>
<td>StdDev.</td>
<td>Avege</td>
</tr>
<tr>
<td>CFF (Hz)</td>
<td></td>
<td>before</td>
<td>35.5</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after</td>
<td>34.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Reading CEM</td>
<td></td>
<td>before</td>
<td>414.0</td>
<td>19.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after</td>
<td>410.0</td>
<td>11.1</td>
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<tr>
<td>VAS of Fatigue Level</td>
<td></td>
<td>before</td>
<td>32.0</td>
<td>19.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after</td>
<td>34.0</td>
<td>13.4</td>
</tr>
<tr>
<td>VAS of Sleepiness Level</td>
<td></td>
<td>before</td>
<td>34.5</td>
<td>22.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after</td>
<td>55.1</td>
<td>14.3</td>
</tr>
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</table>
### Exercise Workload

<table>
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<th>Heavy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ratio of Wrong Answers (%)</strong></td>
<td>0.7</td>
<td>3.3</td>
<td>9.3</td>
</tr>
<tr>
<td><strong>Calling CEM</strong></td>
<td>271.7</td>
<td>317.9</td>
<td>329.3</td>
</tr>
<tr>
<td><strong>Heart Pulse Rate (pulses/min)</strong></td>
<td>65.7</td>
<td>68.7</td>
<td>77.3</td>
</tr>
</tbody>
</table>
The Figure shows the relationship between the Call-ing-CEM value and workload level of exercise (Relationship-A), and the relationship between HR and workload level of exercise (Relationship-B). The trend shown in Relationship-A is different from that of the Relationship-B. The Calling-CEM seems to show the state of the function of the neo cortex while the HR shows the state of the function of the autonomic nervous system.

Thank you for your attention!