A Study for Exploration of Relationships between Behaviors and Mental States of Learners for an Automatic Estimation System

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Agenda

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• 2. Experiment 1
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1. Introduction
1. Introduction

Current e-learning systems

Synchronous

Asynchronous
1. Introduction

Current e-learning systems

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<tr>
<th>Synchronous</th>
<th>Asynchronous</th>
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**Estimation System**

Automatically detects changes of learners’ mental states by observing their behaviors.
1. Introduction

Estimation systems to detect unusual behaviors

- **Using response time**
  - Cannot specify sources that cause unusual responses in problem solving processes

- **Based on interval time between operations**
  - Needs learning contents that embed particular materials, such as buttons to present hints

- **Based on behavioral data and interval time among input operations**
  - Needs a specific device

- **Based on velocities of mouse movements**
  - Needs models for behavioral detection
1. Introduction

Concept

Real Time Estimation
No Specific Operations
No Specific Devices
1. Introduction

Purpose of the current study

Examine relationships between behaviors and mental states of a learner in order to expand the detection model.
2. Experiment 1
2. Experiment 1

Purpose

To examine relationships between behaviors and mental states of a learner

Collected with experimental tools

Obtained from the learner’s protocol data
2. Experiment 1

Learning Contents

Answering a question with multiple choices

Mouse pointers tracks depend on representation of learning contents, such as textual sentences or figures [Horiguchi et al. 2008]

Reading English sentences (only textual sentences)
No scroll operation
No keyboard operation
Only mouse operation
2. Experiment 1

Behavioral Data of Learner

Estimation of learners’ impressions of problem difficulties based on terminal features and facial features
[Nakamura et al. 2007]
2. Experiment 1

Behavioral Data of Learner

**Mouse Data**

- Positions \{x, y\}
- States of a mouse button (on, off)

**Sampling-rate:** 60Hz

**Face Data**

- Positions \{x, y\}
- Inclination of face within \{\theta\}
- Distance between face and monitor \{w\}

**Sampling-rate:** 5〜7Hz

*Used OpenCV for the web camera image analysis*
2. Experiment 1

Mental State Data of Learner

Step. 1
- Problem solving with learning interface
- Think aloud

Step. 2
- Answering interview
- Retrospective report

Step. 3
- Making a sheet of mental change

I don’t know this word...
A? ... D? ...
I have no idea...
3. Experiment 1 Results & Discussions
3. Experiment 1 Results & Discussions

Experiment Information

1 Lerner 4 Trials*
(4 training trials)

* 1 of 4 was abandoned because the learner was exhausted
3. Experiment 1  Results & Discussions

Classifications of the Mental States

... 14 periods in 3 trials

Periods of impasses (get stacked)
3. Experiment 1 Results & Discussions

A Relationship between Speeds of Mouse Movements and Impasses

1. Speeds of mouse movements were slower in periods of impasses.
3. Experiment 1 Results & Discussions

Features of Mouse Tracking

2. Words or sentences the mouse pointed consistent with those the learner reported as sources of the impasses

In all 14 periods of impasses

"a centerfold for Popular Mechanics"

"Eleanor Lambert"

"concurrence of opinion of the fashion industry of the world"
3. Experiment 1  Results & Discussions

A Relationship between Hesitations and Face Movements

3. The learner’s face kept away from the monitor in periods of impasses
3. Experiment 1 Results & Discussions

Conclusions

1. Speeds of mouse movements were slow in periods of impasses.

2. Words or sentences the mouse pointed consistent with those the learner reported as sources of the impasses.

3. The learner’s face kept away from the monitor in the periods of impasses.
3. Experiment 1  Results & Discussions

Sampling Time for Computing Mouse Speeds

- 5.0 sec.
- 3.0 sec.
- 1.0 sec.
- 0.1 sec.

Most appropriate: 1.0 sec.
3. Experiment 1 Results & Discussions

Sampling Time for Computing of Speeds of Face Movements
(away from the monitor)

<table>
<thead>
<tr>
<th>Sampling Time</th>
<th>Speeds of Face Movements</th>
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</thead>
<tbody>
<tr>
<td>5.0 sec.</td>
<td>![Graph 5.0 sec.]</td>
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<tr>
<td>3.0 sec.</td>
<td>![Graph 3.0 sec.]</td>
</tr>
<tr>
<td>1.0 sec.</td>
<td>![Graph 1.0 sec.]</td>
</tr>
<tr>
<td>0.1 sec.</td>
<td>![Graph 0.1 sec.]</td>
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</tbody>
</table>

Most appropriate: 0.5〜1.0 sec.
3. Experiment 1 Results & Discussions

Features of Mouse Tracking & Face Movements

I don’t know this word...

Periods of impasses

about 5〜10 sec.

I don’t know this word... Is this correct?
3. Experiment 1  Results & Discussions

Automatic Estimation Model

Detecting Changes of Speeds of Mouse Movements
⇒ When the speeds are kept less than a threshold over five consecutive seconds

&

Detecting Changes of Speeds of Face Movements
⇒ When the speed is less than a threshold

Succeeded in detecting Periods of Impasses: 62% (9/14)
4. Experiment 2
4. Experiment 2

Difference Between Experiment 1 and 2

Experiment 1

Learner was asked: All mental states

Experiment 2

Learner was asked: When finding impasse (Level of an impasse)
4. Experiment 2

Definition of Level of an Impasse

<table>
<thead>
<tr>
<th>Level of an Impasse</th>
<th>Positive behaviors</th>
<th>Negative behaviors</th>
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<tbody>
<tr>
<td></td>
<td>- In problem solving -</td>
<td>- Not in problem solving -</td>
</tr>
<tr>
<td>Omission</td>
<td></td>
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<tr>
<td>Tiredness</td>
<td></td>
<td></td>
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<tr>
<td>Lapse in concentration</td>
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<tr>
<td>Break etc...</td>
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<tr>
<td>Usualness</td>
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<tr>
<td>Think</td>
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<tr>
<td>Impasse (Stall)</td>
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</table>
5. Experiment 2 Results & Discussions
5. Experiment 2  Results & Discussions

Experiment Information

1 Learner*  3 Trials
(2 Practices)

*Another learner
5. Experiment 2 Results & Discussions

Levels of an Impasse Distribution

- **Usualness**

- **Think**
  - 5 periods in 3 trials (Ave. 25 sec.)

- **Impasse (Stall)**
  - 3 periods in 2 trials (Ave. 93 sec.)
5. Experiment 2 Results & Discussions

Features of Speeds of Mouse Movements

Usualness

Impasse (Stall)

Period of impasse : 145 sec.
5. Experiment 2 Results & Discussions

Compare Experiment 1 with 2

"I don't know this word"

"I have no idea which is the correct answer"

Speeds of Mouse

Experiment 1

Experiment 2
5. Experiment 2 Results & Discussions

Compare Experiment 1 with 2

Behavior of comparison among choices
“A?...B?.....C?...”
5. Experiment 2 Results & Discussions

Features of Speeds of Mouse Movements

Can we find out periods of impasses from these patterns?

Behavior characteristic of comparison among choices
5. Experiment 2 Results & Discussions

Supplementation (Pattern of Negative action)

Concentrated in problem solving: Diversified

Lapse in concentration: Stationary
6. Conclusions
Conclusions

Purpose
Examined relationships between behaviors and mental states of a learner in order to expand the detection model.

Results
- Change speeds of mouse and face movements
  Detect Periods of Impasses: 62%
- Behavior characteristic of comparison among choices

Future
- Can we estimate period of impasse with these patterns?
6. Conclusions

Future Work

- Further experiments with a number of learners
- Establish estimation models
  - Method of detecting behavior characteristic
    - Using Bayes prediction
- Implement Build an Estimation System
  - Immediately gives learners feedback during problem solving