

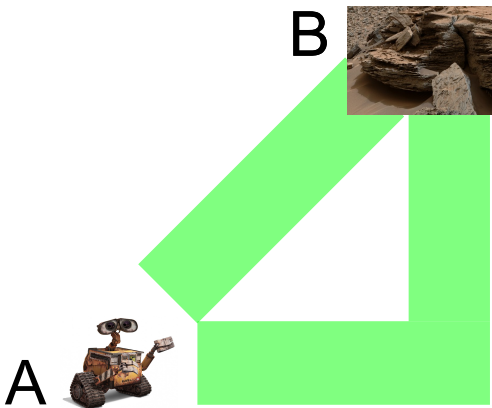
When the system knows that the human operator knows that something is going wrong

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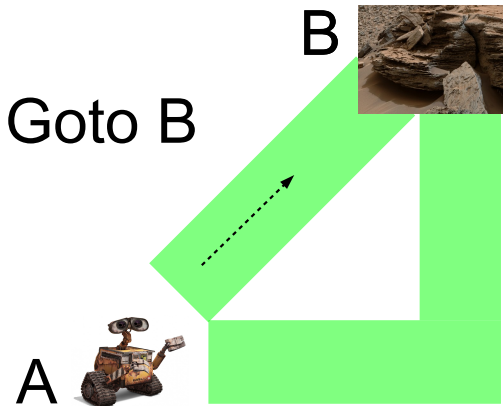
Why should something be going wrong?

Let's rock sample...



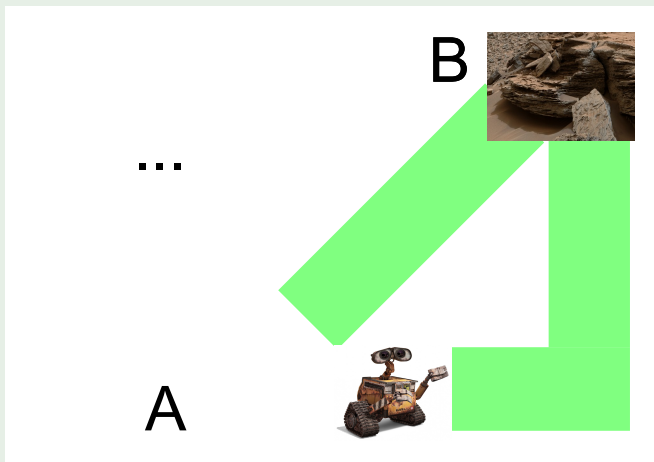
Why should something be going wrong?

Let's rock sample...



Why should something be going wrong?

Let's rock sample...



Why should something be going wrong?

Let's rock sample...

???

B



A



Why should something be going wrong?

Let's rock sample...

Ok...

A

B



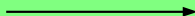
Why should something be going wrong?

Let's rock sample...

Or...

A

B

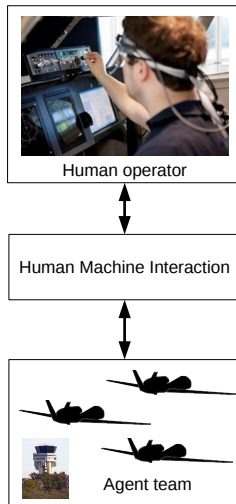


Context

- Pilots question the system's behavior [Wiener, 1989]
- "Automation surprises" [Sarter et al., 1997]
- Drone piloting task

Problem

- How to detect "automation surprise"?
- What counter-measures can be used?



1 Detecting that something is going wrong

- Detection
- Error-related EEG potentials
- Anomaly detection

2 Getting a confusion state

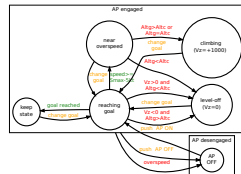
- Protocol description
- Feedback error
- Future architecture

3 Conclusion & future works

- 1 Detecting that something is going wrong
 - Detection
 - Error-related EEG potentials
 - Anomaly detection
- 2 Getting a confusion state
- 3 Conclusion & future works

Available data

■ Automation state



Available data

- Automation state
- Behavioral sensors



Available data

- Automation state
- Behavioral sensors
- **Neurophysiological sensors**



Available data

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EEG-related error potentials (ErrP) [Teeuw, 2010]

1 Response Error Potential



Bridgekeeper: What... is your favourite colour?
Galahad: Blue. No, yel...
Galahad: auuuuuuugh.

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EEG-related error potentials (ErrP) [Teeuw, 2010]

- 1 Response Error Potential
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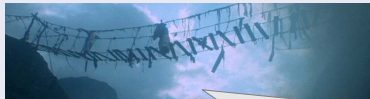
Available data

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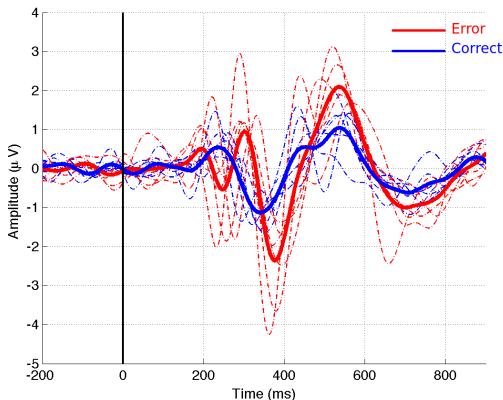


EEG-related error potentials (ErrP) [Teeuw, 2010]

- 1 Response Error Potential
- 2 Recognition Error Potential
- 3 Interaction Error Potential
- 4 Feedback Error Potential



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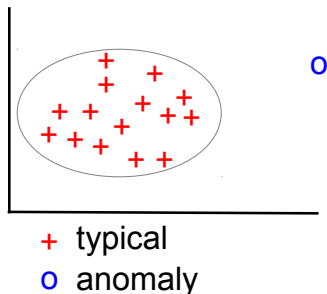
Error-related EEG potentials (ErrP) [Chavarriaga et al., 2015]

- [Buttfield et al. 2006, Ferrez et Millan 2005, 2008]
- Single Trial [Chavarriaga et al., 2015]

Detecting bugs: detecting outliers

Anomaly detection

- Review
[Chandola et. al. 2009, 2012]
- In aeronautics
[Budalakoti et. al. 2006, 2009]
- Space shuttle
[Sriastava et al., 2005]
[Martin et al., 2007]

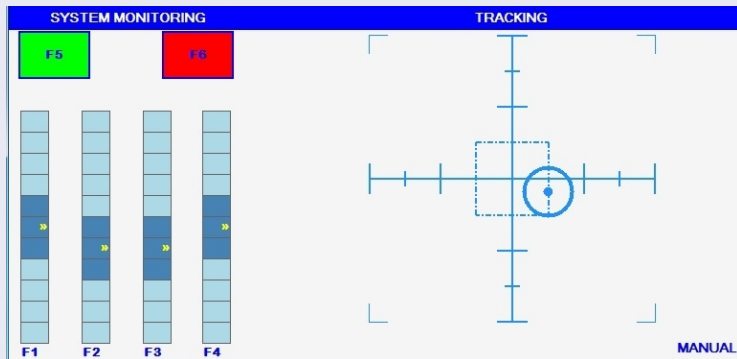


- Discrete sequences

- 1 Detecting that something is going wrong
- 2 Getting a confusion state
 - Protocol description
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- 3 Conclusion & future works

Protocol description

- MATB inspired [Comstock Jr and Arnegard, 1992]



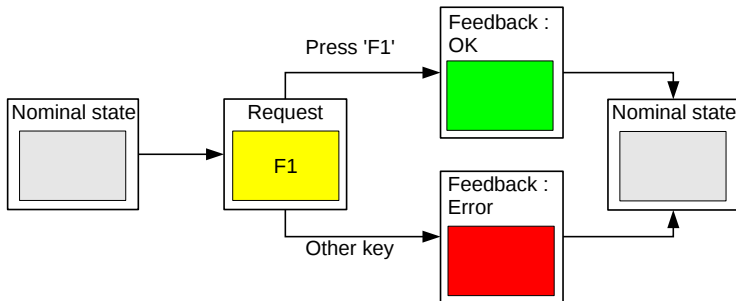
■ 1h30

■ 150 events

■ 10% of “bugs”

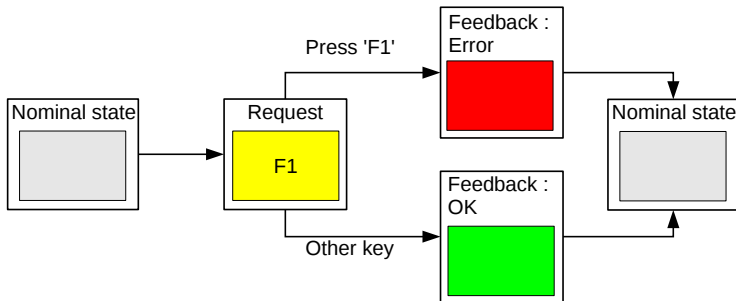
Warning lights “bug”

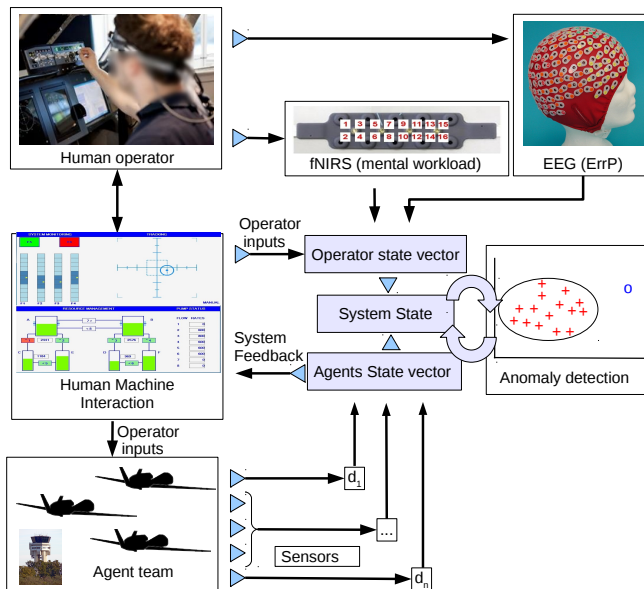
Standard behavior



Warning lights “bug”

Inconsistent behavior





- 1 Detecting that something is going wrong
- 2 Getting a confusion state
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Take home message

- System state
 - Automation state > artificial agents states
 - Operator's state > behavioral & neurophysiological sensors

Take home message

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Take home message

- System state
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- Detecting "automation surprise"
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Future works

- Run the protocol...
- Counter measures?
 - Which one?
 - Effect of the loop in the detection protocol?

Thank you for your attention. Any question ?



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