USAGE OF ATTENTION IN ADAPTATION OF INTELLIGENT SYSTEMS
A systematic literature review

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1. BACKGROUND

- Intelligent systems are increasingly prevalent in everyday life
- A lack of focus can impair performance
- Increased amount of research on this topic
  - A literature survey was chosen to analyse attention in adaptive systems

Attention:
"A state in which cognitive resources are focused on certain aspects of the environment rather than on others." [1]

An adaptive system:
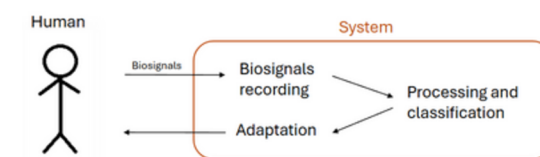
2. RESEARCH QUESTION

How do intelligent systems acquire and use information related to attention?

Split into smaller questions
1. What forms of information related to attention has been used for adaptation of intelligent systems?
2. For what objectives has this been used?
3. How has this been used, and are there trends or patterns?
4. In which domains?
5. Are there any overall patterns, and what challenges and trends exist?

3. METHODOLOGY

The steps required for a systematic literature review:

Report using PRISMA 2020 [2]
- Ensures reproducibility

Protocol:
1. Identify the core concepts from key themes
   a. Attention
   b. Adaptive systems
   c. User
2. Related terms were collected
3. Group terms together to create a query, and apply intersection to the databases
   a. Scopus
   b. IEEE Xplore
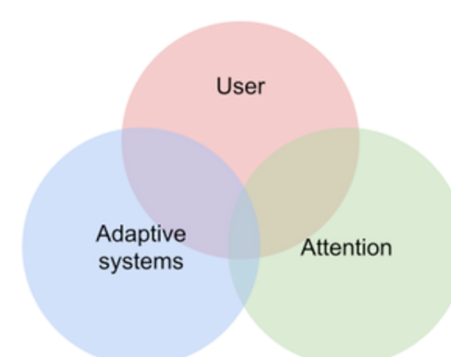   c. Web of Science

Exclusion critera:
- Not in English
- Surveys and reviews
- Not about human attention
- Not an adaptive computer system

Screening:
1. Remove duplications
2. Assess titles and abstracts
3. Document retrieval
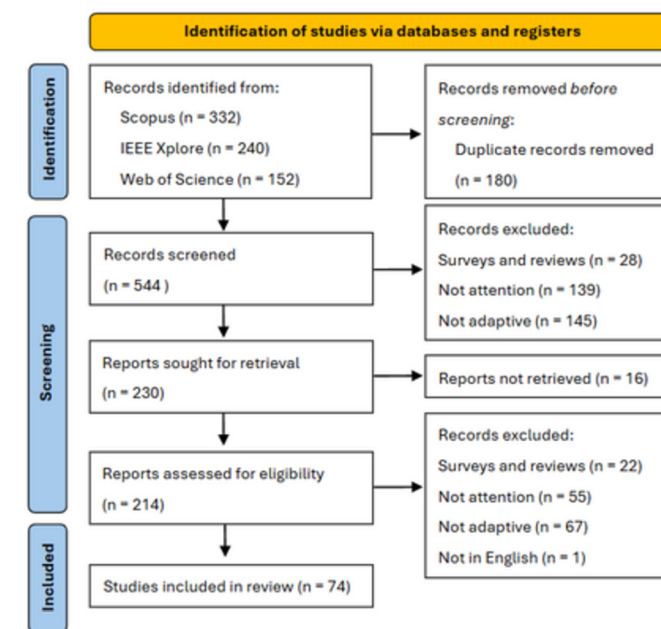4. Full-text assessment

Data extraction:
Information related to each research questions was documented per paper.

4. RESULTS

Search results
Started with 724 papers
Included 74 papers in the survey

Information used
Common sensor input:
- Eye-gaze
- BCI

Common models:
- Attention
- Workload
- Mental state

Objectives
- Support and guidance
- Performance improvement
- Workload reduction

Adaptations
- User interface
- Feedback timing
- Automation level
- Difficulty adjustments
- Behavioral feedback

Domains
Common domains:
- Education
- Accessibility
- Safe driving
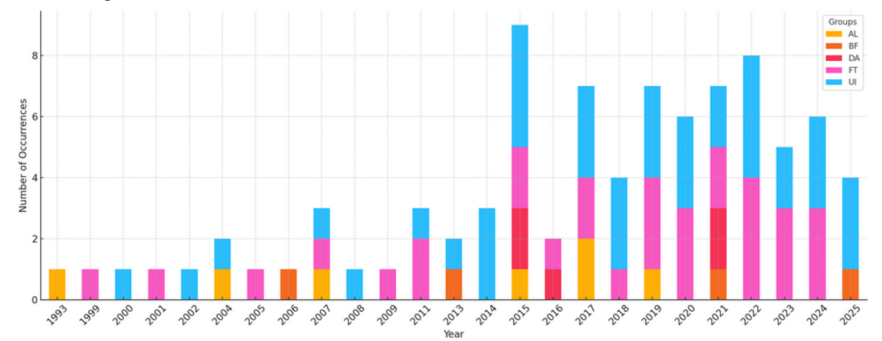
Trends and patterns
Recent development:
- Some development in eye-gaze tracking
  - 1993: Data volume issues [4]
  - 2011: Accuracy issues [5]
  - 2025: No issues reported [6]
- Little development with BCI
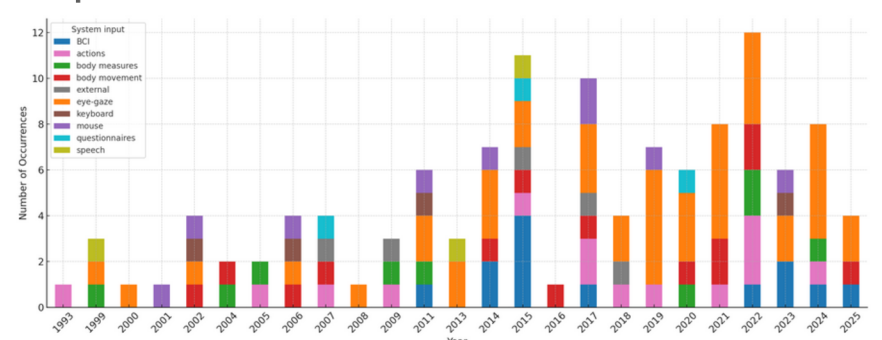 - 2014: EEG usage [7]
  - 2025: EEG usage [8]

Long term challenges:
- Not addressed in the studies

Adaptations over time

Inputs over time

5. DISCUSSIONS

Problems with BCI usage compared to eye-gaze
- Is it less compatible with adaptive systems?
  - EEG is highly sensitive to movement
- Is the access to BCI equipment limited?
  - Recently more consumer-friendly
  - But is it accessible?

Infrequent use of adaptive difficulty adjustment
- 17 papers within the education domain
- Only 4 papers use difficulty adjustment

- Is it more complex?
- Does it improve learning outcomes?
  - Compared to feedback and hints

Wide range of application domains
Education and safe driving has clear connections to attention.

But what about accessibility?
- Provides alternatives to keyboard and mouse
  - Virtual keyboards
  - Turn gaze into mouse and keyboard inputs

6. CONCLUSION

There was a **large variety** in:
- Sensor input
- Modeling
- Objectives
- Domain

Adaptation strategies were summarized by:
- UI change
- Feedback timing
- Automation level
- Difficulty adjustment
- Behavioral feedback.

+ Combinations of categories

UI changes and feedback timing ➡ the most popular
- Especially from 2015

Difficulty adjustments ➡ rarely utilized

Challenges described ➡ focus on short term improvements, not of long term issues

Future work:
- Which strategies achieved intended outcome?

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[2] T. Schultz and A. Maedche, "Biosignals meet AdaptiveSystems", SN Appl. Sci., vol. 5, no. 9, pp. 1–12, Sep. 2023
[3] C. Sohrabi et al., "PRISMA 2020 statement: What's new andthe importance of reporting guidelines", International Journal ofSurgery, vol. 88, p. 105918, Apr. 2021
[4] F. Arai, T. Fukuda, Y. Yamamoto, T. Naito, and T. Matsui, "Interactive adaptive interface using recursive fuzzy reasoning", pp. 104–110, Sept. 1993.
[5] O. Komogortsev, C. Holland, and J. Camou, "Adaptive eye-gaze-guided interfaces: De sign & performance evaluation," pp. 1255–1260, 2011.
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[8] F. Chiossi, C. Ou, C. Gerhardt, F. Putze, and S. Mayer, "Designing and Evaluating an Adaptive Virtual Reality System using EEG Frequencies to Balance Internal and Ex ternal Attention States," International Journal of Human Computer Studies, vol. 196, 2025.