A Computational Model of Task Selection During Human-Automation Interaction

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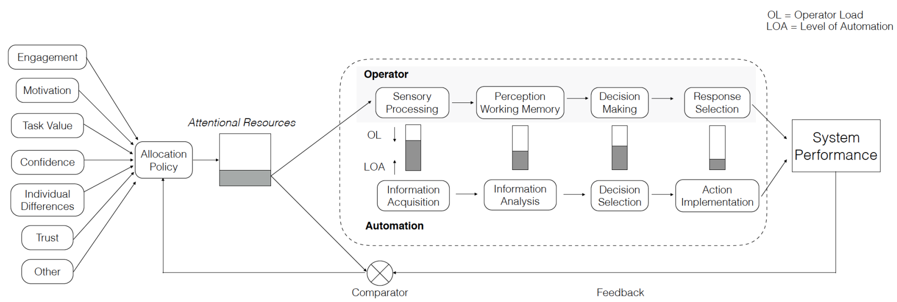
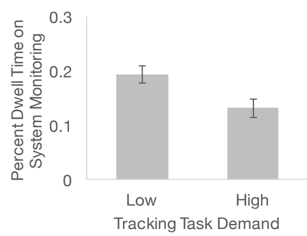
Attention Model of HAI

- Modern automation technology allows operators to perform cognitive tasks with reduced workload.
- Operators may misuse when automation is highly reliable or disuse when unreliable, and may not resume manual control when automation breaks down (Endsley & Kiris, 1995).
- Our attention-based model of human-automation interaction (HAI) accounts such suboptimal automation use in terms of poor allocation of attentional resources for both monitoring automation and additional secondary tasks.



Example: Effects of primary task demand on allocation of attention and trust toward imperfect automated system (Karpinsky, Chancey, & Yamani, 2016)

- Subjects performed a tracking task with a joystick (primary task) while monitoring system breakdown (secondary task) with assistance of imperfect automation .
- Percent dwell time on the system monitoring display was lower and their subjective trust was rated lower when the primary task required more manual correction.



Goal

- Wickens (2002) proposed a computational model of multitasking in applied environments, allowing task designers to predict operators' task interference between paired tasks.
- The present work aims to modify Wickens' model to reflect 1) alleviation of task demand by automation and 2) reallocation of attentional resources freed by the automation to another concurrent task.

Computational Model

- The model multiplicatively combines attention resource demand for each pair of tasks and a conflict matrix representing humans' multitasking capabilities.

$$\text{Conflict value} = \sum_{i=1}^{n}\sum_{j=1}^{n}(d_i d_j)\mathbf{C}_{ij}$$

d_i : resource demand vector for task i
C : conflict matrix

Example: Secondary task selection during level-2 vs. level-3 automated driving (Llaneras et al. 2013)

- Drivers voluntarily engaged in various in-vehicle secondary tasks
- Adaptive Crouse Control (ACC; Level-2 automation) vs. Limited Ability Autonomous Driving Systems (LAADS; Level-3 automation)
- Measured proportions of drivers who engaged in in-vehicle tasks such as "listening to music" and "Texting/ E-mailing"

1. Attention demands and LOA are rated for each of Sensory processing, Perception/WM, Cognition, and Response.

S P C R

$$d_{driving} = \begin{bmatrix}3 & 4 & 4 & 3\end{bmatrix}$$
$$A_{ACC} = \begin{bmatrix}2 & 2 & 2 & 2\end{bmatrix}$$
$$A_{LAADS} = \begin{bmatrix}2 & 3 & 4 & 3\end{bmatrix}$$
$$d_{texting} = \begin{bmatrix}3 & 4 & 2 & 4\end{bmatrix}$$
$$d_{music} = \begin{bmatrix}1 & 1 & 0 & 0\end{bmatrix}$$

2. The demands alleviated by automation are subtracted from the original task demand.

$$d_{driving,ACC} = \begin{bmatrix}1 & 2 & 2 & 1\end{bmatrix}$$
$$d_{driving,LAADS} = \begin{bmatrix}1 & 1 & 0 & 0\end{bmatrix}$$

3. Using a conflict matrix below, conflict values are computed.

PC R

$$C = \begin{bmatrix}0.8 & 0.3 \\ 0.3 & 1\end{bmatrix}$$

The model outputs:

- For "listening to music", conflict values with the assisted driving task were 8.6 (ACC) and 3.2 (LAADS), resulting in the saving of 5.4.
- For "texting", conflict values were 48.7 (ACC) and 16.8 (LAADS), producing the saving of 31.9.

Conclusion

- The model accounts for impact of resources freed by automation and predicts selection of a secondary task during human-automation interaction.
- The automation-adjusted conflict values can be used to predict users' task selection.