Visualization Tools for PHM:
Metrics of Effective HMI

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Requisite Disclaimer

Commercial equipment and materials are identified in order to adequately specify certain procedures. In no case does such identification imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Image source: Baltimore Sun

State-of-the-Art in HMI: Robotics

Image source:

Image source: Sta

Image source:

Image source: Rethink Robotics

Degrees of Interface Separation

- Process interface: Easy-access buttons and lights
  - Start, stop, pause functions
  - Move up/down, left/right
  - Light towers for quick status updates
- Auxiliary interface: PLC
  - Limited robot status via DIO (safety system status, enable state, program state, etc.)
- Principal interface: Teach pendant
  - Robot position (joint & Cartesian), forces and torques, etc.
  - Program position
  - Error codes
  - Maintenance cycles (backup battery, mastery, etc.)
- Workcell level: PLC
  - Coordinate multiple PLCs/controllers
  - Provision of workcell safety
- Factory floor level: Fleet management software
  - Coordinate flow of parts/materials to different workcells
  - Monitor line status and dispatch maintenance
  - Monitor and manage resources

Image source: Babylonbee.com

Image source: KUKA

Image source: Siemens

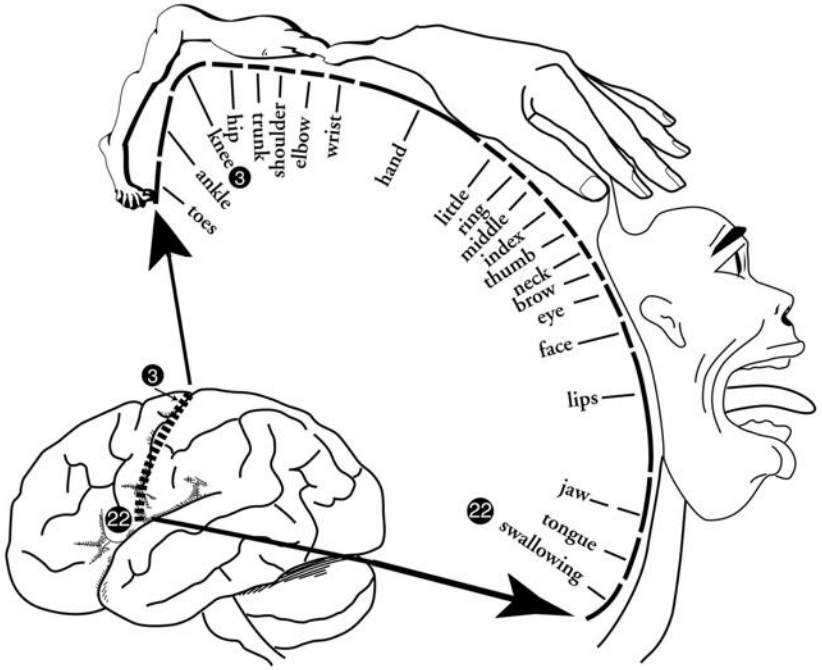
Interfaces Dictate Interaction

- Purpose of interface:
  - Information presentation
  - System/process control
- Consumer goods are human-centric
  - Ease of use and intuition
  - Clear and contextual feedback in real-time
  - Reduction of user strain
- Cost reduction, not operator's needs, drive industry HMI designs*
- Generational differences result
  - Younger generations put off by antiquated interfaces

* - B. Shneiderman. Designing the User Interface: Strategiest for Effective Human-Computer Interaction. 1998.

Physiological Bases

- Fitts' Law
  - Time required to move one's hand to a target location
- Goal-oriented thought cycle:
  - Form a goal
  - Choose and execute actions to make progress
  - Assess impacts of selected actions
  - Repeat previous two steps until goal achieved
- Change blindness
- Inattentional blindness
- Gestalt theory of perception
  - Association of objects clustered/moving together
  - People draw conclusions in absence of structure and fill in gaps
  - Poor management of information leads to information disassociation
- Uncertainty principal
  - Decision time increases as a function of the uncertainty of decision, or the number of alternative answers



Metrics

- Software quality
  - ISO/IEC 25010:2011
    - Quality in use – evaluate impacts and outcomes resulting from the use of the system
    - Product quality – characterize system by its properties
- Interface
  - ISO 9241-210:2010 (Human-centered design for interactive systems)
    - User-based testing
    - Inspection-based evaluation
  - Impacts of use:
    - Learning time, expert use time, error cost, functionality
  - Information quality
    - Response to presented information correct?
    - Time lapsed between presentation and response
  - Power Law of Practice
    - Time to perform tasks decreases as a function of repeated use
  - Clarity and conciseness of message
- User response
  - Mental effort (impact of time, stress, team diversity)

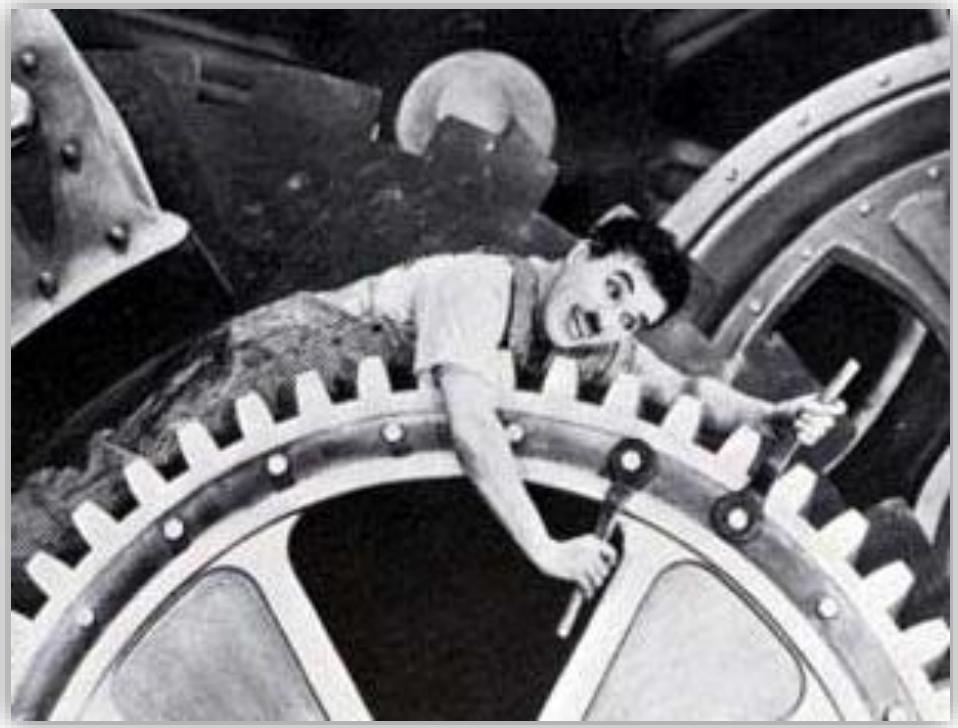


Image source: United Artists

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