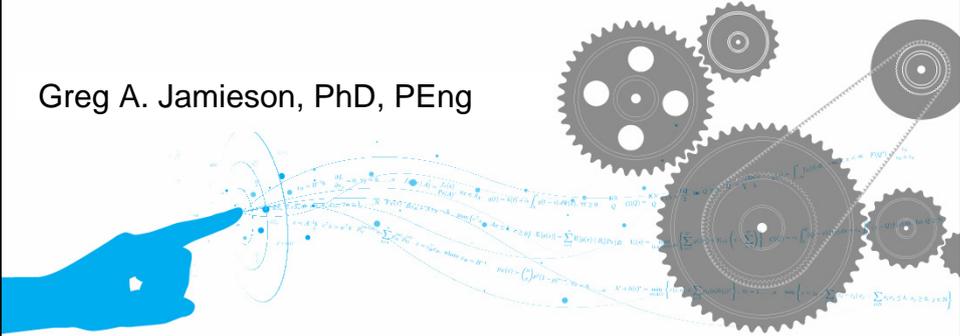Cognitive Engineering Laboratory

New Concepts for Human Interaction with Process Automation

Greg A. Jamieson, PhD, PEng

Design inspired by 2010 contest winner **Heyse Li** (MIE 1T0 + PEY)

Mechanical & Industrial Engineering
UNIVERSITY OF TORONTO

FACULTY
OF APPLIED
SCIENCE &
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ABB 2014 Research Grant Program

- Topic 7: The future of control rooms in times of pervasive mobile devices
  - How does the concept of a plant control room develop if all workers have a mobile device in use?
  - What types of mobile solutions support the workers' communication and interaction in different settings?
  - How can a mobile device be used by field workers to collect contextual information?
  - How can information be shared between workers?
  - How can information be used for maintenance?

CEL Proposal

- Consolidating Operations and Maintenance through Mobile Devices and Ubiquitous Service
- Vision: Flexible Operations and Management teams (flex-O&M)
  - Role consolidation
  - Truth maintenance
 - Service at the point of work

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Technology and Place Vision

- Existing and near future technology
  - Mobile phones, tablets
  - Google Glass, wearable?
- Suite of control areas
  - real and virtual,
  - local and remote,
  - central and distributed,
  - individual and collaborative.

Work Process Vision

- Inspired by Toyota Production System
  - ◆ Genchi Genbutsu: The act of diagnosing and solving problems by visiting…
  - ◆ Gemba: the actual place where work is done…
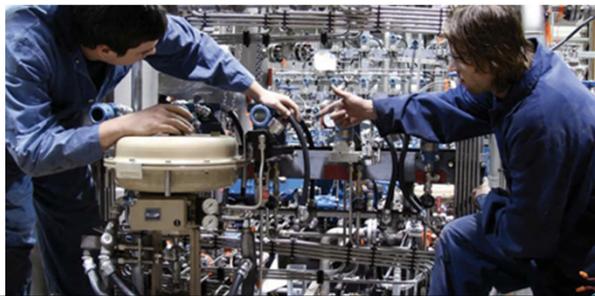 - ◆ to observe, understand, and develop more effective solutions.
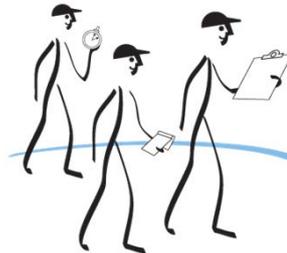
Maintenance Agent Case Study

Paper-based Work Support

- Inefficient data collection and transfer
- Error-prone, not auditable
- Replication of tasks and incident reports
- Fails to exploit the worker's capabilities

Technology Opportunities

- Near Field Communication
- Image processing library
- Accelerometer

Fig 7: NFC Screen – Wrong Equipment Scanned

Fig 8: Equipment Details

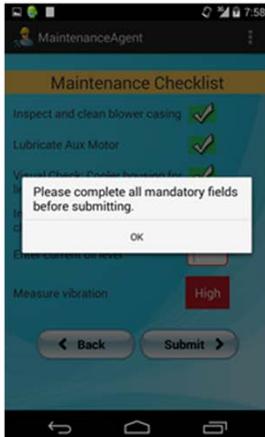Fig 9: Maintenance History

Fig 10: Repair History

Fig 11: Maintenance Checklist

Fig 12: Maintenance Checklist – Data Validation

Vibration Measurement
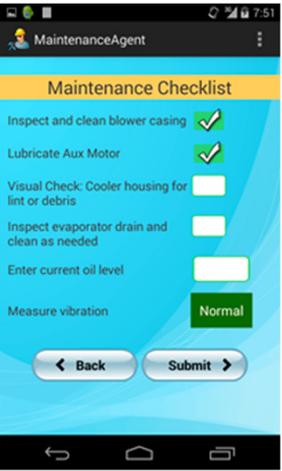

Fig 13: Vibration Measurement
Instruction

Fig 14: Vibration Measurement
Countdown

Fig 15: Vibration Measurement
Result - Normal

Image Library Search

Fig 16: Object Identification –
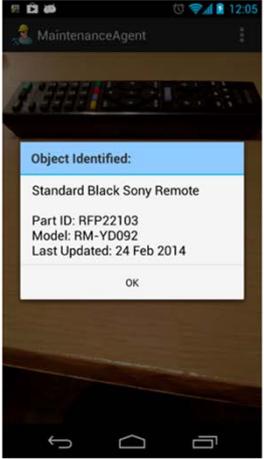Measuring Tape

Fig 17: Object Identification –
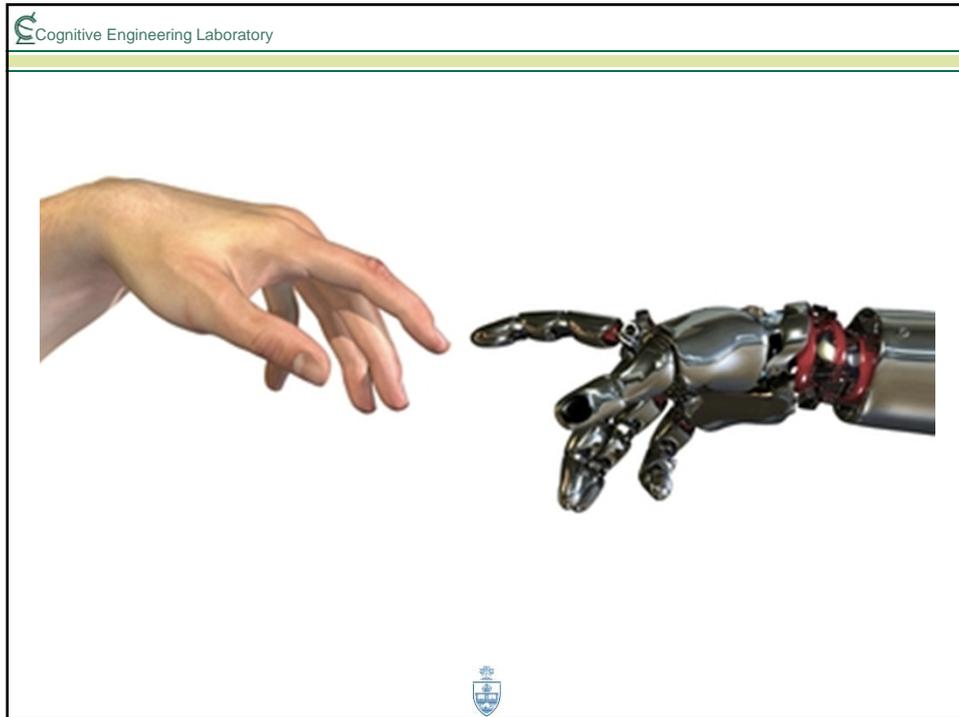Sony Remote
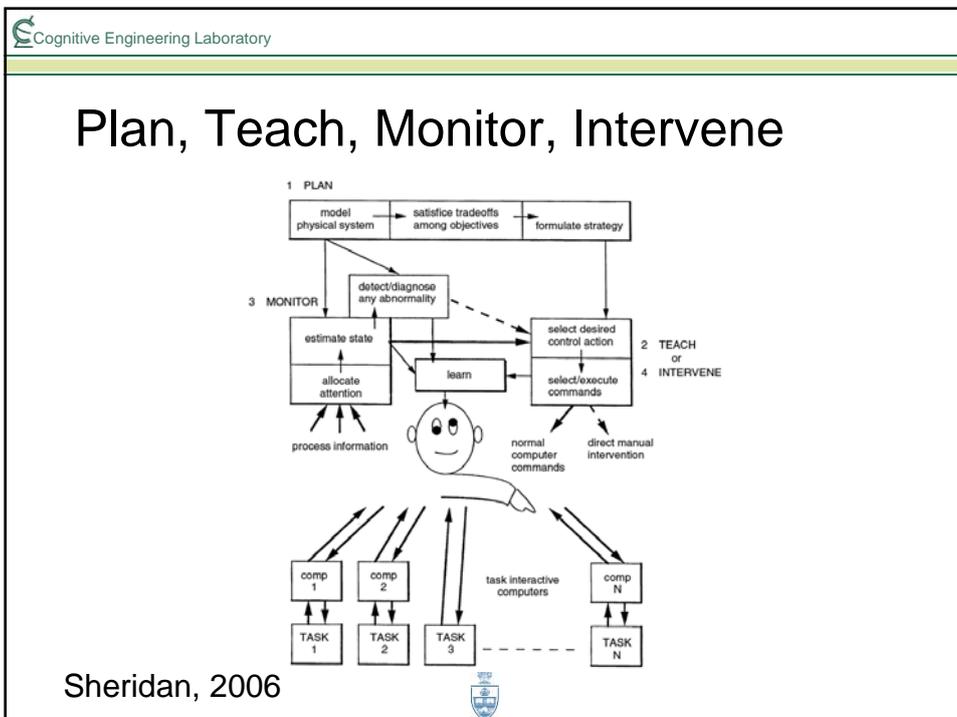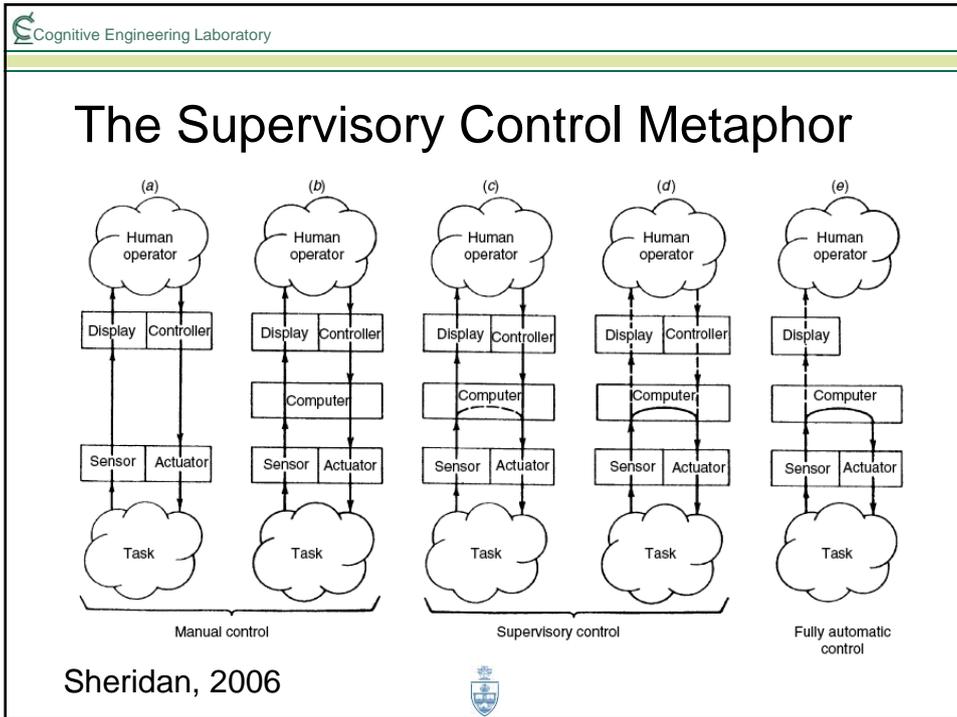
Fig 18: Object Identification –
Electric Capacitor

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Metaphors for relating to automation

- Supervisory control (Sheridan, 1976)
- Automation as a team player (Christoffersen & Woods, 2002)
- Human-automation marriage (Lee, 2011)

The Supervisory Control Metaphor

Sheridan, 2006

Plan, Teach, Monitor, Intervene

Sheridan, 2006

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"It is our conclusion, based on what we know about human abilities, that as a rule machines should monitor men." Fitts et al (1951)

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Automation as Team Player

- To be cooperative, automation must be:
  - ◆ Observable: Shared representation of the problem and shared activities
  - ◆ Directable: Human remains in charge
- Design goal: Low cost, open work environments

(Christoffersen & Woods, 2002)

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To be a team player, an agent must:

1) Agree to work together with other agents and operators

2) Be able to model other participants' intentions and actions

3) Be mutually predictable

4) Be directable

5) Be able to make their status and intentions obvious

6) Be able to observe and interpret signals of status and intentions

7) Be able to engage in negotiation

8) Enable a collaborative approach

9) Be able to participate in managing attention

10) Help to control the costs of coordinated activity

Klein, Woods, Bradshaw, Hoffman & Feltovich (2004)

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"Making automation a team player in complex work settings has proven to be considerably harder to do than to imagine." Cook, Nemeth & Dekker (2008)
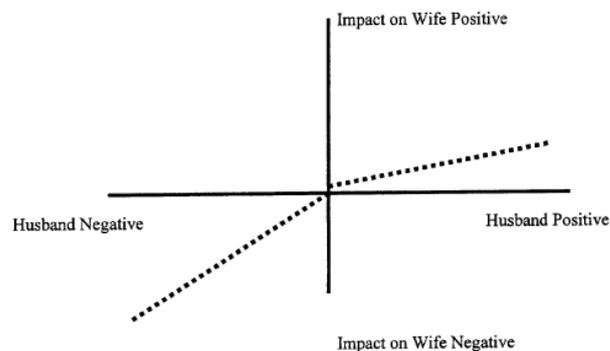

Social Responses to Technology

- Collapsing boundaries between humans and technology; increasingly social technology and increasingly social interaction with technology
- Nass & Moon (2000); Humans mindlessly apply:
  - social categories (e.g., gender, ethnicity),
  - social responses (e.g, politeness, reciprocity),
  - premature cognitive commitmenst (e.g., to expertise), and
  - response to computer "personality" (e.g., passivity/aggression)
- What social relationships can be applied productively to thinking about human-automation interaction?

Gottman et al. (2002)

- A mathematical theory of marriage using nonlinear differential equations

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Marriage Metaphor (Lee, 2011)

Inertia
Dynamics
Asymmetry
Contingency

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Social Robots in Popular Culture

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Alternative Social Metaphors

- Authority metaphors
  - Officer-Soldier
  - Parent-Child
  - Police officer-Citizen
  - Teacher-Student
- Transaction metaphors
  - Butler-Lord
  - Host-Guest

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The Butler

- Anticipates needs
- Unobtrusive
- Efficient dialogue
- Avoids conflict/contradiction
- Graceful and precise
- Loyal and discrete
- Suggests an "obvious" course of action

Kazuo Ishiguro's <u>Remains of the Day</u>

Dignity:

To inhabit the professional role; to be unshaken by events, however surprising, alarming or vexing.

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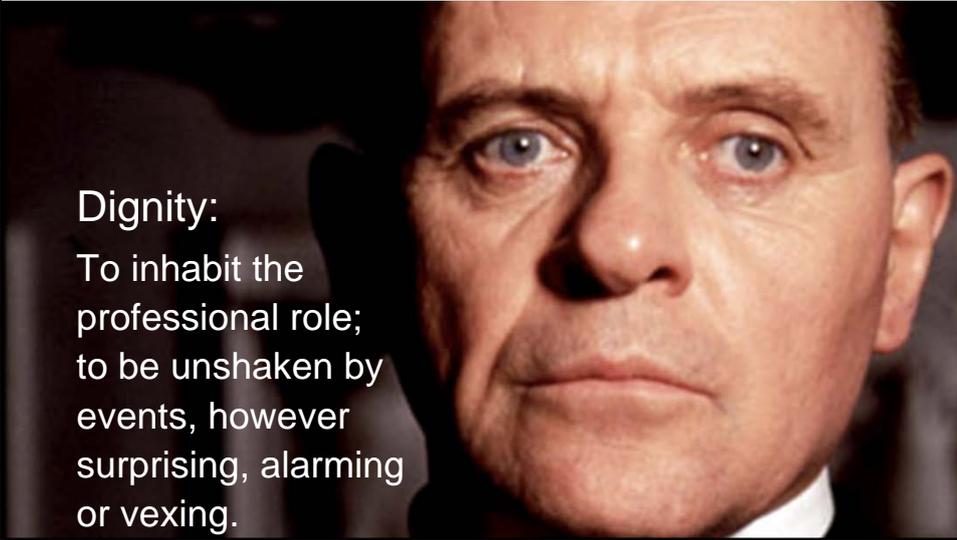
The Butler as Chief of Staff

Application of talent to provide good service to a great gentleman
Ishiguro, 1989

The Butler Metaphor of Automation

- Intricate knowledge of complex work domain
- Scripted, predictable interaction with domain-appropriate depth features
- High autonomy and authority, but restricted scope of work

- Intermediary between master and staff agents
- Catering to:
  - process facilities
  - process automation
  - process work and workers

Conclusion

- Information technology is collapsing process facility worker roles
- Simple automation and information tools can be powerful and good for workers
- "Smart" automation must be "social"
- Need context-relevant design metaphors