The contribution of tacit knowledge to industrial efficiency with human-robot interaction systems

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Topics

- Intuitive interaction with technology
- Complex working environments (CWE)
- Interfaces in CWE
- Complexity: with or without skilled workers?
- Job design in CWE
- Shared workspace of human and robot
- Decision support for operators
- Safety is still a key issue
- Main findings
Intuitive interaction with technology

- The study of applications on industrial environments using robots include the arguments of **intuitive interaction with technology**.
- The **social dimension of worker-robot interaction** is becoming a decisive aspect of robotics development. This dimension includes the **knowledge** necessary to operate machines and systems of machines.
- That can be highly relevant in **complex working environments** (robots, autonomous systems, etc) in the manufacturing industry.
- It is also necessary to investigate the **transferability of results** from industrial environments to other fields where the introduction of robotics is planned (health care, agriculture, mining, underwater, logistics, space operations, inspection, disaster management, medicine, etc.).
- The study of **robotic applications and their social implications** provided clear evidence of this transferability. The main research questions are usually related to industrial applications.
Complex working environments (CWE)

- **Advanced automated systems** with well-designed work places are not usual. Are exceptions.

- Problems of **robotics development** are not only related to technical issues but framed by social aspects. The **design of work organisations** under CWE should also include concepts as
  - responsibility,
  - decision making,
  - use of tacit knowledge,
  - situation awareness and
  - risk assessment.

- **Human-robot interaction** (HRI) as a specific research field of robotics tackles this issue which integrates manual and automatic working units
  - settings in which human actors/robot operators and technological artefacts (robots) work ‘together’
  - where working and organizing are inextricably linked to the use of these technologies.

- Under CWE these issues are critical and highly relevant for **its performance**
Combination of a manual and an automatic work station
Interfaces in CWE

- The “complexity” of technology is shown by the features of **interfaces** between human and machines, or operators and robots.
- In the HRI one can have **remote interfaces** such as
  - visual interfaces,
  - interfaces for gestures and voice and
  - physical interfaces such as
    - haptic interfaces,
    - displays and
    - head mounted displays (HMDs)
    - force feedback systems
Interfaces (CNC programming)
Workplace sharing hybrid system (team@work)

Team@Work
(FhG-IPK, FhG-IPA)
Complexity: with or without skilled workers?

“To run a batch manufacturing shop on an around-the-clock basis, systems have to be able to respond to unexpected events, such as extra stock, defective material, and premature tool wear out”.

- What „systems“ are? Humans? Autonomous agents?
- How „systems respond“? Do they re-act? Or they provide information?
- Who’s the final decision?
- If an „unexpected event“ occurs which are the implications for the economic efficiency (costs, delivery times, quality)?

But Bard added also a curious statement:

- “Adaptive control, coupled with robots, makes this possible by largely eliminating the need for a skilled operator to be present” (Bard, 1986: 103).

This can be one of our key issues to be discussed: job displacement and knowledge use.
Questions

- Are Complex Working Environments trustworthy without skilled and responsible workers involved directly?

- Is it possible to develop CWE with unskilled labour?

- Are automated systems “unmanned” systems?

- Which implications for “unexpected events”? 
Job design in CWE

- **Job definition** and **task design** is biased by strategies of development of work organization in the manufacturing system.

- Two different approaches are possible on the model:
  - **Tayloristic production model** where:
    - one job that supervises and manages all the system,
    - one job to each machine or element, with segmented tasks and quite pre-determined functions
  - Or development of **new forms of work organization**, where
    - jobs require some specialization,
    - but are basically polyvalent with tasks enrichment (vertical enlargement of aggregated tasks)

- The **network organization** (vertical and horizontal task enlargement, and operators frequent inter-acting) and the constitution of **working teams**, seems to be good strategies for situations with **high levels of working qualification and technological complexity**.
Sociological problems and questions

- The fact that **work organisation** is the main element to provide a variation of the model of quality of working life, it is the mean to define the individual conditions of work and living;

- Work organisation models are deeply rooted in **systems of power relations**: more distributed and de-centralised vs. more centralised and authoritarian;

- The issues of **time management** and **de-localisation** become more important with the development of new technologies at the workplace;

- The **human-robot interaction** embodies the time and space changes;

- It becomes more usual that **repetitive and monotonous tasks** do not disapear, but are displaced to other regions or countries, while the value chain becomes globalised. This means that not necessarily the robotics applications are replacing the worse jobs. It can be a mean for a **reorganisation of value chains**
Robotic assist system
Cobots are potentially well-suited to safety-critical tasks (e.g. surgery) or those which involve large interaction forces (e.g. automobile assembly) power (Colgate, Wannasuphposrit and Peshkin, 1996: 433).
Shared workspace of human and robot

"a careful design of so-called intelligent assist systems (IAS) or intelligent automation devices (IAD) and their operating procedures is necessary when physical collaboration between machines and human workers also have to follow ergonomic targets" (Krüger, Lien and Verl, 2009: 628).

(project JAHIR - Joint Action for Humans and Industrial Robots)
Interfaces operator-robot
Decision support for operators

- When discussing interface design for HRI, it is most important to consider the type of information that is provided to operators for decision support (Yanco & Drury, 2002)
- Robot assistants are not able to communicate and interact in a “human-like way” (Hägele, Schaaf, Helms, 2002)
- In the near future work [of HRI research] the multimodal language and the augmented reality environment will be integrated even further (Akan, et al. 2011)
- The application of augmented reality also provides the operators with various simulation options in robotic planning (Fang, Ong, Nee, 2012)
- Operator expertise interacts with automation reliability to affect performance, such that expertise is more valuable to performance in conditions of imperfect automation (Prewett et al., 2010)
- The focus on tacit knowledge becomes more important with CWE
Safety is still a key issue

- It is important to identify relevant research questions about the possibility of development of **safer robot systems** in closer human-machine intuitive interaction systems at the manufacturing shop-floor level.

- In the case of **physically interacting robot assistants** it is obvious that a proven safety is of paramount importance (Hägele, Schaaf, Helms, 2002)

- To ensure safety, the **workspaces** of humans and robots are strictly separated in time or in space (Lenz et al. 2008)

- Tacit knowledge, **qualified and experienced jobs** are key elements to improve safer workplaces with complex environments (CWE)

- Robotic manufacturers are developing **new safe robots** to enable working besides each other (Wallhoff et al. 2010)
Main findings

- The social sciences approach to **robotic technology assessment** is of high relevance to understand the dimension of the intuitive interaction concept with robots and the role of time and space management in global value chains.

- Many problems and difficulties of **robotics development** are not only related to technical issues but framed by social aspects (safety, knowledge, acceptance, trust, quality).

- Less **cognitive and perceptual workload/stress** for robot operators in complex working systems are important for a safer workplace.
  - **Intuitive** interaction and **participation** in the decision process
  - **Tacit knowledge** use is important for an improved efficiency

- **Trust in technological systems** will be as influential on social development as it is in our own human-human relationships (Hancock et al., 2011)

- Whenever more **complex are the working environments**, the less will be possible to “**eliminate the need for a skilled operator**”.

- **New forms of work organisation** are conditions for application of robots in work environments if the aim the improvement of working conditions, job satisfaction and economic efficiency.
Thank you for your attention!

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