AI-Based Knowledge-Services for Training in Smart Production

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*Indo-German Science & Technology Centre (IGSTC) Workshop on "Strategies and Concepts for Advanced Manufacturing"*
Towards Industry 4.0

1. Industrial Revolution
   - Through introduction of mechanical production facilities powered by water and steam
   - End of 18th Century

2. Industrial Revolution
   - Through introduction of mass production based on the division of labour powered by electrical energy
   - Start of 20th Century

3. Industrial Revolution
   - Electronics and IT and heavy-duty industrial robots for a further automation of production
   - Start of 70ies

4. Industrial Revolution
   - Based on Cyber-Physical Production Systems
   - Today

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IGSTC Workshop
What is the LPS Training Factory?

- Production environment that produces a real product

Scope

- Simulation of complete production process: from customer order to delivery of product, including information and product workflows
- Realistic usage of analysis and optimization tools
- Learning about current approaches of production management and industrial engineering
- Imparting practical knowledge about methods in production systems
LPS Training Factory: Examples
LPS Training Factory: Examples

- Cooperation between management and employees
- Experiencing different roles
- Joint decision making
LPS Training Factory: Also for Industry

Training of employees

- Lean Production
- Lean Administration
- Lean Service
- Lean Maintenance
- Lean Development
Smart Production

- High automation
- Integrated in IT infrastructure
- Decentralized, autonomous production
- Presentation of production data and error messages via cryptic messages based on sensor information

Humans

- Identification and authorization of employees by the machines
- Massive amount of information and highly complex processes pose challenges for workers
- Maintenance / repair requires significant expertise and/or time

Organization

- Limited knowledge transfer between machine construction and subsequent configuration, maintenance or repair
- Organizational change through technology: IT, privacy, competencies, work culture
Smart Production: How Companies see the Future

- Merging of various data and knowledge sources: implicit/explicit knowledge, data and content repositories, data from machines
- Human-Machine interactions have been defined based on job expertise, required competencies, personal characteristics
- Integration of worker expertise into knowledge of the organization
- Efficient information exchange, collaboration, networking
- Sharing and commenting/revising of captured knowledge among workers and between workers and machines
- Technical standards and best practices for implementing CPS have been devised
- Structures/standards for managing expertise/competencies and integrating organizational knowledge exist
- Proven business models to monetize new software and assistance services
- Hard- and software solutions have been developed
Research Challenges

- How to present information and knowledge about CPS (machine and process) to the employee?
- How to record/store interactions?

- How to personalize the presentation of information and processes according to the individual characteristics of the employee?

- How to implement such systems in the real workplace? What are the organizational constraints, who needs to be involved and how?

- How to transfer/transform these services and apps into valuable business models? What new business models do arise?
Technological Innovation
Technological Innovation

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Smart Factory ::: Multimodal Learning

- Speech
- Graphics
- Gesture
- Eyetracking
- Physical Action
- Facial Expression
- Body Language

Multimodal Interaction

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Workplace Based Learning

Industrial Environment

Industrial Worker with Google Glasses

Tools

Mobile, Interactive and Situation-Aware Tutoring

close ball valve

remove the tube with 2 flanges

remove the ball valve
Augmented Learning Environment
Augmented Learning Environment

Learn Workflow

Record new sequence
Technological Innovation
Information and Knowledge Services

- Information and Support Service
- Maintenance Service
- Process Service
- Simulation Service
- Collaboration Service
- Authoring/Recording Service
- Emergency Service
- Authentication Service
- Compliance Service
Intelligent Support and Knowledge Services

System

Collects

Constructs

Produces

Data about user

User Model

Adaptation Effect

User Modeling

Adaptation

Data

Personalized Presentation
Example from Mathematics: ActiveMath

A hiking tour

Mary and Michael were on a hiking tour. Their hiking booklet contains a profile of their tour.

Modeling the problem (very easy)

In order to grasp the hiking tour mathematically, Mary and Michael need to develop some adequate mathematical model. In this case, this is not difficult: they copy the profile into some coordinate system. They plan their tour from hut to hut by selecting some reasonable points of the computed profile.

Definition of the derivative function

Suppose a function \( f \) is defined on an interval \( I \). Then this function is called differentiable (in \( I \)) if it is differentiable at every \( x_0 \in I \), i.e., if the limit

\[
\lim_{x \to x_0} \frac{f(x) - f(x_0)}{x - x_0}
\]

differs for all \( x_0 \in I \). The function \( f' \) (say: "\( f \)-prime") that assigns the value \( f'(x) \) to every \( x \in I \), is called derivative function (of \( f \) in \( I \)).

Also, if this limit exists for all \( x \in I \), then \( f \) is said to be differentiable on \( I \).

Hence, if \( f \) is differentiable on \( I \), then the function

\[
f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}
\]

is defined on \( I \), and is called the derivative of \( f \) on \( I \).
Example from Mathematics: ActiveMath

“derivation”

Course Generator

Repository
Definition of the difference quotient

At a real function $f$ between two different points $P_0$ and $P_1$ one builds the differences $\Delta x = x_1 - x_0$, resp., $\Delta y = y_1 - y_0$, and calls the quotient

$$
\frac{\Delta y}{\Delta x}(x_0,x_1) = \frac{y_1 - y_0}{x_1 - x_0}
$$

the difference quotient (to $x_1$ at $x_0$).
Smart Factory :::: Location based Learning
Smart Factory ::: Location based Assistance Systems

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Smart Factory :: Application Store

M120 App Store

- High Precision App: 5000 €
- High Speed App: 3000 €
- Energy Sav. App: 1000 €
- Standard Usage App: free
APPsist ::: Intelligent Knowledge Services for Smart Production
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