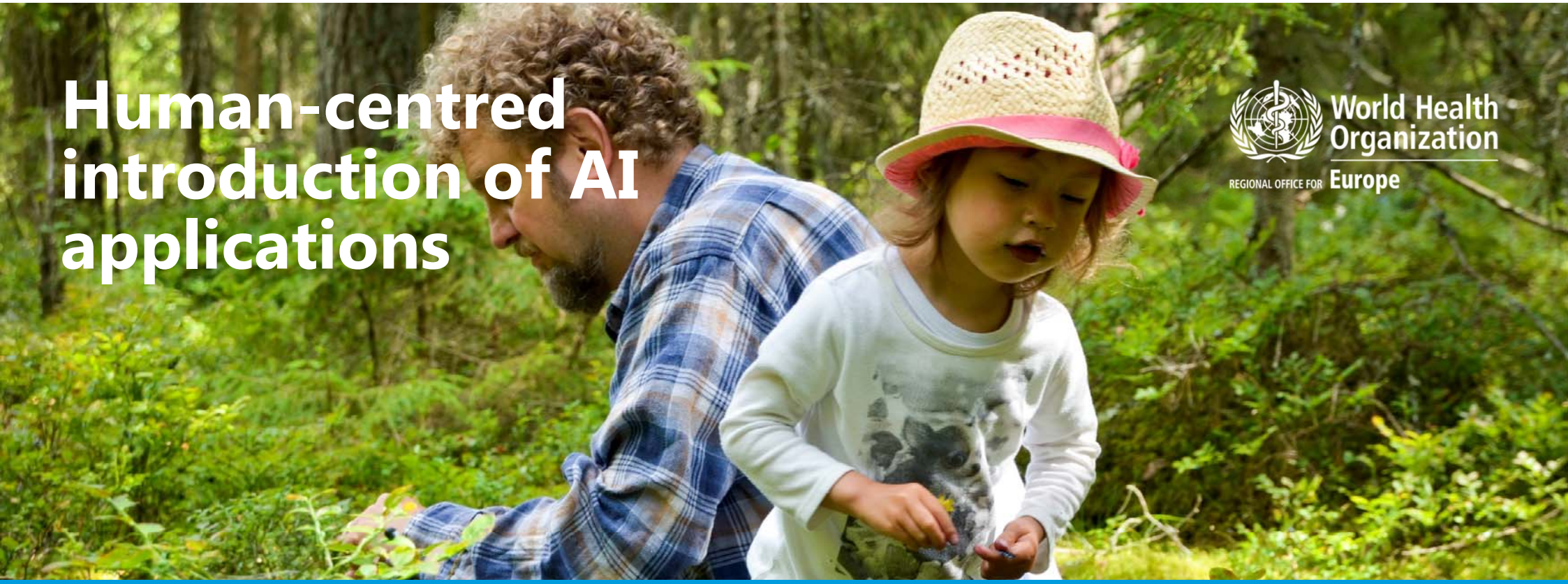

Human-centred introduction of AI applications

Winter School – Impact Training on Big Data for Healthcare Systems

February

Dr. Jan-Paul Leuteritz | Researcher | Fraunhofer IAO - Ergonomics & Vehicle Interaction | Germany

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KI-ULTRA

»Corporate laboratories for transformation and change towards the use of Artificial Intelligence in working contexts«

Financed by: Bundesministerium für Arbeit und Soziales

Research partners: Fraunhofer IAO, Universität Stuttgart Institut für Arbeitswissenschaft und Technologiemanagement IAT

29 corporate labs:
MTU, TRUMPF, Wichelhaus, Geberit, Allianz, …

Contents

Definitions

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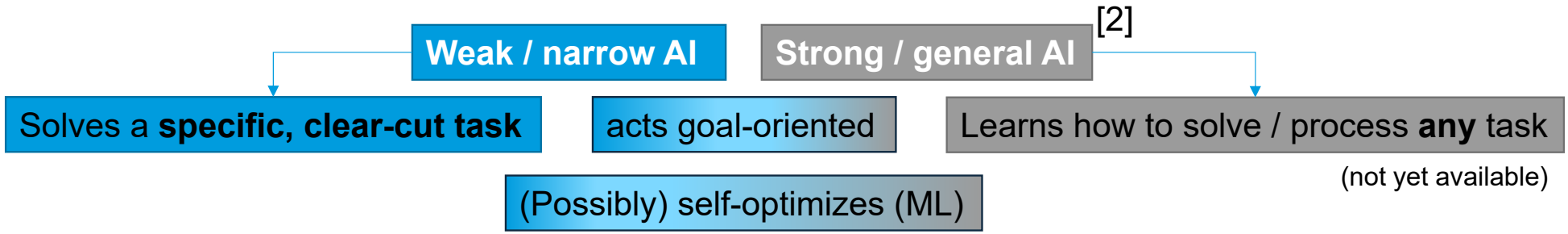
01

Definitions

- **Data science:** the entire process of generating knowledge from complex data.
- **Big Data: "**methods to process and analyze big, unstructured amounts of data effectively" [1]. Amounts of data are "big" if their analysis requires more than standard software (e.g., MS excel) or hardware (e.g., standard PC)."
- **Artificial Intelligence (AI):** IT-systems that solve complex problems through adaptation to context conditions or other input factors (e.g., through machine learning).
  - *Practically speaking, throughout this entire presentation, we can just picture machine learning applications when talking about "AI".*



[1] Welzel & Gorsch (2018). Das ÖFIT-Trendsonar Künstliche Intelligenz. Kompetenzzentrum Öffentliche IT. [2] Kurzweil, (2014). The singularity is near, *Ethics and Emerging Technologies*, Springer, 393–406

Success factors of AI introduction

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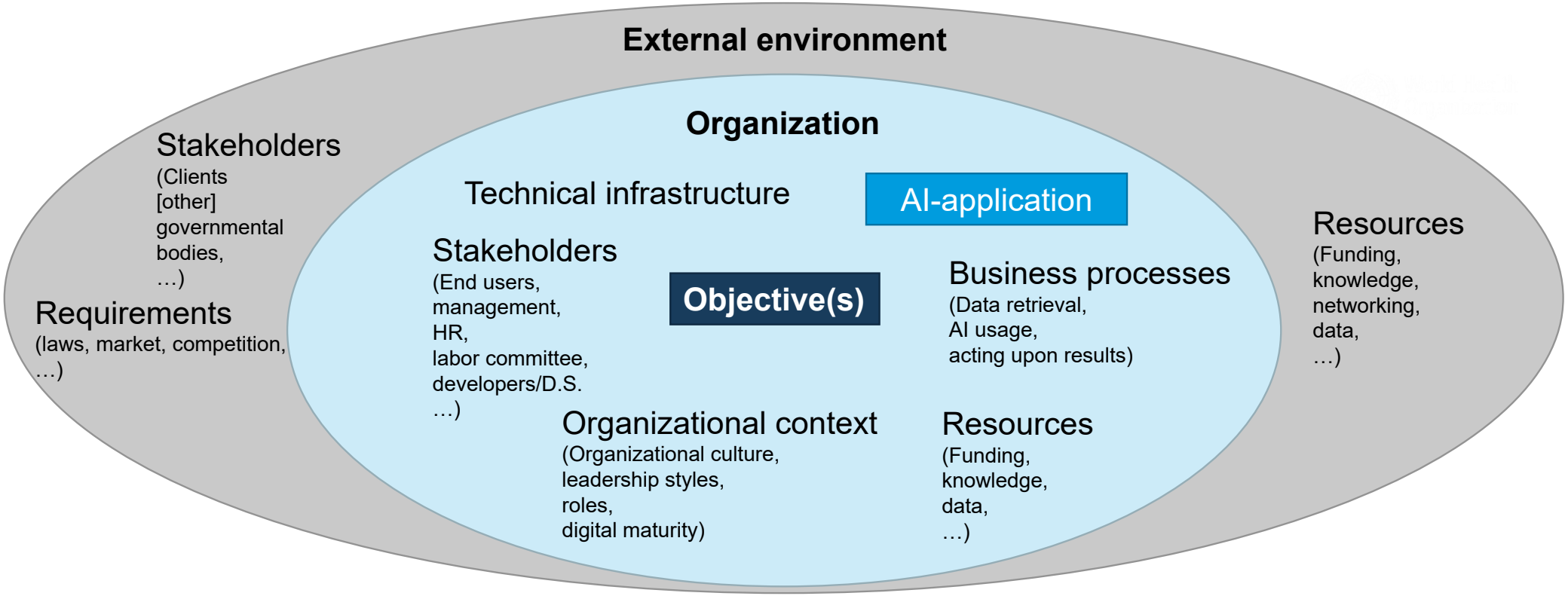
02

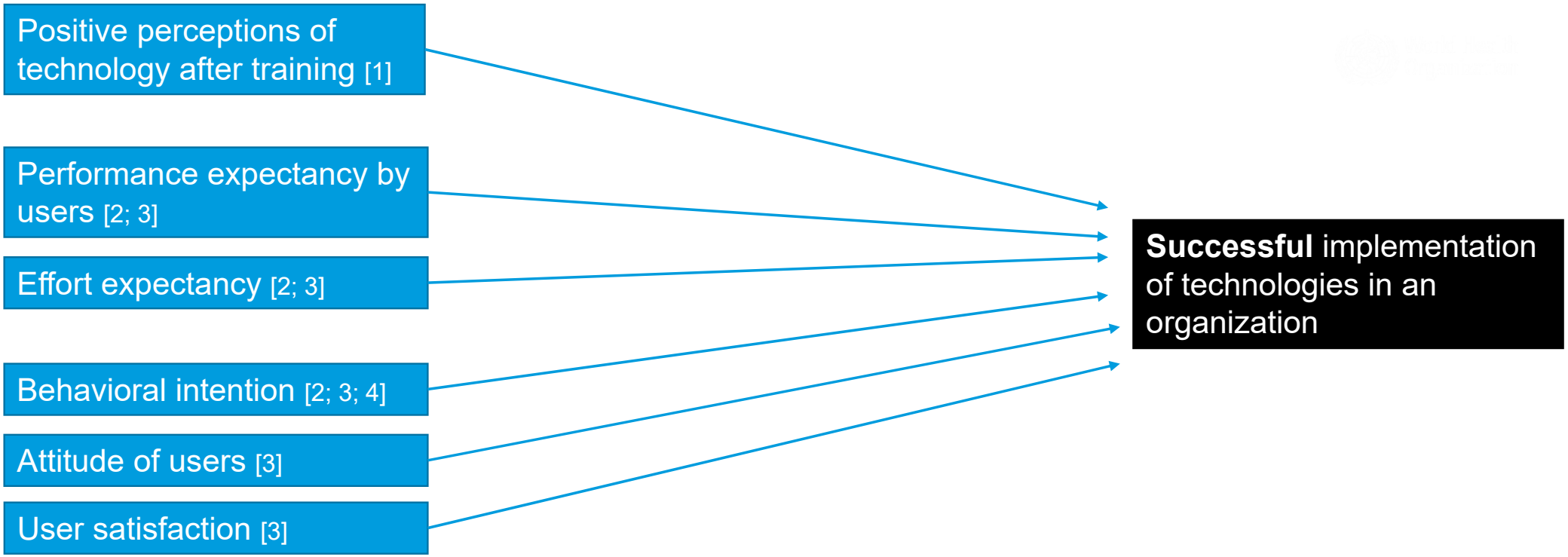
Success factors of AI introduction

AI as a part of a workplace



Success factors of AI introduction

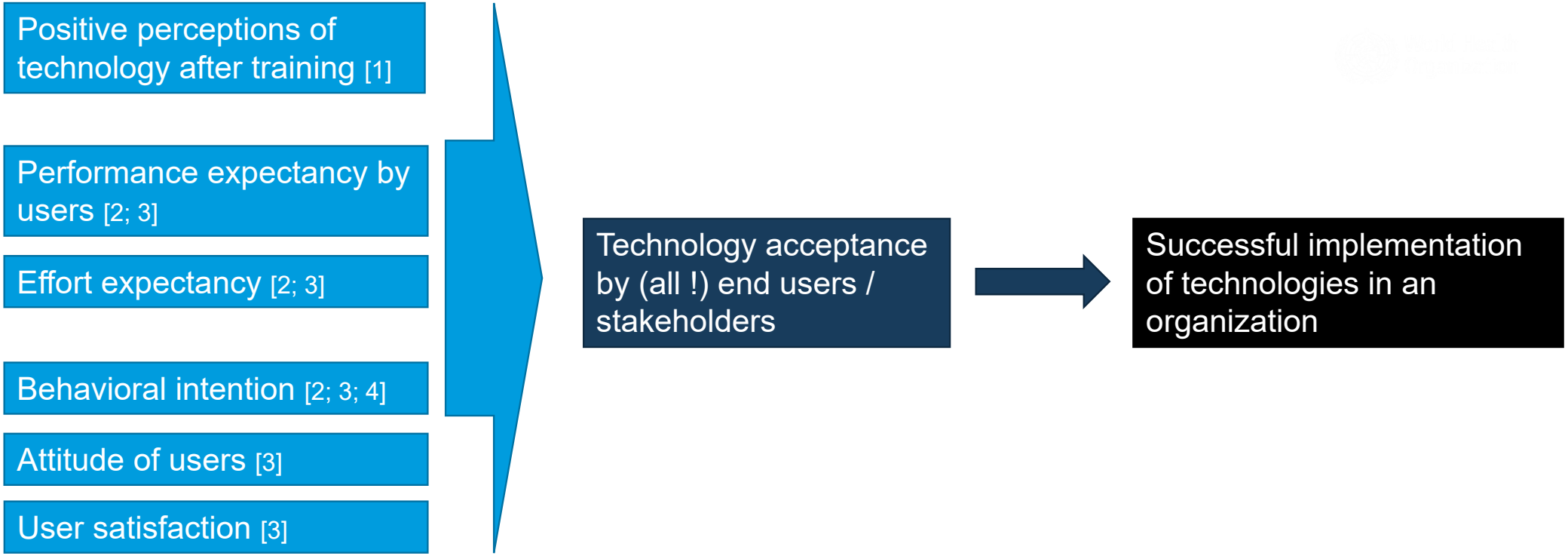
Managing expectations



[1] Speier, Venkatesh 2002; [2] Venkatesh et al., 2003; [3] Chatterjee et al., 2020; [4] Chatterjee, 2019

Success factors of AI introduction

Managing expectations



[1] Speier, Venkatesh 2002; [2] Venkatesh et al., 2003; [3] Chatterjee et al., 2020; [4] Chatterjee, 2019

Success factors of AI introduction

How to foster technology acceptance

1. Create a common understanding of the capabilities of Big Data / AI-based applications (“AI awareness”; [1]). Someone should be in charge of fostering information flow and translating technical aspects into common language [2].
2. Inform early (!) in the process users about the changes expected by the introduction of Big Data / AI-based applications: effort, (expected) quality of output, processes and responsibilities, required qualifications, etc.
3. Invite all relevant stakeholders [3] to participate in the process of creating / introducing the Big Data / AI-based application.
4. Processes should be inclusive and transparent; give the user community a voice and allow for / accept negative feedback on past Big Data / AI-projects.
5. Ensure high usability / positive user experience (UX) of the respective user interfaces [4].

[1] Jöhnk et al., 2020; [2] Long et al., 2013; [3] Schraeder et al., 2006); [4] Chatterjee 2019

Success factors of AI introduction

Reasons of failure

- Lack of funding [1]
- Consumer trust [2]
- Organization lacks the skills to evaluate, build, and deploy AI solutions [2]
- Employee fear of change [2]
- Unclear business case [2]
- Lack of leadership support [2; 3]
- AI-security concerns [2]
- (Technical) complexity [3]
- (Technical) compatibility [3]

Failed implementation of (AI) technologies in an organization

[1] Alsheibani, 2020; [2] Alsheibani, 2018; [3] Chen et al., 2021

Success factors of AI introduction

Mastering obstacles

1. Data Governance: create a general framework for data management, control of data security, data protection and compliance [1; 2]
    1. Introduce an adequate security mechanism [3]
    2. Develop a privacy policy [3]
    3. Support legal requirements [3]
    4. Assign resources for maintenance [4]
2. Ensure top management support (and support by the lead of the application area) from an early stage on, to mobilize resources and to foster entrepreneurial behavior by the involved actors.
3. Provide positive perspectives to employees with affected organizational roles (e.g., job security) and foster an organizational culture that embraces change.
4. The AI / Big Data strategy should include a forecast on required competencies, and management should provide respective resources for training / hiring. → Multidisciplinary project team [5]

[1] Cheong & Chang, 2007; [2] Klievink et al. 2017; [3] Chatterjee, 2019; [4] Gerbert et al., 2018; [5] Lokuge et al., 2019

Organizational strategy

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03

Organizational strategy

Organizational AI readiness factors

Strategic alignment

AI-business potentials: pick AI use cases that will benefit the organization.

Customer AI readiness: internal / external customers can use the AI.

Top Management support: enable change across the organization.

AI process fit: standardize or re-engineer processes.

Data-driven decision making: foster openness to DDDM.

Resources

Financial budget: high level of uncertainty.

Personnel: implementation, maintenance, new processes.

IT infrastructure: prepare for high workloads and data storage requirements.

Knowledge

AI awareness: ensure employees have an adequate understanding of AI

Upskilling: learn / develop AI-related skills

AI ethics: implement measures to prevent bias, safety issues, & discrimination.

Culture

Innovativeness: willingness to change

Collaborative work: form multidisciplinary, diverse teams

Change management: actively shape the required organizational change

Jöhnk et al., 2020

Organizational strategy

Organizational AI readiness factors

Data

Data availability

Data quality

Data accessibility

Data flow

Jöhnk et al., 2020

Organizational strategy

Key factors

Develop and implement AI solutions through a transparent process, in which all relevant stakeholders may participate (and really have a say) from the beginning.

Besides that, these factors should be taken into account:

1. Identifying relevant use cases (e.g., economically viable)
2. Human Factors / Industrial Engineering
3. Organizational development
4. Human Resources development
5. Data strategy

KI-ULTRA project financed by BMAS (German Ministry of labor and social affairs)

Organizational strategy

Key factors: (1) Identifying relevant use cases

1. Establish an AI strategy at the organization: where do we want to get with AI and how?
2. Digital maturity: what is possible? How do we make it possible?
3. How do we identify use cases? Top-down vs. bottom-up?
    - AI hubs / communities
    - Communication strategies. → Everyone gets a say.
    - Decide how to ensure sufficient level of prioritization of data-science projects
4. Technology-induced vs. problem-induced approach
5. Get low-hanging fruits: maximum *relevance* + minimum *complexity*
6. Define requirements based on KPIs (if possible) early in the process

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Organizational strategy

Key factors: (2) Human Factors / Industrial Engineering

(Of course, we should guarantee **decent work**: https://www.ilo.org/), but with AI, a couple of aspects are particularly important:

1. New processes (now with AI) should foster communication, cooperation, and social integration.
2. New processes (now with AI) should preserve workers' autonomy on how / when to do things
3. Make sure workers stay in control; this requires careful and elaborate feedback.
4. Make sure efficiency gains with AI will not go at the expense of workers (e.g. only highly demanding tasks remaining); workload and working time should be planned based on knowledge about human performance capabilities.
5. Be careful about collecting performance data of employees (even as a side product).

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Organizational strategy

Key factors: (2) Human Factors / Industrial Engineering

Sociological perspective: Possible scenarios

- The replaced employee
  - High-routine jobs can be automated
- The dominated employee
  - »The Frankenstein complex«
- The augmented employee
  - Worker learns new competences, thanks to the AI
- The re-humanized employee
  - The new job role is less technology-bound than before, and more fit to human capacities

Ferguson, Y. (2019).

Organizational strategy

Key factors: (3) Organizational development

Organizational development is required for

1. Creating an organizational culture that supports the use of AI and allows to benefit from its effects. This is under investigation but reasonable guesses are:
    1. Change- / innovation- oriented culture
    2. Trust- / collaboration culture
2. Leadership: fostering intrinsic motivation and empowering employees (e.g. transformational leadership).
3. Providing required structures / roles

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Organizational strategy

Key factors: (4) Human Resources development

1. Take Human learning into account when designing user interfaces (UI).
2. Strategic assessment: which competencies do we need (internal / external)?
3. Empower employees to create their individualized training curricula
4. Networking with other organizations.

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Organizational strategy

Key factors: (5) Data strategy

1. Define required roles and rights
2. Design processes for (lawful) collection and storage of data
3. Make sure data access is efficient
4. Provide the necessary data storage hardware

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Organizational strategy

(Re-)Designing processes

Introducing AI applications to workplaces will require re-defining work processes. Quality criteria of AI-supported processes are:

- **Objectives / strategic values** of the AI-supported process are well-defined
- **Coordination:** Roles, responsibilities, interfaces, and input-output-relations of the AI-supported processes are defined
- **Efficiency:** Costs, Time, Productivity of the AI-supported processes have been / are being optimized
- **Quality:** Product- and Service results have been / are being optimized
- **Flexibility:** Alternative or escalation processes ensure that the AI-supported processes are adaptive
- **Integration:** Internal and external AI-supported processes share an overarching coordination.

Ganz, et al. (2021)

The role of ethics

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04

Ethical guidelines for AI applications

An array of options

The AI Ethics Guidelines Global Inventory by Algorithmwatch currently features **173 guidelines**. Examples in English language are:

1. Ethical Guidelines for Trustworthy AI
   (Independent High-Level Expert Group on Artificial Intelligence set up by the European Commission, 2019).

2. Trustworthy Use of Artificial Intelligence
   (Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS, 2020)

3. Responsible AI practice
   (Google)

4. IBM's Principles for Trust and Transparency (2018); Trusted AI; Everyday Ethics for Artificial Intelligence
   (IBM)

5. Ethically Aligned Design
   (IEEE)

These examples cover AI / automation ethics at a very general level.

https://inventory.algorithmwatch.org

Ethical guidelines for AI applications

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An array of options

Some ethics guidelines are specific to the health sector, e.g.:

1. Ethics of Artificial Intelligence in Radiology: Summary of the Joint European and North American Multisociety Statement
   (American College of Radiology; European Society of Radiology; Radiology Society of North America; Society for Imaging Informatics in Medicine; European Society of Medical Imaging Informatics; Canadian Association of Radiologists; American Association of Physicists in Medicine, 2019)

2. Policy Recommendations on Augmented Intelligence in Health Care H480.940
   (American Medical Association (AMA), 2018)

3. Code of conduct for data-driven health and care technology
   (Department of Health and Social Care – UK, 2019)

4. Digital Technology and Healthcare. Which Ethical Issues for which Regulations?
   (French National Ethical Consultative Committee for Life Sciences and Health (CCNE), 2014)

5. Ethical, social, and political challenges of Artificial Intelligence in Health
   (Future Advocacy – UK, 2018)

6. Five guiding principles for responsible use of AI in healthcare and healthy living
   (Philips - Netherlands, 2020)

https://inventory.algorithmwatch.org

Ethical guidelines for AI applications

Why are ethics guidelines essential?

- Ensure the support by all involved stakeholders from within the organization
    - Management or members of workers committees may have a wrong picture of what AI does and is capable of. An ethical framework to which everyone is committed builds trust.
- Create applications that are trustworthy to end users outside the organization (e.g., patients, healthcare organizations).
    - This is critical for AI that depends on data from external end users.
- Not meeting ethical guidelines may result in also failing to meet legal standards (e.g., regarding discrimination) and thus endanger the sustainability of the AI applications developed.
    - Also, the contrary argument can be made: Since not all fundamental human rights (e.g., Charter of Fundamental Rights of the EU) are protected by a specific law, ethical guidelines must fill this gap.
- While taking ethics into account consumes resources in project management and development, ethical guidelines also restrict the space of what is possible and hence contribute to reducing complexity. Functions that are not allowed do not have to be discussed.

Ethical guidelines for AI applications

Key ethics guidelines: American Medical Association (AMA)

Common themes from AI ethics guidelines and regulations

- **Accountability:** AI systems should be subject to oversight during development and deployment; remedies should be provided if harm occurs
- **Safety and Security:** AI systems must be reliable and perform as intended; they must be appropriately protected against external threats.
- **Transparency and Explainability:** It must be clear when AI systems are being used and for what task; justifications for decision outputs should be intelligible
- **Fairness and Non-discrimination:** Steps should be taken to prevent and mitigate against discrimination risks in the design, development, and application of AI systems
- **Human Control of Technology:** Important decisions are still subject to human control
- **Professional responsibility:** Individuals and teams involved in the development and deployment of AI systems take responsibility for the performance and effects of those systems
- **Promotion of human values:** AI systems' objectives and how they are implemented correspond with core social norms

Independent Crigger, Reinbold, Hanson, Kao, Blake & Irons (2022)

Ethical guidelines for AI applications

Exemplary ethical issues

- **Scenario: AI detects risk levels for complications in Diabetes mellitus patients, with the aim of prioritizing them for visits at their physician**
  - Discrimination: low risk patients may be neglected if the physician‘s (time) resources are too limited to see all patients. Compliant patients may suffer from disadvantages.
- **Scenario: AI automatically diagnoses mental disorders. A young patient is diagnosed with a psychotic disorder (e.g., schizophrenia)**
  - Fairness / taking responsible decisions: Even though diagnose criteria for a psychotic disorder are given, the human psychiatrist gives a preliminary diagnose of an adaptation disorder, since once this diagnose is given, it will stick and have a severe impact on the young person’s future.

On ethical dilemmas of AI in healthcare: Sunarti et al. (2021)

Ethical guidelines for AI applications

The »Digitale-Versorgung-Gesetz – DVG« (German: Digital Care Act) from December 10, 2019

- Medical apps paid for by public health ensurance
  - Bundesinstitut für Arzneimittel und Medizinprodukte (BfArM) (Federal Institute for pharmaceutics and medical products) will grant payment for 1 year, after a preliminary check regarding
    - ***safety,***
    - ***correct functioning,***
    - ***quality,***
    - ***data security and privacy***.
- Benefit: Enables development of innovative solutions
- Threat: Ethics?

https://www.bundesgesundheitsministerium.de/digitale-versorgung-gesetz.html

UX engineering for AI applications

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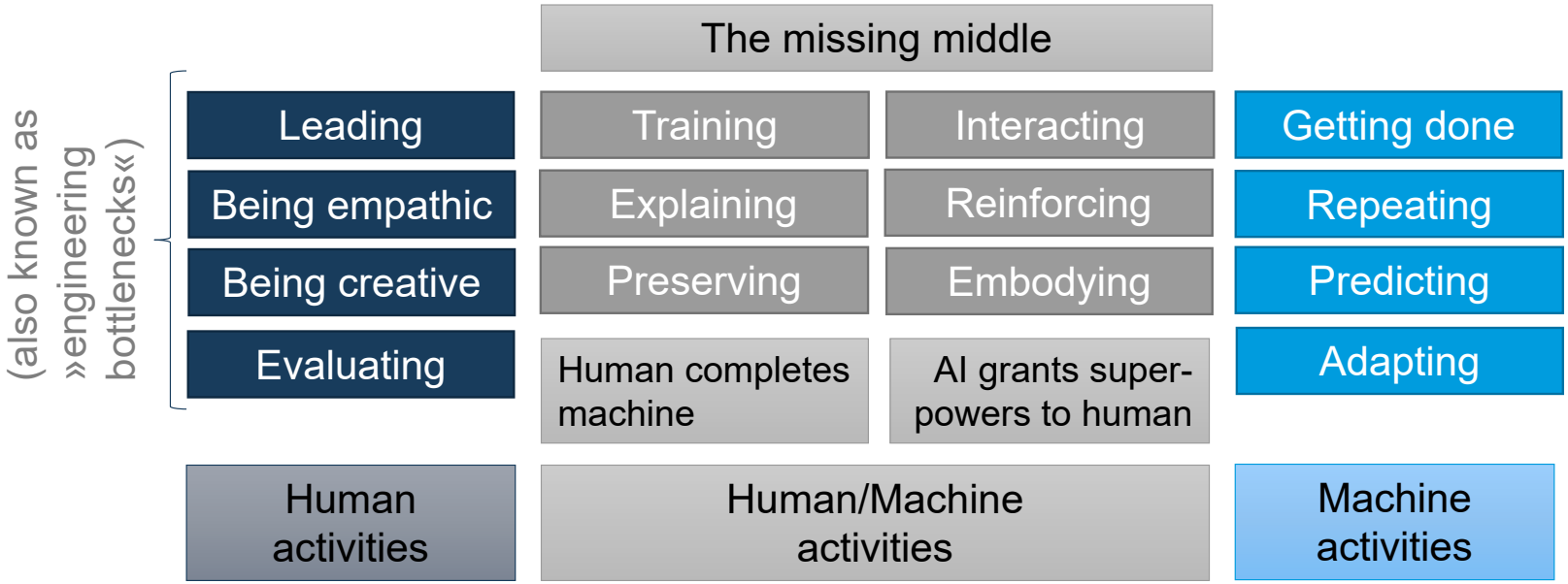
05

UX engineering for AI applications

Human Factors Engineering for AI applications

Human and Machine: the missing middle. Potentials of hybrid cooperation roles of humans and AI applications



Daugherty, P.R. & Wilson, H. J. (2018). Human + Machine: Reimagining Work in the Age of AI. La Vergne: Harvard Business Review Press.

UX engineering for AI applications

Human Factors Engineering for AI applications

Human and Machine: the missing middle. Potentials of hybrid cooperation roles of humans and AI applications

Training

Human trains AI to recognize patients' emotions

Explaining

Human explains AI decision to patient / caregiver

Preserving

Human Ethics-compliance manager ensures the AI acts accordingly to relevant values

Interacting

AI facilitates Interaction between doctor & patient (e.g., automated hotline)

Reinforcing

AI helps attain new knowledge, e.g., through context-sensitive display of x-ray images

Embodying

Co-bots in assisted surgery

Daugherty, P.R. & Wilson, H. J. (2018). Human + Machine: Reimagining Work in the Age of AI. La Vergne: Harvard Business Review Press.

UX Engineering for AI applications

Human Factors Engineering for AI applications

Cluster 1: Protection of individuals

- Safety and protection of (mental and physical) health
- Data protection and responsible gathering of performance-related data
- Sensitivity to behavior and avoiding discrimination

Cluster 2: Trustworthiness

- Quality of available data
- Transparency, explicability and consistency
- Responsibility, liability and trust in the system

Cluster 3: Sensible division of work

- Adequacy, load removal and support
- Agency and situation control
- Adaptivity, error tolerance and personalization

Cluster 4: Conducive working conditions

- Action spaces and rich work
- Promoting learning and experience
- Communication, cooperation and social involvement

N. Huchler et al., (Eds.), 2020. Kriterien für die Mensch-Maschine-Interaktion bei bei Lernenden Systemen: Whitepaper aus der Plattform Lernende Systeme, München, 2020. [Online]. https://www.plattform-lernende-systeme.de/files/Downloads/Publikationen/AG2_Whitepaper2_220620.pdf

UX engineering for AI applications

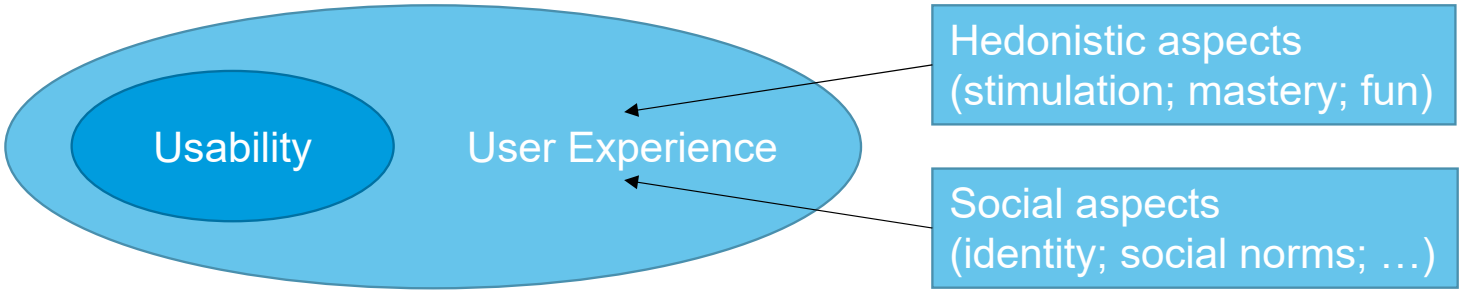
Definitions / standards

Usability

- *ISO 9241 – 11: … the extent to which a system, product or service can be used by specified users to achieve specified goals with **effectiveness, efficiency** and **satisfaction** in a specified context of use*

User Experience

- *ISO 9241 – 210:* „… **all perceptions and responses** of a user that result from the use and/or the anticipated use of a product, system or service.“



UX engineering for AI applications

Other relevant standards in the area of medical products

ISO 13485 Medical Devices

- *Safety and quality requirements for medical devices*

IEC 62304:2006

- *Medical device software — Software life cycle processes*

UX engineering for AI applications

Standard UX engineering for AI applications

Today, we are dealing exclusively with »Weak AI«

- An AI application that serves for a limited, clear-cut task. Does not have capabilites of human intelligence (e.g. learning new tasks/subjects; consciousness of own imperfections)
- AI solution will produce a computational output that is either taken up by a human user or fed directly into a machine to act based on the output.
- Examples:
  - AI-guided robotic arm to aid in surgeries. AI ensures the arm does not collide. → direct feed to actuators. → Interaction with surgeon
  - AI application predicts the number of free beds in a hospital for a given moment in the future. → used by management
  - AI application recommends treatments (cocktail, time intervals, etc.) for chemo-treatment of cancer patients, based on laboratory parameters and other clinical data. → Used by physician.
  - AI application recommends a diagnose based on an analysis of x-ray pictures. → Used by physician.

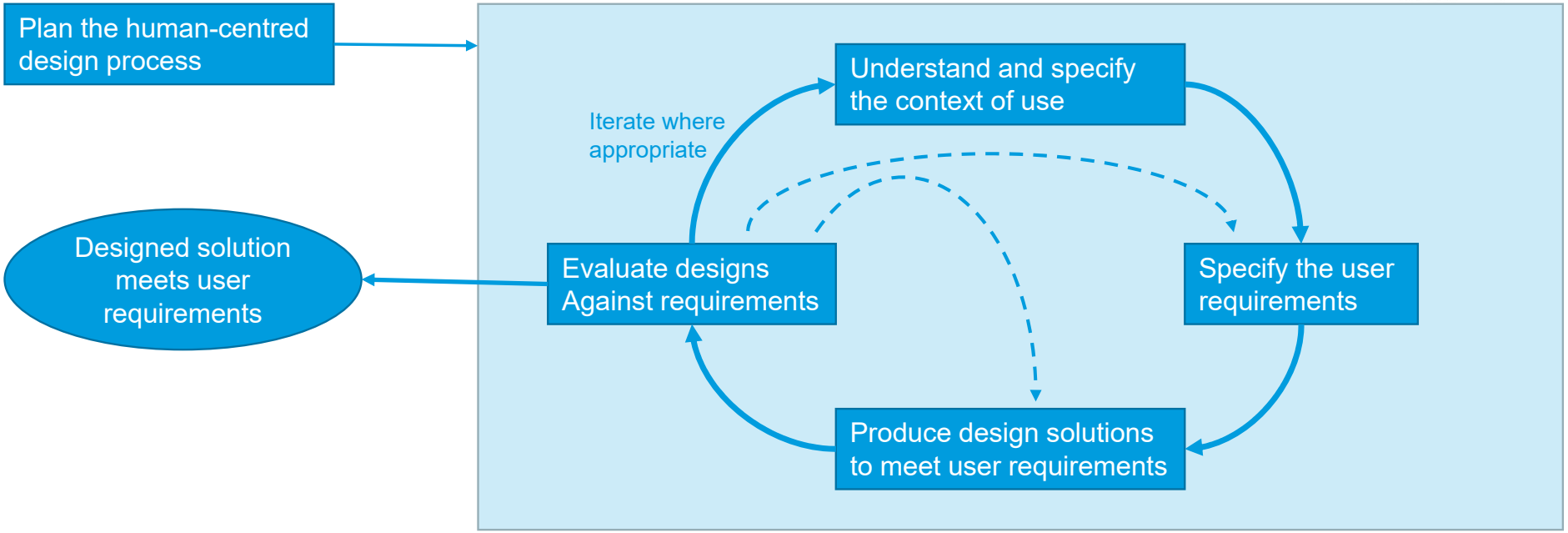
As long as there are humans involved, we have AI-to-user interfaces

UX engineering for AI applications

Standard UX engineering for AI applications

»Weak AI«

- For end user interfaces, e.g. of prediction tools: Business as usual. → **User Centred Design Process** based on **ISO 9241 – 210 (2019)**



UX engineering for AI applications

Challenges of UX engineering for AI applications

Human-AI Interaction Design challenges (examples)

- Difficult to articulate what AI can / cannot do
- Technical feasibility of a design idea is highly dependent on data
- Do not know how to purposefully use AI in the design problem at hand
- Do not know to express AI design ideas
- Difficult to sketch divergent AI interactions
- Cannot fast prototype AI system behavior
- Difficult to explain AI behaviors to users
- Difficult to design interactions that constantly improve AI performance
- Difficult to anticipate / mitigate unpredictable AI behavior
- Difficult to make sure the AI is not creepy
- Do not know whom to hold accountable

➡ AI technical education for designers

➡ Data exploration / storytelling tools

➡ WoZ tools for exploring AI interactions

➡ AI UX- / ethics heuristic guidelines

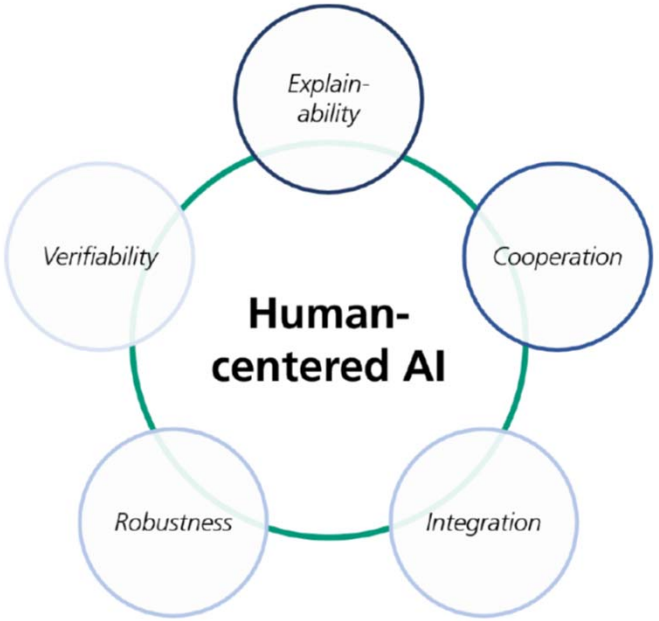
Yang et al. (2020).

UX engineering for AI applications

Quality criteria for AI applications

KI-Fortschrittszentrum (»AI progress centre«)

- **Explainability:** Creating mechanisms that make AI processes transparent and explainable
- **Cooperation:** By means of appropriate interaction mechanisms, AI systems are enabled to cooperate with people and effectively support experts.
- **Integration:** AI systems and experts join forces to build comprehensive knowledge faster and work together to deliver better solutions.
- **Robustness:** AI systems go beyond typical assumptions to satisfy real-world problems. Requires dealing e.g. with uncertainty, limited data, limited computing resources.
- **Verifiability:** Basic features such as security and data protection guaranteed before and during deployment of AI systems.



Internal documentation on the project “KI-Fortschrittszentrum” (AI progress centre) https://www.ki-fortschrittszentrum.de/); Fraunhofer IAO; Fraunhofer IPA

UX engineering for AI applications

Quality criteria for AI applications

Special design criteria for AI applications in the medical field

- **Explicable:** convey the relative importance of features in determining outputs
- **Dynamic:** capture temporal changes in physiologic signals and clinical events
- **Precise:** use high-resolution, multimodal data and aptly complex architecture
- **Autonomous:** learn with minimal supervision and execute without human input
- **Fair:** valuate and mitigate implicit bias and social inequity
- **Reproducible:** validated externally and prospectively and shared with academic communities

→ Overlap with ethical requirements.

Loftus et al. (2022)

UX engineering for AI applications

Explainable AI (XAI)

Methods to achieve explicability [1]

- Visualize ML processes
- Explainable ML algorithms → Using single, explainable building blocks.

XAI based on developmental stage [2]

- Pre-modelling explainability: e.g., *exploratory data analysis*
- Explainable modelling: e.g., *Adopt explainable model family*
- Post-modelling explainability: e.g., *Backward propagation*

[1] Xu W. (2019) ; [2] Khaleghi, (2019)

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