

5.3.9.1 Human-Artificial Intelligence System

A human-AI system includes both computational elements and a human user who must come together to accomplish a purpose.

5.4 What is Explainable AI?

Explainability is a concept that stands at the crossroads of numerous fields of active AI research, with an emphasis on the following domains.

5.4.1 *Fairness*

Can we verify that choices taken by an AI system were done consistently?

5.4.2 *Causality*

Can one learn a system from facts that not only makes the right predictions but also offers some understanding of the core events?

5.4.3 *Safety*

Can we have confidence in the reliability of our AI system without recognizing how it makes its presumptions?

5.4.4 *Bias*

How can we be confident that the AI system hasn't picked up a distorted view of the world due to flaws in the training data or objective function?

5.4.5 *Transparency*

Everyone has a right to be informed about changes that influence us in ways, formats, and languages that we comprehend.

An XAI, also known as a “Transparent AI” or “Interpretable AI”, is an AI whose activities are simple for humans to comprehend and evaluate. A civic privilege to explain can be implemented using XAI.

5.5 Need for Transparency and Trust in AI

The black box AI systems have found their way into many of today’s modern implementations. Transparency and explainability are not critical requirements for machine learning models used as long as the overall efficiency of these systems is adequate. Even if these systems fail, the implications are unexceptional. As a result, the necessities for trust and openness in these types of AI systems are relatively low. The scenario is different in safety-critical applications. In this case, the opaqueness of ML techniques may be a restricting or indeed rejecting component. Particularly when a single misjudgment can endanger human life and health or lead to significant revenue damages, depending on an information system with unintelligible logic will not be an alternative. This lack of transparency is among the causes why the application of machine learning to areas such as healthcare is extremely careful than its application in the consumer, electronic commerce, or media industries.

5.6 The Black Box Deep Learning Models

The method of developing interpretations for AI system behavior will vary based on the type of ML techniques used: techniques that produce implicitly decipherable models vs deep learning algorithms that are intricate information and understanding methods and produce models that are implicitly indecipherable to actual users.

ML techniques such as Bayesian classifiers, decision trees, sparse linear models, and additive models produce decipherable models in the sense that model components can indeed be instantly examined to comprehend the model’s inferences. These technique makes use of relatively small internals, and also provide visibility and traceability in their decision-making. As long as the model is precise for the classification process, these strategies offer awareness of the AI system’s decision-making.

Deep learning algorithms, one on either side, are a class of machine learning technique that sacrifices clarity and interpretability for the predictability. These techniques are now used to create applications such as consumer behavioral forecasting associated with high inputs, voice recognition, natural language processing, and computer vision.

The lack of transparency and understandability in the Deep Learning Algorithms makes them a black box. The black box model is a model which performs its predictions on its own without explaining anything for humans to understand.

The Black Box Problem occurs when artificially intelligent processor architectures are vague.

Chapter 11

Human-AI Interfaces are a Central Component of Trustworthy AI



Markus Plass, Michaela Kargl, Theodore Evans, Luka Brcic, Peter Regitnig, Christian Geißler, Rita Carvalho, Christoph Jansen, Norman Zerbe, Andreas Holzinger, and Heimo Müller

Abstract This chapter demonstrates the crucial role that human-AI interfaces play in conveying the trustworthiness of AI solutions to their users. Explainability is a central component of such interfaces, particularly in high-stake domains where human oversight is essential: justice, finance, security, and medicine. To successfully build and communicate trustworthiness, a user-centered approach to the design and development of AI solutions and their human interfaces is essential. In this chapter, we explain how proven methods for stakeholder analysis and user testing from human-computer interaction (HCI) research can be adapted to human-AI interaction (HAI) in support of this goal. The practical implementation of a user-centric approach is described within the context of AI applications in computational pathology.

11.1 Introduction

The prevalence of Artificial Intelligence (AI) in daily life is ever-increasing. It is integrated into smartphones and consumer goods, transforming the role of the user (Harper et al. 2020) and the human-machine interface. While the traditional human-computer interface simply represents the input-output (I/O) surface of a device (Holzinger 2004), or web page (Ebner et al. 2007), human-AI interfaces transcend the simple I/O paradigm. Besides enabling intelligent interaction via voice or facial recognition, human-AI interfaces can learn from users' behavior, react adaptively, and make predictions about future actions (Holzinger et al. 2022). Accordingly, the scope and challenges of Human-AI Interaction (HAI) research (Xu et al. 2021) differs from that of the traditional field of Human-Computer Interaction (HCI) (Dix et al. 1993). For example: AI chatbots can express human-like communication behavior (Przegalinska et al. 2019); AI-based natural language translation systems show contextual understanding (LeCun et al. 2022); AI-based programs for music co-

M. Plass (✉) · M. Kargl · T. Evans · L. Brcic · P. Regitnig · C. Geißler · R. Carvalho · C. Jansen · N. Zerbe · A. Holzinger · H. Müller
Medical University Graz, Graz, Austria
e-mail: markus.plass@medunigraz.at

creation can generate non-deterministic output (Louie et al. 2020); AI systems can collaborate with humans in teams (Calero Valdez et al. 2012; Robert et al. 2016), augment human intelligence (Crisan and Correll 2021; Holzinger 2016), and continuously learn from user behavior (Ortigosa et al. 2014).

AI has the potential to bring about a range of benefits to society, support individual and social well-being, enhance innovation and progress, and help to realize sustainable development goals (European Commission, Directorate-General for Communications Networks, Content and Technology, 2019). Regarding the case in point, AI applications in healthcare support personalized and precision medicine, drug development, critical surgeries, clinical decision and diagnosis support, medical image processing, and early detection of disease (Rajpurkar et al. 2022).

However, alongside these opportunities, the broadening application of AI brings novel risks and side effects. Fear of negative consequences, whether misplaced or valid, may also result in underuse and/or over-regulation of AI systems, leading to opportunity costs for individuals and societies (Floridi et al. 2018). Therefore, both benefits and risks must be addressed adequately to give people and societies the confidence to accept AI-based solutions, and to trust in their development, deployment, and usage, even in areas where stakes are high, such as medicine, justice, finance, and security. The trustworthiness of AI systems is a prerequisite for their uptake (European Commission 2021).

According to the *High-Level Expert Group on AI*, established by the European Commission in 2018, trustworthy AI has three components (European Commission, Directorate-General for Communications Networks, Content and Technology 2019):

- (a) it should be compliant with the law
- (b) it should be robust (i.e., safe, secure, and reliable to not cause unintentional harm)
- (c) it should be in alignment with the four ethical principles respect for human autonomy, prevention of harm, fairness, and explicability.

This book chapter illustrates the central role that explainability and human-AI interfaces play in realizing, communicating, and verifying the trustworthiness of AI systems and the importance of a user-centered approach to the design and development of these components. The next section describes regulatory requirements for trustworthy AI and the role of human-AI interfaces in fulfilling these. Section 11.3 discusses explicability as one of the core components of trustworthy AI, and demonstrates that explainable AI is key to building trustworthiness. Section 11.4 explains why a user-centered approach is essential for achieving highly explainable and trustworthy AI systems and introduces stakeholder analysis, personas, and user-testing as valuable methods aiding user-centered design and development of AI solutions. Section 11.5 shows, with the aid of the use-case of AI applications in computational pathology, how these methods can be applied to develop human-AI interfaces that support trustworthiness.

11.2 Regulatory Requirements for Trustworthy AI

As described above, one of the three components of trustworthy AI is compliance with the law (European Commission, Directorate-General for Communications Networks, Content and Technology 2019). The *Artificial Intelligence Act* (European Commission 2021) proposed by the European Commission in 2021 is the first legal framework aimed specifically at fostering AI trustworthiness. It sets out requirements that are mandatory for all AI systems that pose significant risks to the health and safety or fundamental rights of persons (European Commission 2021). Communication to the users is a recurring feature in many of the requirements stipulated. Thus, human-AI interfaces play a central role in the fulfillment of these requirements, as illustrated in the following paragraphs:

Communicate the AI system’s intended purpose and associated risks: Point 4 of article 9 ‘Risk management system’ of the Artificial Intelligence Act specifies: *“The risk management measures ... shall be such that any residual risk ... is judged acceptable, provided that the AI system is used in accordance with its intended purpose or under conditions of reasonably foreseeable misuse. Those residual risks shall be communicated to the user”* (European Commission 2021). To meet this requirement, human-AI interfaces must clearly communicate to users the intended purpose of an AI system as well as the residual risks associated with its usage.

Communicate the AI system’s result and all information needed for its interpretation: Point 1 of article 13 ‘Transparency and provision of information to users’ of the Artificial Intelligence Act states: *“AI systems shall be designed and developed in such a way to ensure that their operation is sufficiently transparent to enable users to interpret the system’s output and use it appropriately. An appropriate type and degree of transparency shall be ensured, with a view to achieving compliance with the relevant obligations of the user and the provider”* (European Commission 2021). To support these demands, human-AI interfaces must clearly communicate to users the AI system’s output together with all information needed for the correct interpretation of this output.

Communicate instructions for use of the AI system: Point 2 of article 13 of the Artificial Intelligence Act demands: *“AI systems shall be accompanied by instructions for use ... that include concise, complete, correct and clear information that is relevant, accessible and comprehensible to users”* (European Commission 2021); and point 3 of article 13 of the Artificial Intelligence Act specifies in detail all information that shall be included in these instructions for use, such as for example *“identity and the contact details of the provider ... characteristics, capabilities, and limitations of performance of the high-risk AI system ... human oversight measures ... expected lifetime of the high-risk AI system and any necessary maintenance and care measures to ensure the proper functioning of that AI system”* (European Commission 2021). Human-AI interfaces can help to fulfill this requirement either by providing information on how to access the instructions for use or by conveying all information constituting instructions for use to the user directly.

Support human oversight of the AI system: Article 14 of the Artificial Intelligence Act calls for ‘human oversight’, and explicitly mentions the important role of the human-machine interface as a tool enabling humans to complete this task: “*AI systems shall be designed and developed in such a way, including with appropriate human-machine interface tools that they can be effectively overseen by natural persons during the period in which the AI system is in use*” (European Commission 2021). Point 4 of article 14 describes in detail all functionalities and features that human-AI interfaces must provide to support human oversight: According to point 4 of article 14, AI systems “*shall enable the individuals to whom human oversight is assigned to do the following:*

- (a) *fully understand the capacities and limitations of the high-risk AI system ...;*
- (b) *remain aware of the possible tendency of automatically relying or over-relying on the [AI system’s] output (‘automation bias’), ...*
- (c) *be able to correctly interpret the AI system’s output, taking into account in particular the characteristics of the system and the interpretation tools and methods available;*
- (d) *be able to decide, in any particular situation, not to use the AI system or otherwise disregard, override or reverse the output of the AI system;*
- (e) *be able to intervene on the operation of the AI system or interrupt the system”* (European Commission 2021).

Support the AI system’s cybersecurity: Article 15 ‘Accuracy, robustness and cybersecurity’ of the Artificial Intelligence Act requires that “*AI systems shall be designed and developed in such a way that they achieve, in the light of their intended purpose, an appropriate level of ... cybersecurity*” (European Commission 2021). Human-AI interfaces have important functions with respect to the AI system’s vulnerability to cyber-attacks, for example, by enabling user authentication or by conveying security alerts to the user.

Communicate the AI system’s accuracy: Article 15 ‘Accuracy, robustness and cybersecurity’ of the Artificial Intelligence Act specifies “*AI systems shall be designed and developed in such a way that they achieve, in the light of their intended purpose, an appropriate level of accuracy The levels of accuracy and the relevant accuracy metrics ... shall be declared in the accompanying instructions of use*” (European Commission 2021). This means that human-AI interfaces shall always provide the user with information about the system’s current accuracy so that the user can assess whether or not this level of accuracy is appropriate for the task at hand.

Support robustness of the AI system and prevent user errors Point 3 of article 15 of the Artificial Intelligence Act calls for an AI system’s robustness and fault tolerance also specifically with respect to user errors: “*AI systems shall be resilient as regards errors, faults or inconsistencies that may occur within the system or the environment in which the system operates, in particular due to their interaction with natural persons or other systems*”(European Commission 2021). To fulfill this requirement, the human-AI interface on the one hand plays an important role in providing clear but

graceful feedback to the user when a user-error has occurred. On the other hand, as we know from usability research (Norman 2013) that the human-machine interface is also crucial for preventing the user from both conscious mistakes and unconscious slips during their interaction with the system.

11.3 Explicability—An Ethical Principle for Trustworthy AI

Compliance with the law is only one of the three components of trustworthy AI. Another is adherence to ethical principles and values, of which four are explicitly named by the High-Level Expert Group on AI: three traditional bioethics principles (human autonomy, prevention of harm, and fairness), which are in turn based on those described in the Charter of Fundamental Rights of the European Union (European Parliament, the Council and the Commission 2012), and a fourth: *explicability* (European Commission, Directorate-General for Communications Networks, Content and Technology 2019).

Explicability is a new ethics principle specifically relating to AI. It relates to the tendency for AI systems to act on the basis of complex internal processes that are invisible and/or unintelligible to humans (Floridi et al. 2018), rendering their decision-making processes difficult to understand, interpret, and explain (Holzinger et al. 2017). These are crucial issues for trustworthiness, validation, and acceptance of AI (Ziefle et al. 2013). According to Floridi et al. (2018), explicability recognizes the need to understand and hold to account the decision-making processes of AI.

To address the challenge of explicability, the field of *explainable AI* (XAI) research strives to provide insights into how a given AI model works and why it generates a particular result (Holzinger et al. 2018; Longo et al. 2020). There is a jumble of terms related to this concept in the XAI literature: with the terms explainability and interpretability often being used interchangeably (Zhou et al. 2021). Moreover, a variety of terms, including *transparency*, *accountability*, *intelligibility*, *understandability*, and *interpretability*, *comprehensibility* are used, sometimes interchangeably, sometimes with subtle differences in meaning that vary according to author. Other times, these terms are used without defining their specific meaning, or with one same term used for different meanings, or many different terms all referring to the same concept (Lipton 2018).

Gilpin et al. (2018) describe the concept of explainability as a combination of *interpretability* and *fidelity*, both of which are needed to achieve explainability. Here, interpretability refers to how understandable an explanation is for a human, and fidelity describes how accurately an explanation depicts the behavior of the AI model over the entire feature space. However, this often entails a trade-off between these two qualities, whereby it is difficult to simultaneously achieve both high interpretability and high fidelity: The most comprehensive explanation may not be easily interpreted by a human, and an intuitive explanation may not be sufficiently complete in its