Carte Semiotiche 2024/2

Interfacce

Forme dell'accesso e dispositivi d'intermediazione

la casa USHER

Carte Semiotiche

Rivista Internazionale di Semiotica e Teoria dell'Immagine
Annali 11 - 2024/2

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A cura di
Valeria Burgio e Valentina Manchia

Scritti di
Beato, Bellantuono, Cesaro, Ciaramitaro,
Federico, Reyes, Sanfilippo, Vignali
Zannoni, Zingale, Zinna

la casa USHER

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Sommario

Interfacce.
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Introduzione
Per un'opacizzazione dell'interfaccia *7*
Valeria Burgio e Valentina Manchia

Le design des interfaces entre écriture et supports.
Pour une archéologie des objets d'écriture *17*
Alessandro Zinna

Characterizing AI in media software:
an interdisciplinary approach to user interfaces *36*
Everardo Reyes

L'interfaccia scomparsa.
Ovvero, l'infopoesia come visualizzazione divergente *50*
Salvatore Zingale e Arianna Bellantuono

La relazione dialettica tra agenti umani e agenti digitali
mediata dal design dell'interazione *68*
Michele Zannoni e Virginia Vignali

Tradire le interfacce estrattive.
Le tecnologie persuasive al confronto con i manifesti
di attivismo post-digitale *79*
Mario Ciaramitaro

La domanda è mal posta.
Il dialogo creativo nelle interfacce conversazionali *93*
Martina Federico

Il corpo performático come interfaccia organica
nel teatro e nel cinema *110*
Massimo Roberto Beato

3x3x6: Control Strategies and Surveillance Art *137*
Laura Cesaro

Ibridazione e co-autorialità tra umano e non-umano:
il lavoro artistico di Sougwen Chung *152*
Noemi Rita Sanfilippo

Characterizing AI in media software: an interdisciplinary approach to user interfaces

Everardo Reyes

Abstract

This article explores the user interface as a cultural manifestation where AI technologies and media software converge. We adopt an interdisciplinary perspective that draws upon semiotics, information, and communication sciences. We start by examining media software as an information system in which user interactions are categorized into four functional types: generic, specialized, innovative, and critical. Each category corresponds to different levels of user engagement and expectation. Then, the article traces main milestones in the evolution of AI, from early rule-based systems to modern machine learning algorithms, highlighting their integration into everyday media software. The concept of Human-Centered AI (HCAI) is discussed to emphasize the importance of design patterns that prioritize user experience. An analytical model is proposed to dissect AI user interfaces, uncovering the multiple layers of meaning they convey. The article concludes by advocating for practice-based exploratory methods to engage with AI, suggesting that a closer interaction with these interfaces can help to better understand the effects of digital technologies in our cultural practices.

Keywords: Artificial Intelligence, Information Systems, User Interfaces, Digital Semiotics, Human-Computer Interaction, Human-Centered AI.

1. Introduction

As we witness an increasing adoption of artificial intelligence (AI) technologies in everyday software applications (such as desktop programs, mobile apps, web apps), in this article we use an interdisciplinary approach to address the close relationship of AI and media software, especially through the looking glass of user interfaces. Overall speaking, media software is conceived as a type of information system that integrates a collection of different entities (people, procedures, and equipment) and designed to support five essential tasks: collecting, storing, processing, controlling, and communicating information. The standpoint of information systems facilitates to take into account the technical components of media software within a practical context. In general, the notion of media software refer to «application software for media authoring and editing» (Manovich 2013: 205); it is associated to creative practices that have become pervasive for professional and

common users: reading news, writing messages, sharing opinions, taking photos, editing images, self-curating generated content, to mention only a few.
In section 2, we describe information systems and their uses. As software applications became more accessible to general public, their initial use -which was highly specialized-, gave rise to general purpose uses. Besides these two types, other uses can be accommodated considering insights from semiotics and communication sciences. Then, in section 3, we observe general functionalities of AI in information systems, offering a brief historical review and discussing recent human-centered AI trends. In section 4, we put in practice our typology of uses and we identify four major types of AI user interfaces based on the actions they support. In the last part, we advance a practice-based approach to AI with the intention to facilitate exploratory and experimental methods to engage with these technologies.

2. Information systems and their uses

Historically, information systems are defined as an assembly of actors, procedures, and technologies (Teichroew 2003) that support five essential tasks: collecting, storing, processing, controlling, and communicating information (Reyes 2022). In relation to media software, the entry point of information systems helps to emphasize specific characteristics of informational technologies, such as the nature of different technical components (software, hardware), their structured organization (data, processes), and the levels of specialization commonly required to deal with practical uses (people, organizations). An applied example can be seen in Table 1, which correlates the five essential tasks to some information areas and their common operations.

Essential Task	Domain of Specialization	Operations
To collect	Information retrieval, data mining, data capture.	Input routines, extracting data, curating information.
To store	Document management, file classification, digital archiving.	Managing memory, naming, managing files, protecting, encrypting.
To process	Information modeling, Indexation, Information management, data analytics.	Processing, filtering, ordering, organizing, transforming, data cleansing.
To communicate	Information and knowledge representation, human-computer interaction, information theory, data visualization.	Output routines, generating media (text, image, audio, video), displaying media, transmitting information, addressing, routing.
To control	Digital networks, neural networks, deep learning, cybernetics, automation and robotics.	Feedback, self-regulating, automating, supervised/unsupervised learning, reinforcement learning, genetic algorithms, real-time monitoring, predictive maintenance.

Table 1. Tasks, Domains, and Practices in Information Systems

In practice, the five essential tasks are correlated and affect mutually each other. This means that, for example, a specialist working on a routine to process information depends on the hardware on which the program will run and the data resources at disposition. Although a given user is not always aware of the hardware and data resources while working on a task, the dependencies become more evident when errors, glitches, and bugs occur. In principle, it could be possible to imagine an inventory of technical components required to perform a task, although such list could vary in extension and complexity according to the technical levels of interest for the analysis. In this respect, we will individualize certain components in Section 4 for discussion of a specific case.
Although Table 1 may seem technical, the input/output communication process can be understood as two interrelated sides owing to the theories from information and communication sciences: the «production side» and the «reception side». For example, the well-known communicative functions elaborated by linguist Roman Jakobson (1960) were derived the elements of an interaction process: a sender, a receiver, the message, the context, the channel, and the material aspect of the language. In this framework, a message carries a communicative intention based on the element that is emphasized. The function can be «expressive» when the accent is on the sender, «imperative» when it is on the receiver, «phatic» (the channel), «metalinguistic» (the language itself), «referential» (the context), or «poetic» (the message itself). Often, an interaction process reflects multiple dimensions, but there is always one that takes higher priority in a hierarchical scale. Using this terminology, we can easily observe the «production side» is performed by the sender and the «reception side» is located on the side of the user. The other elements of this scheme can be related to the technical components of information systems (data, protocols, formats, and media).
Over time, Jakobson's theory of communicative functions paved the way for a broader comprehension of the roles, modes, and types of communication. For instance, in interactive and dynamic systems, the role of the user has been seen as a co-producer of content. Another case is the consideration that any interaction process can be seen as a communicative process, as long as interpretation, intentions, and common codes are invited to participate. Furthermore, philosopher Michel Serres (2007) has noted that the actions performed by a sender or a producer do not have to be related exclusively to human agents, but also to organic, technical, and non-living entities.

2.1. A typology of uses

On the reception side, the different manners in which a user interacts with an information system can be organized into types of uses. There are generally two main types of application software: specialized and general purpose. The former derives from early computers, which were designed to solve specific problems and whose electronic components were physically wired for specific algorithms. Later, with the idea of universal computers, the architecture supported the storage of instructions and the execution of different algorithms on universal hardware.
One of the major advancements in the general use of computers came with the consolidation of graphical user interfaces in the Macintosh system, introduced in 1984 and mainly the product of research at Xerox PARC. With the support of authoring and editing media, computers naturally attracted an audience of creative professionals and amateurs. Not surprisingly, the development of media software

took place in the same decade of 1980s. From dedicated software to edit images, to word processors, print design, 3D graphics, web pages, and interactive kiosks. While, over time, creative uses eventually develop styles and conventions, there are also emerging critical uses that aim to go beyond or circumvent the expected functionalities of media software. In this respect, digital art and hacking are two fields where subjective perspectives have encouraged a critical examination of technology's effects on art and society. From this account, a first non-exhaustive typology of uses can include four configurations of practices:

1. general purpose: typically expected by common users across all platforms;
2. specialized actions: address particular needs from one domain or a disciplinary area;
3. innovative actions: emerge once the system is in the social circuit, including those that would not have been easily anticipated at the beginning;
4. critical actions make the system to operate in an opposite manner to its original intention. This type also includes a resistance to digital practices, like refusing to use a system.

This typology has its roots in the work of the scholar Michel de Certeau and in the media theorist Alexander Galloway. While the former was interested in the analysis of culture and the users' tactics to deflect or hijack the space organized by the techniques of socio-cultural production (De Certeau 1990), the latter suggests the study of digital media and their power relations of power. More precisely, Galloway distinguishes four regimes of signification at the heart of interfaces: 1) dominant; 2) privileged; 3) tolerated; and, 4) sidelined (Galloway 2012).
Moreover, these departing configuration can be useful to sketch an analytical terrain to visualize the actions in relation to their communicative function (Fig. 1). To do so, we use the properties of the objects and their associated practices as two axes to structure our diagram.

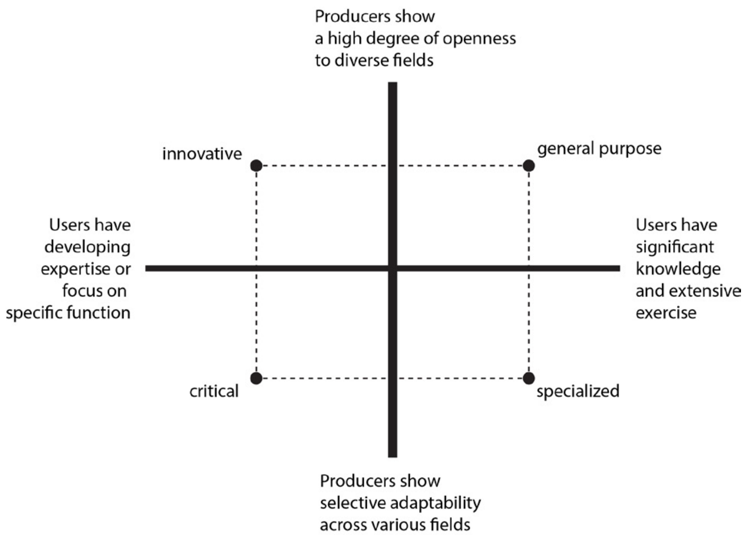

Fig 1. An analytical terrain

On the horizontal axis, we move from practices to uses, illustrating a progression from «developing expertise» to «significant knowledge». Research in instrument ergonomics often distinguishes between uses, practices, and knowledge, viewing them as progressive levels of user engagement with technical objects (Rabardel & Bourmaud 2003). This progression is similar to the state of 'concretization' that philosopher Gilbert Simondon (1958) describes, where an object and its user achieve harmonious cooperation.

On the vertical axis, we place a scale of modal, thematic, and figurative configurations, reflecting the influence of various disciplines and domains in shaping the technical components. In other words, this vertical scale ranges from «selective adaptability» to a 'high degree of openness' in terms of multidisciplinary and multicultural dialogue.

In sum, we propose that, at an entry level, the horizontal axis highlights practices of reception, interpretation, and adoption, while the vertical axis focuses on emission, production, and creation. In section 4, we use this scheme to discuss an applied case study.

3. Characterizing AI functionalities

In this section, we propose studying AI through its technical components to uncover critical insights about their interrelationships.

In a similar way that software applications have become pervasive in our everyday lives, AI functionalities are increasingly implemented in media software. However, we shall first clarify what kind of AI are we interested in investigating. Historically, there have been two main purposes of an AI system: first, to automate a repetitive task, and second, to augment or amplify the possibilities of a human user. These purposes are present in the two main types of AI: domain-specific AI versus artificial general intelligence (AGI).

While AGI implies a higher level of autonomy and self-organization, at the time of writing these lines, it has not yet been developed and it is rather the source of debates over ethical issues, although enthusiastic progress was reached by the end of 2022, with newer versions of Large Language Models (LLMs). In its current state, AI is primarily focused on addressing specific concerns. For example, explainable AI (XAI) is interested in making explicit the computing processes behind the output of an AI routine (Storey et al. 2022); wet AI (WAI) is interested in synthetic forms of life using biochemistry and molecular biology materials (Fellermann 2011), and human-centered AI (HCAI) provides a framework to think, design, and evaluate AI tools (Shneiderman 2022).

Our focus is on AI as applied in media software, specifically through technical components like user interfaces and their material substrates. This is to say that hardware, software, data, and practices interact with each other producing emerging properties. In these processes, AI evolves in terms of technical components but also in terms of the metaphors that define them. As with any computer or information system, AI needs to be used in order to exist, otherwise its mode of existence remains an abstract model waiting to be materialized.

3.1 Brief evolution of AI as user interface

AI technologies have evolved alongside the development of information systems. As we will see, this evolution suggests an integration of AI into the structure and functionality of information systems. For example, at the level of data, machine learning algorithms are used to improve the efficiency of data processing, enabling real-time analytics for decision-making. At the level of instructions, AI can help automate routines and to anticipate new tasks in advance. At the level of user interfaces, AI is contributing to the flourishing of virtual assistants and chatbots that amplify user interactions and experiences, providing personalized and context-aware responses.

While the first bricks of AI were laid down in the mid-1950s, the first integrations in the form of graphical user interfaces came to life in the 1960s, with the introduction of expert systems, which used rule-based logic to imitate the decision-making abilities of a human expert. At that time, GUIs had the form of text-based and command-line interfaces (CLI) whose AI functionalities were largely hidden from the user.

In the 1980s, when Alan Kay and his team at Xerox PARC introduced many of the GUI paradigms still in use today – such as the WIMP interface (windows, icons, mouse, and pointers), the UI became more intuitive for the average user. At the time, much of the AI research was happening in the background, enhancing functionalities like spell checkers or simple recommendation systems. Later, in the 1990s, AI began to be integrated into mainstream software applications. For instance, Microsoft Office introduced Clippy, an early AI-powered assistant that leveraged basic natural language processing and pattern recognition to guide users through common office tasks.

Since the 2000s, the Internet and network technologies have become the primary stage for AI innovation, transforming the way we encounter AI in our everyday lives. Search engines and recommendation systems materialize AI through personalized content that provides relevant results and suggestions to each individual user. In email clients, AI filters spam and suggests replies. Another example is smart assistants such as Siri, Alexa, and ChatGPT, which use voice recognition and natural language processing to interact with users through conversational interfaces.

More recently, the predictive analytics capabilities of AI can be perceived in media platforms such as Spotify and Netflix, which create personalized playlists. Another case is AI-driven chatbots that handle customer service requests, often integrated into websites and mobile apps (from airlines to banks, schools, stores, and games). Another important field is cultural software: in photo-editing apps, AI is behind features such as color correction, facial recognition, and automatic tagging.

This short review reminds us that AI has sometimes been used in ways that go unnoticed. Likewise, users today consume content without certainty that it has been generated by AI, from visual backgrounds and textures, to digital actors, voices, music, and video editing.

3.2 Human-centered AI (HCAI) patterns

Computer scientist Ben Shneiderman, a prominent figure in the field of human-computer interaction, introduced the idea of HCAI to move beyond the traditional engineering and algorithm-focused view of AI. His motivation is guided by the goal to embrace a human-centered perspective that «can shape the future of technology so as to better serve human needs» (Shneiderman 2022: 3).

In this sense, we speak of «UI patterns» as recurring situations that include expected functions of an information system. Design patterns are common in

architecture and urbanism (Alexander 1977), as well as in interface design (Tidwell 2011). Shneiderman elaborates a pattern language for HCAI consisting of solutions to common design problems. Instead of formulating exactly which UI element or technical component to use, a pattern is presented as a general guideline. For example, the pattern «overview first, zoom and filter, then details-on-demand» refers to displaying the whole picture to the user, even if it is difficult to grasp at first sight, and then allowing them to interact with it by filtering and zooming. Once the attention is focused on a single item, the information details about it can be displayed.
The HCAI patterns derive from four pairs of design possibilities that emerge from the two main purposes of an AI system: automating and augmenting. Table 2 summarizes the four pairs adapted from Shneiderman (2022: 84).

First pair	design of intelligent agents (cognitive actors, thinking machines)	design of supertools (empowering users, extending abilities)
Second pair	teammates (collaborators, smart partners)	telebots (steerable instruments)
Third pair	autonomy	control
Fourth pair	connected objects (like anthropomorphic social robots)	low-cost active appliances for wide use and consumption

Table 2. Four pairs of design possibilities that impact HCAI patterns

In our view, these design recommendations influence the design of user interfaces directly or indirectly, regardless of their type. Whether designing a new controller for AR smart glasses or adapting an interface element from one device to another, the goal is to create user interfaces that are comprehensible and predictable for typical users. Designers are expected to find a balance between providing a high level of user control and a high level of automation. In this regard, a notable example is the ability to dismiss smart suggestions, allowing users to continue interacting with the system in a non-intrusive manner.
As mentioned, automating and augmenting are two main purposes of an AI system, and new metaphors are developed to convey these concepts within user interfaces. Let's consider the adjective «magic», already present in tools like the «magic wand» in Photoshop since the late 1980s. Today, web apps and digital tools include steadily more the magic icon as a visual element that indicates the presence of AI-driven features, a special functionality meant to surprise and delight the user and to enhance the overall experience. The «magic wand» conveys broadly creation, transformation, and content generation. Besides this indexical icon, we can cite the «sparkling pen» that stands for text generation or enhancement, the «starburst palette» that suggests artistic or design generation, the «glowing microphone» for AI-generated audio or voice content, and the «enchanted book» that represents AI-generated storytelling or content creation. Following this line, other icons may appear to convey the meaning of potential harmful content generated with AI, or detecting fake news, plagiarism, and phishing, within media software itself.

4. AI in media software UI

In this part we put in practice the analytical terrain described in section 2.1. In doing so, we will first make two methodological remarks. This is important as the type of media software we will explore is in web format.

For us, it is first necessary to distinguish between at least two levels of representation. In a web-based environment, the UI signs visible on the computer screen exist at the surface level. However, these signs are created and defined at the level of programming languages, where HTML tags and other elements are used. We can therefore distinguish between the web-based interface itself and, on the other hand, the web technologies and technical programming languages that enable it. While the most common web languages are HTML, CSS, and JavaScript, the modern web is a complex information system that includes APIs, libraries, services, and algorithms. In addition, the web has evolved into a platform and environment that supports more advanced programming languages such as Python, R, and WebGL. Therefore, as we will discuss below, a designer may not use the same web technologies to build a data visualization as to create an AI-powered chatbot.

The second remark involves considering at least three layers of meaning that converge simultaneously within a user interface. As we have noted elsewhere (Reyes 2022), information systems are polysemic in the sense that they convey a message at three different layers. First, the «technical» layer where components mean their functionality and coherently perform their promised actions. Second, the «domain-specific» layer where signs and symbols follow the terms and conventions of a determined group of users. Third, the «cultural» layer, where the system is considered as a whole and its stance in respect to broader societal trends, such as accessibility, minorities, healthcare, cybersecurity, emerging technologies, and ecology.

4.1. An analytical terrain for AI UI

In applying our analytical terrain, our account begins with the *general-purpose* actions implemented in major AI services. These actions can be observed as modules integrated into commercial software, ranging from text suggestions (such as Smart Compose in Gmail) to generative image features (like in-painting and visual filters). In other cases, the system itself embodies the entire category. OpenAI's ChatGPT is an example that has attracted millions of users, meeting and often exceeding expectations. The generic-purpose category identifies a dominant class of systems whose functions perform as expected (with interfaces that remain faithful to user expectations) and adhere to current design trends, such as minimalism and responsive design.

The second category encompasses *specialized actions*. In these cases, systems prioritize technical functions over potential applications across broader domains. This does not mean that specialized systems ignore other potential purposes or unintended consequences; rather, these applications are considered secondary and typically emerge after the system has been developed. Examples of this category can be found in the research departments of specialized companies and the research labs of universities. Nvidia, for instance, the leading designer and developer of GPUs, publishes prototypes and experiments in its AI Playground, where technical achievements are showcased as demos. Additional examples can be found in conference papers published in specialized venues such as SIGGRAPH, AAAI, NeurIPS, and ICCV.

The third type is characterized by *innovative actions* that emerge once the system enters the social circuit. Unlike the previous category, the emphasis is on the uses, the media, and the message being conveyed. In other words, technical functionality is shaped by the needs of the content. This is not to suggest that technical functionality is unimportant; rather, technical flaws are more readily tolerated if they serve the content's purpose. In our view, notable examples of this category can be found in interdisciplinary projects within the fields of digital humanities and cultural analytics (Leblanc 2024, Ohm et al. 2023). Additional examples can be found within the open-source software community and start-ups developing innovative tools. Social networks prove valuable for exploring trends and recent projects (Dibia 2021, Cherny 2017).

The fourth type includes *critical actions* that question both uses and components. This group includes explicit efforts to challenge the use of information systems, either because of limited access to technical components or as a deliberate stance to critique their messages and effects. Examples of this category can be found in the realm of digital arts, as well as within hacker, maker (DIY), and low-tech communities. Andersen and Pold, for instance, discuss the embedded values, ideologies, and politics present in technical components, referring to them as «metainterface» (Andersen & Pold 2018). The significance of critical artworks, they claim, lies in examining their own materiality and corporate production.

In Fig. 2, we apply our analytical framework to identify services and systems that illustrate the four functions discussed in this section. As shown, this initial exercise takes a broad view of the technical components, and considers them as larger entities. However, a more detailed study could reveal more fundamental components. Additionally, the position of each instance on the map may vary depending on the layers of meaning they convey. In summary, our visual tool serves as a reference for creating more complex or dynamic maps of technical components, tailored to the specific aims of the analysis.

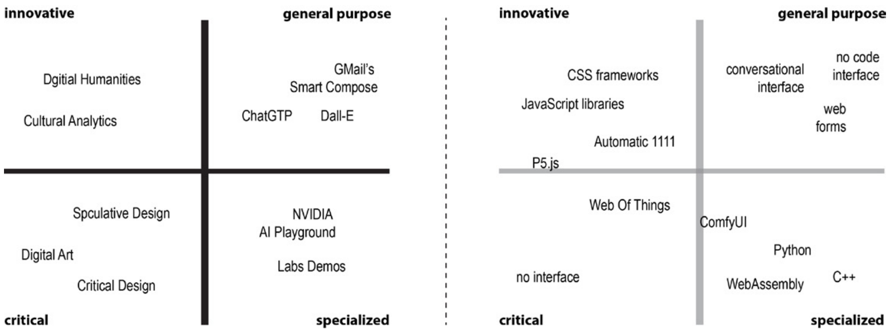

Fig. 2. A populated analytical terrain. The left section provides a broad overview of the technical components, while the right section focuses on more fundamental interface elements.

5. Practice-based experiments

In this final section, we aim to revisit the «production side» (cf. Section 2) to propose a practice-based perspective on AI, with the goal of supporting exploratory and experimental methods for engaging with the experience of these technologies. The objective is to challenge the discourses that portray AI as magical tools. Instead, we envision a scenario where users design their own prototypes or engage in practical exercises with the assistance of AI technologies. In other words, we are interested in exploring the experience of designing tools by interacting with web-based UI environments.

Let's start by experimenting with conversational interfaces, a broad category that includes generative media tools like ChatGPT. To illustrate a simple case, we will consider the design of a basic story generator using graphical interface elements, focusing on the technical components and how they are structured. Figure 3 (left) shows a screenshot of a simple generator created using ChatGPT 4.0. The prompt was intentionally broad to allow the program to make design choices. Our only instruction was to generate an HTML document using the Bootstrap framework. Despite its simplicity, this initial version encourages further exploration of additional UI patterns. More detail could be incorporated into the prompt if a user wanted to continue a conversational text-to-text experience. For instance, we could request compliance with accessibility recommendations, the inclusion of tooltips to indicate the function of each element, or an explanation of how the design was created. Finally, users can also share their prompts for reuse and remix.

We move on to exploring tools based on predefined packages that generate an interface, such as platforms like Hugging Face. Fig. 3, on the right, shows a generator that allows for parameter adjustments. This approach is often more appealing to intermediate users, frequently experienced with web-based user interfaces (like the Web UI AUTOMATIC 1111 for Stable Diffusion) or Python notebooks. Unlike conversational interfaces like ChatGPT, Hugging Face provides access to LLM libraries that users can leverage for more customized applications. Indeed, although the Python code of Fig. 3 (right) was also generated with ChatGPT 4.0 we asked in the prompt to specifically invoke the Gemini Vision module of Google Generative AI, which allows for the automatic analysis of texts and images.

Ultimately, higher-level production environments, such as ComfyUI, provide greater flexibility in terms of machine learning models and data modalities (e.g., text-to-text, image-to-text, text-to-image) but also require more technical expertise and familiarity with the terms and vocabulary used in visual computation, node-based programming, and generative media.

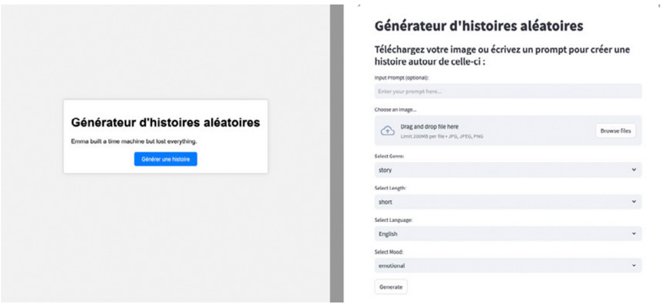

Fig. 3. Two examples of a graphical interface for an automatic story generator

Finally, we explore how these tools can be used in an alternative way to build scenarios that challenge cultural themes. Our graphical poetry series «Stein

Poems», initiated in 2016 (Reyes, Balpe & Szoniecky 2016), aims to materialize the random behavior of computer programs while emphasizing that the logical order is calculated before the actual user interaction, in the form of syntactic, formal, and spatial rules. In one of our recent creations, produced with the assistance of ChatGPT 4.0, the user presses the ENTER key to break down the poem into characters and must press it twice to return to the current state and discover that a new poem has been generated (Fig. 4). In this instance, we asked in the prompt to use the P5.js library to handle the graphical processing of text in the 3D space. Interface elements are intentionally minimal, allowing for an experience that highlights the unpredictable and emergent nature of interaction.

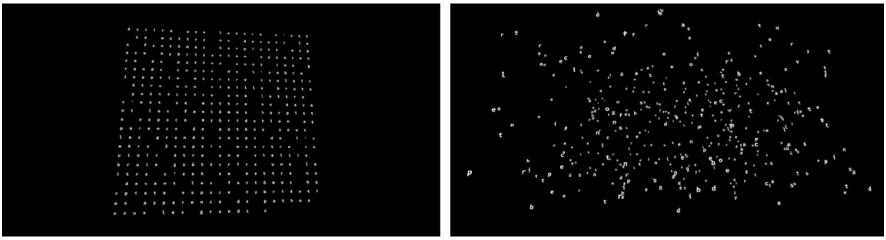

Fig. 4. Two states of a generative poem with minimal user interface

Overall, a practice-based approach contemplates the assistance of generative AI as an invitation to explore different visual variations and to produce new interactive experiences. The manipulation of GUI elements for reading and writing such creative works brings to light what we have called «interface logics» – patterns that combine spatial and visual configurations made up of interface components (Reyes 2017).

As we see, the user of generative AI tools is exposed to language and technical elements that require different kinds of engagement. In the case of chatbots and new UI icons (like the magic symbol), users delegate a wide range of technical decisions to the system. In the case of integrated design platforms (like Hugging Face), the interface is based on frameworks and the user trusts the AI models and libraries. At the highest level, users employ their deep technical knowledge (components, vocabulary, data) to achieve a greater degree of personalization in the output.

6. Conclusion

In this article, we have studied user interfaces as technical components of a particular type of information system: media software. An interdisciplinary approach, drawing on insights from semiotics and communication sciences, allowed us to distinguish between two sides of interaction and communication: the production side and the reception side. Seen as axes, these sides helped to outline an analytical framework for categorizing practices in relation to their communicative function.

AI technologies aimed at the general public, especially in the form of conversational interfaces, often promote a marketing discourse of «magic» around the user experience. However, while using commercial generative AI tools might indeed feel like magic, the type of interface we focus on concerns the production of generative media through web-based UI tools. These tools confront the user with a more complex interaction scheme that, in the end, offers the benefit of adjusting some parameters that exist under the hood of the magic hat. In this respect, a practice-based approach is helpful and it can be systematically carried on when it is supported on an interdisciplinary basis.

Generative media tools attract users to produce texts, images, audio, and 3D models with no-code or low-code experience. AI-powered platforms and web apps offer services enhanced by assistance, predictions, recommendations, and generation of content. Faced with these changes, it seems important to broaden our scale of observation in order to keep in mind that these advancements are based on a layer of technological infrastructure that is often imperceptible. In this article we have concentrated on interface elements, but deeper studies should take into account the field of computer science and engineering, including algorithm analysis, programming languages, data structures, digital and electronic design, networks and protocols, among other fields.

At the same time, it is essential to be sensitive to the effects and changes that AI introduces in society and culture. As the development of information technologies continues to diversify the types of interaction, the classic human-machine model is expanding to include a wider variety of devices and components. For example, the tactile interaction paradigm of a graphical interface is increasingly being replaced by voice and gestures, available in carry on devices and in the public space. To this end, the *innovative actions* and the *critical actions* explored and experimented within digital and emerging art, digital humanities, and cultural analytics remain valuable sources for interdisciplinary inspiration.

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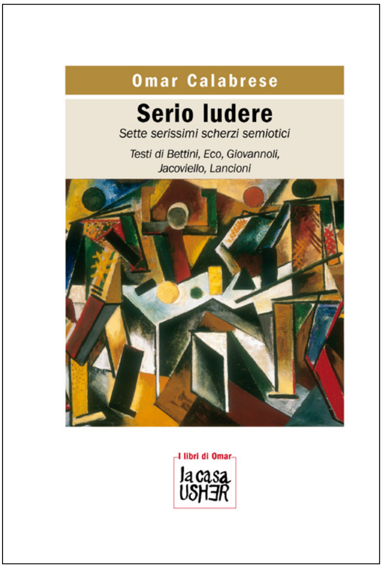

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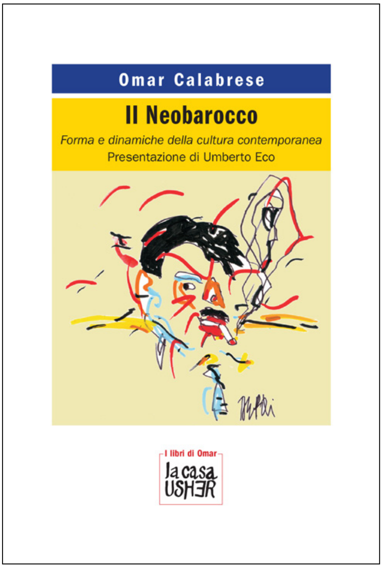

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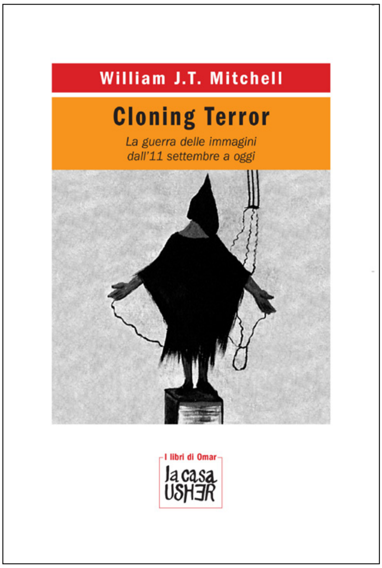

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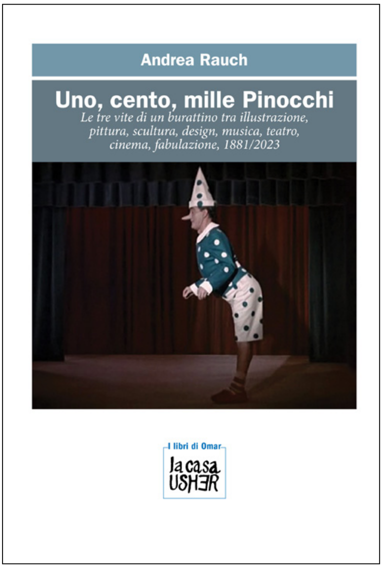

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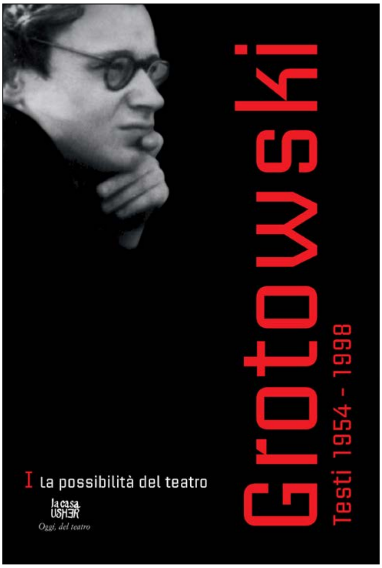

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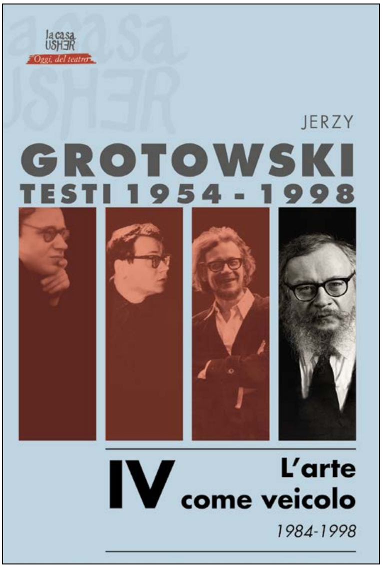

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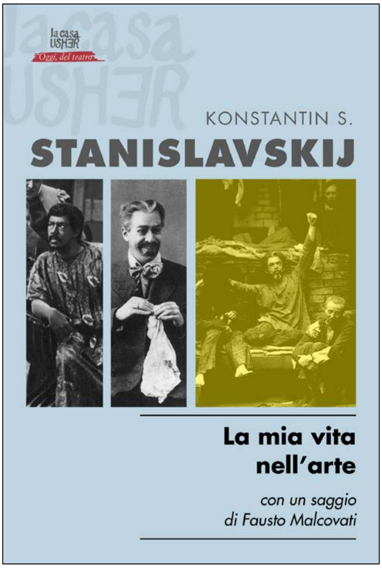

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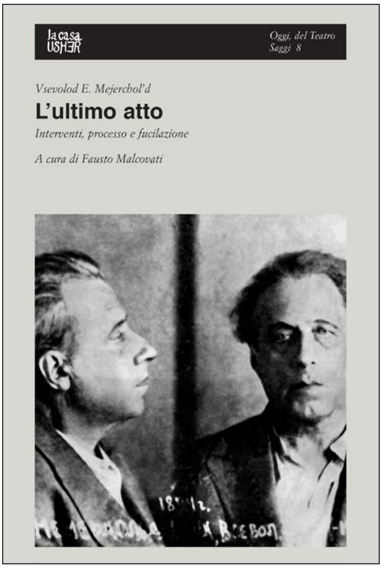

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