Deep Science Publishing, 2025
https://doi.org/10.70593/978-93-7185-625-6_3

Chapter 3: Designing Intelligent Web Interfaces for Interactive Human-Machine Collaboration

3.1. Introduction

Machine learning can reveal valuable patterns and facilitate practical problem-solving. Yet, it is not widely adapted to applications that benefit from interactive human-machine collaboration. The narrative behind these observed patterns can only be crafted in close collaboration with domain experts, who provide the required context to guide the discovery. Additionally, these methods also generate questions during the discovery process, which can invoke interactive workflows. These questions may touch on the credibility of a particular finding, exploration of hypotheses, supplementing data to support outcomes generated from sparse data, and so on. These patterns demand that practitioners not only help incorporate domain into models but also disseminate valuable findings, often backed by supporting evidence.

Machine learning is a powerful yet intricate cargo, which creates a pressing need to design interfaces that can engage practitioners at a diverse range of proficiency levels. It is also important to appreciate the diverse audience that may be interested in model outcomes. Due to the diversity in practitioners' roles, domain focus, and required technical expertise, it is not feasible to adopt a uniform level of technical complexity when creating such intelligent web interfaces. The necessary web interfaces can lead practitioners and domain experts at several levels of technical depth. Beyond practitioners, decision makers, interest groups, investors, etc., also desire a story around the data. They also look for reinforced explanations and better interpretations. These explanations require the flexibility that can be integrated into a dynamic storytelling environment. It is also important not to overlook the "data scientists." Given that data may be proliferated across different stakeholders or collaborators, there is a need for a lightweight means to convey a specific aspect of data in an easily interpretable dynamic report.

3.1.1. Overview of the Study

Recent advances in machine learning and natural language processing have laid the foundations for artificial intelligence (AI) systems. These ML methods can be part of recommender systems that provide users with appropriate recommendations for creative human activities. Web-based entertainment and creative activities, which are often part of social life, are especially important for storing and expressing human creative and emotional skills. As a result, the application of these technologies in the design of high-quality entertainment Web systems is being intensively investigated in data science, which opens up completely new ways of human enjoyment on the Web.

AI techniques have the potential to improve human-machine UX. Where AI is embedded in a real-world product, this can result in AI being a teammate. Applying AI to Web support activities like those described above can transform a product from a tool into an intelligent teammate. A key part of this study, therefore, is the integration of recommender-based AI into an interactive entertainment Web product as a means of creating an intelligent Web-based teammate. In doing so, a first step is the design of a generic AI-enhanced intelligent Web user experience, a design framework suitable for supporting intelligent Web-based teammates for interactive human-machine collaboration.

3.2. Theoretical Framework

The theoretical framework includes a definition of a theoretical approach explaining existing Intelligent Web Interfaces [1-3]. The presented definition is based on a comprehensive investigation of approaches that meet a certain class of properties for human-machine interaction. A foundation for the application aspects illustrates the influence of Intelligent Web Interfaces on task complexity, interaction mode, and the nature of the result of the collaboration. An exhaustive classification of these properties is derived and related to applications of advanced technology to support mission planning, simulation, and analysis in various complex fields.

Human-machine collaboration covers a variety of aspects easily discernible in real-world applications. The need for collaboration between a user and a machine depends on the corresponding complexity of the mission, typically described by several factors. These factors include the number of entities controlled, the degree of autonomy of the entities controlled, the mode of interaction between the entities controlled and the user, and the completion status of the mission goals when the user interacts.

3.2.1. Human-Machine Interaction Models

The coherent orchestration of human and machine agency in the World Wide Web demands the emergence of advanced conceptual interaction models and lightweight APIs enabling Add-AI interaction pattern adoption in AI-powered systems.

Fig 3 . 1 : Human-Machine Collaboration in AI-Powered Web Systems

These interaction models should support a wide range of functionalities (such as user experience management, human-machine task hand-off, or human knowledge exploitation) while preserving user proactivity in cooperation with AI techniques. As inference is central to many AI applications, it is crucial to keep either human knowledge or control at critical points of the process. Thus, interaction frameworks empowering human intervention in several AI inference contours should be applied. Finally, intelligent Web UI development is a major challenge in the Web domain, since it should provide users with a rich interactive experience adequate for collaboration with AI.

The emerging generation of AI paradigms—especially Semantic Web, Linked Data, and Deep Learning—achieves better support for human–computer cooperation by exploiting either human knowledge or data. In the former case, intelligence is embedded in the machine through human-in-the-loop strategies that facilitate human intervention in machine supervision, while in the latter, it is embedded in the human through machine-in-the-loop strategies that exploit many human contributions in the machine training.

Hence, advanced conceptual interaction models and lightweight APIs supporting hybrid inference processes must be prospected, allowing the design of intelligent web applications centered on integrating human, artificial, and machine intelligence. Such applications should perform intelligent Web UI planning and management, facilitating efficient and flexible exploitation of sensible human knowledge at critical points of the AI inference process for interactive human-in-the-loop Web engagement. Interaction at AI inference process contours is essential to develop hybrid inference models suitable for real domains (e.g., e-commerce, tourism) where HAIs form a critical aspect of human–machine collaboration.

3.2.2. Cognitive Load Theory

An important aim of designing and instructing an activity is to reduce extraneous cognitive load and facilitate germane cognitive load within the working memory of learners when performing cognitive tasks. Cognitive Load Theory (CLT) is an idea in cognitive psychology concerning the load on working memory during instruction. It was developed by John Sweller in the late 1980s. Working memory is a cognitive system that holds limited amounts of information for up to a few seconds and manipulates it. Intrinsic cognitive load is caused by the inherent complexity of the learning content. People need to divide the total amount of cognitive resources they allocate to tasks by the number of their interacting elements. Germane cognitive load depends on the use of working-memory resources for processing, construction, and automation of schemas. CLT focuses primarily on how instructional materials can be designed to reduce extraneous cognitive loads and manage intrinsic cognitive loads.

Three ways of measuring cognitive load are: measurement of learning outcomes and mental effort required, subjective rating of mental effort, and physiological responses to the information-instruction presented. The eye blink rate is positively correlated with working memory tasks and is proposed as an indicator of cognitive information processing. The pupil diameter also reflects the cognitive load, but does not accurately indicate the degree of cognitive processing. Regression models of eye gaze parameters, beginning with the controlled attention model, use linear combinations of eye-tracking parameters to predict the cognitive processing of visual stimuli.

3.3. Web Interface Design Principles

Intelligent web interfaces that enable interactive human-machine collaboration can be designed around a convergence of two design paradigms: adaptive automation and automation transparency. Adaptive automation calls for not only smarter automation but also smarter relationships with the human operator. Automation transparency calls for prudent sharing of automation intelligence with the human operator through dynamic information display and interaction.

In practice, human-centric design principles for automation transparency are applied and demonstrated through a design case study of an intelligent web interface, plug-and-play smart grid control centre. Specifically, an adaptive automation scheme that dynamically levels control centre automation based on the operator's task loads is supported by three automation transparency functions – explain automation, justify automation, and predict automation. The transparency functions are designed and assessed for their effects on a planned human-in-the-loop simulation that operationalizes the control centre as an interactive automated decision-making tool for contingency analysis and threat identification.

3.3.1. User-Centered Design

A key goal in interactive systems design is to render computer software usable. User-centered design (UCD) is a well-established, iterative design methodology that creates products that users can understand, learn, and use to perform tasks successfully. UCD uses continuous and extensive user participation in multiple design activities—planning and analysis, requirements gathering, design, and testing—to ensure that resulting products support users' cognitive and work processes. Users directly generate the functionality, interaction semantics, and look-and-feel of the product even before it is built. UCD is viewable as a "shadow" workflow extending the actual software construction V-model. Different project groups are responsible for the distinct activities of the two workflows. The engineering team carries out actual product construction, while the human factors group prepares users for each phase through carefully crafted work systems and continuous communication, training, and feedback. UCD is broadly applicable across project types and can be as elaborate as cost, schedule, and political imperatives dictate.

The majority of research undertaken in HCI and ergonomics delivers the results necessary to practitioners carrying out the user-centered design [2-4]. This discipline encompasses a coherent, integrated set of methods and techniques that implement newfound HCI/ergonomic knowledge through examination of the task and work environment, direct involvement of the users, and structured analysis addressing human cognitive and physical capabilities and limitations. Other proven user-centered design techniques include role-playing, wizard-of-oz simulation, heuristic evaluation, expert walkthroughs, and the application of, for example, established human memory, movement, and performance models.

3.3.2. Accessibility and Inclusivity

Accessibility and inclusivity constitute key factors in facilitating effective intelligent human–machine interaction. Without deliberate attention to these principles during smart interface design, expanding the technology's reach becomes challenging. People with diverse disabilities in vision, hearing, and mobility confront varying interaction-based limitations. For example, traditional windows and doors serve as door-to-door points for visual information delivery; however, real-time communication fails to satisfy the vision-impaired. Building an entrance relying on gestures circumvents window-opening difficulties, enabling interaction with volunteers and non-impaired individuals.

Providing directions for orientation in an unfamiliar environment is not simple, since the mobility-impaired can neither walk nor stand. An intelligent automated wheelchair equipped with an autonomous navigation system can detect obstacles and keep guided users safe. The main objective of intelligent interaction is to involve as many users as possible, regardless of differing factors or disability profiles. Smart interfaces that integrate additional services such as safety, security, and voice commands enhance interest in new application domains for contextual interaction. The next subchapter presents two automatic wheelchair navigation-provisioning systems designed especially for visually impaired people.

3.4. Intelligent Systems Overview

Interactive human-machine collaboration can be enhanced by designing web interfaces with integrated artificial intelligence (AI) back-end systems. Four such systems—Rabble, Whichbot, Orbiter, and Doctor—have each been developed for specific final users. These interact via multi-modal natural language with the AI and its knowledge base. To explore how very different applications are influenced by their nature and context, the four systems are examined across key dimensions influencing design. This reveals how the system-area, the user, communication mode(s), and medium all influence other aspects, such as AI techniques, complexity, naturalness, and specific design decisions.

AI technologies capable of human-like visual and linguistic capabilities open up new application areas with the potential for natural collaborative interaction with customers and users. Four AI systems that employ either natural language or vision-processing—or both—integrated through a web-based interface are examined. The area, the user, the communication modes, and the medium all influence the AI techniques employed, the degree of interaction achieved, and the specific design decisions taken. The four application areas are political engagement, general-purpose enquiry, autonomous guided navigation for vehicles, and medical diagnosis and interpretation. Each application area and its role for intelligent AI-based systems is presented, followed by the intelligent interactive system.

3.4.1. Artificial Intelligence in Web Interfaces

The web, the grandest medium for information delivery, contains a wealth of human information, knowledge, and wisdom. It can therefore be used actively on the World

Fig 3 . 2 : Intelligent Web and Web Mining Techniques

Wide Web. Intelligent agents, robots, and software with artificial intelligence techniques can be used on the Web to rapidly search and collect information, dispense it effectively, and apply it automatically to accomplish specific tasks. Users, especially search engines and online services, can find the intelligent Web useful. Although the Web is the greatest information resource, it is frequently unable to understand and cope with many hidden features, such as the semantically rich properties of search terms, users' interests, the different user profiles and habits, etc. These features help users to perform more efficient searches; they can be recognized and classified if the Web itself becomes intelligent.

The Web can be restructured with the help of information technology by using automated techniques of Web mining such as Web content mining, Web structure mining, and Web usage mining. Today's Web mining techniques have a limited scope. Presently, some automated techniques have evolved for Web content mining to manipulate multimedia data. Web agents can perform efficiently on the Web by exploiting the effects of robotic information retrieval models. They can automatically gather and organize relevant and useful information from the Web. All these techniques can be used in Web mining applications for effective business, e-commerce, education, etc., in day-to-day life.

3.4.2. Machine Learning Algorithms

Machine learning refers to statistical techniques that enable computers to perform tasks without being explicitly programmed.

Although machine learning encompasses a broad range of techniques, it is generally considered part of artificial intelligence. However, not all artificial intelligence involves machine learning.

3.5. Data Collection and Analysis

Data collection strategies should be developed and implemented in consideration of the intelligent design principles outlined earlier. User behavior can be investigated using web analytics tools that primarily offer quantitative insight. Alternatively, or in combination with such a tool, an eye-tracking system may be used to add qualitative information to the analysis. Strategic analysis of the user's interaction and cognitive load can provide a deeper understanding of the conditions that contribute to or result from the operation of a particular web interface.

Although data collection aims to ensure a successful operation of the interface and the application it connects to, such metadata may contain links to the individual identity or activity of the user. Investigators, engineers, and designers should be constantly aware of the policies governing the nature of unbound data, ways of linking information to individual participants, and the regulations of the jurisdiction within which they collect and use that data. All these considerations aim to design an intelligent web interface for interactive human-machine collaboration.

3.5.1. User Behavior Analytics

More companies measure user interactions with their digital products and services and base user experience decisions on data and analytics instead of subjective feelings and impressions. The behavior of real users is recorded, analyzed, and used later for improvements or for a redesign of the product. "User Behavior Analytics" (UBA) describes the processing of historical user interaction data for the purpose of deriving meaningful and actionable clusterings, prediction models, and characteristic user profiles that can be used in the actual user interaction.

UBA encompasses those aspects of a human–machine interactive system that collect and process interaction data and make the results available to the system for feature adaptation. UBA always evaluates the user interaction with the interface rather than the user’s whole lifecycle with a product or service. Keywords for this field of user data analysis are "analytics," "feature adaptation," and "context-awareness." Recently, the field of affective computing is closely related to UBA, since both are interpreting the user, the data, or emotions. However, where affective computing mainly focuses on emotion acquisition and emotion recognition, UBA is more concerned with the application of analytic methods to the collected emotion and behavior data. UBA can also be regarded as an intelligent feature of Internet-of-Things (IoT) ecosystems.

3.5.2. Ethical Considerations in Data Usage

The extent to which an intelligent system supports user tasks depends on the explored information about the users, which is crucial for enabling subsequent adaptation, personalization, and intelligent services. The economy of attention is a resource that needs to be well managed, but it serves the exploitation of the potential of profitable ideas, making users vulnerable to excessive exposure and manipulation through targeting. In addition, society demands the responsible use of users' data and cooperation with partners that follow a general set of human values and morals. While business models based on users' data are logical because data exploration is unavoidable for intelligent processing and related services, sensitive personal information should be handled with special care.

Recognizing the importance of privacy, regulations—such as the European Union's General Data Protection Regulation (GDPR) enacted in 2018—have come into force worldwide. They protect citizens when sensitive personal data is processed and grant users a variety of rights. These include the right to information about the processing activity, the right to confirm if the system holds sensitive personal data, the right to have it corrected or anonymized, and even the right to request its erasure. Applying these regulations in the actual design of an intelligent system is a challenging and complex task [4-6].

3.6. Prototyping Intelligent Interfaces

Graphical user interface toolkits have specialized classes for interface elements such as buttons and form controls. How are interfaces for an intelligent system, and especially its intelligent components, designed and prototyped? Protégè has a plugin called Silicon that supports the development of user interfaces for systems with services described in OWL-S, a Web ontology language for describing services. It proceeds by creating a single rank-2 formal concept analysis lattice over all of the inputs and outputs of all of the services in the set of services. Then it divides the lattice according to the location of a pair of rank-2 pairs, each encompassing one of the two element sets, so that it can produce a minimum spanning tree that admits at least one path visiting every element in each element set. The ultrapath tree thus represents a way of generating particular combinations of inputs and outputs by traversing the services represented in the tree. The tree is then linearly displayed, allowing users to select actual inputs and outputs for services, or to select services themselves. As the services are selected, their filtered inputs and outputs appear in the main tool window. Selected services appear in a side panel.

IBM has constructed a system called Watson that can answer questions in natural language. During a contest on Jeopardy!, the system needed to show that it could rapidly display its most confident answer to a question, the correct response, and the confidence that its answer was correct. The display thus also needed to convey the system's internal confidence scores, the actual evidence used, and what aspects of the evidence supported its choice. On screen, the human contestants could see the same information and decide whether to bet or return on Double Jeopardy! Questions.

3.6.1. Wireframing and Mockups

The prototyping stage of an interface design is a crucial step in the workflow, following initial ideas and all the analysis of the problem domain. Building mockups and gathering feedback leads to the possibility of finding an elegant design solution, as well as discovering possible problems and stumbling blocks. Fixing errors in an early design stage is a lot cheaper — in time and money — rather than in the implementation and production stages [1,3,5]. A "mockup" is a static visualization, i.e., a sketch or a visual static preview that could be a drawing on paper or in a digital format, usually built by graphic designers in tools such as GIMP, Inkscape, or Adobe Photoshop. A "wireframe" is a type of layout technique lacking colors or images. A wireframe prototype is built with rectangles and lines, and its purpose is to address the functionality of the interface and the positioning of the elements. Wireframing is an important activity for designing the layout of an interactive system. A wireframe is a representation of the layout and elements that will be present in the resulting interface—its main function is to serve as a guide for the implementation and make it easier to find the correct indentations.

Conversely, a mockup tends to be a more visual representation, sometimes pixel-perfect, of the final interface. The more precise the mockup, the more useful it is for validating the details of the design. However, wireframes help designers and clients focus on the function of the page or interface, rather than the visual details that come later in the process. A “character map” is a program usually used for selecting the characters and symbols that are present in a font but are not on the computer keyboard. A character map is typically available in most operating systems.

3.6.2. User Testing and Feedback Loops

Human-machine collaboration is an important aspect in developing intelligent interactive Web interfaces. Collaboration among Web-users and Machine-Learning

Fig 3 . 3 : Human-Machine Collaboration in Web Interfaces with Feedback Loop

(ML) is a co-creative process with user feedback to adapt the model to people’s needs in a continuous feedback loop. However, many existing ML-powered Web applications do not take the users’ feedback into account. Instead, ML models are adjusted and retrained for unseen cases by specialists only. This implies that the models must catch the users’ future needs a priori, which is impossible in most cases. Unfortunately, training a new model causes non-negligible costs, so the specialists will try to avoid it as often as possible. Web applications will then remain frozen in time when the user’s current needs no longer meet the model.

To address this issue, an intelligent web interface is proposed that supports human-machine collaboration through a feedback loop. It enables users to provide qualitative feedback to the ML model easily and understandably. Additionally, the interface helps users analyze, validate, and adapt the ML model. Based on the feedback, the model is retrained to integrate new knowledge, and updated predictions are generated. The updated predictions are finally visualized for analysis and validation as well, which closes the loop. The evaluation demonstrates that the model is both effectively and efficiently adaptable to user feedback.

3.7. Interaction Techniques

Information visualization (InfoVis) is concerned with visual representations of abstract data for people to read, from the effects of a drug on a person to the routing of an IP datagram through the Internet. It is closely related to the field of scientific visualization, which focuses on the visualization of often extremely large data sets generated by scientific and engineering processes, such as a computer-simulated wind tunnel. The emphasis is on enabling the human perceptual and cognitive system to work with abstract information in a way that is consistent, informative, clear, interpretable, and perceptually accurate. Equally important are the interaction techniques for InfoVis-Core, as well as for interaction with non-relational data in InfoVis-Rel. Together, they contribute to the process of knowledge generation and presentation.

Interaction techniques enable the visual analysis of data and the real-time manipulation and control of what is presented on screen [5-7]. They involve, for example, database operations (e.g., selection and projection) and the direct mapping to visual forms: zoom, filter, and focus + context. Interaction techniques also provide means to explore the data and the geometry: gzip, fisheyes, zoom, and rotate the triangle. The temporal nature of semantically meaningful animation makes it appropriate for the demonstration of change, such as movement and growth. Animation can also concisely reveal structure and shape that might be difficult to discern from a still image. Other InfoVis-Core techniques, such as brushing and linking, are essential in revealing the presence of or evaluating relationships within multivariate data. Interaction techniques provide how the information presentation design and viewing model can be manipulated and controlled.

3.7.1. Voice User Interfaces

The digital transformation enables pervasive human-machine collaboration for interactive problem solving, assisting human users in various tasks. Language-based interfaces provide an intuitive communication channel with conversational agents and suitable information representation. The design of congruent and fully conversational multimodal voice user interfaces for the problem-solving cycle shapes and guides the interaction and the collaboration.

A voice user interface (VUI) supports access to services or information through voice input and outputs synchronized, synthesized speech. Faster and natural voice input allows users to receive summarized and focused information and is a principal component for the interactive human-machine collaboration with a multimodal problem-solving interface. VUIs for specific tasks need to be carefully designed and implemented to avoid user confusion and dissatisfaction with the conversational limitations. For multimodal problem solving, the design considerations include a well-balanced interaction supported by multiple speech functions that assist the user in speech input, select the appropriate transformation for speech output, and continue the interaction with helpful and suggestive feedback.

3.7.2. Gesture-Based Interactions

Human input to machines can be expressed in speech, text, gestures, and other input methods. However, speech, text, and other inputs might not always be the best way for humans to control or guide a machine, especially intelligent machines like AUVs. Machine input is then converted to some output form that is perceivable by humans. This output can be in the form of voice, text, or graphics on the screen, or even using gestures. The output is closely related to the input. If the input is in the form of speech or text, then the useful output might be in speech or printed on the screen as text. If the input is in the form of navigation information, then the output can be graphical signals guiding the device or person to whom the information is provided. Gesture-based interactions can be extremely simplified while interacting with machines, thus providing a rather natural mode of interaction.

3.8. Future Trends in Human-Machine Collaboration

The synergy between humans and intelligent systems emerges through collaborative communication, interaction, and mutual assistance. Intelligent systems are equipped with mechanisms that enable collaboration with human beings and demonstrate collaborative behavior while interacting with the environment and other systems. Intelligent interfaces foster human-machine collaboration by engaging users in continuous, interactive dialogues, supported by sophisticated questioning strategies that facilitate efficient information exchange and shared understanding [8-10]. The meaningful interaction of humans and intelligent systems is achievable only through an appropriate interaction framework that offers effective means for communication.

The intrinsic nature of intelligent interfaces is contingent on the characteristics of the target collaborative environment. Dialogue generation and analysis, context representation, and selection of appropriate verbal and non-verbal interaction strategies are pivotal features of such interfaces. Dialogue analysis is approached from a collaborative perspective: the aim is not to construct a specific task outcome, but to build a shared understanding of the information, actions, knowledge levels, assumptions, and tasks that the intelligent system and user have in common. Dialogue generation is adaptive to the user's current context. The representation of context accounts for all current user knowledge, assumptions, and tasks. Dialogue strategies incorporate both verbal and non-verbal mechanisms, facilitating a meaningful

3.8.1. Emerging Technologies

Cognitive computing envisions a paradigm in which machines enable humans to make use of digital information, not only as consumers of processed information but also as contributors to knowledge production. In particular, it strives to create human-computer interaction (HMI) systems that learn at scale, reason with purpose, and interact with humans naturally. Yet, when it comes to supporting such nature-like interaction, web interfaces are suffering from a lack of intelligence. Moreover, although the web is a fertile platform for interactive multimodal systems, effective highlighted concept interfaces for cognitive computing have not been fully explored yet.

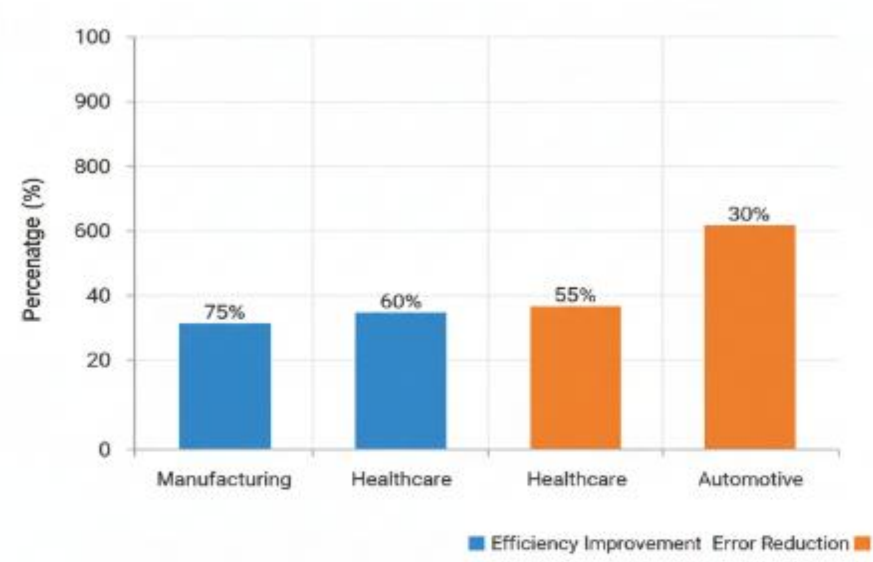

Fig 3 . 4 : Human Machine Interface Statistics

Considering these facts, emerging technologies for interactive multimodal dialogue generation in cognitive computing need to be studied. The goal is to provide people with an enhanced web interaction, turning the web into a smart interface supporting interaction by conversation and by feedback. Grounding—one of the major human cognitive communication processes—is then exploited to provide multimodal human-computer interaction systems with the capacity to support human-like interaction on the web platform.

3.8.2. Predictions for User Engagement

Services on the Web are becoming increasingly intelligent. Prediction models can be useful to anticipate customer satisfaction and provide proactive assistance to users. Supervisors can now predict interactions with users better and plan agents' schedules accordingly, especially for services requiring intensive human-machine collaboration. Moreover, using graphs for prediction enables the detection of possible fraud in graph-structured data such as social networks. Using a graph representation and machine learning techniques, it is shown that it is possible to predict the users' engagement with a service.

Robust prediction models can provide supervisors with a better estimation of the results of the interaction with customers. This exploration serves to examine whether it is possible to predict customer engagement during the initial stages of interaction. Ultimately, it is possible to predict the users' engagement using a graph representation and machine learning techniques. A novel graph that models the flow of the interaction and the relationships of the information within the global interaction is defined. Antony, Klaus, and Alessia explore the design of robust prediction models for a service where an agent and a user share information.

3.9. Conclusion

Over the past decades, the development of intelligent user assistance for the Web has seen considerable progress. Every month, hundreds of Web services are launched and dozens of Web standards are ratified; however, the majority of Web users still do not regard the Web as an information source or a knowledge repository, but as a user interface for information processing in various domains not related to the task of accessing and maintaining knowledge. On the other hand, developers and companies interested in supporting information gathering procedures still consider the process of integrating and evaluating data from distributed databases and repositories a challenging task.

The research and development undertaken have aimed at demonstrating full access to information and knowledge. The proposed user assistance role for the Future Web thus manifests itself through a multitude of features, ranging from intelligent information gathering to the intelligent clustering and classification of heterogeneous collections of knowledge components. Moreover, an intelligent user assistance system should support the communication and discussion of actual or hypothetical situations as well as handle the creation and responsiveness of new solutions and problem hypotheses, ultimately leading to the generation of new knowledge. The intelligent assistant acting in all these functions interacts with the user through a Web-based interface and has the possibility of involving any of the available intelligent services described, orchestrated around a task-specific process. The User Interface and knowledge brokerage activities of an intelligent assistant operating on the Future Web support interaction and understanding of the information upkeep process and its constituent elements: the phases of information gathering, providing information, and the brokering of information services.

3.9.1. Final Reflections and Implications for Practice

In the development of intelligent Web interfaces for human–machine collaboration, the proposed approach differs markedly from the conventional pipeline: first, it models the cooperative knowledge provision behavior by analyzing contributions from the information-seeking oriented perspective of information science. Then, it creates knowledge-intensive task information fillers based on the proposed model. Finally, by adopting the current interaction styles of intelligence products, task information fillers with different filler attributes are designed and presented. Experimentation validates the feasibility of the method and shows that knowledge-intensive intelligent Web interfaces organized around tasks can stimulate information needs and promote cooperation in sharing knowledge in various fields.

The basic form of intelligence is knowledge, and ultimately, what is accomplished by artificial intelligence is knowledge management. In the development of human–computer interaction, interaction design is similarly knowledge-intensive. By adopting the methods and tools of knowledge structure analysis, the knowledge requirements of intelligent products can be targeted, interaction can be effectively guided, and task completion results can be actively optimized. The discussion presented here focuses on the construction of intelligent Web interfaces in general, querying-oriented specific intelligence products that depend on the knowledge work of servers.

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