Research on User Behavior Model-Driven Information System Design

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Abstract

Based on a comprehensive understanding of user-led, user-driven, and user-centered digital libraries, it systematically introduces various details regarding the design of system functions, processes, and interaction methods guided by user models. It proposes an approach of "user psychology and behavior - digital services - information system - market research - system improvement" to optimize the digital library service system.

Full Text

Preamble

Research on User Behavior Model-Driven Information System Design

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Abstract: Based on a comprehensive investigation of user-led, user-driven, and user-centered digital libraries, this article systematically introduces the details of how user models guide the design of information system functions, processes, and interaction methods. It proposes a "user psychology and behavior–digital services–information systems–market research–system improvement" approach to optimize digital library service systems.

Keywords: User modeling; User generated; Multi-user; Personalized service; Human-computer interaction

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1 Introduction

Digital libraries face challenges from many directions: information technology continues to evolve, creating new information environments; users develop new information behaviors within these new environments; when new information environments and new user behaviors overlap, information services must continuously adjust to adapt to this increasingly complex unpredictability. In response to these challenges, digital libraries have gradually developed practical strategies such as user-centered, user-driven, and user-led approaches, doing their utmost to meet user needs.

Related research is summarized in Table 1 . The concepts in Table 1 were extracted from the SCI and SSCI databases through subject searches, using Java programs to extract keywords, titles, and abstract terms, with manual filtering of duplicate subject terms (such as "library," "services") and irrelevant terms (such as "Chinese culture," "South Africa").

(1) User-Centered Digital Libraries: Lin et al. introduced evaluations of Chinese government digital systems and explained how government agencies can design appropriate management measures to promote technology acceptance and usage [1]. Bapna et al. noted that better information systems closely connect with user preferences, behaviors, and personalities to optimize their economic welfare [2]. Martin et al. believed that establishing standardized and optimized practices is essential for creating a World Wide Web experience based on database coverage, timeliness, cost, and mechanisms for creating and maintaining user interfaces, and for making information system design decisions accordingly; an online catalog system should develop toward enhanced classification, access, imaging, and historical data analysis functions related to data [3]. Williamson believed that "user-centered" practice can be achieved through user-selected configurations, resource descriptions, metadata repositories, and linking information resources to specific configurations [4]. Barnard et al. emphasized that user-centered information resource issues can provide beneficial references for information-seeking behaviors and needs [5]. Zhang et al. illustrated an e-government user-centered evaluation model including usefulness, ease of use, and appropriateness [6]. Somerville et al. described cases of inviting users, campus libraries, stakeholders, and beneficiaries to jointly participate in library design, pointing out the necessity of "learning their way" (rather than the library' s way) [7]. Maler studied different types of authentication identification technologies [8]. Deng et al. designed an identity management mechanism to ensure semantic data exchange under different authorizations [9].

(2) User-Driven Digital Libraries: Frias-Martinez et al. believed that a trend in improving digital services is through personalized services, with the most common digital library personalization method being user-driven, which proposes adaptive digital libraries that can automatically learn user preferences and goals to improve the shortcomings of personalized interaction [10]. Curran et al. believed that the difference between Library 1.0 and 2.0 is that Library

1.0 only allows one-way information flow, while 2.0 is a user-oriented read-write database aimed at preserving every library user' s information retrieval time, giving library users the right to decide what services they receive [11]. Spiteri believed that folksonomies can increase the user-friendliness and interactivity of public library catalogs and promote other services, such as informal online communities for readers and users, and library reference services [12]. Wareham et al. reviewed development models for mobile devices and services: adopting design thinking, living laboratories, and other forms of ethnography, including human behaviors such as luck, playfulness, and errors that were previously overlooked by orthodox technical design, to explore product development that keeps consumers consistently paying [13]. Seng et al. proposed a user-driven workflow overview and explained how to support game operations for creative and learning behaviors through training and teaching [14].

(3) User-Led Digital Libraries: Lawrence defined user-led development as hoping to increase user participation and control, usually starting with testing, training, and implementing systems for a small group of users before determining the needs and requirements of user communities [15]. Flynn et al. believed that information systems should construct user needs, allowing users to build their own requirement models [16]. Rowley discussed mechanisms for content page services, abstract and index services, and comprehensive online product information services from the perspectives of database coverage, timeliness, cost, and mechanisms for creating and maintaining user interfaces [17]. Wessels et al. emphasized that e-social science research includes identifying new research priorities, adapting research processes, and developing grid-related research tools [18]. Myhill et al. believed that using Web 2.0 tools can create the foundation for virtual research environments because Web 2.0 has characteristics suitable for users to explore knowledge [19].

There are three approaches to developing digital libraries: (1) observing user behavior from existing information services and applying new information technology to better improve existing information services; (2) tracking new information technology to bring a new generation of digital libraries closer to users' new information environments, thereby applying new information technology to develop new information services; (3) studying users' information behaviors in new information environments and accordingly applying, transforming, developing, or eliminating information technology to achieve new information services. Systematic discussion and exploration of using user models to guide system function, process, and interaction design are still relatively rare. This article focuses on the third development approach, sorting out relevant cases and research, and proposes a "user psychology and behavior–digital services–information systems–market research–system improvement" approach to optimize digital library service systems.

2 Development of User Model-Driven System Design

Creating and using personas is one practical method for digital library system optimization. Lamberts believed that user-centered personas, combined with market segmentation, field research, and market research, can help understand who our users are, what their goals and core tasks are, and how they work [20]. In 2000, Coney et al. claimed that personas can enable website designers and users to communicate, and that website success depends on how completely these personas explain the relationship between website design and website evaluation [21]. Silverman et al. used personas to create a universal toolset simulator and pointed out that integrating TrainingGame and Personas concepts goes beyond design [22]. Eight years ago, Greaney et al. published a human computation process that used principal component analysis to analyze social capital and college/neighborhood concentration, creating personas to design mobile services [23]; this should be an earlier study that moved from a single system to multiple media devices. Later, from devices to software development, it formed multi-system design with different design stages. That is, the user model-driven system design approach belongs to a passive nature.

Five years ago, user scenarios were typically used with personas to represent themes designed for system interaction [24]. However, due to the lack of behavioral calculations, the effects were not obvious. For example, Haikara' s case showed that using personas often failed in the practice phase because clients were unfamiliar with personas, and development teams paid more attention to the referent items of personas rather than fictional characters' names, genders, or ages [25]; thus, personas developed from multiple to dynamic persona concepts. With the gradual expansion of Web 2.0 influence, Silva et al. recently established document-identified personas to develop marketing strategies and tools for online community websites [26]. User model-driven system design began to expand to various levels. Zimmermann et al. pointed out that using personas can establish the ultimate practical use of systems, implement patches at appropriate times with effective methods, avoiding R&D teams from overpursuing technical complexity while neglecting technical applicability [27]. In design process R&D, Hussain et al. realized that personas should intentionally or unintentionally enter team members' thinking during planning, development, or any decision-making process [28].

The user model-driven system design model has gradually matured. The following sections describe the content, cases, causes, and application ideas for digital libraries of various different models.

3 User Model-Driven System Design Approaches

3.1 As an Auxiliary for Interaction Interface

In most information systems, metadata and data, calculation formulas and programs, and functions and operation steps do not consider user behavior models during pre-production planning, mid-term testing, or post-acceptance processes.

Involved user needs are described according to system functions and can be directly transformed from user needs into user requirements for input commands. Thus, "user behavior" equals "user operation steps," which must be executed according to the steps of user requirements defined by system processes.

The significance and scope of user behavior models are clearly limited to interaction interface design. The investigation of user behavior and user behavior-driven system design methods lie in distinguishing different user groups to represent behaviors. User behavior models help distinguish different user groups to represent their behaviors.

The significance and scope of user behavior models are clearly limited to interaction interface design. The investigation of user behavior and user behavior-driven system design methods lie in distinguishing different user groups to represent their behaviors. For example, after interface design, different system interfaces can promote users to quickly and conveniently adapt to input commands for system operations. Lindgren et al. showed that using persona methodology can clearly recognize individual differences and drive group differences [29], thus benefiting future multi-system design. That is, the user model-driven system design approach belongs to a passive nature.

The reason for this design is that software design often needs to rely on hardware device requirements. When hardware requirements or institutions are relatively strong (for example, mobile phone manufacturers subcontracting to software design companies, or library senior staff requiring programmers to write software), software design must prioritize meeting requirements in contracts or planning documents. After completing basic system functions, user behavior is then "defined."

3.2 As an Auxiliary for Determining System Functions

Contrary to most designers who are accustomed to "defining" user behavior, end users believe that user behavior is "not to be defined" but "to be understood and recognized." If designers do not understand or recognize real-world user behavior, then information service systems should at least be designed as "adjustable and changeable systems" to adapt to various types of end users.

For some information systems, among many technical options and practical methods, it is necessary to save time and human resources while meeting system design goals. Although the metadata and data of these information systems are relatively fixed, calculation formulas and programs, as well as functions and operation steps, can have greater flexibility. In early planning, it must be considered which functions are needed, which are not, which should be reserved for future add-ons, and which should be extensible.

The significance and scope of user behavior models expand to early planning, particularly in selecting and determining system functions. For example, Booth designed personas to describe text and context on social networking sites [30].

Because social networking sites need not consider users' internet devices but only how users contact information and how information is presented, as well as how users communicate with each other, some system functions (such as classification catalogs) can be omitted, while others (such as instant communication) need to be strengthened, even requiring careful design after studying user behavior. That is, the user model-driven system design approach belongs to an active nature.

The reason for this design is that software and hardware design are done by the same group of people; or hardware specifications are singular with large space for software design; or the focus is mainly on software design, where hardware specifications have little or no impact. For example, website designers selling goods or services—the goods or services sold are basically unrelated to website equipment, only related to how information is presented on the website and how it is presented. Early considerations of information transmission volume over twisted-pair wires to determine website design traffic issues are hardly considered by website developers, managers, and users in the fiber-optic communication era.

3.3 As an Auxiliary for Designing System Processes

In certain "special" cases, designers need to first deeply understand and recognize user behavior before they can develop information system design. This rare type of information system has hardware and software that are inseparable, and users have uniqueness and non-transferability. The metadata and data, calculation formulas and programs, functions and operation steps of such information systems can be completed in stages and then assembled into an information system. However, all components of the information system need to repeatedly refer to user behavior during pre-production planning, mid-term testing, and post-acceptance processes.

The significance and scope of user behavior models are not only in early planning but run through all information system workflows. In website design, Casas et al. attempted to combine creating personas, using personas, Ambient Intelligence (AmI), and user-centered design to develop a new generation of user modeling [31] as an auxiliary method for designing system processes. That is, the user model-driven system design approach belongs to a necessary nature.

The reason for this design is that software design dominates hardware device production. For example, the design of robotic arms depends not only on users' work or life needs but also on users' habits, funds, individual physical conditions, and other differences. In cases where software design dominates hardware devices, materials, and processes, the definitions and connotations of terms such as "user needs," "user behavior," and "user models" are completely different from interaction design in context. Here, user behavior is not only a determining factor in early planning, mid-term testing, and post-acceptance but also determines every component of the information system, including metadata, data, calcula-

tion formulas, programs, functions, and operation steps. From the perspective of serving mass users and high-end users, this design is only a model that a few intelligence strategic analysis systems can learn from; but from the perspective of digital libraries serving individuals, it is a design model that personalized service systems can learn from.

3.4 As an Auxiliary for Overall Service Planning

Different from the previous three models, as an auxiliary for overall service planning, this approach does not consider software and hardware but considers more abstract services. It first considers the concepts, strategies, and processes of "what to serve," then considers the information systems needed to support this service. This design often emerges in:

(1) Teams that need to continuously generate creativity;
(2) Teams that are cross-lingual, cross-cultural, or cross-professional and need to accelerate communication efficiency;
(3) Teams with high personnel turnover rates.

Because such teams not only face complex and changing external competitive environments and must participate in rapid competition by adopting user model-driven system design methods, but also have complex and changing team compositions that are difficult to quickly 磨合.

For example, in creative R&D design, Okamoto et al. confirmed that scenarios can effectively support participants. They distinguished development groups and user groups to co-create personas with lifestyles and cultural backgrounds [32]. Distinguishing design teams (D-team) to develop creativity and assumptions, while user teams (U-team) describe scenarios and needs, helps cross-cultural communication between Japan and Taiwan, and more accurately solves cross-language communication barriers. In cross-professional teams, Goodall et al. believed that personas help teams logically and coherently design actual user needs, allowing all team members to have a common understanding of project goals and priorities through a memorable story [33], and to develop consistent definitions and understandings of terms such as user needs, user requirements, user behavior, and user modeling.

3.5 Research Difficulties and New Approaches

In summary, user model-driven system design is a future development trend for digital libraries. Summarizing the "research limitations" proposed by cases of user model-driven system design reveals three current research difficulties:

(1) Persona models established through social science methods such as questionnaires, structured and unstructured interviews, or tracking observations are still difficult to objectively evaluate in terms of their actual role in improving interaction design using quantitative methods;

(2) Frequency calculations based on web logs, social network analysis, and nonlinear regression models can still only make inferences within limited samples and have little impact on solving actual interaction design problems;
(3) Results from social science methods and log analysis methods can only "complement" each other rather than mutually verify or corroborate each other, so these complementary results are only theoretical constructs with limited help for practical application.

Based on these research difficulties, this article recommends that new approaches should adopt direct and continuously developing solutions:

(1) Establish models using social and behavioral science research methods;
(2) Design hybrid pattern recognition mechanisms based on models, including log analysis, social tags, and retrieval-based natural language;
(3) Conduct experiments on user behavior prediction to verify persona models through user testing;
(4) Establish human-computer interaction models that conform to learning cognition and research behavior patterns based on results;
(5) Establish information systems embedded in different vehicles;
(6) Establish systems that integrate different workflows;
(7) Revise models and systems based on social and behavioral science research.

4 Discussion

System design must be based on empirical research. When informal information behavior becomes an important activity for learning and research, digital library systems and technology should not and cannot directly jump from concepts such as user-centered, user-oriented, and user-driven to system establishment. The most fundamental solution is to continuously improve existing system services through intensive observation and experimentation without affecting users' normal use of digital libraries.

4.1 Digital Resource Users

From the perspective of digital resource users, if digital libraries recognize that users are not homogeneous but differentiated users with different behaviors and psychological orientations, they will greatly enhance library service functions and roles on the basis of existing practices. Since users' information environments and information behaviors transcend the scope of traditional libraries and traditional digital library services—for example, they not only engage in literature information retrieval but also exchange work experience; they not only use search engines or search for materials in libraries but also enter society websites, portal forums, electronic bulletin boards, and blogs for information searching and exchange—failing to understand users' new behavioral trends and patterns and only focusing on continuously improving the functions and efficiency of existing systems may lead to a phenomenon where reality (user behavior) con-

tradicts wishes (satisfying users). In other words, information service systems should break the constraints of "library" (including physical space, network location, and thinking patterns) and consider from a more general information service perspective. Since users frequently use and trust these network communication modes, more important issues are how to make library services appear more in these forms and how to embed them into users' communication modes and processes.

4.2 Digital Resource Managers

From the perspective of digital resource managers, rather than spending large amounts of time, human resources, and funds to make all users' basic operation behaviors consistent to achieve "low input, high output" economies of scale, it is better to spend small amounts of time, human resources, and funds to create a model that enables each person to leverage their strengths. Libraries can then continuously improve from both failed and successful experiences to achieve economies of scale.

Digital library systems and technology, in addition to tracking changes in the network environment and mastering information technology as a means to integrate information technology into digital library systems to form new service models and methods, can also consider actively understanding different users' different behaviors and characteristics through persona models to discover potential needs. By predicting future information markets as a means, they can plan and design more competitive information services (more transmission efficiency, more time-saving for users, more information analysis, more accurate user query purposes and needs, more cost-saving, and preparing needed information for users earlier), and then invest in information systems and technologies that do not currently exist but will have market potential in the future.

5 Conclusion

Digital libraries are localized information systems. Due to different user compositions, information resources, and financial and human resource structures, it is difficult to completely imitate globalized information systems like Firefox or Google. However, digital libraries can, on the one hand, jointly develop globalization strategies with large information suppliers and service providers to "leverage strength" to serve users; on the other hand, they can also deeply understand service objects by answering questions such as how users' online information behaviors can be accurately defined, how they can be continuously updated, and how they can be efficiently calculated, and then advance services.

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Note: Figure translations are in progress. See original paper for figures.