

## Research Article

# A Study of Ethics on Intelligent Nonlinear Prediction Creative Design

Zuyao Wang  and Yuhong Zhang 

*School of Design, Ningbotech University, Ningbo 315100, China*

Correspondence should be addressed to Yuhong Zhang; [zhangyuhong@nbt.edu.cn](mailto:zhangyuhong@nbt.edu.cn)

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In order to build a safe, credible, responsible, and sustainable intelligent nonlinear prediction creative design system, this paper explores the process of intelligent creative design through four stages of user research, concept ideation, design generation, and design evaluation, then discusses the potential ethical issues in three fields of data perception, experiential computing, and intelligent production in the process of intelligent creative design; and then analyzes the ethical dilemmas that intelligent creative design systems may face. It can establish a necessary theoretical foundation for the upcoming vigorous development of intelligent creative design and set up the situation to rethink design values in the age of artificial intelligence.

## 1. Introduction

With the rise of technologies such as big data, deep learning, and block chain, artificial intelligence is being fully embedded in all aspects of human society. The creative design industry has also started the process of intelligence, and intelligent nonlinear prediction creative design platforms are constantly emerging. Intelligent nonlinear prediction creative design, referred to as intelligent creative design, is the application of nonlinear prediction models in deep learning to creative design. It focuses on the intelligence of the creative design process and uses artificial intelligence technology to help solve design problems and generate design solutions. At present, it has been involved in user research, concept ideation, design generation, and design evaluation [1], such as Ali Luban, Jellyfish Intelligence, and Qualtrics Experience Management. These applications are concentrated in the fields of graphic design, interface design, packaging design, cultural design, etc. [2]. There are also manufacturers who have begun to test the field of product design and explore technologies such as intelligent geometric modeling methods for functional analysis. However, due to the complexity of product design context and design knowledge representation, there is no available application

of product design. The development of intelligent creative design generates more new design paradigms and expands new spaces for creative design and has a far-reaching influence on the creative design industry. On the one hand, intelligent creative design entrusts part of the work to artificial intelligence to make up for the shortcomings of human designers, allowing human designers to focus on more creative work; on the other hand, intelligent creative design greatly enhances the accessibility of creative design by realizing personalized customization automatically and makes it possible for “everyone to be a designer” by lowering the threshold for creative design.

The creative design industry has a completely different attitude towards intelligent design platforms. Technological optimists believe that intelligent creative design will replace more than 90% of the jobs in the field of creative design, while design professionals believe that intelligent creative design can only replace the low-level part of design work, and it is powerless to high-sensitivity and high-creative work. No matter where the intelligent creative design platform goes, the ethical issues brought about by intelligent creative design also need to be considered. On the one hand, early intervention in the development of intelligent creative design can imagine and evaluate the important impact of

intelligent creative design on society and regulate the development of intelligent creative design. On the other hand, the research on the ethics of intelligent creative design is conducive to the creative design industry to reflect on the design value in the era of artificial intelligence and to explore the new possibilities of the creative design industry.

## 2. Related Research Studies

*2.1. Intelligent Creative Design.* Intelligent creative design is a new thing, and scholar's research mostly focus on the procedures, methods, and prospects of intelligent creative design. Liu et al. [3] reviewed the methods, trends, and challenges of generative product design since 1998; Tang et al. [4] proposed an intelligent design system framework based on data modules and design modules; Luo et al. [5] proposed the paradigm and value of creative design integrating intelligent technology to enhance the new economy. Concerning the ethical issues that intelligent creative design may bring, the current concerns are mainly reflected in the substitution of creative design work and the intellectual property dilemma that may arise from intelligent creative design. Humans have lost their information advantage over algorithms, and practitioners in the creative design industry and design research scholars are confused about the positioning of creative design in the era of artificial intelligence. In the postmachine learning era, artificial intelligence has the ability to surpass intermediate designers in some specific fields by simulating the thinking activities of designers, which will lead to a crisis in the relationship between the subject and object of designers and artificial intelligence [6]. Is artificial intelligence challenging creative designers without morality? What changes need to be made in creative design in the era of artificial intelligence to adapt to the development of the times? The creative design industry has to face these problems.

Combining the entire creative design process, technologies such as knowledge graphs, deep learning, affective computing, generative adversarial networks, and block chains continue to pour in, all of which support the development of an intelligent creative design from all angles. Creative design requires a lot of knowledge, support, and information input. Human designers constantly combine the input information with their own knowledge and create new solutions through design thinking and skills. Structured knowledge representation is the basis for artificial intelligence to simulate the creative design process. The knowledge not only comes from the design knowledge and skills that creative designers have learned over the years but also from the domain knowledge of design objects and more of the attributes of users, needs, motives, attitudes, behaviors, values, etc. Some knowledge is explicit, and more knowledge is implicit. Through machine learning and deep learning, artificial intelligence imitates the knowledge and skills of human designers and has advantages in structured knowledge simulation. For design ideas and design styles that can be clearly defined, artificial intelligence has a greater advantage than human designers in the transition from 1 to 100, which is called incremental innovation. But the process

of breakthrough innovation from 0 to 1 is similar to a black box. The high perceptual thinking of human designers in the design process is still difficult to simulate through algorithms. However, with the advancement of technology, especially in the postmachine learning era, the goal of imitating the design thinking and decision-making of human designers will always be gradually approached, which forces the design industry to face transformation and rethink the value of design. We need to think about how creative design can empower artificial intelligence instead of passively accepting the changes that artificial intelligence will bring to the creative design industry.

*2.2. AI Ethics.* Ethics is the inquiry into how we live and how we can live better. It is generally believed that ethics refers to the principles and norms that should be followed when dealing with the relationships between people, people and nature, and people and society [7]. Correspondingly, the ethical issues of artificial intelligence include the ethical conflicts between human beings, human beings and nature, and human beings and society. The ethical conflict of human beings itself is manifested in the dilemma of artificial intelligence, causing people's cognition of themselves, the existence of human subjects, and the division of responsibilities between humans and machines. The ethical conflict between human beings and nature is reflected in the uncertainty of artificial intelligence systems in the decision-making between economic benefits and environmental and ecological issues. The ethical conflict between human beings and society is reflected in social inequality, desertification of interpersonal relationships, and the loss of protection of privacy rights. The ethical issues of artificial intelligence have attracted widespread attention from all over the world. UNESCO adopted the Recommendation on the Ethics of Artificial Intelligence in Paris in 2021, which provides recommendations for member states to regulate artificial intelligence governance in terms of values and principles, policy action areas, and monitoring and evaluation. The challenges faced by the development of the new generation of artificial intelligence in China include breakthrough in the theory of artificial intelligence under the interdisciplinary, standardizing artificial intelligence ethics, and building artificial intelligence development ecology [8]. Not only the government and academic institutions but also artificial intelligence companies have begun to explore artificial intelligence ethics. Google has set up a special ethics committee, and Baidu has repeatedly proposed the establishment of sustainable and responsible artificial intelligence in public. However, ethical issues are often highly controversial. The aforementioned Google ethics committee, which is composed of outsiders, was adjusted to consist entirely of company executives within a week of its establishment.

The ethics of artificial intelligence involve various aspects, and its research is also complicated. Iphofen and Kritikos [9] explore how artificial intelligence makes ethical decisions about its behavior and interactions with humans. Wu et al. [8] believe that when artificial intelligence technology encounters ethical problems, both technical experts

and ethics experts feel powerless or unbearable, and it is necessary to carry out interdisciplinary research based on “design scenarios and use scenarios.” In general, AI ethics has become a worldwide issue that the industry and academia are worried about. It is difficult for all stakeholders to reach a consensus on many issues, which requires continuous exploration in the field of theory and practice.

**2.3. Design Ethics.** Design ethics mainly studies the ethics and social responsibility issues in design behavior and seeks the perfect integration of “instrumental rationality” and “value rationality” [10]. Design is dynamic; it is choice, action, and result; it is the unity of purpose and means; and it is also the concrete embodiment of values. The continuous input of information in the design process will affect the results of the design. Designers are always thinking about who to create value for, what value to create, and how to create value. Value and ethics are closely related, and ethical thinking and design thinking have a lot of overlap [11]. Regardless of whether designers are aware of ethical decisions in the design process, their actions are influenced by ethical thinking, and the design results are also constrained by design ethics. How to actively input moral values into design behavior, especially how to deal with complex human nature with rational and systematic design methods, is a problem that needs to be studied in design ethics.

Design ethics pays attention to design issues such as vulnerable groups, environmental sustainability, fairness and justice, and cultural diversity through inclusive design, sustainable design, discursive design, etc. With the advent of the era of artificial intelligence, design ethics research has gradually begun to pay attention to the design ethics of artificial intelligence products and services, providing a basis for evaluating artificial intelligence ethics. Zhang et al. [12] proposed introducing speculative design into the emerging field of technology ethics and incorporating users into the decision-making process of technology ethics through design fiction and thought experiments. Wang [13] believes that data noise may interfere and threaten the principles of social inclusion, fairness, and justice in creative design. Zhou [14] elaborated on the security issues and data privacy issues caused by robots and called on designers to participate in the ethical construction of artificial intelligence. Zhao et al. [15] started with the interaction between intelligent machines and human society, constructed a moral framework for intelligent machines, and discussed the factors of people’s moral judgment of intelligent machine behaviors. In the future, design trends such as inclusive design, sustainable design, speculative design, social responsibility design, confrontational design, and discursive design are gradually emerging and put into practice. How to eliminate the negative impact of artificial intelligence through design values has become a design ethics focus of research.

Overall, the intelligent creative design is still at a fairly early stage, and its ethical discussion is not rich. Intelligent, creative design is mainly reflected in three aspects, namely, digital perception, experiential computing, and intelligent production. Digital perception utilizes advanced digital

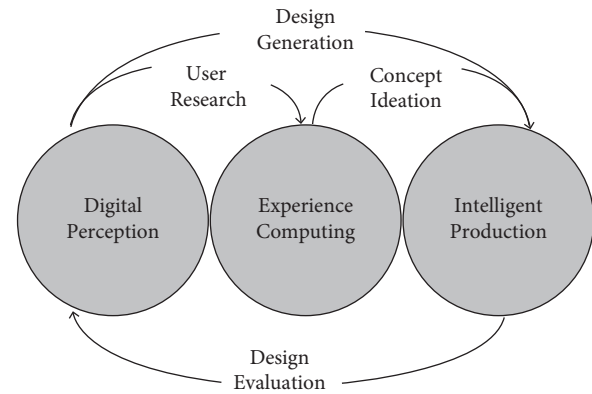


FIGURE 1: Intelligent creative design process.

means to capture, regenerate, or synthesize various sensory inputs from the external world, such as sight, hearing, touch, smell, and taste. Experiential computing is the use of algorithms to obtain experience insights such as user behavior, attitudes, and motivations. Digital perception and experience computing are mainly related to user research and design evaluation and are used for mining and analysis of user needs and pain points and analysis and optimization of product behavior experiences; intelligent production is related to concept ideation and design generation and is used to generate creative solutions based on algorithms (as shown in Figure 1). Intelligent, creative design is dynamic. Digital perception, experiential computing, and intelligent production continue to cycle and iteratively move forward. Data, knowledge, and algorithms are accumulated inside and outside the system and promote the evolution of the system itself. The development of science and technology is a double-edged sword. While promoting human economic and social development, it will also raise a large number of ethical issues, such as the data ethics of digital perception, the algorithm ethics of experiential computing, and the design ethics of intelligent generation. To study the ethics of intelligent creative design is to predict the problems in the development process of intelligent creative design in advance, which is of great significance for building a safe, responsible, and sustainable intelligent creative design system.

### 3. Data Ethics for Digital Perception

**3.1. AI-Enabled User Research.** The value creation of creative design is diverse, and design concepts are also in a situation of blooming. Human-oriented needs are always one of the core principles of various design concepts, and trends and needs are the starting point of creative design most of the time. User research runs through the whole process of creative design. It is not only an important way to capture user needs in the early stages of design but also an important means of design evaluation in the later stages of design. In the process of development, design science has produced many user research methods, such as observation, interview, questionnaire, cultural probe, and contextual interview. On this basis, design studies have also developed research tools

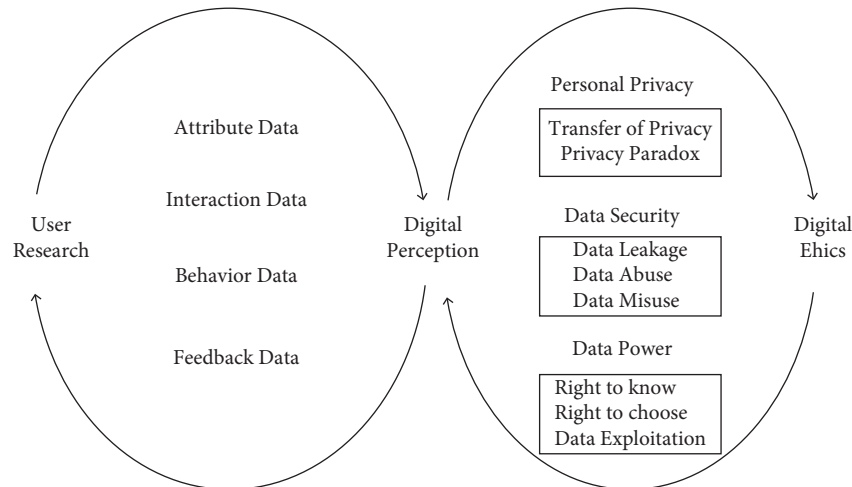


FIGURE 2: Data ethics for digital perception.

such as personas, customer journey maps, stakeholder maps, value network maps, and ecosystem map. Enterprise communities, such as the Xiaomi community, have not only become a bridge between enterprises and users to maintain customer relationships but also become a catalyst for enterprise product development. Participatory design, as one of the main user research methods that Xiaomi used, aggregates the collective wisdom of various stakeholders through community operations, helping enterprises achieve rapid and efficient product iteration and ecological chain expansion. Artificial intelligence has greatly enriched the sample and data volume of user research, creating conditions for improving the reliability of user research.

User research requires a large amount of data, including user attribute data, interaction data, behavior data, and feedback data. There are various means of data collection, such as biometric data, such as face recognition, voice recognition, fingerprint recognition, and behavioral data such as Internet browsing records. After these data are stored, cleaned, analyzed, and visualized, new insights can be obtained. Participatory design methods have also strengthened the breadth and depth of stakeholder participation with the intervention of artificial intelligence, and various network-based cocreations, crowd intelligence innovation, and collaborative design models have surfaced, which are innovative processes that gather the wisdom of the public to complete complex tasks on the Internet platform. The essence of participatory design is to obtain data by strengthening the participation of stakeholders, to find more data support for creative design and to enhance the customer experience of stakeholders. User research must comply with ethical norms, the informed consent of the subjects must be obtained when selecting subjects, and the scope and means of data use must be declared. These conventional norms in reality have not been implemented with the intervention of artificial intelligence, and data ownership has become a perspective of design ethics research. In addition, users behave differently when they know they are being researched and when they do not know they are being researched, which affects the accuracy of the research results. There is a paradox

in this, that is, users who obtain the right to know may have inaccurate feedback on their results, but if they do not obtain the right to know, there will be ethical problems. This ethical dilemma requires the intelligent creative design platform to carefully grasp the content and extent of data collection and prudently handle ethical issues including personal privacy, data security, data power, and data exploitation (as shown in Figure 2).

**3.2. Personal Privacy and Data Security.** We are generating data all the time, from the cameras that can be seen everywhere on the street; the mobile phones everyone holds in their hands, the face recognition in and out of public places during the epidemic; and the smart home products running at home. Even if you walk into a store to buy an item, you are being monitored. It is just that some people perceive that they are being monitored, while others do not. Some monitoring is to detect attacks in public places and maintain public safety, which has its value; some is to monitor the business behavior of enterprises, purely for commercial interest. With the development of smart technology, endless sensors will surround us in the future. The development of intelligent, creative design requires obtaining user needs through data, and the data we generate is reshaping our lives. People mostly have no concept of what data is being collected, but once reminded, they worry about who is collecting data, what data are being collected, whether it is safe, where it is stored, how it will be used, etc. Therefore, it is not that people do not care about these data, but that they do not perceive their existence; once they perceive their existence, people will worry about the possible adverse consequences. There is also a paradox in privacy issues, that is, on the one hand, users are worried about privacy leakage, and on the other hand, they leak their privacy through various media and continue to transfer their privacy rights through smart homes and social media. The privacy paradox involves not only individuals but also operators and market regulators. Breaking the privacy paradox requires the joint efforts of the above three parties.

When big data is involved in user research, it is necessary to label users. The principle behind it is to monitor and rate users' behavior, but this type of technology is very intrusive. Web crawler technology has become a way of user research. Data capture is ubiquitous, all user behavior is undisclosed, and everyone is in the middle of a prison, desperately trying to climb out of this monitored cage. As Foucault said, "Our society is not a society of spectacle, but a society of surveillance" [16]. Personal privacy involves human dignity, and privacy design principles for user research need to be introduced to ensure that users themselves have the right to know, rather than passive consent. In addition, users have choices about user research. The development of artificial intelligence technology is for the common development of mankind, but there is a contradiction between the integrity of human development and the independence of individual development. The more artificial intelligence technology develops, the stronger the artificial intelligence's control over independent individuals. How to balance public interest and privacy protection of personal interest has become a difficult problem with AI-enabled user research [17]. Under different cultural backgrounds, users have different understandings of personal privacy and the boundaries between individuals and others. To carry out ethical data collection, it is necessary to handle the above problems carefully. For privacy protection, distributed decentralized learning, federated learning, cryptography, and technologies such as translucent information filtering have become important development directions. Of course, the development of technology is always rising in a spiral. If there is monitoring technology, there will be anti-surveillance technology. Ethical norms have become a necessary option for the sustainable development of the industry.

Safety is an important perspective of ethical research, and safety is also a basic principle of creative design, including actual safety and perceived safety. The former is based on efficiency-based safety data, representing the objective degree of safety, while the latter includes subjective feelings such as user trust and control. When users perceive that they are being monitored, their concerns about safety immediately appear, just like psychological tests, people's awareness of insecurity is awakened. Data security in user research is also another dimension that data ethics needs to consider. Data leakage, data abuse, and data misuse will all have serious ethical consequences. Face recognition technology itself is particularly fragile and can be easily cracked. Since the face information itself is difficult to change, once it is leaked, it is difficult to recover; the password can be changed; should the face be changed if the face is leaked? In addition, face recognition technology also has the risk of being abused, such as racial discrimination and behavior prediction. User research powered by artificial intelligence is highly dependent on data, and the digital footprint of users gradually left on the media has become the basic support for user research. Once a data security problem occurs in an intelligent creative design platform, it will have a significant negative impact on the platform itself, users, and society.

*3.3. Data Power and Data Exploitation.* Data is a resource, and its ability to "predict" the future enables data owners to have data power, while individual users as data producers have quietly become "data tenants." There is an imbalance of power between individuals who generate data and institutions that utilize data, leading to the phenomenon of data exploitation, the essence of which is reflected in the "information asymmetry" between individual users and data capital [18]. Of course, information asymmetry is ubiquitous and not just a feature unique to the data age, but this asymmetry can be enhanced in the data age through data empowerment. As a result, a few oligarchs control all aspects of the economy and society, the threat of data monopoly is approaching step by step, and the contests and conflicts between countries over data power continue to emerge. The design itself is also a kind of power. Designers shape the lives of the public through their work, and even more and more paternalistic designs are born. The power between the designer and the user is inconsistent, and the designer determines the user's specific senses, aesthetic preferences, and user behavior [19]. When there is a clear difference between the designer's decision and the user's preference, the user will have a strong sense of discomfort and express their dissatisfaction with the design through various channels. Data-driven design is the superposition of data power and design power, which is easily manipulated by data capital and deliberately exploits the fruits of human labor. For example, food delivery riders are limited by the data of food delivery platforms such as Meituan and Eleme, which are the most well-known food delivery service platforms in China. Most of them are troubled by multiple problems, such as unreasonable delivery times, retrograde route planning, and high overtime fines. The solution to these problems requires the constraints of ethical norms.

For data exploitation to occur, it must go through the process of design. The involvement of design ethics is of great significance for maintaining fairness and justice. Design ethics emphasizes the social responsibility of design, especially considering the rationality of design behavior itself from the consequences of design behavior. Designers need to have a full understanding of the complexity of the virtual world and the real world and introduce ethical thinking into the data-driven design thinking model through thinking about the balance of stakeholders' benefits. It is necessary to consider the benefits of stakeholders accurately, which are caused by decisions and actions in the context of data-driven design. The interest of human nature, life safety, and moral hazard is considered necessary conditions for design thinking. All parties have not reached an agreement on the ethical norms of design. Most of the ethical designs come from the bottom-up ethical consciousness of designers. Like responsible artificial intelligence, responsible design requires combining theory with practice, so that data-driven design not only needs to be effective and efficient but also needs to have emotional warmth and human care.

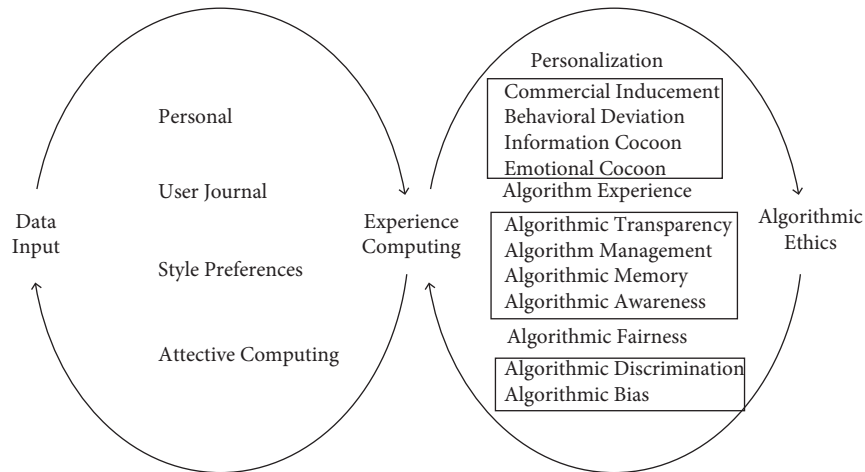


FIGURE 3: Algorithmic ethics of experience computing.

## 4. Algorithmic Ethics of Experience Computing

**4.1. AI-Enabled Experience Insights.** The data itself does not directly generate value, but the transformation of data into meaningful insights through algorithms does. AI-enabled experience insights include persona and user journeys based on dynamic data and design style preferences and evaluations based on imagery boards [20]. A persona is a frequently used tool in the experience insight process, which is defined as a virtual person representing a potential customer or user group, usually created by designers based on insights into real-world situations. The purpose of persona is not only for user-centered design but also for evaluating the user's risk level, business value, etc. In recent years, with the development of data technology, machine learning technology, and the generation of massive data sets, personas summarized by intelligent methods and dynamic personas from generated data have gradually emerged. In addition to personas, there are also tools such as customer journey maps and image boards in the design field to investigate user needs or evaluate design solutions. Artificial intelligence can also generate users' behavior paths to obtain users' usage patterns and combine customers' image boards to obtain customers' aesthetic preferences. Personalization has become a selling point for many companies; therefore, thousand interfaces could be provided for a thousand people. The principle behind it is that companies realize dynamic personas based on algorithms. Massive data generates dynamic personas and customer journey for typical users, which improves the accuracy and precision of services for enterprises. This kind of personalized service is not a true reflection of users' interest but often a behavioral deviation caused by commercial inducement. With the change of the situation, the personalized service derived from the algorithm can easily make the user fall into the dilemma of the information cocoon, and it is difficult to guarantee the user's long-term benefit.

AI-enabled experiential insights bring a series of ethical issues. Users are subtly affixed with various labels and lose their autonomy in defining their own identity. Most users are completely objectified, and most users cannot perceive

the existence of such "portraits" and naturally cannot understand the operating principles and uses behind them [21]. When users cannot perceive this label, we have reason to doubt the lack of legitimacy and rationality caused by this opacity. If the user perceives this label, it will make the user feel manipulated, and the consumer's sense of security and trust will also be reduced. When people know that they are searching for a certain product on an e-commerce platform, the search results are affected by their spending power and present completely different products. Even if each product has a different price for each different buyer; obviously, they have emotional changes. The sustainable development of AI-enabled experience insights needs to be discussed and handled carefully with regard to these ethical issues; otherwise, it will easily lead to confrontation between consumers and enterprises (as shown in Figure 3).

**4.2. Affective Experience and Affective Computing.** Emotions are people's inner feelings, which are often expressed through facial expressions, body movements, voice intonation, etc. People can feel the emotional changes in each other through observation. Emotion is also the focus of human-computer interaction and user experience. The emotional experience in human-computer interaction is divided into positive emotions and negative emotions. Positive emotions include resonance, love, desire, enjoyment, optimism, liveliness, confidence, interest, and satisfaction. Negative emotions include grotesque, masochistic, indulgent, unwilling, and sad [22]. Emotional experience is related to user expectations, which is of great significance to design research. In the field of design, tools such as Kansei Engineering have also been developed to measure emotional experience. Kansei Engineering originated in Japan, and it uses rational methods to study sensibility, including aesthetics, emotion, feelings, and sensitivity in a wide range of meanings. Products that can arouse users' positive emotions often have broad market prospects. In recent years, with the development of artificial intelligence technology, affective computing has become a research field of design science,

often used in the design evaluation of products or services, and has gradually become a new tool for design science to develop new products or services.

Affective computing is the application of artificial intelligence technology to the emotional field. By collecting characteristic clues such as facial expressions, body movements, voice intonation, eye contact, even muscle tremors, and subcutaneous blood flow information, people's emotions can be analyzed through specific algorithm models. Affective computing is widely used in the design, education, medical, and other scenarios. Affective computing helps to increase the chance of design success, but the implementation of affective computing requires the help of a large number of biometric technologies. It generally does not inform users that emotional signal acquisition is in progress, nor does it inform users of the results and their scope of use [23]. For ordinary users, emotional information is sensitive and private. In order to prevent harm, many users will control their emotions so that they are not easily visible. If users perceive their emotions being recognized by the machine in real-time, invisible pressure will be given to users, and a contradiction between technological development and user needs will be presented. Therefore, although affective computing is widely used, its development is also plagued by many factors in real situations, and it is difficult to put it into concrete practice.

*4.3. Algorithmic Black Box and Algorithmic Fairness.* Algorithms are seemed to be mysterious because of their black box nature. Even if users have certain algorithm awareness, it is difficult for users to understand the operating principles and results behind the algorithms. The algorithm is directly related to the user experience of the system to which it belongs. The transparency of algorithm analysis, algorithm management and user control, algorithm memory, and algorithm awareness directly affect the user's algorithm experience. Algorithm experience is used to approach a user-centric view of algorithms and how users perceive algorithms. The algorithm itself is also a concrete manifestation of values. The invisibility of the algorithm leaves room for the black-box operation of stakeholders, which brings problems such as asymmetric benefits and risks. Algorithm creators can shape the product service system according to their own interest, which brings uncertainty to regulation. Therefore, there is an urgent need to develop explainable and understandable AI that takes into account the values of safety, responsibility, explainability, and fairness; eliminates data bias and maintains algorithmic justice; and prevents power alienation.

It is not easy to achieve fairness in algorithms. First, algorithms are implemented by specific people, which may be driven by commercial interests and cause unfairness. Second, humans are biased, and algorithms are created by humans who are particularly vulnerable to bias, which leads to algorithms with inadvertently biased properties. Algorithmic injustice and algorithmic discrimination cause serious social harm. Just like racial discrimination, gender discrimination, and occupational discrimination in reality, algorithms with

biased attributes will strengthen this discrimination and bring hidden worries to the development of human society [24]. In addition to the main purpose of the algorithm, the precision, accuracy, and recall rate of the algorithm itself also affect the fairness of the algorithm. The algorithm precision is the ability of the algorithm to produce accurate results, the algorithm accuracy is the percentage of the algorithm that produces the correct result, and the algorithm recall rate is the ability that finds the relevant results through the algorithm. Therefore, the fairness of the algorithm can also be solved to a certain extent through technical paths such as debiasing algorithms. Experience computing is to calculate the user experience state through an algorithm. In order to obtain an accurate user experience state, it is a necessary condition to ensure the fairness and justice of the algorithm.

## 5. Design Ethics for Intelligent Production

*5.1. AI-Enabled Design Production.* Data-driven generative design is a methodology for automatically creating a large number of design solutions that meet user standards and requirements through an iterative algorithmic framework [25]. The dynamism and variability of data mean that each data update can bring a different design solution. With the help of generative adversarial networks, the creative design content generated by artificial intelligence has been comparable to the level of human designers and can achieve design content generation from text-to-image synthesis, image-to-image translation, image enhancement, and content style transfer. This will lead to a variety of generative design methods based on shape grammar, CAD parameterization, evolutionary algorithms, and so on. Generative design can imitate most designs using machine learning, style transfer, etc. For example, the design styles of design masters such as Naoto Fukasawa, Dieter Rams, and Luigi Clani can be generated under the algorithm.

Like the designs produced by human designers, AI-enabled design productions are also constrained by design ethics and need to meet design principles such as inclusiveness, safety, responsibility, and sustainability. In addition, computational creativity in the field of artificial intelligence and design computing in the field of design have different understandings and implementation paths for creativity in the era of artificial intelligence. Computational creativity is devoted to simulating human intelligence to enhance machine creativity and developing computational models of human creativity, while design computing is devoted to applying models and algorithms to help designers come up with better ideas; the former is devoted to replacing humans with machines, and the latter is dedicated to turning the machines into tools for human designers. At present, the design level of computational creativity is approaching midlevel designers. In the future, with the advent of the postmachine learning era, whether machines can think as wildly as humans do, whether they have emotional warmth and humane care like humans, we still do not know. However, human beings are also gradually adapting to artificial intelligence, and the generative design it can also become the object of design. Creative designers introduce

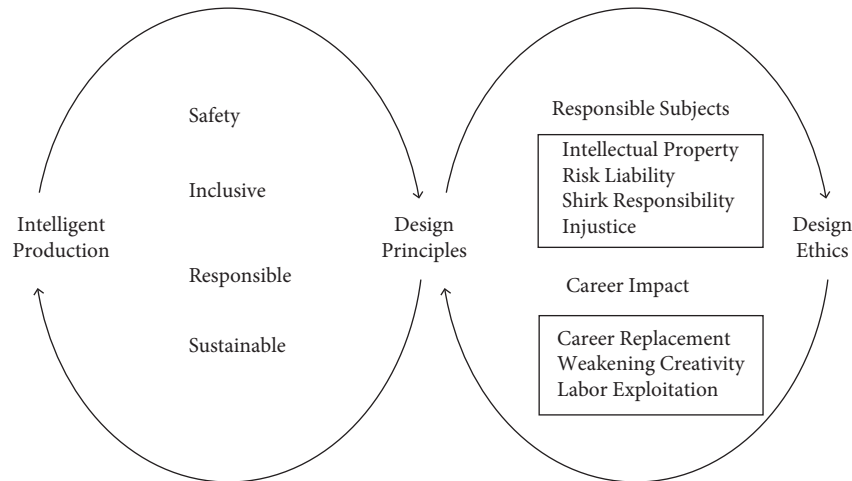


FIGURE 4: Design ethics for intelligent production.

the principles of generative design into the design process so that the previously standardized design solutions can present the characteristics of customization for thousands of people, extending the possibilities of creative design. Both aesthetics and ethics are branches of philosophy whose ideas are often intertwined. Just as the machine age produces machine aesthetics, the age of artificial intelligence will also produce intelligent aesthetics. The general model of the design aesthetic paradigm based on deep learning has become the power source of intelligent creative design. At the same time, AI-enabled design production also brings ethical issues such as unclear responsibility, unclear intellectual property rights, and an impact on human creativity and designer professions (as shown in Figure 4).

**5.2. Intellectual Property Rights and Responsible Subjects.** AI-generated designs rely less and less on human input, and even the generated works can be patented, independently which has raised questions about whether AI can be an ethical subject. For a design work, the stakeholders that may be involved include the AI program itself, AI program developers, and AI program users. The “author” in this context faces the possibility of redefining [26]. At present, the copyright ownership of such works in various countries generally belongs to the “people,” not the algorithm. However, with the continuous evolution of the algorithm, when the algorithm is fully capable of independent design in the future, how will the intellectual property rights of the work belong? If an algorithm can be the designer of a work or the inventor of a patent with the same rights as a human designer, who is responsible for defects or safety risks in products based on that design or invention? According to the principle that rights come with responsibilities, the complexity of the real situation is far more than this.

The core technology of AI-enabled design production is deep learning. Deep learning is to learn the inherent laws and representation levels of sample data. Imitation and plagiarism will be considered an infringement in real design situations, but how to define the degree of imitation and plagiarism and whether deep learning constitutes infringement is difficult to

determine. If the works used to train artificial intelligence are still under copyright protection, it is even more debatable whether these works can be used for deep learning? If the work is suspected of plagiarism, can the algorithm be held liable as the responsible subject? How to take the corresponding responsibility? If the algorithm is the subject of responsibility, then whether there are real “people” who deliberately plagiarize and technically shirk their responsibility. At present, the ultimate responsibility of all countries for the behavior and results of algorithms must always be borne by humans, and algorithms themselves should not acquire legal personality. However, the rights and responsibilities of the stakeholders in running AI, such as designers, developers, optimizers, and users, are not clear. This has resulted in the fuzzy areas of intellectual property rights for intelligent creative design, and these fuzzy areas have hidden dangers for the intellectual property rights of intelligent creative design.

Generative design generates kaleidoscopic design solutions in a short period of time, and for humans, we can define rules and algorithms. However, since the results are unpredictable and difficult to control due to the influence of many variables, it is extremely difficult to effectively monitor such complex results. The artificial intelligence system cannot become the responsible subject, and the real responsible subject cannot supervise the results generated by the algorithm. Attributing responsibility to the responsible subject who cannot implement effective supervision will deprive the responsible subject of the right to defend, resulting in injustice. Creative design solutions in business practice involve many stakeholders, and the consequences of ineffective supervision will bring disorder and confusion to intelligent creative design platforms. “Responsible AI” has become the key to solving such problems. Responsible artificial intelligence strengthens the impact factors of ethics and human controllability in artificial intelligence systems, and “distributed responsibility” has become a new research paradigm.

**5.3. Creativity and Career Impact.** The design activities of human designers include not only rational, structured knowledge but also perceptual unstructured knowledge,



such as analogies, associations, and emotions. Different designers have different understandings of the same thing and create different design solutions which are also attractive [27]. Delegating some of the productive work to AI allows creative designers to focus on higher value, more creative work. However, with the continuous evolution of intelligent creative design, more and more useful design tools are born, which may cause some human designers to over-rely on tools and technologies, further causing concerns about the relative weakening of human designers' creativity [28]. Theoretically, human design knowledge and skills will be learned and continuously evolved by artificial intelligence systems, infinitely approaching the design capabilities of human designers, and even surpassing the design capabilities of human designers in some vertical fields. This places higher demands on human designers themselves to cope with competition from artificial intelligence and the external environment [29].

With the continuous introduction of various intelligent creative design tools, the work at all stages of creative design is constantly being replaced by artificial intelligence systems. Design professionals disdain this kind of work and believe that creative design still needs to come from the hands of professional designers, but technological optimists believe that artificial intelligence will eventually replace most design work, and human beings are increasingly dependent on intelligent creative design tools. As a result, human beings have gradually become the vassals of technology. The two viewpoints will not prevent the evolution and development of intelligent creative design systems, but they will also provide inspiration for people to rethink the relationship between humans and artificial intelligence.

In the scene of human-machine collaboration, some intelligent creative design platforms incorporate the labor of creative designers into the entire service system and drive the operation of the system through algorithms and mechanisms. It is necessary to be alert to such trading platforms that deliberately exploit human work and creativity through algorithms. How to view the division of labor between artificial intelligence systems and humans and how to establish trust and cooperation between humans and artificial intelligence systems deserve further consideration. With the development of technologies such as virtual reality, augmented reality, and block chain, human life and production methods are facing reconstruction, new demands will emerge, and design will also be facing more new opportunities and challenges.

## 6. Conclusion

Through digital perception, experiential computing, and intelligent production, artificial intelligence intervenes in various stages of the creative design process, such as user research, concept ideation, design generation, and design evaluation, and guides intelligent creative design to form a closed loop and iteratively move forward. Of course, how to ensure that ethical values such as data ethics, algorithm ethics, and design ethics are embedded at the beginning of the creation of the intelligent creative design platform so as

to realize the ethical governance of the sustainable development of the platform is beneficial to all interested parties. Data ethics governance needs to ensure privacy protection and data security in AI-enabled user research, design evaluation, etc., while balancing the data rights of stakeholders and preventing excessive data exploitation; algorithm ethics governance needs to ensure fairness and justice of algorithms, enhance user algorithms' experience, and prevent commercial inducement in the name of personalized customization; design ethics governance needs to distinguish between the intellectual property rights and responsible subjects of intelligent creative design to prevent the excessive exploitation of human designers' labor and creativity. Moreover, the ethics of intelligent creative design also involves many ethical dilemmas and paradoxes, such as the informed consent of user research, the accuracy of conclusions, and the ownership and responsibility of intellectual property rights. These ethical dilemmas and paradoxes require further exploration by more interdisciplinary stakeholders. In the field of design research, design concepts such as speculative design, sustainable design, and inclusive design will provide good soil for the ethical research of intelligent creative design. In addition, building an intelligent creative design ecosystem is also a major approach. The intelligent creative design system is like a spear and a shield. While replacing some design work, it is also generating new types of work, such as design architects. The artificial intelligence ecosystem needs interdisciplinary and cross-field participants. In a healthy AI ecosystem, every player across multiple industries and fields can find their own way to develop [9, 30, 31].

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Disclosure

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## Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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