



# Optimization and Theoretical Exploration of Intelligent Advertising System Based on Big Data and Artificial Intelligence

Lan Shi<sup>1</sup>; Dandan Lu<sup>2,\*</sup>

<sup>1</sup>School of Journalism and Cultural Communication, Guangxi University of Finance and Economics, Nanning Guangxi, China

<sup>2</sup>School of Business Administration, Guangxi University of Finance and Economics, Nanning Guangxi, China

\*Email: ludandan163@163.com

**Abstract.** Intelligent advertising combines AI and big data technologies to achieve accurate placement of personalized advertising content by analyzing user behavior and preferences. This paper introduces the construction concept of AdMind, a smart advertising platform, which realizes the whole-process intelligent management of the advertising business process through a full-stack AI tool chain, from data set interface to advertising effect tracking. AdMind platform automates the generation of advertising creative, optimizes the delivery strategy, and monitors the advertising effect in real time through deep learning and intelligent algorithms, forming a self-perfecting closed-loop system. Meanwhile, this paper also looks forward to the future application prospects of smart advertising, including the potential impact of deep learning, edge computing and blockchain technology in improving advertising accuracy and user experience.

**Keywords:** Intelligent Advertising; Big Data; Artificial Intelligence; Personalized Recommendation; Advertising Effect.

## 1 Introduction

The advertising industry is experiencing significant transformation, driven by AI and big data technologies. Intelligent advertising systems analyze user data to deliver personalized advertisements<sup>[1]</sup>, improving effectiveness. However, the theoretical foundations of these systems, particularly in algorithm selection and data strategies, remain underexplored.

While traditional media lacked personalization, online advertising employs recommendation systems and machine learning to improve user experience. Nevertheless, challenges in algorithm accuracy, data processing, and system optimization persist.

This study examines AI and big data applications in optimizing intelligent advertising, addressing challenges like cost control, real-time management, and algorithm improvement, with the aim of advancing intelligent advertising systems in the industry.

## 2 Theoretical Framework and Technological Background

### 2.1 The Development of Artificial Intelligence and Global Strategic Planning

Over the past decade, AI has driven global technological innovation, fueled by advancements in big data, computational capabilities, and deep learning algorithms. AI technologies have been widely applied, including in advertising.

Countries like the U.S., Europe, and Asia have implemented strategies to lead in AI. The U.S. promotes AI through initiatives like the American AI Initiative, with companies such as Google and Amazon advancing intelligent advertising technologies (White House, 2019). In Europe, the Artificial Intelligence White Paper outlines a strategy to enhance competitiveness through significant investments (European Commission, 2020). Germany and France have made progress in personalized advertising and user behavior analysis.

Similarly, Japan and South Korea aim to advance AI, with South Korea targeting global AI leadership by 2030, emphasizing intelligent advertising (Japan Science and Technology Agency, 2017; Korean Government, 2019). China has prioritized AI as a key technology for national competitiveness. The Next Generation Artificial Intelligence Development Plan outlines China's goal to be a global AI leader by 2030<sup>[3]</sup>.

Policies like the Regulations on the Management of Internet Information Service Algorithms aim to regulate AI applications<sup>[2]</sup>. Institutions such as Baidu and Alibaba have made strides in natural language processing, furthering AI's role in advertising<sup>[4]</sup>. Additionally, AI integration with edge computing and blockchain technology enhances responsiveness and security in intelligent advertising<sup>[2,4]</sup>.

### 2.2 The Application of Big Data and Artificial Intelligence in Advertising Systems

Intelligent advertising aims to deliver personalized ads by analyzing user behavior, significantly improving ad effectiveness. As advertising data grows exponentially, challenges in real-time performance and accuracy arise, making algorithm selection and computational resource allocation crucial<sup>[5,6]</sup>.

To process vast user data such as click behavior and browsing history, distributed computing frameworks like Hadoop and Spark are used<sup>[7,8]</sup>. NoSQL databases enhance scalability, while techniques such as clustering and classification predict user needs based on data analysis.

In ad content generation, AI technologies like Generative Adversarial Networks (GANs) and natural language processing optimize ad creatives. Dynamic strategies such as A/B testing improve click-through and conversion rates. Predictive models like Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks aid in forecasting user behavior, further optimizing ad delivery strategies<sup>[9]</sup>.

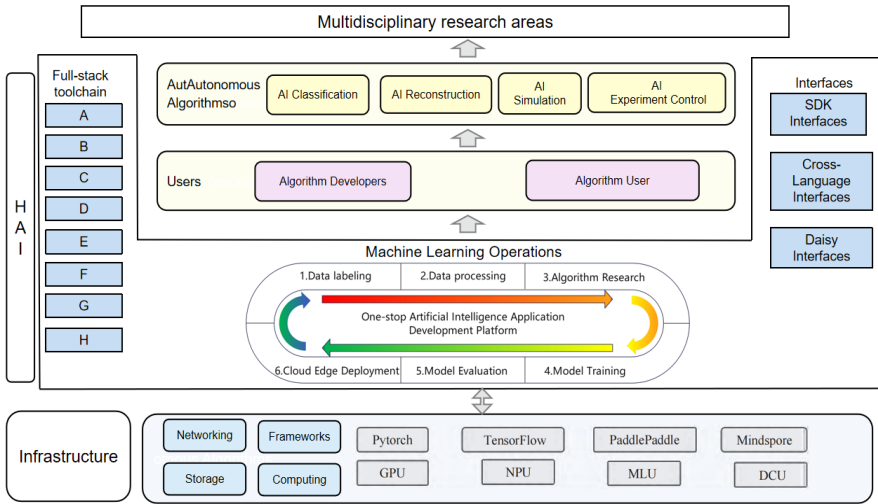
Despite advancements, issues like data privacy and algorithmic fairness remain. Edge computing and blockchain technologies offer solutions for enhancing real-time responsiveness and data security in advertising systems.

### 3 Construction of the Intelligent Advertising Platform

#### 3.1 The Construction of Platform System

Artificial intelligence platforms accelerate scientific research across multiple fields, streamline model iterations, and provide common infrastructure for AI algorithm and application development. These platforms integrate data, models, and computational power to create an interactive environment that supports seamless workflows from data annotation to cloud-edge deployment, offering a comprehensive full-stack toolchain. This reduces the complexity of AI algorithm development and application deployment while improving efficiency. AI platforms for scientific research differ from industrial ones in three key aspects: the transformation and efficient execution of deep learning frameworks, benchmarking methods for AI-based scientific computing, and the general paradigms of scientific computing across various natural science domains.

The artificial intelligence platform HAI, developed by the Institute of High Energy Physics of the Chinese Academy of Sciences (Figure 1), adopts the MLOps concept and serves multiple scientific domains<sup>[8]</sup>. It offers a full-stack AI toolchain and resources, including computing power, algorithm models, and data, and possesses core capabilities such as model construction, management control, technical enablement, and security assurance. HAI is based on a software framework utilizing the MPS architecture, emphasizing usability and efficiency. It also supports domestic infrastructure, promoting the development of the local software ecosystem.



- A: Data set interface
- B: Cutting-edge network construction methods
- C: Heterogeneous Resource Scheduling
- D: Algorithm library interfaces
- E: Visualization Tools
- F: Optimized Deployment Tools
- G: Compilation Tools
- H: Task Scheduling Tools

**Fig. 1.** Architecture of the High-Energy Physics AI Platform (HAI)

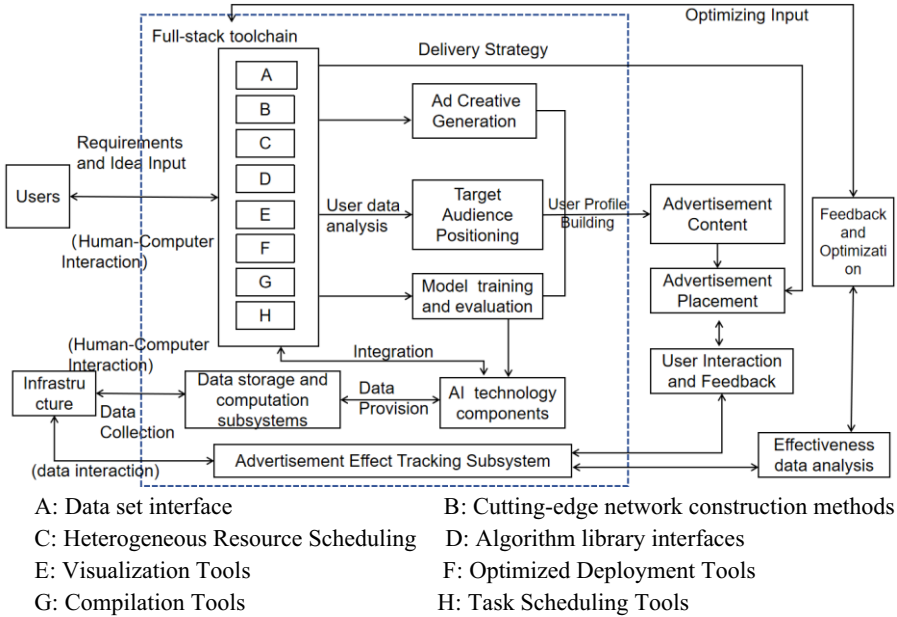
Building on the design principles of the High Energy Physics Artificial Intelligence platform (HAI) and big data processing technologies, this study developed the intelligent advertising platform AdMind, aimed at providing comprehensive and efficient technical support for the advertising industry. The AdMind platform adopts a modular design, integrating dataset interfaces, data processing tools, algorithm research libraries, model training frameworks, performance evaluation tools, and cloud-edge deployment solutions, creating a highly integrated full-stack AI toolchain. The platform's infrastructure centers around a data storage and computing system, which not only supports data processing and analysis but also connects with the advertising effect tracking subsystem via the dataset interface, ensuring real-time monitoring and in-depth analysis of ad performance. The advertising effect tracking subsystem is a critical component of the platform, responsible for collecting user interaction data and providing the basis for optimizing advertising strategies through the effect data analysis module.

The architecture of the intelligent advertising platform (as shown in Figure 2) illustrates the integration of the full-stack toolchain and infrastructure, as well as how these components work together to achieve end-to-end intelligent management of advertising operations. Beginning with the dataset interface that captures user needs and creative inputs, the platform leverages deep learning and intelligent algorithms to generate ad creatives precisely targeted at the intended audience. These creatives undergo model training and evaluation to ensure their appeal and effectiveness. To enhance the capability and accuracy of user behavior prediction, the AdMind platform employs deep learning models based on the Transformer architecture to model user behavior sequences, which have been further optimized within the platform.

Specifically, a loss function  $L(\theta)$  is defined to quantify the difference between the model's predicted value  $y^{(i)}$  and the actual value. The model is trained by optimizing this loss function. The form of the loss function is as follows:

$$L(\theta) = \frac{1}{m} \sum_{i=1}^m (y^{(i)} - \hat{y}^{(i)})^2 + \lambda \sum_{j=1}^n \theta_j^2 \quad (1)$$

Here,  $m$  represents the total number of samples,  $y^{(i)}$  denotes the actual value of the  $i$ th sample,  $\hat{y}^{(i)}$  represents the model's predicted value for the  $i$ th sample,  $\theta_j$  denotes the  $j$ th parameter of the model, and  $\lambda$  is the coefficient of the regularization term, which is used to control model complexity and prevent overfitting.



**Fig. 2.** Architecture of the Intelligent Advertising Platform AdMind

Through model optimization, prediction error was reduced, and generalization ability was enhanced using regularization techniques. This optimization significantly improved the model parameters  $\theta$ , leading to greater accuracy in predicting user behavior. The deployment strategy module then formulates and executes the ad placement plan, collects user feedback, and enables real-time optimization, forming a self-improving closed-loop system. In the design of the AdMind intelligent advertising platform, the data storage and calculation subsystem plays a central role. It stores and processes advertisement-related data and interfaces with the advertisement effect tracking subsystem to support real-time monitoring and analysis. The effect tracking subsystem collects data after ad placement and performs in-depth analysis to ensure accuracy and effectiveness. Through the data feedback mechanism, the system continuously optimizes ad content and placement strategy.

The dataset interface is the data input side of the platform, responsible for obtaining requirements and creative inputs from users and transforming them into data support. The platform interfaces with external data sources through the dataset interface to ensure the comprehensiveness and accuracy of the data. Based on the data and creative input from users, the platform generates advertising creative through deep learning and intelligent algorithms. The ad creative generation module includes target audience positioning, model training and evaluation to ensure that the generated ad creative can accurately attract target users.

After generating the advertising idea, the delivery strategy module develops the specific delivery plan and generates the advertising content. The ad content is further optimized before delivery to ensure that it achieves the best results in actual delivery.

After the ads are placed, user interaction data is collected and analyzed through the user interaction and feedback module.

This module is responsible for real-time analysis of user feedback, which is used to optimize the subsequent advertising ideas and delivery strategies, forming a closed-loop system of continuous self-optimization.

**Table 1.** AdMind Intelligent Advertising Platform Functional Modules

NO.	module	Functional Description
1	Data Collection and Processing	Collect, store, and preprocess user and external data using dataset interfaces.
2	Ad Generation and Evaluation	Use AI algorithms to generate and optimize ad creatives through model training.
3	Ad Placement and Monitoring	Plan and execute ad delivery, monitor performance, and analyze user interactions.
4	User Interaction and Feedback	Collect real-time feedback and integrate insights into the AI system for optimization.
5	Full-Stack Tool-chain	Includes dataset interfaces, network methods, and AI components for model training.

As shown in Table 1, by integrating the technology of high-energy physics artificial intelligence platform, AdMind, the intelligent advertising platform, has constructed an efficient and intelligent advertising business operation platform, which greatly improves the operation efficiency and effect of advertising business and provides new technical support and solutions for the development of the advertising industry.

This platform not only improves the accuracy and effectiveness of advertisement placement, but also realizes the continuous optimization of advertisement content and placement strategy through real-time user feedback and data analysis.

Through the integration of high-energy physics AI technology, the AdMind intelligent advertising platform significantly enhances the efficiency and effectiveness of advertising operations. Specifically, the platform demonstrates outstanding advantages in the following application scenarios:

(1) E-commerce Advertising: The AdMind platform uses deep learning models to analyze user browsing history and purchase preferences, generating personalized ad content that improves click-through rates and conversions. The real-time feedback mechanism allows advertisers to swiftly adjust ad creatives and delivery strategies for optimal performance.

(2) Retail Industry: The platform's ad placement monitoring feature dynamically adjusts the frequency and exposure of ads based on user activity, ensuring that ads reach the target audience most effectively. This results in higher user engagement and sales conversion rates.

(3) Tourism Promotion: By monitoring user click and booking behavior in real time, the AdMind platform optimizes the timing and content of ad placements, significantly increasing booking rates. Its closed-loop feedback system enables advertisers to quickly respond to market changes, continuously improving ad designs and placement strategies.

(4) **Technical Support:** The AdMind platform provides a full-stack toolchain covering every stage from data collection, model training, to ad performance monitoring. This helps advertisers rapidly deploy and optimize ad campaigns, increasing precision in ad targeting while reducing operational costs. The platform also enhances decision-making by providing scientific insights based on real-time data.

Through these applications, the AdMind platform not only improves the accuracy and effectiveness of ad placements but also offers strong technical support for the development of the advertising industry. Its deep application of advanced AI and data processing technologies positions AdMind as an effective tool for intelligent advertising operations, driving innovation and progress in the industry.

It can be seen that the intelligent AdMind platform, which integrates advanced AI technology and data processing methods in all aspects of the advertising business process, reflects the in-depth application of AI technology.

### 3.2 Application areas of the Smart AdMind platform

With the rapid growth of the digital advertising market, the advertising industry is facing many challenges, including key aspects such as ad content generation, placement strategy development and effectiveness evaluation. In order to effectively address these challenges, AdMind, an intelligent advertising platform, integrates advanced artificial intelligence technologies to build a comprehensive advertising intelligence system. The system covers a wide range of aspects, including creative idea generation, strategy development, personalized experience delivery, predictive analytics and automatic content generation, and is designed to help advertisers gain an edge in the highly competitive marketplace.

The AdMind platform has a wide range of applications, from idea generation to tracking and optimization. Table 2 describes in detail the functions of the platform in different application scenarios, as well as its technical implementation and effects.

**Table 2.** Description of application scenarios of intelligent advertising platform

Application module	Application scenario	Applied Technology and Effectiveness
High Quality Ad Effect Generation	E-commerce promotions to generate personalized ad creatives based on user browsing history and purchase preferences.	Deep learning models are used to analyze user data and generate personalized ad creative, and the model training and evaluation module ensures its attractiveness and effectiveness.
Efficient data processing and compression	The advertisement placement data is compressed to reduce storage space requirements and quickly complete data cleaning, labeling and analysis.	Drawing on high-energy physical data screening and compression technology to improve data processing speed, reduce computing costs, and improve the efficiency of data storage and access.
Intelligent real-time control of ad delivery	Promotional advertising for retail enterprises automatically adjusts the frequency of placement and exposure based on user activity.	Real-time control algorithms are utilized to dynamically adjust the advertisement placement strategy to ensure efficient placement of advertisements and improve the conversion rate and effect of advertisements.

<p>Advertisement effect tracking and feedback optimization</p>	<p>Such as tourism promotion ads, real-time monitoring of user clicks, booking behavior data, according to the results of the analysis to adjust the advertising material and placement time.</p>	<p>Real-time monitoring of advertising effects, rapid response to market changes, adjusting the placement strategy, optimizing the ad design and placement strategy through the closed-loop feedback mechanism, improving the efficiency and effectiveness of ad placement.</p>
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As can be seen from the above table, through Table 2, the AdMind platform integrates the technology of high-energy physical artificial intelligence platform to build an efficient and intelligent advertising business operation platform. This platform not only significantly improves the accuracy and effectiveness of advertisement placement, but also continuously optimizes the advertisement content and placement strategy through real-time user feedback and data analysis, forming a self-optimizing closed-loop system. While solving the key challenges of the advertisement industry, the AdMind platform provides new technical support and solutions for the development of the advertisement industry, demonstrating the artificial intelligence technology's It demonstrates the prospect of wide application of AI technology in the advertising field.

## 4 Conclusion

Artificial intelligence and big data are becoming key drivers of change in the advertising industry. By integrating data, models, and computing resources, intelligent advertising platforms enable the automation of creative generation, placement strategy, and effect tracking. AI's main advantage lies in processing large datasets and extracting valuable insights, though challenges like algorithm interpretability and small sample issues remain.

Future development will focus on AI-enabling applications, algorithms, and hardware/software platforms. Applications require not only current technologies but also specialized algorithms for industry-specific problems. Basic research will advance general AI algorithms, and hardware/software platforms will support both AI applications and research. The combined progress in these areas will enhance advertising content generation, placement strategies, and effect analysis, providing strong technical support. Over the next 5 to 10 years, AI and big data will make advertising a key field of technological innov.

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