ISSN: 2710-0588

Design of Intelligent Combined Harvester Based on TRIZ Contradiction Matrix Theory

Youlan Xu

School of Mechanical Engineering, Sichuan University of Science and Engineering, Yibin, China

Abstract

Focusing on the design contradictions in the design of unmanned intelligent harvesters, such as the integration of functions and the overall appearance, the perception of technological sense and reliability, this paper explores the application methods of TRIZ contradiction matrix theory in the field of agricultural machinery appearance design. Based on the TRIZ conflict matrix theory, the subjective judgments in the industrial design of unmanned harvesters are transformed into quantifiable contradiction parameters, and the contradiction parameters and resolution principles suitable for the appearance design of unmanned agricultural machinery are extracted to establish a design strategy framework. Three core strategies, namely "integrated appearance design", "intelligent visual communication design", and "brand consistency design", are proposed and verified through design cases. The TRIZ contradiction matrix theory can effectively guide the appearance innovation design of unmanned intelligent harvesters and provide a systematic methodological reference for the industrial design of intelligent agricultural equipment.

Keywords

TRIZ theory; Contradiction Matrix; Unmanned Driving; Combine Harvester; Industrial Design; Appearance Modeling.

1. Introduction

As a core piece of equipment in agricultural modernization, the performance of combine harvesters directly affects the efficiency of grain production. With the rapid development of intelligent control technology, sensor technology and information technology, combine harvesters are evolving towards intelligence and precision. Against this backdrop, users have put forward higher requirements for the appearance and operation experience of agricultural machinery products. However, traditional agricultural machinery design has long been function-oriented, presenting a "functionalism" feature, that is, exposed structure, strong blockiness and monotonous color [1].

2. Overview of TRIZ Theory

TRIZ theory is a systematic innovation methodology system, with its core tools including 39 universal engineering parameters, 40 inventive principles, and the contradiction matrix. In recent years, researchers have begun to explore the application of TRIZ in the field of industrial design. Some scholars have applied the TRIZ contradiction matrix theory to the field of agricultural machinery industrial design, summarizing the contradiction parameters and resolution principles suitable for the appearance design of agricultural machinery. The results show that the TRIZ contradiction matrix theory can scientifically quantify the subjective judgment in design, improving the efficiency and scientificity of agricultural machinery appearance design. This paper systematically applies the TRIZ contradiction matrix theory to

ISSN: 2710-0588

the design of intelligent combine harvesters, providing a systematic method for resolving design contradictions under new technological conditions [2].

3. Identification of Design Contradictions in Intelligent Combined Harvesters

Referring to the definition of technical contradictions in the TRIZ theory and combining the design reality of intelligent combined harvesters, the following four core design contradictions can be identified:

3.1. The Contradiction between Functional Integration and Stylistic Integrity

The increase in intelligent sensors and electronic control components has led to a greater number of visual elements and fragmented body blocks in the entire machine. How to integrate the redundant components into a unified and smooth styling language is the primary contradiction in the design.

3.2. The Contradiction between Technological Sensation Expression and Driving Friendliness

Sharp lines and high-tech color schemes can convey intelligence, but overemphasizing futurism may sacrifice visual friendliness and the readability of the operation interface. Research indicates that the demands of agricultural machinery in terms of mechanical design, color, safety, and ease of use are often overlooked.

3.3. The Contradiction between Styling Innovation and Process Feasibility

Although bold curved surfaces and complex feature lines can enhance the styling competitiveness, they may lead to increased mold costs, higher assembly difficulty, and even affect the sealing and waterproof performance of various components.

3.4. The Contradiction between Brand Recognition and Detailed Functionality

If brand feature symbols emphasize the overall sense, it may hinder the effective performance of basic functions such as heat dissipation and lighting.

4. Design Strategies Based on the TRIZ Contradiction Matrix

4.1. Integrated Form Design

Applying the "merging" principle, the scattered sensors are integrated into a unified module, reducing external protrusions and creating a clean and neat visual volume. The exposed mechanical structures are covered with continuous and smooth surfaces, and the grain box and engine hood are connected through an integrated skin, eliminating the fragmented appearance caused by exposed structures in traditional agricultural machinery. The color design can adopt a two-color strategy of base color and accent color. The main color covers the main body to form a sense of unity, and the bright accent color outlines the intelligent module area, creating a visual focus [3].

4.2. Intelligent Sensory Visual Communication Design

The autonomous harvester eliminates the driver's cabin and control system, shifting human-machine interaction from in-cab operation to remote monitoring and autonomous operation. Consequently, the exterior design must transition from driver-friendliness to conveying a sense of intelligence, using visual language to communicate the product's autonomy, precision, and reliability. It emphasizes balancing technological expression with reliability perception, as well as the aesthetic representation of intelligent features.

ISSN: 2710-0588

4.3. Brand Consistency Design

Define standardized family features for autonomous harvesters, such as unified grille textures, iconic character lines, and distinctive light strip designs. Utilize the TRIZ "replication" principle to apply the brand's core graphics parametrically at varying densities and angles across different components, creating a visually dynamic yet cohesive rhythm. Meanwhile, convey the precision of manufacturing through details like high-gloss chamfers, refined material contrasts, and meticulous gap control, reinforcing user confidence in the product's reliability [4].

5. Design Practice

5.1. Design Positioning

The product is positioned as an autonomous joint harvester designed for large-scale farms, capable of fully autonomous operation during work. Its core value proposition lies in labor-saving, high efficiency, and precision.

5.2. Styling Design Proposal

On the basis of maintaining the substantial and solid volume of agricultural machinery products, modern design language characterized by fluidity, integration, and technology is incorporated. Components such as RTK antennas, 5G communication, cameras, and radars are integrated into an intelligent dome, forming the visual feature at the top of the machine. A precise, angular surface design enhances the technological visual appeal. At the traditional cab location, a light strip or transparent material-covered electronic module is installed, hinting at the presence of a smart brain while retaining visual focal functionality. Dark gray conveys a sense of sturdiness, cool tones evoke technological sophistication, and neutral hues communicate professionalism. It is recommended to adopt a color scheme with dark gray as the main tone and technological blue as an accent, balancing professionalism and technological appeal. The main body features matte spray painting, while the smart module adopts semi-gloss varnish or a metallic texture. LED light strips are integrated into the smart module, charging interface, and brand logo, conveying "device standby/operation in progress" status information through dynamic lighting effects. While preserving the robust and rugged agricultural machinery characteristics, soft curves are incorporated into details such as line transitions and chamfering to ensure functional priority while maintaining visual harmony [5].

5.3. Presentation of Design Works

According to the preceding analysis, the design scheme presented in Figure 1 is proposed.

Figure 1. Design Scheme of the Intelligent Combine Harvester

ISSN: 2710-0588

6. Conclusion

This paper addresses the core contradictions in the exterior design of autonomous intelligent harvesters by systematically applying the TRIZ contradiction matrix theory, transforming perceptual visual judgments in industrial design into specific parameter conflicts and resolution pathways. For the emerging product category of autonomous vehicles, it proposes innovative design concepts such as "Smart Dome" and "Dynamic Light Effects.";

A comprehensive design strategy framework was established from three dimensions: integrated styling, intelligent perception conveyance, and brand consistency.

It provides a methodological reference with both theoretical foundation and practical value for the industrial design of autonomous agricultural equipment.

References

[1] Shao Rongrong, Cao Longlong. Research on Agricultural Machinery Appearance Design Method Based on TRIZ Conflict Matrix Theory[J]. Southern Agricultural Machinery, 2024, 55(13): 24-28.

[2] Shen Mengna, Sun Wei, Li Maodan. Design of a Qinling Mountain Rescue Drone Based on AHP-TRIZ Theory [J]. Industrial Design, 2026 (02): 147-150.

[3] Li Cuiyu, Sun Hao. Design of an Intelligent Wardrobe Based on the KANO Model and TRIZ Theory [J]. Industrial Design, 2026 (04): 48-52.

[4] Zhai Shiteng, Fang Di. Design of Delivery Robot for Senior Living Apartments Based on TRIZ Theory[J]. Industrial Design, 2026(01): 24-28.

[5] Chen Qiwen, Pan Mixue, Zheng Bin. Research on Learning Furniture Design for School-Age Children Based on TRIZ Theory[J]. Furniture & Interior Decoration, 2025, 32(11): 8-13.