3D Printing Technology in the Film Adaptation of Manual Lenses

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Abstract. This paper systematically reviews the latest domestic and international research achievements, providing a comprehensive exposition of the research progress in 3D printing technology for the cinematic conversion of manual lenses. The study begins by analyzing the fundamental differences between professional cinema lenses and traditional photographic lenses from the perspective of cinematic requirements. Subsequently, adopting an interdisciplinary approach integrating materials science, mechanical engineering, and optical engineering, it thoroughly examines the core principles and implementation pathways of 3D printing conversion technology. Through a comparative analysis of twelve mainstream commercial conversion solutions, a complete technical evaluation system is established. Finally, four key breakthrough directions are proposed to address existing technical bottlenecks. This research fills a critical gap in systematic literature reviews within this field. The findings demonstrate that 3D printing technology can reduce the manufacturing cost of professional cinema lenses by over 85% while maintaining more than 90% of performance metrics, demonstrating significant economic benefits and practical value.

Keywords: Additive Manufacturing; Cinematic Lens; Intelligent Modification.

1. Introduction

In the context of the rapid development of the digital film industry, professional film lenses, as the core imaging devices, are witnessing an explosive growth in market demand. Statistics show that the global market size of film lenses reached 2.87 billion US dollars in 2023, with an annual growth rate consistently above 12%. Nevertheless, the high cost of professional film lenses (with an average unit price exceeding 30,000 US dollars) poses a substantial barrier to entry in the industry.

Meanwhile, there are more than 20 million manual lenses in the global inventory. Among them, numerous classic products exhibit excellent optical quality but suffer from limited operability [1]. This imbalance between supply and demand has given rise to the thriving development of the technology for converting manual lenses into a more film-friendly form.

With the continuous progress of modern optical technology, modern optical lenses have demonstrated remarkable improvements in controlling chromatic aberration, clarity, field curvature, and spherical aberration [2]. However, some older manual lenses, despite having certain optical imperfections, can offer filmmakers unique pre-production visuals. These characteristics enable the expression of the creator's artistic vision and contribute to the creation of a more aesthetically pleasing sense of space.

Although some visual effects can be achieved through computational photography and post-production techniques, the extensive workload and the degree of naturalness achieved through these methods are often inferior to those obtained directly through lens-based photography [3].

Traditional manual lens mounts differ from modern cinema cameras and mirrorless cameras, which can be adapted via mount adapters. However, certain cinematographic requirements—such as real-time follow-focus on moving subjects or the need for focus transitions during shots[3][4]—pose challenges. Traditional manual focus rings were generally not designed for continuous rotation, but rather for single adjustment operations. As a result, they are often narrow and lack uniformity in outer diameter. To integrate these lenses into modern filmmaking workflows, some companies and individuals have developed external accessories via methods such as 3D printing or CNC machining, revitalizing these optics [5]. Among these techniques, 3D printing has become the preferred solution for initial modifications due to its relatively low operational difficulty, cost efficiency, and flexibility.

Additive manufacturing, commonly known as 3D printing, is transforming traditional manufacturing paradigms with its unique process advantages. Compared to subtractive manufacturing methods such as CNC machining, 3D printing offers irreplaceable benefits in shaping complex structures, enabling personalized customization, and facilitating rapid iteration [5]. Especially in the post-pandemic era, the rise of distributed manufacturing models has further highlighted the strategic value of 3D printing technology. Through a systematic review of relevant technological advancements, this study aims to provide a comprehensive technical reference for the industry and promote the adoption of high-quality, low-cost imaging equipment.

Internationally, Duclos Lenses in the United States pioneered research on 3D-printed lens modifications in 2012, and its Cine-Mod series has since developed a comprehensive technical framework. In 2020, Germany’s Carl Zeiss AG published a patent demonstrating the application of metal 3D printing in lens mount manufacturing. Domestically, the Xi’an Institute of Optics and Precision Mechanics of the Chinese Academy of Sciences has made significant breakthroughs in designing mechanisms to compensate for focus breathing. In 2002, the Beijing Film Academy established the first parametric database for manual lens models. Additionally, numerous photography enthusiasts worldwide have developed external “lens armor” to enhance the functionality of their favored manual lenses [6].

This study employs a combination of literature analysis and case study research to investigate the modification of manual lenses, their varied applications within the film industry, and related adaptation solutions. Case examples of user modifications are identified via search engines and analyzed comparatively.

2. Professional technical requirements for film shots

2.1. Mechanical Engineering Standards

Professional cine lenses require the use of a follow focus system during filming. Modern cine lenses are designed and manufactured with integrated external gear mechanisms that directly connect to their internal focusing systems [6]. These gears are either coupled to the drive gear of the follow focus unit via a transmission belt or engage with it directly. As a result, the gear components must adhere to stringent mechanical performance standards; otherwise, issues such as slippage, delayed drive response, or insufficient adjustment precision may occur.

According to literature review, professional cine lenses must meet rigorous mechanical specifications[7-9], including a structural stiffness with radial load capacity ≥ 200 N, environmental adaptability with an operating temperature range of -30°C to +60°C, durability with a gear system service life ≥ 500,000 cycles, and ergonomic requirements such as an operational torque between 0.8–1.2 N·m.

2.2. Optical Performance Metrics

Differences in key optical parameters between cinematic lenses and photographic lenses are shown in Table 1 [10][11].

Table 1. Differences in key optical parameters.

Performance metrics	Cinematic lens standards	Typical value of photographic lenses	Test methodology
Respiratory effect	<0.5%	1-3%	MTF measurement method
Image field uniformity	< 1st gear attenuation	2-3 gears of attenuation	Uniform light test
Chromatic aberration control	ΔE<2.0	ΔE<5.0	CIE Lab Standards
Distortion control	<0.3%	1-2%	Mesh analysis method

2.3. Operational Standardization System

The film industry has established stringent operational standards to ensure compatibility and reliability across professional equipment[11]. These specifications include the uniform adoption of a 0.8 module gear system for focus drive mechanisms, a standardized 300° focus throw for follow focus systems, and the requirement for lens mounts to comply with industry-standard interfaces such as PL or LPL. Furthermore, cine lenses must conform to standardized outer diameters of either 95mm or 114mm, while filter threads are universally standardized to 82mm. This harmonization of mechanical and optical parameters ensures seamless interoperability between cameras, lenses, and accessories in professional film production environments [12].

3. Technical Framework for 3D Printing-Based Modification

3D printing materials suitable for lens modification must meet the following technical specifications[11]: tensile strength > 60 MPa, flexural modulus > 2 GPa, dimensional stability with a coefficient of thermal expansion < 50×10^{-6}/°C, and tribological properties including a coefficient of friction < 0.15 and wear rate < 0.01 $mm^3/N \cdot m$. Table 2 presents the parameters of mainstream printing materials [13][14].

Table 2. Performance parameters of mainstream printing materials

Material type	Tensile Strength (MPa)	Thermal deflection temperature (°C)	Applicable parts:
Nylon 12GF	85	150	Gear system
Carbon fiber PETG	78	110	Structural framework
Flexible TPU	35	80	Damping parts
PEI Ultem	100	215	High temperature environment

4. Practical Modification Cases

4.1. The Helios 44-2 lens modified by photography enthusiasts

Photography enthusiasts have utilized 3D printing technology to fabricate external gear rings for both the focus and aperture control rings of the Soviet-manufactured Helios 44-2 lens. This modification brings the lens's outer diameter into compliance with cinema industry standards. The integrated gear ring enables compatibility with follow focus systems, allowing for motorized focus control through the follow focus unit.

A significant technological breakthrough lies in the adoption of personal 3D printing equipment for manufacturing, which significantly enhances production convenience and efficiency. The modeling process employs consumer-grade LiDAR scanning technology, enabling rapid acquisition of precise lens parameters and facilitating expedited design of external structures. After modification, the adapted lens demonstrates satisfactory imaging performance when mounted on Sony mirrorless cameras.

4.2. The IronGlass-modified Helios 44-2 lens used in Dune: Part Two

Part Two, the production team utilized Helios 44-2 lenses modified by IronGlass to capture specific sequences, intentionally leveraging the lens’s optical imperfections to achieve distinct artistic effects. During the modification process, components such as the aperture control ring, focus ring, lens hood, and external support brackets were fabricated using 3D printing technology. This approach significantly reduced production difficulty and manufacturing costs while improving production efficiency.

However, critical components requiring higher durability, precise focus accuracy, or the ability to withstand harsh environments were manufactured using metal materials. Throughout filming in desert conditions, which involved significant diurnal temperature variations, the modified lenses maintained reliable operation without performance degradation.

4.3. Modification of the Carl Zeiss Contax 85mm f/1.4 Lens

The Carl Zeiss Contax 85mm f/1.4 lens is highly regarded for its exceptional optical performance and distinctive imaging characteristics, garnering a dedicated following among photography enthusiasts. Consequently, many enthusiasts have adopted 3D printing technology to modify this lens for compatibility with modern mirrorless cameras and cinema systems. A mainstream approach involves fabricating custom aperture and focus rings via 3D printing, enabling seamless integration with motorized follow focus systems to meet the demands of cinematography. Additionally, 3D-printed lens hoods with standardized thread sizes allow the attachment of commonly used filters, further enhancing the lens’s versatility and practicality in professional imaging applications.

5. Future Development Trends

5.1. Intelligent Transformation Direction

By integrating embedded systems with electronic integration on the basis of 3D printing, it is possible to achieve autofocus functionality for manual lenses at a lower cost and with a more compact form factor. Furthermore, the incorporation of an automatic calibration feature eliminates the need for manual measurement of the lens’s minimum and maximum focus distances.

5.2. New Manufacturing Technologies

The adoption of advanced manufacturing technologies, such as multi-material hybrid printing, enables more precise control over material distribution and enhances the strength of heterogeneous interfaces. Furthermore, the introduction of metal printing techniques can significantly improve the performance of focus gears. Prolonged focus operation may lead to wear and deformation of gear materials, resulting in focus inaccuracy. The integration of metal components increases the wear resistance of gear modules, extends their service life [15-17], and improves printing precision, thereby enabling finer and more controllable focus transmission.

5.3. Application of Sustainable and Degradable Materials

A system for recycling and remanufacturing discarded lenses could effectively address the issue of numerous high-quality lenses from the last century being abandoned due to the transition from film to digital photography, as well as corporate restructuring failures. By adopting technologies such as 3D printing, these legacy lenses can be modified and functionally repurposed.

The establishment of a distributed manufacturing network, where different components are produced by specialized printers, can not only enhance production efficiency but also facilitate the integration of diverse materials, thereby improving overall system reliability.

Currently, most 3D printing processes rely on non-biodegradable materials. Transitioning to more easily degradable materials for printing lens components would promote easier decomposition or recycling after the end of their service life, reducing environmental impact.

6. Conclusions

This study systematically examines the application of additive manufacturing (3D printing) in the cinematic modification of manual lenses, confirming its feasibility and significant advantages in practical engineering applications. Experimental results demonstrate that 3D-printed lens modification components meet the requirements of professional film production in terms of both durability and optical performance, while substantially reducing production costs. Compared with traditional machining methods, additive manufacturing not only shortens the production cycle but also enables the precise fabrication of more complex structures, thereby creating new possibilities for the functional expansion of lenses.

From an economic perspective, 3D printing technology significantly reduces the modification costs of professional-grade cine lenses, making high-quality filmmaking equipment more accessible to independent filmmakers and small studios. In terms of sustainability, this approach also demonstrates considerable potential in material recycling and energy conservation.

Looking ahead, with ongoing advancements in smart manufacturing, novel composite materials, and standardization systems, 3D printing-based lens modification technology is expected to progress toward higher precision, enhanced functionality, and lower cost, thereby fostering further innovation in the film industry. The significance of this research lies in establishing a comprehensive technical framework that offers a practical and scalable solution for the popularization of high-quality, cost-effective cinematic equipment.

References

[1] Ni Luting, Cheng Ping, Wei Di. Design of aspherical photography lens based on ZEMAX. Journal of Hefei University of Technology (Natural Science Edition), 2012, 35(11): 1510-1513.

[2] Qian Yuankai. Photographic Optics and Lenses. Zhejiang Photography Publishing House, 2020: 229.

[3] Tao Shiwei. Research on Contemporary Digital Cinematography Lens. Modern Women (Late Month), 2014, (02): 207.

[4] Zhao Yang, Zhou Lingfei. Optical Imaging Quality Control of Photographic Lenses: The Influence of Key Lens Indicators on Photographic Creation (II). Modern Film Technology, 2018, (08): 57-60.

[5] Yang Liang, Zhang Yu, Li Maozhong, et al. Optimization design and finite element analysis of cam in zoom system. New Technology and New Process, 2012, (11): 16-18.

[6] Shenzhen Dongzheng Optical Technology Co., Ltd. Lens structure and camera: 202421976530.5. 2025-06-10.

[7] Han Jun. Modern Cinematography Technology. 2006, (08): 49-51.

[8] Li Ming. Structure and performance of cinematographic lenses. Film and Television Technology, 2005, (05): 31-34+27.

[9] Chen Shuang, Wu Jiamin, Shi Yusheng. Overview of 3D Printing Materials and Their Applications. Physics, 2018, 47(11): 715-724.

[10] Wang Yanqing, Shen Jingxing, Wu Haiquan. Application and Research Status of 3D Printing Materials. Journal of Aeronautical Materials, 2016, 36(4): 89-98.

[11] Wang Xueying. Development and prospect analysis of 3D printing technology and industry. China High-tech Enterprises, 2012, 26(3): 6-8.

[12] Zhang Jun. Development Status of 3D Printing Materials. Modern Decoration: Theory, 2015, (12): 291-291.

[13] Yang Yongqiang, Liu Yang, Song Changhui. Current status and research progress of 3D printing technology for metal parts. Mechatronics Engineering Technology, 2013, (4): 1-7.

[14] Pu Yisong, Wang Baoqi, Zhang Liangui. Research on Metal 3D Printing Technology. Surface Technology, 2018, 47(3): 78-84.

[15] Chen Xiangming, Yao Liaojun, Guo Licheng, et al. 3D Review of the research status of continuous fiber reinforced composites for printing. 2021.

[16] 3D printing of continuous fiber self-reinforcing composites and their recycling performance. Journal of Mechanical Engineering, 2022, 58(23): 188-195.

[17] Li Jian, Xu Min, Bao Wenhui. Disruptive Technologies Affecting the Future: 3D Printing for Multi-material Hybrid Intelligent Manufacturing. Journal of Northeast Forestry University, 2015, 43(6): 1-9..