Al-Nahrain Journal for Engineering Sciences **NJES** 28(2)276-280, 2025
http://doi.org/10.29194/NJES.28020276

White Laser in Ophthalmology

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Paper History:

Received: 19th July 2024

Revised: 8th Sep. 2024

Accepted: 8th Dec. 2024

Abstract

This research focuses on enhancing the diagnostic power of the slit lamp, a fundamental ophthalmic instrument, by replacing its traditional halogen light source with a cutting-edge white laser. The objective of this modification is to significantly improve the brightness, intensity, and color accuracy, which are crucial for distinguishing fine ocular details during eye examinations. White laser technology offers a more stable, energy-efficient light source with reduced maintenance needs, making it a valuable upgrade over conventional systems. As part of this redesign, the optical system will be optimized with new filters, lenses, and heat management techniques to accommodate the white laser. Additionally, integrating a high-resolution digital camera with the enhanced illumination system is expected to provide sharper, more accurate imaging for better diagnosis. The anticipated outcome is a transformative improvement in ocular diagnostics, leading to earlier and more precise detection of eye conditions. This advancement holds promise for both patients, through better care, and ophthalmologists, through increased diagnostic efficiency. Challenges in implementation and potential solutions are also considered.

Keyword: Slit Lamp, White Laser, Retinal Eye, And Image.

الليزر الابيض في طب العيون

علي محمود عيسى، زياد طارق الدهان،عمار فؤاد عيسى

الخلاصة:

يستكشف هذا العمل تغيير المصباح الشقي، وهو أداة أساسية لطب العيون، عن طريق استبدال مصدر ضوء الهالوجين التقليدي بالليزر الأبيض. ويهدف هذا التحسين إلى زيادة القدرات التشخيصية وكفاءة الضوء الشقي. تعمل تقنية الليزر الأبيض على تحسين السطوع والكثافة ودقة الألوان، مما يساعد على تمييز أنسجة العين وتصورها. بالإضافة إلى ذلك، تتطلب أجهزة الليزر البيضاء صيانة أقل، وتستخدم طاقة أقل، وتنبعث منها كمية ثابتة من الضوء. وكجزء من عملية إعادة التصميم، سيتم تعديل النظام البصري، وسيتم إدخال مرشحات وعدسات معينة، وسيتم ضمان الإدارة السليمة للحرارة. يعمل الجمع بين نظام الكاميرا الرقمية عالي الدقة ونظام ضوء الليزر الأبيض على تحسين جودة الصورة ودقة التشخيص بشكل كبير. بعد الخطوط العريضة، خلصت الدراسة إلى أن استخدام ليزر المصباح الشقي الأبيض لديه القدرة على تحسين تشخيص العين بشكل كبير، وهو أمر مفيد للمرضى وكذلك أطباء العيون. كما يأخذ في الاعتبار التحديات المحتملة وخيارات التنفيذ.

1. Introduction

In 2004, the World Health Organization (WHO) estimated that 285 million individuals worldwide were visually impaired, and 80 percent of those cases could be prevented or treated [1]. The yearly market for eyewear was valued at more than 20 billion euros in 2012. Furthermore, almost 57% of revenues were generated by eye care goods, diagnostic tools, and eye surgery. Because it has the potential to significantly enhance people's quality of life, research on human vision and eye optics therefore directly affects society [2]. Fig.1. About 90% of the total eye wave is caused by low-order aberrations.

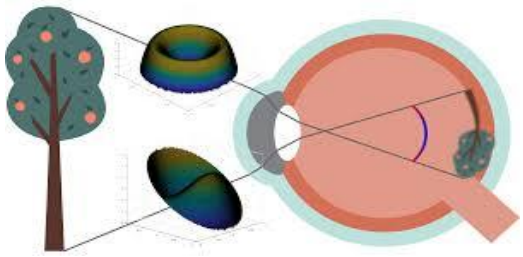

Figure (1): Understanding Ocular Wavefront aberrations [3].

One of the most common pieces of equipment in an ophthalmologist's office is the slit lamp biomicroscope [4], which is used to screen the outer

structure and the anterior segment of the eye. As shown in Fig. 2, the device has three main components: stereomicroscope, slit lamp illumination unit, and the mechanics module.

Figure (2): Slit lamp anatomy [5]

White Laser Light as an Alternative to Slit Lamp.herokuapp.com. The slit lamp is one of the major and most commonly used instruments in ophthalmology, which is used to screen the outer structure and the anterior segment of the eye tissues. Employment of slit light has been a traditional method, and these come with LED or halogen light [6] for illuminating the eye. However, recent advancements in laser technology —particularly in the area of white lasers— offer a potent replacement. This is the first time using white laser in medical field.

2- Materials and methods.

2.1 Redesigning the Slit Lamp with White Laser Illumination

Remodeling the slit lamp with a white laser light source, as depicted in Fig. 3, may improve its functionality and diagnostic capability. For those who provide eye care, this would also increase the lamp's effectiveness and usefulness. The benefits of white laser light over halogen light are shown in Table 1.

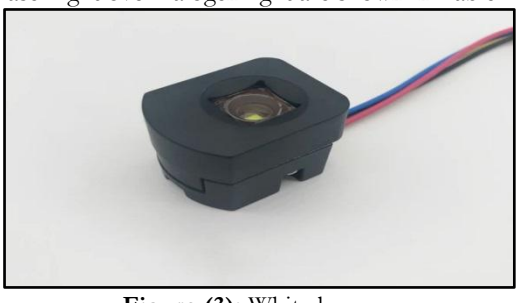

Figure (3): White laser source

2.2 Optical System Adjustments:

- Beam Quality [9]: Ensure the white laser produces a high-quality, uniform beam that can be finely adjusted in width, length, and angle, similar to traditional slit lamp beams.
- Filters and Lenses [10]: Use specialized optical components designed to handle the intensity and specific properties of laser light. This includes UV and IR filtering to protect the eye and the user.
- Light Source Replacement: Secure the installation of laser and remove the methods of attaching cooler systems.
- Optical Path Modifications: Add beam shaping optic filters lenses.
- Power Supply and Control: While using the device, they need to be able to control it either by an appropriate power source and buttons.
- Safety Features: The following organizational laser safety measures and Laser interlocks should be implemented.
- Implementation Steps
- Feasibility Study: Critique the potentials for gain, the challenges that may arise, and the costs.
- Prototyping: Functional testing in actual setting, and enhancements of the prototype.
- Iterative Design: Repeat the entire process based on the feedback received and results obtained.
- Manufacturing and Testing: Since they seek to provide customers with accurate information, the laws should be complied with to ensure that they do not present false information about the products. This paper shows that having white lasers extra to the slit lamps enhances better brightness, precision and time usage in the diagnosis process. Of all the potential redesigns, this particular one promises substantial benefits for the doctors and patients of the specialty. The individual parts and final system design are shown in Fig. 4.

Table (1): Benefits of white laser light

Parameter	White Laser	Halogen Light
Brightness and Intensity	a highly intense and bright light, significantly improving the visibility of fine details in the eye structures[7]	Less intense which may limit the ability to see minute details, especially in highly pigmented or densely packed tissues
Color Accuracy and Rendering:	Superior color rendering and accuracy, closely mimicking natural sunlight. This enhances the differentiation of various tissues and abnormalities in the eye.	broad spectrum of light but with lower color accuracy, which can make it harder to distinguish subtle differences in tissue coloration
Energy Efficiency	More energy-efficient, providing high brightness with lower power consumption, less heat generation and a longer operational lifespan[8]	Consumes more power and generates more heat, which can necessitate additional cooling mechanisms and lead to shorter bulb life

Consistency and Stability	Offers stable and consistent light output over time, reducing the need for frequent adjustments and maintenance	Light output can degrade over time, leading to inconsistent illumination and the need for regular bulb replacements

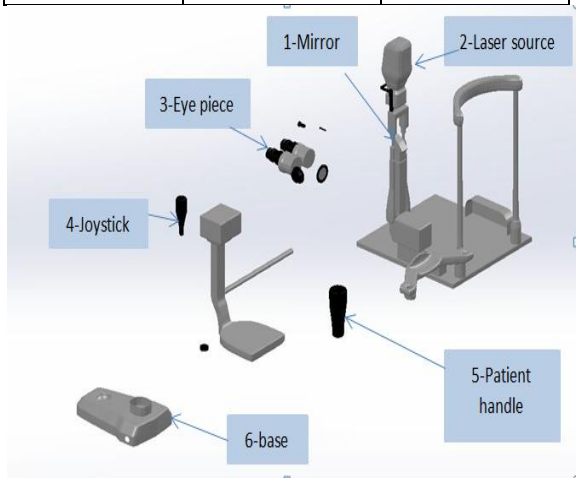

Figure (4): Individual parts and final system design

From figure 4, (1) represent the mirror used for reflection of laser beam, (2) white laser source, (3) Doctor eye piece, (4) user joystick, (5) patient handle, (6) base.

2.3 Thermal Management:

- Cooling Mechanisms [11]: Integrate fresher cooling systems to control the slight heat which the white Laser may produce for it to operate safely and for a long time.
- Materials: Ensure that the heat is well-coupled to reduce the temperature gradients using high thermal conductivity materials to retain the quality of the optical parts as shown in Fig. 5.

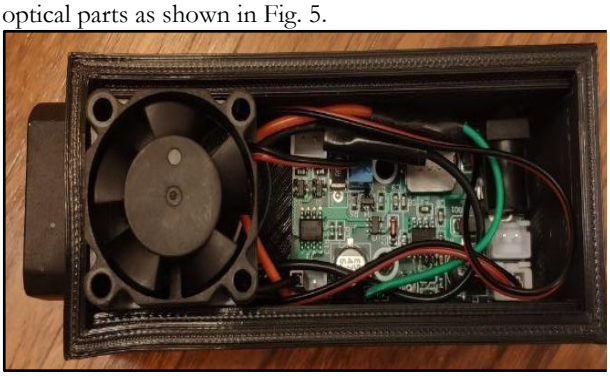

Figure (5): White laser with cooling fan.

3. Results and discussions

A combination of a white laser in a slit lamp is also effective for the enhancement of its illumination, resolution, and power consumption. The following are some of the benefits that one is likely to benefit from whenever he opts for the white laser;

- Higher Intensity [12] and Precision: Provided that light is improved or directed, one gets to see through or visions are enhanced or well-defined.
- Improved Image Quality: Improved performance in brightness and definition of image.
- Adjustable Wavelengths: Various niches to provide ultimate flexibility for changing the lighting for various diagnostics.
- Energy Efficiency: Some other advantages of smart retail include, lower power usage and less heat output from equipment.

Coordinate the white laser with high resolution digital camera system to obtain clearer photographs and videos helping in diagnostic system. Optimize the white laser illumination with an image processing methods that improve image resolution and contrast of captured images.

3.1. Safety Enhancements:

Laser Safety Standards [13]: Manage laser visibility by strictly following the laser safety measures in order to reduce the risk of inflicting the patient or the operator in case something goes wrong using laser power meter the result is 2mW which is safe to human eyes as shown in Fig.6.

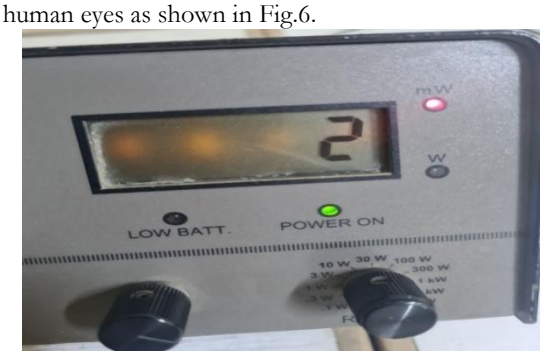

Figure (6): Laser power measurements.

Protective Measures: Install safety systems such as timers and safety switches to minimize instances where the laser beam is likely to fall on people around it.

3.2. Interface and Control:

- Control board [14]: use board that regulate the power to the laser element different types of use boards are used in this are laser diode use board and lamp use board.
- Feedback Mechanisms [15]: Develop features which are feedbacks that depict the state of the laser and the system at a glance- time based as shown in Fig. 7.

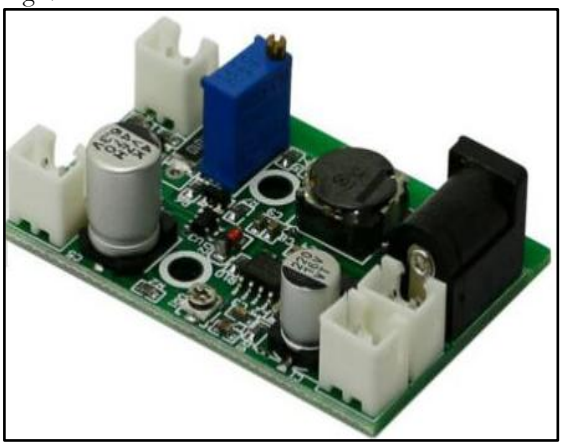

Figure (7): Laser control board [16]

In Figure (8) we can see the brightness of the white laser is more than the halogen light also the white light is more comfortable to the human eyes than the

yellow light. While in figure (9) we can see the eye pictures by using a white laser light in slit lamp. Also Figure (10) shows the eye pictures by using a halogen light in slit lamp.

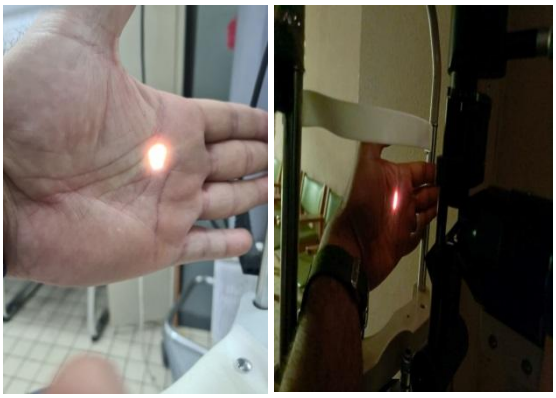

Figure (8): pictures by using white laser on the left and halogen light on the right.

Figure (9): Eye pictures by using white laser light

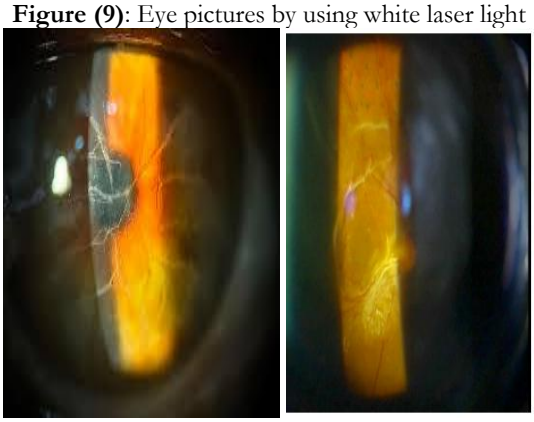

Figure 10: Eye pictures by using halogen light[17]

From laser properties [18] which is coherent [19] that mean it have the ability to penetrate more than the halogen light also the brightness of the white laser is more than the halogen light and the white light is more comfortable [20] to the human eyes than the yellow light therefore the picture enhanced and can be picturing the retina in case of thick glaucoma.

4. Conclusion

The integration of white laser technology into slit lamps significantly enhances the precision and effectiveness of ocular diagnostics. With superior brightness, color accuracy, and stable performance, white lasers provide clearer visualization of eye structures, enabling earlier and more accurate diagnosis. Additionally, their energy efficiency supports sustainable medical practices. Despite the challenges of implementation, this technology opens new possibilities in ophthalmology, particularly with molecular-level imaging, ultimately improving patient outcomes. By advancing both diagnosis and treatment, white laser-enhanced slit lamps have the potential to revolutionize eye care.

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