An Optical Prototype for Simulating the Laser Delivery Method in a Typical LASIK Device

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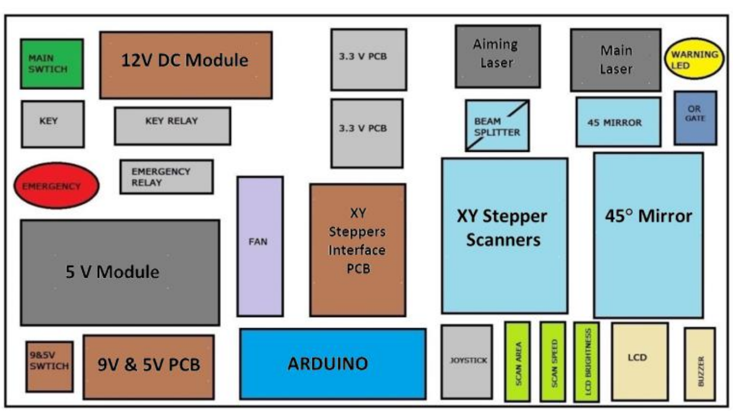
Abstract: In the present work, we simulate the flying-spot laser delivery device utilized in a typical LASIK procedure via a simple, low cost, safe and representative optical prototype suitable for education and training purposes. © 2021 The Author(s)

1. Introduction

Laser-Assisted in Situ Keratomileusis of simply LASIK is a well-known refractive surgery developed to correct common vision disorders such as myopia, hyperopia and astigmatism [1]. The procedure is utilizing the ablation effect of UV-lasers to reshape the cornea and retain its normal characteristics [2,3]. In a typical LASIK practice, surgeon creates a very thin, superficial flab in the treated cornea using either a special tool named "microkeratome" or alternatively a femtosecond laser. After flab creation, a specific layer of the cornea called "stroma" can be reached where the operation is performed by removing some corneal tissue via laser photo-ablation process [4]. Commercially, excimer lasers (ArF) at 193 nm are the mostly used type in LASIK [5]. However, solid-state lasers can also be considered as appropriate alternatives [2]. Practically, LASIK device contains optical system to track the eye and sending the required laser patterns accordingly. These optical systems can be classified to; slit-scanning and spot-scanning. Spot-scanning or sometimes called "flying-spots" lasers are the most common type used in LASIK procedures. Consequently, they utilize small diameter laser beams that provide very smooth corneal treatment. On the other hand, the laser beam in slit-scanning devices is projected to varying-size slit holes that are placed on a rotational stage. Based on that mechanism, the ablation area can be increased accordingly. In the current work, we present an optical prototype for the flying-spot device based on stepper motor scanner controlled by ARDUINO platform to simulate the laser delivery in a basic LASIK device. The prototype is proposed to be a simple method for delivering the main idea to students via visualizing the whole procedure in a safe and illustrative way.

2. The optical system

The presented optical prototype is based on the principle of the flying-spot technique. The prototype employs two laser sources; the aiming beam laser (red at 650 nm) and the main laser used for the corneal reshaping process (UV at 405nm). The two lasers can be projected at different positions of the (X-Y) plane on the same point of the target via two stepper motor scanners controlled by ARDUINO electronics platform through a joystick. Moreover the scan speed and area can be controlled by two potentiometers. The proposed device starts by pressing the main switch and turning the key on. There is also an emergency key switch for safety requirements. In addition to a warring led that lights up when lasers are on. A block diagram of the proposed prototype is presented in Fig. 1(a) and its real photograph is shown in Fig. 1(b).



(a)

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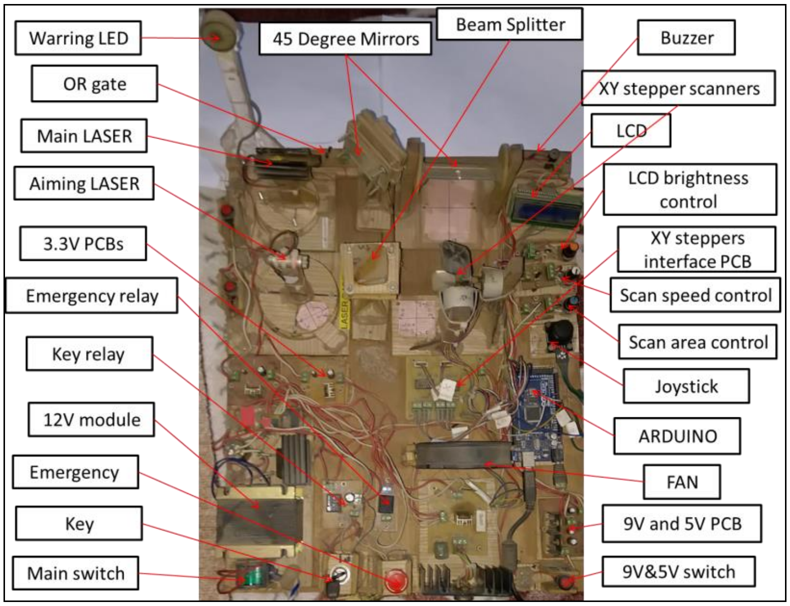
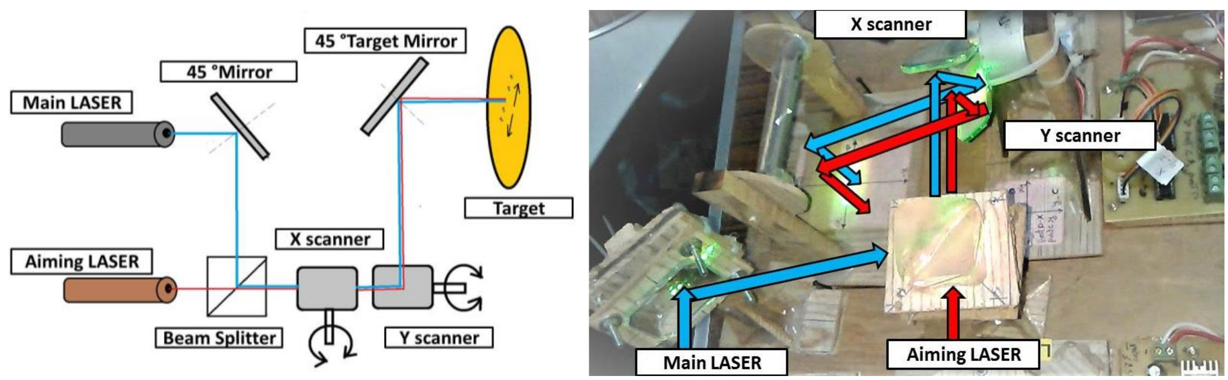


(b)

Fig. 1. (a) Block diagram, (b) Real photograph of the proposed optical prototype

A power supply module (AC 220 V, DC 12 V) is utilized for the device's initial operation. Three voltage regulators (PCBs) are employed to modify the voltage to 9 V, 5 V, and 3.3 V to suit the requirements of some parts including the ARDUINO platform, LCD, stepper motor, scan area/speed control potentiometer, buzzer, warring led and the laser modules. Both laser beams are combined in the beam splitter by the 45° mirror then directed to X scanner which reflects it down to the Y scanner. Then, the two beams have been reflected to the target by the 45° target mirror. The optical configuration and beam pathway are illustrated in details in Fig. 2 (a) and (b).



(a) (b)

Fig. 2. (a) Schematic diagram of the optical pathway, (b) Real photograph of the optical configuration

3. References

[1] C. G. Krader, "Laser refractive surgery advances expand options for myopic patients," Ophthalmol. Times 44(5), 1–9 (2019).
[2] V. V Atezhev, B. V Barchunov, S. K. Vartapetov, and A. S. Zav, "Laser technologies in ophthalmic surgery," Laser Phys. 26, 84010 (2016).
[3] S. B. Han, Y. C. Liu, K. Mohamed-Noriega, and J. S. Mehta, "Application of Femtosecond Laser in Anterior Segment Surgery," J. Ophthalmol. 1–12 (2020).
[4] J. N. Edmonds and M. Moshirfar, "LASIK and Surface Ablation in the Modern Era: Trends and Novel Applications," Curr. Ophthalmol. Rep. 1(1), 20–27 (2013).
[5] A. Pidro, A. Biscevic, M. A. Pjano, I. Mravicic, N. Bejdic, and M. Bohac, "Excimer lasers in refractive surgery," Acta Inform. Medica, 27(4), 278–283 (2019).
[6] N. S. Tsiklis, G. D. Kymionis, G. A. Kounis, I. I. Naoumidi, and I. G. Pallikaris, "Photorefractive keratectomy using solid state laser 213 nm and excimer laser 193 nm: A randomized, contralateral, comparative, experimental study," Investig. Ophthalmol. Vis. Sci. 49(4), 1415–1420 (2008).
[7] M. Shraiki and S. Arba-mosquera, "Simulation of the Impact of Refractive Surgery Ablative Laser Pulses with a Flying-Spot Laser Beam on Intrasurgery Corneal Temperature," Invest. Ophthalmol. Vis. Sci. 52(6), 3713–3722 (2011).