Computer-Assisted Training Tool for Evaluating Operator's Delivery Skills during Laser Skin Treatment

Abeer Attia Tawfik, Mahmoud M.A. Ahmed, Omnia Hamdy* and Salah Hassab Elnaby
[1]
National Institute of Laser Enhanced Science, Cairo University, Giza, 12613, Egypt
** omnia@niles.edu.eg*

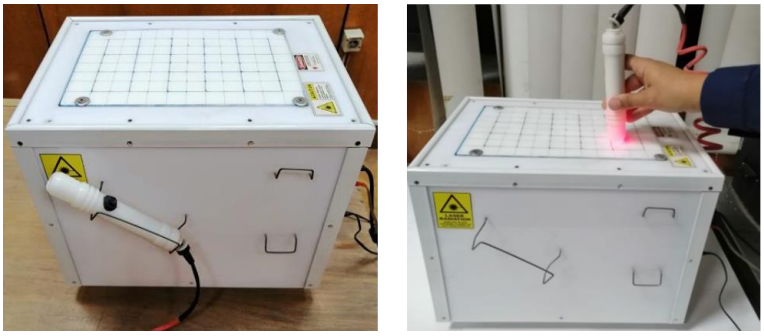
Abstract: We present a simple computerized tool for training on practicing common laser skin treatments. The device is proposed to enhance operator's technical skills and increase his proficiency via detecting overlap percentage of the laser spots.

1. Introduction

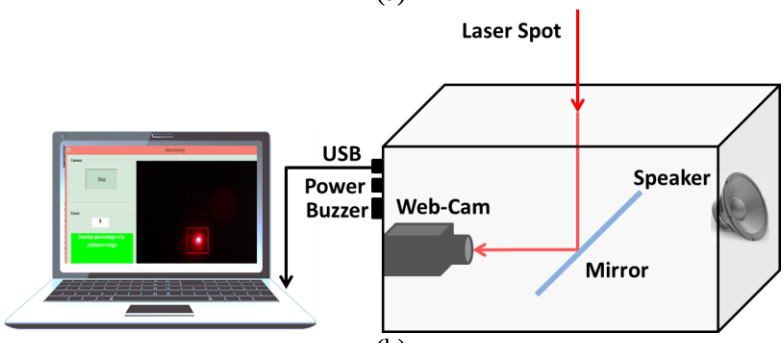
Nowadays, laser is considered a magical tool in dermatology for both diagnostic and therapeutic purposes [1,2]. It has been involved in many skin practices such as removal of pigmented and vascular lesions, scars, tattoo, and undesired hair [3,4]. Nonetheless, these procedures require delivering uniform laser energy to the targeted areas in order to obtain optimum results [5,6]. Consequently, it is necessary to adjust the speed of the handpiece to prevent any overlapping in the delivered laser pulses. Our proposed device is designed to train operators to get that skill (i.e., hand speed and pulses overlap) in a simple and accurate way. The device includes a continuous laser source mounted in a handpiece which emulates the commercial medical laser devices. The trainee sweeps the laser handpiece on the surface of a flat target while the in-house developed software analyzes the user's hand speed via recording the laser spots then calculating the percentage of overlapping. An error signal notifies the user when the user's hand movement becomes unacceptable.

2. The device prototype

The proposed tool is a computerized portable model that consists of a diode laser source (650 nm), flat target, 45° mirror, and camera. The camera has a resolution of 1280×1024 pixel^2 with 720p video recording and it is utilized to detect and record the incident laser spot. The user triggers the laser spots by pressing on a key switch and sweeps on the flat target at different locations similar to what is performed in the practical skin treatment.



(a)



(b)

Fig. 1 (a) the proptotype of the proposed device, (b) schematic diagram illustarting the principle of operation

Sixteenth Conference on Education and Training in Optics and Photonics: ETOP 2021,
edited by A. Danner, A. Poulin-Girard, N. Wong, Proc. of SPIE Vol. 12297, 122970H
© 2022 SPIE · 0277-786X · doi: 10.1117/12.2635518

There are two modes of training all of which improve the overlap and hand speed skills of the trainees. That is, by the continuous press on the hand switch in the hand piece, the user can test the hand speed since the recording is governed by the number of the acquired frames per second (fps) as well as the overlap percentage. Moreover, by intermittent press on the hand switch, the user can test the capability of obtaining acceptable overlap percentage. The proposed device and its principle of operation are illustrated in Fig. 1.

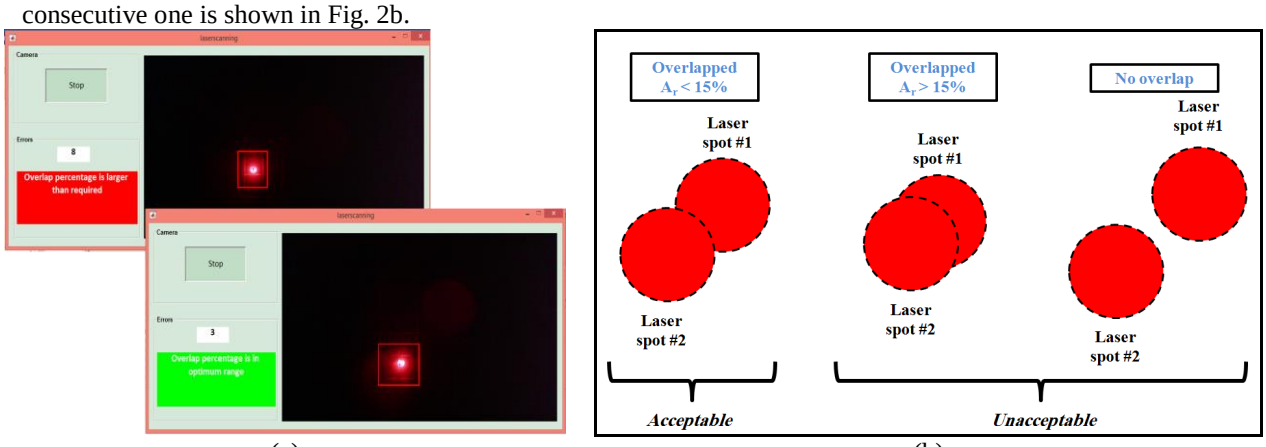
2.1. The user's computer interface

An in-house developed Matlab code is used for determining the size and location of the real-time captured laser spot applied on the surface of the flat target. The captured frame has a field of view of 210×168 mm^2 which yields a resolution of a 164.1 μm/pixel. The software calculates the overlap percentage between any two consecutive frames and beeps if this percentage exceeds a pre-defined overlapping ratio (A_r) of a 15%. The operator's hand training speed is adjustable by selecting the appropriate the video acquisition frame grabbing interval (or fps).

The raw acquired frame is filtered using a median filter of a size of 3×3 and then converted to a binarized image using a threshold of 82% of the maximum image intensity. The small residues in the resulted binarized image are then removed where the regions that contain less than 300 pixels are removed. Finally, the centroid, radius, and area of the laser spot are determined while the bounding box (see Fig. 2a) is labeled. Based on the selected binarization threshold, the estimated error in the laser spot area detection is found to be ±3%.

Once the radius, area, and centroid are calculated, if the distance between the centroids of two consecutive laser spots is smaller than the sum of the two radii of these consecutive laser spots, the software divides the two areas of the two consecutive laser spots where a ration higher than 15% indicates unacceptable overlap percentage (see Fig. 2a, the red error message). Similar error message appears if the distance between the centroids of two consecutive laser spots is larger than the sum of the two radii, where there is a gap between the two consecutive laser spots.

On the other hand, the software shows no error and indices acceptable overlap percentage when the ratio between the two areas of the two consecutive laser spots lies between the range of $0 < Ar \leq 15\%$ (see Fig. 2a, the green message). A demonstration for the selection criteria of the appropriate laser spot location with respect to the consecutive one is shown in Fig. 2b.



(a) (b)

Fig. 2. (a) The software graphical user interface, (b) Example of the acceptance/rejection criteria of two consecutive laser spots.

3. References

[1] N. Bendsoe and K. Svanberg, in Lasers in dermatology. (Woodhead Publishing Limited 2013).
[2] H. H. Beigvand et al., "Assessment of laser effects on skin rejuvenation," J. Lasers Med. Sci. 11(2), 212–219 (2020).
[3] Z. Husain and T. S. Alster, "The role of lasers and intense pulsed light technology in dermatology," Clin. Cosmet. Investig. Dermatol. 9, 29–40 (2016).
[4] S. Gianfaldoni et al., "An overview of laser in dermatology: The past, the present and … the future (?)," Open Access Maced. J. Med. Sci. 5(4) 526–530, (2017).
[5] S. Noh et al., "Tool to visualize and evaluate operator proficiency in laser hair-removal treatments," Biomed. Eng. Online 13(1), 1–17, (2014).
[6] W. Koh et al., "A Pilot Study on the Evaluation of Physicians' Laser Delivery Performance Using a Laser Beam Detection Kit," Photomed. Laser Surg. 35(6), 317–323, (2017).