Laser Illumination Designs for Snapshot Multi-Spectral-Line Imaging

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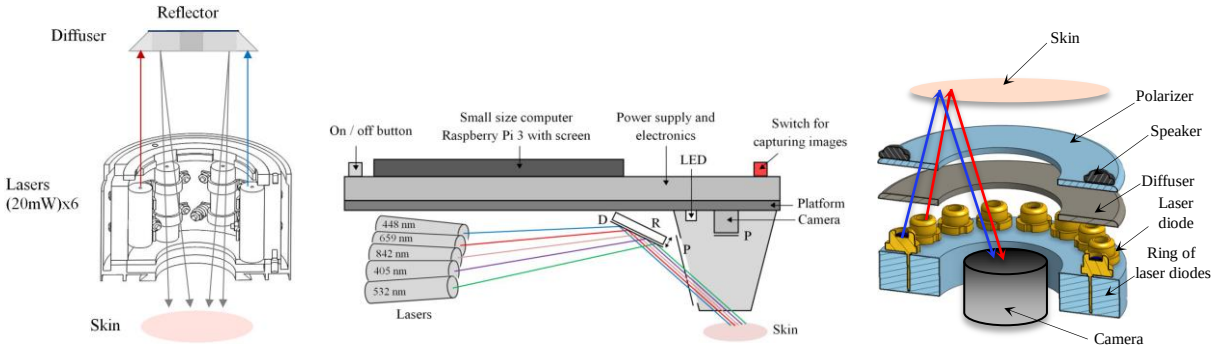
For multi-spectral imaging, both acquisition time of the spectral image set and the spectral bandwidth of each image have to be minimized. Ultimate performance can be achieved if the set of monochromatic (single-wavelength) spectral images is obtained with a single snapshot - a technique provisionally called "snapshot multi-spectral-line imaging" or SMSLI. Using contemporary RGB colour cameras, up to three spectral line images can be extracted from a snapshot image data cube at specific illumination that comprises only three spectral lines, each of them positioned within one of the detection bands (R, G or B) [1]. Techniques able to provide more spectral line images are under development, and optimal design enabling uniform illumination of target simultaneously by several laser lines is a key challenge.

Our first design for simultaneous three laser line illumination was based on a special optical fibre bundle – each laser beam was launched in 7 fibres with 21 randomly distributed output ends fixed in the illumination ring [2]. It ensured uniform illumination of target at all three wavelengths but was too robust for use outside laboratory. The second design illustrated in Fig.1,a was better adapted for clinical use [3]. Uniform three wavelength (448 nm, 532 nm and 659 nm) illumination of the target area (diameter 40 mm) was ensured by flat ring-shaped laser diffuser. Three pairs of compact 20 mW power laser modules served as light sources; each pair of the equal-wavelength modules was mounted on opposite sides of the 3D-printed cylindrical plastic shielding wall. All laser beams were reflected from the 45 degree sloped edge of specially designed Plexiglas optical element and turned radial to its diffusing central part made of milky Plexiglas.



a b c

Fig. 1 Three designs for multi-laser illumination: a – coaxial with flat reflective diffuser, b – planar with reflective side diffuser, c – coaxial with transmitting diffuser.

Another design concept – plane-arranged multi-laser side illumination using sloped diffusive reflector – is illustrated on Fig.1,b as a part of 5-wavelength imaging prototype [4]. However, this design could not provide enough uniform target illumination, so another illumination design based on laser diode ring with transmitting diffuser is under development (Fig.1,c). System comprises 20 laser diodes emitting 5 different wavelengths - 4 x 405nm, 4 x 450nm, 4 x 520nm, 4 x 660nm and 4x850nm; same wavelength diodes are arranged diagonally opposite each other. Laser diode beams pass the film diffuser and linear polarizer film before reaching the target area of skin. Speakers added to polarizer induce vibrations for reducing speckle artefacts in spectral images [5].

Financial support from the Latvian Council of Science (grant #lzp2018/2-0006) is highly appreciated.

References

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