A galvanometer based laser dynamic focusing system

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Abstract

The dynamic focus shifting, which enables high-speed focal length alteration in an optical system, is in demand in various fields, such as optical imaging system, laser microprocessing and 3D printing. For the application of laser processing, the processing precision and efficiency can be improved by a higher speed and more accurate focus positioning technique. Conventional ways to move the laser focus are mainly based on the principle of moving the optical elements or changing the optical path between two lenses in the laser focusing system, which adversely affects the high-speed positioning of the laser focus. We propose, in this paper, a novel design of a dynamic focusing unit based on an optical setup driven by galvanometers to position the laser focus with high frequency and precision. The proposed optical configuration is comprised of two parabolic reflectors and two galvanometers, which consist of two rotational reflectors and motors. During the operation of dynamic focusing, the entrance beam and exit one will be along their fixed optical axes when the mirrors of galvanometers rotate, which can modify the divergence of the exit beam. In the proposed optical system, it is established that the relationship between the divergence of the exit beam and the rotational angles of the galvanometers' mirrors, which are able to determine the focus position of the exit beam.

Given the high precison and ultra-fast response (~kHz) of the galvanometer, the repeatability of the laser focus positioning can have the same magnitude of the Rayleigh length of the beam, and its response time can be significantly reduced comparing to that in the traditional way to move the optical elements. The proposed galvanometer-driven system can be utilized in a 3D laser scanning system, in which the dynamic focus unit is integrated with the same galvanometers-based XY scanner to position the laser focus within a large spatial area in a simultaneous, rapid and precision fashion. The simulation and experiments are conducted to verify the feasibility and performance of the proposed dynamic focusing unit. It is shown that our dynamic focusing system is suited for applications demanding focus positioning with precision within the Rayleigh length and focus tunning frequency up to 1kHz.

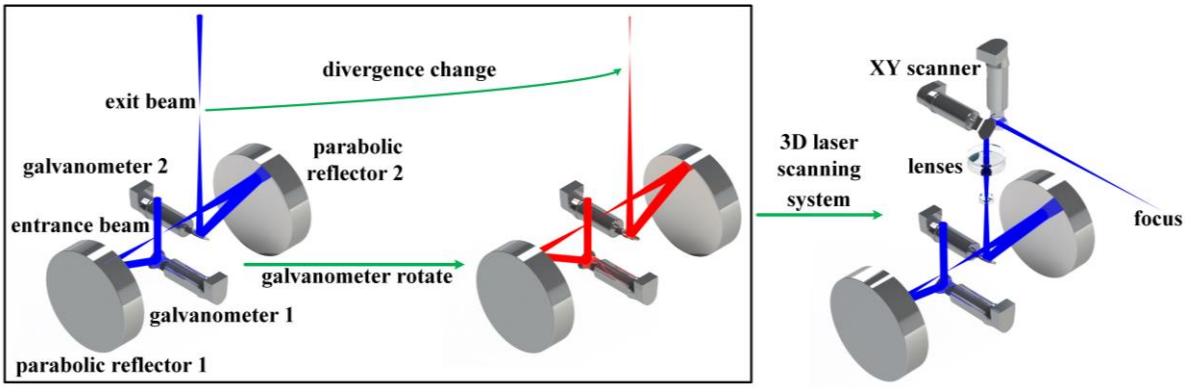

Figure 1: Galvanometer based dynamic focusing system and its application in a 3D laser scanning system