Optical particle trapping and dynamic manipulation using spatial light modulation - DTU Orbit (10/08/2019)

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This thesis deals with the spatial phase-control of light and its application for optical trapping and manipulation of micron-scale objects.
Utilizing the radiation pressure, light exerts on dielectric micron-scale particles, functionality of optical tweezers can be obtained. Multiple intensity spots acting as tweezers beams are generated using phase-only spatial light modulation of an incident laser beam together with a generalized phase contrast (GPC) filter.
The GPC method acts as a common-path interferometer, which converts encoded phase information into an appropriate intensity pattern suitable for optical trapping. A phase-only spatial light modulator (SLM) is used for the phase encoding of the laser beam.
The SLM is controlled directly from a standard computer where phase information is represented as gray-scale image information.
Experimentally, both linear and angular movements of trapped colloidal micron-sized polystyrene particles and cell structures were accomplished. Furthermore, fixed arrays consisting of up to 25-trapped particles have been generated. Experimentally, ternary phase encoding has been demonstrated, supporting the GPC theory. Binary intensity patterns having compression factors of two, which is not achievable with binary phase encoding, have been successfully demonstrated.
In addition, the GPC method has been miniaturized and implemented in a planar optical platform and shown to work acceptably, with relatively high visibility. Furthermore, the GPC method has proven capable of generating a phase pattern from an input amplitude distribution.
The birefringent nature of liquid crystals in the SLM is utilized for the generation of an arbitrary two-dimensional state of polarization using two-cascaded SLMs. By means of elliptically polarized light, generated by one SLM and a lens-array, angular momentum transfer to multiple birefringent particles is achieved in an optical tweezers system. The rotation direction and angular orientation of the trapped particles are controlled from the SLM device that directly affects the state of polarization.
In addition, a novel SLM technique has been used for the deflection of trapping-beams based on diffraction gratings in combination with a lens-array, and used for controlled movements of micron sized beads.

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Eriksen, R. L.
Publication date: 2003

Publication information
Place of publication: Roskilde, Denmark
Publisher: Risø National Laboratory
Original language: English