Optical identification of sea-mines - Gated viewing three-dimensional laser radar

A gated viewing high accuracy mono-static laser radar has been developed for the purpose of improving the optical underwater sea-mine identification handled by the Navy. In the final stage of the sea-mine detection, classification and identification process the Navy applies a remote operated vehicle for optical identification of the bottom seamine. The experimental results of the thesis indicate that replacing the conventional optical video and spotlight system applied by the Navy with the gated viewing two- and three-dimensional laser radar can improve the underwater optical sea-mine identification. The laser radar has also a number of applications on land, for example, face recognition at several hundred meters range. The main components of the laser radar system are a green pulsed laser and a fast gating intensified CCD camera. The laser radar system innovation is a combination of the short laser pulses (0.5 ns), the high laser pulse repetition rate (32.4 kHz), the fast gating camera (0.2 ns), the short camera delay steps (0.1 ns), the applied optical single mode fiber, and the applied algorithm for three-dimensional imaging. The gated viewing laser radar system configuration is an innovative variation of other gated viewing laser radar systems applying a pulsed laser and a range gated CCD camera, among which the Canadians do not make three-dimensional images, (e.g. [Fournier et al. 1993]), and the Swedes do not apply an optical fiber, (e.g. [Steinvall et al. 2003]), for example. The innovative gated viewing laser radar system configuration provides a previous unseen high accuracy in the three-dimensional non-scanning laser radar images. The high accuracy of the presented three-dimensional images is unprecedented among the existing gated viewing monostatic laser radar systems. Underwater three-dimensional images recorded with the gated viewing three-dimensional laser radar have never been reported. The underwater images of a low contrast target are recorded at 4-5 m range. The presented underwater images compare well with the best of the reported three-dimensional underwater optical images recorded with alternative laser radar techniques, among which the most promising is the streak tube imaging laser radar developed in United States. A variety of gated viewing three-dimensional laser radar experiments are presented, where the gated viewing three-dimensional laser radar performance is tested at short, medium, and long range. The performance is also tested in low contrast conditions in the air and underwater. It is shown that three-dimensional imaging has an advantage over two-dimensional imaging, when the objects have low contrast. Compared to the performance in air the performance underwater is deteriorated by the exponential absorption and scattering. Two new lines of approach have been taken to improve underwater optical sea-mine identification by digital image enhancement and by knowledge of the optical properties of water. The first approach is taken with a Canadian scattering phase function model and an underwater optical data set. The second approach is to determine the line spread function of water from recorded slit images. A gated viewing three-dimensional laser radar digital simulation tool has been developed to gain knowledge and deeper insight into the laser radar performance in air and underwater.

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