Title	Development of the microwave transmitter and receiver of a Lidar- radar system for marine optic applications
Context	Maritime safety (navigation in hazardous areas (coastal areas, new shipping lanes), in conflict zones (mine warfare), and monitoring of the marine environment (detection of drifting floating objects, retrieving objects lost to sea)) are topics of current research. However, the conventionally used detection techniques have numerous limitations. Indeed, use of the sonar for detection of targets or slightly submerged obstacles (a few meters) is hardly possible due to the proximity of the interface and the conventional radar systems can not be directly used for detecting underwater because microwaves do not penetrate water. Since a blue-green optical pulse relatively well penetrates the marine environment over a few tens of meters (minimum attenuation of the medium at these wavelengths), the LIDAR (Light Detection and Ranging) can be a potential answer this problem. However, techniques based on coherent detection, inspired by advanced radar systems, can not be applied directly to the optical signal as the light quickly loses its coherence during propagation in water. This disadvantage results in range loss and low contrast targets detected in the optical domain. Therefore it seems natural to consider benefit of these two complementary behaviors (capacity of propagation of an optical wave in the marine environment and sophisticated radar treatments) by combining optical and radar technologies to improve the resolution and sensitivity of detection systems and localization of underwater targets. This leads to propose a new detection scheme involving a modulated lidar system and filtering in the range of microwave [1], [2]. Preliminary studies on this topic have been conducted in recent years at LSOL laboratory on this concept of lidar - radar. The LSOL has designed and developed the first rudimentary version of microwave lidar modulated lidar. This model has been tested experimentally in the laboratory and in a wave tank, in the context of mine warfare and the first results are very promising [3-5].
Objectives	The proposed subject of study focuses on the development of the lidar-radar technique to detect, on front of a ship or from land, floating and / or submerged objects, at a distance ranging from a few hundred meters up 1 km, with immersion up to ten meters deep. The subject will focus on the study and optimization of the overall system architecture with particular attention to the transmission block but also on the receipt block of the system given the very low level signals backscattered by the target. Indeed, in the context of eye safety, the level of the transmitted signal will be limited and given the context of grazing incidence, the backscattered signal detected by the receiver will be extremely low. The developments made during this thesis will concern both the transmitting and receiving parts of the proposed system.
Novelty of the project	The context of detection proposed is innovative because it does not exist at present sensor other than human eye able to meet this need of detection. Indeed, "classic" sensors such as radar and sonar are ineffective in this context (radar waves do not penetrate the water and close to the surface is an obstacle to the use of sonar). The idea behind the concept of microwave modulated lidar based on a quite remarkable feature of the frequency response of volume backscatter of a seawater column: it has a transfer function low-pass type with a cutoff frequency of the order of one hundred MHz [1,6] , this cutoff frequency obviously depends on the scattering characteristics of the water column , while the frequency response of a submerged target may be considered independent of the frequency. Thus temporally modulating the laser pulse emitted at a frequency at a time much lower than the frequency of the optical carrier and much higher than the cutoff frequency of the diffusing liquid column between the emitter and the target, it is possible to greatly improve the detection of the target by a suitable treatment [7]. The ambitious goal of detecting a target submerged by up to ten meters and located at a distance of 1 km constitutes a real challenge match in the first place to a concern for national defense. To our knowledge to date no system is capable of detecting in these conditions.
International collaboration	The "Laboratoire de Spectrométrie et Optique Laser" (LSOL - EA 938) will be the main proponent. It will develop the optical part of the system and will provide experimental validation of the device. DCNS will act as an end user for mine warfare subject application and specify the particular specifications for this application. Detection tests beachfront will be considered at the end of thesis in partnership and with the support of DCNS. The design portion of the microwave receiver will be carried out with the support of the DIM team of the Lab-STICC, the realization of microwave components will be subcontracted to Elliptika company which has the competence in this field.
Expectations	The main advance of the work carried out during the thesis will focus on the development of a new sensor for mine warfare applications (GDM). However, these developments have other potential applications, since the innovative principle of microwave modulation and filter can lead to applications not only of detection, but also of communication or imaging in turbid medium. The proposed work both on the source and the receiver, leading the way in the development of lightweight systems which can eventually be integrated into drones, but also lead to improved performance of airborne bathymetric systems, in addition to the immediate application of GDM referred.

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