SPIDVE

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Operations in Degraded Visual Environments (DVE) are frequent during military actions due to either natural (poor light, fog, glare, etc.) or man-made (smoke, dust etc.) conditions. These conditions adversely affect the performance of Electro-Optical (EO) sensors by reducing their range of effectiveness in terms of Detection, Recognition and Identification (DRI) and navigation capability, and therefore hamper the situational awareness and safety of the personnel. Against this background, EDA launched a call for tenders (code 19.ESI.NP3.291) for a "Study on EO Sensors Performance Improvement in Degraded Visual Environment (SPIDVE)", focused on new technologies to improve, model and measure the performances of EO systems in DVE conditions.

A consortium formed by Leonardo SpA, FlyBy Srl and CNR-INO developed the project in response to the call, from February 2019 to March 2020.

Background

In recent years, there has been a significant improvement in EO system's effectiveness, due to the availability of large focal plane array detectors with higher performance, as well as strong processing capabilities. Both in homeland surveillance and in military situational awareness, the use of EO systems (operating from Visible to Infrared) has grown dramatically. The wealth of visual information that is now possible to acquire, due to the availability of cameras operating in many spectral bands (from Visible to Long Wavelength Infrared) exceeds the human capability of exploitation.

To fully use this potential it is necessary to investigate how DVE conditions influence the different spectral bands: which of them is better suited for a defined scenario (haze, fog, dust, etc.); how to mitigate DVE impact; how to fuse the different spectral bands in a final image reporting the most important information and minimising artifacts.

Objectives

The goals of the project were to:

- carry out an extensive survey of the state of the art on DVE modeling, simulation and measurement; image enhancement and fusion, new optical technologies for DVE mitigation;
- identify the most relevant cases in terms of scenarios, applications and DVE conditions by directly consulting the military end users;
- identify the most promising technologies for the DVE mitigation of the selected scenarios;
- provide a roadmap for the required technical developments addressed to the improvement of the EU's defense capabilities.

To start with, an extensive literature review was carried out to assess the available state of the art.

The analysis included several causes of DVE conditions, natural and manmade, focusing on their optical and spectral properties. Several DVE mitigation techniques were analysed: passive imaging systems, active imaging, image restoration algorithms, in all the relevant spectral bands, including emerging technologies. Image qual-

Fig. 1 – Set up for the acquisition of the images (left) and comparison of SWIR and LWIR images of an urban scenario at dusk (right).

ity indexes were reviewed, as tools for the comparative evaluation of the image restoration algorithms.

The recognition of the user needs was the subject of a workshop (held in Rome, IT, April 5th, 2019). The aim was to identify and prioritise realistic military situations where the safety and reliability of the operations can be affected by the performance of EO sensors. The highest priority was attributed to the detection, recognition and tracking, as well as the navigation, surveillance and self-protection of helicopters in urban scenarios, with fog, rain and man-made smoke as DVE causes, including asymmetrical and unconventional threats.

An ideal sensor suite was outlined, including LWIR and SWIR imagers featuring wide field of view and high image rate; a navigation LIDAR (for obstacle detection) and an improved laser targeting system were also included. Augmented reality was considered very useful to improve the man/machine interaction.

A data acquisition and processing campaign was carried out to validate the behavior of the spectral bands in a composite scenario, using SWIR and LWIR cameras.

In daytime conditions, SWIR overcomes haze better than Visible, due to longer wavelengths, but the lack of colors reduces small objects' visibility (e.g. cables). Night time hampers VIS sensors whereas SWIR ones can exploit night glow and moon irradiance. LWIR was considered indispensable as it is not affected by darkness.

A quality index measured the improvement derived by the adoption of inverse modelling and contrast enhancement techniques.

Finally, an extensive campaign of numerical tests was carried out in order to:

- simulate the effect of obscurants on image;
- evaluate the degradation using reliable quality indexes;
- apply several image restoration approaches;
- evaluate the quality of the restored images.

For this purpose, a proprietary software tool was set up, and a database of the spectral properties of obscurants (including 10 different substances) was compiled to support this activity.

Way ahead

The following roadmap was outlined, articulated in different development phases:

- development of novel image processing algorithms aimed to DVE effect mitigation exploiting Artificial Intelligence;
- development of a new modular hardware platform for the collection and the fusion of data from multiple sensors;
- development of new specific sensors tool (active and passive), featuring robustness against DVE.