Final Report of Short-Term Mobility Project

Integration of Optical and 2-D Forward-Look Sonar Image Information for Effective Automation and Autonomy in Underwater Visual Tasks

by

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Overview:

This report outlines activities during the author's ISSIA-CNR visit, aimed at exploring applications where either or the integration of optical and sonar visual data could support the automated operation of land and subsea robotics platforms, and (or) enable operations that cannot be readily carried out by human agents.
Such technologies have previously proven to be equally instrumental in monitoring, surveying and assessing the health of natural resources (e.g., coral reefs), to document historical sites (shipwrecks), inspection of subsea structures (oil pipelines, bridge pilings, dams).

Moreover, the visit was also targeted to explore how to facilitate the collaboration between two strong research teams in addressing fundamental problems in land and marine robotics: 1) University of Miami (UoM) with expertise in both underwater optical and sonar imaging and computer vision; 2) ISSIA-CNR extensive work and ongoing activities in various aspects of robotics research.

Summary of Activities:

Since 2005, the UoM researchers under the direction of Professor S. Negahdaripour have extended their pioneering underwater computer vision activities to explore the utilization of 2-D multi-beam forward-look video imaging sonar systems. A strong motivation is to address key shortcomings of optical systems under poor visibility conditions. Moreover, a novel *opt-acoustic stereo imaging paradigm* has been explored to integrate visual cues in both optical and sonar images to complement capabilities and overcome shortcomings of each individual modality. This has led to the development of a number of novel methodologies.

As the initial activity, a number of three-hour lectures, organized and held at the Politecnico di Bari, were attended by nearly 10 CV and Pattern Recognition researchers from ISSIA-CNR. These presentations were aimed to introduce both the underlying fundamentals and some applications. Given the multi-disciplinary nature of robotics research and technical background of various researchers, these presentations were very instrumental in familiarizing the audience with the technical aspects 2-D forward-scan sonar imaging and integration with optical imagery. As a result, stimulating conversations

took place where new potential applications were discussed.

One new research direction, discussed in detail with Dr. Annalisa Milella and her collaborator Dr. Giulio Reina from the Department of Engineering for Innovation at University of Salento, was the adaptation of *opt-acoustic stereo imaging paradigm* for the processing of 2-D optical and radar image data. This was deemed to be very promising since 1) 2-D radar imagery has the same projection geometry as underwater 2-D sonar imaging systems; 2) radar instead of 2-D sonar imaging enables application in the terrestrial domain, e.g., for autonomous vehicle navigation and obstacle detection; 3) radar is a robust sensor under low visibility conditions. e.g., rain, fog and haze, dust, etc. For instance, of special interest would be to recognize excessive slopes, water or low-overhang obstacles, and non-traversable tree trunks in off-roads and other unstructured environments. Some existing data collected by the Italian researchers have been shared and will be processed at the University of Miami in the near future. We expect the experimental results to lead to new methodologies to enhance terrestrial autonomous navigation, to be reported in joint publications.

Two meetings with Professor Massimo Caccia, the Director of CNR- ISSIA, explored various research and collaborative activities. Among them was the testing of some opti-acoustic stereo imaging methodologies with data to be collected with the CNR undersea robotics platforms at the Genova lab.