Title

Augmented/Virtual Reality applied to the control and supervision of heterogeneous robotic vehicles in cooperative missions.

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Summary

This thesis combines techniques from Augmented/Virtual Reality and signal processing for automation, control and supervision of robotic systems with applications to the cooperative control of ocean and air going vehicles. This work follows from the ongoing cooperation between the Underwater Systems and Technology laboratory from FEUP and the Fraunhofer Institute IFF in Magdeburg in Germany.
The proposed research aims at combining signal processing techniques, which are applied to a wide variety of sensors, with Virtual Reality techniques for operator immersion in the remote vehicle environment and also with Augmented Virtual Reality for real and virtual information fusion generating a feedback to the system.
The combination of these techniques will be used to develop a modular framework, based on the virtual interfaces, for data analysis and robotic vehicle control.

State of the art

Since the 80's one of the goals of developments in computer graphics has been oriented towards the human machine interfaces [1].
Today, researchers and technology developers are devoting significant efforts to the development of concepts of operation for networked vehicle systems. In these systems vehicles come and go and interact through inter-operated networks with other vehicles and human operators. Surprisingly, or not, the role of human operators is receiving significant attention in the development of concepts of operation for future robotic systems. In fact, this is the reason why researchers and technology developers have introduced the concept of mixed initiative interactions where planning procedures and execution control must allow intervention by experienced human operators [2]. In part this is because essential experience and operational insight of these operators cannot be reflected in mathematical models, so the operators must approve or modify the plan and the execution. Also, it is impossible to design (say) vehicle and team controllers that can respond satisfactorily to every possible contingency. In unforeseen situations, these controllers ask the human operators for direction.
The different perspectives about this duality autonomy-operator have been leading to promised innovations in the human-machine interface [3]. Computer and control scientists have been addressing this challenge by developing powerful tools to connect

monitoring and user interactivity with the autonomous layer of the system [4]. Augmented/Virtual Reality (RVA) it is a relative new research field, with applicability in the most diverse areas. By definition Augmented/Virtual Reality consists in augmenting sensing perception providing information that can not be directly acquired by the sensor itself [5] [6]. One of the major goals of this research concerns providing additional information (apart of obvious reality) to the human perception [7] [8]. In the thesis context, Augmented/Virtual Reality will be addressed in two ways: 1) Sensor fusion of virtual and real sensors for a better control automation [9] and 2) the creation of an advanced virtual environment to provide mixed, virtual and real, information to the operator for monitoring and remote operation [10].
Planning robot paths [11], medical training [12], air traffic control [13] are just some examples where Augmented/Virtual reality can be applied. One big and recent example of RVA application to support operators controlling vehicles is presented by the aerospace company Gulfstream [14]. The technology, developed by Honeywell [15], SV-PFD (synthetic vision primary flight display) is based on the inclusion in the primary flight panel of a synthetic view of the world. The possibility to offer the operator a larger view of the world is especially important in sub aquatic vehicles where navigation is fundamentally based in acoustic sensors and previous acquired virtual maps. In the Underwater System and Technologies Laboratory [16], of DEEC at FEUP, has been developing underwater vehicles ([17], [18]) and also air vehicles [19] which will be used for experimentation and testing of the developments of this thesis.
Another interesting example of Augmented/Virtual Reality applied to cooperative missions of unmanned air vehicles was developed at Sydney University [20]. In this example, simulated virtual vehicles interact with real vehicles in a cooperative manner. The Augmented Reality can be increased in a way that vehicles cam be equipped with virtual sensors. Virtual sensors can interact with virtual objects like targets or others virtual vehicles of the synthetic world.
Signal processing techniques, in particular video and image processing applied to stereo viewing and panoramic vision [21] (with multi-sensor panoramic cameras), obstacle avoidance [22], motion estimation, distance maps formulations [23] and pattern recognition, are very closely associated to Augmented Reality techniques.

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