Advanced image processing for an intelligent vision system for avionics

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Abstract of the paper

3D reconstruction from 2D images is a common issue of several research domains. In the last years, the interest in 3D models has dramatically increased and 3D model reconstruction plays a very important role in computer vision, as well as in different engineering applications.

In many aerospace and avionic scenarios, the object reconstruction and identification is crucial for the mission success.

For example, in the active space debris removal (i.e., a new method to remove space debris exploiting unmanned spacecrafts) a spacecraft must be able to autonomously: detect a debris, analyze it, and, eventually, rendezvous with it. During the analysis phase, the spacecraft must be able to understand dimension, weight and shape of the debris, so a 3D model reconstruction is mandatory.

An additional significant example in the avionic application is provided by the collision avoidance during aircraft taxiing, which would dramatically benefit from the 3D object reconstruction.

In the geographic information field, the creation of digital model of cities has increased its importance for allowing a smart urban grown and for detecting illegal buildings. Thus, the exaction of 3D building information efficiently and quickly has become essential. The emerging trend is to equip Unmanned Avionic Vehicles (UAV) with cameras and, then, use the UAV to acquire pictures of the city to create the desired 3D model.

The shape reconstruction problem involves high computationally intensive algorithms. In addition, in both the space and avionic applications, this task has to be accomplished in hard real time.

Since the standard aerospace- and avionic- qualified cameras have high output frame rate, a software implementation of these computational intensive algorithms cannot reach the required performances. Thus, a hardware implementation is needed.

The paper addresses the design of a 3D object reconstruction hardware accelerator system, making use of standard equipments and devices in order to provide an affordable system for aerospace as well as for aeronautic contexts.

Starting from the selection of candidate approaches for solving the mathematical problems and the selection of image acquisition devices, the processing algorithms have been implemented at hardware level via properly qualified FPGA-based systems.

The paper will present:

- The algorithm selection methodology;
- The performed software modeling of the selected algorithms;
- The analysis performed on the software models to detect the most computationally intensive tasks that must be computed in hardware;
- The architectural prototypes of the developed hardware modules;
- Analysis of performances and benefit provided by the hardware acceleration.