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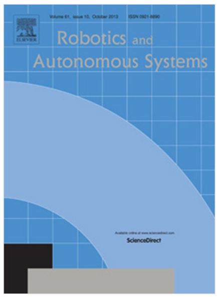

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Embedding SLAM Algorithms: Has it Come of Age?

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Abstract

Development of Simultaneous Localization and Mapping (SLAM) systems in the era of autonomous navigation and the growing demand for autonomous robots have put into question how to reduce the computational complexity and make use of SLAM algorithms to operate in real time. Our work, aims to take advantage of low-power embedded architectures to implement SLAM algorithms. Precisely, we evaluate the promise held by the new modern low power architectures in accelerating the execution time of SLAM algorithms. Throughout this, we map and implement 4 well-known SLAM algorithms that find utility in very different robot applications and autonomous navigation, on different architectures based embedded systems. We present first a processing time evaluation of these algorithms on different CPU based architectures. Results demonstrate that FastSLAM2.0 allows a compromise between the computation time and the consistency of the localization results. The algorithm has been modified to be adapted to large environments. It is then optimized for parallel implementations on GPU and FPGA. A comparative study of the resulting implementations is given. Our results show that an embedded FPGA based SoC architecture is an interesting alternative for a SLAM algorithm implementation using the hardware-software co-design approach. Hence, the system meets performance requirements of a robot to operate in real-time constraints.

Keywords: SLAM Algorithms, Heterogeneous Architectures, GPU, CPU, FPGA, Hardware Software Codesign

1 Introduction

SLAM algorithms allow an autonomous navigation of robots in an unknown environment. Localization and mapping represent a concurrent problem that cannot be solved independently. Indeed, if a mobile robot follows an unknown trajectory in an unknown environment, the estimation of the robot's pose and the explored map becomes more complicated. In such situation, no information is previously known by the mobile robot which is supposed to create a map and to localize itself according to the created map. Before the robot can estimate the position of a given landmark, it needs to know from which location this landmark was observed. At the same time it is difficult to estimate the actual position of the robot without a map. A good map is necessary for localization while an accurate pose estimate is needed for map reconstruction, hence the name of **S**imultaneous **L**ocalization **A**nd **M**apping.

Over the span of the last decade, SLAM algorithms have been executed on high-performance machines because of their computational complexity. This is to ensure real-time performances and accurate map construction. In practical situation, SLAM algorithms are an interesting topic specially when it comes to explore extremely difficult situations where the dimension of the robot may not allow using high performance machine to execute SLAM algorithms. Therefore, there is a general need, in case of embedded systems, to have an ar-

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