Cascaded Evolutionary Estimator for Robot Localization

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ABSTRACT

All processes in the real world are burdened with interference to some extent. The present work shows a method permitting effective interference filtration using sensor data applied for localization possibilities in the known environment using 2D-laser-range-finder. So called cascaded estimator is utilized for filtration mechanism consisted of up to five serially arranged strategies that are able to navigate successfully in useful data. The interference level, at which the estimator devised is able to work, equals up to 100 percent of the original signal. The novelty of the cascaded estimator includes successful evolutionary computations replacing high-performance accelerator with keeping all necessary features of the original algorithms. It is possible to draw up a large quantity of various strategies having specific features. A behavioural analysis of various estimators is performed for verification of features of individual types with application of brute force and classic gradient algorithm. Comparison of efficiency and time requirements is executed utilizing evolutionary methods together with robustness demonstration and reliability of selected types in various kinds of environment. Their advantages, disadvantages, and efficiency are discussed in the course of classification. The number of experiments executed gives wider and mainly practical view on problems of cascaded estimator application for interference filtration and navigation.

Keywords: Cascaded Evolutionary Estimator, Evolutionary Robotics, Interference, L1-Norm, Robot Localization

1. INTRODUCTION

Probability methods belong among the most applied algorithms of mobile robotics used for map creation of an unknown environment and for localization in a known environment. Only seldom algorithms of brute force for calculations connected with position changes of robots are applied. A gradient type of algorithm can be found, for example in Lu and Milios (1997a). The authors used previous works, for example (Cox, 1991). The disadvantage of their method is a very low resistance to disturbing factors, e.g., interference. It is both interference caused by moving objects and interference caused by erroneous reflections. In the real world interference is present everywhere. A mobile robot which utilizes e.g., 2DLS is thus limited in motion in a sterile laboratory environment. The Monte Carlo Method belongs among the most applied computing accelerators. A practical project can be found e.g., in Fox et al. (1999). It is an algorithm without any internal intelligence and for its good functionality it needs up to 20 times more particles compared to any other EA method (Vahdat et al., 2007). The aim of this

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presented work has been to devise and test an algorithm which could be able to work even in an environment in which the sensor applied is continuously exposed to interference effects of various kind and at the same time it would work in real time.

Detection and interference filtration in sensor data, orientation ability in inconvenient conditions – this all reminds us the real world we are normally moving in. In case of necessity to automate an activity also including a machine working in an environment that is not fully sterile, there is a problem, how to get maximum information from the sensor data with respect to technological possibilities and so called real state-of art in given region. The presented work shows a method proposing using so called cascaded estimator able to filtrate effectively various types of interference from sensor data. This method also represents the function of a good navigation instrument that can be applied in various types of environment also without moving objects. The algorithms given can be also used to some extent in the environment having changeable character, i.e., moving parts of the walls.

The essence of the proposed mechanism is a system of simple algebraic criteria based on so called L1-norm. A larger survey can be found e.g., in these works (Martin et al., 2009; Moreno et al., 2011; Josselin, 2001; Sebahatín & Šišman, 2010; Fuchs, 1980; Fu et al., 2006; Bilgiç, 2010) etc. Such a procedure can be easily given in algorithms and it can also be easily transferred into hardware form by means of programmable logic circuits. Large heuristics that should be necessarily extended during operation are not used here. The form of essence of proposed method remains then invariable. Algorithms are suitable for application in internal environment. The most suitable therefore are office rooms, production factory halls, libraries, hospital areas etc. The only navigation sensor is used here, namely 2DLS. Evolution algorithms represent a substantial part of the proposed work. Thanks to their application it is possible to apply individual estimators in practice with preservation of the need for rapid time response. Evolution algorithms are not now only a new unexplored territory. They have become an integral part of many algorithmic methods and they are very efficient. Thanks to the research done into this field during recent decades, it is possible to set exactly selected EA methods so that they could bring optimal results, i.e., they could solve a specific task optimally. This technique is called tuning. A comparatively large behavioural analysis of the proposed algorithms is given in this article using various types of EA methods and it has been shown which EA methods and under what conditions they are well applicable. EA methods at the same time represent a position of a high-performance computing accelerator. Thanks to it the proposed algorithms are practically applicable, adequately rapid and stable in usual working conditions.

2. RELATED WORK

The proposed work gets information from various fields of research. To be able to understand and more clearly include the contexts described in this work, you can find the summaries of works related somehow with the proposed method. They are related to the field of robotics, evolutionary computer technologies and partly also wider fields of mathematics.

In well known paper (Borenstein et al., 1996) authors created general survey in area of mobile robotics and defined basic presumptions a robot can move in an environment. Continual robot localization as a standalone method is very important for map building, global robot localization or path planning. At the same time continual robot localization belongs to relatively easy method if a priori map of environment is available. Map can be defined by many different ways: geometric primitives, grid based, sensorial data, landmarks – natural or artificial, RFID marks or suitable combination of any previously mentioned technique etc. More difficult situation occur if environment is not fully static (moving walls) or if moving objects like people or other robots are placed into the

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