EVOLUTIONARY MULTIMODEL PARTITIONING FILTERS FOR NONLINEAR SYSTEMS*

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Abstract

The problem of designing adaptive filters for nonlinear systems is faced in this work. The proposed evolution program combines the effectiveness of the Multi Model Adaptive Filters and the robustness of Genetic Algorithms. Specifically, a bank of different Extended Kalman Filters is implemented. Then, the a posteriori probability that a specific model, of the bank of the conditional models, is the true model, can be used as fitness function for the Genetic Algorithm. The superiority of the algorithm is that it evolves concurrently the models' population with the initial conditions. Thus, this procedure alleviates the Extended Kalman Filter's sensitivity on the initial conditions, by estimating the best values. Finally, a variety of defined crossover and mutation operators is investigated in order to accelerate the algorithm's convergence.

1 Summary

The nonlinear filtering problem, has been a central issue in the field of signal processing. The most widely known approach is the so-called Extended Kalman Filter (EKF). Although its applicability, it is known that the EKF suffers from the proper determination of the initial conditions, that affects dramatically the convergence of the algorithm. In the literature, some methods are proposed to determine the initial conditions, but there is no unified framework for the general solution to this problem. There are two parameters which are essential to the convergence of the algorithm $\underline{\theta}_0$ and S_k. The first one affects the smoothness of the convergence, that is if there are many values diverging from the true one or if the majority of the values converge to the true one. The second one is even more significant. It affects the convergence itself. A wrong choice in the value of S_k will probably lead the algorithm to a wrong solution. A new Evolution Program which combines the effectiveness of adaptive multi model partitioning filters and GAs' robustness has been developed in this work that focuses on the system identification problem. Specifically, a bank of EKFs is implemented, each fitting to a different nonlinear conditional model. Then the a posteriori probability that a specific model of the bank is the true model, can be used as fitness function for the GA. In this way, the algorithm identifies the true model even in the case where it is not included in the filters' bank. Evolving the initial population of the models, the sets of the respective initial conditions can be evolved simultaneously. Thus, it is clear that the evolution of the population of the filter's bank improves the filter's performance, since the algorithm can search the whole parameter space, for both the correct parameters' values and the best initial conditions. The method is not restricted to the Gaussian case, it is applicable to on-line/adaptive operation and is computationally efficient. Furthermore, it can be realized in a parallel processing fashion, a fact which make it amenable to VLSI implementation. The structure of the EP that has been developed has two versions. According to the first version, we first make an initial population of m pairs of real numbers each of them representing possible values of S_k and $\underline{\theta}_0$. For each population of possible solutions we apply an MMAF and have as result the respective a posteriori probability. This is the fitness of each possible solution. According to the second version, we first make an initial population of s vectors of m pairs of real numbers (each pair representing a possible value of $(S_k, \underline{\theta}_0)$). For each such vector we apply a MMAF and have as result the a posteriori probability of each value. The biggest a posteriori probability is the fitness of each vector.

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