A modified unscented filter for delay tracking in asynchronous CDMA systems

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Abstract

In this paper, we present a modification on delay estimation and tracking using the unscented filter for an asynchronous CDMA system. The algorithm is based on utilizing the minimum excess mean square error criteria (MEMSEC) in deriving the filter update equation. Computer simulations are presented to illustrate the new filter’s performance. More specifically, the delay estimation errors for multipath multiuser CDMA systems are evaluated using the unscented and the proposed modified unscented filters. The results show that the modified unscented filter tracks the delay variations with less errors than the unscented filter.

Article info

Article history:
Received 19 January 2009
Accepted 2 December 2009

Keywords:
Kalman filter
Unscented filter
Modified unscented filter
Multiuser CDMA systems

1. Introduction

In the transmission–reception process, the channel has many effects on the signal in different aspects. Estimating these channel effects is essential to recover the transmitted signal back at the receiver. These effects are considered as parameters of the channel of interest. Thus, channel parameter estimation evolves as an important issue in signal recovery. One of these channel parameters is the delay in the received signal. The delay occurs due to the fact that the signal has to propagate through a certain distance before reaching the receiver. Because the delay is varying due to the movement of the wireless transceivers or due to objects moving in the wireless environment, therefore, tracking algorithms are used to keep the receiver updated with any delay variations. Many delay trackers were introduced in the literature as in [1–7]. In [1], an extended Kalman filter (EKF) was developed to track delays in a CDMA system. Time delay trackers based on the delay locked loop (DLL) combined with interference cancellation techniques have also been developed [2,3]. Delay estimation and tracking based on filtering approaches have been presented in [4] for the EKF and [5] for the unscented filter. The method in [6] employs an adaptive filter whose taps are adapted using a block least-mean square algorithm to track the delay. In [7], the authors propose an adaptive delay detector to suppress the disturbance from neighboring multipath components.

Enhancement of delay estimation in a multiuser–multipath environment is of great benefit for many applications which make use of delay estimates in their methods. One of these applications is Rake receiver which uses the delay estimates to combat frequency selective multipath effect. The main idea of Rake receivers is to synchronize the different paths received signals and then add them up constructively. Thus, accurate delay estimation and tracking plays an important role in Rake receivers performance. Another application in which delay estimates play an important role is wireless location tracking [8,9]. A small error in delay estimate will cause the location algorithm of a moving target to give track estimates far away from the true track.

In this paper, we follow the filtering approach to present a modified delay estimation/tracking algorithm for asynchronous CDMA system based on the unscented filter presented in [5]. The filter modifies the form of unscented filtering by including the derivative of the filter estimation error in the gain update equation. This conclusion is achieved by deriving the error function for the update equation under the minimum excess mean square error criteria (MEMSEC). In [10], the authors presented a method to find the MEMSEC error functions for non-time varying parameters. Whereas, in this paper we derive the MEMSEC error function for a time varying parameter (which is the delay for the received signal). Further, our approach does not require linearization in its tracking procedure as in the EKF and has better tracking ability than the unscented filter.

The paper is organized as follows: Section 2 introduces the system model that forms the foundation for our tracking filter. The unscented filter is presented in Section 3. In Section 4, we present the modified unscented filter with its derivation. Section 5 presents the simulated performance of the modified unscented filter. Finally, conclusions are drawn in Section 6.