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MATCH FILTERING APPROACH FOR SIGNAL ACQUISITION IN RADIO-PULSAR NAVIGATION

Abstract

Pulsars with their periodic pulses and known positions are ideal beacons for navigation. The challenge, however, is the detection of the very weak pulsar signals that are submerged in noise. Radio based approaches allow the use of advanced techniques and methods for the detection and acquisition of such weak signals. In this paper, an effective signal acquisition method based on epoch folding and matched filtering is proposed that can enable pulsar navigation on spacecraft. Epoch folding is an algorithm that has been traditionally used by astronomers to search and detect pulsars. However, epoch folding is a time and power consuming process, and therefore inefficient. Optimal implementation of these algorithms has been investigated that reduce the detection time by a factor of around 6. Furthermore, since a pulsar navigation system uses signals from known pulsars, advanced algorithms can reduce the time and processing power required for pulsar detection. Therefore, the detection speed can be further increased by employing techniques like matched filtering that exploit a-priori knowledge such as pulse shape of the signal. Matched filtering is the basic tool for extracting known wavelets from a signal that has been contaminated by noise. A matched filter is obtained by correlating the observation with a template of a known signal, to detect its presence. Such a matched filter is the optimal linear filter for maximizing the signal-to-noise-ratio (SNR) in the presence of additive stochastic noise. The paper outlines an approach that combines epoch folding and matched filtering for acquisition of pulsar signals. Preliminary results show that this method significantly increases detection and acquisition speeds while reducing power consumption. This method is then expanded to search through the entire solution space for all possible Doppler shifts which leads to significant acquisition speed increases.