Weak GPS Signal Tracking Using Square Root Filter Algorithm

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INTRODUCTION
This paper proposes a new method on GPS weak signal tracking, which is based on square-root Kalman filter. It uses square root form of estimate error covariance matrices instead of themselves to alleviate the numerical round-off errors effectively. A new GPS signal tracking measurements model is developed, which involves both coherent and incoherent integrations, and the reverse of navigation data bit is treated in a special way. The simulation results show that the weak signal with carrier-to-noise ratio as low as 17dB-Hz can be well tracked by the proposed method.

SQUARE ROOT KALMAN FILTER
In traditional EKF algorithm, the numerical round-off errors may cause non-positive definite of the error covariance matrices, which could lead the iterative results to divergence. So a square root Kalman filter is implemented to keep us away from this phenomenon. Square root Kalman filter uses the square roots of the error covariance matrices instead of themselves. And it guarantees convergence of the whole algorithm.

SQUARE ROOT FILTER-BASED TRACKING OF WEAK GPS SIGNALS
This section is the most important part of this paper. In this section, some improved measurement models are involved. And the whole square root filter algorithm for tracking weak GPS signals is developed here.

RESULTS FROM SIMULATION AND ANALYSIS

![Fig 1 Results of Tracking with C/No=17dB-Hz in proposed method](image)

Due to the proposed method, which is based on the square root EKF algorithm, the ability of tracking weak GPS signal is strongly enhanced. It involves incoherent integration after coherent integration. And then the output is squared, so the disturbance, caused by reverse of data bit, is greatly alleviated. When the quantity of operation is increased, square root filter guarantees the positive definition of error covariance matrices, because of the decreased numerical round-off errors. As a result, the tracking algorithm could converge perfectly, which is shown in the pictures above.

CONCLUSIONS
This paper applies square root Kalman filter to track weak GPS signals, and compares it with the old method, just like traditional EKF and UKF. Simulations with different carrier-to-noise ratio are done. It could be found that the proposed method can track weak signal with C/No=17dB-Hz. This paper focus on precise tracking algorithm with weak signal, and it lays the foundation for the research of indoor GPS receiver.

REFERENCES