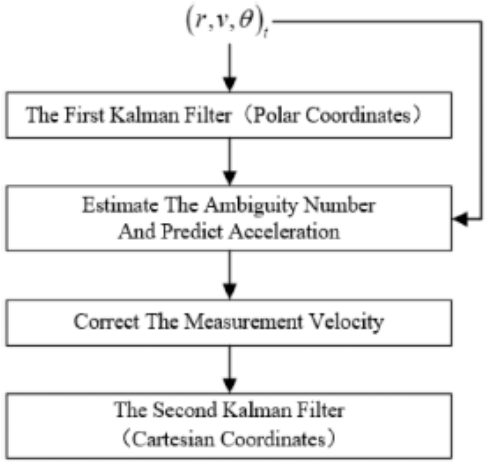
1) Abstract:

Worldwide, people spend so much time traveling from one place to another. In recent years, especially in the last decade, scientists have studied the field of self-driving cars for developing more convenient transportation. These robotic cars have artificial intelligence, radars, lidars, cameras, and other sensors to have safe travel. By using radars, the velocity, range, and angle of different objects can be detected. The FMCW chirp sequence has been used in almost automotive radars for these purposes.

The FMCW radars have to estimate the exact velocity because it is one of the most critical factors in object tracking and detection. In [1], two fundamental problems are discussed: unambiguous velocity and measurement errors in automotive radar; these issues would be tackled by using the cascade Kalman Filter; as a result, object detection and tracking are enhanced. Then by implementing this method in three scenarios, we can find out its effectiveness.

2) Proposed method



Flowchart of Cascaded Kalman Filter

First Kalman Filter Equations

$$X(t|t-1) = FX(t-1/t-1)$$
$$P(t|t-1) = FP(t-1|t-1)F^T + Q$$
$$\varepsilon(t) = Z(t) - HX(t|t-1)$$
$$K(t) = P(t|t-1)H^T(HP(t|t-1)H^T + R)^{-1}$$
$$X(t|t) = X(t|t-1) + K(t)\varepsilon(t)$$
$$P(t|t) = (I_3 - K(t)H)P(t|t-1)$$

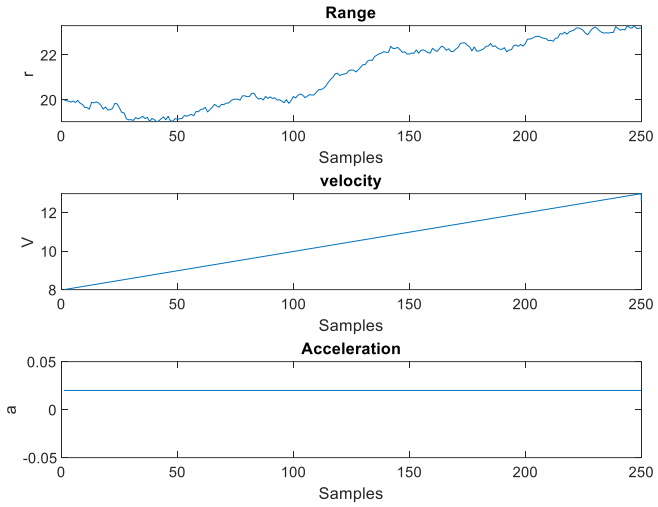
Second Kalman Filter

$$X_{EKF}(t|t-1) = F_{EKF}X_{EKF}(t-1|t-1) + W_{EKF}(t-1)$$
$$Z_{EKF}(t) = h\big(X_{EKF}(t|t-1)\big) + n_{EKF}(t)$$

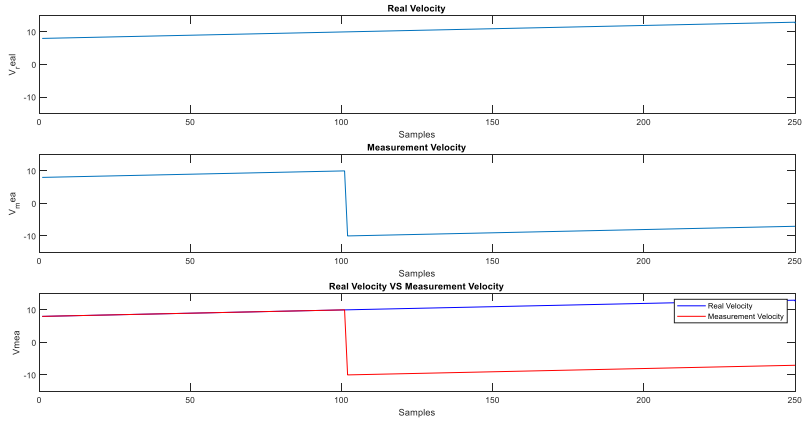
3) First Scenario

Unambiguous velocity region: [-10 m/s , +10 m/s]

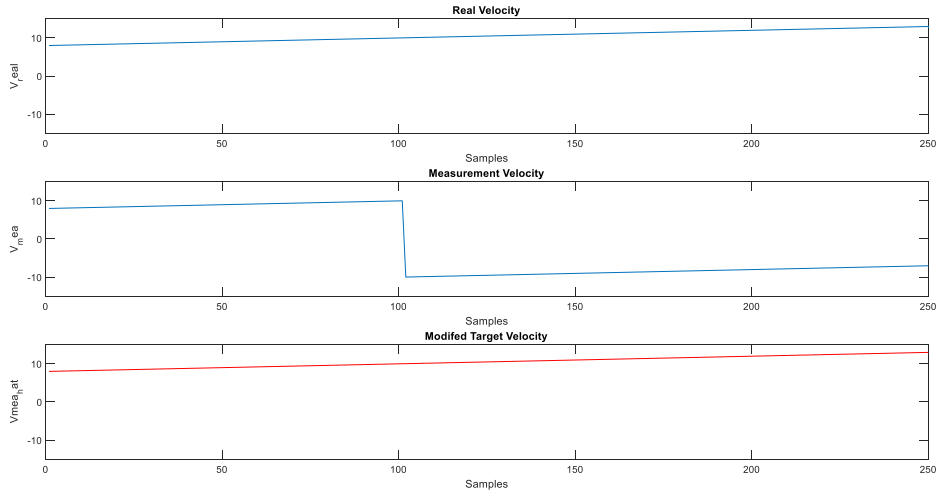
Increasing Velocity



The real value of car in scenario one



Comparison of real velocity and measured one

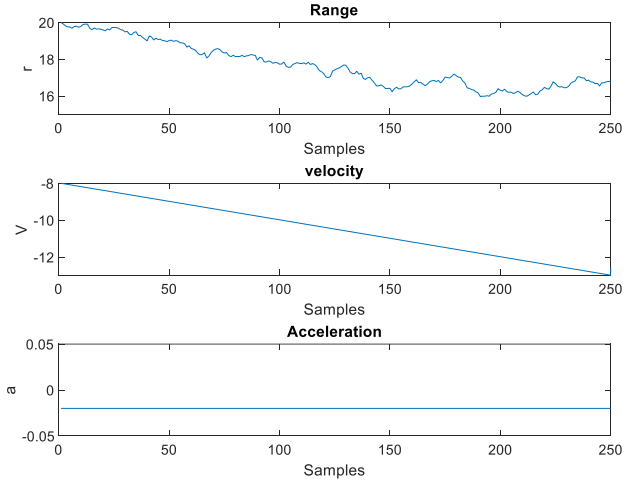


Modified velocity by cascaded Kalman Filter

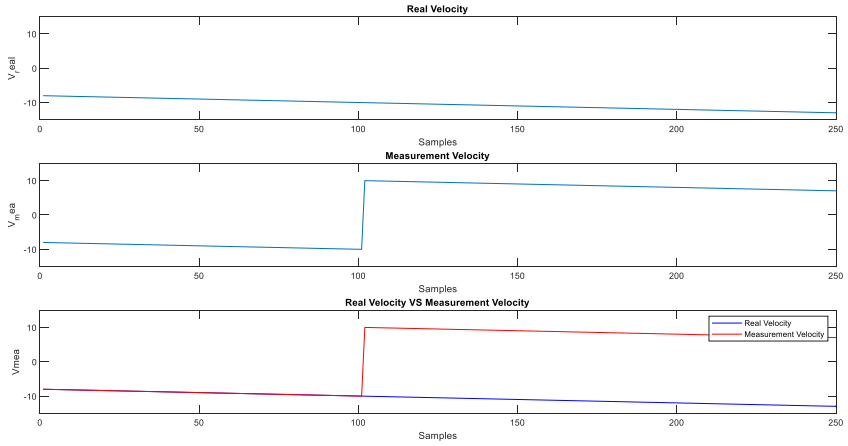
4) **Second Scenario**

Unambiguous velocity region: [-10 m/s , +10 m/s]

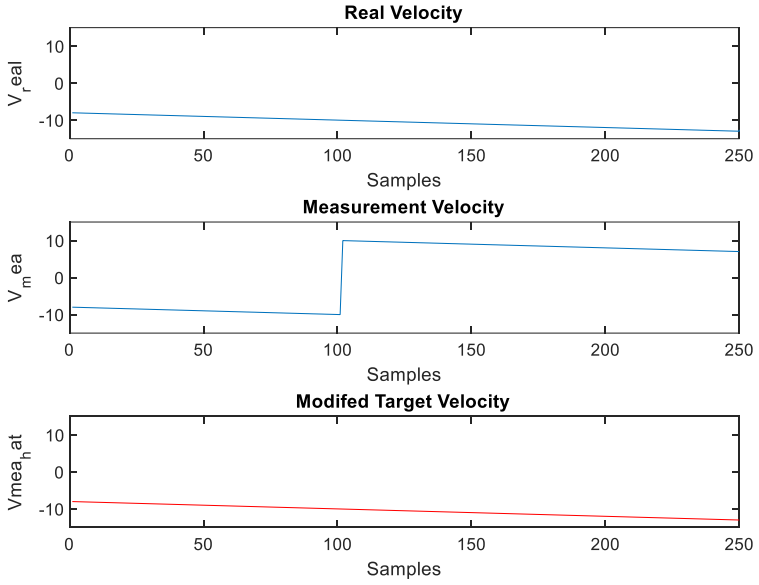
Decreasing Velocity



The real value of car in scenario two



Comparison of real velocity and measured one

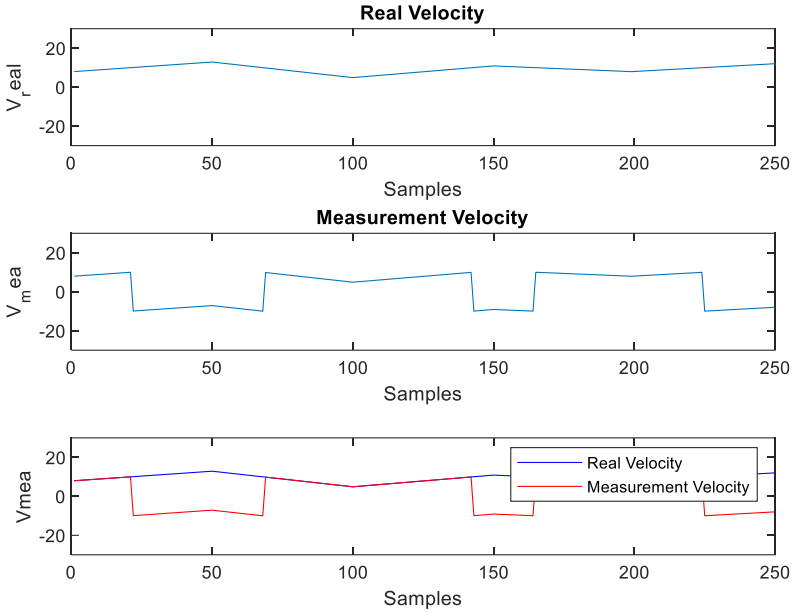


Modified velocity by cascaded Kalman Filter

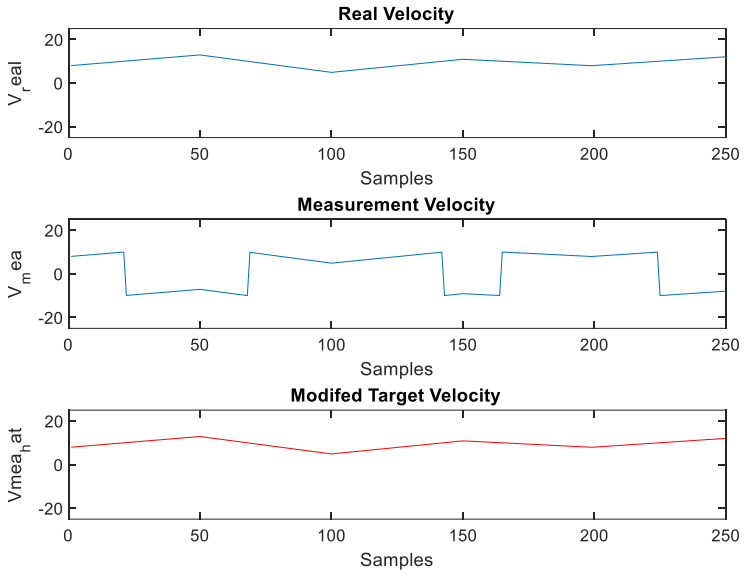
5) Third Scenario

Unambiguous velocity region: [-10 m/s , +10 m/s]

Different acceleration



Comparison of real velocity and measured one



Modified velocity by cascaded Kalman Filter

[1] Li, Y., Liang, C., Lu, M., Hu, X. and Wang, Y., 2019. Cascaded Kalman filter for target tracking in automotive radar. *The Journal of Engineering*, *2019*(19), pp.6264-6267.