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An extended processing scheme for coherent integration and parameter estimation based on matched filtering in passive radar

Key words: Keystone transform, Matched filtering, MDCFT, Mismatching, Passive radar, Velocity estimation

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Motivation

- To provide analyses of four main factors that affect the performance of coherent integration and parameter estimation in passive radar and use an extended processing scheme to improve the performance.

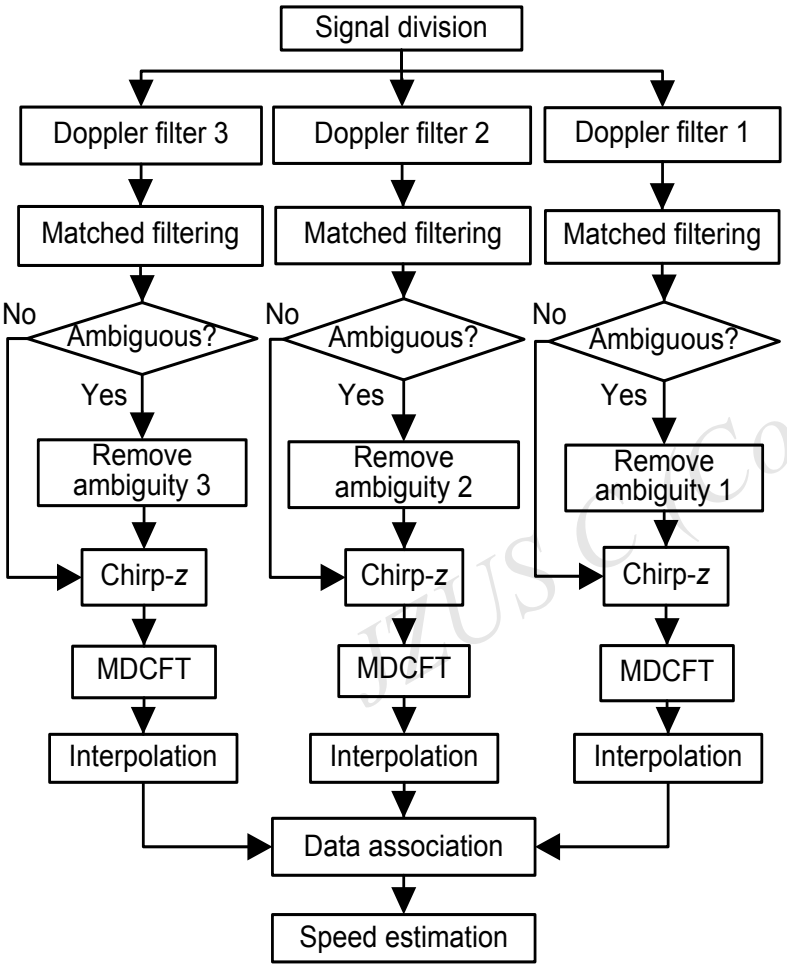
- Disadvantages of existing methods:
  - Matched filtering introduces mismatching for high speed targets
  - Interpolation based keystone transform results in loss of integration gain
  - Discretization has impact on detection performance
  - Doppler expansion leads to loss of integration gain and decreases the parameter estimation ability

Features of our method

- Use of Doppler filter banks reduces mismatching in matched filtering
- Application of keystone transform based on Chirp-*z* offers high precision for range migration
- Interpolation can reduce the impact of discretization with increased computation cost
- Resolution of MDCFT based Doppler expansion compensation is provided
- Velocity estimation based on a single reciever and a singe frame is provided based on the results of MDCFT

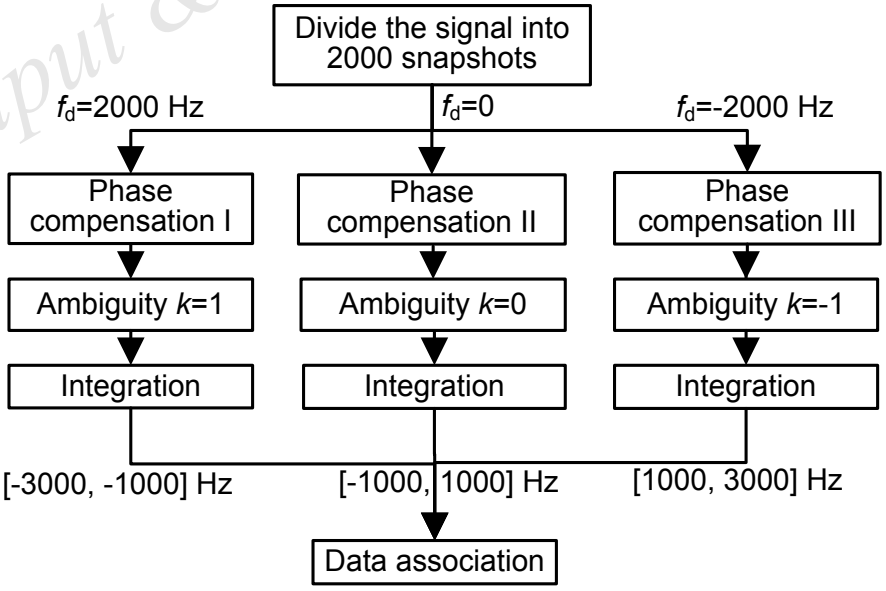
Framework of our method (I)

1. Doppler filter banks



Extended processing scheme

Use different Doppler frequencies to compensate for the mismatching introduced by target speed

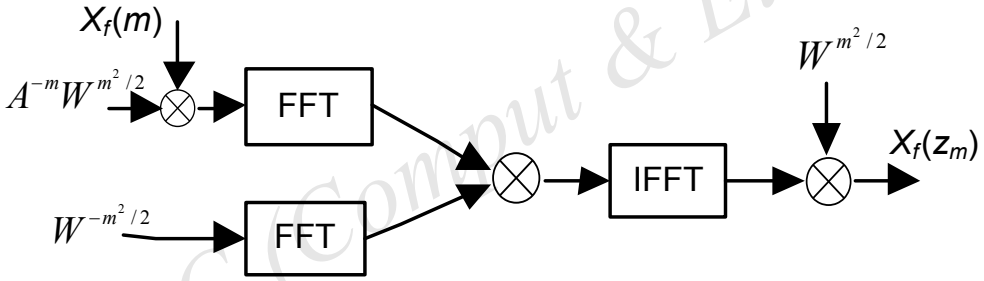


Phase compensation and ambiguity removal (k=3)

Framework of our method (II)

2. Precison of keystone transform

Chirp-*z* transform shows better precison than the interpolation method like linear interpolation and costs less than methods like sinc interpolation in passive radar range migration rectification.



Keystone transform implemented based on Chirp-*z*

3. Interpolation to reduce loss introduced by discretization when the Nyquist sampling rate is satisfied.

However, the interpolation increases the amount of data and leads to higher complexity. Therefore, the interpolation should be considered according to the real-time processing requirement.

Framework of our method (III)

4. MDCFT based Doppler extansion compensation

The area of the sidelobes can be described as

$$\text{Area} = f_{\text{d},i} - (K_i - k)m / N,$$
$$k \in [K_{\min}, K_{\max}],\ m \in [0, M-1].$$

5. Velocity estimation

$$v_i = \sqrt{v_{\text{q},i}^2 + v_{\text{r},i}^2},\quad v_{\text{q},i} = \frac{-a_{1,i} \pm \sqrt{a_{1,i}^2 - 4a_{2,i}a_{3,i}}}{2a_{2,i}},$$

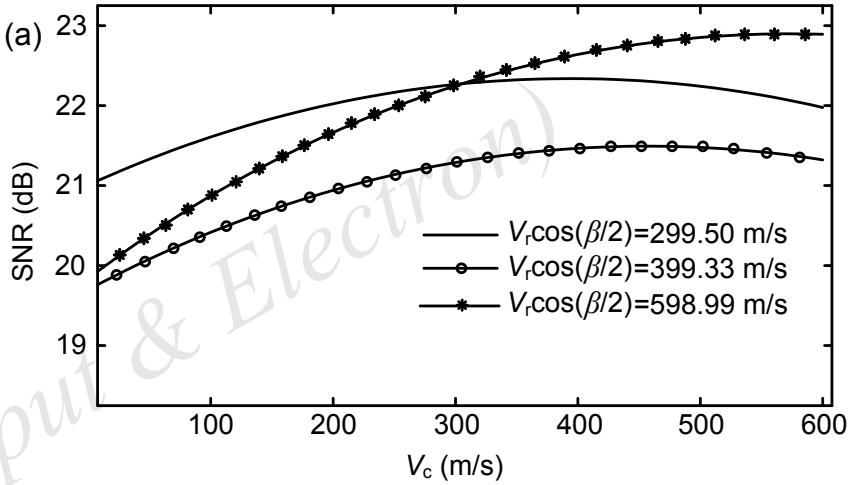
where

$$a_{2,i} = (R_{\text{R0},i} + R_{\text{T0},i})\cos^2(\beta_i / 2),\quad a_{1,i} = v_{\text{r},i}(R_{\text{T0},i} - R_{\text{R0},i})\sin\beta_i,$$

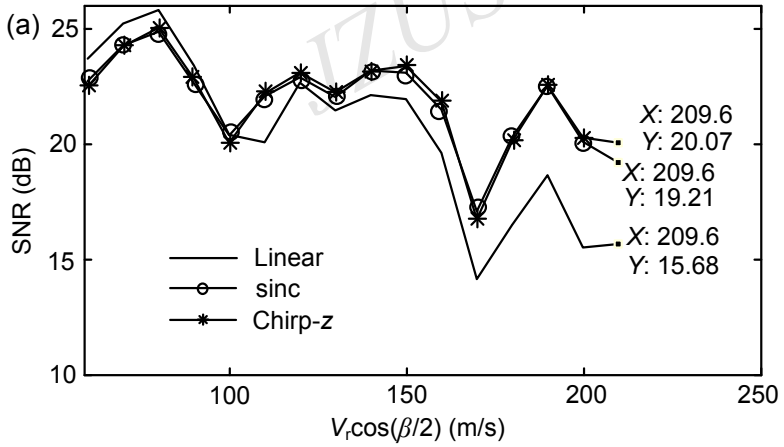
$$a_{3,i} = v_{\text{r},i}^2 \sin^2(\beta_i / 2)(R_{\text{R0},i} + R_{\text{T0},i}) - K_i \lambda R_{\text{T0},i} R_{\text{R0},i}.$$

Major results (I)

1. Doppler filter with different frequencies (V_c)



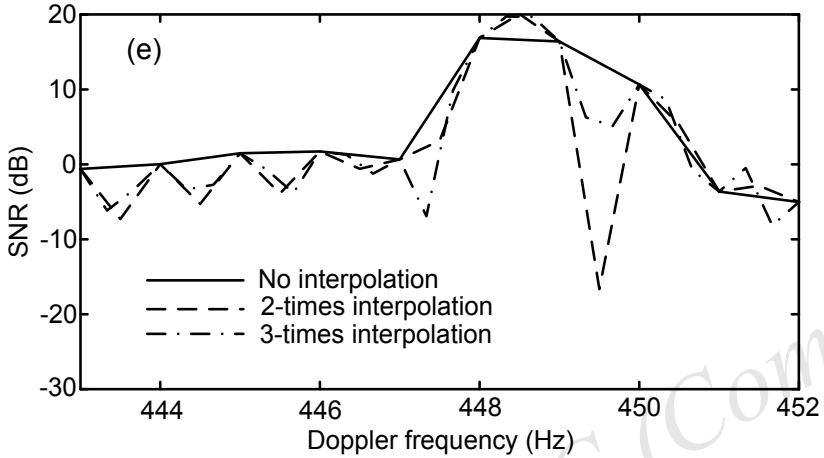
2. Precison and processing time of keystone transform



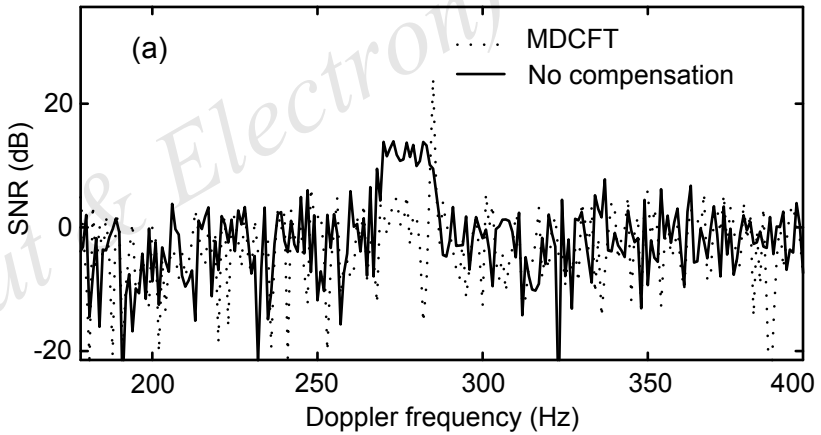
Number of snapshots	Execution time (s)		
	Linear	sinc	Chirp-*z*
	5.7721	213.0998	29.4695
2000	8.3823	428.1781	61.6649

Major results (II)

3. Discretization and interpolation



4. Results of MDCFT



5. Velocity estimation