LOW-COMPLEXITY PARAMETER LEARNING FOR OTFS MODULATION BASED AUTOMOTIVE RADAR

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Introduction

- The design of **joint radar and communication (JRC)** system has aroused extensive attention.
- OTFS modulation is more robust against doubly-selective channels in **high mobility scenarios** than OFDM modulation.
- A **low-complexity** target detection method is demanded for automotive radars to handle the large number of subcarriers and symbols.

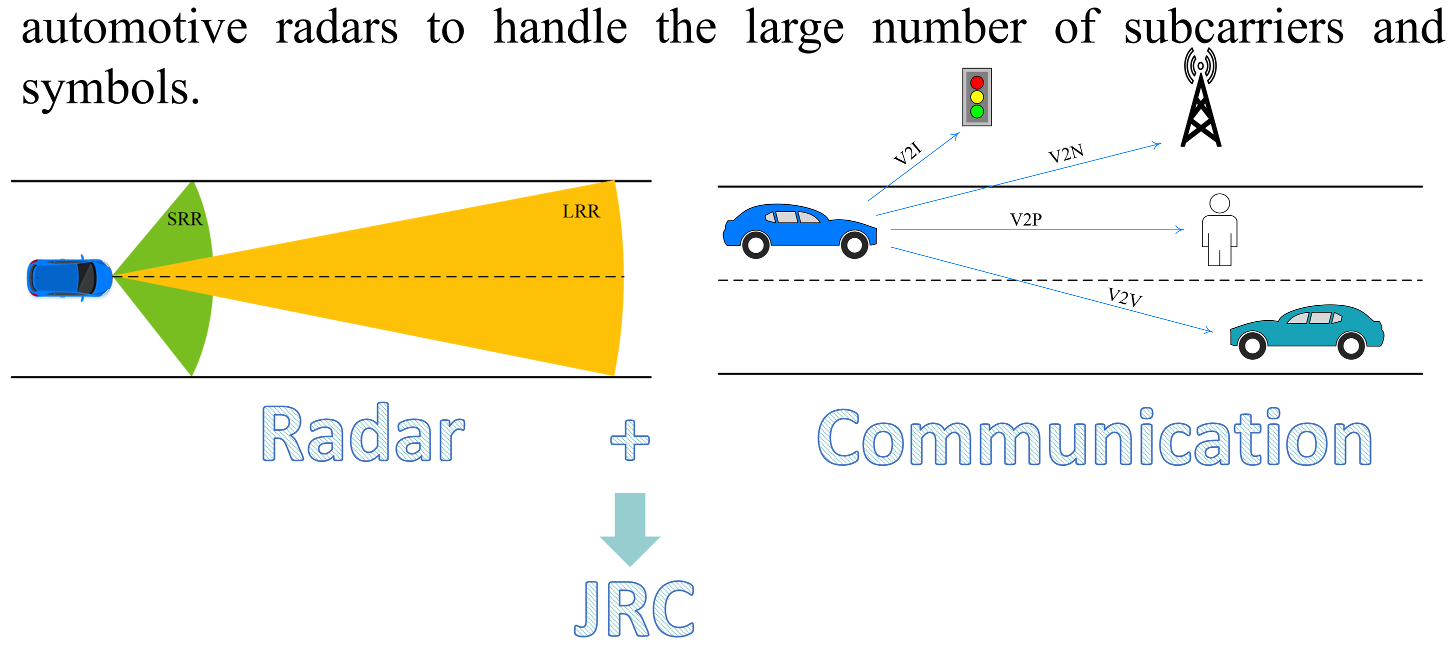

Fig. 1: A brief illustration of JRC system.

OTFS Signal Model

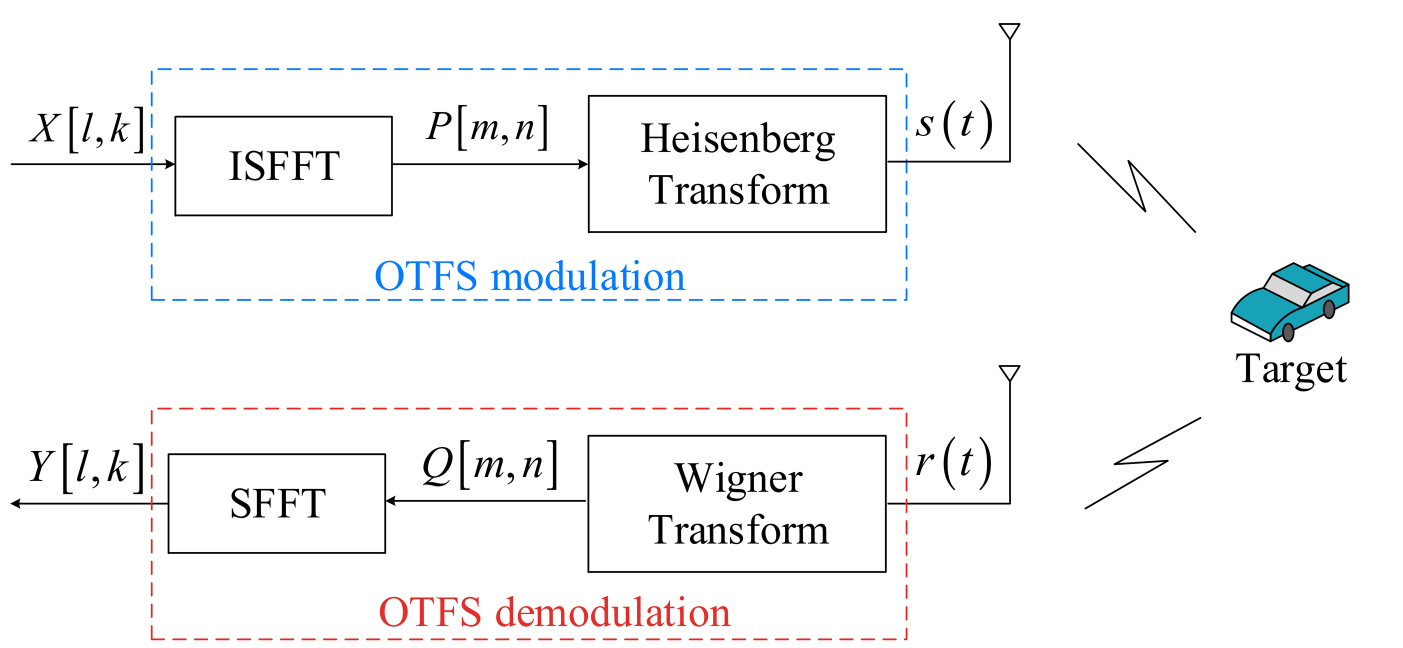

Fig. 2: A brief block diagram of the information signal flow in an OTFS radar.

Discrete Radar Channel in the Delay-Doppler Domain:

$$H(\tau,\nu)=\sum_{\breve{k}=0}^{N-1}\sum_{\breve{l}=0}^{M-1}H[\breve{l},\breve{k}]\delta\left(\tau-\frac{\breve{l}}{Mf_s}\right)\delta\left(\nu-\frac{(\breve{k})_N}{NT_s}\right)$$

Doppler Tap of Target:

$$(\breve{k})_N=\begin{cases}\breve{k}, & \breve{k}\le N/2,\\ \breve{k}-N, & \text{otherwise.}\end{cases}$$

CPCSBL-GAMP Method

- The radar channel vector is **sparse** which encourages the use of advanced sparse representation algorithms.
- The MAP estimation of h is derived via **expectation maximization (EM)** method exploiting the signal sparsity.
- The E-step in the EM method is implemented via **complex GAMP**.

$$\breve{\mathbf{y}}=\mathbf{A}\mathbf{h}+\mathbf{w} \qquad p(\mathbf{h}|\boldsymbol{\alpha})=\prod_{n=0}^{M_{\rm eff}N_{\rm eff}-1}\mathcal{CN}(h_n|0,\eta_n^{-1})$$

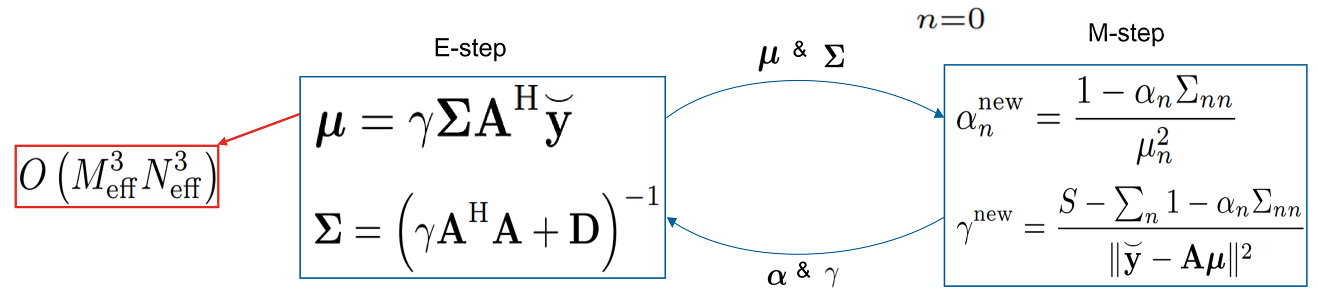

Fig. 3: Block diagram of the parameter update of EM method.

Experimental Setup

- Quadrature phase shift keying (QPSK) symbols are selected.
- The proposed CPCSBL-GAMP algorithm is compared with the OTFS-based matched filter algorithm and OFDM-based FFT algorithm.

Table 1. Simulation parameters.

Symbol	Value	Symbol	Value
f_c	77 GHz	B	100 MHz
M	512	N	128
f_s	195.3125 KHz	T_s	5.12 μs
ΔR	1.5 m	ΔV	2.9725 m/s
$R_{\max}$	180 m	$V_{\max}$	70 m/s
$M_{\rm eff}$	121	$N_{\rm eff}$	50
SNR	10 dB	S	128
$N_{\rm iter}$	200	ε	10^{-7}

Results

Target with R = 90 m, V = 59.45 m/s.

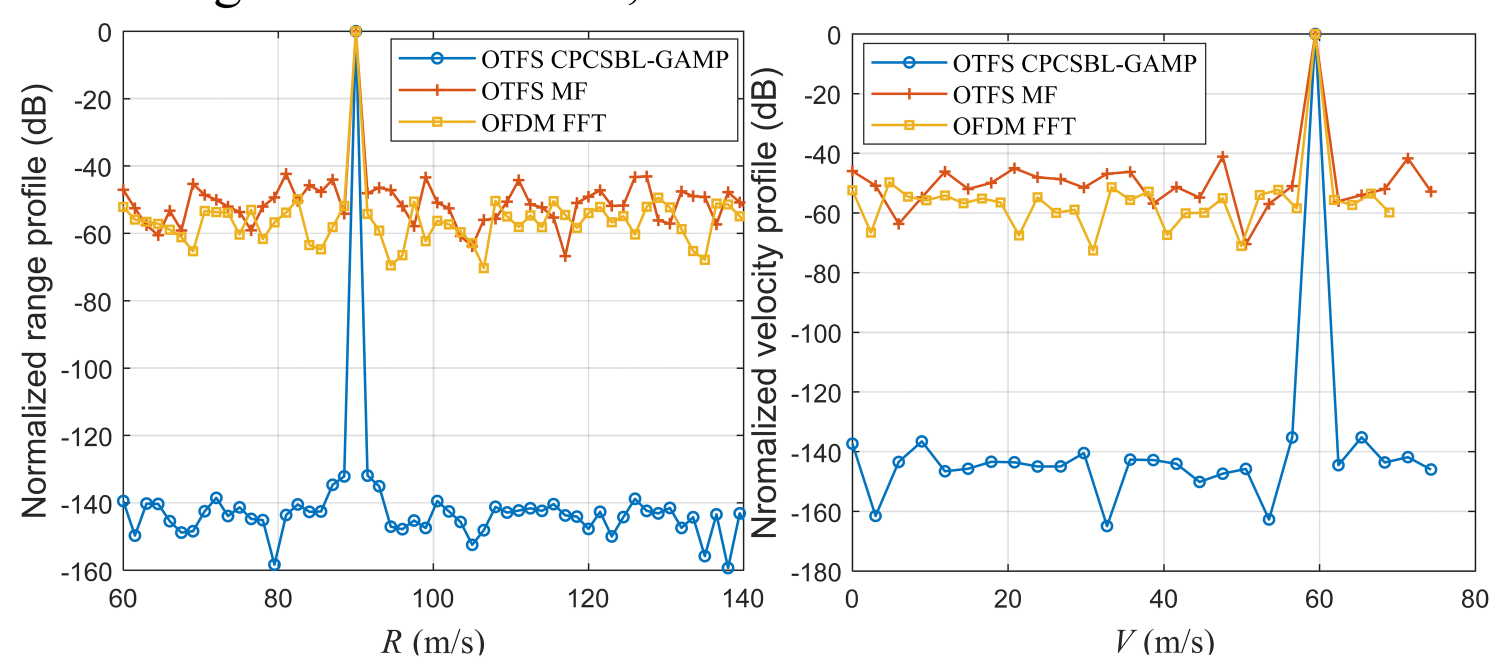

Fig. 4. Target detection results using different methods. (a) Range profile. (b) Relative velocity profile.

Target at R = 90 m but with varying relative velocity.

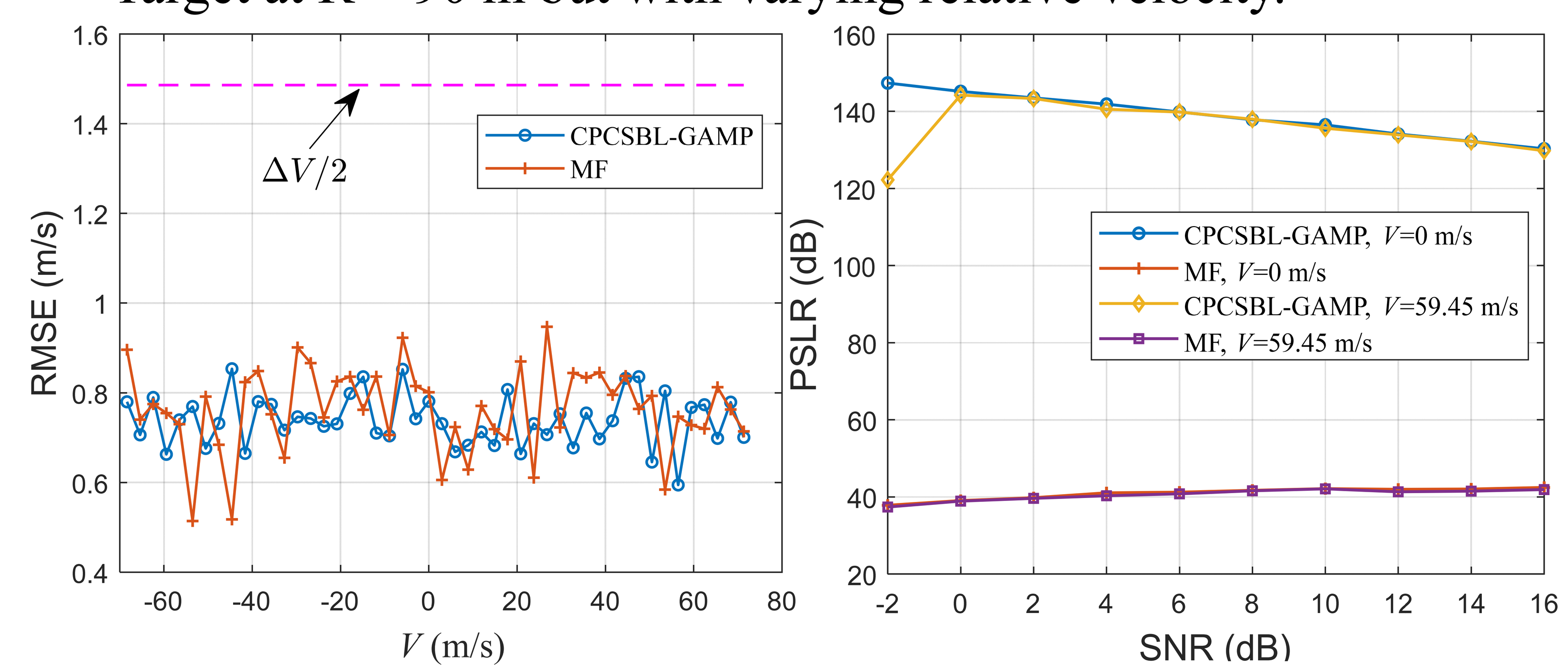

Fig. 5. Performance evaluation using objective metrics. (a) Performance evaluation using objective metrics. (b) PSLR versus SNR and relative velocity.

Conclusion

- Some **prior information** is utilized to reduce the dimension of radar channel vector.
- The structural **sparsity** of radar channel in delay-Doppler domain is observed.
- A **low-complexity CPCSBL-GAMP algorithm** is designed to obtain MAP estimation of radar channel vector.
- The algorithmic performance of the proposed scheme in joint range and velocity estimation is confirmed by **simulation results**.

References

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