

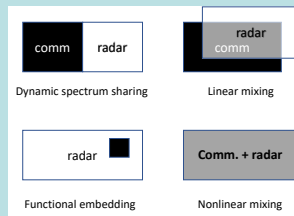


Nonlinear and Inseparable Radar And Data Transmission Framework for Efficient Spectrum Access Networks

Husheng Li, Zhu Han, H. Vincent Poor

Purdue University, University of Houston, Princeton University

Purpose of Project



Why Marry Communications and Sensing?

- Similar signal structure
- Similar hardware and frequency band
- Forward propagation for communications and backward propagation for sensing

Need a Unified Framework

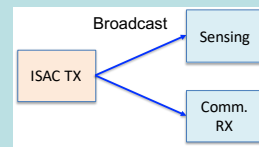
- Comm and radar are developed independently.
- They have different functions and features.
- Need a mathematically elegant framework for the integration

Conflict and Trade-off



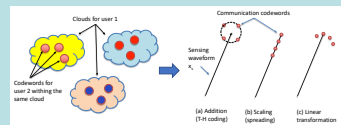
- Randomness-Determinism Subspace conflict
- Environmental conflict: DoF of EM field
- PSD desirability conflict
- ...

Broadcast Framework



Broadcast Channel Framework

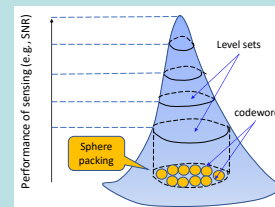
- We consider sensing as a virtual user and communication as genuine user. Therefore, ISAC is a downlink broadcast.
- Many existing approaches in broadcast channels can be leveraged.



Superposition Coding Approach

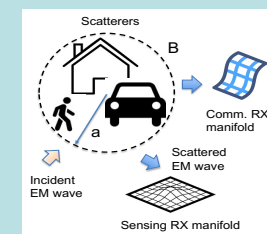
- We first generate the sensing waveform (e.g., FMCW waveform).
- The final waveform is generated using a transformation determined by the communication message:
 - ❖ Addition: dirty paper coding
 - ❖ Scaling: spread spectrum
 - ❖ Linear transformation: OFDM+PSK

Fundamental Trade-off



Sphere Packing

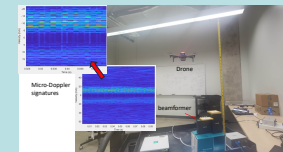
- We evaluate the volume of level sets of sensing performance metric in the waveform (codeword) space
- Sphere-packing argument is used to bound the number of codewords (data rate)



Sphere Packing

- The DoF of EM field depends on the scatterers
- Communications desire more DoF, while sensing does not.

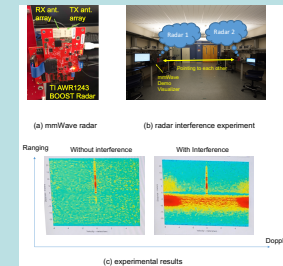
Experiment Demos



Drone Detection

Parameters	Values
Sampling rate at the transmitter (f_s)	200 MHz
Downsample rate (α)	16
Central frequency (f_c)	28 GHz
# of subcarriers (M)	80
# of symbols (N)	80
# of pilots (N_p)	16
Subcarrier spacing (Δf)	2.5 MHz

Synthetic ISAC



Interference in Sensing