

Millimeter wave References and Open Issues

Mm-wave Picocells

Marzi, Ramasamy, Madhow, *Compressive channel estimation and tracking for large arrays in mm wave picocells*, IEEE J. Selected Topics in Signal Processing, April 2016. (See also Allerton'12 paper by Ramasamy, Venkateswaran, Madhow).

Zhu et al, *Demystifying 60 GHz Outdoor Picocells*, Mobicom 2014.

Marzi, Madhow, Zheng, *Interference analysis for mm-wave picocells*, Globecom 2015.

Rasekh, Marzi, Zhu, Madhow, Zheng, *Noncoherent mmWave path tracking*, Hotmobile 2017.

Open Issues

- Demonstrating compressive picocell architecture experimentally
- Abstractions for protocol design and evaluation
- Base station coordination, handoffs, end-to-end performance

Large Arrays

Ramasamy, Venkateswaran, Madhow, *Compressive adaptation of large steerable arrays*, ITA 2012.

Ramasamy, Venkateswaran, Madhow, *Compressive parameter estimation in AWGN*, IEEE Trans. Signal Proc., December 2014.

Marzi, Ramasamy, Madhow, *Compressive channel estimation and tracking for large arrays in mm wave picocells*, IEEE J. Selected Topics in Signal Processing, April 2016. (See also Allerton'12 paper by Ramasamy, Venkateswaran, Madhow).

Mamandipoor, Ramasamy, Madhow, "Newtonized Orthogonal Matching Pursuit: Frequency Estimation over the Continuum," IEEE Trans. Signal Processing, Oct 2016 (see also GlobalSIP'15 paper by same authors).

Open Issues

- Demonstrating compressive estimation for large arrays experimentally (beamforming, nullforming, tracking)
- Hybrid transceiver architectures, multi-user MIMO

LoS MIMO

Sheldon, Seo, Torkildson, Madhow, Rodwell, *A 2.4 Gb/s millimeter-wave link using adaptive spatial multiplexing*, APS-URSI 2010.

Torkildson, Madhow, Rodwell, *Indoor millimeter wave MIMO: feasibility and performance*, IEEE Trans. Wireless Comm., Dec 2011.

Mamandipoor, Sawaby, Arbabian, Madhow, *Hardware-constrained signal processing for mm-wave LoS MIMO links*, Asilomar 2015

Irish, Quitin, Madhow, *Sidestepping the Rayleigh limit for LoS spatial multiplexing: a distributed architecture for long-range wireless fiber*, ITA 2013.

Irish, Quitin, Madhow, *Achieving multiple degrees of freedom in long-range mm-wave MIMO channels using randomly distributed relays*, Asilomar 2013.

Open Issues

- Networked MIMO links

- Wireless backhaul design

- Distributed architectures and relays, including the role of full duplex

- Hybrid analog/digital signal processing architectures and algorithms

- Fundamental limits under hardware constraints

Mesh Networks

Singh, Mudumbai, Madhow, *Interference analysis for highly directional 60-GHz mesh networks: the case for rethinking medium access control*, IEEE/ACM Trans. Networking, October 2011.

Singh, Mudumbai, Madhow, *Distributed coordination with deaf neighbors: efficient medium access for 60 GHz mesh networks*, IEEE Infocom 2010.

Rasekh, Guo, Madhow, *Interference-aware routing and spectrum allocation for millimeter wave backhaul in urban picocells*, Allerton 2015.

Open Issues

Comprehensive design and evaluation for picocellular backhaul and last mile applications

Tractable optimization framework and interference/propagation models

Architectures and evaluation for novel system concepts (e.g., drones, satellites)

Analytical characterization and optimization of decentralized mesh networks

Millimeter wave radar

Mamandipoor et al, *Spatial-Domain Technique to Overcome Grating Lobes in Sparse Monostatic mm-Wave Imaging Systems*, IMS 2016.

Mamandipoor, Ramasamy, Madhow, “Newtonized Orthogonal Matching Pursuit: Frequency Estimation over the Continuum,” to appear, *IEEE Trans. Signal Processing* (see also GlobalSIP’15 paper by same authors).

Open Issues

Fundamental characterization of short-range delay/Doppler imaging

Design and evaluation in specific contexts: gesture recognition,
vehicular automation

Interface with machine learning algorithms

Prototyping and experimental validation

ADC-limited communication

Ponnuru, Seo, Madhow, Rodwell, *Joint mismatch and channel compensation for high-speed OFDM receivers with time-interleaved ADCs*, IEEE TCOM, August 2010.

Singh, Dabeer, Madhow, *On the limits of communication with low-precision analog-to-digital conversion at the receiver*, IEEE TCOM, December 2009.

Wadhwa, Shanbhag, Madhow, *Space-time slicer architectures for analog-to-information conversion in channel equalizers*, ICC 2014.

Roufarshbaf, Madhow, *Analog multiband: efficient bandwidth scaling for mm wave communication*, IEEE J. Selected Topics in Signal Processing, April 2016.

Open issues

Fundamental limits and architectures for various settings

-- mm-wave MIMO with large bandwidths

--low-power, short range links

Hardware demonstrations

Integration with higher layers

Open issues: Making mmWave as mobile and ubiquitous as WiFi/4G

New network architectures

- Reflector-assisted mmWave networks
- mmWave mesh backbone

Integration with transport-layer protocols

- Making TCP resilient under mmWave link dynamics
- mmWave connectivity for highly mobile vehicles

Serving for demanding applications

- 4K/8K video streaming; Wireless VR, etc.

Making mmWave systems mobile friendly

- Energy efficiency protocols
- Computational issues (packet processing at 10+ Gbps)

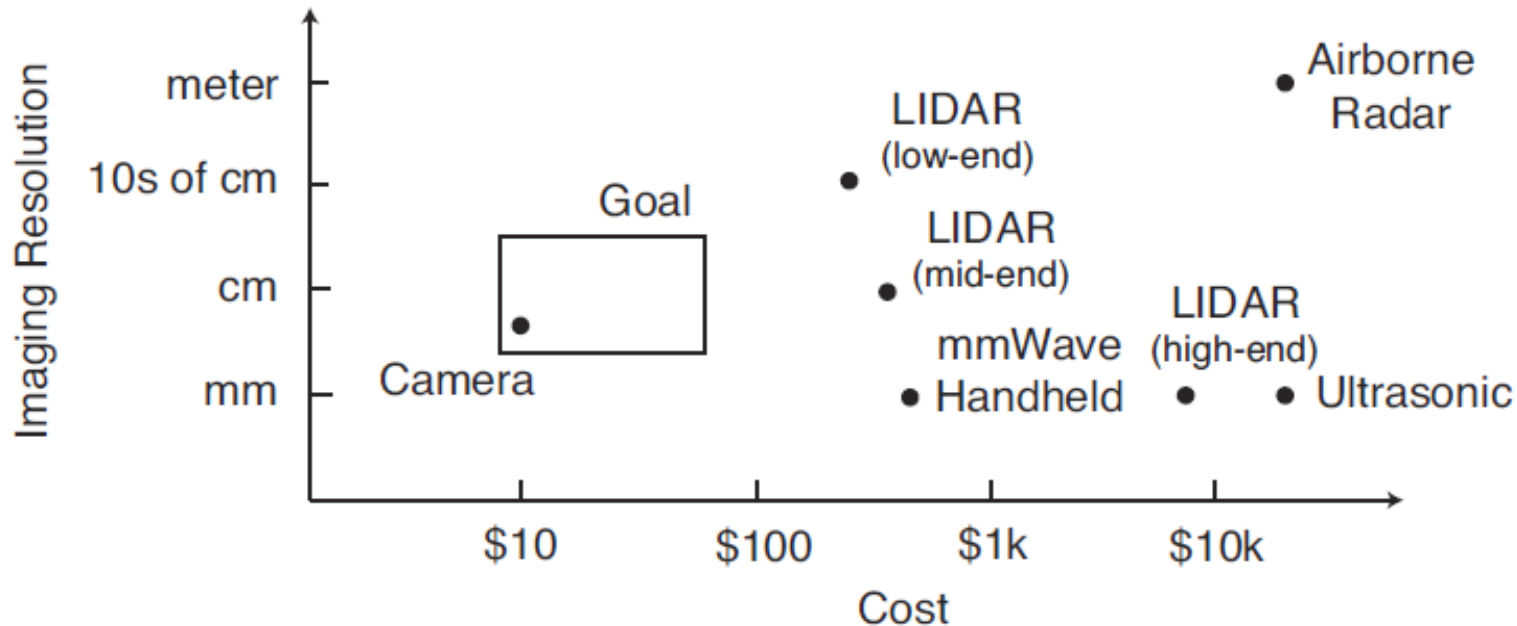
Ubiquitous mmWave sensing/imaging

Open issues: New sensing/imaging algorithms and applications on mobile mmWave devices

Potentials for mmWave imaging

-- Low cost (< \$50, cost of 60 GHz NIC)

-- cm or mm level resolution (possible with large bandwidth and large phased array)



Ubiquitous mmWave sensing/imaging

Open issues: New sensing/imaging algorithms and applications on mobile mmWave devices

Potentials for mmWave sensing

- Wireless health (sensing physiological status, e.g., heart rate, breathing rate)
- Ultra-high resolution activity sensing (e.g., sensing acoustic vibration, motor activities)