ILLINOIS
Electrical & Computer Engineering
COLLEGE OF ENGINEERING

C3SR center for cognitive computing systems research

PreSense: A Hardware-Agnostic mmWave Radar Software Platform

IBM

PreSense

Introduction

Fast evolving millimeter wave (mmWave) radar hardware design enables tremendous opportunities from the software side, such as re-discovering signal processing algorithms to harness the power of parallel computation and machine learning advancement. PreSense provides a hardware-agnostic solution for pipelining DSP, tracking, clustering and machine learning.

Processing Flow Example

ADC Data

ADC data comes from multiple down-converted receiver signals. Current automobile FMCW radar usually operates at 77GHz with 8-12 virtual receivers.

2D FFT

2D FFT on ADC data will generate range and doppler information. This is typically done on-chip with specialized hardware but can also be accelerated on GPU with cuFFT.

Constant False Alarm Rate (CFAR)

Classical radar algorithm to differentiate targets from clutter. Can be accelerated with specialized hardware for some algorithms such as cell-average but can also be treated as a pooling problem with GPU support.

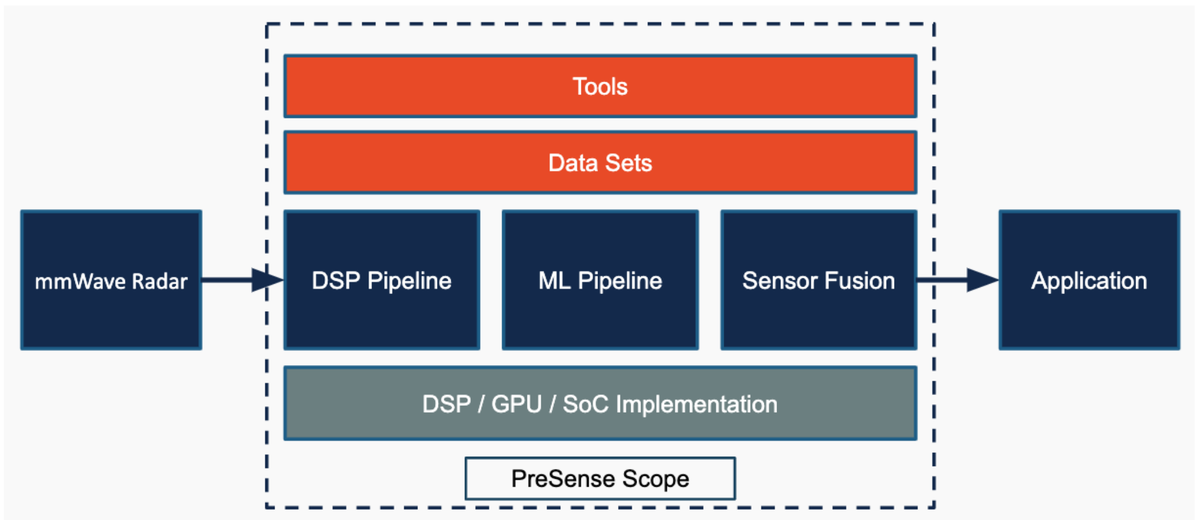
Angle of Arrival (AoA)

Estimate objects' angles based on received signals. Beamforming is typically used for affordable computation and robustness. Subspace methods, e.g. MUSIC provides super-resolution yet computationally expensive. GPU can greatly speed up this.

Tracking, Clustering & Machine Learning

4D point cloud (x, y, z, v) is generated after radar signal processing. Traditional tracking algorithms such as Kalman Filter, machine learning based clustering or detection algorithms will take over for decision making.

PreSense Technology Stack



Current Work

- PreSense Library is currently functional and usable based on Texas Instruments (TI) xWR1642 & (TI) xWR1843 radar evaluation modules.

Range Processing	Core
Doppler Processing	Core
Naive Direction of Arrival (AoA)	Core
Beamforming (AoA)	Enhancing
Zoom FFT	Enhancing
Landmark Extraction Algorithm (LEA)	Noise Removal
Constant False Alarm Rate (CFAR)	Noise Removal
Extended Kalman Filter (EKF)	Tracking
DBSCAN	Clustering

- Work in progress
  1) Human movement classification based on micro-doppler signature.
  2) GPU acceleration on critical algorithms.
  3) Novel noise removal algorithms (sensor fusion based, Weiner filter).
  4) Advanced tracking algorithms (UKF).
  5) More hardware platform support (high resolution, different brands, etc).

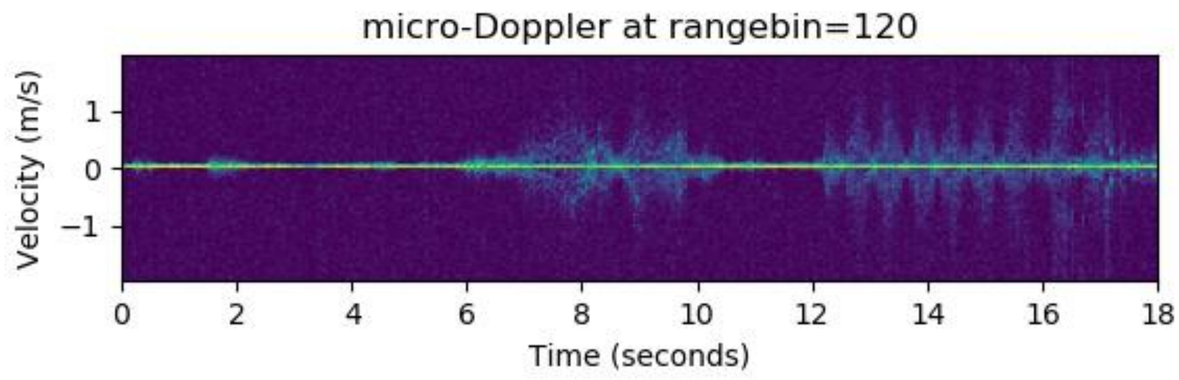


Fig: Micro-doppler signature of a human standing, walking and then wiggling (periodically).

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