Constant Modulus & LS-CM Beamforming

Smart Antennas – Overview

- • Use antenna arrays with adaptive weights
- • Enhance desired signal, suppress interference
- • Adaptive beamforming can be training-based or blind

Motivation for Constant Modulus

- • Many communication signals have constant envelope
- • Examples: BPSK, QPSK, M-PSK
- • Enables blind beamforming (no training sequence)

Signal Model

- • Array input vector: $x(n)$
- • Beamformer output: $y(n) = w^H x(n)$
- • Goal: adjust w so that $|y(n)|$ is constant

Constant Modulus (CM) Criterion

- • Cost function:
- $J = E[(|y(n)|^2 - R)^2]$
- • R depends on modulation (R = 1 for PSK)
- • Forces output signal to have constant magnitude

Constant Modulus Algorithm (CMA)

- • Blind stochastic gradient algorithm
- • Weight update:
- $w(n+1) = w(n) + \mu\, x(n)y(n)(R - |y(n)|^2)$
- • No steering vector or training required

CMA Characteristics

- • Blind adaptation
- • Low computational complexity
- • Slow convergence
- • Suffers from local minima and phase ambiguity

Least Squares Constant Modulus (LS-CM)

- • Batch version of CMA
- • Uses multiple snapshots
- • Improves convergence speed and stability

LS-CM Cost Function

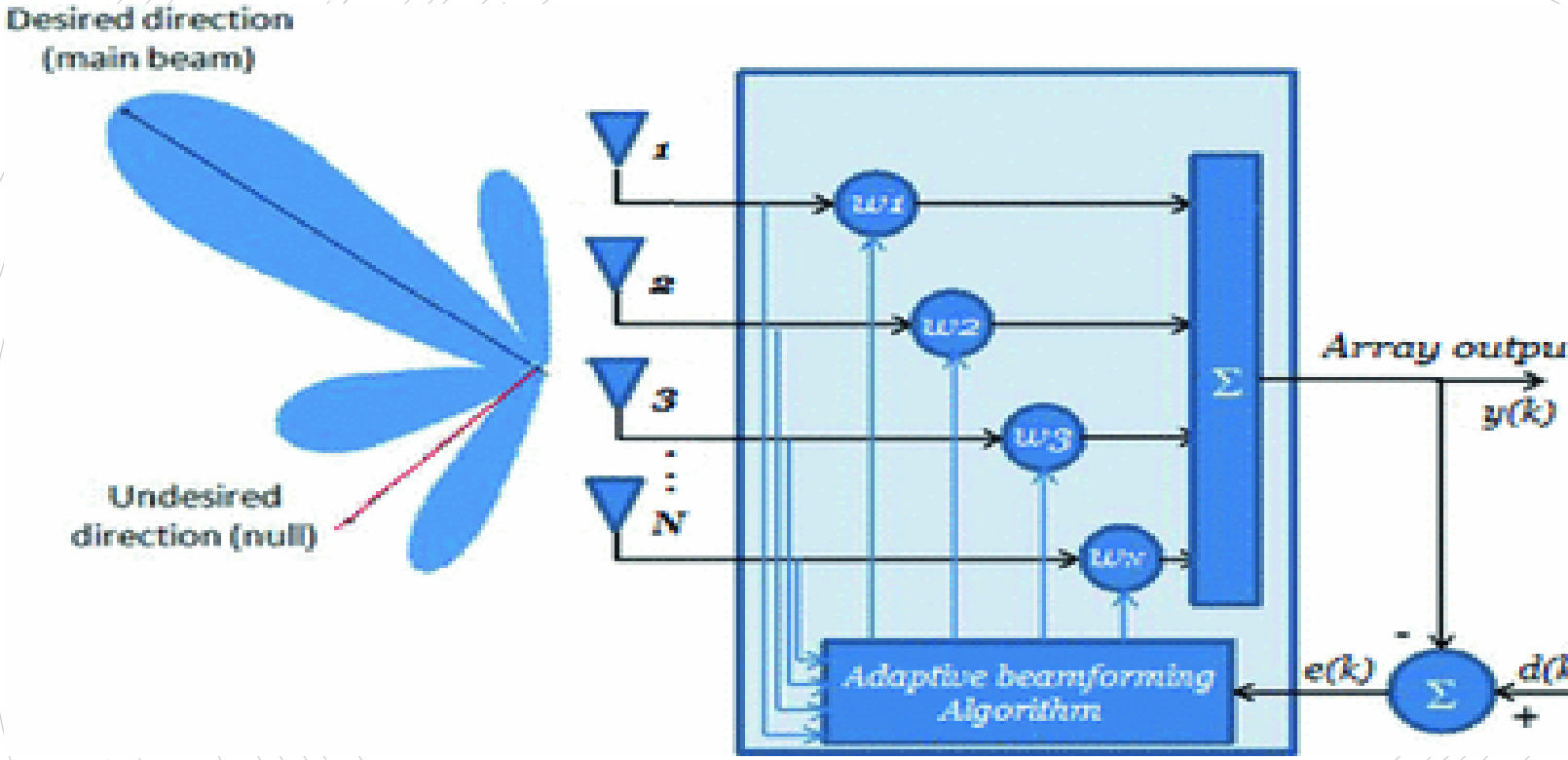
- • LS cost:
- $J = \Sigma (|w^H x(n)|^2 - R)^2$
- • Nonlinear least-squares problem
- • No closed-form solution

LS-CM Solution Methods

- • Iterative gradient methods
- • Gauss-Newton or conjugate gradient
- • Recursive LS-CM (RLS-CM)
- • Often initialized with conventional beamformer

CMA vs LS-CM

- • CMA: simple, low complexity, slow convergence
- • LS-CM: faster convergence, higher complexity
- • Both are blind beamforming techniques


Desired direction
(main beam)
Undesired
direction (null)
1
2
3
N
w1
w2
w3
wN
Σ
Array output
y(k)
Adaptive beamforming
Algorithm
e(k)
-
+

Applications

- • Smart antenna receivers
- • Wireless and mobile communications
- • Satellite communication systems
- • Interference suppression without training