The background features a series of concentric circles in light gray, some solid and some dashed, emanating from the left side. A large red speech bubble is positioned in the upper left, containing the title text. A small red triangle points downwards from the bottom center of the speech bubble.

Constant Modulus & LS-CM Beamforming

The background of the slide features several thin, curved lines in a light gray color, some solid and some dashed, creating a sense of motion or signal waves. A red speech bubble shape is positioned on the left side, containing the title text.

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: $\mathbf{x}(n)$
- • Beamformer output: $y(n) = \mathbf{w}^H \mathbf{x}(n)$
- • Goal: adjust \mathbf{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

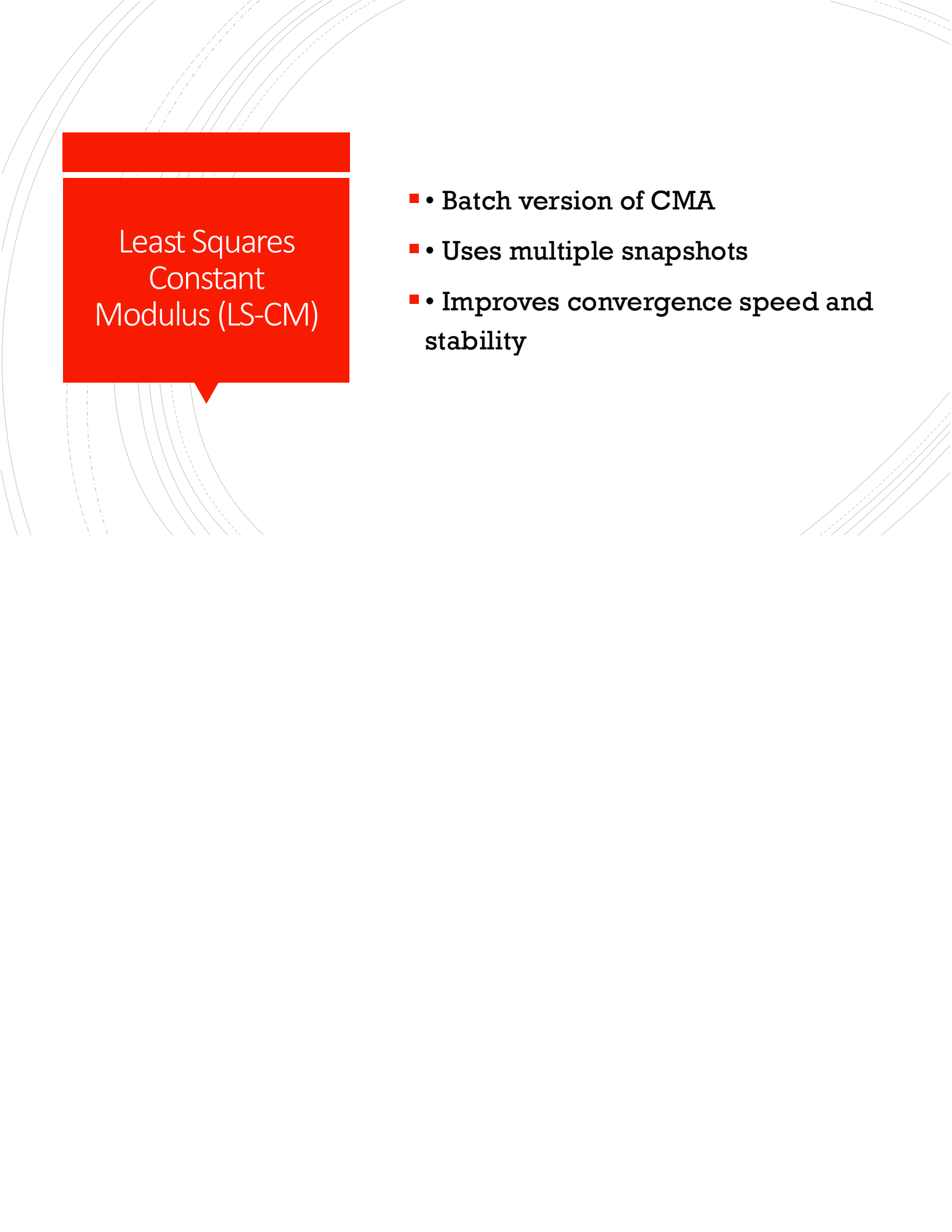
Constant Modulus Algorithm (CMA)

- • 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

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CMA Characteristics

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

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Least Squares Constant Modulus (LS-CM)

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

LS-CM Cost Function

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



LS-CM Solution Methods

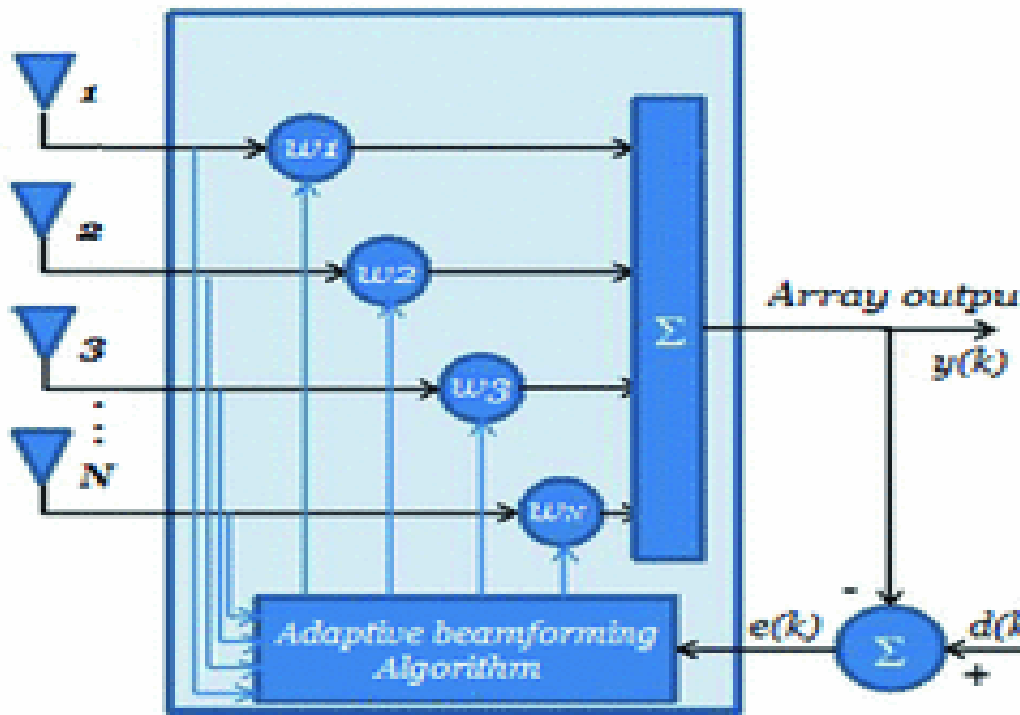
- • Iterative gradient methods
- • Gauss-Newton or conjugate gradient
- • Recursive LS-CM (RLS-CM)
- • Often initialized with conventional beamformer

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)



The background features several thin, curved lines in light gray and white, creating a sense of motion or signal waves. A large red speech bubble is positioned on the left side, containing the word 'Applications'.

Applications

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