A Gridless DOA Estimation Method Based on Convolutional Neural Network With Toeplitz Prior

M : # of sensors , L : # of snapshots , K : # of sources

N : position of the last sensor in our sparse array

A_Ω : $M \times K$ manifold matrix of our SLA

A : $N \times K$ manifold matrix of our virtual array (ULA)

$\longrightarrow$ $A_\Omega = \Gamma_\Omega A$ where Γ_Ω is $M \times N$

Example :

$\longrightarrow$ The sensor array

o o x x o x x o x o

$\longrightarrow$ The virtual array

o o o o o o o o o o

$$A_\Omega = \underbrace{\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}}_{\Gamma_\Omega} A$$

$$y_\Omega = A_\Omega s + n$$

$$R_\Omega = \frac{1}{L} A_\Omega s s^H A_\Omega^H + \sigma_n^2 \cdot I_M = A_\Omega R_s A_\Omega^H + \sigma_n^2 \cdot I_M$$

$$= \Gamma_\Omega \underbrace{A R_s A^H}_{R} \Gamma_\Omega^H + \sigma_n^2 \cdot I_M$$

↳ covariance matrix of noiseless ULA measurement

TDN (detects number of sources)

→ input: R_Ω $(M \times M)$

→ output: k ($N \times 1$ vector where all entries are zero except the K^{th} entry)

CRN

→ input: R_Ω $(M \times M)$

→ output: u ($N \times 1$ vector which is the first column of the toeplitz matrix R)

After R is composed, root-MUSIC algorithm is applied.