Deep Neural Networks for Direction of Arrival Estimation of Multiple Targets with Sparse Priors for Line-of-Sight Scenarios

Signal Sparse Representation

$\underline{\Phi = [\phi_1, \phi_2, \dots, \phi_P]^T}$: potential space of DOAs with $\Delta\phi = \phi_{p+1} - \phi_p \ \forall p$

$$y(t) = \sum_{p=1}^{P} a(\phi_p)\bar{s}_p(t) + n(t) \quad \text{where} \quad \bar{s}_p(t) = \begin{cases} s_k(t) & \text{if } \phi_p = \theta_k \\ 0 & \text{o.w.} \end{cases}$$

$$\Rightarrow \quad R = E\{y(t)y^H(t)\} = \sum_{p=1}^{P} \eta_p a(\phi_p)a^H(\phi_p) + \sigma_n^2 I_M, \quad \eta_p = E\{\bar{s}_p(t)\bar{s}_p^H(t)\}$$

$$c_m = \sum_{p=1}^{P} \eta_p a(\phi_p)a^H(\phi_p)e_m + \sigma_n^2 I_M e_m, \quad e_m = [0\ 0 \cdots 0\ \underset{m^{th}\text{ location}}{1}\ 0 \cdots 0]^T \in R^{1\times M}$$

m^{th} column of R

$$= [a(\phi_1)a^H(\phi_1)e_m \ \cdots \ a(\phi_P)a^H(\phi_P)e_m]\eta + \sigma_n^2 e_m$$

$$= A_m \eta + \sigma_n^2 e_m$$

$[\eta_1\ \eta_2 \cdots \eta_K]^T$

$$\rightarrow \quad c = vec(R) = [c_1; c_2; \cdots; c_P]$$

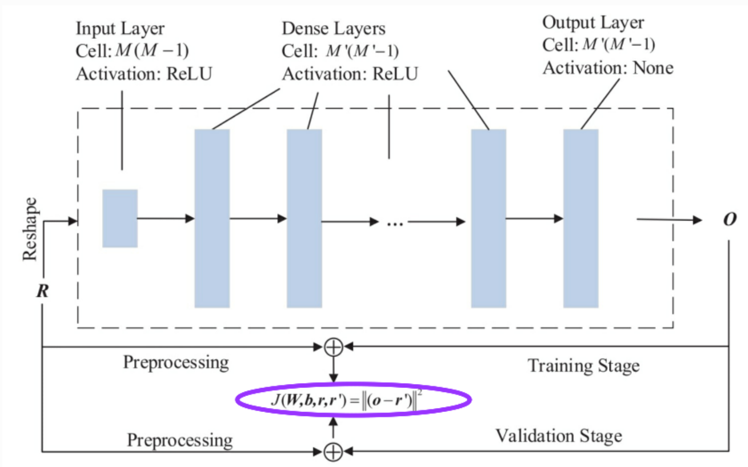
$$= [A_1; A_2; \cdots; A_M]\eta + \sigma_n^2 [e_1; e_2; \cdots; e_M]$$

$$= \tilde{A}\eta + \sigma_n^2 \vec{I}_n$$

$$A^* \odot A = [a_1^* \otimes a_1 \quad a_2^* \otimes a_2 \ \cdots \ a_P^* \otimes a_P]$$

$$\rightarrow \quad \eta = \tilde{A}^H c \quad \text{(reconstructed sparse spatial spectrum)}$$

DNN Learning Framework



$$\tilde{r} = [R_{12}\ R_{13} \cdots R_{ij} \cdots R_{M-1,M}]$$

$$\hat{r} = [Re\{\tilde{r}\},\ Im\{\tilde{r}\}]$$

$$\rightarrow \quad r = \frac{\hat{r} - \mu_r}{\sigma_r}$$

$$\rightarrow \quad o^q = \begin{cases} \sigma(z^q) = \underset{\text{ReLU}}{\sigma}(W^q o^{q-1} + b^q), & q = 1, 2, \dots, Q-1 \\ W^q o^{q-1} + b^q, & q = Q \end{cases}$$

$$W^q = W^{q-1} - \mu\left[\frac{\partial(J(W,b,r,r'))}{\partial W^{q-1}}\right]$$

$$b^q = b^{q-1} - \mu\left[\frac{\partial(J(W,b,r,r'))}{\partial b^{q-1}}\right]$$