Lattice–Ladder Structure For 2D ARMA Filters

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- Calculation of Coefficients

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- Concluding Remarks

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- The 2D lattice-ladder structure has the properties of orthogonality and modularity as in the 1D case.
- The lattice-ladder structure might prove useful in 2D adaptive filtering applications.

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- 1D ARMA lattice-ladder structures have found applications in adaptive filtering and speech processing.
- The 1D ARMA lattice-ladder structure consists of an all-pole lattice section realizing the AR part of the system and the all-zero ladder section providing the MA part .
- In the literature there is yet no compatible lattice-ladder structure for 2D ARMA digital filters.

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- This model eliminates any redundancy from the lattice reflection coefficients.
- A recursive algorithm to calculate the lattice-ladder coefficients for any given 2D ARMA transfer function is also presented.
- The 2D lattice-ladder structure maintains the orthogonality of prediction errors and modularity properties of its 1D counterpart.

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&= \frac{\sum\sum_{(n_1,n_2)\in\mathscr{R}} b(n_1,n_2) z_1^{-n_1} z_2^{-n_2}}{1 + \sum\sum_{(n_1,n_2)\in\mathscr{R}-(0,0)} a(n_1,n_2) z_1^{-n_1} z_2^{-n_2}}
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- We assume that the support for both polynomials is the same.

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- We present a novel structure for 2D ARMA filters by adding a ladder section to this 2D AR model.

Figure

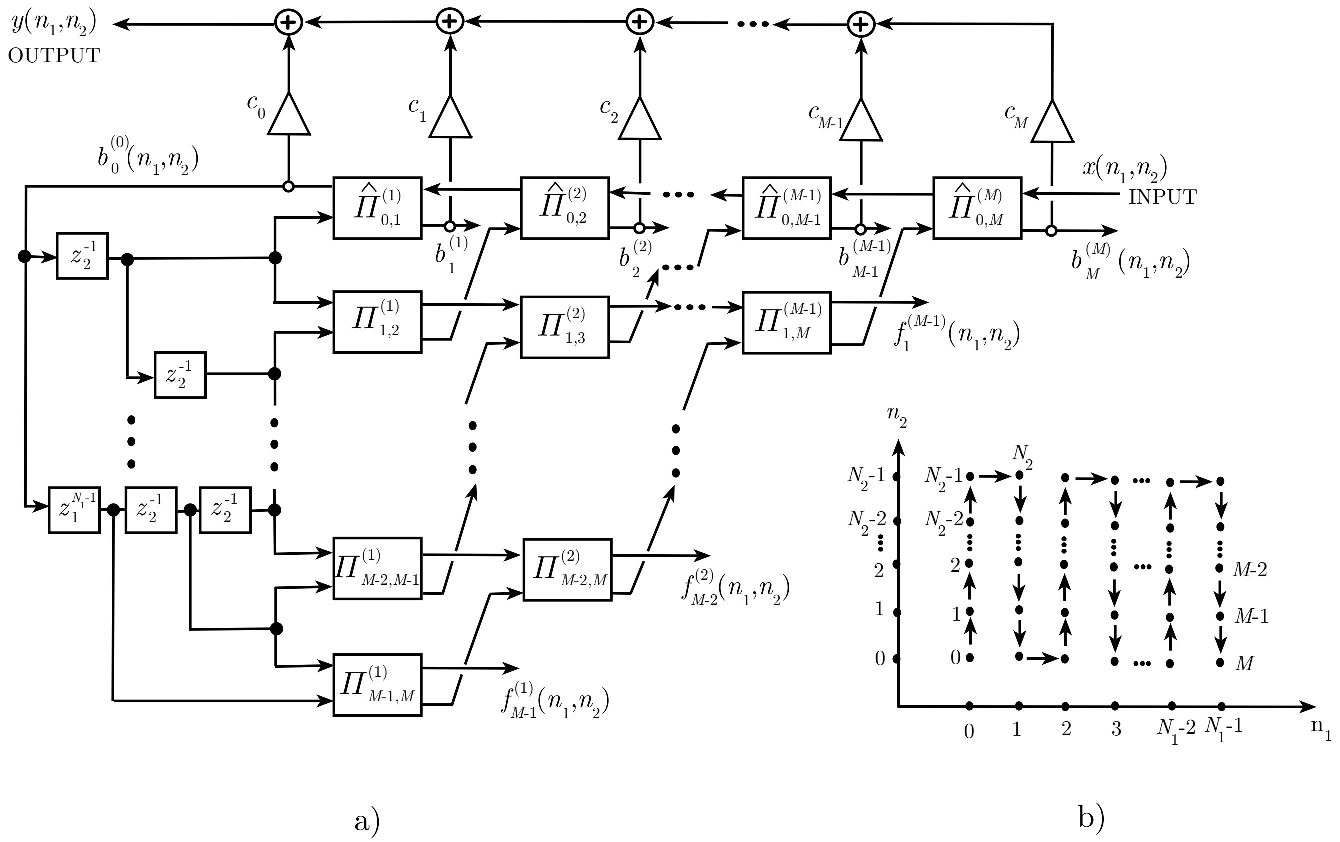

Figure 1: Lattice-ladder structure; a) Lattice-ladder structure for 2D ARMA filter, b) Ordering scheme in the support region

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$$y(n_1, n_2) = \sum_{p=0}^{M} c_p \, b_p^{(p)}(n_1, n_2) \tag{2}$$

2D Lattice-Ladder Model - Figure

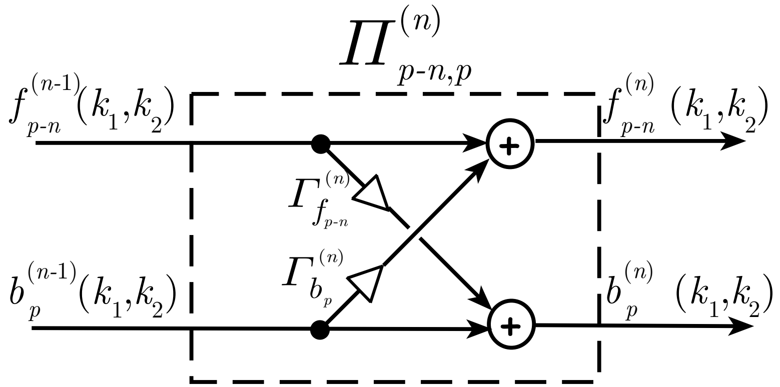
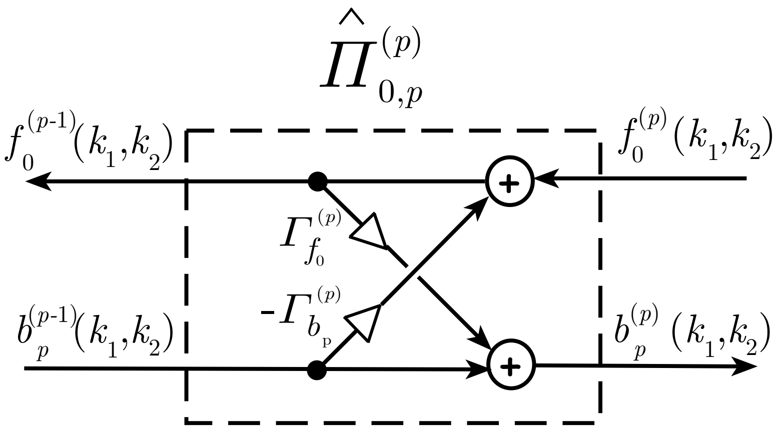


Figure 2: Internal structure of the FIR lattice module



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- We assume that the reflection coefficients for the lattice part are already determined.

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- We need some definitions to this end.

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- The backward prediction error transfer function $\left(G_p^{(p)}(z_1, z_2)\right)$ is defined as the transfer function between the input of the MA section $\left(\text{i.e. } b_0^{(0)}(n_1, n_2)\right)$, and the backward prediction error $\left(b_p^{(p)}(n_1, n_2)\right)$:

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$$G_p^{(p)}(z_1, z_2) = \frac{B_p^{(p)}(z_1, z_2)}{B_0^{(0)}(z_1, z_2)} = \sum\sum_{(n_1, n_2)\in\mathscr{R}} g_p^{(p)}(n_1, n_2)\, z_1^{-n_1} z_2^{-n_2} \tag{6}$$

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- The coefficients for the backward prediction error transfer functions in (6) are defined as $g_p^{(p)}(n_1, n_2)$, $(n_1, n_2) \in \mathscr{R}$.

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$$D_m(z_1, z_2) = D_{m-1}(z_1, z_2) + c_m G_m^{(m)}(z_1, z_2) \tag{8}$$

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- Using these definitions, the recursive algorithm for the calculation of the ladder coefficients is developed.

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- 2D adaptive filtering applications and comparison with existing structures will be a subject of further study.

Thanks for your kind attention.

References

Kayran, A. H., 1996. Two-dimensional orthogonal lattice structures for autoregressive modeling of random fields, *IEEE Trans. Signal Processing*, **44**(4), 963–978.