# Adaptive Algorithms

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<tr>
<th>Algorithm</th>
<th>Convergence Rate</th>
<th>Computational Requirements</th>
<th>Numerical Properties</th>
<th>Implementation Considerations</th>
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<tr>
<td>LMS</td>
<td>3</td>
<td>N</td>
<td>1</td>
<td>2</td>
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<tr>
<td>RLS (Direct-Form)</td>
<td>1</td>
<td>$2N^{**2}+4.5N$</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Fast RLS (Direct-form)</td>
<td>1</td>
<td>$7N+14$</td>
<td>3</td>
<td>2</td>
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<tr>
<td>Gradient (Lattice-Ladder)</td>
<td>2</td>
<td>$13N-8$</td>
<td>2</td>
<td>1 (VLSI)</td>
</tr>
<tr>
<td>RLS (Lattice-Ladder)</td>
<td>1</td>
<td>$15N-11$</td>
<td>1</td>
<td>1 (VLSI)</td>
</tr>
<tr>
<td>RLS (Square-Root)</td>
<td>1</td>
<td>$1.5N^{**2}+6.5N$</td>
<td>2</td>
<td>1 (VLSI)</td>
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</table>
Blind Equalizers

\[ CF_{RCA} = E[| \hat{E}_{T,n} |^2] = E[| Y_n - R_R \cdot \text{csign}(Y_n) |^2] \]

\[ CF_{CMA} = E[| Y_n |^2 - R_R^2] \]

\[ CF_{MMA} = E[(y_n^2 - R_M)^2 + (\hat{y}_n^2 - R_M^2)^2] \]
Blind Equalizers

MMA

GMMA
Convergence to Wrong Solutions

(a) 16-point constellation  (b) 32-point constellation

RCA/MMA

CMA
MLSE Equalizer

- Estimating the state of finite-state machine
  - Discrete-time channel - Coefficients: \( \{f_k\} \)
  - ISI spans over \( L+1 \) symbols (\( L \) interfering comp.)
  - The state at time \( k \):
    \[
    S_k = (a_{k-1}, a_{k-2}, \ldots, a_{k-L})
    \]
  - VA will have \( M^L \) states in the trellis, \( M^{L+1} \) sequences

\[
PM_1(\bar{a}_{L+1}) \equiv PM_1(a_{L+1}, a_L, \ldots, a_2) = \max_{a_1} \sum_{k=1}^{L+1} \ln p(u_k | a_k, a_{k-1}, \ldots, a_{k-L})
\]

\[
PM_k(\bar{a}_{L+k}) = \max_{a_k} \left[ \ln p(u_{L+k} | a_{L+k}, \ldots, a_k) + PM_{k-1}(\bar{a}_{L+k-1}) \right]
\]