Linear Predictive Coding

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Idea The speech sample values can be approximated by the linear combination of the past sample values

Model

$$s[n] = \sum_{k=1}^{p} a_k s[n-k] + A u_g[n]$$

- **$s[n]$:** Speech output
- **a_k:** Linear predictive coefficient
- **$u_g[n]$:** Vocal tract intput

Also named "Autoregression(AR) Modle"

Theoretical Derivation

Define p-order linear predictor:

$$\widetilde{s}[n] = \sum_{k=1}^{p} \alpha_k s[n-k]$$

corresponding z transformation:

$$\widetilde{S}(z) = P(z)S(z)$$

and predictive filter:

$$P(z) = \sum_{k=1}^{p} \alpha_k z^{-k}$$

Predictive error:

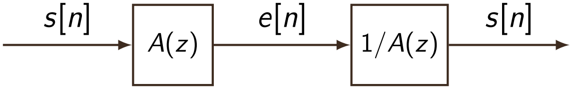
$$
\begin{aligned}
e[n] &= s[n] - \widetilde{s}[n] \\
&= \sum_{k=1}^{p} a_k s[n-k] + Au_g[n] - \sum_{k=1}^{p} \alpha_k s[n-k] \\
&\approx Au_g[n] \ (when\ \alpha_k \approx a_k)
\end{aligned}
$$

corresponding z transformation:

$$E(z) = S(z)(1 - P(z)) = S(z)A(z)$$

and predictive error filter:

$$A(z) = 1 - P(z)$$



MATLAB Code Example

```
[x, fs] = audioread('C6_2_y.wav');
LENGTH = length(x);
n = 0:1/fs:(LENGTH - 1)/fs;

subplot(3,1,1),plot(n*1000, x),grid
xlabel('Time/s'); ylabel('Amplitude');
title('Original Signal')

subplot(3,1,2)
order = 20;
[a,g] = lpc(x,order);
error = filter(a,1,x);
plot(n*1000,error,'r')
xlabel('Time/s'); ylabel('Amplitude');
title('Predictive Error')

est_x = filter(1,a,error);
subplot(3,1,3), plot(n*1000,est_x), grid;
xlabel('Time/s'); ylabel('Amplitude');
title('Predictive Signal')
```

MATLAB Plot Example