

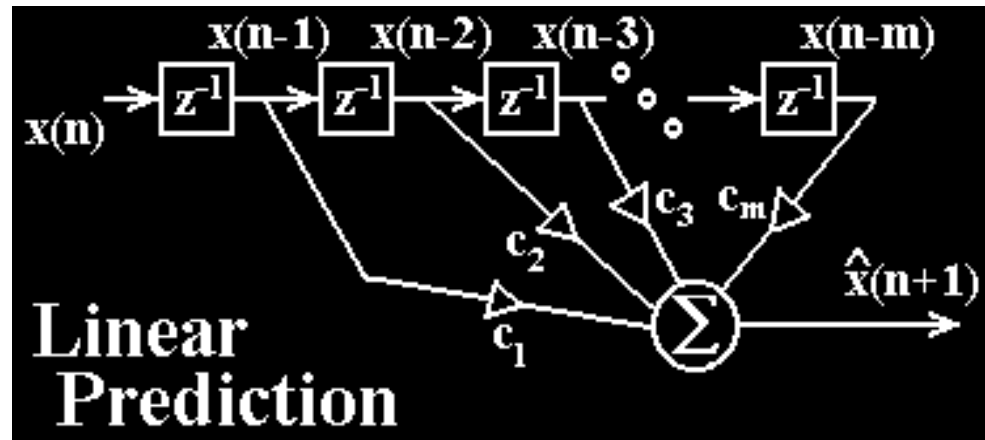
Subtractive Synthesis: LPC

Prediction signal

$$\hat{x}(n) = \sum_{k=1}^m c_k x(n-k)$$

Error signal

$$e(n) = x(n) - \hat{x}(n)$$



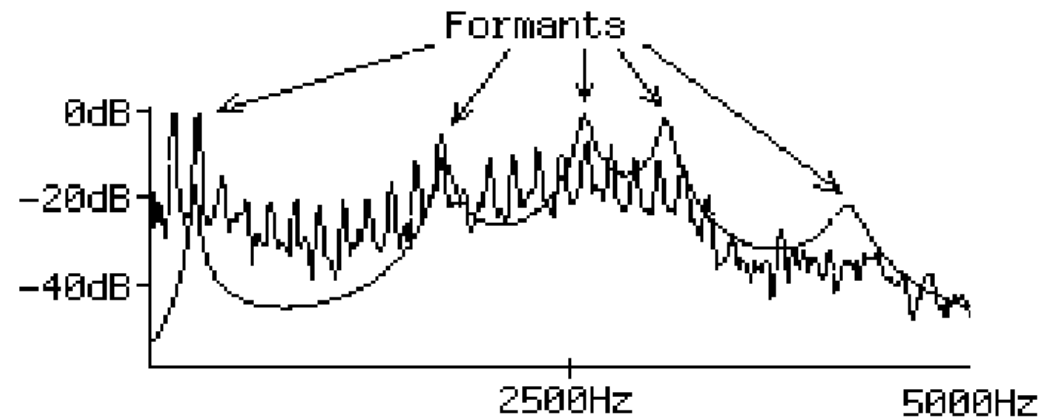
MSE

$$E = \frac{1}{P} \sum_{n=0}^P e(n)^2$$

“Design” c_k to minimize
Mean Squared Error (MSE)
over block length P

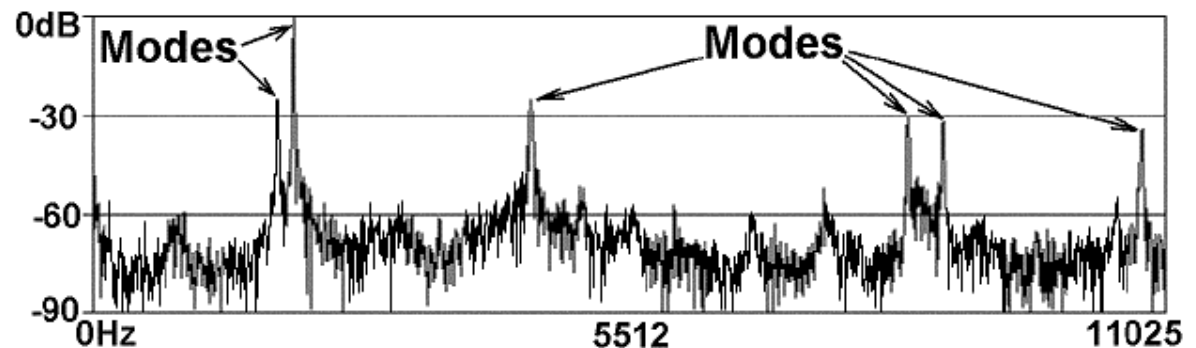
LPC continued

- **LPC is well suited to speech**



LPC filter envelope (smooth line)
fit to human vowel sound / i / (eee)

- **Also well suited to many sounds with resonances (modes!!)**



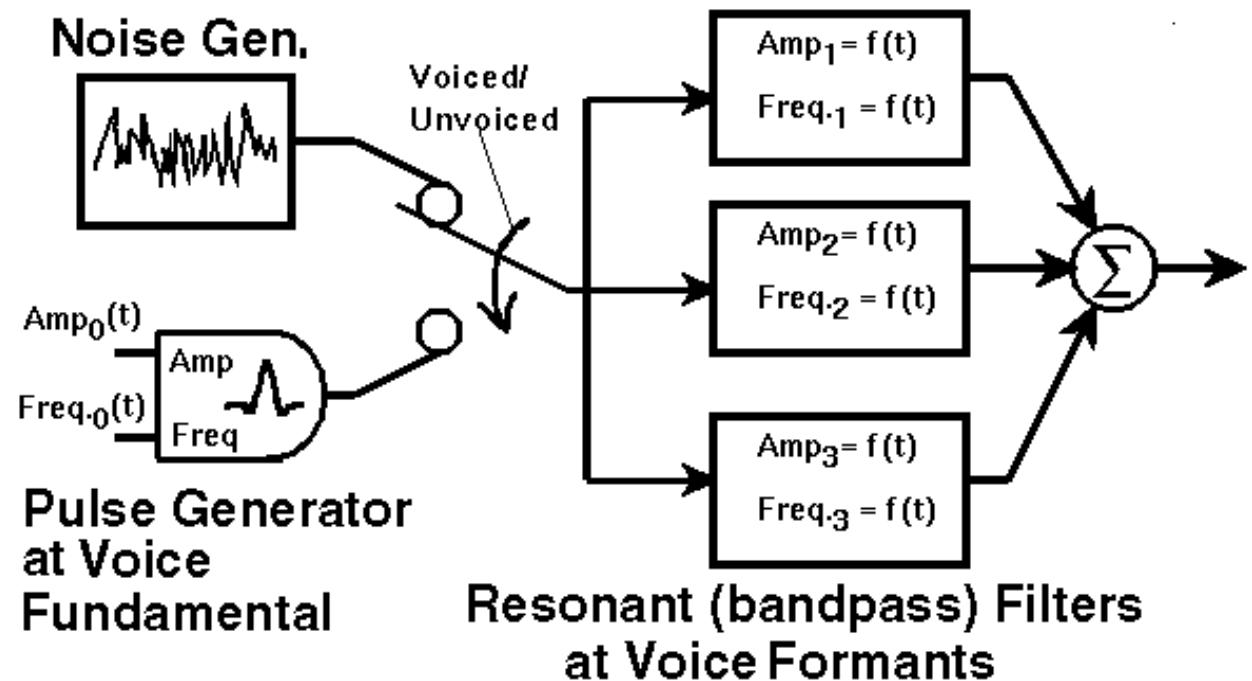
Formant Synthesis

Factor into resonators

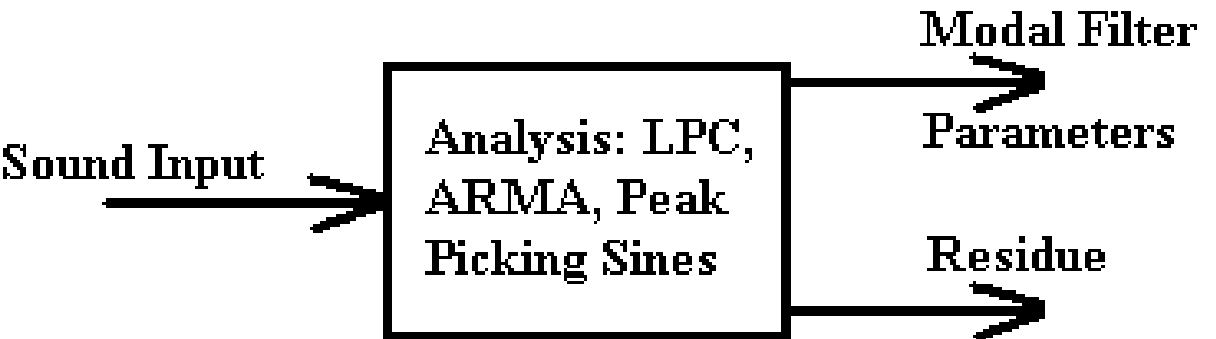
Drive with parametric sources

“Formant Synthesis”

Subtractive Voice Synthesis Block Diagram



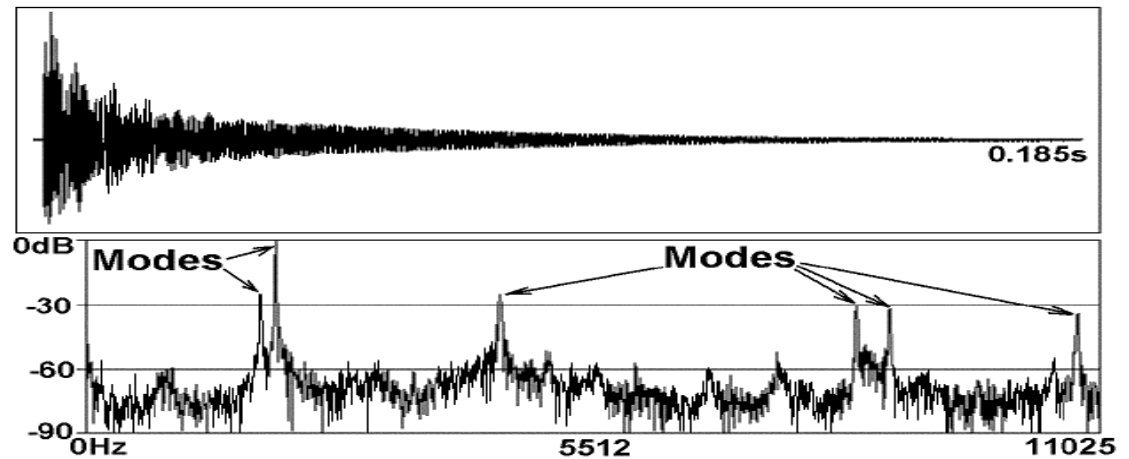
LPC/Modal: Residual Excitation

- **Linear source/filter decomposition**


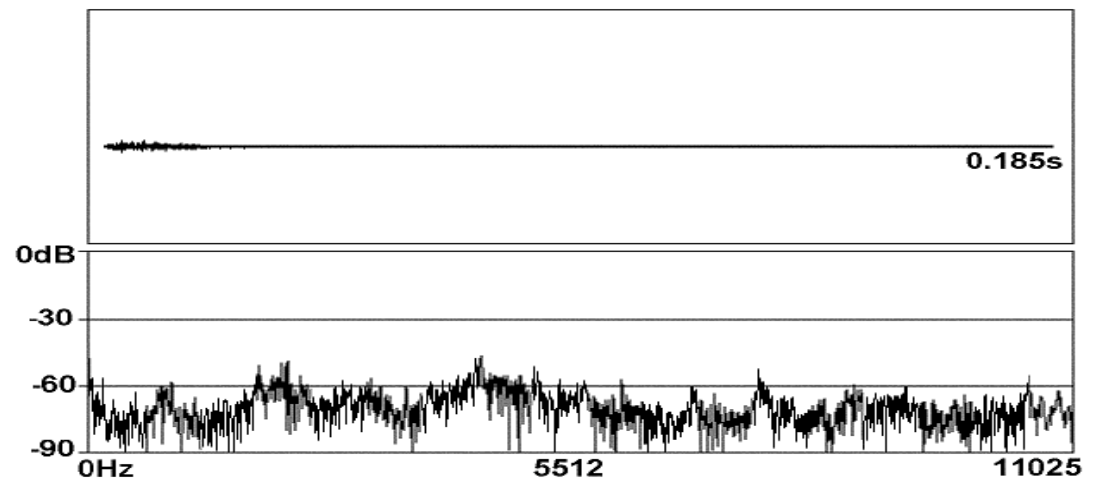
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graph LR; A[Sound Input] --> B[Analysis: LPC, ARMA, Peak Picking Sines]; B --> C[Modal Filter Parameters]; B --> D[Residue]
```
- **“Parametric sampling”**
 - Drive filters with residual and get back original signal exactly
 - Can modify the parameters in interesting ways
- **Can also do this for 1D waveguides!!**

Residual Extraction Example

- Original struck coffee mug



- After modal subtraction



References: LPC and Subtractive

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