A Bayesian Network Approach Combining Pitch and Spectral Envelope Features to Reduce Channel Mismatch in Speaker Verification and Forensic Speaker Recognition

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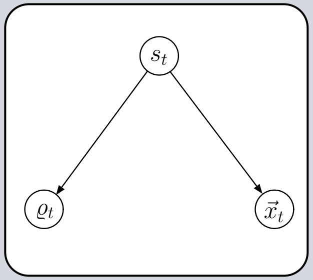
Context:
- Channel mismatch
- Speaker verification
- Forensic speaker recognition

Key Points:
- Bayesian networks
- Combining pitch and spectral envelope features

The Bayesian Network

Pitch ϱ and spectral envelope features $\vec{x}$ are conditionally independent, given the voicing status s.

$$p(\vec{x}_t|\varrho_t, s_t) = p(\vec{x}_t|s_t)$$



$$
\begin{aligned}
p(s=i) &= w_i, \\
p(\vec{x}|s=i) &\quad \text{defined by two Gaussian mixtures } \lambda_i^{\vec{x}}, \\
p(\varrho|s=1) &\quad \text{defined by one Gaussian mixture } \lambda^{\varrho}, \\
p(\varrho=0|s=2)=1 \;&;\; p(\varrho \neq 0|s=2)=0.
\end{aligned}
$$

Likelihood Estimation

Definitions:

$O = \{\eta_1, ..., \eta_T\}$ Set of testing data

where $\eta_t = \{\varrho_t, \vec{x}_t\}$

$S = \{s_1, ..., s_T\}$ Set of voicing status values

Likelihood Expression:

$$p(O|S,\lambda) = p(X|S,\lambda) \cdot p(P|S,\lambda) \;;$$

$$\Downarrow$$

$$p(O|S,\lambda) = p(X_V|\lambda_1^{\vec{x}}) \cdot p(X_U|\lambda_2^{\vec{x}}) \cdot p(P_V|\lambda^{\varrho}) \;;$$

The Database: EPFL-IPSC03

Forensic speaker recognition database (EPFL-IPSC03)

Six speech segments (15 to 180 seconds) for 60 Swiss French speakers which include recordings through:

- switched public telephone network (PSTN).
- global system for mobile communications (GSM).
- direct recording in the calling room, via a digital recorder (room).

Speaker Verification Results

Table 1: EERs when the training data is speech recorded through PSTN

Speech used for Tests	GMM-UBM EER [%]	BN system EER [%]
PSTN	4.8	3.3
GSM	42.3	31.9
Room	37.5	22.5

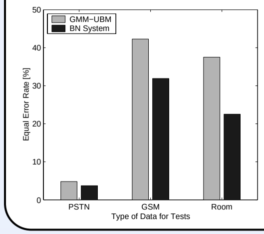
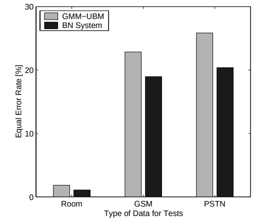
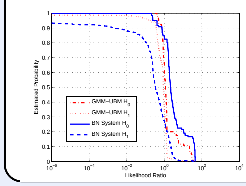


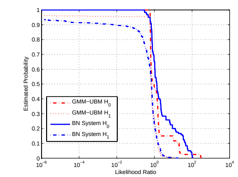
Table 1: EERs when the training data is speech recorded in the calling room.

Speech used for Tests	GMM-UBM EER [%]	BN System EER [%]
Room	1.8	1.0
GSM	22.8	18.9
PSTN	25.8	20.4



Forensic Speaker Recognition Evaluation





CONCLUSIONS:

- Convolutional modifications introduced by the PSTN or GSM channel severely affect the spectral envelope features but have almost no influence on the pitch values.
- The Bayesian network efficiently combines both features and improves both speaker verification and forensic speaker recognition systems.

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