AIM
Develop a quantitative description (roomprint) which enables us to answer questions about where a recording was made:
1. Verification: If it is claimed that a recording was made in a particular room, is there sufficient evidence to reject the claim?
2. Identification: If it is known that a recording was made in one of a number of rooms, can we determine which one is most likely?

ROOMPRINTS

Requirements
- Reference roomprint measured with full access to room
- Latent roomprint extracted from a recording
- Features should be invariant to location of talker and microphone
- Features should also be time invariant
- Amount of variance should be included in the reference roomprint

Types of information
- Geometric features – time invariant but difficult to infer from recording
- Acoustic parameters – $T_{60}$ known to be position invariant and can be estimated from speech
- Environmental sounds – not time invariant, but may be useful if time of recording is known or in ad hoc analysis

$T_{60}$-BASED FEATURES
- $T_{60}$ is unlikely to provide necessary resolution
- Consider frequency-dependent reverberation time in 1/3-octave bands, $\psi_{ij,k}$, where $i$ is room, $j$ is configuration of talker and microphone and $k$ is frequency band

PROBLEM FORMULATION
- Each room described by mean, $\mu_i$, and variance, $\Sigma_i$, of $K$-dimensional multi-variate Gaussian distribution
- Can calculate probability of an observed value $\psi_{ij,k}$ for a room with given roomprint
- For identification task, choose room which maximises this probability

DATA TRANSFORMATIONS
- Transformations of $\Psi$ may improve the validity of the model
  - $\ln(\Psi)$ may be more normal
  - Karhunen-Loève Transform (KLT) makes the dimensions independent but is data-dependent
  - Discrete Cosine Transform (DCT) also reduces correlation but is data independent

EXPERIMENT
- Room identification task using measured impulse responses
- 484 measurements (22 rooms x 22 measurements per room)
- Each measurement classified using leave-one-out cross-validation

CONCLUSIONS
- Introduced concept of roomprints
- Considered types of information which can be used
- Illustrated concept of roomprints using logarithm of frequency dependent reverberation time as roomprinting feature
- Achieved 3.9% error rate in room identification task with 22 rooms

1/3-OCTAVE RESULTS
- In all cases the results are substantially better than the baseline
- Log transformation gives the best results (3.9% error)
- Confusion matrix for $\ln(\Psi)$ results shows very few confusions
- Most are caused by confusions between two pairs of rooms
  - G vs H
  - M vs N
- These are rooms built to the same plan

The distribution of $\Psi_{ijk}$ for G and H is remarkably similar
- Despite this, our classifier is able to distinguish even these rooms correctly in 70% of trials

$\begin{align*}
\Psi' &= \Psi \\
\psi' &= \ln(\psi) \\
\psi' &= KLT(\psi) \\
\psi' &= KLT(\ln(\psi)) \\
\psi' &= DCT(\psi) \\
\psi' &= DCT(\ln(\psi))
\end{align*}$

\begin{tabular}{|c|c|}
\hline
Transform & Error [%] \\
\hline
$\Psi$ & 4.1 \\
$KLT(\psi)$ & 5.4 \\
$DCT(\ln(\psi))$ & 6.6 \\
\hline
\end{tabular}