# EE5602: Probabilistic Graphical Models, Fall 2018 (56)

Indian Institute of Technology Hyderabad

HW 0, Assigned: Sunday 18.11.2018.

**Due: Tuesday 27.11.2018 at 11:59 pm.**

1. Using the notation introduced in class, show how $Q(\theta|\theta^{\text{old}}) = \sum_{k=1}^{N} \gamma(z_{1k}) \ln \pi_k + \sum_{n=2}^{N} \sum_{j=1}^{K} \sum_{k=1}^{K} \xi(z_{n-1,j}, z_{nk}) \ln A_{jk} + \sum_{n=1}^{N} \sum_{k=1}^{K} \gamma(z_{nk}) \ln p(\mathbf{x}_n|\phi_k)$ for a Hidden Markov Model (HMM). (10)

2. Assuming Gaussian emission densities, maximize $Q(\theta|\theta^{\text{old}})$ from the previous problem to find the parameter updates in the M-step. Ensure that this maximization takes into account the constraints on the parameters. (10)

3. Implement the forward backward (also known as the Baum-Welch) algorithm to learn the parameters of a HMM. Assume Gaussian emission densities. (30)

   - Database description: The database is composed of 151 basic phones. Several speech samples (wav files) are available for each phone that can be used for training and testing (without overlap).
   - Pick any two phones of your choice and construct a HMM for each phone. Assume the same model architecture (i.e., same number of parameters) for both your HMMs. As discussed in class, find Mel-Frequency Cepstral Coefficients (MFCCs) from the raw speech samples. Pick 25 ms worth of speech samples with a 10 ms overlap to find MFCCs. Use the basic 13 element version of MFCC as the feature vector representing 25 ms of speech. You are free to use any Python library to find this feature.
   - Implement a basic two-class classifier using the HMMs constructed in the previous step. In practise, test samples come from a continuous speech waveform. Here however, test your classifier using samples from the database. Your classifier should simply construct the likelihood of the test sample and choose the phone with higher likelihood.
   - Experiment with different model orders (i.e., $K = 3, 5, 7$) and report your findings in terms of the classifier's performance.