

# Codebook Training

## 1 Questions

1. What are applications of codebooks?
2. What are the two outputs of a codebook vector search? Give examples how they are used in some applications!
3. What is a common distance function? What properties should a distance function have?
4. What is the general cost function for the codebook training? Why may it be useful to limit its value range?
5. What is the difference between the k-means and the LBG algorithm?
6. What are abortion criteria for the two algorithms?
7. How are codebooks used for a piecewise affine linear mapping?

## 2 Answers

1. Speaker recognition, speech reconstruction, bandwidth extension, coding, sound classification...
2. Outputs are the codebook vector (index) and the distance between the input vector and the selected codebook vector according to the chosen distance function. The distance can be used to perform a speaker recognition, whereas the codebook vector may be used directly for speech reconstruction and the index of the codebook vector may help in extending the signal bandwidth.
3. The squared Euclidian norm of the difference vector of both vectors is often used. The elements of the difference vector may, additionally, be individually weighted. Generally, a distance function should be computationally cheap as it has to be computed often and also in real-time.
4. For each training vector one of the codebook vectors out of the pool of all current codebook vectors produces the minimum distance. The cost function is then the average minimum distance over all available training vectors. That average is to be minimized. A value limit may be introduced for the element differences since especially logarithmic features can take large negative values.
5. The k-means algorithm works with a fixed number of codebook vectors in all iterations. The LBG algorithm starts with one codebook vector and increases the number of vectors through its iterations. Within one LBG iteration the number of codebook vectors is fixed (after its increase at the very beginning of the iteration) and the k-means algorithm can be used for optimization of the codebook vectors.
6. k-means: max number of iterations, cost function threshold, relative improvement threshold. LBG: k-means conditions + max number of codebook vectors, relative split improvement threshold.
7. The codebook search (index) decides which "piece" of the mapping function is applied to the original input vector.