POLITECNICO MILANO 1863	052820 SOUND ANALYSIS, SYNTHESIS AND PROCESSING Module 1: DIGITAL AUDIO ANALYSIS AND PROCESSING Academic Year 2024/2025	DAAP Homework Linear Predictive Coding

Assignment: Speech coding using LPC

For this homework assignment you will explore the topic of Linear Predictive Coding (LPC).
LPC is described on the slides:

- DAAP-05_linear_predictive_coding

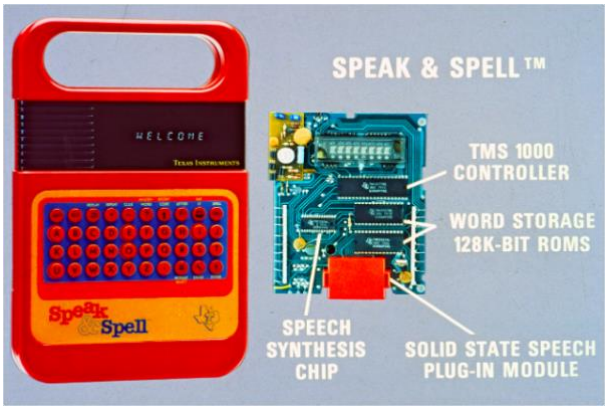

Figure 1 Source: http://hackeducation.com/2015/01/13/speak-and-spell

The "Speak & Spell" is an iconic educational toy developed by Texas Instruments in the late 1970s and commercialized in Italy with the name “Grillo parlante”. It was one of the first consumer products to use digital speech synthesis, based on Linear Predictive Coding (LPC). The device could produce intelligible speech by storing and processing compressed representations of words, showcasing the capabilities of LPC for efficient speech synthesis.
This homework will guide you through the implementation of the LPC algorithm, simulating the speech synthesis approach used in the Speak & Spell.

You are required to implement the LPC-10 coding algorithm in MATLAB, including the calculation of LPC coefficients from speech frames, the reconstruction of the speech signal from the LPC parameters, and the evaluation of reconstruction quality compared to the original signal. The implementation must be modular, with independent functions handling LPC coefficient extraction, speech signal synthesis.
The LPC-10 coding adopts a variable prediction order according to the type of sound (voiced/unvoiced) in particular the order P is
$P = 10$ for voiced (pitched) sounds;
$P = 4$ for unvoiced frames.

The script performing the encoding and decoding must be implemented in Matlab. A modular approach is recommended, writing independent functions for code blocks such as voiced frames identification, Pitch Detection and overlap-and-add processing.
In order to guarantee a minimum result, some code implementation details not covered during the course will be given.

Please provide and be ready to discuss the following:

- Main script performing the encoding and decoding procedure
- Encoding script that compute the LPC representation of the signal and saves
- Figures with 3 subplot showing
  - Spectrum of a frame and the magnitude of the shaping filter on top
  - Prediction error for the frame in time
  - Spectrum of the prediction error
- Decoding script that reproduces the encoded sounds
- A Matlab function that generate the excitation signal
- A Matlab function that computes the pitch of a frame

Make sure to label the axes correctly, e.g., by expressing time in seconds, frequency in Hertz. Please note that this homework assignment is designed for didactic purposes, so you should refrain from using built-in functions or library methods that carry out high-level operations.

- Please provide the **source codes** and explain the implementation details and results **in a report as a PDF file** which explains **how** the LPC is implemented and your choices.
- Groups of **at most 2 people** are allowed.
- Each group should upload the code on WeBeep as a **single zip file.** One student will submit a zip file for the entire group; **do not upload the same HW twice.**
- The zip file should be named with the surnames of all group members, e.g., Mario Rossi and Maria Bianchi will upload a file named DAAP_HW1_Rossi_Bianchi.zip
- Upload the required file using the WeBeep platform in the delivery folder.