CWLab Readme

Release 1.0 updated 2022.12.18 BG4XSD

Some definition in CWLab:

1. WPM

The word PARIS is the standard to determine CW code speed. Each dit is 1 element and each dah is 3 elements. Between each character the space is 1 element. The spacing between each character in a word is 3 elements; and the spacing between each word is 7 elements.

The word PARIS is exactly 50 elements. Note that after each dit/dah of the letter P -- one element spacing is used except the last one. (Intra-Character). After the last dit of P is sent, 3 elements are added (Inter-Character). After the word PARIS - 7 elements are used.

If you send PARIS 5 times in a minute (5 WPM) you have sent 250 elements (using correct spacing). 250 elements into 60 seconds per minute = 240 milliseconds per element. 13 words-per-minute is one element every 92.31 milliseconds. So, we can get 60 sec/250unit is 240ms/unit @ 5WPM, then 120ms/unit @ 10WPM, 60ms/unit @20WPM, 30ms/unit @40WPM。

In CWLab, we try to deal with the QSO sending speed in the range from 10 to 40.

2. Sample rate

The CW pitch is limited from 1~1000hz, and is often used from 400~600hz for most of CWer. According Shannon Sampling Theorem, the sample rate should be >= 2 times of pitch frequency.

In CWLab, SAMPLE_FREQ is 2000, 6000 and 8000. 2Khz is the value from original nn-morse. Using 2khz sample rate, the neural network is smaller, faster. And higher sample rate is used for curiosity, another reason is many audio process software can only work with 6Khz and 8khz sampled dataset.

3. Sample window length/size

While using Spectrogram, we can adjust the frequency resolution and time resolution by changing window size, because of sample rate is pointed.

In the previous spectrogram, the window size was set to 256, and sampling rate was 4000. Therefore, each window contains

time resolution: $\frac{window\ size}{sample\ rate} = \frac{256}{4000} = 0.064\ sec$

The frequency resoulsion has the reciprocal relation and it is:

freq resolution: $\frac{sample\ rate}{window\ size} = \frac{4000}{256} = 15.6Hz$

In conclusion,

The windows size = resolution x sample rate

In the fast cw QSO, 30ms/unit, for a single char E, if we want to recognized it correctly, we should make sure the time resolution less than 30ms, if we choose 20ms time resolution, we can get the window size is 40.

HERE, I am not sure if I use it right or not, but I can do some experiments later.

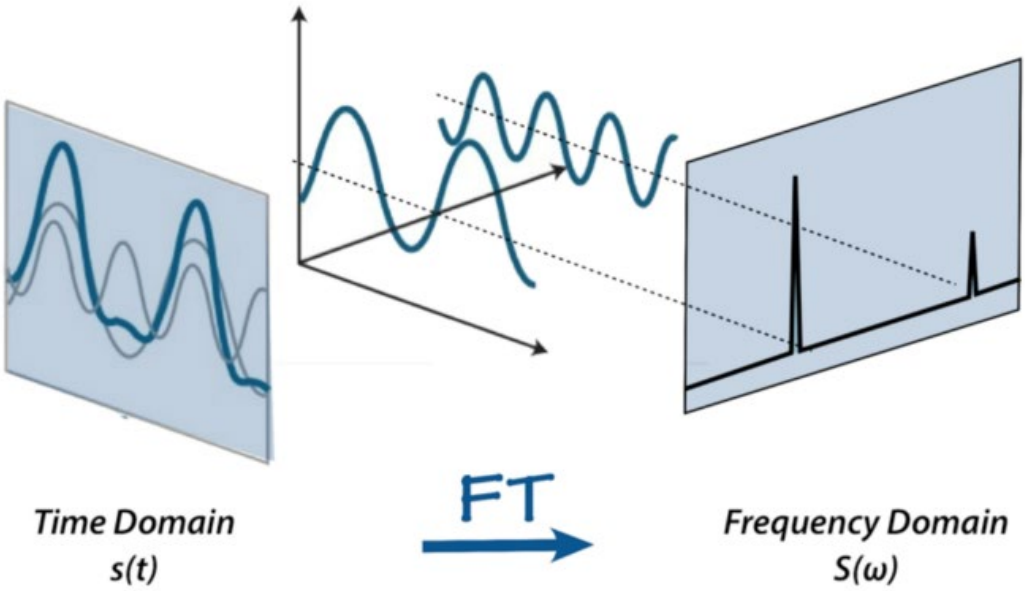
Ref:

Implement the Spectrogram from scratch in python (fairyonice.github.io)

基于 python 手动画出 spectrogram(语谱图)

4. Spectrogram/Fbank/MFCC

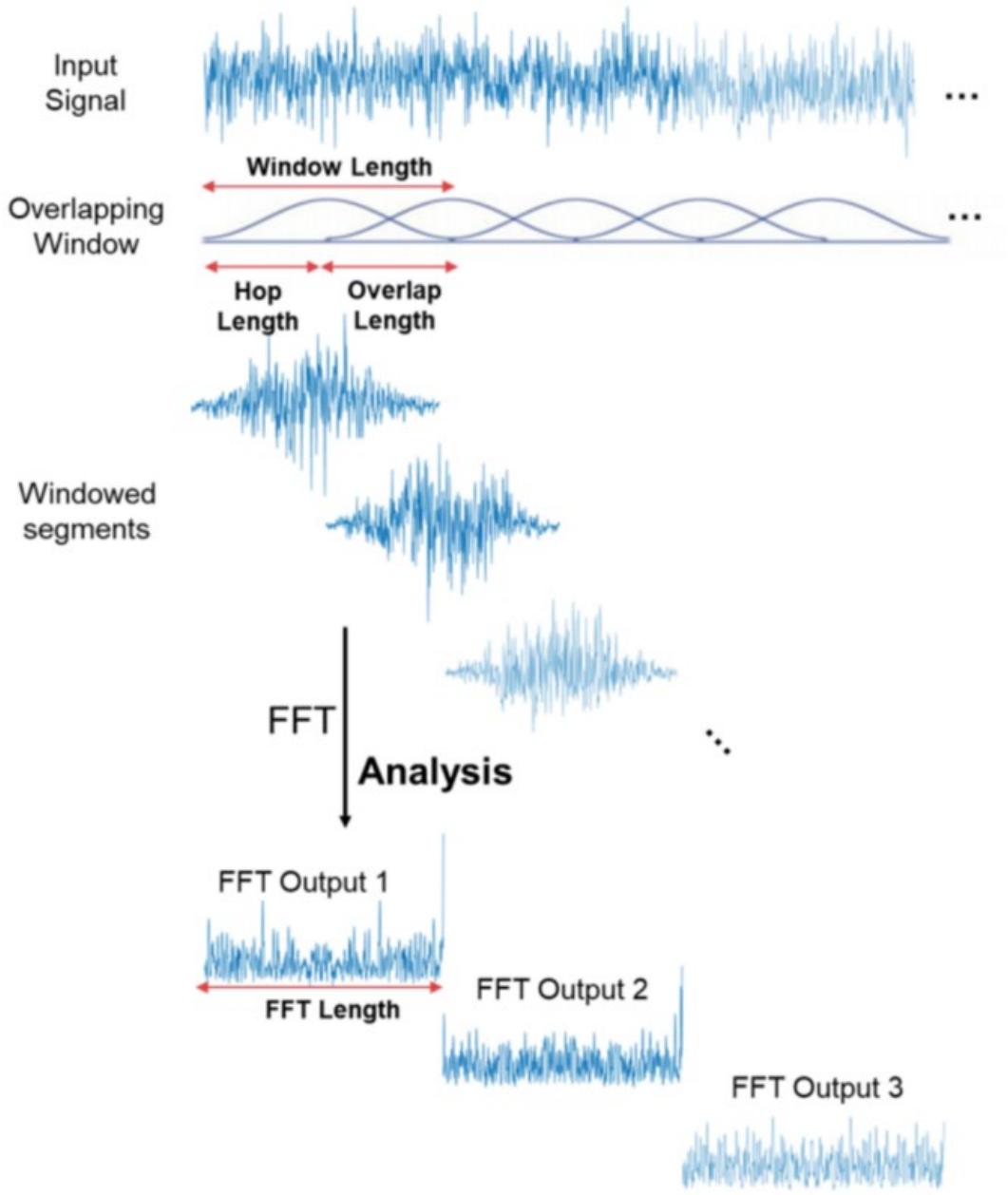
Spectrogram, MelSpec, FBank and MFCC can be used as an audio feature in deep learning. A spectrogram is a visual representation of the spectrum of frequencies of a signal as it varies with time. MelSpec is called Mel-filter bank coefficients. FBank is called Log Mel-filter bank coefficients, it can be computed by log(MelSpec).MFCC is called Mel-frequency cepstral coefficients.



In CWLab, Spectrogram is a key procedure to transform the audio signal into the dataset for Neural Network. You can think of a spectrogram as a bunch of FFTs stacked on top of each other. It is a way to visually represent a signal's loudness, or amplitude, as it varies over time at different frequencies. There are some

additional details going on behind the scenes when computing the spectrogram.

Google these words, write down your own notes, know them, master them and use them.



Ref:

Comparison of Different Feature Types for Acoustic Event Detection System | SpringerLink

Understanding the Mel Spectrogram | by Leland Roberts | Analytics Vidhya | Medium

Log Spectrogram and MFCC, Filter Bank Example | Kaggle

Speech Processing for Machine Learning: Filter banks, Mel-Frequency Cepstral Coefficients (MFCCs) and What's In-Between | Haytham Fayek

Mel-Spectrogram and MFCCs | Lecture 72 (Part 1) | Applied Deep Learning - YouTube

理解梅尔倒频谱系数 MFCC - 知乎 (zhihu.com)

5. Neural Network

In CWLab, PyTorch is used, TensorFlow and Kera are very useful, too. If I say it’s piece of cake, would you believe it? If you have enough time, try them both, Neural Network is very interesting, just like machine learning and statistic methods, all of them are very interesting and useful.

Robustness test of CWLab 1.0
Test Env:

1. Sample Rate = 2000 Hz
2. Using new morse dictionary, in which has 59 chars.
3. Train the network A, in batch szie =64, 1st stage 1500 epochs with lr=1e-3, the 2nd stage 1500 epochs with lr=1e-4, the 3rd stage 2000 epochs with lr=1e-5. The plan B, make a little difference, in batch szie =64, 1st stage 1500 epochs with lr=1e-3, the 2nd stage 2000 epochs with lr=1e-4, the 3rd stage 2000 epochs with lr=1e-5.
4. Model A : models_Len10-20_Batch64_Lr_e3-e5_3stage_5kEpoch
5. Model B : models_Len10-20_Batch64_Lr_e3-e5_3stage_5.5kEpoch

Start to run test case ...

1. Test the ability of find the blank/white space, five chars in a group.

Using QSO : demo_with_mobile_sound.wav

- Model A: 001800.pt

HAAPPP KUA MAP MUPAA PPPKMA SSPPAM AAKKP PPS AURAP APA PPAA SAKSP AAAPPP KPUP A

- Model A: 005000.pt

#UAPPP KUA MAP MUPAA PPPKMA SSPPAM AAKKP PPS AURAP APA PPAA SAKSP AAAPPP KPUP A

- Model B: 001880.pt

APMUAAPMUPAAPPPKMASSPPAMAAKKP PPS AURAP APA PPAA SAKSP AAAPPP KPUP A

- Model B: 005090.pt

APPKUAAPMUPAAPPPKMA SSPPAMAAKKP PPS AURAP APAPPAASAKSP AAAPPP KPUP A

Result : BAD

2. Test words in lower cw speed, 12wpm
Using QSO : 100MostCommonEnglishWords12.wav

- Model A: 001800.pt

AN THE THIS THESE THAT SOME ALL ANY EVERY WHO WHICH WHAT SUCH OTHER ^I ME MY WE US OUR YOU YOUR HE HIM HIS SHE HER IT ITS THEY THEM THEIR ^MAN MEN PEOPLE TIME WORK WELL MAY WILL CAN ONE TWO GREAT LITTLE FIRST ^AT BY ON UPON OVER BEFORE TO FROMWITH IN INTO OUT FOR OF ABOUT UP ^WHEN THEN NOW HOW SO LIKE AS WELL VERY ONLY NONOT MORE THERE THAN; AND OR IF BUT ^BE AMIS ARE WAS WEFE BEEN HAS HAV HAD MAY CAN COULD WILL WOULD SHALL SHOULD MUST SAY SAIDLIKE GO COME DO MADE

- Model A: 005000.pt

AN THE THIS THESE THAT SOME ALL ANY EVERY WHO WHICH WHAT SUCH OTHER ^I ME MY WE US OUR YOU YOUR HE HIM HIS SHE HER IT ITS THEY THEM THEIR ^MAN MEN PEOPLE TIME WORK WELL MAY WILL CAN ONE TWO GREAT LITTLE FIRST ^AT BY ON UPON OVER BEFORE TO FROM WITH IN INTO OUT FOR OF ABOUT UP ^WHEN THEN NOW HOW SO LIKE AS WELL VERY ONLY NO NOT MORE THERE THAN; AND OR IF BUT ^BE AM IS ARE WAS WERE BEEN HAS HAVE HAD MAY CAN COULD WILL WOULD SHALL SHOULD MUST SAY SAID LIKE GO COME DO MADE

- Model B: 001880.pt

A AN THE THIS THESE THATSOMEALL ANYEVERY WHO WHICH WHATSUCH OTHER -I ME MYWEUS OUR YOUYOUR HE HIM HIS SHE HER ITITS THEYTHEMTHEIR -MANMENPEOPLE TIME WORKWELL MAYWILL CANONE TWOGREATLITTLE FIRST -AT BYONUPONOVERBEFORE TOFROMWITH IN INTOOUTFOR OF ABOUTUP -WHENTHENNOWHOWSOLIKE AS WELL VERYONLYNONOTMORE THERETHAN;AND OR IF BUT -BE AM IS ARE WAS WERE BEENHAS HAVEHAD MAYCANCOULD WILL WOULD SHALL SHOULD MUSTSASAID LIKE GOCOME DO MADE

- Model B: 005090.pt

A AN THE THIS THESE THAT SOME ALL ANY EVERY WHO WHICH WHAT SUCH OTHER =I ME MY WE US OUR YOU YOUR HE HIM HIS SHE HER IT ITS THEY THEM THEIR =MANMENPEOPLE TIME WORK WELL MAY WILL CAN ONE TWO GREAT LITTLE FIRST =AT BY ON UPON OVER BEFORE TO FROM WITH ININTO OUTFOR OF ABOUT UP =WHEN THEN NOW HOW SO LIKE AS WELL VERY ONLY NO NOT MORE THERE THAN; AND OR IF BUT =BE AM IS ARE WAS WERE BEEN HAS HAVE HAD MAY CANCOULD WILL WOULD SHALL SHOULD MUST SAY SAID LIKE GO COME DO MADE

Result : Seems work

3. Test words in normal cw speed, 24wpm
Using QSO : 100MostCommonEnglishWords24.wav

- Model A: 001800.pt

AN THE THIS THESE THAT SOME ALL ANY EVERY WHO WHICH WHAT SUCH OTHER ^I ME MY WE US OUR YOU YOUR HE HIM HIS SHE HER IT ITS THEY THEM THEIR ^MAN MEN PEOPLE TIME WORK WELL MAY WILL CAN ONE TWO GREAT LITTLE FIRST ^AT BY ON UPON OVER BEFORE TO FROM WITH IN INTO OUT FOR OF ABOUT UP ^WHEN THEN NOW HOW SO LIKE AS WELL VERY ONLY NO NOT MORE THERE THAN; AND OR IF BUT ^BE AM IS ARE WAS WERE BEEN HAS HAVE HAD MAY CAN COULD WILL WOULD SHALL SHOULD MUST SAY SAID LIKE GO COME DO MADE

- Model A: 005000.pt

AN THE THIS THESE THAT SOME ALL ANY EVERY WHO WHICH WHAT SUCH OTHER ^I ME MY WE US OUR YOU YOUR HE HIM HIS SHE HER IT ITS THEY THEM THEIR ^MAN MEN PEOPLE TIME WORK WELL MAY WILL CAN ONE TWO GREAT LITTLE FIRST ^AT BY ON UPON OVER BEFORE TO FROM WITH IN INTO OUT FOR OF ABOUT UP ^WHEN THEN NOW HOW SO LIKE AS WELL VERY ONLY NO NOT MORE THERE THAN; AND OR IF BUT ^BE AM IS ARE WAS WERE BEEN HAS HAVE HAD MAY CAN COULD WILL WOULD SHALL SHOULD MUST SAY SAID LIKE GO COME DO MADE

- Model B: 001880.pt

A AN THE THISTHESETHATSOMEALLANYEVERYWHOWHICHWHATSUCH OTHER =IMEMY WEUS OUR YOU YOUR HE HIMHIS SHE HER ITITSTHEYTHEMTHEIR =MANMENPEOPLETIMEWORKWELLMAYWILL CANONE TWOGREATLITTLE FIRST =ATBY ONUPONOVERBEFORETOFROMWITHININTOOUTFOROFABOUTUP =WHENTHENNOW HOW SO LIKEAS WELL VERY ONLYNONOTMORETHERETHAN;ANDORIFBUT=BEAMISAREWASWEREBEENHASHAVEHAD MAY CANCOULD WILL WOULD SHALL SHOULDMUSTSAYSAIDLIKEGOCOMEDOMADE

- Model B: 005090.pt

A ANTHE THIS THESE THATSOME ALL ANYEVERYWHOWHICH WHATSUCHOTHER ^I ME MY WE US OUR YOU YOUR HE HIMHIS SHE HERITITSTHEYTHEMTHEIR =MANMENPEOPLE TIME WORKWELL MAYWILL CANONE TWOGREATLITTLE FIRST =AT BY ONUPONOVERBEFORE TOFROMWITH ININTOOUTFOROF ABOUTUP ^WHENTHENNOWHOWSO LIKE AS WELL VERY ONLY NO NOTMORE THERE THAN;ANDORIF BUT =BE AMISARE WASWERE BEENHASHAVE HAD MAY CANCOULD WILL WOULD SHALL SHOULDMUSTSAYSAIDLIKEGOCOME DOMADE

Result : Something Wrong

4. Test standard QSO
Using QSO : CallCQ_pitch545_wpm27_noise128_amplitude46.wav
Model A: 001800.pt
SQ CQ CQ DE BG4XSD BG4XSD PSE K E E
Model A: 005000.pt
TQ CQ CQ DE BG4XSD BG4XSD PSE K E E
Model B: 001880.pt
CQ CQ CQ DE BG4XSD BG4XSD PSE K E E
Model B: 005090.pt
CQ CQ CQ DE BG4XSD BG4XSD PSE K E E

Result : Something Wrong

In conclusion, after adding more chars into the morse dictionary, the training method and neural network seem not work well. Both of them need to be improved.

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