gnssMPy

August 30, 2021

[1]:
```
import numpy as np
import scipy as sp
import matplotlib.pyplot as plt
```

[2]:
```
fileName = '/home/pranav/Documents/leosIN/2013_04_04_GNSS_SIGNAL_at_CTTC_SPAIN/
↪2013_04_04_GNSS_SIGNAL_at_CTTC_SPAIN.dat'
```

0.1 PreProcessing

Constants

[3]:
```
## Satellite Frequency
FREQ1 = 1.57542e9         #L1_CA
FREQ2 = 1.22760e9;        #  L2     frequency (Hz)
FREQ5 = 1.17645e9;        #  L5/E5a frequency (Hz)
FREQ6 = 1.27875e9;        #  E6/LEX frequency (Hz)
FREQ7 = 1.20714e9;        #  E5b    frequency (Hz)
FREQ8 = 1.191795e9;       #  E5a+b  frequency (Hz)
FREQ9 = 2.492028e9;       #  S      frequency (Hz)
FREQ1_GLO = 1.60200e9;    #  GLONASS G1 base frequency (Hz)
DFRQ1_GLO = 0.56250e6;    #  GLONASS G1 bias frequency (Hz/n)
FREQ2_GLO = 1.24600e9;    #  GLONASS G2 base frequency (Hz)
DFRQ2_GLO = 0.43750e6;    #  GLONASS G2 bias frequency (Hz/n)
FREQ3_GLO = 1.202025e9;   #  GLONASS G3 frequency (Hz)
FREQ1_BDS = 1.561098e9;   #  BeiDou B1 frequency (Hz)
FREQ2_BDS = 1.20714e9;    #  BeiDou B2 frequency (Hz)
FREQ3_BDS = 1.26852e9;    #  BeiDou B3 frequency (Hz)
```

[4]:
```
#Sat frequency
acq_fs = FREQ1
### Raw signal Parameters
IF = 0
samplingFreq=4e6
codeFreqBasis = 1.023e6
codeLength = 1023
samplesPerCode = round(samplingFreq/(codeFreqBasis/codeLength))

### Acquisition Settings
```

```
skipAcquisition = 0
acqSatelliteList = list(range(0,37))
acqSearchBand = 14
acqThreshold = 2.5
acquisitionCohCodePeriods=2
acquisitionNonCodePeriods=2

fileType=2
dataOffset=80
```

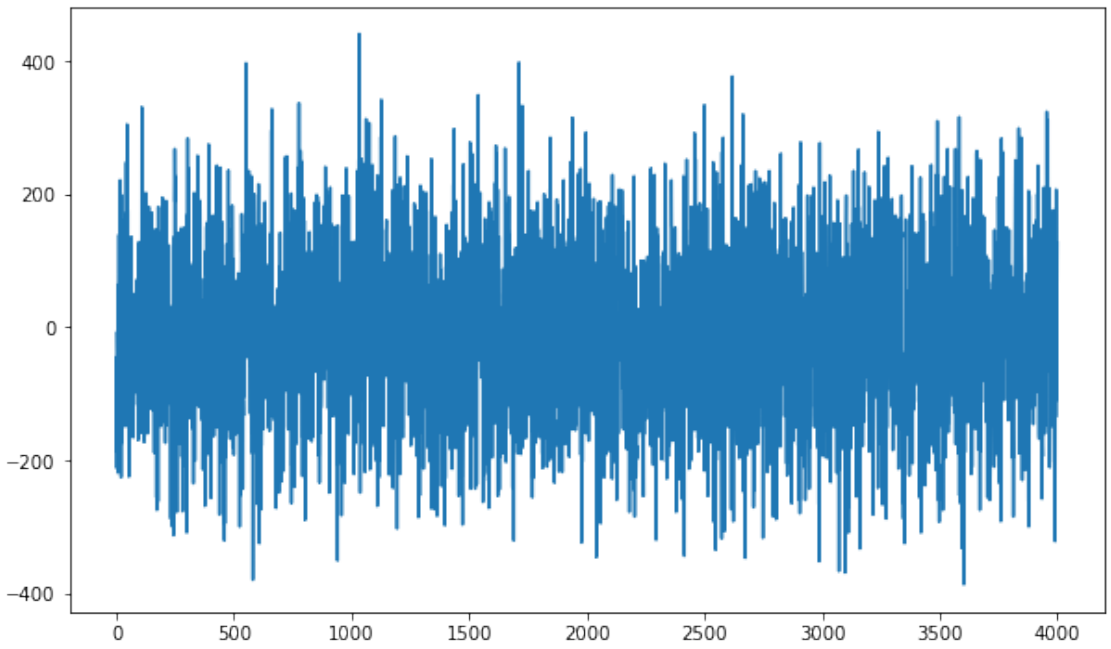
File I/O

[5]:
```
if fileType==1:
    dataType = np.complex64
elif fileType==2:
    dataType=np.int16
data= np.fromfile(fileName,dataType,offset=dataOffset,
count=10*(acquisitionCohCodePeriods*acquisitionNonCodePeriods)*samplesPerCode*6
)
data.shape
```

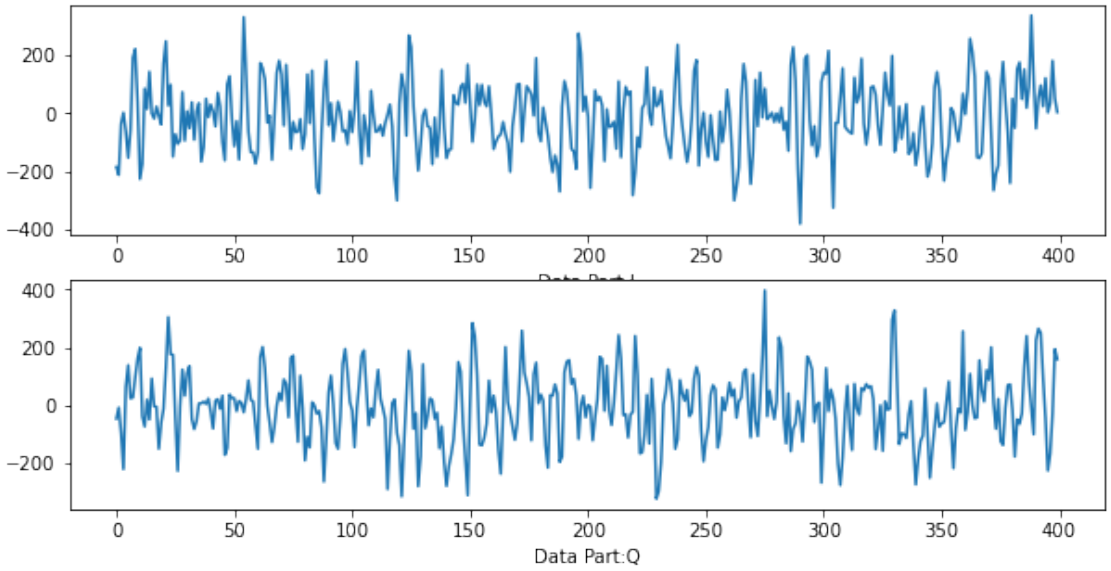
[5]: (960000,)

[6]:
```
fig = plt.figure(figsize=(10,6))
plt.plot(data[:samplesPerCode])
```

[6]: [<matplotlib.lines.Line2D at 0x7f47e40082b0>]



[7]:
```
if fileType==2:
    I = data[::2]
    Q = data[1::2]
    fig = plt.figure(figsize=(10,5))
    plt.subplot(211)
    plt.plot(I[:samplesPerCode//10])
    plt.xlabel('Data Part:I')
    plt.subplot(212)
    plt.plot(Q[:samplesPerCode//10])
    plt.xlabel('Data Part:Q')
```



[8]:
```
if fileType==2:
    signal = I + 1j*Q
else:
    signal = data
```

Signal Processing low_pass(double gain, double sampling_freq, double cutoff_freq, double transition_width, win_type window = WIN_HAMMING, double beta = 6.76)

0.2 Acquisition

[9]:
```
signal1 = signal[0:samplesPerCode]
signal2 = signal[samplesPerCode:2*samplesPerCode]
signal0DC = signal-np.mean(signal)
ts = 1/samplingFreq
```

[10]:
```
def generateCACode(prn):
    g2s = [  5,   6,   7,   8,  17,  18, 139, 140, 141, 251,
       252, 254, 255, 256, 257, 258, 469, 470, 471, 472,
       473, 474, 509, 512, 513, 514, 515, 516, 859, 860,
       861, 862,863,950,947,948,950]

    g2shift = g2s[prn]

    g1 = np.zeros((1023))
    reg = -1*np.ones((10))
    for i in range(codeLength):
        g1[i]      = reg[9]
        saveBit    = reg[2]*reg[9]
        reg[1:10]   = reg[0:9]
        reg[0]     = saveBit

    g2 = np.zeros((1023))
    reg = -1*np.ones((10))
    for i in range(codeLength):
        g2[i] = reg[9]
        saveBit     = reg[1]*reg[2]*reg[5]*reg[7]*reg[8]*reg[9]
        reg[1:10]   = reg[0:9]
        reg[0]      = saveBit

    g2 = np.concatenate([g2[1023-g2shift:],g2[0:1023-g2shift]])
    CAcode = -1*np.multiply(g1,g2)
    return CAcode

def makeCATable():
    caCodesTable = np.zeros((37,samplesPerCode))
    ts = 1/samplingFreq
    tc = 1/codeFreqBasis

    for i in range(37):
        caCode = generateCACode(i)
        cvi = ts * np.arange(1,samplesPerCode+1)/ tc
        codeValueIndex = np.ceil(cvi-1)

        # Correct the last index (due to number rounding issues) -----------
        codeValueIndex[-1] = 1022
        codeValueIndex = list(map(int,list(codeValueIndex)))
        # Make the digitized version of the C/A code ----------------------
        #The "upsampled" code is made by selecting values form the CA code
        # chip array (caCode) for the time instances of each sample.
        caCodesTable[i, :] = caCode[codeValueIndex]
```

```
    return caCodesTable
```

Processing

[11]:
```
phasePoints = (np.arange(0,samplesPerCode))*2*np.pi*ts
numberOfFrqBins = round(acqSearchBand*2)+1
caCodesTable = makeCATable()
results = np.zeros((numberOfFrqBins,samplesPerCode))
frqBins = np.zeros((numberOfFrqBins))
```

[12]:
```
carrFreq = np.zeros((37))
codePhaseRes = np.zeros((37))
peakMetric = np.zeros((37))
def nextpow2(x):
    return 1 if x == 0 else 2**np.ceil(np.log2(abs(x)))
```

[13]:
```
def acqResults():
    for i in acqSatelliteList:
        caCodesT = caCodesTable[i]
        caCodeFreqDom = np.conj(np.fft.fft(caCodesT))
        for j in range(numberOfFrqBins):

            # Generate carrier wave frequency grid (0.5kHz step) -----------
            frqBins[j] = IF - (acqSearchBand/2) * 1000 + 0.25e3 * j

            # Generate local sine and cosine -------------------------------
            sigCarr = np.exp(1j*frqBins[j]*phasePoints)

            # "Remove carrier" from the signal -----------------------------
            I1      = np.real(sigCarr * signal1)
            Q1      = np.imag(sigCarr * signal1)
            I2      = np.real(sigCarr * signal2)
            Q2      = np.imag(sigCarr * signal2)

            # Convert the baseband signal to frequency domain --------------
            IQfreqDom1 = np.fft.fft(I1 + 1j*Q1)
            IQfreqDom2 = np.fft.fft(I2 + 1j*Q2)

            # Multiplication in the frequency domain (correlation in␣
↪time%domain)
            convCodeIQ1 = np.multiply(IQfreqDom1, caCodeFreqDom)
            convCodeIQ2 = np.multiply(IQfreqDom2 , caCodeFreqDom)

            # Perform inverse DFT and store correlation results ------------
            acqRes1 =np.power(abs(np.fft.ifft(convCodeIQ1)),2)
            acqRes2 = np.power(abs(np.fft.ifft(convCodeIQ2)),2)
```

```
            # Check which msec had the greater power and save that, will
            # 1st and 2nd msec but will correct data bit issues
            if (max(acqRes1) > max(acqRes2)):
                results[j, :] = acqRes1
            else:
                results[j, :] = acqRes2
        np.savetxt('test.csv', results, delimiter=',', fmt='%s')
        # Looking for correlation peaks
        peakSize= np.amax(np.amax(results,axis=0))
        frequencyBinIndex = np.amax(results.argmax(axis=0),)#np.amax(np.
↪where(results[j,:]==peakSize))
        frequencyBinIndex = frequencyBinIndex
        #print(peakSize,frequencyBinIndex)

        # Find code phase of the same correlation peak ---------------------
        peakSize = np.amax(np.amax(results,axis=1))
        codePhase = np.amax(results.argmax(axis=1))
        #print(peakSize,codePhase)
        # Find 1 chip wide C/A code phase exclude range around the peak ----
        samplesPerCodeChip   = round(samplingFreq /codeFreqBasis)
        excludeRangeIndex1 = codePhase - samplesPerCodeChip
        excludeRangeIndex2 = codePhase + samplesPerCodeChip

        # Correct C/A code phase exclude range if the range includes array
        #boundaries
        if excludeRangeIndex1 < 2:
            codePhaseRange = np.arange(excludeRangeIndex2 ,(samplesPerCode +␣
↪excludeRangeIndex1-1))

        elif excludeRangeIndex2 >= samplesPerCode:
            codePhaseRange = np.arange(excludeRangeIndex2 -␣
↪samplesPerCode,excludeRangeIndex1-1)
        else:
            codePhaseRange = np.hstack((np.arange(1,excludeRangeIndex1),np.
↪arange(excludeRangeIndex2 ,samplesPerCode-1)))


        # Find the second highest correlation peak in the same freq. bin ---
        secondPeakSize = np.amax(results[frequencyBinIndex, codePhaseRange])
        #print(peakSize/secondPeakSize)
        # Store result -----------------------------------------------------
        peakMetric[i] = peakSize/secondPeakSize
        # If the result is above threshold, then there is a signal
        if (peakSize/secondPeakSize) > acqThreshold:
            caCode = generateCACode(i)
            codeValueIndex = np.floor((ts * np.arange(1,10*samplesPerCode)) /
```

```
                                    (1/codeFreqBasis))
            #print(codeValueIndex)
            #print(np.remainder(codeValueIndex,1023) + 1)
            longCaCode = caCode[list((np.remainder(codeValueIndex,1023).
↪astype(np.int8) + 1))]

            # Remove C/A code modulation from the original signal ----------
            # (Using detected C/A code phase)
            xCarrier = np.multiply(signal0DC[codePhase:(codePhase +␣
↪10*samplesPerCode-1)]
                , longCaCode)

            # Compute the magnitude of the FFT, find maximum and the
            #associated carrier frequency
            nextPow2=np.ceil(np.log2(abs(len(xCarrier)))).astype('int')
            # Find the next highest power of two and increase by 8x --------
            fftNumPts = 8*(2**(nextPow2))

            # Compute the magnitude of the FFT, find maximum and the
            #associated carrier frequency
            fftxc = abs(np.fft.fft(xCarrier, fftNumPts))


            uniqFftPts = np.ceil((fftNumPts + 1) / 2)
            [fftMax, fftMaxIndex] = np.amax(fftxc),np.argmax(fftxc);
            fftFreqBins = np.arange(0 ,uniqFftPts-1) *samplingFreq/fftNumPts;
            if (fftMaxIndex > uniqFftPts): #%and should validate using complex␣
↪data
                if (rem(fftNumPts,2)==0):  #even number of points, so DC and Fs/
↪2 computed
                    fftFreqBinsRev=-fftFreqBins[(uniqFftPts-1):-1:2];
                    fftMax, fftMaxIndex = np.arange(np.
↪amax(fftxc[(uniqFftPts+1),len(fftxc)])),np.
↪argmax(fftxc[(uniqFftPts+1),len(fftxc)]);
                    carrFreq[i]  = -fftFreqBinsRev[fftMaxIndex];
                else:  #%odd points so only DC is not included
                    fftFreqBinsRev=-np.flip(fftFreqBins[2:(uniqFftPts)]);
                    [fftMax, fftMaxIndex] = np.amax(fftxc[(uniqFftPts+1):
↪length(fftxc)]),np.argmax(fftxc[(uniqFftPts+1):length(fftxc)])
                    carrFreq[i] = fftFreqBinsRev[fftMaxIndex]
                end
            else:
                carrFreq[i]  = (-1)**(fileType-1)*fftFreqBins[fftMaxIndex]


            codePhaseRes[i] = codePhase;
```

```
            print(i+1,end =" ")
        else:
            # No signal with this PRN ------------------------------------
            print('. ',end =" ")
    return peakMetric,results
```

[14]:
```
peakMetric,results= acqResults()
```

```
1 . . . . . . . . . . 11 . . . . . . . . . . . . . . . . . . . . . .
. . . 31 32 . . . . . .
```

[15]:
```
fig = plt.figure(figsize=(12,7))
plt.bar(list(range(1,38)),peakMetric)
plt.grid()
plt.title ( 'Acquisition results',fontdict={'fontsize':14,'fontweight':'bold'})
plt.xlim([0,37])
plt.yticks(np.arange(0,max(peakMetric),0.5))
plt.xticks(np.arange(0,39,1))
plt.xlabel( 'PRN number',
           fontdict={'fontsize':12,'fontweight':'bold'});
plt.ylabel( 'Acquisition Metric',fontdict={'fontsize':12,'fontweight':'bold'});
```