Problem_A_7_3

October 1, 2021

1 A 7.3

Reading the audiofile

```
[ ]: using WAV
     x, f = wavread("audio_filtering_original.wav")
     x = vec(x)
```

```
[ ]: 441000-element Vector{Float64}:
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0

      0.2860805094242096
      0.29850155115127563
      0.299630731344223
      0.28992584347724915
      0.2713095545768738
      0.24967192113399506
      0.23129978775978088
      0.21637623012065887
      0.20450453460216522
      0.19547104835510254
      0.18588824570178986
      0.17609180510044098
```

```
[ ]: wavplay(x, f)
```

2 a)

Convolving the input audio with h^{smooth} vector

```
[ ]: using DSP
     h_smooth = 1 / 44 * ones(44)
     output = conv(h_smooth, x)
```

```
[ ]: 441043-element Vector{Float64}:
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0

      0.06601708551699467
      0.05951525575735354
      0.05273112959482454
      0.045921340246092186
      0.039332116530700165
      0.033165990290316666
      0.027491628446362243
      0.022234815088185415
      0.01731717349453407
      0.012669343162666671
      0.008226819336414365
      0.004002086479555481
```

Playing the output

```
[ ]: wavplay(output, f)
```

In the output audio above, the final amplitude is $\frac{1}{44}th$ of an amplitude combined with the previous 43 values i.e the average amplitude values of every 1ms

This results in the audio being pleasant to hear, whereas in the original audio the rough edges were clearly felt while hearing. This overall will result in a smooth audio curve.

3 b)

Computing k

k should be of length 441000*0.25/10

```
[ ]: k = Int64(size(x,1) * 0.25 / 10)
```

```
[ ]: 11025
```

Creating the h^{echo} vector

k+1-Vector $h^{echo} = [1,0,0,...,0.5]$

```
[ ]: h_echo = 0 * ones(k)
     h_echo[1] = 1
     push!(h_echo, 0.5)
```

```
[ ]: 11026-element Vector{Float64}:
      1.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0

      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.0
      0.5
```

Computing the audio vector with echo

```
[ ]: output_echo = conv(h_echo, x)
```

```
[ ]: 452025-element Vector{Float64}:
      -3.122502256758253e-17
       0.0
```

```
 -1.214306433183765e-17
 -1.3010426069826053e-17
 -2.42861286636753e-17
 -9.324138683375338e-18
  1.214306433183765e-17
  3.5128150388530344e-17
  6.938893903907228e-18
 -6.938893903907228e-18
 -1.734723475976807e-18
 -7.37257477290143e-18
 -1.3877787807814457e-17

  0.14304025471210485
  0.14925077557563776
  0.14981536567211157
  0.14496292173862457
  0.13565477728843683
  0.12483596056699751
  0.11564989387989044
  0.10818811506032945
  0.10225226730108262
  0.09773552417755121
  0.09294412285089498
  0.08804590255022045
```

Playing the echo output

```
[ ]: wavplay(output_echo, f)
```

Computing the audio vector with echo twice

```
[ ]: output_echo_echo = conv(h_echo, conv(h_echo, x))
```

```
[ ]: 463050-element Vector{Float64}:
 -1.5612511283791264e-17
  1.8214596497756474e-17
 -3.2959746043559335e-17
 -3.209238430557093e-17
 -4.0766001685454967e-17
 -3.382710778154774e-17
  3.469446951953614e-17
  6.331740687315346e-17
 -2.42861286636753e-17
 -1.3877787807814457e-17
 -2.949029909160572e-17
  8.673617379884035e-18
  1.0408340855860843e-17
```

```
0.07152012735605243
0.07462538778781898
0.07490768283605576
0.07248146086931244
0.06782738864421842
0.062417980283498875
0.057824946939945165
0.054094057530164774
0.05112613365054133
0.04886776208877572
0.046472061425447506
0.04402295127511027
```

Playing the output with echo vector added twice

```
[ ]: wavplay(output_echo_echo, f)
```

In the output sample $h^{echo} * \text{x}$ there was an echo added after 0.25 second at half the amplitude and the echo was confirmed while playing the audio

In the output sample $h^{echo} * h^{echo} * \text{x}$ there were two echo vectors convolved and hence the resultant audio had 3 additional echoes each at a different amplitude and this was confirmed while playing the audio