Audio Signal Generation

Young Won Lim 1/22/18 Copyright (c) 2016 - 2018 Young W. Lim.

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Please send corrections (or suggestions) to youngwlim@hotmail.com.

This document was produced by using OpenOffice.

Young Won Lim 1/22/18 Signal Processing with Free Software : Practical Experiments F. Auger http://sox.sourceforge.net/Docs/Documentation

http://www.thegeekstuff.com/2009/05/sound-exchange-sox-15-examples-to-manipulate-audi o-files/

http://billposer.org/Linguistics/Computation/SoxTutorial.html

Audacity information

http://www.library.kent.edu/files/SMS_Audacity_Basics.pdf

http://manual.audacityteam.org/man/tutorials.html

https://multimedia.journalism.berkeley.edu/tutorials/audacity/

http://ctlt.jhsph.edu/help/views/tutorials/audacity/GuideToUsingAudacity.pdf

http://www.sillanumsoft.org/

sudo apt-get install sox sudo apt-get install libsox-fmt-mp3

7

sox -n s1.wav synth	3.5	sine	440
sox -n s2.wav synth	90000s	sine	660:1000
sox -n s3.wav synth	1:20	triangle	440
sox -n s4.wav synth	1:20	trapezium	440
sox -n s5.wav synth	6	square	440 0 0 40
sox -n s6.wav synth	5	noise	

time duration

frequency

-V0, -V1, -V2, -V3, -V4 : verbosity levels -n (null) : absence of an input signal



- 1.0	. o _t o	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
x s1	O		168000	is 3.5							Į
x s2	• • •	00s 1.87	75								Į
x s3	0										ĺ
x s4	• 0-										ĺ
X 55	• 0-				28800)0s (6				Į
x s6 ▽	▼ 0-			240000	s 5						Į

Audio Signal	
Generation	





Audio Signal
Generation

A. sox -n s1.wav synth 3.5 sine 440

3.5 seconds A sinusoid with a frequency of 440 Hz

1/48000 = 2.0833e-05

 $T_{s} = 0.0208 msec$

 $T/T_s = 3.5 \cdot 48000 = 168000$ samples

sox: SoX v14.4.1	
sox INFO nulfile: sample rate not specified; using 48000	
Input File : '' (null)	
Channels : 1	
Sample Rate : 48000	
Precision : 32-bit	
sox INFO sox: Overwriting `sl.wav'	
Output File : 's1.wav'	
Channels : 1	
Sample Rate : 48000	
Precision : 32-bit	
Sample Encoding: 32-bit Signed Integer PCM	
Endian Type : little	
Reverse Nibbles: no	
Reverse Bits : no	
Comment 'Processed by SoX'	
sox INEO sox: effects chain: input 48000Hz 1 channels	
sox INFO sox: effects chain: synth 48000Hz 1 channels	
sox INFO sox: effects chain: output 48000012 1 channels	
sox INFO sox: effects chain: output 48000Hz 1 channels	

Audio	Signal
Gener	ation

A. sox -n s1.wav synth 3.5 sine 440



90000 samples A sinusoidal signal with a frequency That varies in a linear manner from 660 to 1000 Hz

1/48000 = 2.0833e-05

- $T_{s} = 0.0208 msec$
- $T = 90000 / 48000 = 1.875 \ sec$

SOX: SOX V14.4.1
sox INFO nulfile: sample rate not specified; using 48000
Input File : '' (null) Channels : 1 Sample Rate : 48000 Precision : 32-bit
sox INFO sox: Overwriting `s2.wav'
Output File : 's2.wav'
Channels : 1
Sample Rate : 48000
Precision : 32-bit
Sample Encoding: 32-bit Signed Integer PCM
Endian Type 🛛 : little
Reverse Nibbles: no
Reverse Bits : no
Comment : 'Processed by SoX'
sox INFO sox: effects chain: input 48000Hz 1 channels
sox INFO sox: effects chain: synth 48000Hz 1 channels
sox INFO sox: effects chain: output 48000Hz 1 channels

B. sox -n s2.wav synth 90000s sine 660:1000



1 minutes and 20 seconds A triangular signal A frequency of 440 Hz

1/48000 = 2.0833e-05

 $T_{s} = 0.0208 msec$

 $T/T_{s} = 80 \cdot 48000 = 3840000$ samples

sox: SoX	v14.4.1
sox INFO nulfi	le: sample rate not specified; using 48000
2	
Input File	: '' (null)
Channels	···1
Sample Rate	: 48000
Precision	: 32-bit
sox INFO sox:	Overwriting `s3.wav'
Output File	: 's3.wav'
Channels	
Sample Rate	: 48000
Precision	: 32-bit
Sample Encodin	ig: 32-bit Signed Integer PCM
Endian Type	: LITTLE
Reverse Nibble	s: no
Reverse Bits	: NO
Comment	: 'Processed by Sox'
CON THEO CON	offocts chain: input 4000047 1 channels
SOX INFO SOX.	offocts chain: input 40000Hz 1 channels
SOX INFO SOX:	offocts chain: synth 4000002 I channels
50X INFU 50X.	40000nz I Chalinets

C. sox -n s3.wav synth 1:20 triangle 440



1 minutes and 20 seconds A trapezoidal signal A frequency of 440 Hz

1/48000 = 2.0833e-05

 $T_{s} = 0.0208 msec$

 $T/T_{s} = 80 \cdot 48000 = 3840000$ samples

sox: SoX	v14.4.1	-			ľ
sox INFO nulfi	le: sample rate	e not specifi	ed; using	48000	
Input File	: '' (null)				
Channels	: 1				
Sample Rate	: 48000				
Precision	: 32-bit				
sox INFO sox:	Overwriting `s4	4.wav'			
Output File	: 's4.wav'				
Channels	: 1				
Sample Rate	: 48000				
Precision	: 32-bit				
Sample Encodir	ig: 32-bit Signe	ed Integer PC	М		
Endian Type	: little				
Reverse Nibble	es: no				
Reverse Bits	: no				
Comment	: 'Processed I	by SoX'			
sox INFO sox:	effects chain:	input	48000Hz	1 channels	
sox INFO sox:	effects chain:	synth	48000Hz	1 channels	
sox INFO sox:	effects chain:	output	48000Hz	1 channels	

D. sox -n s4.wav synth 1:20 trapezium 440

r				\$5		- + ×
File Edit View	Transport Trad	cks Generate Effect Ana	alyze Help			
				-57 -48 -(-57 -48 -4 -57 -48 -4	Click to Start Monitorin 2 -36 -30 -24 P P R P	g 8 -12-9 -6 -3 0 -18 -12-9 -6 -3 0
ALSA V	default: Front Mic	::0 🔻 2 (Ster	reo) Rec 💌 📲 def	ault		
- 0.0005	0.000	0.0005	0.0010	0.0015	0.0020	0.0025
X s5 V Mono, 48000Hz 32-bit float Mute Solo	1.0 0.8· 0.7· 0.6· 0.5· 0.4· 0.3· 0.2· 0.1· 0.0· -0.1· -0.2· -0.3· -0.4· -0.5· -0.6· -0.7· -0.8· -1.0					
- Droingt Data (1		Coloction Starts	Cod Oto	weth Audio D	- ition.	
Project Rate (F	12): Snap lo:	Selection Start:		Audio Po		
48000	Off	00 h 00 m 00.000	s 00 h 00 m 0	00 h 0	00 m 00.000 s▼	
Stopped.	Click and d	lrag to select audio, Ctrl-Clic	k to scrub, Ctrl-Doub	le-Click to scroll-scrub, (Ctrl-drag to seek	

6 seconds A square signal A null offset (no continuous component) A null phase A duty cycle of 40 %

1/48000 = 2.0833e-05

 $T_{s} = 0.0208 msec$

 $T/T_s = 6 \cdot 48000 = 288000$ samples

sox: SoX v14.4.1
sox INFO nulfile: sample rate not specified; using 48000
Input File : '' (null) Channels : 1 Sample Rate : 48000 Precision : 32-bit
sox INFO sox: Overwriting `s5.wav'
Output File : 's5.wav' Channels : 1 Sample Rate : 48000 Precision : 32-bit Sample Encoding: 32-bit Signed Integer PCM Endian Type : little Reverse Nibbles: no Reverse Bits : no Comment : 'Processed by SoX'
sox INF0 sox: effects chain: input48000Hz1 channelssox INF0 sox: effects chain: synth48000Hz1 channelssox INF0 sox: effects chain: output48000Hz1 channels

E. sox -n s5.wav synth 6 square 440 0 0 40

			S	5		- + ×
File Edit View	Transport Tracks	Generate Effect Anal	/ze Help			
	default: Front Mic:0	▶ ● I I P	→ <	-57 -48 - Cl -57 -48 -42 -57 -48 -42 -57 -48 -42	ick to Start Monitoring	18 -12 -9 -6 -3 0 18 -12 -9 -6 -3 0
- 0.0005	0.000	0.0005	0.0010	0.0015	0.0020	0.0025
X s5 V Mono, 48000Hz 32-bit float Mute Solo	1.0 0.8 0.7 0.6 0.5- 0.4 0.3 0.2 0.1 -0.0- -0.1 -0.2 -0.3 -0.4 -0.5- -0.6 -0.7 -0.8 -1.0					
Project Rate (H	Iz): Snap To:	Selection Start:	🔘 End 🔵 Lei	ngth Audio Pos	ition:	
48000 -	Off ▼	00 h 00 m 00.000 s	• 00 h 00 m 0	0.000 s	m 00.000 s -	
Stopped.	Click and dra	g to select audio, Ctrl-Click	to scrub, Ctrl-Double	e-Click to scroll-scrub, Ct	rl-drag to seek	

5 seconds A white noise A value ranging from -1 to +1 An average value of 0

1/48000 = 2.0833e-05

 $T_{s} = 0.0208 msec$

 $T/T_{s} = 5 \cdot 48000 = 240000$ samples

sox: SoX v14.4.1
sox INFO nulfile: sample rate not specified; using 48000
Input File : '' (null)
Channels : 1
Sample Rate : 48000
Precision : 32-Dit
sox INFO sox: Overwriting so.wav
Output File - 's6 wow'
Channels 1
Sample Rate : ARAAA
Precision : 32-hit
Sample Encoding: 32-bit Signed Integer PCM
Endian Type : little
Reverse Nibbles: no
Reverse Bits : no
Comment : 'Processed by SoX'
sox INFO sox: effects chain: input 48000Hz 1 channels
sox INFO sox: effects chain: synth 48000Hz 1 channels
sox INFO sox: effects chain: output 48000Hz 1 channels

F. sox -n s6.wav synth 5 noise



Time and Frequency

sox -n s1.wav synth 3.5 sox -n s2.wav synth 90000s sox -n s3.wav synth 1:20 sox -n s4.wav synth 1:20 sox -n s5.wav synth 6 sox -n s6.wav synth 5 sine440sine660:1000triangle440trapezium440square440 0 0 40noise

3.5	3.5 sec
90000s	90000 samples
1:20	1 min 20 sec
1:20	1 min 20 sec
6	6 sec
5	5 sec

440	440 Hz
660:1000	660 Hz to 1000 Hz
440	440 Hz
440	440 Hz
440	440 Hz

for %%i in (200, 300, 400) do ^ sox -n s7_%%i.mp3 synth 15 sine %%i

sox -n s7_200.mp3 synth 15 sine 200 sox -n s7_300.mp3 synth 15 sine 300 sox -n s7_400.mp3 synth 15 sine 400

```
sox s1.wav t1.wav vol -6 dB
sox s1.wav t2.wav vol -0.4 amplitude
```

```
sox s1.wav s2.wav t3.wav
sox s2.wav -v 0.6 t1.wav t4.wav
```

```
sox s1.wav t5.wav pad 1
sox s1.wav t6.wav pad 1 0.5
sox s1.wav t7.wav pad 1 5000@3 0.5
```

```
sox -m s3.wav s4.wav t8.wav
```

sox s1.wav t1.wav vol -6 dB

			s1				+ x)
File Edit View Trar	nsport Tracks G	enerate Effect Analyze	Help				
			 	-48 -{Click to Start -48 -42 -36 -3	Monitoring 8 0 -24 -18	-12-9 -6 -3 0 -12-9 -6 -3 0	
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- 0.5	o _t o	0.5 1.0	1.5	2.0	2.5	3.0	3.5
× s1 ▼ 1.0 Mono, 48000Hz 0.5 32-bit float 0.5 Mute Solo - + 0.0 - - -							
)		
Project Rate (Hz):	Snap To: Se	lection Start:	O End O Length	Audio Position:			
48000 🔻	Off 🔻 🛛	0 h 00 m 00.000 s 🗸 🛛	00 h 00 m 00.000 s	00 h 00 m 00.00	0 s •		
Stopped.	Multi-Tool Mode:	Ctrl+P for Mouse and Keyb	ooard Preferences.				

sox s1.wav t2.wav vol -0.4 amplitude

			s1			-	+ ×
File Edit View Trar	nsport Tracks Genera	te Effect Analyze Hel	р				
			$ \begin{array}{c c} $	48 -{Click 48 -42	to Start Monitoring 8- 36 -30 -24 -18	-12-9-6-30 -12-9-6-30	
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ALSA 🔻 🎤 defau	ult: Front Mic:0	👻 🛛 2 (Stereo) Rec 🔻	/ ・) default	•			
- 0.5	0 ₁ 0 0.5	1.0	1.5	2.0	2.5	3.0	3,5
× s1 ▼ 1.0 Mono, 48000Hz 0.5 32-bit float 0.5 Mute Solo Image: solo -0.5 Image: solo -1.0 × t2 1.0 Mono, 48000Hz 0.5 Image: solo -1.0 × t2 1.0 Mono, 48000Hz 0.5 Image: solo 0.0 Image: solo 0.0	5						
LR -0.5 ▲ ○ -1.0	5. 						
Project Rate (Hz)	Snan To: Selection	Start:	nd O Length	Audio Positio	n:		
48000 V	Off • 00 h 0	0 m 00.000 s	h 00 m 00.000 s	00 h 00 m	00.000 s		
Stopped.	Click and drag to edit th	ne amplitude envelope					

sox s1.wav s2.wav t3.wav



sox s2.wav -v 0.6 t1.wav t4.wav



Signal Processing Operations (1)

sox s1.wav t5.wav pad 1 sox s1.wav t6.wav pad 1 0.5 sox s1.wav t7.wav pad 1 5000@3 0.5

Signal Processing Operations (1)

x sl 🔻	1,0		
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Silencio Solo	0,0-		
<u>L</u> R	-0,5	un den de la companya	
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Mono, 48000Hz		n krzte nedze ko	
32 bits, flotante	0,5-		
Silencio Solo	0.0		
· · · · · · · · · · · · · · · · · · ·	0,0-		
	-0.5		
	0,0		
	-1,0		
x t6 🔻	1,0		
Mono, 48000Hz	0.5.	ТАТИМИЧЕТ ЧТО ЧТО ЧТО ЧТО ИТ КОЛОЗАТ У ЧТО ПРОСКОТКО ЧТОЛТЯ СРОДОТИ И ТАТИМИКОТО И ВАЛИТИ ОТКОЛОЗАТИ И ВОЛОЗАТИ ПОТОЛТИ И ПОТОЛТИ И ПОТОЛТИ И ПОТОЛТИ И ПОТОЛТИ И ПОТОЛТИ И ПОТОЛИ ВАЛИТИ И ВАЛИТИ И ВАЛИТИ И ВОЛОЗАТИ И ПОТОЛТИ	
Silencio Solo	0,5		
- +	0,0-		
<u>Less</u> erri			
L	-0,5		
	-1 0	ŨŶŨŊŨŦŔĸŢĸĸŢĸŨŢŨĬŢŔŊŔĸŢĸŎŢĸŎŢŨŶŨŢĸŎŢŔĊŢĊŎŢŔĊŢŨŶŨŢŔĸŢŔŎŢŎŢŎŢŎŢŔŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢŔŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢŔŎŢŨŢŨŢĸŎŢĸŎŢĸŎ ŨŶŨŊŨŦŔĸŢĸĸŢĸŎŢĸŨŢŨŢŔĸŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎŢĸŎ	
	1.0		
Mono, 48000Hz	1,0	u la dur nee he kan	
32 bits, flotante	0,5		
Silencio Solo			
	0,0-		
<u>L</u>	-0,5		
	-1,0		

Signal Processing Operations (2)

sox s1.mp3 t9.mp3 dcshift 0.05

sox s1.mp3 t10.mp3 reverse

sox s3.mp3 t11.mp3 trim 1.5 2

sox s3.mp3 t12.mp3 t 10 1:00 20

- soxi s1.wav sox s1.wav -n stat
- sox s1.wav -n stats

Input File : 's1.wav' Channels : 2 Sample Rate : 48000 Precision : 16-bit Duration : 00:00:20.65 = 991232 samples ~ 1548.8 CDDA sectors File Size : 3.96M Bit Rate : 1.54M Sample Encoding: 16-bit Signed Integer PCM

Samples	read:	1982464
Length (seconds):	20.650667
Scaled b	by:	2147483647.0
Maximum	amplitude:	0.007813
Minimum	amplitude:	-0.003174
Midline	amplitude:	0.002319
Mean	norm:	0.000202
Mean	amplitude:	-0.000016
RMS	amplitude:	0.000255
Maximum	delta:	0.008545
Minimum	delta:	0.00000
Mean	delta:	0.000142
RMS	delta:	0.000180
Rough	frequency:	5413
Volume a	djustment:	128.000

sox s1.wav -n stats

	0verall	Left	Right
DC offset	-0.000016	-0.000016	-0.000016
Min level	-0.003174	-0.001190	-0.003174
Max level	0.007812	0.001282	0.007812
Pk lev dB	-42.14	-57.84	-42.14
RMS lev dB	-71.88	-71.73	-72.05
RMS Pk dB	-67.08	-67.08	-68.21
RMS Tr dB	-74.06	-73.44	-74.06
Crest factor	r -	4.95	31.27
Flat factor	0.00	0.00	0.00
Pk count	2.50	3	2
Bit-depth	9/16	7/16	9/16
Num samples	991k		
Length s	20.651		
Scale max	1.000000		
Window s	0.050		

References

[1] F. Auger, Signal Processing with Free Software : Practical Experiments