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ANALYZE USERS' GUIDE

Steve Azevedo

October 1982

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ANALYZE USERS' GUIDE

Steve Azevedo

This report is a reproduction of the visuals that were used in the "ANALYZE Users' Guide" lectures of the videotaped LLNL Continuing Education Course CE2018-H, State Space Lectures. The course was given in Spring 1982 through the EE Department Education Office.

Since ANALYZE is menu-driven, interactive, and has self-explanatory questions (sort of), these visuals and the two 50-minute videotapes are the only documentation which comes with the code. More information about the algorithms contained in ANALYZ can be obtained from the IEEE book on Programs for Digital Signal Processing (IEEE Press, Edited by the DSP Committee of IEEE-ASSP Society, John Wiley and Sons, New York, N.Y., 1979).

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ANALYZ

(A Signal Processing, Analysis, and Display Program)

User's Guide

by

STEVE AZEVEDO

ANALYZE USERS' GUIDE

- * Introduction & History
- * ANALYZE Example
- * ANALYZE Structure
- * ANALYZE Specifications
- * Getting Started
- * Options

ANALYZE **is ...**

A GENERAL PROGRAM FOR

- **Signal Processing** (Filtering, Averaging...)
- **Signal Analysis** (Fourier, Power Spec ...)
- **Signal Display** (Plots)

ANALYZE DESIGN PHILOSOPHY

- ☺ Plot Data on our Mini-Computer
- ☺ Perform Simple Signal Processing
- ☺ EASY TO USE!!

In

1) look

h

2) W

3) E

6

HISTORY

- Nov. 1980 -- **ANALYZE** born
plotting & FFT
- SIPRG Members Added Features
- IEEE - DSP Package
- Some Proprietary (Releases Available)
- **ANALYZE** 40% complete gave birth to **SIG** ANALYZE frozen

EXAMPLE

Time Response, File name = SINE

SINE is a
file containing
the sum of two
sinusoids.

This is its time
history...

4-MAY-82

Fourier transform of file SINE
(Semi-log Scaling)

... and here
is the frequency
spectrum.

Filtered version of file SINE
Butterworth low pass filter; Cutoff is 2.0000E+00

A low pass
Butterworth
filter at 2 Hz.
removes the
high frequency
part ...

Fourier transform of file SINELO (Semi-log Scaling)

...and the
Fourier transform
shows this too.

(the filtered signal
was stored in
SINELO)

ANALYZE Structure

ANALYZE Specifications

◆ FORTRAN IV

◆ DEC Machines { LSI 11/23 using RSX-11M
PDP 11/70 using IAS
VAX 11/780 using VMS

◆ Tektronix 4014 Series Graphics (or emulator)

◆ Uses 32 K Words (Overlaid)

◆ Menu driven (Interactive)

◆ Simple Data Format (ASCII)

Getting Started

© How to Invoke: In response to system prompt, type

ANA

or to return previously stored data base

ANA file name

© Special Characters :

Rubout or Delete	--	Delete previous character
Control - U	--	Delete current line
Control - Z	--	Go up one level (or exit from top)

© Type Ahead :

Space delimited lists; If you know the questions!

ANALYZE File Format

- Header (optional) -- must not have '(' in column 1
left paren →
- Format specifier -- Standard FORTRAN format specifier (surrounded by parens) and followed by ...
- Data -- May be more than one per line but must follow FORMAT specifier.

```
(E15.5)
-0.92904E-02
0.11453E+01
-0.17826E-01
0.18775E+01
-0.22599E-02
0.19328E+01
0.36398E-01
0.12915E+01
0.80787E-01
0.18536E+00
0.10465E+00
-0.98659E+00
0.86163E-01
-0.18017E+01
```

ANALYZE

Global Parameters

✓ File names (Max=12)

One signal per file

Signal = Time series of equally spaced points

✓ Sampling Interval

✓ Start Sample (or time)

✓ Number of Samples
(final time) (Max=1024)

OPTIONS

Signal Analysis Program

Type the number of the option requested

- 0) Stop
- 1) Reset the signal window to be analyzed
- 2) Type statistical information of a signal
- 3) Plot the time history
- 4) Plot the magnitude of the Fourier transform
- 5) Perform correlation and spectral analysis
- 6) Perform parameter estimation
- 7) Perform filtering functions
- 8) Perform operations on multiple signals

Option?>

This is the main menu displayed
when you type ANA

Typing 'Ø' in response to 'Option?>'
will exit the program.

System Prompt
ANA DEMO

Current Run Information

File # 1: SINE
File # 2: SINELO
File # 3: SINE TRN
File # 4: FSINE CUT
File # 5: FSINE IMP
File # 6: RAW1
File # 7: RAW2.MIS

1) Starting signal time: 0.00000E+00 seconds
2) Final signal time: 2.55000E+01 seconds
3) Starting sample number: 1
4) Number of samples: 256
5) Sampling period: 1.00000E-01 seconds

Type 0 to return, or the number to change

>3
Value?>100

1) Starting signal time: 9.90000E+00 seconds
2) Final signal time: 3.54000E+01 seconds
3) Starting sample number: 100
4) Number of samples: 256
5) Sampling period: 1.00000E-01 seconds

Type 0 to return, or the number to change

>3 1

1) Starting signal time: 0.00000E+00 seconds
2) Final signal time: 2.55000E+01 seconds
3) Starting sample number: 1
4) Number of samples: 256
5) Sampling period: 1.00000E-01 seconds

Type 0 to return, or the number to change

>0

Typing 'ANA filename' retrieves
the stored global parameters

← The parameters are easy to change

← Note: The time parameters are kept
in line with the window selected

Note: Number of samples does not
change with start sample
so other windows of 256
points may be observed.

Note: Type-ahead of known
answers to questions
(Space delimited).

Signal Analysis Program

Type the number of the option requested

- 0) Stop
- 1) Reset the signal window to be analyzed
- 2) Type statistical information of a signal
- 3) Plot the time history
- 4) Plot the magnitude of the Fourier transform
- 5) Perform correlation and spectral analysis
- 6) Perform parameter estimation
- 7) Perform filtering functions
- 8) Perform operations on multiple signals

Option?>1

Current Run Information

File # 1: SINE
File # 2: SINELO
File # 3: SINE TRN
File # 4: FSINE OUT
File # 5: FSINE IMP
File # 6: RAW1
File # 7: RAW2.MIS

1) Starting signal time: 0.00000E+00 seconds
2) Final signal time: 2.55000E+01 seconds
3) Starting sample number: 1
4) Number of samples: 256
5) Sampling period: 1.00000E-01 seconds

Type 0 to return, or the number to change

>0

Option #1:
Changes global parameters
as in previous slide

Signal Analysis Program

Type the number of the option requested

- 0) Stop
- 1) Reset the signal window to be analyzed
- 2) Type statistical information of a signal
- 3) Plot the time history
- 4) Plot the magnitude of the Fourier transform
- 5) Perform correlation and spectral analysis
- 6) Perform parameter estimation
- 7) Perform filtering functions
- 8) Perform operations on multiple signals

Option?) 2

- 1) SINE
- 2) SINE LO
- 3) SINE TRH
- 4) FSINE CUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2 MIS

Type file number or 0 if not on list?

>

Signal information

Maximum	=	1.97380E+00 at sample	25 or time	2.50000E+00
Minimum	=	-1.96390E+00 at sample	35 or time	3.50000E+00
Mean	=	1.08131E-02		
Variance	=	9.95457E-01		
Standard Deviation	=	9.9726E-01		

Option?)

Option #2:
Displays statistical
information

Signal Analysis Program

Type the number of the option requested

- 0) Stop
- 1) Reset the signal window to be analyzed
- 2) Type statistical information of a signal
- 3) Plot the time history
- 4) Plot the magnitude of the Fourier transform
- 5) Perform correlation and spectral analysis
- 6) Perform parameter estimation
- 7) Perform filtering functions
- 8) Perform operations on multiple signals

Option?>3

- 1) SINE
- 2) SINELO
- 3) SINE.TRM
- 4) FSINE.OUT
- 5) FSINE.IMP
- 6) RAW1
- 7) RAW2.MIS

Type file number or 0 if not on list?

>1

Auto-scale? (Y/N)

>N

Minimum?>-1

Maximum?>1

Note:
Type '0' to
add another file
to the list.

Option #3:

Time History plot.

May provide your own
vertical scaling.

Results of
plotting
file 'SINE'
with fixed
scaling of
(-1, 1)
→ Overshoot

Signal Analysis Program

Type the number of the option requested

- 0) Stop
- 1) Reset the signal window to be analyzed
- 2) Type statistical information of a signal
- 3) Plot the time history
- 4) Plot the magnitude of the Fourier transform
- 5) Perform correlation and spectral analysis
- 6) Perform parameter estimation
- 7) Perform filtering functions
- 8) Perform operations on multiple signals

Option?>4

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAU1
- 7) RAU2.NIS

Type file number or 0 if not on list?

>1

FFT size = 256

Window type (0=Rect, 1=Hann, 2=Hann) ?

>0

Scaling? (1=LIN, 2=XLIN-YLOG, 3=XLOG-YLIN, 4=LOG-LOG, 0=exit)

>2

No. of frequency points = 129, How many to plot?

Start freq. point and no. points? (^Z to exit)

>1

Number of points?

>40

Option #4:

FFT plot
"Power of 2" FFT

→ 3 types of windows

Rectangular

Hamming

Hanning

→ 4 types of axis scaling

→ May view parts of spectrum

Fourier transform of file SINE (Semi-log Scaling)

Spectral plot
of 'SINE'
only over
first 40
spectral point

→ Only low
freq. peak
appears

Correlation and Spectral Analysis

Operates on 1024 sample sections of input

Power Spectral Estimation

This segment uses the correlation method for power spectral estimation described in chapter 2.2 of "Programs for Digital Signal Processing", edited by the DSP Committee of the IEEE-ASSP Society, IEEE Press, 1979.

First, the algorithm computes the auto- (or cross-) correlation (or covariance) function and plots it.

Then, this correlation function is windowed (Rectangular, Hamming, or Hanning) to a fixed length, L , and Fourier-transformed to obtain the power spectral estimate.

A small L gives a wide spectrum with little detail.

A large L gives a narrow spectrum with greater detail.

What type of correlation?

- 0) Return
- 1) Autocorrelation
- 2) Cross-correlation
- 3) Autocovariance
- 4) Cross-covariance

Number??3

- 1) SINE
- 2) SINELO
- 3) SINE TAN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2.MIS

Type file number or 0 if not on list?

>1

Number of samples to be used (<32768) ?
(Will use sections of 1024 samples)

>>256

Number of correlation values used (L)?

>128

Window type (1-Rect., 2-Hamm., 3-Hann.) ?

>2

Scaling (0=linear, 1=dB) ?

>1

Option #5: Power Spectral Estimation

Note: May use up to 32K samples.

Does not use "Number of samples" global parameter

Autocovariance Function

File - SINE

Power Spectral Estimate (dB)

File - SINE

Model Order Estimation

* Problem : Determine the order of a model describing a signal

- * Solution :
- ① Fit several order models
 - ② Determine sum of squared errors
 - ③ Plot Error vs. Order

Parameter Estimation

Type the number of the option requested

- 0) Return to previous menu
- 1) Linear Prediction
- 2) Recursive Least Squares

Option?>1

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2 MIS

Type file number or 0 if not on list?

>1

An order test is performed on the signal, and plotted then you may request to examine the coefficients.

Maximum order for error plot?

>8

Option #6:

Parameter Estimation

→ Linear Prediction

→ RLS

Linear Prediction Error Plots

Linear
Prediction
Error vs. Order^{0.75}
for file
'SINE'.
Appears to
be 4th order.
(minimum
prediction
error)

)
Would you like to see the predictor coefficients?

Y

Order?>4

Predictor Coefficients

Coeff # 1: -6.15784E-03

Coeff # 2: -1.63872E+00

Coeff # 3: -6.15797E-03

Coeff # 4: 9.99998E-01

Would you like to see other coefficients?

N

Also may get a list of
coefficients for a particular order

FILTERING FUNCTIONS

(Option #7 in main menu)

Functions

- 1) Subtract scalar
- 2) Multiply scalar
- 3) Rescale (desired min & max)
- 4) Mean removal ~~and simple~~

are not covered but are simple
(Try them!)

FILTERING FUNCTION # 5:

Trend Removal

*** Problem:** Remove a "trend" in the data of order N .

*** Solution:** ① Fit the data with N^{th} order polynomial

$$\hat{y}(t) = \hat{a}_0 + \hat{a}_1 t + \hat{a}_2 t^2 + \dots \hat{a}_N t^N$$

② Subtract from data

$$z(t) = y(t) - \hat{y}(t)$$

Filtering Functions

Type the number of the option requested

- 0) Return to previous menu
- 1) Subtract a Scalar Constant
- 2) Multiply by a Scalar Constant
- 3) Rescale a Signal
- 4) Mean Removal
- 5) Trend Removal
- 6) Resample a Signal
- 7) Median Filter (Magic!)
- 8) Analog Prototype Filter
- 9) Deconvolution
- 10) Adaptive Noise Canceller

Option?>5

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2.MIS

Type file number or 0 if not on list?

>3

Order? (Max=10)

>1

FUNCTION # 5:

TREND REMOVAL

Trend of file SINE.TRN

Order = 1

'SINE.TRN'
is the same
as 'SINE'
except with
a ramp added

Trend Removed from file SINE.TRN

*Trend now
removed*

Filtering Function #6

Resample

- ① Interpolate or Decimate
- ① **MUST** Filter Before Decimating
to prevent aliasing
- ① Must Filter after interpolating because
zeroes added between points
- ① Only by integer amounts

Filtering Functions

Type the number of the option requested

- 0) Return to previous menu
- 1) Subtract a Scalar Constant
- 2) Multiply by a Scalar Constant
- 3) Rescale a Signal
- 4) Mean Removal
- 5) Trend Removal
- 6) Resample a Signal
- 7) Median Filter (Magic!)
- 8) Analog Prototype Filter
- 9) Deconvolution
- 10) Adaptive Noise Canceller

Option?>6

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2.MIS

Type file number or 0 if not on list?

>2

Type 1 for interpolation 2 for decimation

>2

Integer resampling factor?

>2

Function #6:

Resample

Interpolate or decimate

Resampled version of file SINELO

Sampling interval = 2.0000E-01

Filtering Function #2:

Median Filter

✓ Median Value in a window

✓ Removes spurious spikes

✓ 3, 5, and 7th order

Example :

Filtering Functions

Type the number of the option requested

- 0) Return to previous menu
- 1) Subtract a Scalar Constant
- 2) Multiply by a Scalar Constant
- 3) Rescale a Signal
- 4) Mean Removal
- 5) Trend Removal
- 6) Resample a Signal
- 7) Median Filter (Magic!)
- 8) Analog Prototype Filter
- 9) Deconvolution
- 10) Adaptive Noise Canceller

Option?>7

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAWI
- 7) RAW2.MIS

Type file number or 0 if not on list?

>1

Filter order (3.5 or 7) ?

>3

Function #7:

Median Filter

Filtered version of file SINE

Median filtered, Order = 3

Removes
High frequency
spikes from
'SINE'

Filtering Function # 8

ANALOG PROTOTYPE (IIR) FILTERS

Choice of:

• Butterworth

• Bessel

• Chebyshev I

• Chebyshev II

* Low Pass

* Band Pass

* High Pass

* Band Reject

• Forward • Backward

• Several Orders

Filtering Functions

Type the number of the option requested

- 0) Return to previous menu
- 1) Subtract a Scalar Constant
- 2) Multiply by a Scalar Constant
- 3) Rescale a Signal
- 4) Mean Removal
- 5) Trend Removal
- 6) Resample a Signal
- 7) Median Filter (Magic!)
- 8) Analog Prototype Filter
- 9) Deconvolution
- 10) Adaptive Noise Canceller

Option?>8

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2.MIS

Type file number or 0 if not on list?

>1

What analog prototype filter?

- 1) Butterworth
- 2) Bessel
- 3) Chebyshev type I
- 4) Chebyshev type II

Number?>1

What type of filter?

- 1) Low pass
- 2) High pass
- 3) Band pass
- 4) Band reject

!US 1?>1

High frequency cut-off (Hz) ?

>2

Order? (<11)

>5

How many passes?

- 1) Forward only
- 2) Forward and reverse (zero phase)

Number?>1

Function #8:

Analog Prototype (IIR)
Filters

Filtered version of file SINE
Butterworth low pass filter: Cutoff is 2.000E+00

Filtering Function # 9

Deconvolution

* Problem: Deconvolve the input, u , given output, y , and impulse response, h .

* Solution: ① Find inverse filter h^{-1}
② Convolve y

FSINE.OUT

FSINE.IMP

$$H(z) = \frac{1}{1 + 0.5z^{-1}}$$

Filtering Functions

Type the number of the option requested

- 0) Return to previous menu
- 1) Subtract a Scalar Constant
- 2) Multiply by a Scalar Constant
- 3) Rescale a Signal
- 4) Mean Removal
- 5) Trend Removal
- 6) Resample a Signal
- 7) Median Filter (Magic!)
- 8) Analog Prototype Filter
- 9) Deconvolution
- 10) Adaptive Noise Canceller

Option??9

This routine deconvolves the frequency response of one data-set from another. This is done by designing a prediction error filter on the first signal (h) and applying it to the second, i.e. given the following diagram:

The user enters h and y, and the algorithm computes u.
(h and y may be the same data-set)

First enter the file containing h(k)

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2 MIS

Type file number or 0 if not on list?

>5

Second enter the file containing y(k)

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2 MIS

Type file number or 0 if not on list?

>4

Start sample for modeling window?

>1

Modeling window length?

>50

Number of filter coefficients

>2

Function #9

Deconvolution

Deconvolution of FSINE.OUT

From file FSINE.IMP

We retrieve
'SINE'
from the
deconvolution

Filtering Function # 10

ADAPTIVE NOISE CANCELLER

Filtering Functions

Type the number of the option requested

- 0) Return to previous menu
- 1) Subtract a Scalar Constant
- 2) Multiply by a Scalar Constant
- 3) Rescale a Signal
- 4) Mean Removal
- 5) Trend Removal
- 6) Resample a Signal
- 7) Median Filter (Magic!)
- 8) Analog Prototype Filter
- 9) Deconvolution
- 10) Adaptive Noise Canceller

Option??>10

Pick the signal-plus-noise file

- 1) SINE
- 2) SINELO
- 3) SINE.TRN
- 4) FSINE.OUT
- 5) FSINE.IMP
- 6) RAW1
- 7) RAW2.MIS

Type file number or 0 if not on list?

>1

Pick the noise (reference) file

- 1) SINE
- 2) SINELO
- 3) SINE.TRN
- 4) FSINE.OUT
- 5) FSINE.IMP
- 6) RAW1
- 7) RAW2.MIS

Type file number or 0 if not on list?

>2

Number of weights (<100)?

>5

Adaption constant (MU) ?

>.01

Number of passes?

>1

Function # 10

Adaptive Noise Canceller

Adaptive Filter

Signal and Reference files: SINE and SINELO

*Adaptively
removing
low-frequency
sinusoid.*

ENSEMBLE OPERATIONS

(Option #8 in main menu)

- Items 1 and 2 in menu are the same as 1 and 2 in main menu.
- Items 6 (pointwise addition) and 7 (pointwise subtraction) are not covered but are obvious

Ensemble Operations

Type the number of the option requested

- 0) Return to previous menu
- 1) Reset the signal window to be analyzed
- 2) Type statistical information of a signal
- 3) Align signals (registering)
- 4) Ensemble average
- 5) Ensemble variance
- 6) Sample waveform addition
- 7) Sample waveform subtraction

Option? 3

Pick the reference file

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2.MIS

Type file number or 0 if not on list?

>6

Pick the aligning file

- 1) SINE
- 2) SINELO
- 3) SINE TRN
- 4) FSINE OUT
- 5) FSINE IMP
- 6) RAW1
- 7) RAW2.MIS

Type file number or 0 if not on list?

>7

Operation # 3:

Align

→ Reference is plotted first

Aligning file RAW2.MIS

Reference file: RAW1

Original
Align
Plot

0-Return.1-Horis.2-Vert.3-Replot

4-MAY-82

>1
Number of samples?
>5

Aligning file RAW2.MIS

Reference file: RAW1

-1
x10

After
moving
'RAW2.MIS'
by +5 samples

Aligning file RAW2.MIS
Reference file: RAW1

After
Replot
to clear screen

PAGES 59 to 60
WERE INTENTIONALLY
LEFT BLANK

Ensemble Average of Family RAW

Signal Analysis Program

Type the number of the option requested

- 0) Stop
- 1) Reset the signal window to be analyzed
- 2) Type statistical information of a signal
- 3) Plot the time history
- 4) Plot the magnitude of the Fourier transform
- 5) Perform correlation and spectral analysis
- 6) Perform parameter estimation
- 7) Perform filtering functions
- 8) Perform operations on multiple signals

Option?)

THE END

OR

"BEGINNING"

ANALYZE DEMOS

ON VAX 11/780

- After logging on type:

SET DEFAULT SEPR6: [CLASS. DATA]

- Then to get the initial example type:

@ANA1

and hit return's after each plot

- Then to get the data base for the entire demo, type:

ANA DEMO

and try the functions we have presented.

HAPPY ANALYZING !!!

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076-100	8.00	401-425	21.00
101-125	9.00	426-450	22.00
126-150	10.00	451-475	23.00
151-175	11.00	476-500	24.00
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