## Virtual Instrumentation

Samuel Alberg Thrysøe, PhD, Assistant Professor,
Contact info: Email: sat@iha.dk, Phone: +45 41893236
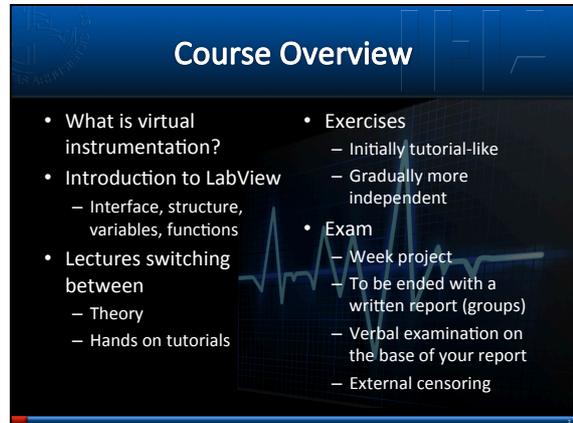
Course Overview

- What is virtual instrumentation?
- Introduction to LabView
  - Interface, structure, variables, functions
- Lectures switching between
  - Theory
  - Hands on tutorials

- Exercises
  - Initially tutorial-like
  - Gradually more independent
- Exam
  - Week project
  - To be ended with a written report (groups)
  - Verbal examination on the base of your report
  - External censoring
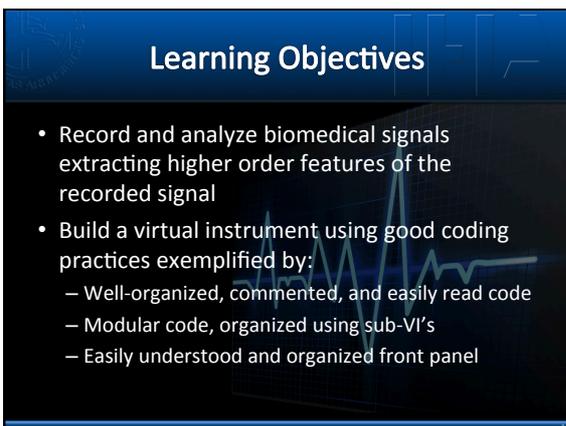
Learning Objectives

- Record and analyze biomedical signals extracting higher order features of the recorded signal
- Build a virtual instrument using good coding practices exemplified by:
  - Well-organized, commented, and easily read code
  - Modular code, organized using sub-VI's
 - Easily understood and organized front panel
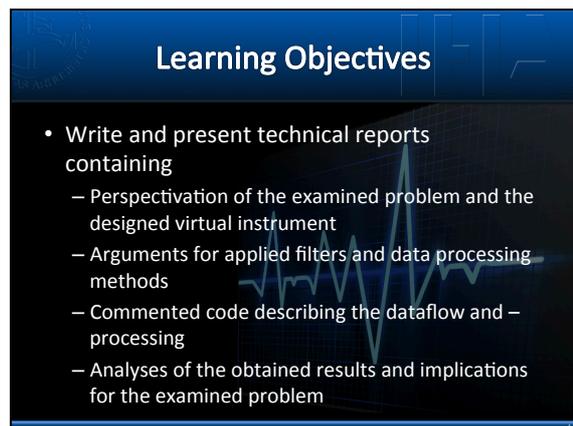
Learning Objectives

- Write and present technical reports containing
  - Perspectivation of the examined problem and the designed virtual instrument
  - Arguments for applied filters and data processing methods
  - Commented code describing the dataflow and – processing
  - Analyses of the obtained results and implications for the examined problem
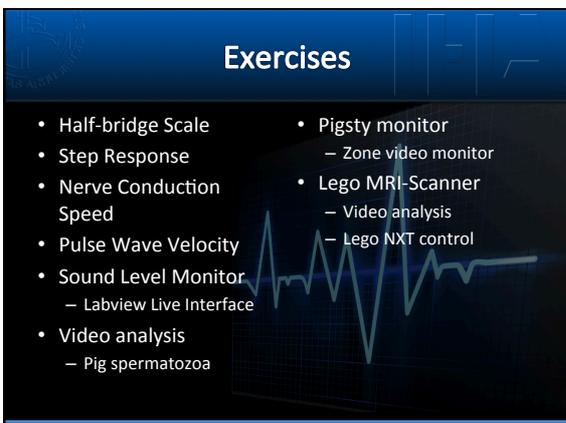
Exercises

- Half-bridge Scale
- Step Response
- Nerve Conduction Speed
- Pulse Wave Velocity
- Sound Level Monitor
  - Labview Live Interface
- Video analysis
  - Pig spermatozoa

- Pigsty monitor
  - Zone video monitor
- Lego MRI-Scanner
  - Video analysis
  - Lego NXT control
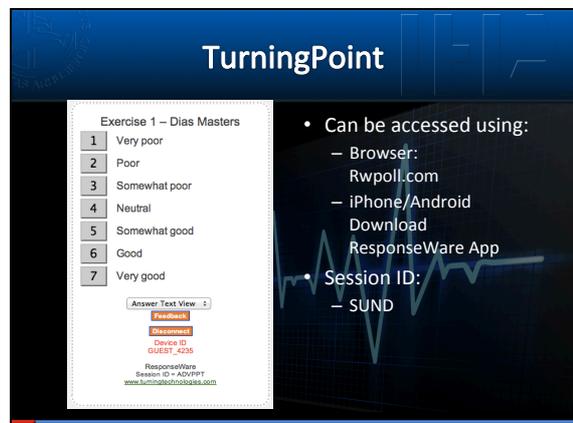
TurningPoint

Exercise 1 – Dias Masters

|	
1	Very poor
2	Poor
3	Somewhat poor
4	Neutral
5	Somewhat good
6	Good
7	Very good

Answer Text View

Feedback
Disconnect
Device ID
GUEST_4235

ResponseWare
Session ID = ADVPPT
www.turningtechnologies.com

- Can be accessed using:
  - Browser: Rwpoll.com
  - iPhone/Android Download ResponseWare App
- Session ID:
  - SUND

Your background?

1. Health Technology
2. Other Engineering Specialties
3. Other

33%   33%   33%

1.   2.   3.

How much programming experience do you have?

1. A very great deal
2. A lot of experience
3. Some experience
4. Almost no experience
5. None whatsoever

20%   20%   20%   20%   20%

1.   2.   3.   4.   5.

How much LabView-experience do you have?

1. A very great deal
2. A lot of experience
3. Some experience
4. Almost no experience
5. None whatsoever

20%   20%   20%   20%   20%

1.   2.   3.   4.   5.

Introduction to LabView (1)

What is Virtual Instrumentation?

- Combination of
  - Software
  - Hardware
- User constructed measurement/control systems
- *Virtual Instruments*
- LabView
  - Graphical user interface
  - Graphical programming

LabView

- Laboratory Virtual Instrumentation
- Graphical programmering language
- LabView Program = VI
  - Virtual Instrument
  - Imitates real machines/control panelse
    - Controls
      - Sliders/contacts/knobs
    - Indicators
      - LED lamps, thermometers, graphs

LabView IO

- User defined input
  - Text boxes, controls
- Data from "the real world"
  - DAQ (Data Acquisition)
  - Record/transmit fysical signals
    - Voltage, resistance, capacity etc.
    - Digital data
  - Examples
   - Temperature, flow, velocity/acceleration, pressure, sound intensity etc.

LabView structure

Front panel
- User interaction
- Resembles control panel

Block diagram
- Graphical programming
- Replaces "normal" programming text interface
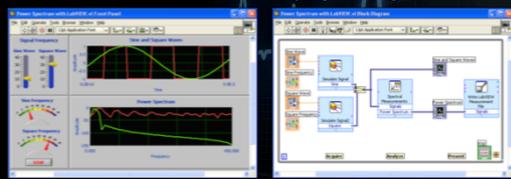
Where would you insert buttons and LED-lights?

1. On the Front Panel
2. On the Block Diagram

50%   50%

1.   2.
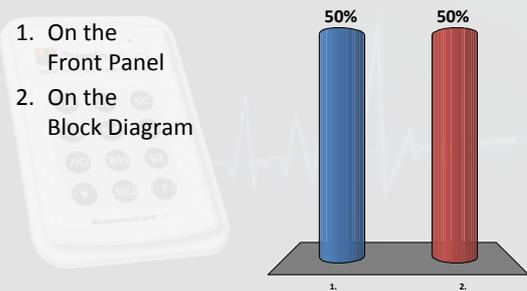
Where would you insert buttons and LED-lights?

1. På Front panelet
2. På Block diagrammet

## Front Panel

- User interaction
- Data input
  - Text boxes
  - Sliders
  - Buttons
- Output
  - Indicators
    - LED
    - Thermometers
    - Graphs

Front Panel

Menus

Toolbar

Free label

Icon/Connector

Boolean Contakt
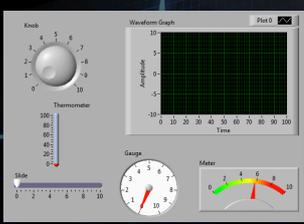
Controls
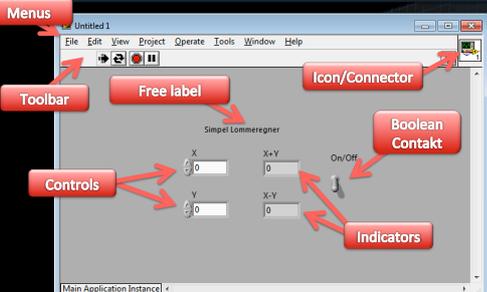
Indicators

Front Panel: Controls

- Right click on the front panel
  - *Controls*
- Click needle to keep open
- Categorized
  - Expand by clicking the bottom arrow

Block Diagram

- "Programming"
- Icons = nodes
  - Terminals
    - Controls/ indicators from the front panel
  - Functions
    - Addition/subtraction, comparisons etc.
  - Loop structures
    - While/for loops
    - Case/ sequence structures
- Wires
  - Color coded

Block Diagram

Which of these is an indicator?

1. Numeric
2. Numeric 2

Block Diagram: Functions

To Find Functions

- LabView has hundreds of functions
  - It can be hard finding the right one
- Use the search function
- Click and drag elements from the search window directly into the block diagram
- Double-click the element to show it's location

Function types

- Express VI
  - Interactive VIs with configuration page
  - Blue
- Standard VI
  - Modular VI
  - Can be modified connecting different wires
- Functions
  - Fundamental LabView functions
  - No front panel
  - Yellow

Tone Measurements
Signals
Amplitude
Frequency

Multiply

Which of these is a function?

1. Spectral Measurements — 43%

2. — 29%

3. — 29%

Toolbar

Runtime control

Ordering tools

Run / Running

Continuous Run / Running

Error (Click to specify)

Abort Execution

Error list
Items with errors
Random Array LED.vi
1 errors and warnings   Show Warnings
Block Diagram Errors
Add: Contains unwired or bad terminal
Details
One or more required inputs to this function are not wired or are wired incorrectly. Show the Context Help window to see what the connections to this function should be.
Close   Show Error   Help

Alignment

Align Objects Ring   Distribute Objects Ring

Simple_Adding_Machine.vi
File Edit Operate Tools Browse Window Help
SIMPLE ADDING MACHINE

Align Horizontal Top   Align Horizontal Center   Align Horizontal Bottom

Align Vertical Left   Align Vertical Center   Align Vertical Right

Multiple_Shift_Ring_Example.vi *
File Edit Operate Tools Browse Window Help
Indicator 1
Indicator 2
Indicator 3
Indicator 4

Automatic Cleanup

Answer
Base

Height
2

Base   Answer
2
Height

Wiring

Cableicon: Draw from terminal to terminal

Ctrl Terminal   Divide Function

The cable follows, when the control is moved.

Ctrl Terminal   Divide Function

Dashed Line (Bad)

Whole Line (Good)

Ctrl + B

Remove "Bad wires" (disconnected ends etc.)

5

Good shortcuts

Ctrl + T
Front panel → Left
Block Diagram → Right

Ctrl + R
Run VI

Ctrl + E
Chagne between Front panel and Block Diagram

Ctrl + H
Show context dependent help

Ctrl + B
Remove "Bad wires"

Ctrl + træk
Move elements

Right click node terminals — Shortcut for making constants, indicaters etc.

LabView Interface
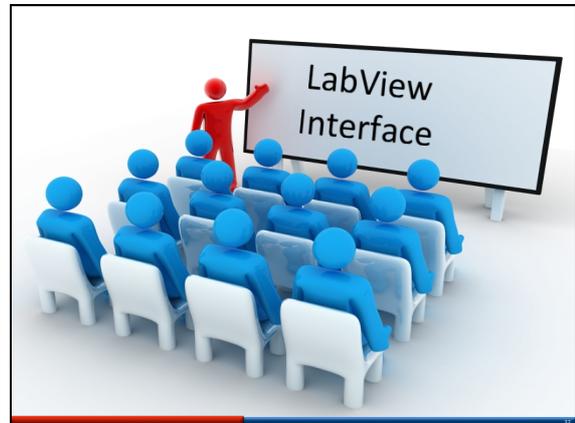
LabVIEW Data Types

Debugging

Debugging tools

Execution Highlighting Button

Retain Wire Values Button

Step Over
VI runs from node til node
Nodes blink when running

Step Into
Step into loop or sub VI

Step Out
Step out of loop orsub VI
Ends VI

- Click on running wires =
  - Probe
- Right-click on wires
  - Breakpoints

1.1 LabView Basics Exercises

- Instructions at sttvi.samle.dk
- 1.1.1 – Calculator
- 1.1.2 – Temperature
- 1.1.3 – Temperature Conversion
- 1.1.4 – Temperature 2

Loops

Loops

- While Loop
  - Terminal counts iterations
  - Will always run at least once
  - Runs until STOP condition is fulfulled
- For Loop
  - Terminal counts iterations
  - Runs until N is reached
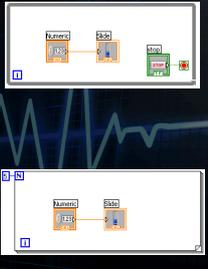
Loop drawing
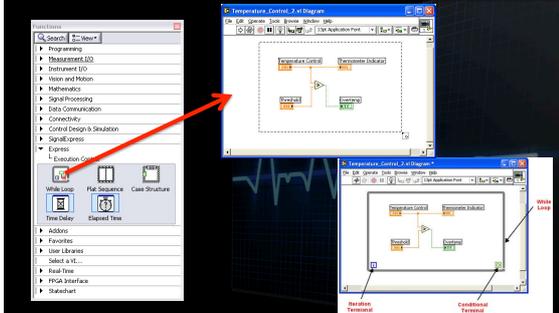
Loops on the Temperature VI
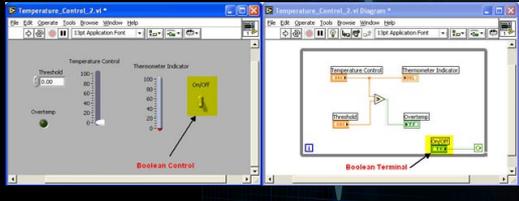
## Which is the While Loop?

1.

2.

100%

0%
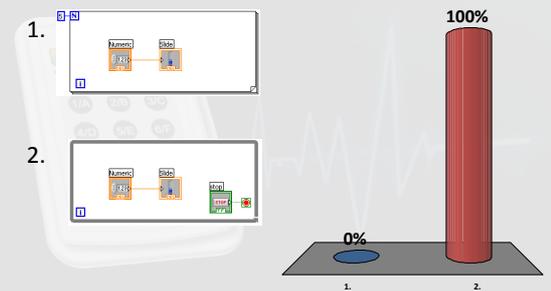
1.2 Loop Exercises

- 1.2.1 – Temperature 3
- 1.2.2 – Temperature 4
- *1.2.3 – Time to Match
  *Asterisk = Optional
 Do the exercise if you have time
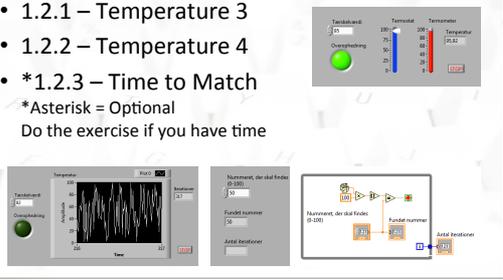
Charts / Graphs
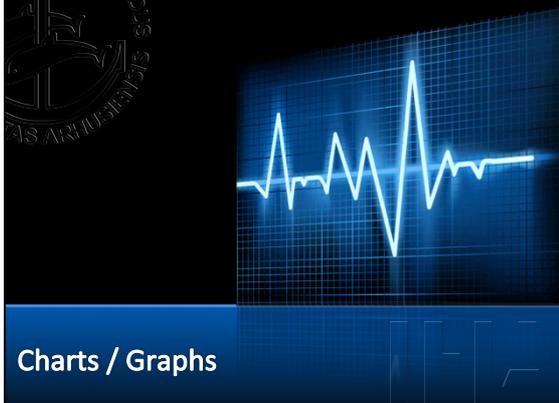
Waveform Charts

- Numerical indicator
  - One or more Scalar plots
- Usually within loops
- Y is data, X is time
- Y and X can be scaled
 - Automatically
  - Manually
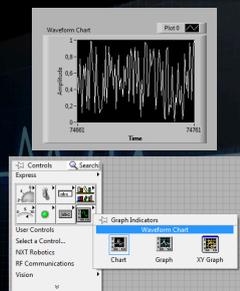
Waveform Charts Updating

- Strip Chart
  - Like paper strip
  - Data scrolls to the right, when it reaches right side, old data are pushed out to the left
- Scope Chart
  - When data reaches right side, the display is blanked and the plot restarts
- Sweep Chart
  - Like the Scope Chart, but instead of blanking the display, a vertical line is shown drawing the data
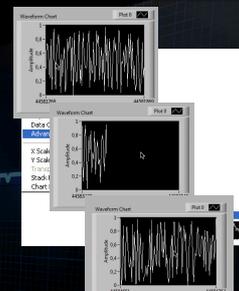

Multiple data in Waveform Charts

- Cluster
  - Collection of scalar data
  - Bundle function
    ~Collecting phone wires into a cable
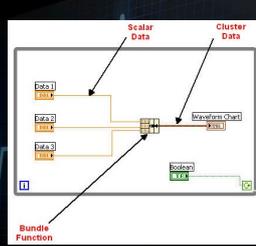

Control and Indicator Properties

- Right click control/ indicator
  - E.g. on properties, which can be modified
    - Size
    - Color
    - Plot style
    - Plot color
    - Axes
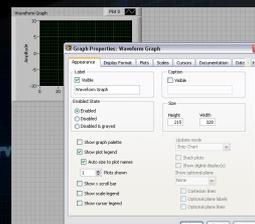
1.3 Charts/Graphs

- 1.3.1 – Signal Processing
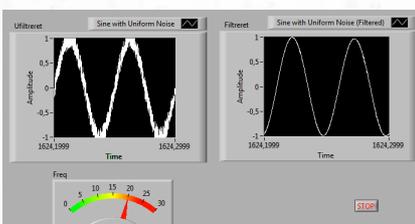
Registers

Shift Registers

- Variables
  - Transferred between loop iterations
  - Terminals on either vertical end of loop
  - After each iteration the value is saved to the right
  - At the start of the next iteration: Transferred (shifted) to the left terminal
    - Ready for the next iteration

Creating Shift Registers

Adding additional shift registers
- Right click existing
- Add Element

After running the program, what will be displayed on top?

After running the program, what will displayed at the bottom?

1.4 Shift Registers

- 1.4.1 – Temperature with Running Average
- 1.4.2 – Dice Throws

Arrays

Arrays

- Arrays are collections of data elements
  - Like a table
- All datatypes can be part of an array
  - Numerical, boolean, text, cluster, controls
  - But they must all be the same
- Can be 1-n dimensional

Index and values

- LabView arrays are 0-indexed
 - So the first cell is no. 0, the next no. 1 and so forth

Index	0	1	2	3	4	5	6
Værdi	1.2	1.1	2.5	7.9	8.2	9.0	3.1

Index	0	1	2	3	4	5	6
0	1.2	1.1	2.5	7.9	8.2	9.0	3.1
1	5.8	3.8	4.4	6.9	2.7	6.4	7.2
2	1.3	9.2	5.7	9.4	3.2	4.9	4.2
3	3.4	7.8	8.2	2.4	5.9	6.8	3.4

Auto-indexing

- When values are drawn across loops, they are auto-indexed

-

- You can disable/enable this by right-clicking the node
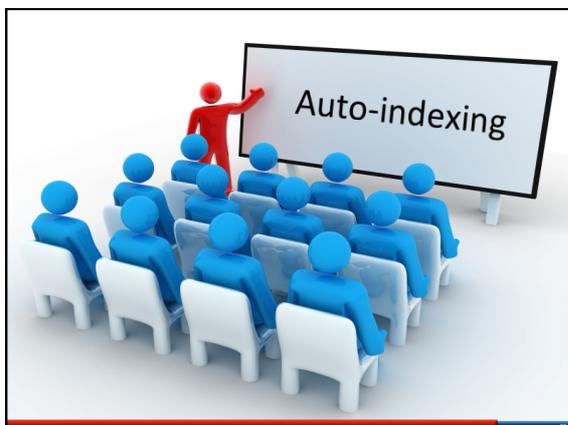
Array Functions (Block diagram)

Array Functions (Block diagram)

Index Array

Returns the value at the index

n-dimension array
index 0
index n-1 → element or subarray

Array Subset

Returns a subset of the array

Array 1 2 7 3 2 5 8
Index 2
Length 4 → 7 3 2 5 Array Subset

Array Functions (Block diagram)

Replace Array Subset

Replaces array subset with new values

n-dimension array
index 0
index n-1 → output array
new element/subarray

Insert Into Array

Inserts element/row/column

n-dim array
index 0
index n-1 → output array
n or n-1 dim array

Control Arrays

- Array af controls
  - Numerical inputs/indicators, LEDs etc.

Control Arrays
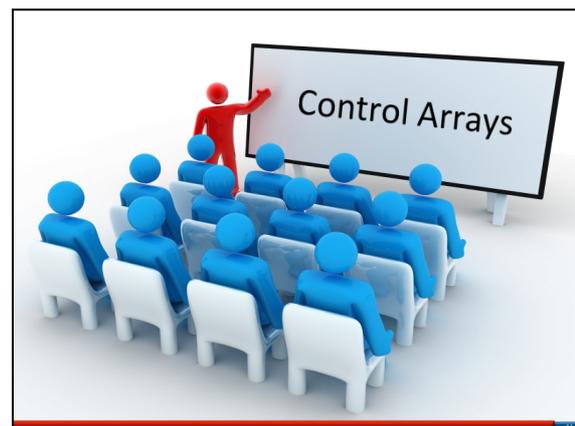
1.5 Arrays

- 1.5.1 – Dice throws 2
- *1.5.2 – Random LED