Software for measurement systems
CHRISTIAN ANTFOLK

Structure of a measurement system

<table>
<thead>
<tr>
<th>Physical quantity</th>
<th>Measurement system</th>
<th>Presentation (and control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pressure</td>
<td>Signal conditioning</td>
<td>Graphical programming</td>
</tr>
<tr>
<td>temperature</td>
<td>DAQ-cards</td>
<td>LabVIEW</td>
</tr>
<tr>
<td>speed</td>
<td>Bus control of instruments</td>
<td>Agilent VEE</td>
</tr>
<tr>
<td>angular velocity</td>
<td></td>
<td>DASYlab</td>
</tr>
<tr>
<td>luminosity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>force</td>
<td></td>
<td>Textual programming</td>
</tr>
</tbody>
</table>

- Graphical programming
  - LabVIEW
  - Agilent VEE
  - DASYlab
- Textual programming
  - LabWindows CVI
  - Measurement Studio
  - Visual Basic
  - Visual C/C++
  - Matlab

Lund University | Faculty of Engineering | Dept. of Biomedical Engineering
Which is which….

- LeCroy HDO6000 oscilloscope
- 2.5 GSa/s
- 12-bit resolution
- Intel core i5
- Windows Embedded
- Can run MATLAB
- Real time MATLAB functionality through XDEV

Dedicated SW & HW
The role of SW

- Communication with the operator
  - Presentation, control, storage
- Communication with the instrument
- Communication with other applications
- Processing of measurement data
Software planning

• Programming language
  – C/C++, Java, Python, Graphical (LabVIEW, Keysight VEE)
• OS
  – Windows, Linux/Unix, MacOs
• User interface
  – What is the use? Only control, logging only, other?
• Driver availability?
  – Are there drivers available for the programming language chosen?

Programming languages

• Text-based
  – Eg. Visual C++, Visual Basic, LabWindows CVI, Python, Java
• Graphical
  – LabVIEW, Keysight VEE, DASYlab
How big is LabVIEW?

- NI: revenue of ~1 billion USD, ~7000 employees
- Mathworks: revenue of ~0.75 billion USD, ~3000 employees
- Keysight (was Agilent (was HP)): revenue of ~3 billion, ~10000 employees

LabWindows CVI

- C for Virtual Instrumentation (CVI)
- ANSI C Integrated Development Environment (IDE)
- Build distribution for installation and use on another computer
LabWindows CVI

Measurement Studio

- Measurement Studio is a suite of tools and class libraries for .NET
- Build measurement applications using Visual Studio
- Visual C# and Visual Basic .NET
Keysight VEE

1. Design "Waveform" block
   Use this to generate waveforms for testing.

2. Design "Analog" block
   Use this to create analog signals for testing.

3. Design "Fixed" block
   Use this to set fixed values for testing.

4. Design "Output" block
   Use this to output signals for testing.

5. Design "Inhibit" block
   Use this to inhibit signals for testing.

Lund University | Faculty of Engineering | Dept. of Biomedical Engineering
Keysight VEE

[Image of a graphical user interface for Keysight VEE]
Software demos

DIY Measurement system

• EMG (electromyogram) acquisition board
• Computer running VC++ application
• SmartHand project
Schematic

Actual PCB
Program code for microcontroller

- IAR IDE, C-code

```c
#define...

// Function: void delay(unsigned int n)
void delay(unsigned int n) {
    unsigned int i, j;
    for (i = 0; i < n; i++)
        for (j = 0; j < 10000; j++)
            delayT();
}
```

Program

- Programmed in VC++

![Image of hand with medical equipment]
Classification scheme

- knn-classifier (EMG data "mapped" to glove joint angles)

Video
Arduino DAQ

- Demonstration