Description of the remote UTC WebLaboratory for engineering education and interactive demonstration by online experiments

University of Applied Sciences Darmstadt (h_da) collaborating with the WebLab
University of Tennessee at Chattanooga (UTC)

http://www.eit.h-da.de  http://chem.engr.utc.edu

http://www.eit.h-da.de/studieninteressierte-eit/international-master-electrical-engineering/index.htm
But first, **Who are these people?**

Robert F. Curl, Rice University

John B. Fenn, Princeton & Yale
Brief History

History of collaborations

Samples – Batch and Interactive

Design Guidelines

Collaborations

Specific Collaboration with Hochschule Darmstadt
Brief History -- Chemical & Controls

1995 — First System, Batch Control experiments

1995 — 2000 — Six additional Batch Control Systems

2001 — Interactive system, Distillation

2001 — 2010 — Ten additional Interactive Systems
Brief History -- Mechanical

2001 – 2006 – Three Interactive Systems

Working with Dr. Charles Knight
Batch is sharable in near-real time and historically (with team-mates and instructor)

<table>
<thead>
<tr>
<th>Experiment ID</th>
<th>Voltage constant</th>
<th>Time(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(49137)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.181</td>
<td>75.000</td>
<td>0.442</td>
</tr>
<tr>
<td>0.193</td>
<td>75.000</td>
<td>0.546</td>
</tr>
</tbody>
</table>
Usage in past 6 years
• ~50,000 total experiments
• ~25,000 “complete” experiments
• ~4,000 from Diponagoro
• ~900 Koeln Applied Sciences
• ~800 Darmstadt Applied Sciences
• ~600 MIT
• ~300 UEM Resita, Romania (Ioan Ruja)
Interactive is sharable in real time and historically (with team-mates and instructor)
Design Guidelines

- Broadly available (HTML where feasible)
- Multi-lingual
- 24/7/365
- Safety – inherently stable
- Low cost or bartering
Remote Control of the Batch Reactor-Model: www.szacher.de

Collaborations
- U. Sydney, Med School
- U. Tennessee Space Institute
- Dipanogoro U.
- U. Pittsburgh
- Washington State U.
- Köln University of Applied Sciences
- U. Illinois-UC
- Yerevan Armenia
- ISS
- Thu 1 Jul / 11:06 PM for 2 minutes
- International Space Station/Boeing
- Houston

UTC LabVIEW Payload Software

Boeing/UTC EXPRESS Payload Simulator Monitor

Ground Station
Collaborations

• U. Sydney, Med School
• U. Tennessee Space Institute
• Dipanogoro U.
• U. Pittsburgh
• Washington State U.
• Koeln University of Applied Sciences
• U. Illinois-UC +
• Rochester Poly +
• Zacatecas Mexico +
• Yerevan Armenia +
• UEM Resita Romania +
• Darmstadt University of Applied Sciences +
• International Space Station/Boeing +
Remote Control of the Batch Reactor-Model

MSE Team-Project
of the University of Applied Sciences Darmstadt (h_da)
co-operating with the WebLab
of the University of Tennessee at Chattanooga (UTC)

http://www.eit.h-da.de  http://chem.engr.utc.edu

http://www.eit.h-da.de/studieninteressierte-eit/international-master-electrical-engineering/index.htm
The task of the project is to design and to realize the temperature cascade control of the batch reactor-model.

The engineering will be done by three groups:

- **UTC WebLab, Tennessee**: Remote Control
- **UTC WebLab, Tennessee**: Remote Experiments
- **h_da Darmstadt**: Model of Reactor

**Group X**
- **UTC WebLab, Tennessee**: Remote Control
- **h_da Darmstadt**: Main-loop design

**Group Y**
- **UTC WebLab, Tennessee**: Remote Experiments
- **h_da Darmstadt**: Inner-loop Design

**Group Z**
- **h_da Darmstadt**: Control and SCADA
The purpose of the project is the **data exchange and remote experiments**.
Project Group:

Group X:
Ashish Kanadia  
Chetan Gobbur  
Virag Metha

Group Y:
Hashim Ali  
Sagorika Roy

Group Z:
Danijel Marinovic  
Michael Augart  
Kaushal Shah

Project Manager:
Adrien Hansel

Supervisor of the project:
Prof. Dr.-Ing. Serge Zacher, h_da, Darmstadt

Supervisor of the UTC Weblab:
Prof. Jim Henry, Univ. of Tennessee, Chattanooga
The group Y is getting experiments values from the UTC WebLab. From this results they get the transfer function of the inner loop. They send the result to the groups X and Z.

After wiring the PLC, the group Z were programming the level and temperature control and get the step responses from the reactor. They send the step responses to the group X.

After receiving the inner loop transfer and the step response, the group X calculated the transfer function of the plant. They develop the main PID controller and simulate the whole loop with LabVIEW. It is supposed to send the results to the UTC-project group.
Results

- Group X
- Group Y
- Group Z
Group Y: Identification of the inner loop

Identification of the motor-drive in UTC WebLab

The transfer function of valve position controller

\[ G_{v1}(s) = \frac{K_{pv1} (1 + sT_{v1})}{1 + sT_R} \]

The transfer function of the valve with drive

\[ G_{r1}(s) = \frac{K_{pv1}}{1 + sT_1} \times s^{-sT_2} = \frac{K_{pv1}}{(1 + sT_1) \times (1 + sT_2)} \]
Group Y: Remote experiment http://chem.engr.utc.edu/

Determining the step responses from the UTC Weblabor by remote experiments
Define the length of the experiment, configure the panel and run the experiment.
Group Y: Identification and modelling

Using Matlab the transfer function of the plant $G(s)$ and the parameters are defined.

The result will be send to the group X and the group Z.
Group X: Side Studies: Implementation Approach for Labview

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Group X: Simulation of Cascade Control

The result are supposed to be send to the UTC as a LabVIEW-Application; actually the results are send to the group Z.
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Group Z: PLC Programming

PLC Software Architecture

- Program is separated in Function Block Diagrams (FBD)
- Few reusable parts programmed in Function Blocks (DFB)
- One FBD for each Use Case (UC)
- FBD 5&6: Cascade Control with controller parameter values from Group X
- Commissioning with the help of GUI

<table>
<thead>
<tr>
<th>PLC SW Architecture</th>
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<tbody>
<tr>
<td><strong>FBD 1: Operation Mode</strong></td>
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<tr>
<td><strong>FBD 2: Manual Operation Mode</strong></td>
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<tr>
<td><strong>FBD 3: Level Control</strong></td>
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<tr>
<td><strong>FBD 4: Temperature Control Commissioning</strong></td>
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<td><strong>FBD 5: Temperature Control (Main loop)</strong></td>
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<tr>
<td><strong>FBD 6: Temperature Control (Inner loop)</strong></td>
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Group Z: GUI Development

• Programming the GUI in NI Lookout Software
• PC is connected via RS 232 to the PLC
• Addressing and defining of variables to be used in the GUI
• 3 UC’s are defined in the requirements
  • ->2 main functional parts = PLC display + monitoring display
  • ->1 additional/auxiliary part = commissioning i/o
Group Z: GUI Development

PLC Display
- Shows the states of all PLC inputs and outputs
- Interface for the operator: Buttons Start/Stop and manual operating functions
- Desired temperature is set by simulation model via potentiometer

Monitoring display
- Displays continuously the changing of all system variables
- Tool for observing control loop behavior while commissioning, maintenance and operation
Batch reactor visualization
- Displays the state of each component of the batch reactor
- Open/closed valves by different colors
- Filling level of reactor
- Heating function
- Mixer motor function

Commissioning i/o
- Changing / testing values while commissioning and maintenance

Level Control:
- Desired value for reactor level
- Level control only via GUI
THANK YOU!

Tack!

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FUTURE

Available through
iLab
Lab2go

Real Labs Experiments soon in
Darmstadt, Germany
Zacatecas, Mexico
Yerevan, Armenia
Resita, Romania

Free Offer
Acknowledgements

Dr. Serge Zacher & students
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Many students
Many other colleagues