

WALC-Web Assisted Laboratory for Control Engineering on-line Education
Laboratório Assistido pela Web para o Ensino de Engenharia de Controlo


WALC - Web Assisted Laboratory for Control Engineering on-line

(Apoio no ensino a distância para a o ensino de Engenharia de Conrolo)

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UISPA, Unidade de Integração de sistemas e Processos Automatizados, FEUP, 13 Feb 2009

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Motivation and Objectives

- Need for new methodologies to interact with students, improve students' activity of learning and, helping to reach with success his university degree.
- Provide an enriched computing environment for students' sharing results and collaborations.
- Following the current e-learning evolution path based on a user-centric model: *“Establishment of a form of education that goes beyond course and curriculum centric models and envisions a learner-centred and learner-controlled model for lifelong learning”* (Chatti et al., 2007)

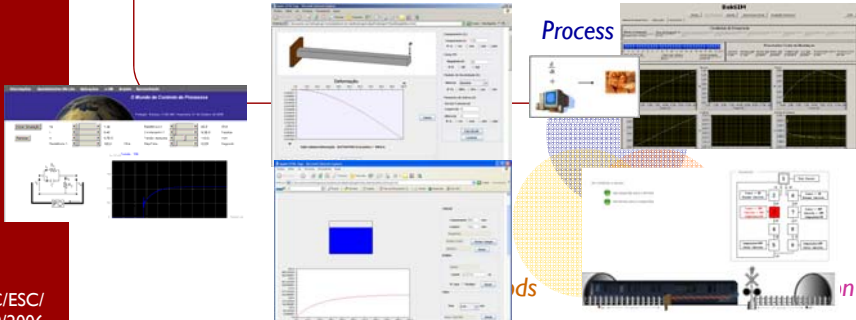
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Brief history

1. In the past: different web-aided applications for undergraduate students: numerical methods and process control (Leão & Soares, 2006)



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2. Currently: **virtual laboratory** (SimLab) for the simulation and modeling of real world problems in process control engineering is being developed.

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Virtual Laboratory – SimLab

SimLab
Laboratório Virtual de Controlo

Home Métodos Numéricos Controlo Simulador/Sistemas

Sistemas

- Home
- Hidráulicos
- Térmicos
- Mecânicos
- Eléctricos

Fundamentos teóricos

Métodos numéricos

Controlo

Bem vindo ao SimLab: Laboratório virtual de Controlo

Simulações

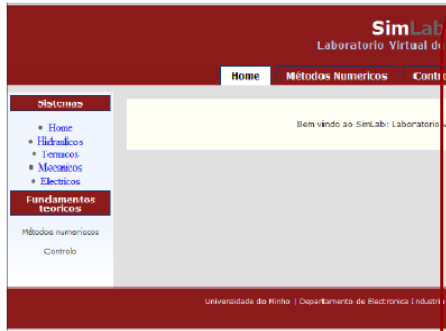
- Simulação 1
- Simulação 2
- Simulação 3

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Main web page for Control Simulator

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Virtual Laboratory – SimLab

SimLab
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- Virtual simulation of different real world systems:
 - Electrical
 - Hydraulic
 - Thermal
 - Mechanical
 - ...
- Open or close loop modes
- On-line change of process and control parameters
- Several numerical methods to solve the defined systems of ODEs
- Theoretical support

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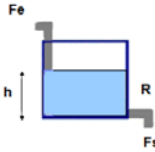
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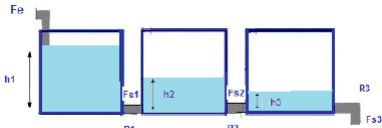
SimLab

$$\text{level variation}() = \frac{1}{A} (\text{InletFlows}) - \frac{1}{A} (\text{OutletFlows})$$

Hydraulic problem examples:
 level control problem in a tank



In a system with three tanks



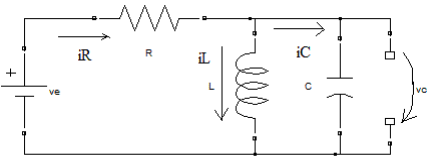
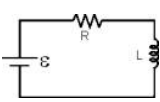
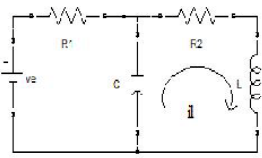
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Electrical problem examples:
 RLC circuit


$$\frac{df_2}{dt} = \frac{e}{L} - \frac{Rf_2}{L}$$

$$\begin{bmatrix} \frac{dv_0}{dt} \\ \frac{df_2}{dt} \end{bmatrix} = \begin{bmatrix} -\frac{1}{RC} & -\frac{1}{C} \\ \frac{1}{L} & 0 \end{bmatrix} \begin{bmatrix} v_0 \\ f_2 \end{bmatrix} + \begin{bmatrix} \frac{1}{RC} \\ 0 \end{bmatrix} v_2$$

$$\begin{bmatrix} \frac{dx_1}{dt} \\ \frac{dx_2}{dt} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ \frac{R_1}{R_1 CL} & -\frac{1}{R_1 CL} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{R_1 CL} \end{bmatrix} u$$

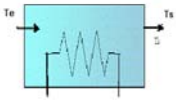
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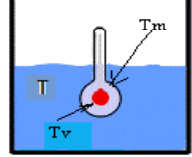
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SimLab






Thermal problem examples:

$$\frac{dT_c}{dt} = \frac{P}{C_T} + \frac{C_p Q T_c}{C_T} - \frac{C_p Q T_c}{C_T}$$

$$\begin{bmatrix} \frac{dT_c}{dt} \\ \frac{dT_m}{dt} \end{bmatrix} = \begin{bmatrix} -\left(\frac{1}{R_{T_c} C_{T_c}} + \frac{1}{R_{T_{12m}} C_{T_c}}\right) & \frac{1}{R_{T_{12m}} C_{T_c}} \\ \frac{1}{R_{T_{12m}} C_{T_m}} & -\frac{1}{R_{T_{12m}} C_{T_m}} \end{bmatrix} \begin{bmatrix} T_c \\ T_m \end{bmatrix} + \begin{bmatrix} \frac{1}{R_{T_c} C_{T_c}} \\ 0 \end{bmatrix} T$$

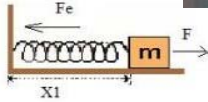
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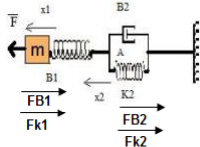
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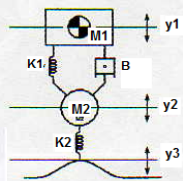


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SimLab







Mechanical problem examples:

$$\frac{d^2x}{dt^2} = -\frac{B}{M} \frac{dx}{dt} - \frac{k}{M} x + \frac{1}{M} F.$$

$$\Sigma F = m \times a.$$

$$\begin{bmatrix} \frac{dx_1}{dt} \\ \frac{dx_2}{dt} \\ \frac{dx_3}{dt} \\ \frac{dx_4}{dt} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -\frac{K1}{M1} & -\frac{B}{M1} & \frac{K1}{M1} & \frac{0}{M1} \\ 0 & 0 & 0 & 1 \\ \frac{K1}{M2} & \frac{B}{M2} & -\frac{K1}{M2} & -\frac{K2}{M2} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} + \begin{bmatrix} 0 \\ -1 \\ 0 \\ -1 \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \begin{bmatrix} F \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

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ON - OFF controller

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Diagram block for PID controller

$$u(t) = Kp \left(e(t) + \frac{1}{Ti} \int e(t) dt + Td \frac{de(t)}{dt} \right)$$

Velocity algorithm:

$$u_{(k)} = u_{(k-1)} + Kp \times (e_{(k)} - e_{(k-1)}) + Ki \times e_{(k)} + Kd \times (e_{(k)} - 2 \times e_{(k-1)} + e_{(k-2)})$$

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SimLab – user interface

Conceptual e-learning platform view

The screenshot displays the SimLab control simulation interface. It includes a parameter configuration panel on the right with sections for 'Parâmetros do Sistema', 'Tipo de simulação', 'Tipo de controlador', 'Parâmetros Do Controlador PID', 'Tipo de Algoritmo PID', and 'Método Numérico'. A small 3D model of a cart on a track is visible on the left. Below the parameters is a graph showing 'Altura (m)' on the y-axis (0 to 150) and 'Tempo (s)' on the x-axis (0.0 to 8.0). The graph shows a blue curve that rises from 0 and levels off at approximately 50 meters. The text 'Reiniciar Simulação' and 'Continuar' is visible at the bottom of the parameter panel.

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SimLab – user interface

Conceptual e-learning platform view

This screenshot shows the same SimLab interface as above, but with a different graph. The graph area is mostly empty, with only a small blue line at the bottom. The parameter configuration panel on the right is identical to the first screenshot, showing the same settings for system parameters, simulation type, controller type, PID parameters, algorithm type, and numerical method.

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2. Currently: **virtual laboratory** (SimLab) for the simulation and modeling of real world problems in process control engineering is being developed.
3. **others activities**

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Didactic Kits



I – Crossroad traffic light management

Automobiles can only circulate in one direction.
Pedestrians can use whichever zebra crossing they choose, as long as they activate the green button, to ask permission for crossing the road.

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Didactic Kits




II – Contest queue management system


Control system for a contest queue management system, used in a public competition hold at the University of Minho.

This public competition, the promotion of the School of Engineering, involved four groups of pupils of different schools, from secondary to professional.

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Learning Activities of MN and PC courses







Set-up of the experiment
"Intelligent House"

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Learning Activities of MN and PC courses



Several features:
staircase illumination,
alarm intrusion,
automatic internal illumination
and entrance door opening
control

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Learning Activities of MN and PC courses

The program developed in LabVIEW also permits the remote control of the IH through the visualization by a WebCam (Trust, 120 Spacecam). The set-up has a camera for viewing and monitoring, and is designed to provide to students real-time experiments via the Internet.

Basic scheme of the remote lab for the IH

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Learning Activities of MN and PC courses


Remote Control of an "Intelligent House"

The needed Webcam drivers were installed in the computer.

The IH controls permits the publication of the IH on the Internet.

Lab View front panel and block diagram Interface of the Webcam for monitoring and remote control of the IH.

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2. Currently: virtual laboratory (SimLab) for the simulation and modeling of real world problems in process control engineering is being developed.
3. **In present:** specification of an e-learning platform that follows the principles of a social network.

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Web 2.0 principles overview

- WWW is emerging as a platform where users control their own data.
- Web 2.0 websites allow users to do more than just retrieve information:
“personal web pages are turning into blogs, encyclopaedias into wikis, publishing into participation (...)” (O’Reilly, 2007)
- Web 2.0 services engage users. They apply user participation to produce better results and become more attractive.

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E-learning 2.0 environment features

High-level requirements that should be met by our social platform:

1. Personalisation;
 - Students should be able to construct their own learning process.
2. User as contributor;
 - Students publish their work: exercises and experiments results, pointers to different types of documents.
3. Integration and search of distribution content;
 - Provides a means for students integrate, remix and made content available to other students.
4. Rich user experience;
 - Enables the integration of different social network platforms: YouTube, Flickr, ...
5. Synchronous and asynchronous interaction.
 - Communication as a very important tool in students learning process.


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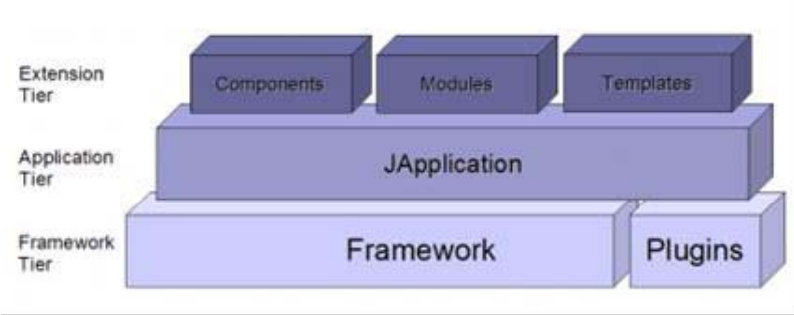
Platform specification and implementation overview

Conceptual e-learning platform view

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Platform specification and implementation overview



Extension Tier: Components, Modules, Templates


Application Tier: JApplication

Framework Tier: Framework, Plugins

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Joomla content management system reference model
(<http://demo.joomla.org>)

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conclusions & future work

- Present our motivation for the design and implementation of a user-centred, dynamic and shared Web site to support the learning activities for university students.
- Tools developed by students for students.
- Multidisciplinary project building the bridge between MN and PC (apparently with no relationship)

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conclusions & future work

- Web 2.0 principles have been successfully applied to the e-learning environment and we have achieved a set of requirements.
- In the near future, the implementation of this platform will be validated by students.
To study how students use the system and how will they appropriate the available functionalities.

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thank you for your attention

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