Control Systems Engineering Group

Prof. Dr.-Ing. Helmut Hoyer

Universitätsstraße 27
58084 Hagen

Phone: +49-(0)2331-987-1100
Fax: +49-(0)2331-987-354
E-Mail: helmut.hoyer@fernuni-hagen.de

Academic staff:

Dipl.-Ing. Andreas Bischoff -1105
Dr.-Ing. Ulrich Borgolte -1106
Dr.-Ing. Michael Gerke -1107
Dipl.-Ing. Ivan Ivanov -1117
Dipl.-Ing. Dimitrios Lepentsiotis -1192
Dipl.-Ing. Ivan Masar -1117
Dipl.-Ing. Christof Röhrig -1102
Multiuser Virtual Reality based learning environment

Andreas Bischoff

To provide a learning environment to a group of students, a virtual reality based 3D-chatroom was realized.

A well known seminar room of the University of Hagen was modeled in VRML. This virtual room is equipped with a virtual beamer and screen, to render a live audio/video stream (e.g. a lecture) or the desktop of a shared computer. The introduced multi-user virtual reality seminar environment [1] consists of the underlying DeepMatrix [5] Java-based client-server system, an interface to the existing ‘virtual-university’-user-database of the University of Hagen, a streaming video application (Real-Server, Real-Producer [2]) and the open-source ‘Virtual Network Computing’ (VNC)-tool.

All the remote users are represented by realistic human avatars. Every user is able to control gestures of the personal avatar. Some of these avatar-gestures are especially adapted to a typical classroom situation, e.g. ‘put one’s hand up’ and ‘point to’, to provide non-verbal communication to all users. Today’s VRML-browsers like Blaxxun Contact [3] and Parallelgraphics Cortona [4] are able to display Real-live-stream inside the VRML-world, if the Real-Player is installed onto the client-computer. So the streaming video could be used as a video-beamer application inside the modeled VRML-room.

To provide the users with a whiteboard a universal solution was selected. Not only Presentation-software like PowerPoint is frequently used to explain topics to a group of users. In different disciplines user-groups need different software-tools, or operating systems during seminar events. A universal solution is the remote control of a shared PC, simultaneously useable for all participants.

LDAP directory server access for user authentication in 3D- learning environments

Andreas Bischoff

To provide a learning environment to a group of students, a virtual reality based 3D-chatroom for seminar-like events was realized [1].

The communication middleware is based on the open-source (a special license, free for educational usage) VRML-Multi-User-Software DeepMatrix which implements its functionality by Java-VRML coupling via the EAI. DeepMatrix itself is a pair of client and server software implemented in Java [2]. The server is implemented as a Java application which communicates with all clients and provides them with updates of the 3D-scene. The client applet controls the local VRML-browser-plug-in via the EAI to update the scene (the positions of other avatars) and senses the local user movements to send new positions to the server.

Figure 1: User avatars with real-names from LDAP

Seminars at the University of Hagen are usually part of an examination, so an authentication procedure is required. The DeepMatrix-client-server system is initially intended for anonymous 3D-chat. Nevertheless the open-source distribution of the DeepMatrix allows modifications to the Java-sourcecode to provide a connection to the existing LDAP-directory service at the University of Hagen. This modification is very convenient for the users because no extra passwords and administrational effort is necessary. LDAP, the Lightweight Directory Access Protocol was proposed in 1995 (RFC 1777) as an open standard for directory services on the Internet. The virtual university environment of the university of Hagen [3] (platform 2001) is based on LDAP.

The user authentication names for students of the University of Hagen are usually numbers. To provide a convenient interface for the learning group and the tutor, real names of the user are also fetched from the directory server database.


[3] https://vu.fernuni-hagen.de/
For handicapped persons, there are situations where it is desirable to have a device that tracks and follows the user. Potential users are arm amputees, or frail persons which should walk on crutches. But able-bodied customers, e.g. in super markets, may profit from such a system as well.

At the current stage, the system is a test bed for different sensorial interaction modes with users. The basic system is a motorised platform with two actuated and four supporting wheels (castors). It is able to follow the user at walking velocity. The sensors for tracking a person are ultrasonic transducers in a stereo mounting.

There are two modes of operating S-Mobil. While in remote control mode, the user is endowed with a special transponder which allows her/him to exchange commands and control information via a bidirectional infrared link. This allows remote start/stop of tracking, as well as remote driving of the system. In tracking mode, the user wears a belt with an active ultrasonic transmitter. This device is detected and tracked by the transducers of S-Mobil. The software computes distance and direction of the belt and controls S-Mobil to follow the user at a pre-defined distance.

To avoid collisions with objects or other persons, there is a second ring of ultrasonic sensors on S-Mobile. As the system is not autonomous (i.e. it is always guided by the user), collision avoidance with fixed objects (e.g. walls) is done by modifications of the path, while avoidance with moving objects (e.g. other persons) in general is done by altering the velocity.

If the contact between belt and S-Mobile is broken (e.g. if the system can not keep up with the speed of the user, or if an obstacle hides the belt) S-Mobile will slow down up to standstill and wait for the contact to come up again.


Our control systems engineering group at the FernUniversität Hagen contributed to the ‘3rd Mission’ exhibition in the state government building in Duesseldorf, Northrhine-Westfalia. The focus of our exhibit was the ‘Virtual Lab(oratory)’, which is a major component of the on-line learning environment of our university. As an eye-catcher a remotely controlled blimp (airship) traveled in the airspace above our exhibit site. This flight experiment could be radio controlled from a computer system on our site with the help of an on-board video camera and a web browser including video and control applets. At the same time these flight manoeuvres could be observed directly to illustrate the feasability and basic principles of Internet-based lab experiments. During this exhibition on-line experiments with our real laboratory systems in Hagen were demonstrated via remote Internet access. The following laboratory systems are available: a mobile robot platform used for experiments in controller design and a model railroad used for education in PLC programming. Other Internet-based lab experiments are currently under development in our research group.

Figure 1: The blimp experiment

In the near future the blimp system will be used for Internet-based practise in control systems engineering and in different research areas including visual servoing and gyro servoing.


Virtual Laboratory for Real-Time Control of Inverted Pendulum/Gantry Crane

Ivan Masar, Ivan Ivanov, Michael Gerke, Andreas Bischoff, Christof Röhrig

This lab is one part of our contribution to the project ‘LearNet’, in which several German universities collaborate for purpose of development of a common platform for learning and experimentation in control theory. This project will finish in 12/2003, but we expect first students testing our lab as early as in summer term of this year.

Our new virtual lab allows students to control the inverted pendulum/gantry crane system. The ability of this system to provide interesting and dramatic experiments makes it very attractive for users. Another advantage is the possibility to exploit various control techniques to control this system (PID controllers, fuzzy logic, state-space methods, etc.) and thereby to provide to students their comparative study.

The components of the lab are depicted in Figure 1. The inverted pendulum/gantry crane system is a triaxial system which consists of the gantry moving in x-axis and the pendulum/crane system placed on it. Control algorithms are generated by Real-Time Workshop/xPC Target toolboxes that extend the capabilities of the Matlab/Simulink software package. In our case, the real-time applications run on the target computer (xPC Target), while their development is done on the host computer. The xPC Target Server implements the interface with the user and operates the Target PC. Because of the safety requirements, the students can only choose appropriate control algorithms and set-up the parameters of the controllers and set-points. The xPC Target Server loads the corresponding application with the new parameters to the Target PC and starts the experiment. During experimentation, the user can observe the lab by means of a camera (live video stream is provided by Multimedia Server, developed at the cooperating Ruhr-University in Bochum), and the server sends also the real-time data from the Target PC.

Graphical representation of the time series as well as GUI for the experimental setup are implemented by Java applets. The third method of the experiment visualisation is a VRML model of the controlled system, animated by using real-time data from the Target PC.

Figure 1: Virtual lab components

Current Waveform Optimization for Force Ripple Compensation of Linear Synchronous Motors

Christof Röhrig

Linear motors are beginning to find widespread industrial applications, particularly for tasks requiring a high precision in positioning such as various semiconductor fabrication and inspection processes. The main benefits of linear motors are the high force density achievable and the high positioning precision and accuracy associated with the mechanical simplicity of such systems.

The main problem in improving the tracking performance of linear permanent magnet motors is the presence of force ripple caused by inaccuracy in commutation of the phase currents by the servo amplifier. Force ripple is an electro-magnetic effect and causes a periodic variation of the force constant. Only if the back-EMF waveforms of the motor phases are sinusoidal, sinusoidal current waveforms generate ideally smooth force.

The proposed compensation method is based on optimized current waveforms which produce minimal copper losses and maximize motor efficiency. The optimal current waveforms depend directly on the waveforms of the back-EMF. They are based on Fourier series approximation and are identified in a closed position control loop.

![Optimized Current Waveforms](image)

Figure 1: Optimized Current Waveforms

The figure shows the optimized current command waveforms which produce smooth force and minimal copper losses.