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Web based system for microscope observation with structural analyzer EPIQUANT

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Introduction

The purpose of the current handwork is developing of a software and hardware system which allows users to manage and observe the structural analyzer EPIQUANT over the Internet.

There have been a number of publications regarding such kind of web based systems for controlling CCTV, power stations, television over Internet, etc in the recent years. The majority of those systems are client-server oriented or server oriented software relaying on dynamic based web pages using PHP, ASP or DOT.NET and additional hardware to control a PC printer port, serial port or another port.

Depending on the requirements for the quality of the image and the bandwidth of the Internet connection video streams or quasi video streams are used.
The interactive control of the hardware is made using abilities of the dynamic web pages.

There are number of problems that need to be solved to achieve the main objective of this project.

- Choosing the Operating system (OS)
- Choosing the Internet Web Server supporting dynamic web pages
- Choosing the Video capturing hardware
- Choosing the Camera
- Software supporting the video capturing device
- Software (dynamic web pages) for displaying the output of the capture device
- The way the image is transferred from the microscope to the client
- Software to secure the web pages from being observed by unauthorized users (using certificates, so users, who don't have a certificate can not view the pages)
- Software (web pages) to create and manage certificates for new users
- Hardware to control the microscope using the printer port of a PC

Structure of the system

1. Windows Server 2003 – Windows Server 2003 comes with a streaming media server (not installed by default) service that can handle the video streaming over the Internet.
    - Pros
        - Very easy installation and configuration using a graphical user interface (GUI)
        - Supports a large number of video capturing devices
        - High level of integration of the video streaming in IIS Server
        - Online and telephone technical support from Microsoft*
    - Cons
        - Very high price

- Windows Server 2003 requires high performance hardware to be installed on and when used for video streaming it requires additional costs for hardware.

2. CentOS – CentOS is an Open Source free cloning of Red Hat Enterprise Server.

   - Pros
     - High security and stability of the operating system
     - Video4Linux module integrated in kernel versions after 2.4.0. This module is used for processing video streaming
     - Minimal requirements for the hardware on which the operation system runs
   - Cons
     - Very few video capturing devices supported
     - Difficult and not user friendly configuration

Having in mind the limited budget of the project for an operating system was chosen the free one – CentOS.

That was the leading fact for choosing an Apache server (also free) for a web server. In order to satisfy the requirements for dynamic web pages the Apache PHP module has been chosen (free license). For a video capturing device has been chosen an ATI All in Wonder because it is supported by the kernel of the operating system.

Apache
The Apache web server supports variety of additional modules. Some of them are of great importance for the project:

- mod_ssl – this module is required for the web server to support the SSL (Secure Socket Layer) Protocol. This protocol is used to establish a secure connection between the client and the server. To compile the Apache web server with that module is required an initial installation of OpenSSL.
- mod_php – this module is required for the web server to support dynamic web pages. Initial installation of PHP is required for this module to be compiled.
- Virtual host support

PHP
PHP is a free language for writing dynamic web pages. Due to its free license PHP is highly supported language with a lot of documentation and scripts written by ordinary users.

Video Capturing Device
For video capturing device is used an ATI ALLinWonder capture card due to the fact that it is made using the BT878 chipset which is supported by the integrated Vide4Linux module in the kernel.

For video streaming through the Internet are used mainly video streams and quazi quasi video streams.
Video streams may be divided in two groups – peer-to-peer and multicast.
In the peer-to-peer video streaming a communication channel is opened between the client and the server and the video stream is being sent to the client in a previously defined format (mpeg3, DVB, RA, etc.) by using UDP packets.

Using this type of streaming, there is only one client that can see the video stream.
Using the multicast type of streaming means that the video stream is being sent to a multicast address (in the range 224.0.0.0-239.255.255.255) of the network. By this type of streaming multiple clients can receive the video streaming.

Having in mind the compression made by video codecs the bandwidth needed to transfer a stream in 320x240 format is 0.5Mbps-4Mbps using MPEG4 compression. Due to the fact that the bandwidth of the university where the microscope is located is 384kbps, this type of streaming is practically carried out. A decision was made that a quasi video streaming should be used.

Using the quasi video streaming a static image (usually in jpeg format) is being visualized in a defined interval (interval would be < 1sec). On the server used for microscopically research (shown at fig.1) were compiled the following modules:

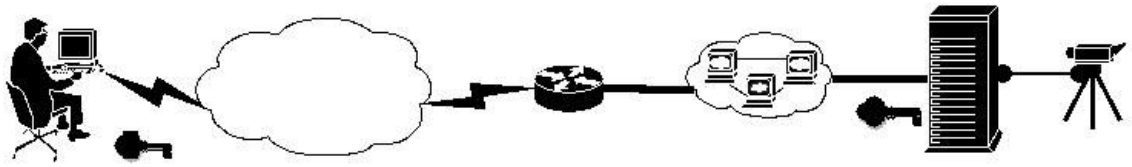


Fig.1

The following modules were compiled on the server used for microscopically research (shown at fig.1):

- CentOS v.4.1 Linux Distribution with precompiled kernel v2.6.9
- Video4Linux module to support the video capture device with BT878 chipset
- XawTV – quasi video streaming application
- Apache web server v2.0.52
- PHP v4.3.9
- OpenSSL v0.9.7a – the OpenSSL package is used for generating digital certificates and for crypting the traffic between the server and the clients so non-authorized clients /without a digital certificate/ can not open the communication channel to the server

As it was said above, the client-to-server connection could be maintained either by an application developed to receive video streams or by using an ordinary web browser (Internet Explorer, Mozilla Firefox, etc.). Using an application could be difficult for a user to configure and deal with the application and the better solution for client software would be an internet browser.

Using an application

Pros

- The application could control more precisely the microscope
- GUI interface

Cons

- The application depends on the operation system used by the user
- It is hard to add new functions to the application
- The application could be difficult to be configured by an ordinary user

Using an Internet browser

Pros

- Every operating system comes with a integrated internet browser

- The internet browser is easily configured

Cons

- Users must install the digital certificate

Software and Hardware Design

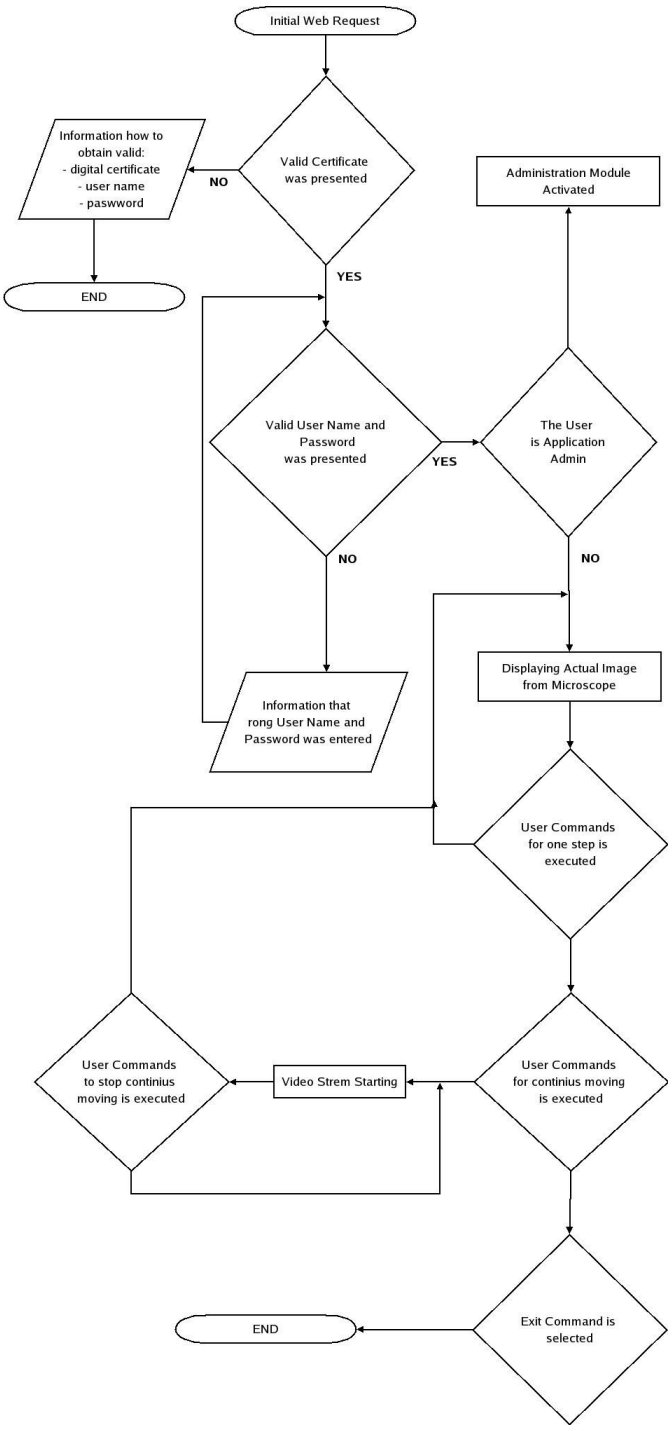


Fig. 2

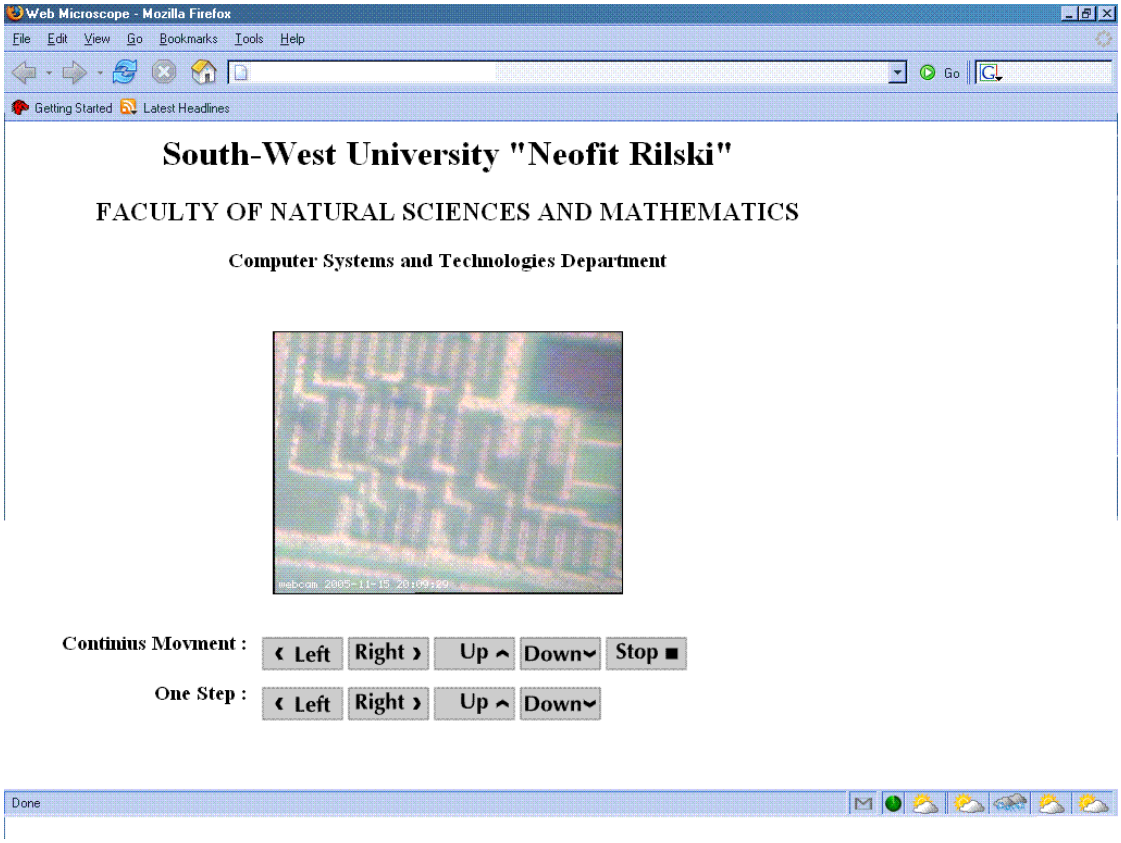
While initiating a connection to the server the clients must authenticate their selves with a password and a valid digital certificate that they should have received from the administrator of the system (fig. 2). If the authentication is not valid in any reason (either because of bad password or invalid or missing digital certificate) the client is being redirected to a web page

with instructions how to obtain a digital certificate or that he has entered wrong password. The purpose of the authentication is so unauthorized person could not observe or control the research.

After a valid authentication a check is made to verify if the client is administrator. If the client is an administrator an administrator's web page is being sent to the client. Using this web page a client with administrative creditentials can create, delete, activate, and deactivate certificates and passwords for other users. If the user is not a administrator of the system, he is sent to a web page divided in two (fig.3). In one of the parts the video stream is shown and in the other part there are control buttons to control the image (to pause the video stream, to play the video stream again) and the microscope. The control buttons for the image were added after a period of testing of the system in the network of the university and in Internet. It seems that a constant refresh frequency is not appropriate for users using low Internet bandwidth because transferring the image time to the client exceeds the refresh time.

If a request to control to the microscope is received the server passes the binary code to the printer port (LPT1) and after the request is processed the new image is transferred to the client. After some experiments the exact time delays were defined for sending the binary number (representation of 1,2,4 and 8 decimal numbers) over the printer port (this numbers are used to control the zoom and the visual area of the microscope).

An application was written to solve the problem for sending the control numbers from the web page form to the printer port. The problem was solved using the opportunity that linux based operating systems use human-writable files to control devices and port of the computer. So the control numbers are being sent to the printer port while writing them on the exact linux device file. The value zero (0) is used to stop the microscope, and the other numbers (1,2,4,8) are used to move the microscope forward, backwards, left and right.



Camera

Several cameras were examined in reference to achieve maximum brightness and contrast of the image and the way the cameras attach to the microscope. The CX-42HP camera has the best results. The device that is used to attach the camera to the microscope is shown at fig.4.

The electric circuit of the device used to attach the microscope to the printer port of the computer is shown at fig.5. The device is realized using two relays and two contact systems. A specific relay is switched when a high level is set on the desired bus (D_0, D_1, D_2 and D_3) on the printer port. A important specification of the circuit is that using one of the relay systems is disabled the "joystick" of the microscope and the other system is used to control the electric motor of the microscope. This fact disables manual control on the movements of the microscope when the web system is used.

Conclusion

The following paper describes the developed web based system for microscope observation. After analysis a decision was made for the operating system, web server, dynamic pages platform and the way the video streaming is done. There are enclosed functional diagram of the software and hardware and for the security. Additional hardware was developed to control the microscope using a computer printer port. In order to have the microscopical research results for many times usage and later identification of the homogenous matirials in the researched patterns and defining their quantity of proportion, it would be advisable developing of additional program modules for storage of the whole image of the researched pattern in a database as well as modules for identifing of etalonni structures (materials).

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