**Ce:YAG laser control system and Graphical user interface via Raspberry-Pi**

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**Abstract**

A system which controls Ce:YAG laser and monitors useful data about eye operation, users using the system and some feedback about diodes and laser status.

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# Introduction

In this report you can find all steps for preparing Raspberry to run the application including installing some utilities like web server, how to connect the raspberry to the outside world and most importantly all information about the application itself and its functionalities and properties. The system is GUI is written in Html and JS and the server side operations are in PHP which takes action on the Raspberry pins by using WiringPI C library.

# Raspberry Pi Configuration

In this section we will discuss little bit about Raspberry Pi’s and how to configure them

## Choosing Raspberry Pi

There are many Raspberry Pi models out there but there are essentially the same; Powerful minicomputers that are best choice for Embedded Systems.

## Mounting Operating System

Raspberries come with no operating system inside. They don’t have hard disk, but they use Flash Card (Micro SD) as their storage memory. To boot operating system, we have to mount operating system on that card and put it in Raspberry Pi SD slot. Now we will explain how to mount OS.

## Choosing and Finding Operating System

There are many operating systems for Raspberry Pi but the most used one is Raspbian. You can download Raspbian from its official page: <https://www.raspberrypi.org/downloads/raspbian/>

### Preparing SD Card

Firstly, we need to format SD card to flash Raspbian. Now we can use flash tool called Etcher: <https://etcher.io/>with this tool we can easily flash our operating system to SD card. Follow these steps:

* + - * + Connect an SD card reader with the SD card inside
        + Open Etcher and select from hard drive .img or .zip file you wish to write to the SD card
        + Select the SD card you wish to write your image to
        + Review your selections and click “Flash!” to begin writing data to the SD card

### Inserting into Raspberry Pi

After you successfully written Raspbian onto SD card, plug it into Raspberry Pi and connect power. Raspberry Pi will now boot, there are two LEDs that indicate booting process. Red LED should be on all the time and Green LED will be flashing while the computer is booting, and it will turn off once the Raspberry Pi is booted.

## Connecting Raspberry Pi to I/O Devices

As Raspberry is just a little box where is your motherboard and all necessary components located, we have to use external I/O Devices to share information.

### Display Device

Our Raspberry Pi has HDMI port for connecting to external display device. For first time you should use this to display your Raspberry Pi because it is not necessary to do anything else than plugging HDMI cable into port. Later on, we will connect Raspberry Pi via UTP (Ethernet) cable and display its screen on desktop’s screen. Also, there are external Raspberry Pi’s LCD displays that fits onto Raspberry Pi’s pins. We will configure that one also.

### Pointing Device

Raspberry Pi has USB ports for data exchange. To use comfortably our Rasp- berry Pi, we can connect mouse to it like to every other PC. It has no PS/2 ports so just USB mouse’s can be connected (both wired and wireless).

### Typing Device

There is also possibility to connect keyboard, but we used On-Screen Keyboard for this project because it hasn’t got much typing on Raspberry Pi side. Later, when we connect via UTP (Ethernet) cable or Wi-Fi we can use desktop’s keyboard to type on Raspberry Pi.

### Other Devices

You can connect speakers, camera or other devices if you want full comfort with your Raspberry Pi.

## Connecting Raspberry Pi via UTP Cable or Wi-Fi

At this step, you should have your Raspberry Pi configured for using like ordinary computer. Now we will configure it to easily connect and access Raspberry Pi through UTP (Ethernet) Cable or Wi-Fi. Reason for doing that is to don’t have any external I/O devices because we can do everything via desktop.

### Setting Static IP Address

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Description automatically generatedTo communicate with your Raspberry Pi, you have to know it’s IP address. If you always know what is IP address of your Raspberry Pi, you don’t have to this step, but, most of network devices are set to automatically obtain IP address via DHCP server, so it is changed almost every time when you connect your Raspberry Pi to network. Firstly, click right mouse button on your network icon (upper right corner in Raspbian) and choose Wireless and Wired Connection Settings.

Figure 1: Wireless & Wired Network Settings

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Description automatically generatedThere you can choose which interface setting you want to set (Ethernet or Wi-Fi). Then type in first blank area (IPv4) your static IP address. It is recommended to use same subnet as your desktop. In our example we used 192.168.1.100. You can leave other fields blank and choose to automatically fill them.

Figure 2: Network Preferences

After that, you would have to reboot your Raspberry Pi.

### Checking for Success

You can hover mouse to your network icon in upper right corner and you should see your IP addresses.

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Figure 3: Checking IP Address

### If it is not same as you set, you have to check your configuration again and troubleshoot. Do not proceed Trying to Ping Raspberry Pi

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Description automatically generatedYou can check connections between Raspberry Pi and desktop by pinging one from another. To ping Raspberry Pi from your desktop, you enter IFCONFIG in Terminal and type ping command followed by destination IP. For example: ping 192.168.1.100if you didn’t fix this step.

Figure 4: Pinging Response If you get response, you did it.

## **Display Settings**

### Changing Display Resolution

Initial resolution can be uncomfortable for eyes. To change resolution, we go to Main Menu

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Figure 5: Raspberry Pi Configuration

At the next screen, we select Set Resolution and choose which one do you want. We recommend using 720x480.

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Figure 6: Setting the Resolution

### Changing Background (optional)

Changing background in Raspbian is very similar like on Windows 10. Right click on desktop > Desktop Preferences. Now you can change many settings.

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Figure 7: Changing Background

## Interfaces

In order to make our life easier and to be able to control Raspberry Pi from main computer we have to enable two interfaces on Raspberry Pi. VNC and SSH. VNC is used for creating the remote desktop server that allows us to control the Raspberry Pi desktop (visually) by connecting to it from main computer. SSH is used to control the other computer from command line, it is also necessary to allow it in order to transfer files and use cross compiling tools.

## Remote Desktop Server

To have look on Raspberry Pi’s screen without external display, we have to use some kind of Remote Desktop. In our project we are using RealVNC server that comes preinstalled in Raspberry Pi and it uses VNC protocol. VNC protocol allows us to connect to other computers (in this case Raspberry Pi) and to see the screen with all features as in our desktop (mouse navigation, keyboard input, clipboard...). Be sure to enable it on Raspberry Pi’s startup, so you don’t have to enable it every time Raspberry Pi boots.

Steps are:

* + - * + Connect Raspberry Pi and desktop over Ethernet of Wi-Fi network
        + Go to Raspberry Pi configuration
        + Open "Interfaces" tab
        + Enable VNC server to auto-start
        + Reboot

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Description automatically generatedNow, we should have done configuring Raspberry Pi for communicating with desktop computer and from now it is not necessary to use I/O devices.

Figure 8: Interface

## Connecting to Remote Desktop Server

Now we connect our desktop to Raspberry Pi’s viewer via VNC:

* Download Chrome extension called "VNC Viewer for Chrome"
* Open VNC Viewer for Chrome
* Enter IP address of Raspberry Pi and connect

# Installing web server on Raspberry

## Installing Apache

Apache web server is the software that allows the machine to analyze user requests (in http form), and to return the file corresponding to the request. And it is downloaded on the raspberry following the next steps.

1. Open terminal
2. Make sure the machine is up to date by typing the following commands

**sudo apt update**

**sudo apt upgrade**

**sudo apt update**

1. Now install apache by typing

**sudo apt install apache2**

1. Give apache the permission to read and write files

**sudo chown -R pi:www-data /var/www/html/**

**sudo chmod -R 770 /var/www/html/**

Now we just need to check if the apache server is working, open the Raspberry web browser, and go to “http://127.0.0.1”. You should then get a page with a message like “It works! “

## Installing PHP and PHPMyadmin

1. Open terminal
2. sudo apt install php php-mbstring
3. sudo apt install phpmyadmin

Raspberry is ready to run the application.

# WiringPI

***WiringPi*** is a ***PIN*** based GPIO access library written in C. *WiringPi*  is preinstalled with standard Raspbian systems.

# Getting Application files from GitHub repository

1. Open terminal
2. Go to the www folder by typing

cd var/www/html

1. Clone the files (for the first time only)

git clone <https://github.com/Bakirbrkic/Oci>

1. Pull (to get updates on repository)

git pull

Now we have installed everything needed for Raspberry to RUN the application and to control the PINs, the Next part will be focusing on the application itself.

To run the application just open the browser on the raspberry and type localhost it will show the directories available in www folder if you cloned the project files correctly you will find a folder called Oci when you click on it, it will open the application.

# Application GUI and functionalities

## System workflow

1. User takes an action on the application
2. The application sends events to the sever based on taken actions
3. Server takes action

Actions can be to do some calculations or to use WiringPi to control pins to send digital or PWM signal

1. PWM signal is connected to external circuit to convert it to real analog signal

## PWM

PWM is technique which is used to control analog circuits with digital outputs. Commonly microprocessors chips are used to generate these signals because of their fast switching capabilities. It is applications can be seen in many areas including power electronics and telecommunication.

The application is composed of 3 parts.

## Light tab

This is the main control page it has 2 buttons to control the main light and blue light in the laser, beside the buttons it has a slider to control the intensity of main light. Also, the main app page has an eye toxicity index bar which fills in by time and time it takes to fill differs depending on how much is the intensity of the main light and whether the blue light is shining or not. The last things shown is the time duration of the operation.

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## Diagnostic tab

The second part of the project is the diagnostic part, this part shows the total working hours of the laser because this laser has finite working hours after which the diodes should be changed so cumulative timer is shown in that page. When the diodes are changed the user has the button to reset the timer.

Also, on the diagnostic tab there is an indicator for the state of each 5 diodes in the laser, which are 5 digital input pins on the pi in the case any of the diodes is not working the application will automatically send you to the diagnostic page and the diode which is not working will blink red.

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## User tab

The last part of the application is the user login, in this tab users can switch account, create new account or delete an existing account.

For each user some information are shown including

1. Total user operation time

2. Duration of last operation

3. Toxicity index of last operation

This information shows all the possibilities and information that can collected and calculated. With more time and resources, we would be able to show more useful information like histograms.

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# Conclusion

We tried to show all the steps to use the system we implanted from the most basic steps of configuring the raspberry pi to the functions of each part the application itself. We learned a lot throw the process of creating this application, basic physical layer of Ce:YAG and using raspberry pins with web-based app and many other details.