Biometric Systems
Capturing of 2D Hand Geometry With Line Camera

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1 Assignment

The aim of the project is to assemble a mechanical device and create software for acquiring 2D hand geometry via a line camera. A solution for camera mount and hand placement is proposed in the following sections for best geometry acquisition and image reconstruction.

The document is structured as follows: in section 2 we describe the hardware part of the project, what hardware was used and we describe a solution for camera mount and hand placement. In section 3 we present the software needed for camera control and image reconstruction. In section 4 we detail created database of hand geometry data and method of acquisition. In last two sections 5 and 6 we sum up hardware and software solution and propose further improvements on our solution.

2 Hardware

In this section hardware used in the process of creating capture device is described.

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2.1 Hardware Setup

To be able to effectively scan 2d biometry of hand various hardware is necessary. Firstly we need structure to hold all other hardware together robust enought to hold weight and absorb vibrations generated by rail. This need is satisfied by using aluminium framework. Rail itself is mounted in this framework in a way to allow slide to move freely above the hand position. Camera and light are mounted on the slide moving along the rail to allow continuous capture of hand geometry with best lightning conditions. Control module consists from controllers running software necessary for capturing hand geometry.

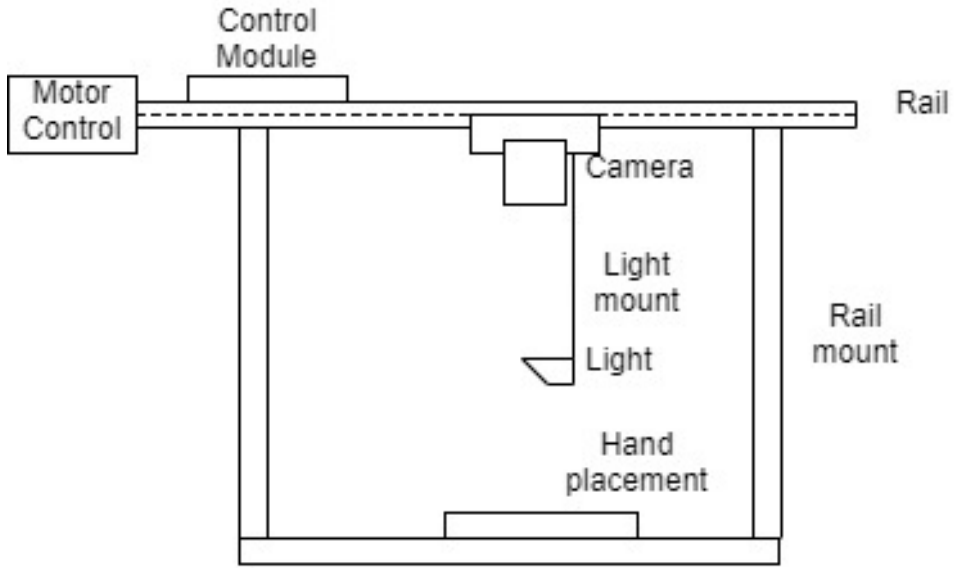

Figure 1: Schematic of hardware setup.

Camera

The selected camera is Basler raL6144-16gm. This camera provides us with the resolution of 6144 × 1 pixels with line rate up to 17 kHz. The captured image is in greyscale colors which is the desired output for our usecase. The camera's shutter can be operated either via hardware or software trigger[1].

The camera is equipped with AF Nikkor 50mm f1.8D lens. The lens suits our needs for multiple reasons: It is relatively inexpensive, simple to use and has good depth-of-field control with aperture ranging from f/1.8 up to f/22.

Camera Mount

In order to acquire images with line camera either scanned object or camera have to move in smooth direct line to cover whole scan area. We decided to move the camera because of trivial reason: to minimize errors during scaning. Hand is placed on stable platform and with only camera mount moving, human error is minimized and user experience is improved.

Slide moving along the rail houses platform where camera is mounted. This platform is facing down with camera and light mounted as seen in figure 2.1.

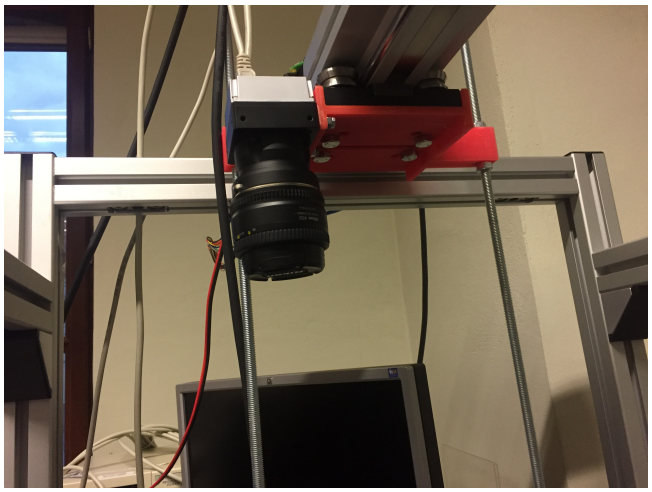

Figure 2: camera mount setup

Slide Rail & Stepper Motor

Slide moves on the rail in uniform motion along rail axis. Slide movement is controlled by a stepper motorwhich controls direction and speed of the movement. Rail is mounted on the framework in specified height calculated from camera and light focus.

Preco je to v danej vyske, vypocet vysky

The stepper motor itself is controlled by Leadshine EM705 Digital Stepper Drive which is controlled by pulse width modulation generated by Arduino UNO with our custom code generating 976 Hz PWM with 50% duty cycle.

skontrolovat cisla

The PWM can be calculated as follows:

$PWM_{Frequency} = 16000000/(Prescale\_Factor * 256)$

where $Prescale\_Factor$ can be set to 1, 8, 64, 256 or 1024. The default value is 64 which results in aforementioned 976 Hz PWM.

[1]The camera also enables "free-run mode".

2.2 Slide Rail Control

Program control running on Raspberry PI 3. The stepper motor's speed is controlled by the PWM generated on Arduino UNO providing 5V through GPIO [2]. Direction and `ENABLE` state are controlled through software control from Arduino UNO.

Here should be the calculation of speed

2.3 Light

To acquire high precision images of hand it is necessary to have proper light source. Light is mounted directly below the slide platform angled towards camera axis. Light used is Corona II line scan light providing ability to illuminate currently scanned region of hand with bright light. Without this light images would be very dark, whereas after light integration images became very clear.

Light is controlled through the RS232 interface on control unit XLC4 connected to Raspberry Pi control module.

light intensity light.cmd("IY E 1200")

RS232 Interface is configured as follows:

Serial Port COM4

Baudrate 115200

Databits 8

Stop Bits 1

Parity None

2.4 Hand Placement

The hand is placed in the centre of the framework on a prepared platform which aligns and spreads the fingers in order to capture the same hand geometry during different scans. The hand is stable during image capture procedure which minimizes human error. Figure 2.4 shows placement of hand during scan.

Figure 3: Hand placement during scan

zmenit/orezat foto

[2] When stepper motor is controlled directly from Raspberry 3.3V are insufficient and stuttering occurs.

2.5 Control module

Control module - Raspberry Pi connects all of the hardware parts and runs software necessary for control of other parts. To control rail slide Arduino Uno is utilizied because of neccesity for output voltage of 5V of its GPIO.

Schema zapojenia pi

3 Software

Hardware solution for proposed device consists from three main parts: moving slide on rail, camera and light. Each of these parts needs to be controlled in order to scan images of hand geometry. All of the software as well as webserver storing results runs on control module - Raspberry Pi.

3.1 Used Software

Software is implemented in python language for its ease of use and comprehension. With all necessary software running on Raspbery Pi minimum setup is necessary.

Slide platform is controlled through serial bus by writing to GPIO pins direction and enable signals. Light is controlled via its XLC4 controller through RS232 interface. Light status is controlled through commands `LC A 1` and `LC A 0` for turning it on/off respectively.

camera control, skladanie obrazkov

referencie na zdrojove kody

zoznam dependencies, instalacia

3.2 Acquiring Images

To acquire images simple setup is necessary. Assembly and connection of all hardware parts is necessary with individual parts connected to Raspberry Pi control module according to schematics. Raspberry control module needs to be setup and software installed. When Raspberry is connected to internet image acquisition can be done through remote access without need for whole desktop. Firstly hand is placed on designated platform and then software is run. Firstly lights are switched on, then camera starts recording and slide moves along the rail till it completes the scan. After scan slide moves to initial position and device is immediately ready for another scan.

4 Hand Geometry Database

Scanned images are stored directly on Raspberry Pi immedietly after capture. Images are exposed through webserver and are availible for direct downlaod through web browser.

Image naming convention allows to distinguish between different takes just by storing time of capture with filename as follows: result_<timestamp>. Where timestamp means standart Unix timestamp.

Ako dlho trva snimanie, kvalita snimkov

5 Achieved Results

Solution described in this report was assembled and implemented with excellent results. Integration of all hardware parts and software control results in images being scanned very quickly in great resolution. During testing it was proved to be effective to not only scan images of hand geometry but also fingerprints which leads to general purpose sensoric solution for capturing multiple biometric data. Furthermore, solution is able to function with very limited resources necessary and provides instant access to scanned images.

rychlost, kvalita, mnostvo snimkov

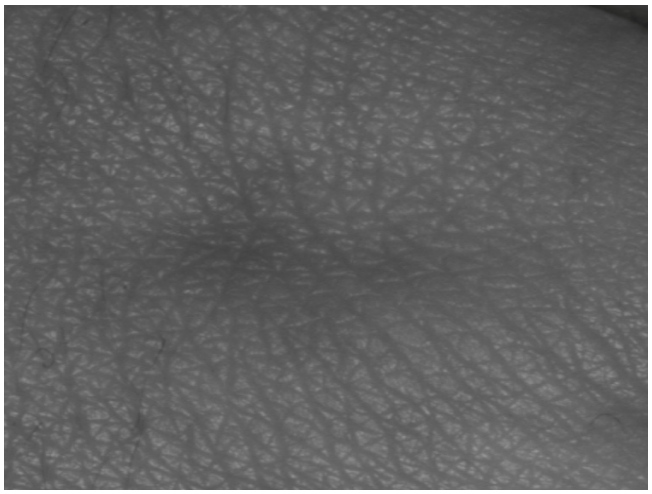

Figure 4: Dorsal detail of scanned hand

6 Summary

preciznost HW, vylepsenie - antivibracna podlozka, 3d geometria, distancne stlpky a palcement ruky

As previously dicussed in 5 proposed solution si able to quickly and accurately provide 2D hand geometry in great resolution. Solution was used to create initial image database with emphasisis on ease of use and precision so this database can be quickly expanded. Solution proved to be effective to not only capture 2D hand geometry but also capture other biometric data such as fingertip scans. This results in ability to make multiple models from data and design efficient classification and identification algorhitms.