Interakcja tkanek człowieka ze światłem widzialnym jako biometria

(Visual light and human tissues interaction as biometrics)

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Biometrics is increasingly being used to control access to specific areas and authorize certain resource for users. With its use, we can verify whether a person is the one he claims to be and determine this person identity (by selecting the most similar set of features of a given data set). In the broadest sense, biometrics can be divided into physiological biometrics (based on physiological characteristics of human) and behavioral biometrics (related to the human behavior) [1].

Since the physiological characteristics are visible without special tools, people were involved in that part of biometrics for many years and have acquired wealth of knowledge about it. Physiological biometrics is easy to acquisition and analyze using a simple hardware and what is more, it has a much greater distinctiveness than behavioral biometrics. Therefore, the identification and verification of the identity is more often carried out by analysis of physiological characteristics [3, 6].

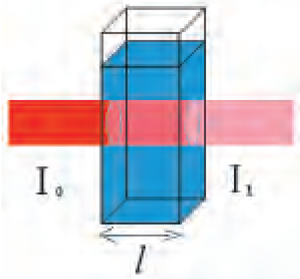
The most popular method to verify the person identity is a fingerprint. This technique involves taking the fingerprint, its analysis and determination of characteristic fragments – minutiae. This method is very easy to implement, but it is sensitive to the position of the finger and its contamination [4]. To verify access to the premises a face recognition is often used. In order to accomplish this task fields of image processing, computer vision, computer graphics, pattern recognition, neural networks, and psychology are combined. The correctness of the algorithm depends on the lighting, the position of the person being tested, as well as facial expressions [2, 7]. Another widely known method of identifying is iris biometrics. The analysis begins by finding the image area where the eye is, then determined the iris field and extracted its particular characteristics [8].

These popularized biometric identification methods are not completely immune to fraud. They are used for a long time in many places, consequently unauthorized person can know most of the used algorithms and try to avoid them i.e. by placing a piece of paper with a printed fingerprint in the reader. For this reason, there are more and more innovative biometric methods which rely on a simple measurement, but which are difficult to counterfeit. An example of this approach is the facial thermography, which is based on recording the thermal radiation emitted by a physical object. Every person has a different facial temperature distribution which allows for verification of identity, there are some solutions based on hand's thermogram analysis. Another alternative technique of biometric is the analysis of the finger's blood vessels arrangement. In order to obtain the finger vein pattern, the finger is placed between the infrared radiation source and a camera with filter. There are also algorithms that analyze the shape of the ear – image data are collected with a photo or ear print, the main axes are determined and the individual lengths are measured as differentiating characteristics. A modern approach is also to read the information stored in the human nail. The phase of the maximum amplitude polarized optical signal is measured and on this basis neilbed dimensions are reconstructed [2, 5].

In this paper, an approach that uses red radiation to analyze the internal structure of a finger has been described.

Light interaction with matter

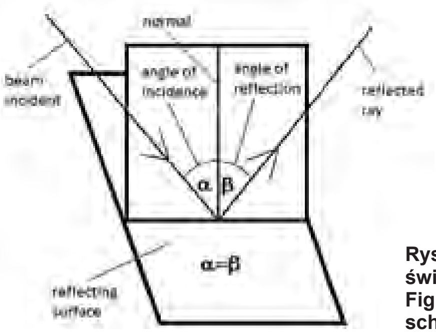
The human eye with the entire range of electromagnetic radiation reacts only to the narrow range (approx. 380…780 nm) called visible light. When we split white light using a prism, red is the least and purple is the most refracted individual component. The red light is a wave with the lowest frequency and maximum length.



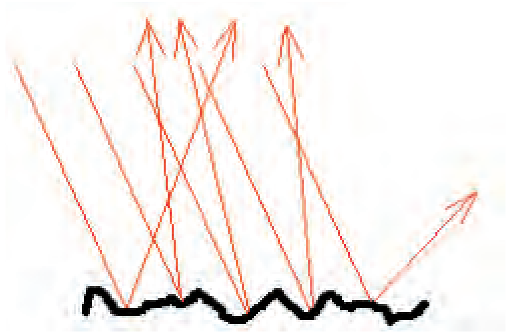
Rys. 1. Schemat absorpcji światła (I_0 – natężenie wiązki wchodzącej do ośrodka, I_1 – natężenie wiązki przepuszczonej, l – droga pokonana przez światło w obiekcie)
Fig. 1. Light absorption scheme (I_0 – intensity of beam entering the center, I_1 – intensity of beam passed through, l – path flown by the light in the substance)

The light is subject to different physical phenomena such as absorption, diffraction, interference, reflection, dispersion and luminescence. Light absorption is the process of electromagnetic waves energy absorption by a physical substance (*Fig. 1*).

Diffraction as a wave bending, is the phenomena of change of wave propagation direction at the edges and in the vicinity of



Rys. 2. Schemat odbicia światła
Fig. 2. Light reflection scheme



Rys. 3. Rozpraszanie światła. Fig. 3. Light dispersion

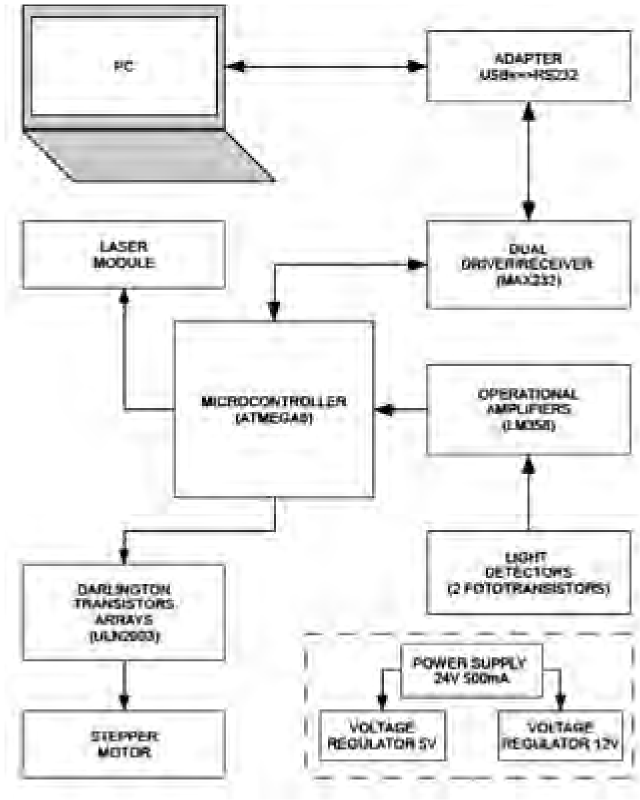
obstacles. Reflection of light, according to the law of reflection, occurs when the angle of reflection equals the angle of incidence. The incident beam and the reflected beam are in the same plane, and a reflecting surface is smooth (*Fig. 2*).

Otherwise the light will be reflected in different directions being dispersed (this phenomenon is illustrated in *Fig. 3*) [9].

In the presented prototype device we used light source which is a red laser. This is the most common laser color (so-called red indicators), it generates radiation in the 630…680 nm and it is equipped with a laser diode with GaAsP and collimating lens. The emitted laser light is notable for its high degree of spatial and temporal coherence. The essential parts of the laser are the active medium, the optical resonator and the pumping system that supplies energy. Under the right conditions, laser shares occur i.e. quantum strengthening of photons and the optical system allow to select the appropriate photons. In order to get laser shares, strengthening of the radiation in the active area must at least compensate the loss of radiation inside the resonator and emission of part of radiation outside the resonator [10, 11].

Device construction

The device consists of: frame made of Lego Technic, a stepper motor, the optoelectronic components and electronic system. The central element of the electronic device is Atmega8 microcontroller manufactured by Atmel. The microcontroller is responsible for controlling the device. Chip operates at a frequency of 8 MHz and a supply voltage of 5 V. Communication with PC is done by the serial controller USART (Universal Synchronous Asynchronous

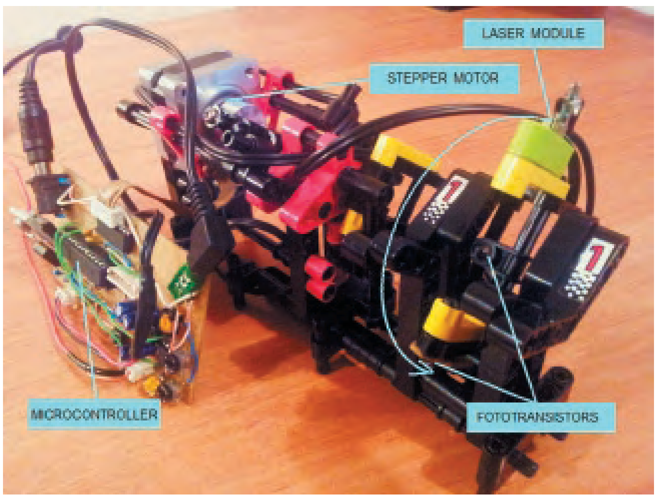


Rys. 5. Schemat blokowy urządzenia. Fig. 5. Device block diagram

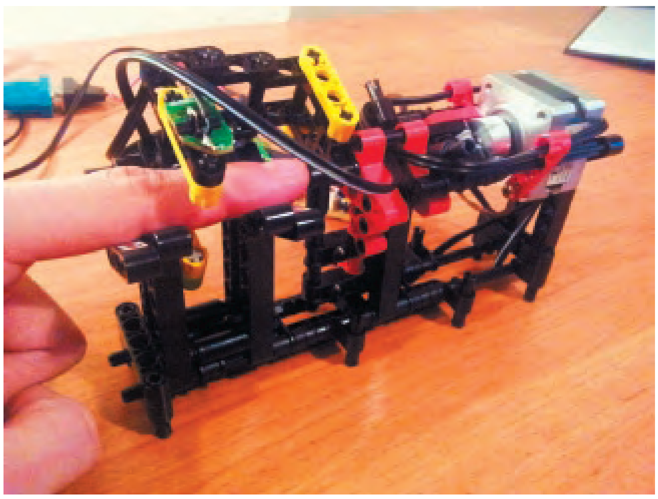
Receiver and Transmitter). The constructed device with marked direction of movement is presented in *Fig. 4*.

To adjust the voltage levels of the RS-232 and TTL (0V/5V) standards integrated circuit MAX232 was used. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. Computers without port RS-232 can be connected to the device via RS232-USB adapter. Adapter uses the drivers that create a virtual serial port. Communication between particular elements is shown in the block diagram (*Fig. 5*).

Another important element is a stepper motor that is powered by 12V DC. The control is provided by the chip ULN2003,

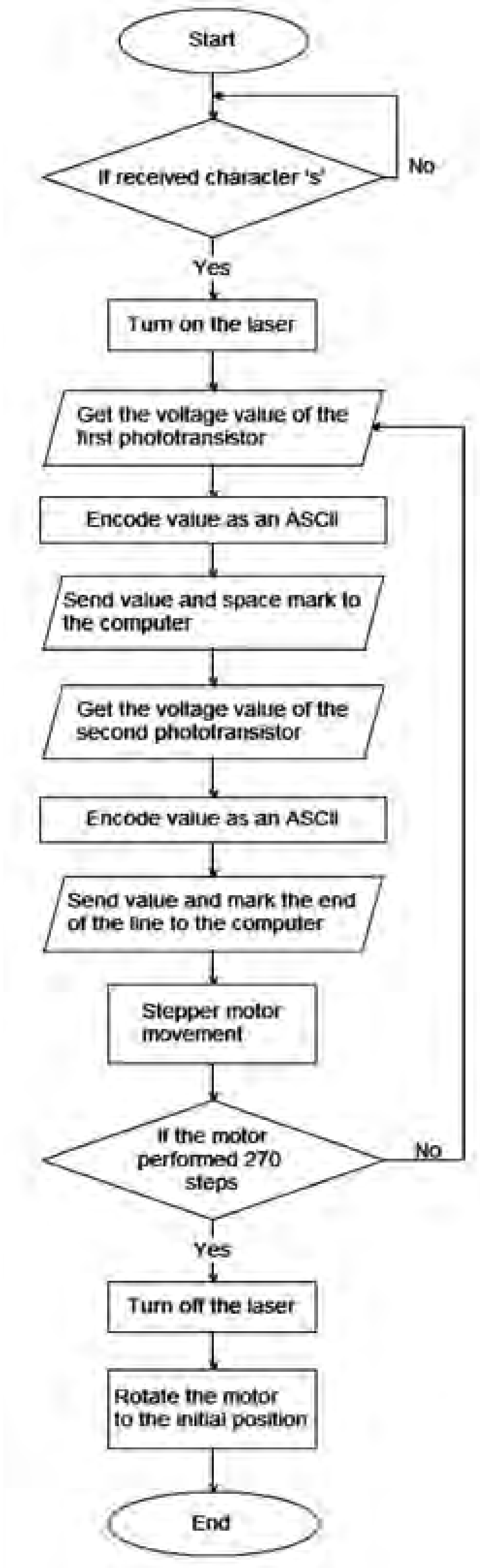


Rys. 4. Urządzenie pomiarowe. Fig. 4. Measurement device



Rys. 6. Skanowanie palca. Fig. 6. Finger scanning

which is high-current Darlington transistor arrays. To increase the number of steps and the engine power half stepping control is used.



Rys. 7. Schemat blokowy algorytmu. Fig. 7. Flowchart of the algorithm

Optoelectronic components are laser and two phototransistors. Laser module has been removed from the laser pointer, and its power does not exceed 5 mW. Phototransistors used to measure the intensity of light are mounted perpendicular to each other. They work in voltage dividers with properly adjusted potentiometers. Voltages are further amplified by the high-gain operational amplifiers LM358.

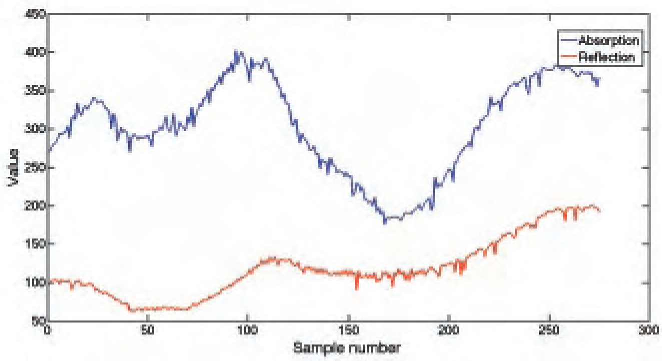
Scanning refers to the transmission of light through the finger, that is placed in the device (*Fig. 6*). The intensity of scattered and passed through the finger radiation is registered by the phototransistors. During the test, frame with laser module and phototransistors revolves around the finger.

Measurement procedure

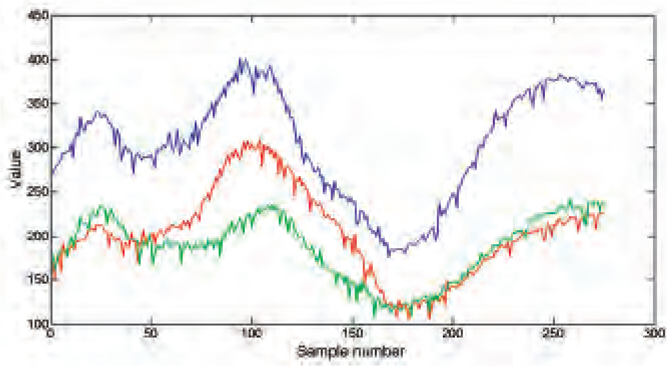
The measurement starts after sending to the microcontroller binary value 0b01110011, which corresponds to character 's'. Pin connected to the laser module goes high and energizing it. Value from the first phototransistor is strengthened by the operational amplifier and registered by the ten-bit A/D converter. It converts the voltage to the value in the range from 0 to 1023. The microcontroller sends the retrieved value with a space character as a ASCII characters to the computer. Then, registered value from the second phototransistor is sent with a newline character and the next step of the stroke engine is performed. The measurement interval is half a step motor which gives two hundred seventy values from each phototransistor. The algorithm is illustrated in the flowchart (*Fig. 7*).

Results

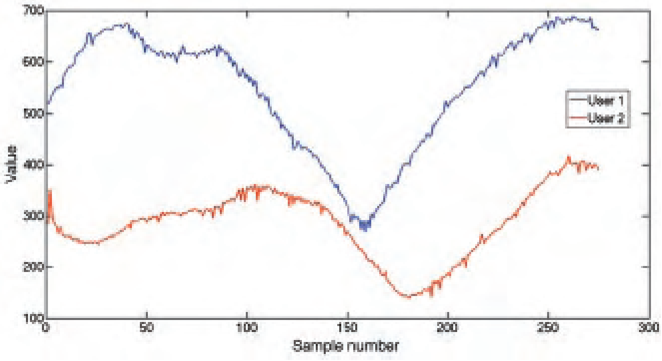
The results of the measurements are two vectors containing two hundred seventy values. The first vector describes the tissue absorption level and he second one tissue reflection level (*Fig. 8*).



Rys. 8. Zarejestrowane wartości absorpcji i odbicia światła
Fig. 8. Registered values of light absorption and reflection



Rys. 9. Zmierzone wartości absorpcji dla jednego użytkownika
Fig. 9. Registered absorption values for one user



Rys. 10. Zmierzone wartości absorpcji dla dwóch użytkowników
Fig. 10. Registered absorption values for two users

The nature and intensity of individual phenomena is determined by the structure of the object. The obtained values depend on the size and shape of the finger bone, fat, skin structure, vascular tissue, skin tone, reflectivity and absorption of red light by tissue.

Over thirty measurements have been gathered from 19 people. Due to the large influence of external illumination on the result, the experiment has been carried out in total darkness. Adequate lighting conditions has been provided by a cardboard box with a hole on finger. To prevent accidental laser beam reflections from the walls, the interior of the box has been covered with black paint. Sample courses for the same person are shown in *Fig. 6*. In *Fig. 7* two graphs for different people is presented. It can be noticed that the waveforms of the same person are similar, while the recorded signal for various people are different. It can therefore be assumed that the presented method of measuring tissue interaction with light can be a biometric feature.

Any pre-processing has been carried out on the registered signal. The process of assessing the accuracy of the measured features was carried out by comparing the course of a person with other registered measurements. Calculating the correlation coefficient between two vectors, the level of conformity has been assessed. The couple of vectors, for which the highest value of that factor has been archived, it was considered to belong to the same person. The test accuracy is calculated as follows:

$$acc = \frac{c_i}{c_i + u},$$

where: c_i – number of correct identification, u_i – number of incorrect identification.

Using this simple method an accuracy of 79% has been achieved. According to the fact that this first experiment with new biometric modality this value is very high. The Dynamic Time Warping has been also tested but it yields lower results.

Podsumowanie i wnioski

Biometrics remains in the area of scientific interest in the field of biomedical engineering and biocybernetics not only because of the possibility of its application in the automatic authentication procedures or tasks related to identification. Perhaps the more important practical applications of biometrics seems to be Kansei-Engineering or biometrics emotional states, which the subject of discussion is human psychophysical condition under the impact of different stimuli. Search for new biometric techniques in such context of very eligible, and the method proposed in the paper comes out in front of this trend.

The proposed biometrics is non-invasive and provides high security. Biometric techniques that require contact with the sensor are reluctantly accepted due to presumption of lack of hygiene. Measurement of skin tissue interaction with visible light meets these expectations. Not without significance is also the fact that the technique, in its simplest (physiological) approach, provides an attractive level of correct pattern recognition. Such a technique should be in the directory of conceptually different authentication method in multi-modal biometrics solutions, which are in the center of author's interest.

The presented solution can extended on behavioral biometrics because the exposition of emotional state through the top layer of the skin in anatomical terms is obvious. In futher works an algorithm for human stimulation will be developed. It will use sound stimuli with basic methods of modulation of selected elements of music like rhythm, meter, and dynamics. Based on the positive prototype tests a model version of the measuring system will be prepared.

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