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Reliability of camera systems to recognize facial features for access to specialized production areas

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Abstract. The article deals with ergonomics and reliability of camera systems for recognition of facial features and identify person for access to specialized areas. The monitoring of areas relates not only to crime, but it is also an integral part of access to specialized production areas (pharmaceutical production, chemical production, specialized food production, etc.). It is therefore important to adequately secure these premises using the relevant system. One of them is a system based on user identification using specific facial features. For this purpose, there are CCTV systems for recognition of facial features of different price categories (conventional cameras, semi-professional and professional) on the world market. However, problematic situations may occur when identifying. For example, by having the user partially masked face. This research is focusing on the problem. The main goal of the research is establishing the scale of negative impact, in case the identified person has partially masked face, on camera systems recognizing facial features, primarily on recognition time. The results are evaluated in detail. Some camera systems are not suitable in specialized production areas due to their insufficient recognition ability. From all the tested devices, the HIKVISION iDS-2CD8426G0 / F-I camera identification system has proved to be optimal for identification purposes. In the case of designing, it is therefore necessary to choose suitable camera systems that have ergonomics and reliability at a level that will guarantee their sufficient use in the mentioned areas, while decreasing comfort and user-friendliness as little as possible. By measuring the ergonomics and reliability of these CCTV systems, it can be stated that there are statistically significant differences between conventional, semi-professional and professional systems, and it's not just a design change, but also a more efficient recognition method.

Key words: security, agricultural buildings, ergonomics, camera systems, face detection.

INTRODUCTION

Nowadays, due to the growing property criminality, it is highly advisable that even agricultural buildings (pharmaceutical production, chemical production, specialized food production, etc) are adequately secured, with respect to the entry to the premises, by authorized individuals only. These agricultural building should be secured for authorized access by face recognition. Especially pharmaceutical or chemical

production. Because in the case of criminality, it can have major negative consequences (chemical leak, escape of viruses and bacteria, steal of medicine, etc) (Hartová & Hart, 2017).

For this purpose, it is congruous to use already existing systems for recognizing a person's identity by recognizing the facial features. These systems are most commonly used as security elements for unauthorized persons to enter a specific building. The camera systems suitable for this purpose include a high-quality video sensor capable of recording in at least Full HD (1080p) in both day and night mode (Hartová et al., 2018; Al-Obaydy & Suandi, 2019).

Elementary camera systems use, for the identity recognition, an additional storage facility which ensures the formula output. More sophisticated camera recording systems utilize an internal software recognition solution along with an internal memory in Micro SSD card format (Mahdi et al., 2017; Tan et al., 2019).

The software solution for recognizing human identity is frequently solved by using the Eigenfaces method, a detection method using Haar's symptoms. Facial recognition represents an extensive and tough task in terms of interference and obstructive recognition. These effects primarily include changes in facial expression, rotation of the angle, distance to the scanned face, and in particular head and face covers. These aspects principally affect the likelihood of false rejection and the time taken to identify an individual (Nagano et al., 2019).

MATERIALS AND METHODS

The following standard face recognizing camera systems (Fig. 1) were selected for the test series: Netatmo Welcome, HIKVISION model DS-2CD4D36FWD-IZS and a professional model iDS-2CD8426G0/F-I. Netatmo welcome is the cheapest from the mentioned above and is designed primarily for the general public purposes. The semi-professional device is represented by HIKVISION model DS-2CD4D36FWD-IZS. The third tested device is a professional camera system for face recognition of an individual HIKVISION iDS-2CD8426G0/F-I.

Figure 1. Tested recognition camera system (from the left: Netatmo Welcome, HIKVISION iDS-2CD8426G0/F-I, HIKVISION DS-2CD4D36FWD-IZS).

The measurement was performed to determine the average time value needed to recognize an individual by the camera system. In order to successfully measure the average time value of the face recognizing camera systems, it was necessary to ensure the most consistent conditions. The room with white walls without disturbing elements (paintings, photographs, animals) was used. The room temperature was maintained at 23 °C and the light intensity for measurement was determined to be 374 lux with a tolerance of 10% with the CEM DT-3809.

The camera systems were installed on the table and were pointing to the center of the room, which the tested subjects entered. During the testing of the time recognition capabilities of the camera systems, an individual entered the room by opening the door and approaching at a distance of 80 cm opposite the lens. After recording the measured values, the person left the room and waited 30 seconds before repeating the scanning.

To ensure higher accuracy, system stability and equal recognition conditions, a personal computer was used to measure the time needed for the subject recognition by the camera system. For the individual recognition, a timeframe of 10 seconds was set and afterwards the individual recognition was evaluated and set as 'unsuccessful' (the measured time was replaced).

The measurement consisted in recording the necessary time values for recognizing an individual behind the camera system using characteristic facial features. Overall, 5 types of tests were performed:

- The necessary time recognition of an exposed face
- The necessary time recognition of a face with glasses
- The necessary time recognition of a face with a scarf around neck and chin
- The necessary time recognition of a face with a baseball cap
- The necessary time recognition of a face with all previously mentioned elements.

The measurement was performed on 5 subjects (2 men and 3 women). Each test consisted of 10 repeated measurements per person and per device. Each test, to achieve the highest possible correctness, was performed twice. Thus, one series of measurements of one test per device on one person contained 100 measured values. In total, 1,500 recorded readings in compliance with the statistic unpaired t-tests were evaluated on all devices, all subjects and in all tests.

RESULTS AND DISCUSSION

Out of the three compared facial recognition camera systems, the HIKVISION iDS-2CD8426G0 / F-I had the lowest recognition time (Fig. 2) and proved the best recognition ability in all tests performed. In the test without covering the face, the average recognition time was 0.92 sec. In the test with glasses on, the average recognition time was 2.12 sec. In the third test with the scarf covering, the average recognition time was 1.56 sec. In the fourth test, covering the face with a baseball cap, the average time was 3.55 sec. In the last one, by covering all the previous elements, it achieved an average time value of 6.23 sec.

The second tested device, HIKVISION DS-2CD4D36FWD-IZ (Fig. 3), got a moderate average time value. In the first test without covering the face, the device achieved an average recognition time of 1.94 sec. In the second test with glasses on, the average time was 2.91 sec. In the third one, these values reached 2.14 sec. In the fourth test, using a baseball cap, the average recognition time was 3.83 sec. In the last test, the combination of all the previous elements, was an average recognition time of 6.87 sec.

The third tested device, Netatmo Welcome, achieved the slowest recognition times (Fig. 4). In the first test, 2.72 sec without covering the face. In the second test, covering with glasses on, it reached 5.20 sec. The third one, scarf covering test, reached 4.17 sec. In the fourth test with baseball cap, it achieved an average recognition value of 7.24 sec. In the last and most challenging test due to the application of all previous elements, it reached 8.37 sec.

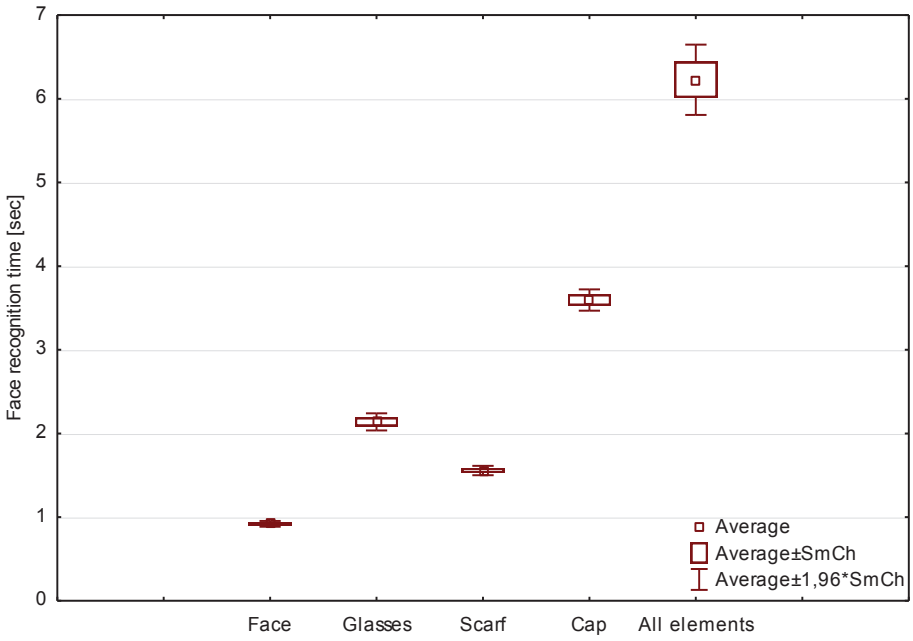

Figure 2. Results of average recognition time by HIKVISION iDS-2CD8426G0/F-I.

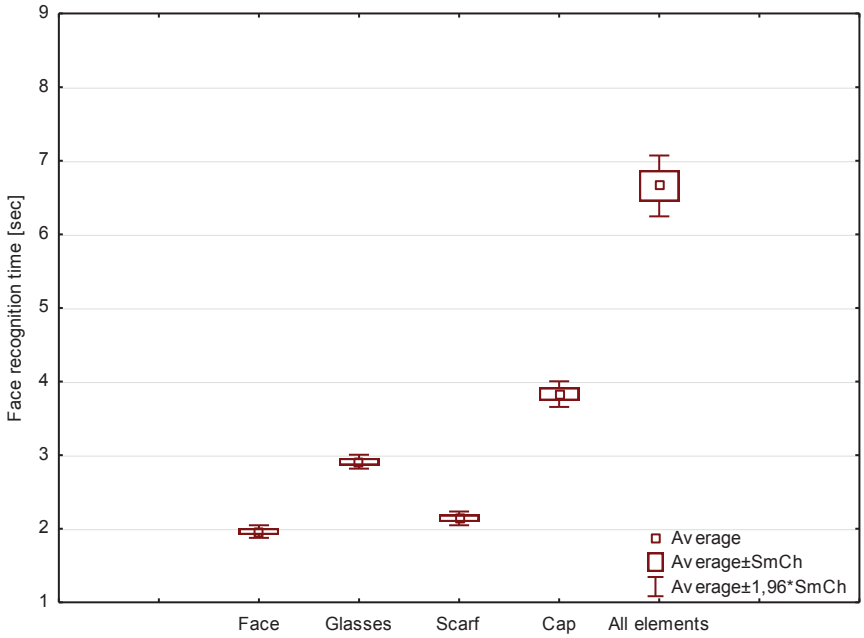

Figure 3. Results of average recognition time by HIKVISION DS-2CD4D36FWD-IZ.

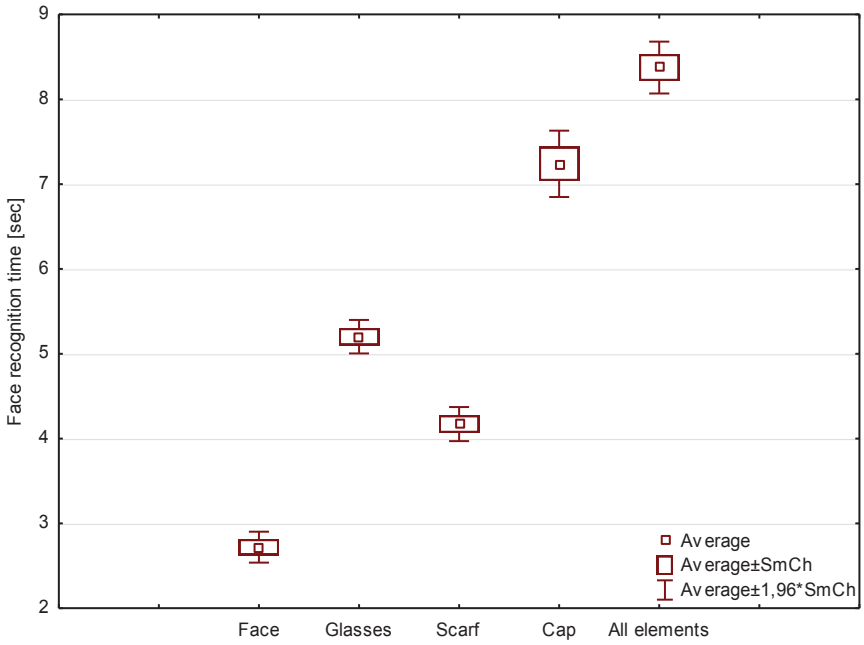

Figure 4. Results of average recognition time by Netatmo Welcome.

Unpaired statistical t-tests in Statistica software were applied to the measured values. By applying the measured data according to these tests, the following results were achieved. For all tests carried out, the p-value was less than 0.05 ($p < 0.05$), with the exceptions (Table 1). We can reject the hypothesis of obtaining a similar measurement time for various devices with different face masking except for the tests.

Table 1. Results of applied t-tests

Type of camera (group 1 vs. 2)	Type of test	Average time of group 1 (sec)	Average time of group 2 (sec)	t value	*p* value
C vs. B	All elements vs All elements	6.227	6.657	-1.3339	0.185837
B vs. A	All elements vs Hat	6.657	7.238	-1.9439	0.055509
C vs. B	Glasses vs Scarf	2.137	2.141	-0.0526	0.958074
B vs. A	Glasses vs Face	2.911	2.720	1.7878	0.075633

when A – Netatmo Welcome; B – HIKVISION DS-2CD4D36FWD-IZ; C – HIKVISION iDS-2CD8426G0/F-I.

On these unpaired t-tests, we cannot dismiss the hypothesis of obtaining a similar measurement time on different devices using a different principle of face coverage. Interestingly, HIKVISION iDS-2CD8426G0 / F-I vs. HIKVISION DS-2CD4D36FWD-IZ achieved the highest equality of applied t-tests in the Glasses vs Scarf test type.

The core result in applied unpaired tests using different devices, nevertheless with the same principle of the face covering, is that we always reject the hypothesis with a single exception. This exception, in testing faces covered by all elements, represents the

device HIKVISION iDS-2CD8426G0 / F-I vs. HIKVISION DS-2CD4D36FWD-IZ. In this case the hypothesis definitely cannot be rejected. Both devices disclose similar results at this application, but with the others they significantly differ.

According to the statistic Friedman's test and Kendall's conformity test used in software Statistica (Table 2), the conformity assessment of the individual measurement results was clearly determined for uncovered face.

Table 2. Applied Friedman's test and Kendall's conformity test for uncovered face

Type of test and camera system	Average rank	Sum order	Average	Stan. deviation
Uncovered face A	2.746835	217.000	2.724526	0.069981
Uncovered face B	2.253165	178.000	1.969087	0.418242
Uncovered face C	1.000000	79.000	0.897380	0.172362

The most suitable device according to the average recognition times is HIKVISION iDS-2CD8426G0/F-I with an average rating of 1. The second suitable device according to these tests is HIKVISION DS-2CD4D36FWD-IZS with an average rating of 2.253165. Netatmo Welcome, with an average rating of 2.746835, got unambiguously the last place. The final average values of Friedman's test and Kendall's conformity test are demonstrated in the following graph (Fig. 5).

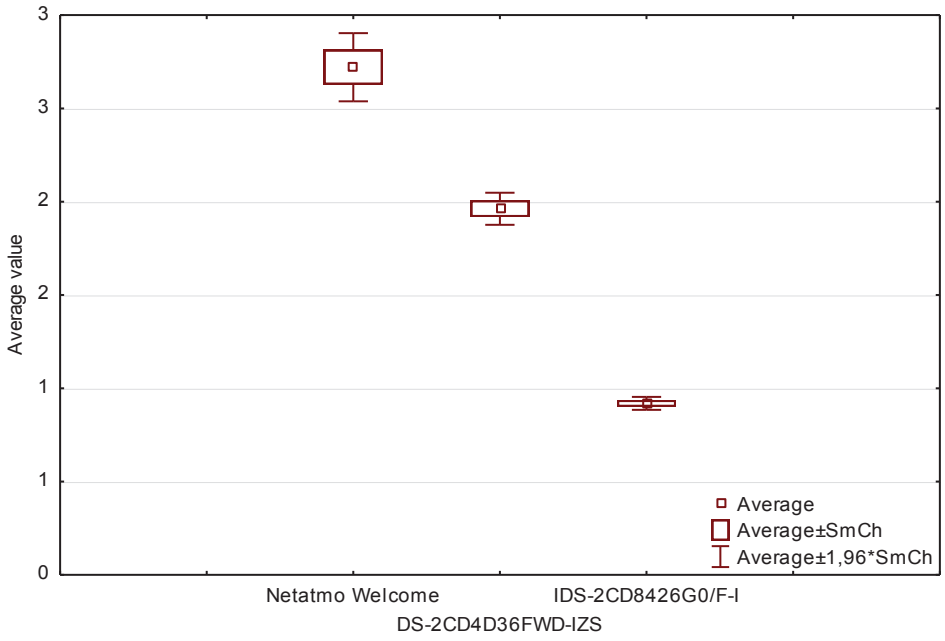

Figure 5. Average values of Friedman's test and Kendall's conformity test.

For the more results statistic Friedman's test and Kendall's conformity test used in software Statistica, the conformity assessment of the individual measurement results was clearly determined for all elements (Table 3).

Table 3. Applied Friedman's test and Kendall's conformity test for all elements

Type of test and camera system	Average rank	Sum order	Average	Stan. deviation
Covered face by all elements A	2.333333	14.0000	8.182618	0.943636
Covered face by all elements B	1.833333	11.0000	6.396292	1.541099
Covered face by all elements C	1.833333	11.0000	7.435432	1.806244

The most suitable device according to the average recognition times is not clearly determined. For this case of identifying, there are HIKVISION DS-2CD4D36FWD-IZ and HIKVISION iDS-2CD8426G0/F-I at the same level. Netatmo Welcome, with an average rating of 2.746835, got unambiguously the last place. The final average values of Friedman's test and Kendall's conformity test are demonstrated in the following graph (Fig. 6).

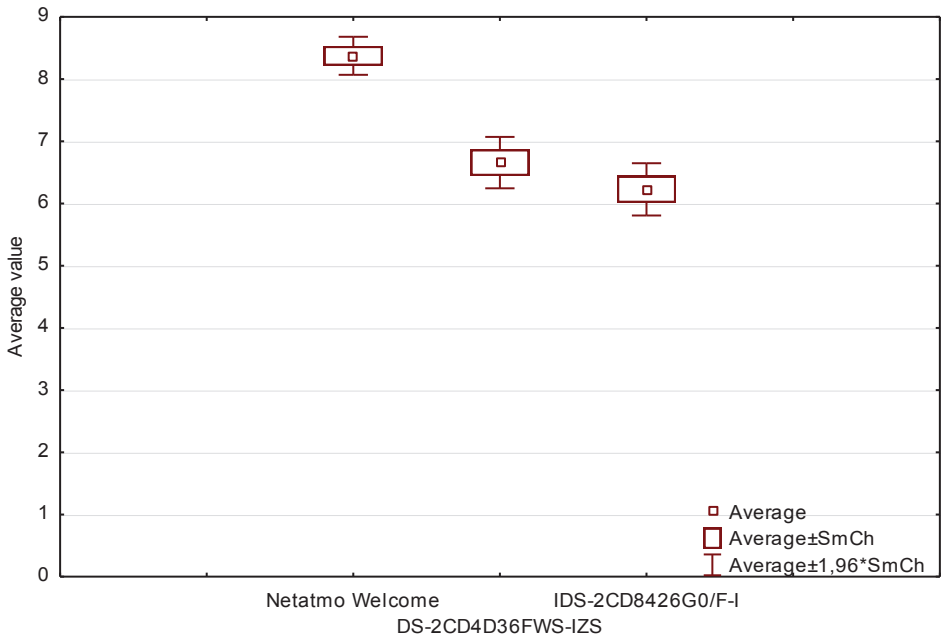

Figure 6. Average values of Friedman's test and Kendall's conformity test.

According to recent research, the gradual disguising of facial parts during the identification of an individual, leads to a very significant degradation of the ability of these systems to recognize the individual. This has already been described in the article 'Deep face recognition imperfect facial data'. Such research comprehensively describes face detection and individual identification. It also includes a part of face covering and its partial disposal by the software. This research also recommends having an exposed face without any objects to improve the overall system recognition attributes. (Elmahmudi & Ugail, 2019)

CONCLUSIONS

The time required for camera systems to recognize facial features increases dramatically when the user is disguised with a facial cover. The measured values evince that when the face is covered, the time required by the person identification device increases and thus negatively affects the process of effective identification of an individual.

In the agri-food complex, it is therefore recommended, according to the results of this measurement, to remove the plaids (masks, gas masks) from the face, as it prevents unambiguous identification of the individual by characteristic facial features. Eliminating this aspect during the identification process, this process will clearly be improved and thus will increase the security against unauthorized entry.

In the agri-food complex, it is therefore recommended, according to the results of this measurement, to remove the plaids (masks, gas masks) from the face, as it prevents unambiguous identification of the individual by characteristic facial features. Eliminating this aspect during the identification process, this process will clearly be improved and thus will increase the security against unauthorized entry.

From among the tested devices, the HIKVISION iDS-2CD8426G0 / F-I camera identification system has proved to be optimal for identification purposes. It had the best individual identification time response. Other tested detectors have been significantly worse than HIKVISION iDS-2CD8426G0 / F-I, therefore are not suitable for securing against unauthorized access to the agri-food complex.

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