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Modern, Blockchain-Based Fire Protection Solutions through In-School Security Cameras

Modern blokklánc alapú tűzvédelmi megoldások iskolai biztonsági kamerák által

Today's modern camera systems possess numerous analytic functions, such as face detection, headcount, or thermal detection. In order to increase the security, however, the further development of these features is recommended, in the best interest of fire protection. The present article discusses the introduction of a camera system which would be capable of determining the students' whereabouts within the premises in an automated way. Thus, the system has to be able to determine who, when, and where is located within the premises of the educational institution in question. This could provide useful information in case of a fire within the institution. Thereby, the security service or rescue teams could determine the exact location of the students – even by name – and their number, and they could rescue the students stuck inside more easily. Furthermore, the storage of the video footage is most frequently saved in 'traditional' clouds, whereas the solutions based on decentralised clouds provide greater security. The aim of the research is to introduce a solution for fire protection, based on a security camera system which is considered an outstanding development nowadays.

Keywords: blockchain, fire protection, security camera

A mai modern iskolai kamerarendszerek számos analitikai funkcióval rendelkeznek, úgymint arcfelismerés, emberszámlálás, illetve hőérzékelés. A biztonság fokozása érdekében azonban ajánlatos ezeket továbbgondolni a tűzvédelmi megoldások érdekében. A cikk részleteiben tárgyalja egy olyan kamerarendszernek a bemutatását, amely automatizált módon képes a hallgatók tartózkodási helyét meghatározni. Ebből kifolyólag a rendszernek tudnia kell, hogy ki, mikor és merre tartózkodik az oktatási

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intézmény falain belül. Ez hasznos információ lehet egy iskolai tűz esetében. Ezáltal a biztonsági szolgálat, illetve a mentőcsapatok akár név szerint is tudhatják a tanulók pontos tartózkodási helyét, azok számát, valamint az evakuáció során bent rekedt tanulókat is könnyebben kimenekíthetik. Továbbá a videófelvevételek tárolása leggyakrabban a „hagyományos” felhőkben történik, holott a decentralizált felhőalapú megoldások nagyobb biztonságot nyújtanak. A kutatás célja, hogy bemutasson olyan biztonsági kamerarendszeren alapuló tűzvédelmi megoldást, amely egyedülállóan számít napjainkban.

Kulcsszavak: blokklánc, tűzvédelem, biztonsági kamera

1. Introduction

Thanks to the rapid development of IT-technology, and diminishing unit prices respectively, security cameras are widely utilised in educational institutions, with their basic function being surveillance, as well as the rise of the security level.

The analytical functions are widening the camera systems' capabilities increasingly, combining the hardware with artificial intelligence, enabling the enhancement of efficiency. Naturally, the aim is to increase the rate of automatisation, with the inclusion of the human factor at the lowest possible rate.

Modern solutions for fire protection are increasingly spreading in schools. There may be hundreds of students on the premises of the educational institutions during the lectures in a single timeframe, therefore, continuous monitoring of the newest solutions for fire protection is necessary, and to procure and install them respectively. Universities, however, may experience occurrences of building fires not only during the educative work, but during weekends and holidays, not to mention the vacation in the summer and winter.²

Every society in the world defines vulnerability and the immediate endangerment of life and property in connection with occurrences of building fires, even with the various fire extinguishing techniques and warning measures present.³

Thus, it is advisable for the universities to consider the implementation of a camera system that would not only be utilised for 'basic surveillance' so to say, but would be collaterally used most efficiently in the fire protection on a daily basis.

This work is structured as follows: after the chapter about the modern security cameras in the fire protection, the article introduces cameras with heat detection, then it points out the importance of artificial intelligence, which is required to be included in a professional level security camera. Last but not least, the most secure way of storing video footage will be discussed, with blockchain-based technologies in mind.

² Tamás Berek and Krisztián Bálint, 'Possible Computerized, Modern Solutions for Fire Protection of the Universities in Subotica, Serbia,' in *Mobilitás: A Magyar Tannyelvű Tanítóképző Kar tudományos konferenciáinak tanulmánygyűjteménye*, ed. by É. Borsos, R. Horák, C. Kovács and Zs. Námesztovszky (Subotica [Szabadka]: Újvidéki Egyetem Magyar Tannyelvű Tanítóképző Kar, 2019), 42.

³ Dóra Laczik, 'Hamis tűzjelzés kiszűrésének elvi és gyakorlati lehetősége a tűzvédelemben' [Theoretical and practical possibility of filtering out false fire alarms in fire protection], *Hadmérnök* 7, no 1 (2012), 16.

2. Modern security cameras in fire protection

The constitution of a modern, in-school fire protection system is a serious and difficult task. It can be observed that these systems are becoming more complex over time, respectively, they possess numerous modules enabling their future expansion. These security cameras are including more and more analytical functions, such as:

1. Headcount;
2. Crossing of lines;
3. Human recognition;
4. Facial recognition;
5. Personal identification;
6. Thermal detection;
7. Tracking of various objects.

These capabilities, at least all of them at once, are seldom present in a single camera, as the functions described are included only in a narrow niche of specialised, professional equipment as of yet. Furthermore, security cameras featuring technologies signaling fire alarms may also constitute a part of the fire protection system.

Thanks to the possibility of personal identification, through tighter linking of analytical functions the camera system may gain the capability of determining the exact location of every student within the premises of the university.

Luckily, educational institutions, colleges, students' boarding facilities seldom experience a building fire. If, however a fire would occur, it would have more serious consequences. Thus, it is expedient to consider a camera system that would be able to monitor the students' movements within the premises, with the identification of the students from a built-in database.

The majority of people hardly think of the actions required in the case of a fire, thus, many exhibit a behaviour endangering oneself and the others, too. The emergence of hyperexcitation is particularly aided by fire-related phenomena, such as the smoke, the heat, the noise, and the odour. With the increase of the intensity of these characteristics, the individuals may develop a drastic rise of hyperexcitation, thus, they may have difficulties in reaching appropriate decisions.⁴

In case a student has to be found who was eventually trapped in the premises, a security system capable of personal identification and tracking may presumably greatly contribute to the actions of the rescue teams inbound.

During the constitution of such a system, it is imperative to consider all the possibilities. As it is a camera system in question, it will record a considerable amount of footage on a daily basis. Thus, the data incurred should be attended with due precaution. Decentralised, cloud-based solutions are just starting to spread in the IT-community. The basic notion is the blockchain technology, which has been present since 2001, even so, data storage based on it is still considered a novelty. The aim of the operation is that the blockchain can safeguard data in a more secure manner.

⁴ Tamás Miskey, 'Az emberi tényezők és egy új kiürítéstámogató rendszer bemutatása' [Demonstration of human factors and a new evacuation support system], *Hadmérnök* 4, no 2 (2009), 58.

3. Heat detecting cameras

In order to be able to utilise a camera in the role of fire protection, it must be equipped with a heat sensor. Thermography occurs in objects hotter than -237 degrees Celsius and emitting infra-red waves. These waves are invisible to the human eye. However, the camera with thermal imaging converts the waves to electric signals, so they appear as thermal images to a human observer.⁵ The figure below shows a Dahua Ultra series thermal imaging camera, which would even be suitable among the strict conditions at the universities.



Figure 1

Dahua Ultra Series DH-TPC-SD8621-T

Source: 'Dahua Technology: Ultra series DH-TPC-SD8621-T.' Budapest, 2019, 1–4.

Two types of microbolometers are distinguished in case of the thermal cameras. These are the Vanadium-oxide microbolometer and the Amorphous silicon bolometer.

Formerly, only a few camera-types featured Fire Detection and Alarm analytics. Today, these innovations are spreading. Furthermore, they are able to detect fires in an ever-increasing efficiency with their built-in sensors. In the beginning, they were hardly capable to detect even a 10-degree temperature difference, which is considered a weak performance. The first table shows the technical specifications of the thermal module of the Dahua Ultra Series security camera introduced above:

⁵ 'BK Components: Simply see more without touch,' Budapest, Testo, 2020.

Table 1

Dahua Thermal Camera Specifications Thermal Module

Source: 'Dahua Technology: Thermal Camera Specifications.' Budapest, 2019, 1–4.

Thermal Camera max. Resolution (effective pixel)	640 × 512
NETD (Noise Equivalent Temperature Difference)	< 40mk
Temperature Accuracy	Max (+/-2°C, +/-2%) operating temperature
Temperature Measurement Range	Low temperature mode: -20°C to +150°C High temperature mode: -0°C to + 550°C
Temperature Range	-20°C ~ 150°C
Thermal Detector Type	Vanadium oxide uncooled focal plane detector

3.1. The thermal imaging camera's image sensors

The thermographic solutions of the thermal imaging cameras operate the following way:

1. The microbolometer based on vanadium-oxide or amorphous silicon is decidedly developed for the utilisation in thermal cameras, and they are capable of detecting the smallest differences in temperature. Presently, the microbolometer produced in the highest quantity includes crystalline vanadium-oxide sensor elements. The matrix-like arrangement of the thermal sensor elements strongly resembles the construction of CCD and CMOS sensors operating in visible light conditions. Every single pixel of the sensor's matrix plate represents an elementary microbolometer, in which the incoming infrared radiation causes a change in the electric resistance.
2. In some ways, the amorphous silicon-based microbolometer has more favourable parameters. Deviations cannot be observed in the structure of amorphous silicon, which fact secures an outstandingly uniform shaping on the level of pixels. It responds to changes in the temperature more predictably, thus, the sensor can be set up more easily. Its energy consumption is low, which is considered primarily in the case of portable thermal cameras. Highly sensitive sensors can be produced from amorphous silicon, which is not a negligible fact. The aim of the development of each type of camera is that the composed image should approach the quality of the live one. These days, the satisfactory results would be around 25 frames/sec. This can be hardly reached in case of a thermal camera without a cooling unit, as many types are capable of only about 8 frames/sec of refresh rate. However, it is easier to achieve a faster refresh rate with amorphous silicon sensors, as their thermal time constant is 30-40% lower than that of the VOx sensors.⁶

⁶ 'Thermal Camera System.' Oktel, Electronics, Szekszárd, 2018, 3.

3.2. NETD- Noise Equivalent Temperature Difference sensor

Thermal sensitivity is quite an important factor in the case of thermal cameras. It influences the heat sensitivity. The lower this value is, the more efficiently the camera reacts to the temperature difference. This value is given in millikelvin (mK). Usually, the following boundaries are set for the different values:

1. < 40mk – a very good value;
2. < 50mk – a good value;
3. < 60mk – an average value;
4. < 70mk – a weak value, so the camera is not efficient in sensing temperature difference;
5. < 80mk – very bad value.

3.3. Artificial intelligence

The science of security applies artificial intelligence in facial detection, facial recognition, as well as in head counting⁷ where it can be successfully utilised. By the implementation of artificial intelligence, the number of tasks encumbering the security service may be lessened, as the security footage does not need to be monitored 24 hours a day, as it is sufficient to view a certain portion if need be. Today's modern analytic cameras would be less efficient without the inclusion of the artificial intelligence, what is more, some tasks would not be manageable at all. These cameras are capable of continuous learning, thus lessening the number of false detections or identifications. Presumably, the cameras on the premises of the universities would need a longer time period to learn, as these need to identify numerous students on a daily basis. The factors aggravating the identification maybe the following:

1. Facial expressions;
2. Overlapping;
3. Image quality;
4. Presence of facial features;
5. Light conditions.

3.4. Facial recognition and detection

A camera can utilise metadata during its learning cycle. The more metadata it possesses, the less mistakes it will commit, its output values will be more accurate. Metadata of higher importance would be the students' attire, hairdo, male facial hair, sunglasses, also coats and scarfs in the winter. The attire worn at the moment will greatly aggravate the identification or may enhance the number of false detections.

⁷ Csaba Kollár, 'A mesterséges intelligencia és a kapcsolódó technológiák bemutatása a biztonságtudomány fókuszában' [Demonstration of artificial intelligence and related technologies with a focus on security science], in *Kiberbiztonság – Cybersecurity 2*, ed. by Zoltán Rajnai (Budapest: Biztonságtudományi Doktori Iskola, 2019), 47–61.

With the utilisation of artificial intelligence, the features hindering the efficient identification can be diminished, as the camera could learn to recognise these so-called 'hindering' factors.⁸

The PCA (Principal Component Analysis) is a solution that is able to deconstruct a facial image to its own basic components, which are fed into the process of grading and decision making. After the components of all the images in the database are known, the components of every testing facial images just need a comparison with the already acquired components. The principles of operation are as follows:

1. The first, 'own' face (eigenface), is an averaged one, the others are representing the differences, deviations from the first one. The eigenface is a good filter: every single face that follows, gives per pixels – as a scalar product with the average face – a value approaching 1, while in case of an image not depicting a face, this value will be much less than 1. The direction of the largest variation (compared to the eigenface) is given by the second eigenvector. The direction of the second largest variation is given by the third eigenvector, and so on. Every single eigenvector may be seen as a feature. If we depict a face in a reduced face space, its vector will provide the importance of each of the features on that particular face.
2. In the next steps, the operation of the PCA based facial recognition can be observed. The process receives a learning face file for an input, containing the images of many persons from many angles, then, with the PCA method, it produces a very limited number of eigenfaces. Naturally, the first step in every experiment is the definition of the eigenfaces. After that, the reduced face space may be populated with the known facial images, which are commonly taken from the learning facial images. Every single known face is transformed in the face space, and their components are saved to the memory. Only then the facial recognition may begin.⁹

4. Blockchain-based data storage

The revolution that happened in information technology has brought the need for digitalisation, more precisely, the desire for the work processes, databases, and data to be accessible on computers. The five foremost advantages of the digitalisation are considered as tracking, efficiency, reliability, swiftness, and flexibility. These qualities match the opinions about the blockchains. Blockchains are public or private distributed ledgers, consisting of blocks (heaps of data) linked in a diachronic order, similar to links in a chain. Every blockchain is constituted individually, and there is

⁸ Krisztián Bálint, 'Composition of an Automated Attendance Register of Students by Security Cameras, as part of Smart City,' paper presented at *Smart City Conference, SSSCC*, Óbuda University, Budapest, 2020.

⁹ László Dudás, *Alkalmazott Mesterséges Intelligencia* [Applied artificial intelligence], Kempelen Farkas Hallgatói Információs Központ, 2011. Available: https://regi.tankonyvtar.hu/hu/tartalom/tamop425/0046_alkalmazott_mesterseges_intelligencia/adatok.html (18. 04. 2020.)

a responsibility on every participant (data miner) in its constitution and maintenance, as the data blocks are distributed amongst those involved.¹⁰

The decentralised, blockchain-based systems are capable of storing and forwarding information securely. Moreover, they have constituted a new platform of transactional management, credibility, and quality insurance. However, besides the currency, this technology is also capable of becoming a ledger, a registry of other types of directional data flows.¹¹

The in-school security cameras usually save their footage to a cloud, or locally, on the NVR's (Network Video Recorder) hard disk. These two solutions do not provide the security needed, since:

1. The 'traditional clouds' are owned by great brands as providers, so basically, a person may easily feel dependent on them. If they fail to adhere to the appropriate norms and regulations, the data may be compromised. There have been numerous instances of data leaks or hacker attacks.
2. NVRs usually utilise the following storage architecture: DAS (Direct Attached Storage), NAS (Network Attached Storage), SAN (Storage Area Network), RAID (Redundant Array of Independent Disk). These solutions are proven during all these years, while there are more modern and progressive solutions in existence.

4.1. Off-Chain and On-Chain data storage

There are two ways for blockchain-based data storage. These are the Off-Chain data storage and the On-Chain data storage.

In the case of universities, the best option is the Off-Chain based storage, as the video footages contain a large amount of data. The cameras are capable of Full HD and 4K resolution, and not even the most efficient compression processes are able to reduce the data quantity generated. Presently, blockchains are capable of storing transactional information at best. For instance, the size of an Ethereum block is 30k, while the size of a Bitcoin Cash is 100k. It is foreseeable that a task requiring the storage of more GB of data is impossible to complete.

The On-Chain solution operates in the following way: every single instance of data is saved to all the blocks of a blockchain. Stemming from the sheer size of a video footage, the On-Chain storage cannot be a good solution, whereas this would be the most secure one. Not a single On-Chain network presently in existence could store the extent of data in question.

In the case of Off-Chain storage, the video footage could be stored on miners' computers, while the blocks would only store the hash values of the data in question. The data would be divided into smaller units, then these would be distributed to various physical locations. In a situation like this, the task of the Off-Chain would

¹⁰ Éva Ambrus, 'Blockláncok' [Blockchains], *Hadmérnök* 12, no 2 (2017), 226.

¹¹ László Karvalics and Gábor Dániel Nagy, 'Blokklánc és társadalmi makroevolúció' [Block chain and social macro-evolution], *Információs Társadalom* 17, no 3 (2017), 8.

be to establish a link between the storage and the miners' hard disks. In practice, the miners would provide their clients (for example the university) with storage space in exchange for coins. Moreover, the same data would be saved to many miners. Before the dispatching, data should be encrypted through various cryptographic methods. Figure 2 shows an Off-Chain structure capable of storing video footage:

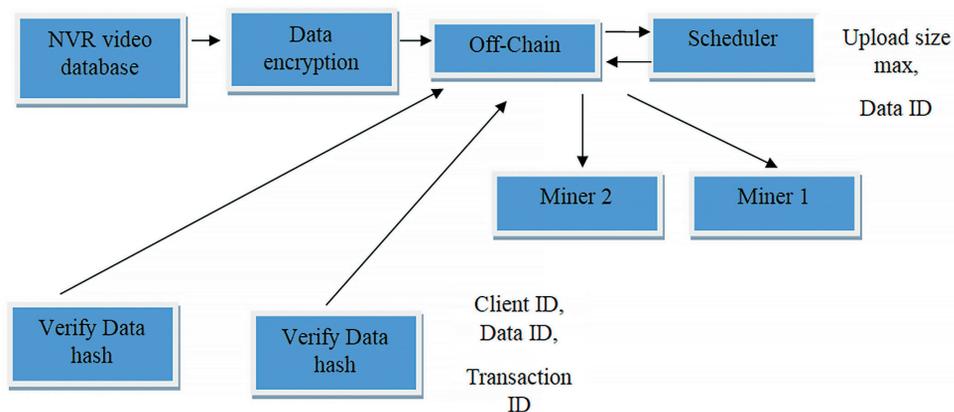


Figure 2

Video recording via Off-Chain structure

Source: edited by the author

5. Conclusions

The universities are in a difficult situation, as they have to use up-to-date security solutions, for the sake of the security of the students and the employees, all the while adhering to the legal regulations in a strict manner.

A modern security camera system would greatly enhance the existing level of security. With the inclusion of the analytic functions, these assets would be capable of performing a growing number of tasks. During the coming years, the forefront of the development would shift to more precise identification and tracking, resulting in the possibility of determining the exact location of every single student within the university's premises at a minute's notice.

It may seem worrying a little bit, but the solution has a positive side, too. In case of a fire, the students' whereabouts could be determined more easily, and this may greatly contribute to a successful evacuation.

Furthermore, in favour of the secure storage of video footage, it is worth to consider the implementation of the blockchain technology, besides the use of traditional, cloud-based solutions.

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