SECTION: INFORMATION TECHNOLOGY AND CYBERSECURITY

DOI 10.70286/ISU-22.04.2026.008

HUMAN-ORIENTED CONTROL OF SURVEILLANCE AREAS IN INTELLIGENT VIDEO MONITORING SYSTEMS

Bondariev Illia
Master of Arts in International Relations,
Technical Product Manager,
Amazon.com Services LLC, USA

Introduction. Video surveillance and monitoring have become key tools for security and resource management, with smart video surveillance systems gaining particular importance due to their ability to automatically track objects and territories using artificial intelligence and computer vision algorithms. At the same time, the effectiveness of such systems largely depends on taking into account behavioral, social, and ethical factors, since automated solutions often do not reflect the nuances of people's perception of surveillance and the specifics of their behavior under different environmental conditions. Insufficient integration of the needs of operators, law enforcement agencies, and the public into the system design process limits their practical effectiveness and requires the development of approaches that balance security and human rights.

Modern research rarely considers the adaptation of technologies to changing conditions and rapidly evolving social contexts, even though these factors significantly affect the accuracy of detection and tracking. In this context, the study of human-oriented control of surveillance zones not only lays the theoretical foundations for video monitoring systems but also provides practical recommendations for designing effective adaptive solutions that account for human behavior and environmental specifics.

Given modern challenges such as the growth of crime, social instability and technological risks, the results of this study can be used to increase the accuracy and reliability of monitoring systems, optimize operator work and develop security policies [1, p.74; 2, p.26].

The purpose of the study is to substantiate and develop methods for human-oriented control of surveillance zones in smart video monitoring systems to improve decision-making quality, timely detection of potentially dangerous situations, and the balance between security and privacy.

The objectives of the study are to analyze the factors that affect the effectiveness of surveillance zone control, taking into account human behavioral characteristics and environmental conditions, to develop methods for dynamic surveillance zone control based on intelligent video data analysis, and to determine evaluation criteria and conduct a comparative analysis of the effectiveness of the proposed solutions in typical video monitoring scenarios.

Methodology. The study used a systems analysis to determine the relationships between human behavioral characteristics and environmental parameters. Correlation analysis (Pearson coefficient) was used to assess the influence of factors (flow density, lighting, speed of movement). The development of methods for dynamic surveillance zone control was carried out using computer vision and machine learning algorithms (YOLO, SORT/DeepSORT). The effectiveness of the approach was evaluated experimentally by comparing it with static models, using Student's t-test to assess statistical significance. Data sources. The empirical base was made up of open video data (PETS2009, MOT) and our own set of videos from public spaces. In total, more than 120 video fragments collected in 2025 were analyzed, accounting for various environmental conditions and behavioral scenarios. Analysis tools. Data processing was performed in Python using OpenCV, TensorFlow, PyTorch, NumPy and Pandas. Results were visualized using Matplotlib and Microsoft Excel. Research limitations. The results depend on the quality of video data and shooting conditions and are focused on typical public spaces. Additional adaptation may be required for specialized environments.

Main part. The effectiveness of surveillance zone control in smart video monitoring systems is influenced by technical parameters, behavioral characteristics of people and environmental features [3, p. 101]. The intensity of traffic and the trajectories of visitors to public spaces, such as shopping malls or train stations, make it difficult to identify and track individuals, especially in high-density or fast-moving environments, which require adaptive tuning of algorithms [4, p. 56]. Abnormal behavior patterns, such as a person staying in one area for a long time, signal potential risk and require the system to automatically detect deviations [5, p. 3].

Lighting conditions and video resolution determine image quality and object recognition accuracy, while obstacles and occlusions limit visibility and require optimal camera placement. Environmental dynamics, including weather conditions, object movement, and time of day, change people's behavior and recording conditions, requiring algorithms to adapt to the context. Private or restricted areas require special frame processing to comply with human rights and ethical norms [6, p.4].

Only by taking into account all these factors and their interaction can adaptive video surveillance systems be created that can effectively respond to changing environmental conditions and people's behavior, ensuring a high level of security and meeting modern requirements for (minor) residential, public and commercial spaces.

The study implemented a dynamic surveillance zone management method based on video data analysis and evaluated its effectiveness compared with static approaches.

Comparing the effectiveness of monitoring surveillance zones by key indicators using static and dynamic methods allows us to assess the advantages of the adaptive approach and its impact on detection accuracy, tracking completeness, and the level of false positives (Table 1).

Table 1. Comparison of the effectiveness of methods for monitoring surveillance zones

Indicator	Static zones	Dynamic zones	%
Detection accuracy	0.81	0.89	+9.9
Completeness	0.76	0.87	+14.5
F1-measure	0.78	0.88	+12.8
False detection rate	0.19	0.11	–42.1
Average system response time (ms)	145	162	+11.7

Source: author's development

It is shown that the detection accuracy, which is 0.81 in static zones, increases to 0.89 in dynamic zones, reflecting the ability of adaptive algorithms to identify objects even in conditions of high visitor density in shopping centers or educational institutions, where trajectories of movement intersect. At the same time, the completeness of detection, which is 0.76 in static zones and increases to 0.87 in dynamic systems, confirms their ability to capture a larger number of relevant objects under different conditions, including rapidly changing scenarios. The combined F1-measure of 0.78 in static zones and 0.88 in dynamic ones indicates a more balanced operation of adaptive algorithms, allowing simultaneous increases in accuracy and completeness of identification. The false alarm rate decreases from 0.19 to 0.11, indicating effective filtering of noise signals, reduced risk of false alarms, and, therefore, increased confidence in the system and savings in response resources. The average system response time increases from 145 ms to 162 ms due to additional data processing, but this is offset by improvements in accuracy and completeness, especially under active pedestrian movement and variable lighting conditions.

Thus, a comparison of methods for controlling surveillance zones confirms the advantage of dynamic zones over static ones, as their adaptability enables more accurate and complete object detection, reducing false alarms and improving the system's response efficiency in real monitoring conditions.

Table 2 presents the influence of the density of the flow of people on the efficiency of methods for controlling surveillance zones, estimated by the indicators of accuracy (Precision), completeness (Recall) and balanced measure (F1), which allows comparing the operation of systems in conditions of different levels of space occupancy.

Table 2. The impact of flow density on the effectiveness of control methods

Flow density	Method	Precision	Recall	F1
Low	Static	0.87	0.82	0.84
Low	Dynamic	0.91	0.89	0.90
High	Static	0.74	0.68	0.71
High	Dynamic	0.86	0.84	0.85

Source: author's development

It is shown that at low load in educational buildings and shopping malls, the static method provides an accuracy of 0.87 and a completeness of 0.82. This indicates its ability to identify objects with a small number of visitors. The dynamic method under the same conditions achieves an accuracy of 0.91 and a completeness of 0.89, demonstrating greater adaptability to changes in people's behavior, even in a relatively calm environment. The F1-measure of 0.90 confirms a balance between accuracy and completeness, thereby increasing the reliability of the system. With increasing flow density in peak traffic conditions, the efficiency of the static method decreases sharply, and the accuracy drops to 0.74 and the completeness to 0.68, indicating its limited ability to cope with high load and the loss of some objects in the observation field. The dynamic method under the same conditions maintains an accuracy of 0.86 and a completeness of 0.84, demonstrating greater resistance to changing conditions and the ability to maintain stable performance even under heavy human traffic.

The results obtained emphasize that the choice of control method should depend on flow density and the specific environment. Thus, dynamic systems are more promising for scenarios with high visitor activity, while static methods can be effectively used in calm conditions with low load, which provides a basis for further optimization and the development of adaptive solutions in the field of video surveillance.

Table 3 determines the impact of different lighting conditions on the effectiveness of surveillance zone control methods, evaluated by accuracy, completeness and balanced measure, which allows comparing the operation of systems in bright and darkened rooms and during night surveillance.

Table 3. Effectiveness of control methods under different lighting conditions

Lighting conditions	Method	Precision	Recall	F1
Stable	Dynamic	0.90	0.88	0.89
Variable	Dynamic	0.85	0.83	0.84
Low	Dynamic	0.81	0.79	0.80

Source: author's development

In stable indoor lighting conditions, such as shopping malls or educational buildings, the dynamic method achieves 0.90 accuracy and 0.88 completeness, demonstrating its ability to effectively identify objects and maintain a high level of control. With changing lighting conditions, such as dusk or changing artificial light intensity, the accuracy decreases to 0.85 and the completeness to 0.83, indicating the need to adapt the algorithms to new challenges without losing overall efficiency. Even in low light, the accuracy and completeness remain at 0.81 and 0.79, respectively, demonstrating the advantage of the dynamic approach over static methods, which exhibit even lower performance under the same conditions. Statistical analysis confirms the significance of these results, as the difference between the static and dynamic methods across all lighting modes is significant ($t = 3.27$; $p < 0.01$), indicating a stable advantage for adaptive algorithms. This allows us to conclude that a dynamic control method is appropriate across different lighting conditions, ensuring stable system performance and rapid adaptation to changing environments.

Scientific novelty. For the first time, a method for dynamic control of surveillance zones in smart video monitoring systems has been proposed, accounting for people's behavioral characteristics and environmental context. Computer vision algorithms for adaptive redistribution of camera resources have been improved, resulting in a 9–14% increase in detection accuracy and a 42% reduction in false positives compared to standard static methods.

Practical significance. The developed approach can be applied to video monitoring systems for public spaces (airports, train stations, shopping malls, educational institutions) to enhance security and quickly detect potentially dangerous situations. Based on the results, video surveillance operators and security service partners can make real-time decisions on dynamic camera reconfiguration, thereby optimizing system resources and reducing the number of false alarms.

Conclusion. The effectiveness of monitoring surveillance zones in smart video monitoring systems is significantly increased when using dynamic zones compared to static ones, which is manifested in an increase in detection accuracy and completeness of object detection by 9–14%. The density of the flow of people affects the system's performance; with high activity, dynamic methods maintain stable accuracy and completeness indicators, while static methods demonstrate a significant decrease in the ability to identify objects. Lighting conditions directly affect the system's operation; under low or changing lighting, dynamic methods maintain higher accuracy and completeness indicators than static methods, confirming their adaptability and reliability across various scenarios. Dynamic methods reduce the false positive rate by 42%, providing more accurate and stable monitoring even under difficult environmental conditions, thereby increasing confidence in the system and the effectiveness of the response. The average response time of dynamic systems is higher than that of static systems, but the advantages in accuracy, completeness, and F1-measure compensate for this increase, making them suitable for real-world applications in rapidly changing conditions. Prospects for further research lie in developing integrated algorithms that combine dynamic zone management with adaptive lighting parameters and human behavior prediction, thereby improving the effectiveness of video monitoring systems across diverse environments.

References

1. Shmatko, O. V., Hamaiun, I. P., Kolomiitsev, O. V., Tretiak, V. F., Rudakov, I. S., & Berdochnyk, A. D. (2025). [Research and evaluation of the subsystem for detecting and classifying objects in a video stream]. Information processing systems, 4(179), 70–80. https://doi.org/10.30748/soi.2024.179.08 [in Ukrainian].

2. Bulbotka, N., & Polshakova, O. (2025). [Application of computer vision for an automated object tracking system]. Adaptive automatic control systems, 1(46), 22–34. https://doi.org/10.20535/1560-8956.46.2025.323655 [in Ukrainian].

3. Bondarchuk, A. P., Melnyk, I. Yu., Sukhanevych, Ye. I., & Abramov, V. O. (2025). [Improving the efficiency of video surveillance systems through a hybrid method of key frame selection and decision interpretation]. Telecommunications and information technologies, 88(3), 101–105. https://doi.org/10.31673/2412-4338.2025.038710 [in Ukrainian].

4. Bondarenko, D. A., Holovchenko, A. V., Tkalenko, O. M., & Polonevych, O. V. (2025). [Research into the impact of artificial intelligence on the development of video

surveillance systems]. A scientist's word: Science, exploitation, production, 1(173), 55–60. https://doi.org/10.31673/2412-9070.2025.019458 [in Ukrainian].
5. Ouardirhi, Z., Mahmoudi, S. A., & Zbakh, M. (2024). Enhancing object detection in smart video surveillance: A survey of occlusion-handling approaches. Electronics, 13(3), 541. https://doi.org/10.3390/electronics13030541
6. Jeong, J., Park, K., Kim, T., & Park, W. (2025). An intelligent surveillance framework for pedestrian safety under low-illuminance street lighting conditions. Applied Sciences, 15(24), 13201. https://doi.org/10.3390/app152413201

ОЦІНЮВАННЯ ЕФЕКТИВНОСТІ КОНТЕЙНЕРНИХ БЕКЕНД-СЕРВІСІВ ПРИ ФАЙЛООБРОБНИХ НАВАНТАЖЕННЯХ

Кириченко Олександр Олексійович
асистент
Обершт Валентина Василівна
здобувачка вищої освіти бакалаврського рівня
Кафедра математичних проблем управління і кібернетики
Чернівецький національний університет імені Юрія Федьковича
Чернівці, Україна

Анотація: Здійснено порівняльне оцінювання продуктивності контейнерних бекенд-сервісів, реалізованих на Node.js (Express) та Python (FastAPI), за одинадцятьма метриками в умовах файл обробного навантаження (архівація PDF у ZIP). Введено нормалізований показник ресурсної ефективності (REI), що дозволяє формалізувати вибір серверної платформи для хмарних розподілених систем.

Ключові слова: node.js, python, контейнеризація, розподілені системи, хмарна платформа, масштабування, навантажувальне тестування

Вибір серверного фреймворку є важливим архітектурним рішенням, що безпосередньо впливає на продуктивність, масштабованість та експлуатаційну вартість програмних систем. Node.js та Python залишаються двома домінуючими екосистемами для розробки бекенд-API, проте наявні бенчмарки оцінюють фреймворки переважно на синтетичних задачах – серіалізації JSON або одиничних запитах до бази даних [1]. Такий підхід не відображає поведінки систем у реалістичних виробничих сценаріях, де поєднуються операції вводу-виводу та процесорні обчислення.

Метою дослідження є розробка підходу для порівняльного аналізу контейнерних бекенд-сервісів із урахуванням показників продуктивності, масштабованості та ресурсоефективності у реалістичних сценаріях навантаження.

Реалізовано два функціонально ідентичні сервіси: на основі Node.js v22 із фреймворком Express та на основі Python 3.12 із FastAPI. Обидва сервіси