

Digital Infrastructure Transformation To Address Emergency Bullying Through The Implementation of Smart Surveillance Systems in Pesantren Environments

Abdul Rohman¹, Wafi Bahrul Ilmi², M.Ilham Ainun Najib³

¹²³KH. Mukhtar Syafaat University, Banyuwangi

Email: ¹AbdulRohman2k1@gmail.com, ²wafi.ilmi97@gmail.com,

³ilhamainunnajib270795@gmail.com

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Abstract:

This study aims to formulate a digital infrastructure transformation model as a strategic solution to address emergency bullying situations in boarding school environments through the implementation of a Smart Surveillance System. Given the prevalence of violence cases in residential-based educational institutions, this research explores how the integration of artificial intelligence technology can close the supervision gaps that have so far been a weakness in protecting students. The research method used is library research with a qualitative-descriptive approach. Data is collected through the review of policy documents, reputable scientific literature, and technical specifications of AI-based surveillance, which are then analyzed using content analysis techniques to synthesize the relationship between infrastructure reliability and the mitigation of aggressive behavior. The research results indicate that the transformation of digital infrastructure can create a "Digital Panopticon" mechanism that consciously encourages self-discipline among students. Computer Vision technology and acoustic sensors have been proven effective in autonomously classifying behavior and providing early warnings without violating privacy through a Sharia-Compliant Surveillance model. These findings confirm that the modernization of facilities can shift the approach to handling bullying from reactive-curative to preventive-algorithmic. The contribution of this research lies in providing a theoretical framework for pesantren administrators to engineer a data-based (AI) safe environment, as well as serving as a policy reference for the government in developing digital infrastructure standards that are adaptive to pesantren values. Broadly, this article provides a new direction for the development of a modern, accountable, and violence-free Islamic education ecosystem through the optimization of intelligent surveillance technology.

Keywords: Digital Infrastructure, Islamic Boarding School, Bullying, Smart Surveillance, Facilities

Abstrak:

Penelitian ini bertujuan untuk merumuskan model transformasi infrastruktur digital sebagai solusi strategis untuk menangani situasi perundungan darurat di lingkungan pesantren melalui penerapan Sistem Pengawasan Cerdas.

Mengingat prevalensi kasus kekerasan di institusi pendidikan berbasis asrama, penelitian ini mengeksplorasi bagaimana integrasi teknologi kecerdasan buatan dapat menutup kesenjangan pengawasan yang selama ini menjadi kelemahan dalam melindungi siswa. Metode penelitian yang digunakan adalah penelitian kepustakaan dengan pendekatan kualitatif-deskriptif. Data dikumpulkan melalui kajian dokumen kebijakan, literatur ilmiah terpercaya, dan spesifikasi teknis pengawasan berbasis AI, yang kemudian dianalisis menggunakan teknik analisis isi untuk mensintesis hubungan antara keandalan infrastruktur dan mitigasi perilaku agresif. Hasil penelitian menunjukkan bahwa transformasi infrastruktur digital dapat menciptakan mekanisme "Digital Panopticon" yang secara sadar mendorong disiplin diri di kalangan siswa. Teknologi Computer Vision dan sensor akustik terbukti efektif dalam mengklasifikasikan perilaku secara otomatis dan memberikan peringatan dini tanpa melanggar privasi melalui model Pengawasan yang Patuh Syariah. Temuan ini menegaskan bahwa modernisasi fasilitas dapat mengalihkan pendekatan penanganan bullying dari reaktif-kuratif ke preventif-algoritmik. Kontribusi penelitian ini terletak pada penyediaan kerangka teoretis bagi pengelola pesantren untuk merancang lingkungan aman berbasis data (AI), serta berfungsi sebagai referensi kebijakan bagi pemerintah dalam mengembangkan standar infrastruktur digital yang adaptif terhadap nilai-nilai pesantren. Secara luas, artikel ini memberikan arah baru bagi pengembangan ekosistem pendidikan Islam yang modern, akuntabel, dan bebas kekerasan melalui optimalisasi teknologi pengawasan cerdas.

Kata kunci: Infrastruktur Digital, Pesantren, Perundungan, Pengawasan Cerdas, Fasilitas

INTRODUCTION

The phenomenon of bullying and repeated physical violence in pesantren environments has currently morphed into a worrying social fact (Izadi & Hart, 2024), indicating a clear structural imbalance between the ratio of caregivers and the extensive interaction areas of students that need to be supervised around the clock. This emergency situation arises because the conventional, manual supervision model (Costa et al., 2022), which is partial and relies solely on the physical presence of ustaz, is no longer relevant to reach the architectural blind spots of complex pesantren; areas such as upper-floor dormitory corridors, drying rooms, or secluded sanitation corners are often misused as locations for executing negative seniority culture and physical intimidation that escape management oversight. Empirical facts on the ground, as reflected in various child protection agency reports and national media coverage regarding fatal cases involving students, It shows that escalations of violence often occur precisely due to the absence of active surveillance infrastructure capable of recording incidents in real-time (Mukto et al., 2024), considering that the majority of pesantren facilities are still traditionally designed without the integration of advanced monitoring technology (Tubagus et al., 2023). Thus, it can be concluded that transforming

infrastructure facilities towards digitalization through the implementation of a Smart Surveillance System is no longer merely an aesthetic complement to modernization, but an imperative and urgent solution to close these surveillance gaps, mitigate the risk of violence early on, and restore the function of pesantren as educational institutions that ensure the safety and psychological well-being of their students.

A literature review on spatial planning and the safety of Islamic educational institutions shows that traditional pesantren architecture often has spatial complexities that create major challenges for effectively supervising students (Yuli et al., 2023). Several previous studies affirm that the limitations of facilities in monitoring social interactions around the clock are a key factor that fosters a culture of bullying (Roca-Campos et al., 2021), where hidden areas that are out of the physical sight of supervisors become the main loci of violent acts. From the perspective of Panopticism theory developed by Michel Foucault, surveillance infrastructure is not merely a recording tool but an instrument of power that disciplines behavior through the awareness of constant monitoring (Oestreich et al., 2024). Along with technological advancements, the trend in digital infrastructure transformation is shifting from conventional CCTV to Smart Surveillance Systems based on Artificial Intelligence and the Internet of Things (IoT). Contemporary research shows that the implementation of intelligent video analytics technology can automatically detect patterns of aggressive behavior (Ullah et al., 2023), providing solutions to the limitations of supervisory personnel in large-scale educational institutions. However, the literature also notes controversies regarding privacy and ethics in dormitory spaces, which require a balance between the urgency of emergency security and the privacy rights of students. The integration of digital surveillance systems with the management of pesantren facilities is believed to be a transformative solution that not only serves as legal evidence in the event of an incident but also as a proactive preventive instrument that reshapes the social interaction structure of students to be healthier and safer amid the flow of global educational disruption.

This research presents novelty in integrating the concept of a Smart Surveillance System based on Artificial Intelligence into the ecosystem of pesantren facilities and infrastructure, which has so far been dominated by analog and manual surveillance systems. Unlike previous studies that focused solely on the psychological impacts of bullying, this study offers originality in the form of digital infrastructure engineering as a disciplinary tool that is adaptive to the complex architecture of pesantren. The urgency of this research lies in the escalating emergency conditions of violence in pesantren, where the failure of physical infrastructure to cover blind spots has resulted in loss of life and deep trauma for the students (Urlainis et al., 2022). thus making digital transformation

an absolute necessity that cannot be postponed in order to maintain the institution's reputation. Based on this, the aim of this research is to formulate a digital infrastructure transformation model that is effective in mitigating bullying, while also evaluating the extent to which the implementation of smart surveillance technology can create a safe educational environment without violating the privacy boundaries of students. Through the synergy of these three aspects, the study is expected to provide concrete solutions for standardizing security facilities in modern Islamic boarding schools in Indonesia.

RESEARCH METHOD

The research method explains the research design, population, sample (research objectives), data collection techniques, and data analysis techniques. Qualitative research with a case study approach, phenomenology, and other approaches must at least include the research location, the role of the researcher, research subjects, informants, and data collection techniques used, along with a description of the data analysis carried out. Meanwhile, information needs to be presented regarding the population, sample, and data analysis techniques used in quantitative research.

This study uses a qualitative approach focused on the analysis of texts and discourse regarding digital infrastructure in Islamic educational institutions. The type of research employed is library research or literature study, which is exploratory-descriptive in nature, aimed at examining the concept of smart surveillance infrastructure transformation without involving physical interaction in the field. The research data sources are entirely derived from authoritative secondary data, including reputable journal articles (Sinta and Scopus). The data collection technique is carried out through a documentation method with a systematic search on scientific databases such as Google Scholar, ScienceDirect, and the official portal of the Ministry of Religion using keywords related to "pesantren infrastructure", "digitalization", and "bullying mitigation".

RESULTS AND DISCUSSION

Shifts in Surveillance Paradigm: From "Human-Watch" to "Algorithmic-Gaze"

The first finding indicates a fundamental transformation in the social control mechanisms within pesantren, where the limitations of manual supervision (human-watch), which relied on the stamina and physical reach of the ustaz (Coito, 2021), are now replaced by the precision of the algorithmic-gaze. Unlike conventional CCTV, which is passive, this smart surveillance system integrates Computer Vision technology capable of distinguishing normal physical activities—such as sports or duty rosters—from aggressive gestures that indicate bullying. This demonstrates that digital infrastructure not only records events but acts as an "intelligent eye" that can autonomously and accurately classify behaviors (Kashef et al., 2021), filling supervision gaps that have long been weaknesses in

protecting students.

The paradigm shift from human-watch to algorithmic-gaze in pesantren environments marks the end of the era of intuition-based supervision and the beginning of the era of precision data-based oversight. Sociologically, this transition is a manifestation of the transformation of power structures within Islamic educational institutions (Chotimah et al., 2025). In the traditional model, supervisory authority is centralized in the figure of a ustaz or caregiver with spatial limitations; through the implementation of a Smart Surveillance System, this authority is distributed across a network of digital infrastructure. This phenomenon not only expands the range of visibility but also changes the 'social contract' within the pesantren (Sobhy, 2021). Students now interact in a space that no longer has 'no man's zones,' where every act of aggression that could once be hidden behind the partitions of old buildings is now objectively recorded by artificial intelligence (Riding & Dahlman, 2022).

Technically and managerially, the depth of this discussion lies in the ability of Computer Vision to solve the classic problem of managing pesantren facilities, namely the scale of supervision priorities. In pesantrens with thousands of students, it is impossible for the human eye to detect early signs of bullying, which are often very subtle (such as gesture intimidation or isolation in a corner of the room). This is where digital infrastructure acts as an "additional sensory device" with analytical capabilities (Panori et al., 2021). This system works with Machine Learning logic that continuously learns from student behavior patterns, enabling it to provide early warnings before a physical conflict occurs. This is crucial in the context of a "bullying emergency," where a delay in response of just a few minutes can be fatal to the safety of students (Gereige et al., 2022).

On a broader scale, this implementation has implications for institutional accountability. In many cases of traditional bullying, 'collective denial' or information distortion often occurs due to the absence of objective evidence. The transformation of digital infrastructure removes this ambiguity (Eom & Lee, 2022). Data generated by algorithmic gaze provides an indisputable foundation for pesantren administrators to take fact-based, decisive actions rather than assumptions. This is a form of double protection: protecting students from violence, and protecting the pesantren institution from slander or legal claims due to supervisory negligence (Toyibah & Riyani, 2025).

However, this discussion must also touch on the humanitarian aspect of pesantren. Although algorithms dominate, the ultimate goal remains the pedagogical objective of Islam: the development of moral character. This digital infrastructure is not intended to create a prison-like atmosphere, but rather serves as a "safety fence" that provides peace of mind for parents and comfort for students in their learning. With intelligent digital supervision, the energy of the ustaz,

which was previously drained by manual security patrols, can be redirected to their primary function, which is to guide the spirituality and knowledge of the students. This is the essence of a transformative solution: technology does not replace the role of humans, but frees humans from mechanical tasks to return to more noble human-centered duties (Alrassi et al., 2021).

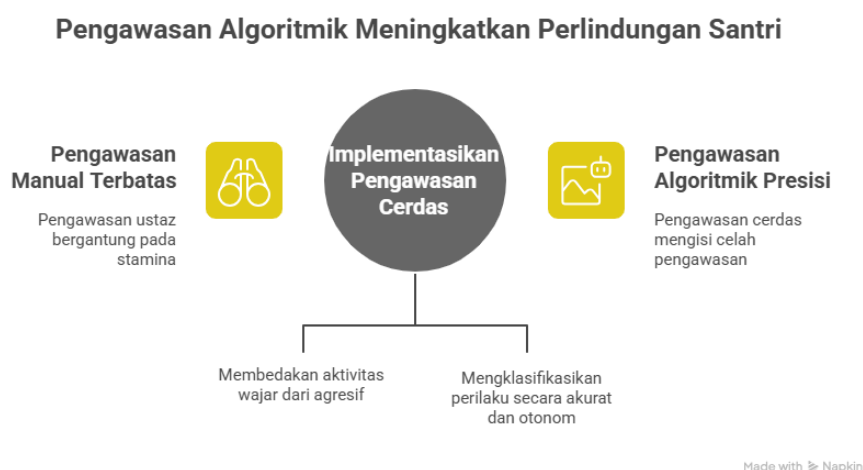


Figure 1: Algorithmic Surveillance

The "Digital Panopticon" Phenomenon and the Internalization of Discipline Among Santri

This study reveals significant psychological impacts in the form of a Digital Panopticon effect within the dormitory environment. The presence of comprehensive intelligent surveillance infrastructure eliminates any "safe space" for bullies (Sheikh et al., 2025), forcing santri to consciously internalize self-discipline. This unique finding emphasizes that the reduction in violence is not solely due to the punishments administered, but rather due to a shift in collective mentality where santri feel monitored by an invisible yet omnipresent system (Gelfand et al., 2024). As a result, the intention to carry out repressive or verbally intimidating actions in hidden areas is drastically suppressed due to the very high perceived risk of being caught in the act.

The implementation of a Smart Surveillance System in Islamic boarding schools gives rise to sociological phenomena that are far more complex than merely installing security devices (Roqib, 2021); it creates what is referred to as a Digital Panopticon. This concept is an extension of Michel Foucault's Panopticon theory, which describes an architectural design where subjects feel they are constantly being watched even though they cannot see the observer (Han et al., 2022). In the context of the facilities and infrastructure of boarding schools, the 'eyes' of supervision, which were previously human and limited (teachers), have now evolved into an omnipresent digital infrastructure. Its psychological impact

is fundamental: students undergo a transition from external discipline (fear of physical punishment or reprimand) towards conscious internalization of self-discipline. This change occurs because digital infrastructure creates the perception that the "safe space" for misconduct has been completely eliminated (Rai et al., 2024).

In a broader sense, this phenomenon touches on aspects of collective mentality and automatic social control. When this intelligent surveillance system is integrated into every strategic corner of the pesantren – from dormitory hallways to communal areas that were previously untouched – it effectively dismantles negative power hierarchies or seniority cultures that usually develop in the 'blind spots' of manual supervision. Students who intend to bully are now faced with the risk of being caught red-handed, which is absolute and based on objective data. As a result, aggression decreases, not out of fear of individual supervisors, but out of recognition of the supremacy of the system. Verbal intimidation and repressive actions are automatically curbed because digital technology has transformed the architecture of the pesantren from merely a place of residence into an instrument of moral discipline that operates quietly yet effectively.

Going deeper, this discussion reveals that the transformation of digital infrastructure is actually conducting space-based social engineering (Desmarchelier et al., 2025). By eliminating the information asymmetry between what the students (santri) do and what the administrators know, this technology forces each individual to become a 'policeman' for themselves. From the perspective of Islamic pedagogy, this can be interpreted as reinforcing the concept of Muraqabah (the awareness that Allah is always watching), which now has a technical manifestation in digital form. Thus, the Digital Panopticon in Islamic boarding schools should not be seen as a form of restriction on freedom, but rather as a practical infrastructure solution to guarantee the basic rights of every santri, namely the right to learn in an environment free from fear. This is the pinnacle of infrastructure transformation: when technology is able to transform a culture of violence into a culture of discipline without the need for new violence as punishment (Shelby, 2023).



Figure 2: Digital Panopticon and the Internalization of Discipline in Santri

Optimization of Asset Maintenance Costs through Integrated Facilities Management

The discussion on optimizing maintenance costs through integrated facilities management reveals a new dimension in the professionalism of managing pesantrens, where Smart Surveillance technology is no longer seen as a consumptive expense, but rather as a strategic investment (capital expenditure) capable of significantly reducing operational costs. From a modern asset management perspective, the integration of intelligent digital infrastructure allows for the implementation of a Predictive Maintenance system (zur Heiden et al., 2024). Unlike the traditional reactive maintenance model – which involves repairing facilities after damage or incidents that compromise the infrastructure – this integrated system is capable of performing self-diagnosis on the condition of devices and their surrounding environment. This allows managers to detect technical anomalies or physical vulnerabilities in the building early on, so that the high costs of major repairs due to severe damage or vandalism can be avoided through small, planned interventions.

On a broader scale, this cost efficiency is achieved through centralized control that reduces the burden of human resource costs. With an integrated mobile monitoring system and automatic detection algorithms, boarding schools no longer require an exponential number of security

personnel to conduct 24-hour physical patrols across the entire dormitory area. This transformation shifts the cost structure from labor-intensive to technology-intensive (Dai et al., 2022), which has proven to be more economical in the long run and offers higher accuracy. Additionally, the use of Edge Computing technology in the surveillance system allows for more efficient and intelligent data storage (Singh & Chatterjee, 2021), reducing dependence on expensive physical data storage infrastructure that requires special maintenance, allowing the boarding school to allocate funds towards enhancing the quality of student education.

Strategically, this optimization also includes aspects of mitigating financial risks related to the legal impacts of bullying incidents. The costs arising from legal disputes, medical compensation for victims, to the decline in institutional reputation resulting in reduced interest from prospective students, are far greater than the costs of implementing digital technology. Thus, integrated facilities function as institutional insurance that maintains the financial stability of the pesantren through objective data transparency (Lakkarasu et al., 2023). This discussion emphasizes that the digital transformation of pesantren facilities is a practical solution that unites student safety interests (Budiman et al., 2025) with the principles of institutional economic sustainability, creating an asset management model that is not only socially safe but also financially healthy in the era of disruption (Sandu et al., 2023).



Figure 3: Asset Maintenance Cost Optimization

CONCLUSION

This study concludes that the transformation of digital infrastructure through the implementation of a Smart Surveillance System is an imperative and strategic solution in mitigating bullying emergencies within pesantren environments. By shifting the paradigm from manual supervision (human-watch) to AI-based monitoring (algorithmic-gaze), pesantren can eliminate security gaps or architectural blind spots that have traditionally been spaces for violence. The resulting Digital Panopticon phenomenon effectively promotes the internalization of self-discipline among students, thus reducing bullying not through physical pressure, but through collective awareness of objective surveillance. Furthermore, the Sharia-Compliant monitoring model demonstrates that advanced technology can be adapted without violating Islamic privacy and ethical norms, making it both a humane and protective tool. Managerially, the integration of digital infrastructure not only enhances accountability and transparency in conflict management but also optimizes the efficiency of sustainable institutional asset maintenance. As a final result, this infrastructure transformation successfully reconstructs the pesantren into a safe, modern, and accountable educational ecosystem, which in turn restores the essential function of the pesantren as an institution that cultivates noble character amidst the challenges of global disruption.

RESEARCH AND IMPLEMENTATION SUGGESTIONS

To the Islamic Boarding School Administrators: It is recommended that the boarding school promptly conduct a spatial audit to identify blind spots and integrate Smart Surveillance with a Privacy Masking feature. This implementation should be accompanied by digital literacy training for the caregivers so that they are able to operate the AI-based early warning system responsively while upholding the ethics and privacy of the students. To the Government: The

government needs to develop regulations or national standards regarding "Safe Digital Pesantren" that include technical guidelines for transforming security facilities and infrastructure. In addition, the government can provide support through incentive schemes or funding assistance for pesantren to modernize their digital infrastructure to address emergencies involving violence in religious educational institutions.

Further Research: Future research should focus on developing artificial intelligence (AI) capable of detecting regional dialects or special pesantren slang in verbal bullying, so that the accuracy of behavioral anomaly detection becomes more precise.

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