IAES International Journal of Artificial Intelligence (IJ-AI)
Vol. 13, No. 2, June 2024, pp. 1214~1226
ISSN: 2252-8938, DOI: 10.11591/ijai.v13.i2.pp1214-1226

Smart prison technology and challenges: a systematic literature reviews

Ejo Imandeka[1,2], Achmad Nizar Hidayanto[1], Mufti Mahmud[3]
[1]Department of Computer Science, Faculty of Computers Science, University of Indonesia, Depok, Indonesia
[2]Correctional Engineering Program, Department of Corrections, Polytechnic of Correctional Science, Depok, Indonesia
[3]Cognitive Computing and Brain Informatics Research Group, Department of Computer Science, Nottingham Trent University, Nottingham, United Kingdom

Article Info

Article history:

Received Jan 12, 2023
Revised Oct 23, 2023
Accepted Nov 16, 2023

Keywords:

Internet of things architecture
Prison
Prison challenges
Smart prison
Technology-organization-environment framework

ABSTRACT

The rapid rise of intelligent technology, particularly in government, is igniting a new phase of the industrial revolution around the world. As governmental entities, prisons oversee upholding social order and lowering current crime. The concept of the smart prison has not received much attention but is gaining traction. The goal of this research is to conduct a literature review to identify current prison technologies and to analyse the challenges associated with implementing smart prisons using the preferred reporting items for systematic reviews and meta-analyses (PRISMA) protocol. Nine credible publishers were looked up between October 2022 and December 2022. The initial search yielded 362 articles, of which 25 were included in the final phase. This research provides the current state of prison according to technology-organization-environment (TOE). Some challenges arise in the context of TOE, such as the high cost of smart technology, inadequate technology design, poor management, ineffective service, overcrowding, ageing facilities, increasing violence, disease spread, and ethical problems. This study also classifies smart prison technology based on the internet of things (IoT) architecture layer. By providing the first comprehensive review on smart prison technology, this study makes an essential contribution to the subject of prisons.

Corresponding Author:

Ejo Imandeka
Department of Computer Science, Faculty of Computer Science, University of Indonesia
Margonda Raya, Depok, West Java, Indonesia
Email: ejo.imandeka21@ui.ac.id

1. INTRODUCTION

The implementation of smart technology, especially in government areas, is diverse. Innovation is an essential component that describes intelligence in government [1]. Many government organizations have attempted to improve people's lives by utilizing smart government services such as information and communication technology (ICT) management, data, and policies [2], [3]. Extensive data integration improves management system, data sharing, investment, smart office system development, talent team development, and optimization measures [4] within government organizations. The concept of smarts in government areas has been widely popular, and it is on the agenda for discussions about smart government in general. The notion of intelligence in government areas has gained widespread popularity and has become a prominent topic of discussion in relation to smart city for at least a decade.

Smart prison is a new prison concept that focuses on rehabilitation, education, and reintegration using digital services. The smart prison concept is a cost-effective and rehabilitative way to use cutting-edge

technology to reduce recidivism and support reintegration [5], [6]. The study of smart prisons is currently scattered. Smart technology in prisons is rarely considered, despite the smart city debate drawing numerous research initiatives. The concept of a 'smart prison' has not received much attention, but it has recently gained ground [7]. The finding articles are dominated by the implementation of technology in prisons, but limited research is collecting prison technology articles into general objectives of imprisonment. Then, this study is interested in gathering all the smart prison technology in literature study. This research used the technology-organization-environment (TOE) framework. The TOE framework has been used to explain the adoption of inter-organizational systems, and a wide range of general information system (IS) applications. It combines a scheme of technological characteristics, organizational factors, and elements of the macro environment [8]. TOE framework is an analytical framework that is used to study the adoption and assimilation of different types of innovation at the organizational level in the context of internal and external organizations. This framework fits to the culture of prison organization which is heterogeneous and represents different types of organizational level. As a result, the TOE framework is utilised as an analytical framework to examine the culture of the prison environment and current diverse types of smart technology in the prison.

A thorough literature review is required to better comprehend the idea of smart prisons. By gathering, evaluating, and synthesizing all available empirical information that satisfies established criteria, a systematic review of the literature enables thorough and fruitful answers to research issues [9]. This research will shed light on the current state of prison technology and the challenges associated with implementing smart prisons. This study attempts to conduct a systematic literature review (SLR) approach from the databases Scopus, association for computing machinery (ACM) digital library, ScienceDirect, multidisciplinary digital publishing institute (MDPI), Emerald, Sarah and George (SAGE) publishing, IEEE Xplore, Taylor & Francis, and Google Scholar.

2. METHOD

A novel concept, referred to as 'smart', strives to enhance our everyday experiences by seamlessly blending physical and digital components, utilizing embedded sensors to link us with intelligent devices. This transformative shift involves a thorough examination of our actions through extensive data analysis, with the goal of promoting productivity and elevating our quality of life. Smart prison represents an innovative approach to penitentiaries, emphasizing digital services for rehabilitation, education, and societal reintegration. The concept of a 'smart prison' encompasses a comprehensive management and analytics tool, delivering real-time information [10]. Furthermore, these initiatives may employ digital technologies to provide education and training for inmates, aiding their preparation for reintegration into society upon release. This approach not only reduces costs but also bolsters public safety and security, curbing recidivism rates, promoting reintegration, and transforming the culture surrounding repeat offenses. This research used the preferred reporting items for systematic reviews and meta-analyses (PRISMA) Protocol. PRISMA is an evidence-based minimum set of items for systematic review and meta-analysis reporting. PRISMA is designed primarily for the reporting of reviews evaluating the effects of interventions, but it can also be used to report systematic reviews that do not have the goal of evaluating interventions [11]. PRISMA may also be useful for assessing previously published systematic reviews.

The first stage begins with formulating the main objectives of the research. The formulation of research objectives aims to limit the problems discussed in the smart prison topic. It is important to develop a review plan or protocol to determine the inclusion and exclusion criteria to use. It helps to relate the validity and merit of a research process that reduces risk of bias and promotes a systematic rather than ad hoc approach to the review process. Identify the criteria that will be used to determine which research studies will be included. The inclusion and exclusion criteria are established prior to the evaluation and cover all requirements for a study to be included. Exclusion criteria are the factors that would make a study ineligible to be included. Having defined exclusion criteria from the beginning allows individuals conducting the screening process to operate in an efficient manner. The protocol used in this research can be seen in Table 1.

The problem identification was also done by reviewing articles with annotated bibliography. This annotation aims to determine the cited sources' relevance, accuracy, and quality. This study uses annotated bibliographic network visualization using VOSviewer. VOSviewer is a new software tool that can be used to create, visualize, and analyze bibliometric networks [12]. Visualization of annotated bibliography can be seen in Figure 1. Based on the results of the network visualization, it is known that the potential relationship of keywords that have been determined in the searching key ("Smart Prison" OR "Intelligent Prison" OR "Digital Prison" OR "Electronic Prison" AND "challenge" OR "problem" OR "trend" OR "issue ") will produce other related keywords such as: prisons, monitoring, big data, intelligent systems, artificial intelligence (AI), internet of things (IoT), network security, video analysis, intelligent video surveillance,

image processing, and decision making (see Figure 1). These keywords will be the topic of discussion in the results of the literature study.

Table 1. Research protocol

Criteria	Description
Keywords	Prison issue, smart prison, TOE framework, prisons condition, prisons challenges, SLR
Databases	ACM digital library, IEEE Xplore, Scopus, Springer, SAGE, Emerald, MDPI, Taylor & Francis, Google Scholar
Searching key	"Smart Prison" OR "Intelligent Prison" OR "Digital Prison" OR "Electronic Prison" AND "challenge" OR "problem" OR "trend" OR "issue"
Inclusion Criteria	1. Ranging from 1995 (the initial of smart prison research) to December 2022 2. Collected from well-known publisher's electronic databases and reputed journals and Conferences 3. Outlined a purposive smart technology in prison 4. Explain the issues or problem or challenges
Exclusion criteria	1. Not journal or proceeding 2. Not full-paper version) 3. Not written in English

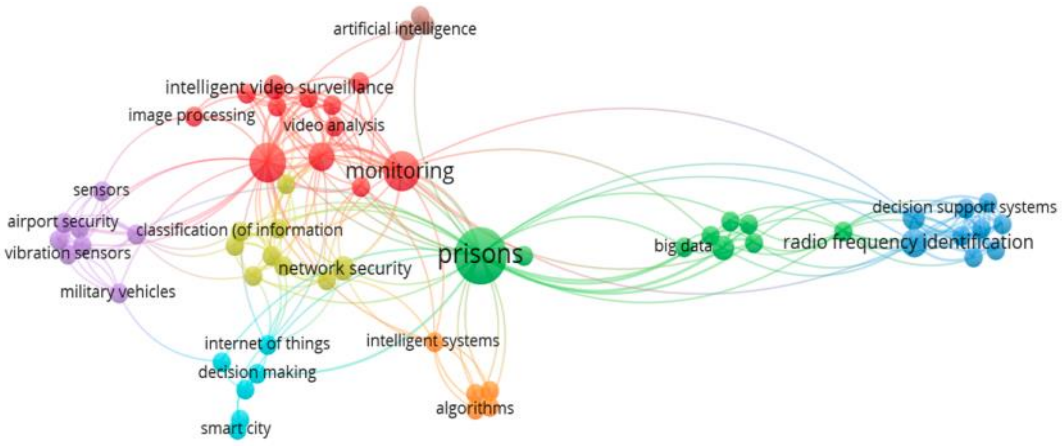

Figure 1. Network visualization of annotated bibliography using VOSviewer

Conducting a comprehensive literature study is a meticulous process that involves several crucial steps, each contributing to the overarching goal of identifying and selecting the most pertinent articles for the research endeavor. This methodical approach encompasses the definition of clear eligibility criteria, meticulous identification of relevant information sources, a thorough and systematic selection of literature, diligent data collection, and the discerning selection of essential data items. Through this rigorous effort, the objective is to ensure that only the highest quality articles, rich in valuable insights and information, are included in the study, thereby enhancing the overall robustness and credibility of the research findings. The search was targeted to articles published between 1995 (since the initial article of smart prison technology) and 2022. The articles should be published in peer-reviewed journals, and only English spoken-language was included. All publications on smart prisons using information technology (IT), including IoT, big data, smart technology, augmented or virtual reality, and digital technology. Any articles were not smart prison context, and irrelevant issues were excluded. Informaion sources are defined through a thorough search of reputable scientific databases, including Scopus, IEEE Xplore, ScienceDirect, ACM digital library, Taylor & Francis, and Google Scholar. The search process involves the use of specific keywords, and the initial search is performed on Scopus using a combination of keywords such as "Smart Prison," "Intelligent Prison," "Digital Prison," or "Electronic Prison," along with terms like "challenge," "problem," "trend," or "issue". This comprehensive search strategy ensures that a wide range of relevant sources are considered. By utilizing a combination of keywords, the search process is refined to focus on the desired topic, ensuring that the identified sources are highly relevant.

After the process of defining the source of information, the literature selection process is carried out by checking for duplicates in the articles that have been collected. The title, abstract, and keywords in the paper obtained from the search results are examined. Following that, read all or part of the articles that were

not removed to evaluate whether they should be included in the review based on the eligibility criteria. Finally, the selected papers were reviewed to find other related studies. Data collection is conducted manually by creating a data extraction form. A google spreadsheet was used to tabulate the required information from the included studies, such as title, authors, publication year, the country in which the study was conducted, targeted group, participant demographics, and primary focus (i.e., smart technology, intelligent system, IoT, and big data). At this stage, articles identified by the search strategy were imported into Mendeley, a tool for reference managers. The PRISMA protocol comprises an item checklist addressing the introduction, methods, results and discussion sections of a systematic review report. This study used the item checklist for included articles. If item was described in the report, we rated it as 'Yes' with score 1, if described partly, we scored it as 0.5, then 0 for 'No'. The total score for PRISMA was calculated by summing each score. After excluding the articles in the previous step, only a few articles will be included in the selected step. These are the most qualified articles with the results in article demographics and smart prison technology and challenges. Of the 362 papers included in the quality test, 25 articles will be included in the research map, consisting of ACM digital library (4), MDPI (2), SAGE (1), Emerald (1), IEEE Xplore (2), Springer (1), Scopus (3), Taylor & Francis (3) and Google Scholar (8). This research consists of a multidisciplinary study so that the topic of discussion is not limited to the computer field. Figure 2 depicts the steps of the PRISMA-based literature review.

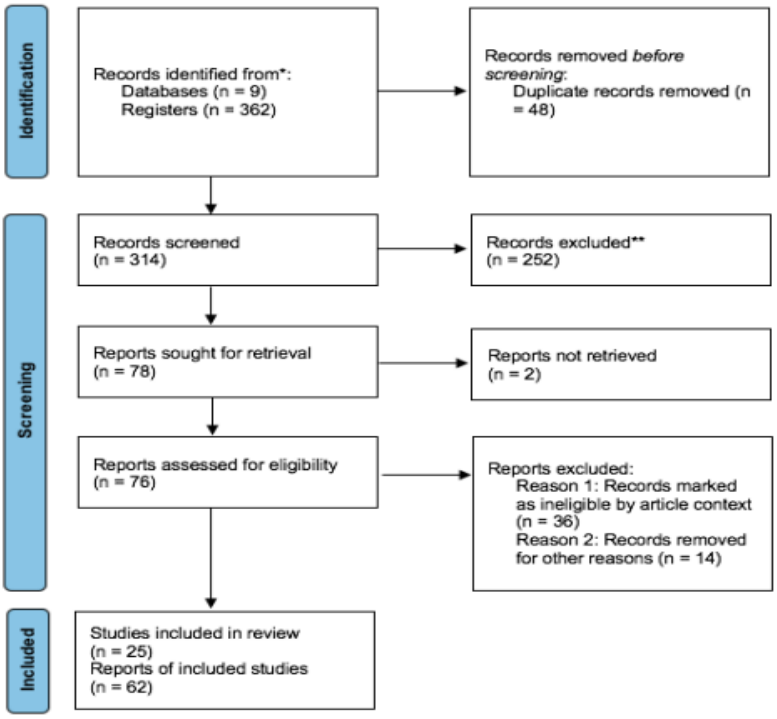

Figure 2. Literature study steps using PRISMA

The primary objective of this research is to undertake a comprehensive literature review with the dual purpose of discerning the existing landscape of prison technologies and critically analyzing the obstacles and complexities linked to the implementation of smart prison initiatives, employing the PRISMA protocol as our methodological framework. This undertaking involved an exhaustive and meticulous search spanning from October 2022 to December 2022, wherein we meticulously scrutinized nine reputable publishers. This thorough examination yielded an initial pool of 362 articles, reflecting the breadth and depth of the subject matter. Subsequently, employing rigorous inclusion criteria and a discerning selection process, we distilled this extensive body of literature to a refined set of 62 articles included in studies, and 25 articles included in review, see Figure 2. This is to ensure that our final phase encompasses only the most pertinent and high-quality sources for our in-depth analysis.

The analysis and discussion section within the framework of a research paper holds a pivotal position, representing one of the conclusive phases wherein the author not only synthesizes their research findings but also engages in a rigorous process of evaluation and interpretation. Within this critical endeavor,

the ramifications of these findings are meticulously explored, shedding light on their profound implications, and illuminating the intricate web of connections they establish with the overarching study topic. This stage serves as a fulcrum where the established evidence within the literature review is subjected to a thorough and often critical examination. This critical lens may encompass the reevaluation of previously established facts and assumptions from different perspectives or angles, or it may introduce a diverse array of events and information that either challenge or provide alternative viewpoints. Consequently, the focus pivots towards elucidating and dissecting the essence of what the author has unearthed, elucidating how it intimately interlaces with the existing body of literature, and constructing a compelling argument that supports the conclusion of the study. In essence, the analysis and discussion section are the intellectual arena where the research's significance is brought to the forefront, offering a profound insight into the implications and broader context of the study's findings. The conclusion serves as the destination in the review study, skillfully summarizing the author's arguments, weaving together the paper's central themes, and delivering a concise yet impactful encapsulation of the main findings, all while providing a definitive answer to the research question. Beyond a mere reiteration of content, the conclusion's pivotal role lies in elucidating the research's broader significance and real-world relevance. Striking a delicate balance between conciseness and engagement, it ensures readers leave with a profound understanding of the study's contributions to the existing body of knowledge, leaving an enduring mark on their perspective and emphasizing the lasting importance of the research's insights.

3. RESULTS AND DISCUSSION

In this section, we delve into an in-depth exploration and analysis of the research findings, combining a comprehensive discussion with a presentation of the results through illustrative tables. This multifaceted discussion will be thoughtfully organized into a series of carefully delineated sub-sections, each addressing specific aspects, nuances, and implications of the findings. Through this systematic approach, we aim to provide readers with a clear and structured understanding of the outcomes of our research, facilitating a more nuanced comprehension of the broader context and significance of the results.

3.1. Results

The research landscape pertaining to the integration of smart technology within prisons is steadily expanding in tandem with the broader proliferation of advanced technology within society at large. Over the past decade, spanning from 2012 to 2022, there has been a notable surge in scholarly interest, culminating in the publication of 55 distinct studies focused on various facets of prison technology. These investigations have collectively contributed to the burgeoning body of knowledge in this domain. For a comprehensive visual representation of the data derived from the reviewed studies, please refer to Figure 3, which encapsulates the trends gleaned from the extensive research conducted on this subject according by year of publication.

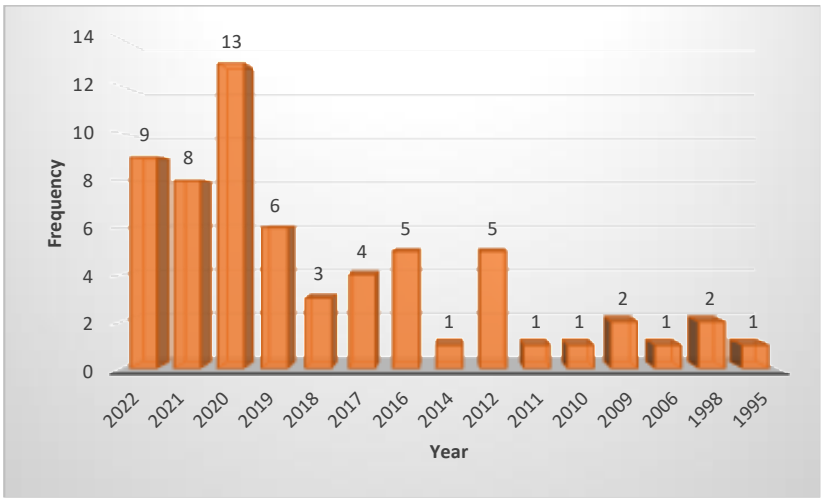

Figure 3. Research on prison technology by year of publication

The corpus of included articles has been meticulously categorized into two distinct clusters, with 25 articles adopting an IS approach and 36 articles adopting a 'computer science' perspective. This classification allows for a comprehensive exploration of the multifaceted facets of the subject matter, catering to diverse research interests and methodologies. Within this extensive body of literature, the methodological diversity is readily evident, comprising a spectrum of research approaches, including conceptual papers (9 articles) that provide valuable theoretical foundations, empirical methods (5 articles) offering real-world insights, a singular mixed methods study (1 article) combining qualitative and quantitative approaches, qualitative research methods (7 articles) delving into in-depth explorations of phenomena, quantitative methods (3 articles) for rigorous numerical analyses, and experimental studies (with a cumulative count of 36 studies) contributing valuable experimental data. For a more detailed and visual representation of this nuanced research methodology, please refer to Figure 4.

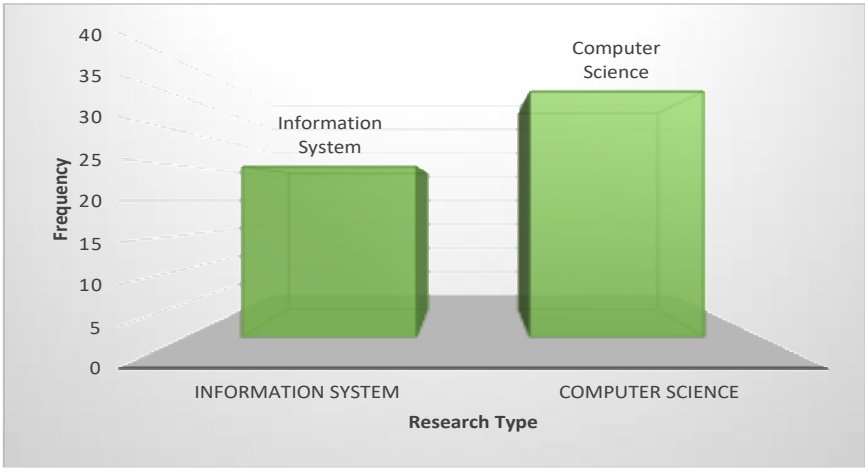

Figure 4. Research on prison technology by research type

This research mapped the distribution of articles by countries and publishers in Figure 5. The exploration of prison technology as a research topic has predominantly emanated from China, with a notable count of 12 articles, signifying the burgeoning interest and substantial contributions from this region. Following closely, the United States has made a significant scholarly footprint with 6 articles, while England has also made a noteworthy presence with 5 articles. Finland and India have equally demonstrated their research prowess, each contributing 4 articles to the growing body of literature in this field. The research landscape further unfolds across various European, Australian, and Asian countries, with a scattering of 1 to 3 articles, collectively showcasing the global interest and engagement with the multifaceted realm of smart prison technology. For a comprehensive visual representation of these geographically diverse research efforts which encapsulates the distribution of smart prison topics by country, refer to Figure 5(a).

In the realm of peer-reviewed articles, recent technology emerges as a resounding focal point, and its prominence is vividly reflected in the citation patterns across esteemed academic platforms. Leading the charge is IEEE Xplore, commanding a substantial 37.1% of citations, thus solidifying its status as the primary repository for cutting-edge technological research. Following closely, ACM digital library and Google Scholar jointly contribute significantly, with a cumulative citation share of 16.1%, attesting to their pivotal roles in disseminating knowledge within the academic community. SpringerLink, with its 9.7% citation rate, and Scopus, accounting for 8.1%, further underscore the breadth of resources available for researcher's seeking insights into recent technology. Meanwhile, various other publishers collectively contribute less than 5% of citations, affirming the diverse range of sources scholars consult. For a more comprehensive breakdown of these citation dynamics, refer to Figure 5(b) which provides detailed data elucidating the distribution of citations across these influential publishers.

The author analyzes the current prison state using the TOE framework. This theoretical framework explains how how the technological context, organizational context, and environmental context influence the technological innovation process [13]. The TOE model has been used to explain the adoption of the inter-organizational systems [14], e-business [15], electronic data interchange (EDI) [16], open systems [17], enterprise systems [18], and a broad spectrum of general IS applications [19]. TOE framework is an analytical framework that is used to study the adoption and assimilation of different types of innovation at the

organizational level in the context of internal and external organizations. This framework fits to the culture of prison organization which is heterogeneous and represents different types of organizational level. The analysis of the prison situation using the TOE approach resulted in several factors that could be considered based on the data obtained in the literature study. In terms of technology, the current prison situation raises several concerns, including the high cost of smart technology, ineffective technology design, and the process of implementing smart technology. The emerging factors in the organizational context are a lack of local standards for smart technology, a lack of experts, poor facility management, a lack of staff training programs, a lack of capacity for prisoner coaching, a lack of a systematic classification of prisoners, and ineffective service. In the context of the environment, several conditions emerge in prisons, including overcrowding, aging facilities, increased violence in prisons, disease spread, intervention by human-rights organizations, ethical concerns, and a gap between reality and future vision. The current state of prison conditions according to the TOE framework can be seen in Table 2.

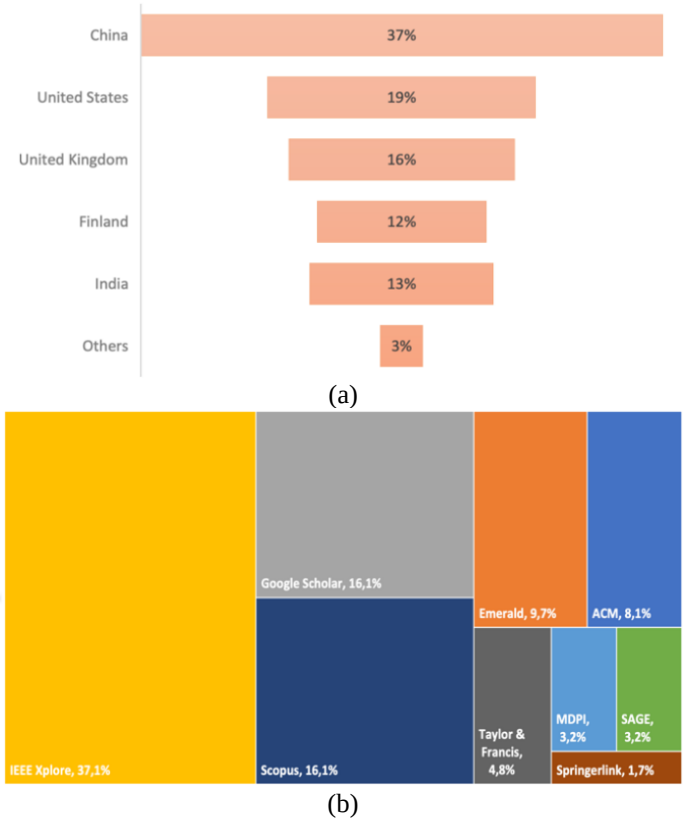

Figure 5. Research on prison technology by (a) group of countries (b) publisher

Table 2. The current state of prison

Context	Factor	Reference
Technology	High cost of smart technology	[6], [10], [20]–[23]
	Ineffective design of technology	
	Process of smart technology	
Organization	Lack of systematic classification of prisoners	[10], [20], [24], [25]
	Lack of local standards for smart technology	
	Lack of training program for staff	
	Ineffective service	
	Lack of experts	
	Lack of capacity for prisoner's coaching	
	Poor management of facilities	
	Gap of reality to future vision	
Environment	Ethical concerns	[10], [20], [21], [26]–[28]
	Increased violence	
	Intervention of human-rights agencies	
	Spread of diseases	
	Aging facilities	
	Overcapacity	

The IoT offers a good chance for prison control by integrating all prison sensors into a unified monitoring system. To ensure a secure prison environment, various IoT infrastructures must be built to monitor prisoners' status and activity inside or outside prison. IoT provides monitoring systems in prisons and integrate them into a global monitoring system based on wireless sensor networks and cloud computing technology [29]–[31]. IoT functions according to the various applications for which it was designed/developed. The functionality and implementation of IoT in prison determines its architecture. IoT architecture-based smart prison technology can be seen in Table 3. The TOE approach was also used to analyze the prison challenges. In terms of technology, the current prison challenges raise several concerns, including the high cost of smart technology and aging outdated facilities. The emerging challenges in the organizational context are the continuous addition of prisoners, the maintenance of the prison's conduciveness, and the automated administration process. In terms of the environment, several challenges include ethical concerns, the debate over smart technology, and preparing prisoners for release. Prison challenges based on the TOE framework can be seen in Table 4.

Table 3. Smart prison technology based on IoT architecture

Layer	Smart Technology
Physical/device	Facial recognition [21]
	Smart sensor [10]
	Fire protection [20], [32]
	Building automation system (BAS) [10], [32]
	Heat, ventilation, and air-conditioning system (HVAC) [32]
	Lighting [20], [32]
	Vertical transportation system [32]
	Energy and sustainability system [32]
	Robot wardens [21]
	Tracking wristbands [10], [21]
	Personal communication devices [10], [21]
	Virtual reality-technology [33]
	Audio-video system [20], [33]
Network	Networking [32]
	Wiring infrastructure [10], [33]
Data/database	Data sharing with public service institutions [10]
Analytics/visualization	Phone calls analytics [10]
	Video analytics [10], [21], [34]–[36]
	Alert/recommender prison authorities [10], [37], [38]
Application/integration	E-shopping [20], [33]
	Advanced IS [10], [21], [33]
	Healthcare system [10], [24]
	Smartphone-based applications [6], [23], [27]
	E-messaging [32]
	Digital self-service [6], [10], [21]
	Digital participation [28]
	Funds transfer [20], [33]
	Digital devices for rehabilitation [21], [38]–[40]
	AI-based personal assistant [10]
Security and management	Building management system (BMS) [32]
	Video surveillance system [21], [32], [36], [41]

Table 4. Challenges in smart prison

Context	Challenges
Technology	High cost of smart technology [10], [20]
	Aging outdated facilities and non-compatibility of existing buildings with smart technologies [20]
	Lack of regulatory policy and local standards for smart technology [20], [28]
	Implementation and integration of the prison system into smart technology [6], [7], [20], [21], [23]–[26], [39], [40], [42], [43]
Organization	Continuous addition of prisoners [20]
	Maintain the conduciveness of the prison [23]–[28], [40], [42], [44]
	Automated administration process [10]
	Deficiency of accredited suppliers [20]
	Lack of competent staff for maintenance [20]
	Delay in budget approval [27]
Environment	Ethical concerns [21], [36]
	Ignorance of beneficiary's requirements [6], [20]
	Controversy of smart technology [10], [26], [28], [45], [46]
	Changing behavior and preparing prisoners before release [6], [23], [24], [26], [36], [39], [42]
	Communication within prisoner and family [21], [23], [25]

3.2. Discussion

This part begins with a discussion of the findings from our research, shedding light on the most important discoveries and insights. It delves into the several issues linked with the current situation of the prison system, such as overcrowding, rehabilitation effectiveness, and security concerns. Furthermore, we investigate the opportunities and challenges posed by the integration of smart technology into prison facilities, including privacy, cost, and the possibility for misuse. This section includes a thorough examination of the findings, revealing underlying patterns and consequences, followed by a concise review of the important conclusions. Finally, it critically assess our research's broader significance in the context of criminal justice reform and the growth of smart prison technologies.

3.2.1. The current state of the prison

In recent years, prisons have primarily come to be associated with separation from society rather than punishment. The basic goals of prisons are correction of misbehavior, preparation of prisoners for reintegration into society as responsible individuals, and prevention of recidivism [47]. Researchers look at how collaborative, smart, and IoT technologies might improve individual support in a variety of settings, including rehabilitation, security, learning, health, and other areas. Even though using digital technology has become the ‘new normal’ in society, prison administrations are nonetheless having trouble utilizing digital media to their advantage and engaging offenders in it. There is a push for the development of digital technology to allow lawbreakers access to education, communication, leisure, and self-development opportunities, including technology. It assists prisons in providing rehabilitation programs, improving access to health care, and facilitating safe communication with family members outside of prison. Even though many technological options are readily available, technology adoption in prisons is still very early and premature. Most current implementations are far from what can be considered digital transformation. Despite the critical role that prisons play in society, limited research is being conducted to determine how prison officers can benefit from this technology.

Access to digital technologies and instruments for prisoners is a sensitive and contentious issue, characterized by mistrust and prejudice toward prisoners. This small subset of research is currently focused on understanding how ICT can be used to improve access to security, rehabilitation, information, communication, and self-development. Jewkes and Johnston's [48] provides a historical overview of prison and emphasizes the prevention of communication. They relate this to current strategies in European prisons, where restricted access makes prisoners appear to be second-class citizens in the age of IT, or how prisoners perceive themselves as cavemen in an era of light-speed technology [48]. The current approach in prison, which provides no or very limited access to digital instruments and the internet, creates a new level of disconnect between prison and society [49]. Many prisoners see the nearly complete lack of computers and internet access as censorship, reducing them to second-class citizens in the information age [50]. Hadlington and Knight's [51] also gives prisoners a voice about how technology withdrawal can affect their relationships with others. Digital technologies have transformed modern societies, and for many, it is one of the primaries means of contact with the outside world [52].

3.2.2. The smart technology in the prison

There is a growing interest in making prison environments more like modern society through digital technology and the use of tablet computers. For several years, solutions based on sensor networks have been used for monitoring and control purposes in prison monitoring and security. Sensors are built into the handcuffs, allowing information about the prisoner's location and status to be collected [53]. Numerous technologies are used in administration, security, and prisoner training. Some literature demonstrates the use of intelligent technology in prison implementations, such as the use of IoT in monitoring systems, which integrate data into global monitoring systems based on wireless sensor networks and cloud computing technology, as well as the use of video surveillance and analytics systems, digital and self-service devices. This demonstrates that smart prison technology is increasingly being used to improve existing business processes and solve problems and challenges in the prison setting. Most applications in prison contexts are in the realm of security and surveillance. Such advanced applications can be found in Asian countries such as China and Hongkong, where intelligent surveillance systems are designed to always monitor prisoners, including while they are in cells. A network of cameras and sensors can track prisoners in real time and feed them into an AI system that uses facial recognition technology and motion analysis to generate daily reports on each prisoner's activity and flags unusual behavior [5]. The same type of surveillance system is used in Hongkong, where cameras with analytical monitoring functions detect unusual behavior, such as prisoners injuring themselves or passing out, and can alert officers. Another example of prison security technology is a mass monitoring system of prisoner’s phone calls in US prisons [5]. The system employs speech recognition technology, semantic analytics, and machine learning software to create a database of words that can flag suspicious calls, including threats such as criminal

conspiracy, drug smuggling into prison, and other information. Image and pattern recognition technologies, such as the AI-based video analysis platforms currently being implemented in some prisons. The security cameras are monitored by AI to prevent smuggling and to detect other suspicious behavior [54]. Another thing that occurs in prisons is the use of smart technology in risk assessment tools [55]. The goal of implementing smart technology in prison management is to improve decision-making to meet needs while minimizing prison risks [56]. The finnish criminal sanctions agency worked on an AI application for offender management. This application will supplement the current risk and needs assessment tools, increasing the accuracy of the recommended services provided to prisoners. Accuracy refers to meeting violators' needs and lowering their risk of re-offending [22]. Several studies have also begun to consider the potential use of AI to address isolation by employing intelligent assistants as a type of 'companion' for prisoners [56]. Another important aspect for prisoners is education [52], [57], [58]. Not only are education and digital literacy essential requirements for obtaining a reasonable job after imprisonment [59], but also for assisting with reintegration into society. Several countries use and develop prison digital self-service systems, which can be seen as part of a broader digitalization or even smart trend in services and environments, culminating in so-called ‘smart cities’ [26]. Digital solutions for improving learning have been found to be beneficial in prisons as well [60]. It has been argued that using this type of technology increases a prisoner's sense of autonomy, life management, and selfesteem [61]. Digitalization has an impact on interactions and relationships between staff and prisoners, as well as staff roles and the overall prison culture [7]. Prisons should implement small-scale digital transformation initiatives based on comprehensive needs assessments and interorganizational networking [26].

3.2.3. Challenges in the smart prisons

Prison security is a national challenge, to ensure a safe prison environment an IoT infrastructure needs to be built to monitor the status of prisoners and activities inside and outside the prison. It can build monitoring systems in prisons and integrate them into global monitoring systems based on wireless networks and cloud computing technologies. The prison environment is a restricted area where all prisoners, people, and vehicles entering and leaving must be monitored. To meet the above monitoring requirements, different sensors are connected to form a sensor network to collect various information, for example, location, status, and detection of prisoners. Integrating this complex information becomes a significant challenge in building prison technology systems. Smart technology in prison is commonly used in 5 (five) areas: i) digital resources for security needs, ii) digital resources for overcoming social isolation, iii) digital resources for preparation of prisoners to live in a digital society, iv) digital resources for more efficient work, and v) digital resources for avoiding recidivism.

According to the literature, ethical concerns about implementing smart technology in prisons must be thoroughly discussed. The need for technology ethics to prevent the emergence of more punitive technological interventions [26]. The increased use of AI in monitoring technology without proper analysis will have an impact on the entire prison environment and culture. Continuous monitoring can increase prisoners' stress and anxiety while decreasing their trust. Prisons must consider the amount of monitoring and the potential for interference placed in cells, bodies, and community areas, as well as be able to answer questions about what sensors are used for, how they are measured (signal types such as sound, image, video, and specific digital monitor signals), and how long data is stored. The authors argue that digital technologies for prisoners can improve modes of surveillance (via data capture and analytics), aid in rehabilitation (via therapy such as gaming and virtual reality), and monitor academic and vocational progress (via e-learning) [22], but it should consider the ethical concerns about the application of smart technology in prisons.

4. CONCLUSION

This study contributes to the field of corrections by presenting the initial review of smart prison technology. The research examines the current state of technology in prisons and the challenges associated with implementing smart technology. The analysis of the prison state has identified several factors according to the TOE approach. In terms of technology, the current prison environment raises various concerns, including the high cost of smart technology, ineffective design of technology systems, and challenges in the implementation process. There are also emerging factors within the organizational context, such as the absence of standards for smart technology, a lack of experts, inadequate facility, and insufficient training programs. Furthermore, several conditions have emerged in the environmental context, including overcrowding, aging facilities, heightened levels of violence, the spread of diseases, the intervention by human rights agencies, ethical concerns, and a disparity between current reality and future vision. The TOE approach was also employed to analyze the challenges faced by prison. These include the exorbitant cost associated with smart technology, the presence of outdated and deteriorating facilities that are incompatible with smart technologies, and a lack of regulatory policies. In terms of the organizational context, emerging challenges include the continuous influx of prisoners, the maintenance of a conducive prison environment,

and the administrative processes. Moreover, there are several challenges pertaining to the environment, such as ethical considerations, debates surrounding smart technology, and the preparation of prisoners for their eventual release. Finally, this study offers a comprehensive overview of the current utilization of digital technology in prisons, employing an IoT architecture layer. The study groups smart technology into six layers, namely the physical, network, data, analytics, application, and security and management layers. The article selection criteria for this research may have been a shoddy process, and the evaluation of the validity of the selected papers may not have met the necessary standards to prevent bias. This aspect should be considered when conducting future study reviews.

ACKNOWLEDGEMENTS

This research is supported by Universitas Indonesia through PUTI Q1 grant No. NKB-293/UN2.RST/HKP.05.00/2023. We convey our gratitude to our university for their continued support in improving research quality. The author would also thank the LPDP Scholarship for the contributions.

REFERENCES

[1] J. R. Gil-Garcia, J. Zhang, and G. Puron-Cid, "Conceptualizing smartness in government: An integrative and multi-dimensional view," *Government Information Quarterly*, vol. 33, no. 3, pp. 524–534, 2016, doi: 10.1016/j.giq.2016.03.002.

[2] J. N. Witanto, H. Lim, and M. Atiquzzaman, "Smart government framework with geo-crowdsourcing and social media analysis," *Future Generation Computer Systems*, vol. 89, pp. 1–9, 2018, doi: 10.1016/j.future.2018.06.019.

[3] E. B. Sifah, H. Xia, C. N. A. Cobblah, Q. Xia, J. Gao, and X. Du, "BEMPAS: A decentralized employee performance assessment system based on blockchain for smart city governance," *IEEE Access*, vol. 8, pp. 99528–99539, 2020, doi: 10.1109/ACCESS.2020.2997650.

[4] J. Yang, "Big data technology and prison management analysis," in *2021 International Conference on Big Data Analysis and Computer Science (BDACS)*, IEEE, 2021, pp. 35–38. doi: 10.1109/BDACS53596.2021.00016.

[5] P. Puolakka and S. Van De Steene, "Artificial intelligence in prisons in 2030: an exploration on the future of AI in prisons," *Advancing Corrections Journal*, vol. 11, pp. 128–138, 2021.

[6] M. Grierson, D. Varghese, M. Bolton, and P. Olivier, "Design considerations for a digital service to support prison leavers," in *Designing Interactive Systems Conference*, New York, NY, USA: ACM, 2022, pp. 504–516. doi: 10.1145/3532106.3533567.

[7] S. Knight, Victoria and Van De Steene, "The capacity and capability of digital innovation in prisons: Towards smart prisons," *Advancing Corrections*, vol. 4, pp. 88–101, 2017.

[8] P. Ifinedo, "Understanding information systems security policy compliance: An integration of the theory of planned behavior and the protection motivation theory," *Computers and Security*, vol. 31, no. 1, pp. 83–95, 2012, doi: 10.1016/j.cose.2011.10.007.

[9] S. M. Yannascoli, M. L. Schenker, J. L. Carey, J. Ahn, and K. D. Baldwin, "How to write a systematic review: a step-by-step guide," *University of Pennsylvania Orthopaedic Journal*, vol. 23, pp. 64–69, 2013.

[10] A. Kaun and F. Stiernstedt, "Doing time, the smart way? Temporalities of the smart prison," *New Media and Society*, vol. 22, no. 9, pp. 1580–1599, 2020, doi: 10.1177/1461444820914865.

[11] L. Shamseer *et al.*, "Preferred reporting items for systematic review and meta-analysis protocols (prisma-p) 2015: Elaboration and explanation," *BMJ*, vol. 349, pp. 1–25, 2015, doi: 10.1136/bmj.g7647.

[12] N. J. van Eck and L. Waltman, "Software survey: VOSviewer, a computer program for bibliometric mapping," *Scientometrics*, vol. 84, no. 2, pp. 523–538, 2010, doi: 10.1007/s11192-009-0146-3.

[13] R. Drazin, "The processes of technological innovation," *The Journal of Technology Transfer*, vol. 16, no. 1, pp. 45–46, 1991, doi: 10.1007/bf02371446.

[14] A. H. Segars and V. Grover, "Re-examining perceived ease of use and usefulness: A confirmatory factor analysis," *MIS Quarterly: Management Information Systems*, vol. 17, no. 4, pp. 517–525, 1993, doi: 10.2307/249590.

[15] H. F. Lin and S. M. Lin, "Determinants of e-business diffusion: A test of the technology diffusion perspective," *Technovation*, vol. 28, no. 3, pp. 135–145, 2008, doi: 10.1016/j.technovation.2007.10.003.

[16] K. K. Y. Kuan and P. Y. K. Chau, "A perception-based model for EDI adoption in small businesses using a technology-organization-environment framework," *Information and Management*, vol. 38, no. 8, pp. 507–521, 2001, doi: 10.1016/S0378-7206(01)00073-8.

[17] P. Y. K. Chau and K. Y. Tam, "Factors affecting the adoption of open systems: An exploratory study," *MIS Quarterly: Management Information Systems*, vol. 21, no. 1, pp. 1–20, 1997, doi: 10.2307/249740.

[18] B. Ramdani, D. Chevers, and D. A. Williams, "Predicting SMEs' adoption of enterprise systems," *Journal of Small Business and Enterprise Development*, vol. 20, no. 4, pp. 735–753, 2013.

[19] J. Y. L. Thong, "An integrated model of information systems adoption in small businesses," *Journal of Management Information Systems*, vol. 15, no. 4, pp. 187–214, 1999.

[20] M. A. Aldhaheri and B. Xia, "Challenges to developing smart prisons in the United Arab Emirates," *Facilities*, vol. 40, no. 11/12, pp. 793–808, 2022, doi: 10.1108/F-02-2022-0015.

[21] C. McKay, "The carceral automaton: digital prisons and technologies of detention," *International Journal for Crime, Justice and Social Democracy*, vol. 10, no. 4, pp. 100–119, 2021, doi: 10.5204/IJCJSD.2137.

[22] S. Van De Steene and V. Knight, "Digital transformation for prisons: Developing a needs-based strategy," *Probation Journal*, vol. 64, no. 3, pp. 256–268, 2017, doi: 10.1177/0264550517723722.

[23] C. Nwokoye and I. Ihemelu, "Improving communication, prisoner welfare and support through mobile collaborative technologies," in *Companion of the 2018 ACM Conference on Computer Supported Cooperative Work and Social Computing*, New York, NY, USA: ACM, 2018, pp. 157–160. doi: 10.1145/3272973.3274044.

[24] C. McDougall, D. A. S. Pearson, D. J. Torgerson, and M. Garcia-Reyes, "The effect of digital technology on prisoner behavior and reoffending: a natural stepped-wedge design," *Journal of Experimental Criminology*, vol. 13, no. 4, pp. 455–482, 2017, doi:

10.1007/s11292-017-9303-5.
[25] R. Johnson and K. Hail-Jares, "Prisons and technology: General lessons from the American context," in *Handbook on Prisons: Second Edition*, UK: Routledge, 2016, pp. 284–306. doi: 10.4324/9781315797779.
[26] V. Knight and S. Van De Steene, "Digitizing the prison: the Light and dark future," *Prison Service Journal*, vol. 231, no. 231, pp. 22–30, 2017.
[27] T. Haiduwa, V. Hashiyana, and J. N. Samuel, "An Android-based application for convenient visitation at windhoek correctional facility," in *Proceedings of the 2nd International Conference on Intelligent and Innovative Computing Applications*, New York, NY, USA: ACM, 2020, pp. 1–7. doi: 10.1145/3415088.3415127.
[28] S. Taugerbeck, M. Ahmadi, M. Schorch, D. Unbehaun, K. Aal, and V. Wulf, "Digital participation in rison-a public discourse analysis of the use of ICT by inmates," in *Proceedings of the ACM on Human-Computer Interaction*, 2019, pp. 1–26. doi: 10.1145/3361114.
[29] P. Sun, W. Wei, and M. Xia, "A semantic framework for integration of prison internet," *Advances in Intelligent Systems and Computing*, vol. 180, pp. 767–771, 2013, doi: 10.1007/978-3-642-31656-2_102.
[30] A. Katasonov, O. Kaykova, O. Khriyenko, S. Nikitin, and V. Terziyan, "Smart semantic middleware for the internet of things," in *Proceedings of the Fifth International Conference on Informatics in Control, Automation and Robotics Service*, SciTePress - Science and and Technology Publications, 2008, pp. 169–178. doi: 10.5220/0001489001690178.
[31] L. Yan, Y. Zhang, L. T. Yang, and H. Ning, *The internet of things: from RFID to the next-generation pervasive networked systems*. Boca Raton, New York: Auerbach Publications, 2008.
[32] M. A. M. M. Aldhaheri, B. Xia, and M. Nepal, "Identifying key selection criteria for smart building technologies in the United Arab Emirates prisons," *Buildings*, vol. 4, no. 5, pp. 1–15, 2022, doi: 10.3390/buildings12081171.
[33] K. Oikonomou *et al.*, "Virtual reality in humanistic prisons education. The STEPS project.," in *24th Pan-Hellenic Conference on Informatics*, New York, NY, USA: ACM, 2020, pp. 250–255. doi: 10.1145/3437120.3437318.
[34] Y. Jia and Z. Li, "Anti-tailing Ab-door detection based on motion template algorithm," in *ACM International Conference Proceeding Series*, 2019, pp. 636–642. doi: 10.1145/3349341.3349482.
[35] J. Imran, B. Raman, and A. S. Rajput, "Robust, efficient and privacy-preserving violent activity recognition in videos," in *Proceedings of the 35th Annual ACM Symposium on Applied Computing*, New York, NY, USA: ACM, 2020, pp. 2081–2088. doi: 10.1145/3341105.3373942.
[36] C. Linehan and B. Kirman, "Imagining the cool-ag: Or, freedom considered harmful," in *Proceedings of the Halfway to the Future Symposium 2019*, New York, NY, USA: ACM, 2019, pp. 1–4. doi: 10.1145/3363384.3363485.
[37] B. Jain, L. Fegaras, M. Huber, and R. A. Elmasri, "Singular race models: Addressing bias and accuracy in predicting prisoner recidivism," in *ACM International Conference Proceeding Series*, 2019, pp. 599–607. doi: 10.1145/3316782.3322787.
[38] B. Lindström and P. Puolakka, "Smart prison: the preliminary development process of digital self-services in finnish prisons," *International Corrections & Prisons Association*, vol. 28, pp. 1–48, 2020.
[39] B. C. Reisdorf and J. R. DeCook, "Locked up and left out: Formerly incarcerated people in the context of digital inclusion," *New Media and Society*, vol. 24, no. 2, pp. 478–495, 2022, doi: 10.1177/14614448211063178.
[40] A. Kaun and F. Stiernstedt, "Prison Tech: Imagining the prison as lagging behind and as a test bed for technology advancement," *Communication, Culture and Critique*, vol. 15, no. 1, pp. 69–83, 2022, doi: 10.1093/ccc/tcab032.
[41] B. Chen *et al.*, "Basic psychological need satisfaction, need frustration, and need strength across four cultures," *Motivation and Emotion*, vol. 39, no. 2, pp. 216–236, 2015, doi: 10.1007/s11031-014-9450-1.
[42] T. Ertl, S. Taugerbeck, M. Esau, K. Aal, P. Tolmie, and V. Wulf, "The social mile - how (psychosocial) ICT can help to promote resocialization and to overcome prison," in *Proceedings of the ACM on Human-Computer Interaction*, 2019, pp. 1–31. doi: 10.1145/3370270.
[43] B. Zhang *et al.*, "A spatiotemporal multi-feature extraction framework with space and channel based squeeze-and-excitation blocks for human activity recognition," *Journal of Ambient Intelligence and Humanized Computing*, vol. 12, no. 7, pp. 7983–7995, 2021, doi: 10.1007/s12652-020-02526-6.
[44] F. Stiernstedt and A. Kaun, "The prison media complex: Labour, technology and communication infrastructures in the prison system," *TripleC*, vol. 20, no. 1, pp. 1–18, 2022, doi: 10.31269/triplec.v20i1.1270.
[45] P. S. Smith, "Imprisonment and internet-access: Human rights, the principle of normalization and the question of prisoners access to digital communications technology," *Nordic Journal of Human Rights*, vol. 30, no. 4, pp. 454–482, 2012, doi: 10.1080/18918131.2012.10749861.
[46] E. Järveläinen and T. Rantanen, "Incarcerated people's challenges for digital inclusion in Finnish prisons," *Nordic Journal of Criminology*, vol. 22, no. 2, pp. 240–259, 2021, doi: 10.1080/2578983X.2020.1819092.
[47] L. Schaefer, "Correcting the 'Correctional' component of the corrections officer role: How offender custodians can contribute to rehabilitation and reintegration," *Corrections*, vol. 3, no. 1, pp. 38–55, 2018, doi: 10.1080/23774657.2017.1304811.
[48] Y. Jewkes and H. Johnston, "Cavemen in an era of apeed-of-light technology': Historical and contemporary perspectives on communication within prisons," *The Howard Journal of Criminal Justice*, vol. 48, no. 2, pp. 132–143, 2009, doi: 10.1111/j.1468-2311.2009.00559.x.
[49] Y. Jewkes and B. C. Reisdorf, "A brave new world: The problems and opportunities presented by new media technologies in prisons," *Criminology and Criminal Justice*, vol. 16, no. 5, pp. 534–551, 2016, doi: 10.1177/1748895816654953.
[50] R. Johnson, "Brave new prisons: The growing social isolation of modern penal institutions," in *The Effects of Imprisonment*, New York: Routledge, 2013, pp. 255–284. doi: 10.4324/9781843926030.
[51] L. Hadlington and V. Knight, "Public acceptability of prisoners' access and use of digital technologies in the UK," *Prison Journal*, vol. 102, no. 2, pp. 237–255, 2022, doi: 10.1177/00328855221079290.
[52] M. Barreiro-Gen, I. Novo-Corti, and L. Varela-Candamio, "E-prisons and new technologies: ICT as a mechanism of social inclusion of prisoners," *International Journal of Knowledge Society Research (IJKSR)*, vol. 4, no. 3, pp. 1–10, 2013.
[53] T. Pan, "Intelligent monitoring system for prison perimeter based on cloud intelligence technology," *Wireless Communications and Mobile Computing*, vol. 2022, pp. 1–10, 2022, doi: 10.1155/2022/2517446.
[54] Z. Wu and J. M. McGoogan, "Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72314 cases from the Chinese center for disease control and prevention," *JAMA - Journal of the American Medical Association*, vol. 323, no. 13, pp. 1239–1242, 2020, doi: 10.1001/jama.2020.2648.
[55] V. A. Klinoff, V. B. Van Hasselt, R. A. Black, E. V. Masias, and J. Couwels, "The sssessment of resilience and burnout in correctional officers," *Criminal Justice and Behavior*, vol. 45, no. 8, pp. 1213–1233, 2018, doi: 10.1177/0093854818778719.
[56] A. Završnik, "Criminal justice, artificial intelligence systems, and human rights," *ERA Forum*, vol. 20, no. 4, pp. 567–583, 2020, doi: 10.1007/s12027-020-00602-0.
[57] M. Barreiro-Gen and I. Novo-Corti, "Collaborative learning in environments with restricted access to the internet: Policies to

bridge the digital divide and exclusion in prisons through the development of the skills of inmates," *Computers in Human Behavior*, vol. 51, pp. 1172–1176, 2015, doi: 10.1016/j.chb.2015.01.076.
[58] R. Barros and A. Monteiro, "E-learning for lifelong learning of female inmates: the epris project," in *7th International Conference on Education and New Learning Technologies*, Barcelona, Spain: IATED, 2015, pp. 7056–7063.
[59] H. Entorf, "Crime and the labour market: Evidence from a survey of inmates," *Jahrbucher fur Nationalokonomie und Statistik*, vol. 229, no. 2–3, pp. 254–269, 2009, doi: 10.1515/jbnst-2009-2-311.
[60] S. Hopkins and H. Farley, "E-Learning incarcerated: Prison education and digital inclusion," *International Journal of Humanities Education*, vol. 13, no. 2, pp. 37–45, 2015, doi: 10.18848/2327-0063/cgp/v13i02/43833.
[61] V. Knight, "Some observations on the digital landscape of prisons today," *Prison Service Journal*, no. 220, pp. 3–9, 2015.

BIOGRAPHIES OF AUTHORS

Ejo Imandeka is currently pursuing a Doctor of Computer Science degree from the University of Indonesia. He is currently an associate professor in the Department of Correctional Engineering, Polytechnic of Correctional Sciences, Indonesia. His research areas of interest include e-government, e-business, information systems, information technology, technology adoption, and prison technology. He is a member of the Information Management Laboratory at the Faculty of Computer Science, University of Indonesia. He can be contacted at email: ejo.imandeka21@ui.ac.id.

Prof. Achmad Nizar Hidayanto holds a Bachelor of Computer Science (S.Kom.), Master of Computer Science (M.Kom.), and Ph.D. in information system from Faculty of Computer Science, University of Indonesia. He is currently a professor the Department of Computer Science, University of Indonesia, Indonesia. His research areas of interest include information technology, information system, business intelligence, technology adoption, and electronic commerce. He can be contacted at email: nizar@cs.ui.ac.id.

Dr. Mufti Mahmud is an associate professor of Cognitive Computing at the Department of Computer Science of Nottingham Trent University (NTU). He is a member of the NTU Distance Learning Governance, Operation and Steering committee as well as the International Mobility Committee and serves as an independent end-point assessor for the level 6 B.Sc. (Hons) in Digital & Technology Solutions Professional Degree Apprenticeship, and an expert of the online master's degree in computer science. He is a fellow of the Higher Education Academy, a senior member of the Institute of Electrical and Electronics Engineers (IEEE) and the Association of Computing Machinery (ACM), and a professional member of the British Computer Society (BCS). He can be contacted at email: mufti.mahmud@ntu.ac.uk.