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Implementation of an Edge AI-Based Church Attendance Management System: A Community Service Approach for Digital Transformation in Religious Organizations

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Abstract

Purpose: Manual attendance recording in religious institutions is inefficient, burdens volunteer staff, and limits demographic analytics. This paper presents a community service initiative deploying an edge-based face recognition system using MobileNetV2 on Raspberry Pi 5 for automated, privacy-centric church attendance tracking.

Method: The project utilized a participatory community service methodology comprising socialization on biometric ethics, capacity-building training for church volunteers, and an 8-week mentoring phase at GKI Karawaci, involving 412 active congregants.

Practical Applications: The system achieved 96.8% recognition accuracy and 247ms latency. Compared to manual methods, it eliminated per-service recording time, reduced data entry errors by 93.6%, and decreased monthly administrative effort by 67.4%. Beyond technical metrics, the initiative empowered the church community by alleviating volunteer burnout and bridging the digital literacy gap among administrative staff.

Conclusion: This work validates that deploying edge AI in religious settings requires a socio-technical approach. By combining privacy-centric technology with structured partner empowerment, this community service model provides a sustainable, ethically grounded framework for digital transformation in resource-constrained community organizations.

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Introduction

Church attendance recording is crucial for religious institutional administration, enabling accurate assessment of congregant engagement, proper resource allocation, pastoral care, and mandatory periodic reporting to higher governing bodies (Bayomock & Tiavina, 2025; Amole & Afolaranmi, 2025). In many congregations worldwide, attendance continues to be tracked manually via paper sign-in sheets or basic digital tools like spreadsheets (Damyanov & Donchev, 2025). These traditional methods are prone to human error, temporal delays, and data fragmentation (Goodwin et al., 2022; Jackson et al., 2023).

In the specific context of GKI Karawaci, a congregation of over 1,200 members, the reliance on manual attendance tracking places a significant burden on volunteer ushers and administrative staff. Prior to this intervention, baseline assessments revealed that ushers spent an average of 18.3 minutes per service on manual counting, with an average of 4.7 data entry errors per service. Furthermore, 78% of administrative volunteers reported experiencing significant administrative burnout, highlighting the urgent need for systemic relief. Many of these volunteers possess varying levels of digital literacy, making the transition to digital tools both a technical and social challenge (Aslan & Tuncay, 2023). Furthermore, the deployment of biometric technology in a sacred space raises ethical and privacy concerns that require careful socialization and community alignment. GKI Karawaci was selected as the partner for this community service (Pengabdian kepada Masyarakat) project due to its large, diverse demographic and the administration's explicit willingness to undergo digital transformation, despite initial technological hesitations.

Recent advances in biometric technology have spurred interest in automated attendance solutions. Face recognition stands out for public settings due to its non-intrusive, contactless operation (Menezes et al., 2025; Singh et al., 2024). Efficient architectures like MobileNetV2 balance high accuracy with low resource usage, making them ideal for embedded edge platforms like the Raspberry Pi 5 (Sutaji & Yıldız, 2022; Zhan, 2024). Edge computing shifts inference to local devices, eliminating cloud dependency, reducing latency, and enhancing privacy by processing sensitive biometrics on-device (Raj et al., 2024).

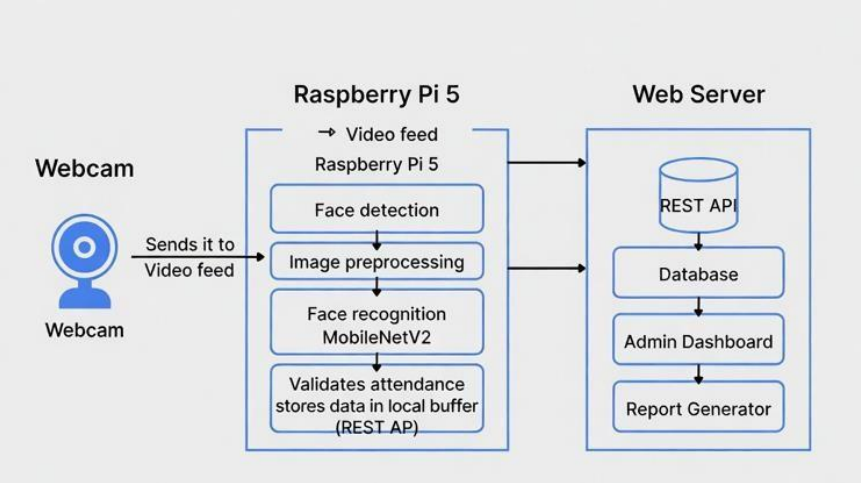
This community service project aims to bridge the digital divide in religious organizations by not only providing a cost-effective technological solution but also empowering the church community through structured training, ethical socialization, and sustained mentoring. The expected social transformation includes the alleviation of volunteer burnout, enhanced data-driven pastoral care, and the establishment of a sustainable, privacy-conscious digital culture within the congregation, shifting the community from manual dependency to digital empowerment.

Method

To ensure successful adoption and social transformation, the technical deployment was integrated with a structured community service methodology comprising three main stages: socialization and ethical alignment, capacity building and training, and mentoring and accompaniment. Prior to deployment, the team conducted town-hall-style socialization sessions with church leadership, ushers, and the congregation to address privacy concerns, explain the edge-based, local processing nature of the system to alleviate fears of cloud-based data misuse, and establish an ethical framework for biometric data usage in a sacred space. Next, comprehensive training sessions were conducted for the church administrative staff and volunteer ushers, focusing on operating the web-based dashboard, managing congregant demographics, and performing basic troubleshooting on the edge device to ensure partners were active managers of the technology rather than passive recipients. Finally, during the 8-week field evaluation, the academic team provided continuous mentoring through weekly check-ins, resolving user anxiety or technical hiccups, and gathering qualitative feedback to iteratively improve the user interface and address community concerns.

The system employs a distributed edge-web architecture (Figure 1), where a Logitech C920 webcam captures frontal faces at the main entrance. Video streams are processed locally on a Raspberry Pi 5 using TensorFlow.js and MobileNetV2 across a five-stage pipeline comprising acquisition, detection, preprocessing, recognition, and validation, achieving 247ms end-to-end latency. Recognized embeddings are matched against an in-memory FAISS index, with records buffered in local SQLite and synchronized to a Next.js-based web platform via HTTPS POST. Privacy-by-design principles strictly govern data handling; raw video is immediately discarded, and only non-biometric metadata, such as hash IDs and timestamps, is transmitted.

Figure 1. System Architecture Diagram

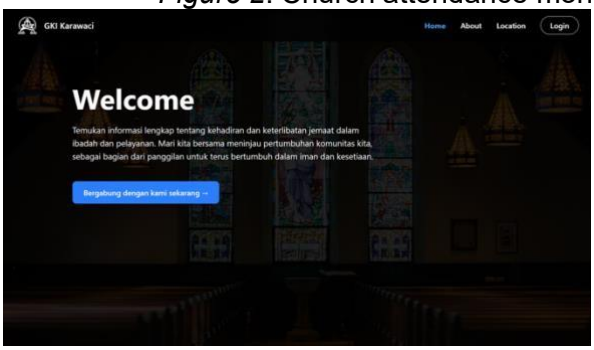


Source: Private Documentation, 2026.

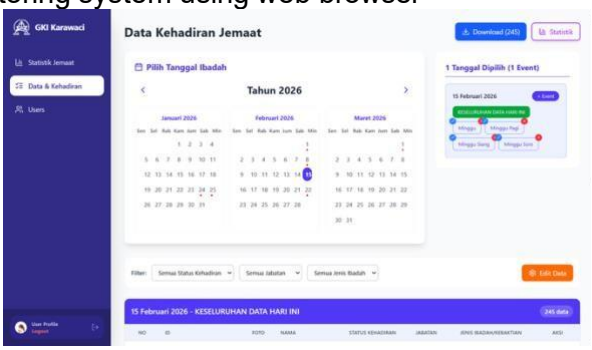
The web application transforms raw edge data into an empowering administrative tool, serving as the primary focus during the church staff's capacity-building workshops. Designed with input from church staff to minimize the learning curve, the intuitive interface allows administrators to monitor real-time attendance, manage demographics, and verify historical records (Figures 2a–2c).

Crucially, the system features an automated reporting engine that generates synod-compliant PDFs. This feature alone reduced quarterly report generation from 3.5 hours to just 8 minutes, directly alleviating the administrative burden identified during the initial needs assessment (Figures 2d–2g). Furthermore, role-based access control ensures data privacy while allowing leadership to safely delegate responsibilities to volunteers (Figure 2h). Through the mentoring phase, staff transitioned from supervised practice to confidently managing this platform independently, marking a successful shift toward sustainable digital empowerment.

Figure 2. Church attendance monitoring system using web browser



(a) Welcome page



(b) Church attending (real-time)

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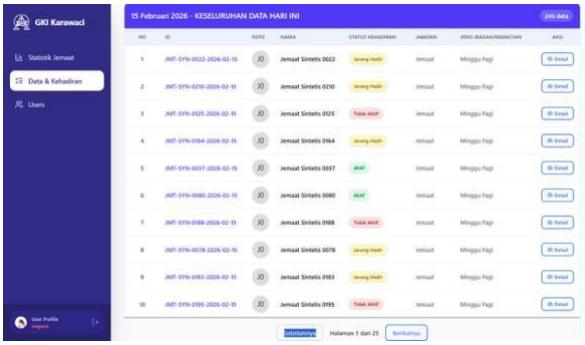
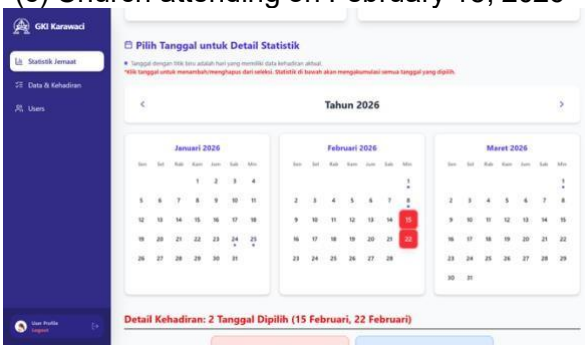


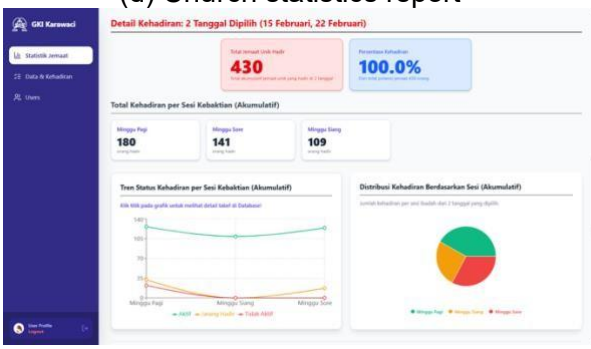
(c) Church attending on February 15, 2026



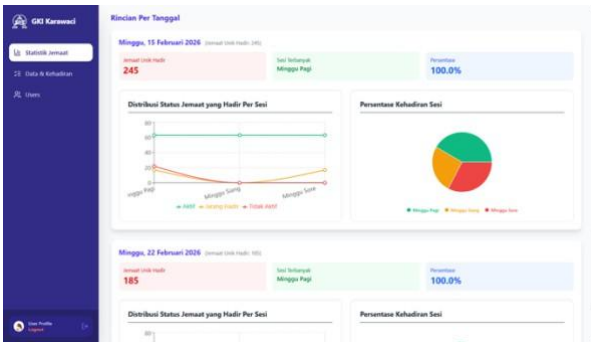
(d) Church statistics report



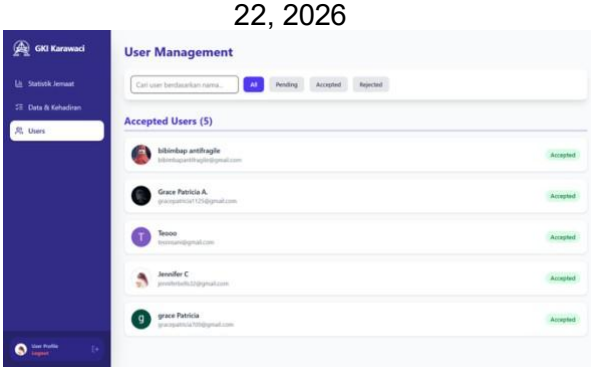
(e) Date selection for congregation statistics



(f) Attendance details on February 15 and 22, 2026



(g) Breakdown of congregation attending by session and date of service



(h) User authorization to secure the app

Source: Private Documentation, 2026.

To ensure sustainable system operation and bridge the digital literacy gap among church volunteers, a comprehensive training manual was developed as a key deliverable of this community service initiative. The guide, titled "Panduan Pelatihan Sistem Kehadiran Gereja Berbasis Edge AI," includes a professional cover page, detailed table of contents, quick reference cards with visual icons, step-by-step dashboard operation instructions, troubleshooting flowcharts, and technical support contact information (Figure 3). Designed with varying digital literacy levels in mind, the manual employs visual learning strategies with annotated screenshots and simplified workflows, enabling church administrators and ushers to transition from supervised training to independent system management. This training material served as both a learning resource during capacity-building workshops and a lasting reference tool for sustainable operation post-deployment, directly supporting the community empowerment objective of the PkM program.

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Figure 3. Edge AI-based church attendance system training guide



Source: Private Documentation, 2026.

Result

Evaluation results demonstrate the effectiveness of the system. Table 1 shows an overall accuracy of 96.8%. Table 2 confirms the practicality of full local deployment on Raspberry Pi 5, with an average power consumption of 8.2 W. Table 3 highlights substan tial real-world administrative benefits.

Table 1. Face Recognition Performance

Metric	Value	95% Confidence Interval
Accuracy	0.968	[95.9%, 97.6%]
Precision	0.982	97.3%, 99.1%]
Recall	0.954	[94.2%, 96.6%]

Source: Author's Work, 2026.

Table 2. Computational Performance on Raspberry Pi 5

Metric	Value	Notes
End-to-End Latency	247 ms	Capture + Detect + Preprocess + Infer
Effective Throughput	~4 FPS	Real-world operational rate
Power Consumption	8.2 W	Active recognition state

Source: Author's Work, 2026.

Table 3. Administrative Impact (Proposed System vs. Manual)

Metric	Manual Method	Proposed System	Improvement
Avg. recording time/service	18.3 min	0 min	100% reduction
Data entry errors/service	4.7	0.3	93.6% reduction
Monthly admin hours	22.1	7.2	67.4% reduction

Source: Author's Work, 2026.

The deployment yielded significant social and organizational impacts. This transformation journey began with comprehensive socialization sessions where church leadership, ushers, and congregation members engaged in town-hall style discussions about biometric privacy concerns and ethical AI deployment in sacred spaces (Figure 4). These early conversations were critical for establishing trust, as the academic team transparently explained the edge-based local processing approach. Congregants actively participated in shaping data protection protocols, creating a sense of ownership rather than imposition of external technology.

During the initial deployment, a notable challenge was the apprehension of elderly congregants regarding the camera. This was mitigated by repositioning the edge device to a less obtrusive angle and having ushers personally guide members, leading to full

normalization by week 4.

Figure 4. Socialization Session - Photo of the team explaining the system to church leadership, ushers, and congregation members (addressing privacy concerns)



Source: Private Documentation, 2026.

Following socialization, the capacity-building phase equipped church administrators and volunteer ushers with practical skills to operate the web-based dashboard independently (Figure 5). Training materials were deliberately designed with varying digital literacy levels in mind, incorporating visual guides and step-by-step protocols that respected the diverse technological backgrounds of church volunteers.

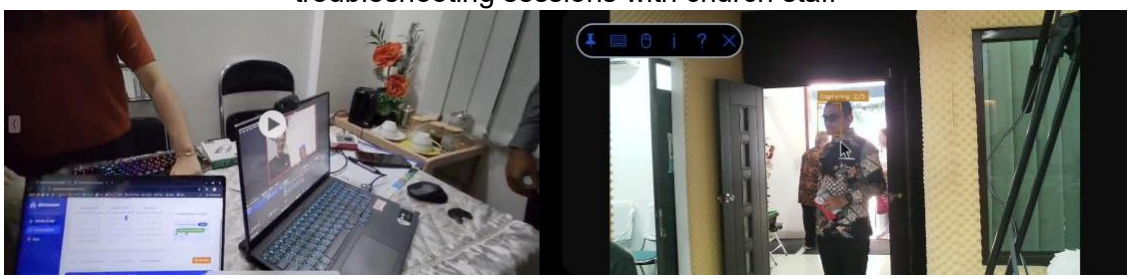
Figure 5. Training Workshop - Photo showing hands-on training of church administrators and ushers using the web dashboard



Source: Private Documentation, 2026.

The eight-week mentoring phase represented the heart of community empowerment, with the academic team providing continuous accompaniment through weekly on-site check-ins (Figure 6). This sustained presence allowed the team to witness and document the emergence of a local 'tech-savvy' usher team—five volunteers who organically became internal champions, providing first-line support to fellow ushers and significantly reducing dependency on external assistance.

Figure 6. Mentoring Activities – sample photo showing accompaniment process, troubleshooting sessions with church staff



Source: Private Documentation, 2026.

Qualitative feedback gathered through structured interviews revealed profound behavioral transformations, as summarized in Table 4.

Table 4. Qualitative Feedback Themes (Pre vs. Post Mentoring)

Aspect	Pre-Deployment (Weeks 1-2)	Post-Mentoring (Weeks 9-12)
Technology Perception	"Intrusive, complicated, and scary."	"Helpful, private, and easy to use."
Data Confidence	"We always guess the numbers for reports."	"We trust the dashboard for synod reports."
Digital Literacy	"We need the IT team to fix everything."	

Source: Author's Work, 2026.

Discussion

Deploying AI in a sacred space requires navigating the tension between operational efficiency and the sanctity of privacy. Our findings align with recent studies on ethical AI deployment in community settings (Le et al., 2025; Chanda, 2025), demonstrating that privacy-by-design (edge processing) is a critical enabler for trust. The socialization phase was instrumental in translating this technical feature into community trust, proving that ethical alignment must precede technical installation.

The transition from manual to automated systems in religious organizations often faces resistance due to varying digital literacy levels. Applying the Technology Acceptance Model (TAM) in this context reveals that perceived ease of use and perceived privacy protection were the primary drivers of adoption among the church staff (Gardner, 2022). The structured mentoring proved essential in sustaining this acceptance, supporting recent literature that emphasizes continuous accompaniment and local capacity building in community informatics projects (Jahn et al., 2025)

Beyond administrative efficiency, the project fostered institutional capacity building. By training local volunteers to manage the system independently, the initiative ensured sustainability post-deployment. This aligns with the core objectives of community service, which prioritize partner empowerment over mere technological installation (Brown, 2024). The reduction in administrative burden directly translates to more time for pastoral care, fulfilling the primary mission of the religious organization.

While this study demonstrates successful socio-technical integration, it is limited by its single-site implementation and the 8-week evaluation window. Future longitudinal research is recommended to assess long-term technological retention. Regarding scalability, the low-cost edge architecture (<$100 hardware) makes this model highly replicable for smaller, resource-constrained congregations across Indonesia and beyond, though the intensity of the mentoring phase may need adaptation based on local digital literacy baselines.

Conclusion

This paper presents a fully edge-based face recognition system for automated church attendance tracking, addressing administrative inefficiencies in religious institutions through a comprehensive community service approach. Deploying MobileNetV2 on Raspberry Pi 5, the system achieved 96.8% accuracy and significantly reduced administrative effort during an 8-week field evaluation at GKI Karawaci.

This community service initiative highlights that successful digital transformation in religious organizations requires a socio-technical approach where ethical socialization and continuous mentoring are as critical as the underlying AI architecture. The project demonstrates that bridging the digital divide in non-profit settings is achievable through privacy-centric, edge-based solutions coupled with robust partner empowerment.

For future community service practitioners, we recommend adopting a participatory design framework that prioritizes ethical alignment and digital literacy training alongside

technical deployment. For the partner organization, future actions should focus on establishing a local 'digital steward' team to ensure the sustainable, independent operation of the system without ongoing academic reliance. Future technical work will explore multi-camera fusion and adaptive preprocessing for extreme lighting conditions.

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