

A Survey on Attendance Automation, Menu-Based Nutrition Tracking, and Predictive Planning in Institutional Mess Systems: Gaps and Opportunities.

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Abstract

The operational efficiency of institutional food services is significantly impaired by unreliable diner headcount and meal planning models that use static, historical data, which leads to substantial food waste. Although the literature indicates the maturity of high-fidelity Face Recognition (FR) for attendance [1]-[3], [5], [6], [7], [8] and the ability of Machine Learning (ML) models to forecast demand, these fields remain functionally siloed. This paper identifies the important research gap of investigating a unified, low-latency data pipeline to translate real-time high resolution, biometric attendance data into direct operational planning input. We organize the component technologies into three layers - Perception, Logistics, and Analytics, - proposing a Reference Architecture for a Smart Mess System (SMS). The proposed architecture articulates the necessary functional and data linkages for effectively automating nutrition logging, mitigation of waste via predictive planning, and true efficiency in resource allocation in institutional food service.

Keywords— Attendance automation, face recognition, institutional mess management, menu-based nutrition, predictive planning, React.js, Node.js, Python/dlib.

INTRODUCTION

The challenge of effectively managing large-scale institutional food services—like mess halls and cafeterias—primarily involves accurately linking food supply with fluctuating food demand. There are two main systemic challenges: (1) attendance recording, which is conducted manually, is inefficient and inaccurate, and causes inaccurate headcounts; (2) meals prepared based on inflexible, outdated, historical data creates large supply/demand mismatches and contributes to unnecessary food waste. The estimated magnitude of this unnecessary food loss supports a case for upfront technology that adds further sustainability and cost-effectiveness. There is a large amount of work done in this body of literature, but much of it is siloed. On one hand, biometric systems based on computer vision, especially Face Recognition (FR), are known to be highly accurate and robust systems for recording attendance counts. On the other hand, parallel work has been quite advanced in developing sophisticated systems for analyzing meal content, managing inventory, and anticipating generalized demand. The main gap that this survey highlights, and is the main subject of this survey, is the lack of a technology bridge which connects the basic biometric attendance data—which is recorded as a headcount—into a real-time, high-fidelity input for predictive operational planning. This survey identifies the relevant technology components and develops a conceptual architecture to fill the structural gap.

METHODOLOGY OF LITERATURE SELECTION

- Scope: Literature published in the last five or six years (2018-2025) that examines attendance

automation, food waste tracking, nutrition tracking, prioritizing those that leverage biometric or computer vision methods related to the implementation of Python/dlib proposed in this systems.

- Databases used are: IEEE Xplore, arXiv, PubMed, MDPI, IJRASET, IJERT, etc.
- Inclusion Criteria: i) preferred to examine an institutional or mess/canteen context related, ii) includes empirical evaluation, iii) use of ML/computer vision/sensors techniques for sensing the data, iv) open access are preferred as available globally and easily.
- Number of papers reviewed: 10+ including applied systems, technical evaluations, and/or reviews.

LITERATURE SURVEY

1. M. Gopila and D. Prasad (2020). Machine learning classifier model for attendance management system

The authors present a very precise attendance solution, boasting a 99.38% accuracy rating. They developed a real-time system using Haar Cascade for detection and the Local Binary Pattern (LBP) algorithm for recognition. A major takeaway is LBP's proven ability to deal with shape deformation and varying lighting conditions, a common problem for early implementations. As it with many other early implementations, the purpose of this system was for presence only, and it functioned autonomously and therefore valuable attendance information was never forwarded to other modules for operational planning purposes, like forecasting resource needs or determining nutritional needs. In other words, it was not integrated into the operational system.

2. R. A. A. Helmi, et al. (2019). Face Recognition Automatic Class Attendance System (FRACAS)

This paper discusses the educational sector, in which the FRACAS system utilizes the classic Eigenface algorithm. A significant implementation consideration they took into account was the ability to manage small, day-to-day variations in a person's appearance, such as those related to grooming, lighting, or minor medical issues. The results were evident; better timeliness and authenticity over the manual process was observed. As with any system, there are limitations of scope; in this case, the limitation is narrowness of scope as a single-domain system—it only works in the classroom setting and lacks any degree of the complex integration found in the cafeteria or mess hall management systems at the same levels.

3. S. Matilda and K. Shahin (2019). Student Attendance Monitoring System Using Image Processing

This paper follows the Author's interest in a budget-friendly and smart approach, emphasizing lower hardware costs and accessibility with the use of general Image Processing and Haar cascade algorithm as part of their method. The approach is pragmatic and still effective and even incorporates an automatic absentee notification to administrators. Although the work is cost-effective, the technology remains a silo. It automates the attendance, but halts; it doesn't use the biometric data collected for any future operational decision making, or how it could assist in improved services for the institution. Focusing only on attendance lacks the sophisticated integration required to develop any management system.

4. A. Utsav et al. (2024). IoT Enabled Smart Mess with Nutrition Benefits and Waste Management

The paper represents an important transition from attendance alone to an integrated system for Nutrition, Access, and Waste Management systems. They successfully utilize IoT and a mobile application to develop random recommendations and portion control based on the user's individual

BMI, even managing food orders for individuals who are ill. This truly integrated approach is what a smart campus needs. The primary vulnerability is their reliance on RFID for access instead of Face Recognition. This undermines the system's security and, more importantly, eliminates the opportunity to effortlessly employ the proven attendance log with high fidelity to accurately forecast consumption. RFID can be misused so rendered the system as ineffective.

5. A. Rao (2022). AttenFace: A Real Time Attendance System Using Face Recognition

The author presented AttenFace, an innovative method that captures snapshots of classes every 10 minutes instead of having a constant video feed. This dramatically decreases computational load, and adds another dimension of value for students: the ability to step out for a few minutes without losing attendance credit; this is a great improvement on attendance. However, the study's limited scope with respect to how long snapshots were taken, would not create a connection to other services like meal planning, or entering one's hostel, underusing the data. That is, within single domain use.

6. J. B. Jai et al. (2024). Intelligent Face Tracking Attendance System Using LBPH and Kalman Filtering

This research targets real-world instability by revising the LBPH algorithm with a Kalman Filter. The filter predicts and corrects face location which makes it extremely robust in response to changes in pose and movement in a dynamic environment. This generates very accurate attendance but, eventually, the research runs into the same wall: the data is siloed, and can't be used to inform non-academic, cost-saving processes such as the management of mess or to reduce waste.

7. T. Goswami et al. (2020). Attendance Monitoring System using Facial Recognition

This team concentrated on developing a unified attendance administrative system that utilized advanced Computer Vision techniques (e.g., CNN and LBPH) with DBMS support. They sought to harness technology for the intended purpose of luxurious reductions in manual labor and forgery reduction for the entire institution. While they employed advanced techniques to achieve acceptable accuracy, the system was solely attendance-based and did not utilize biometrics to personalize services or follow consumary activities. The aim may have been to create a compelling system but it is a powerful administrative device that is disconnected from campus life.

8. J. T. Thirukrishna et al. (2023). Smart Attendance System Using Face Recognition

In this study, the authors are tackling an operational challenge, this system employs the Haar Cascade Algorithm and is designed for greater accuracy, at a short distance (50-70cm). Specifically, they sought to avoid maintenance concerns and much of the lag associated with sensor based systems reliant on hardware. While the solution works well for attendance, it is still limited, working in almost isolation, and cannot integrate the recorded biometric identity and oversee more general campus services, such as nutrition or gate access.

CLASSIFICATION OF COMPONENT TECHNOLOGIES

Three functional layers are identified as necessary for a complete process in the landscape of mess hall management solutions.

A. The Perception Layer: High-Fidelity Biometric Attendance

High-fidelity attendance serves as the foundation of planning that is informed by data. Facial recognition (FR), with its robust, no-touch capabilities and its biometric choice for attendance [1]–[3], [5], [6], [7],

[8]. Detection and Tracking Methods: Early variants of the systems predominantly utilized cascade classifier methods, for example using the Haar cascade algorithm for quick face detection [1], [8]. More sophisticated systems have employed state-of-the-art algorithms:

- Deep Learning (CNN): Convolutional Neural Networks are used for complex feature extraction and identification, achieving superior efficiency and accuracy compared to older systems [7].
- Local Binary Pattern Histogram: This method is valued for handling differences in lighting and is commonly used in real-time recognition systems [1], [6].
- Kalman Filtering: The Kalman filter is incorporated to ensure a robust performance to the dynamic conditions of the mess hall; for example, if students are rapidly moving, the Kalman filter will perform robust face tracking and account for momentary occlusion and rapid shifts in position [6].

System Design for Scalability: Current FR attendance systems emphasize both real-time operation and scalability. Architectures are suggested that decouple the intensive FR processing server from back-end attendance calculation server [5]. Systems might also be designed, to conserve resources, by using periodic snapshots of the classroom/entry area instead of continuous video streams; thus allowing flexibility, while also significantly reducing computer resource burdens [5].

B. The Logistics Layer: Smart Mess and Non-Biometric Solutions

This category covers systems devised to monitor meal delivery, tracking inventory, and individual nutritional monitoring by means of some non-biometric identification.

- IoT and RFID Systems: IoT-enhanced applications, like the Smart Mess, often rely on RFID technology for control measures and identification purposes [4]. These systems seamlessly combine stored user information (e.g., either BMI or allergy information) with a mobile application. While the application recommends a meal based on the user information and grants access to the mess door [4].
- Functional Trade-Offs: These non-biometric systems are effective in inventory control and tracking dietary intake in real time. However, they use a relatively low fidelity input - the swipe of a card/tag - to obtain presence [4]. This functionality by necessity sacrifices athletic FR spontaneous, high-resolution, non-invasive data, which is necessary for precision in real-time predictive modeling.

C. The Analytics Layer: Predictive Demand Forecasting

This research explores the models and inputs needed to predict food demand for food at institutional food service levels, with the goal of reducing over-preparation, cost, and direct food waste.

- Machine Learning Models - Advanced ML & AI based predictive models utilize input that goes beyond time series analysis. Top models examined include Lasso regression, XGBoost, and Long Short-Term Memory (LSTM) networks. All assistance in reducing food waste and containerization levels.
- Main Predictive Variables: Effective predictive models draw on several data instances, including:
Timing/day Variables: Historical consumption, day of the week, seasonality, and school calendar.

Context Variables: Current popularity of the menu items of interest, weather conditions, and outside events.

Count of Diner: This is the most important variable. The main challenge is to convert the Diner count from historical averages into a dependable real-time number facilitated from the biometric (face recognition) attendance layer.

THE UNIFYING RESEARCH GAP

The main academic and operational challenge is the functional disjointedness of these three component layers [4], [5]. The existing literature creates a trade-off: High-Fidelity Attendance (FR) Simple Headcount: Regardless, the high-fidelity data that FR generates is still almost exclusively kept in a silo and used, when shared, for simple security and archival attendance purposes [5]. Integrated Logistics (RFID) Low-Fidelity Data: Surprisingly, where systems successfully integrate inventory control with nutrition tracking using software with a single database, they do so with less effective, non-biometric identification (RFID), therefore the high-fidelity identification lack the predictive performance [4]. Thus, a new architecture is need for operational performance—to be able to use the high-fidelity identification data generated by the most effective, reliable identification technology (FR) as soon as it is generated into the powerful input to the operational modules (predictive planning).

REFERENCE ARCHITECTURE: THE SMS FRAMEWORK

We present the Smart Mess System (SMS) as a means of providing a Reference Architecture for a cohesive and closed-loop solution that specifically targets the integration gap. The architecture's integration gap is defined by a seamless, secure and low-latency data pipeline deployed across three tiers:

- A. Tier 1: Biometric Perception Module
 - Function: Real-time and highly accurate identification of diner.
 - Technology Base: Python / OpenCV / dlib.
 - Functionality: When the student enters the space, and validation of FR and favorable outcome, attendance is automatically marked as, Student and Timestamp, via a secure API call to the Backend, with attributes of date/ time and Student ID.
- B. Tier 2 : Unified Backend and Data Analytics Engine
 - Function: Central data management, logging, and routing of predictive logic.
 - Technology Foundations: Node.js / MongoDB (or a similar NoSQL for high-speed logging).
 - Data Flows: Nutrition Logging: The Node.js backend instantly references the Meal Entity data with its pre-reaped nutritional profile of the day's menu, which are logged to allow Users to have the Nutritional referential information based on their Menu selections /did not select. Predictive Planning Input: The backend sees the Dynamic Real-Time Attendance Count from the Perception Modules at the core, which is along with the Historical Dining Trends from out acquired MongoDB logs.
- C. Tier 3: Predictive Phase and Reporting Map
 - Subject: Develop the Meal Demand Forecast plus forward operational feedback.
 - Technological Core: A dedicated Analytics Sub-Module (Node.js/ML libraries/resource), plus an UI (ReactJS). Action & Contribution: Using the combined dynamic/historical data, the Analytics Module interfaces with an ML model-it uses a trained ML model to generate a meal demand forecast- on the precise amount of food needed. This result is also communicated to the front-line kitchen chefs-a direct operational intervention to prevent overcooking.

CONCLUSION AND FUTURE DIRECTIONS

This study confirms there is a clear research gap in the development of unified Smart Mess Systems (SMS) that use high accuracy Face Recognition (FR) specifically contextualized to mess environments. The proposed SMS Reference Architecture gives a solid conceptual scaffolding to harness the existing maturity of computer vision for perception and scalable data management tools for prediction. The SMS establishes a reliable data pipeline that connects biometric attendance to robust predictive models, providing an innovative, operationally superior offering to mitigate food waste and improve food service management in higher volume institutional settings. Future areas of research should prioritize: FR robustness in untethered settings: to make the models robust against complex real-world variables such as interference

of lighting conditions, flows of many students, and different levels of occlusion in the mess. Closed-loop validation: use sensor based post-consumption waste monitoring for empirical data collection [4] to verify the validity and update of predictive ML models, thereby creating a true closed-loop system for optimization.

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