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CIVICMIND: AI-Driven Embedded Grievances Logging System

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Abstract
Public grievance redressal systems play a crucial role in maintaining transparent and responsive governance. However, existing methods including written forms, phone calls, and even web or mobile applications often depend on manual input, lack intelligent prioritization, and fail to provide real-time updates. These limitations result in delayed responses, poor complaint tracking, and reduced citizen satisfaction. The proposed system, Civicmind: An Ai-Driven Embedded Grievances Logging System, introduces an innovative approach by integrating Artificial Intelligence (AI) with an IoT-based embedded framework. The system employs an ESP32 microcontroller, I2S microphone, GPS module, and OLED display to enable users to log verbal complaints conveniently in real time. The recorded data is securely stored on a microSD card and analyzed using Natural Language Processing (NLP) algorithms to evaluate the content's urgency and assign a risk score. High-risk grievances are automatically highlighted and forwarded to relevant authorities through email alerts. A web-based dashboard further enhances the system by providing visualization, geospatial mapping, and analytical insights for administrators. This ensures faster decision-making, efficient resource allocation, and improved accountability. By combining IoT, AI, and automation, CIVICMIND aims to create a smart, transparent, and citizen-centric grievance management system that bridges the gap between the public and governing bodies.

1. Introduction

In modern governance, public grievance redressal serves as a vital mechanism to ensure transparency, accountability, and citizen trust. It allows individuals to voice their concerns, report issues, and seek action from authorities. However, the effectiveness of these systems largely depends on how efficiently complaints are recorded, managed, and resolved. Despite the availability of online portals and mobile applications, most grievance-handling processes still involve manual operations and delayed responses, which often result in citizen dissatisfaction. The increasing volume of complaints and the lack of proper prioritization make it difficult for authorities to identify urgent issues that require immediate attention. Traditional systems rely on text-based or form-based

submissions, which are not accessible to everyone especially in areas with limited digital literacy or internet connectivity. This highlights the need for a more inclusive and intelligent grievance management system that can automate the recording, analysis, and escalation of public complaints. The proposed system, CIVICMIND: AI-Driven Grievance Logger and Risk Prioritization System, introduces a novel approach that integrates Artificial Intelligence (AI) and Internet of Things (IoT) technologies for smarter complaint handling. The embedded hardware setup, powered by an ESP32 microcontroller, includes an I2S microphone, GPS module, and OLED display, allowing users to record their grievances verbally in real time. These audio complaints are stored on a microSD card and later processed using Natural Language Processing (NLP) algorithms to evaluate their urgency. Each complaint is assigned a risk score, enabling automatic prioritization and faster forwarding of critical cases to the concerned authorities via email. Additionally, a web dashboard enhances the system by providing visualization, geospatial mapping, and analytical insights, allowing authorities to monitor issues and take timely action. Thus, CIVICMIND helps build a transparent, responsive, and citizen friendly governance system.

2. Literature Review

More recent studies of AI-based grievance redressal systems predict the growing importance of Natural Language Processing (NLP), embedded platforms, the Internet of Things (IoT), and edge intelligence in automating the process of complaint collection, classification, and prioritisation. Recent research focuses on improving the features of accessibility, multilingual support, offline support, and smart decision-support features of civic complaints systems. Gupta and Mehta suggested an NLP-based framework of classifying and prioritising complaints publicly with rule-based and supervised learning methods. Their findings showed that hybrid models performed better in civic datasets but when it was time to detect sarcasm and contextual sentiment, performance was worse. The authors suggested domain-specific feedback loop and adaptive learning processes to enhance the quality of interpretation [1]. Verma et al. created a decentralised mobile application of municipal complaints recording, which utilises an offline-first application with a local cache and delayed synchronisation. Although this technique ensures continuity of the service in the low-connectivity area, the storage capacity is likely This offline-first recording and storage strategy ensures that complaints can be logged reliably even when internet connectivity is unavailable. It also preserves the original voice evidence securely on the device. Once network connectivity becomes available, the stored complaint records are automatically uploaded to a cloud database using the built-in Wi-Fi module. The recorded audio is then processed using a multilingual speech-to-text AI model to generate accurate textual transcripts. These transcripts, along with complaint category and location metadata, are analyzed by an AI-based prioritization model that estimates urgency and severity levels. Based on the computed priority, the system automatically sends notifications to the appropriate department. All complaint information and status updates are presented through a secure web-based dashboard that allows authorized officials to monitor, track, and record resolution progress. This completes an end-to-end intelligent grievance management workflow from complaint capture to resolution tracking. Prakash and Iqbal considered ethical and governance issues and revealed concerns about the concept of fairness, transparency, and algorithmic bias in AI-powered grievance systems. They suggested easily explainable AI layers and audit trails and stressed the need to have regulatory control and citizen involvement [6]. Roy et al. created an edge-based IoT-NLP framework to categorise real time sanitation complaints into voice and sentiment scoring with the help of voice capture and sentiment scoring devices. The model was accurate in moderate noise conditions with a significant latency restriction [7]. Singh et al. showed that GPS tagged complaint mapping using geospatial analytics and clustering was useful, but with inadequate datasets and irregular coordinates, reliability was compromised [8]. Deshmukh and Jain compared urgency detection based on sentiment analysis between lexicon and deep learning systems, and reported lower accuracy when using mixed language and sarcastic input, and advised culturally sensitive hybrid approaches [9]. Kumar et al. developed a voice-based complaint recording platform based on ESP32 and I2S microphones, speech to-text recognition and NLP prioritization. The system was working, but it had latency and

vocabulary coverage drawbacks, implying lightweight offline models to be adopted to enhance it [10]. Banerjee and Joshi suggested an AI-based complaint-management system that merged NLP with predictive analytics and geospatial mapping with multilingual support and real-time notifications, but the level of integration was too complex, and the governance issue remained [11]. Mohan et al. came up with an offline-first IoT grievance logging architecture based on microSD storage and periodic cloud synchronisation, which enhanced the level of reliability but created synchronisation issues that required version-control measures [12]. The analysis of recent review and framework papers also supports the trend of automated grievance handling, which relies on AI. Massive reviews are focused on real-time analytics, automated prioritisation, and ML triage, but also warn of bias, privacy, and trust concerns [13]. Serious improvements in terms of entity extraction and urgency detection have been noted through AI-based petition and grievance analysis systems, but the system has difficulties with ambiguous phrasing and low-resource languages [14], [26]. AI-driven and NLP-based smart sanitation and governance complaints platforms with smart dashboards have been shown to be beneficial in operation but have reported regional language and sparse data challenges [15]. AI-driven and embedded grievance systems have been shown to exhibit role-based tracking, filtering student grievance, and smart city complaint processes, enhancing transparency and automation, but still do not have well established multilingual and adaptive intelligence layers [16], [22], [27], [28]. Complaint applications, which are voice and GPS enabled, have enhanced accessibility but need improvement in noise management and localisation [10], [23]. Recent semantic clustering with transformers and dashboard-driven complaint analytics have demonstrated potential to enable scalable and correct classification of complaints in new governance systems [24], [25].

Altogether, the literature proves the advancement in AI, NLP, IoT, and embedded-based grievance systems. However, offline intelligence, multilingual strength, edge efficiency, synchronisation reliability as well as ethical governance frameworks still have gaps. It is these gaps that drive the creation of an inbuilt, voice-enabled, artificially intelligent grievance system with offline functionality and prioritisation in context.

3. Methodology

The CivicMind system follows a unified embedded and AI-driven workflow designed to deliver accessible and intelligent grievance management. The overall approach combines voice-based complaint capture, contextual metadata collection, offline storage, cloud synchronization, and automated AI-based analysis into a continuous operational pipeline. The design emphasizes simplicity of use, offline reliability, secure data handling, and automated decision support. User interaction begins with an embedded grievance logging unit that provides a guided interface through an OLED display and a rotary encoder for menu navigation and complaint category selection. This structured interface reduces user confusion and speeds up complaint entry. In deployment scenarios that require controlled usage, keypad-based authentication can be enabled to prevent spam submissions and unauthorized access. When a complaint is registered, a GPS module captures the geographic coordinates of the location. Along with this, the selected complaint category and device location identifier are attached as structured metadata. The complaint itself is captured through voice input using an I2S MEMS microphone connected to the ESP32 controller. The audio signal is digitized and stored locally on an SD card together with its associated metadata through the controller interface. This offline-first recording and storage strategy ensures that complaints can be logged reliably even when internet connectivity is unavailable. It also preserves the original voice evidence securely on the device. Once network connectivity becomes available, the stored complaint records are automatically uploaded to a cloud database using the built-in Wi-Fi module. The recorded audio is then processed using a multilingual speech-to-text AI model to generate accurate textual transcripts. These transcripts, along with complaint category and location metadata, are analyzed by an AI-based prioritization model that estimates urgency and severity levels. Based on the computed priority, the system automatically sends notifications to the appropriate department. All complaint information and status updates are presented through a secure web-based dashboard that allows authorized officials to monitor, track,

and record resolution progress. This completes an end-to-end intelligent grievance management workflow from complaint capture to resolution tracking. Figure 1 shows Methodology

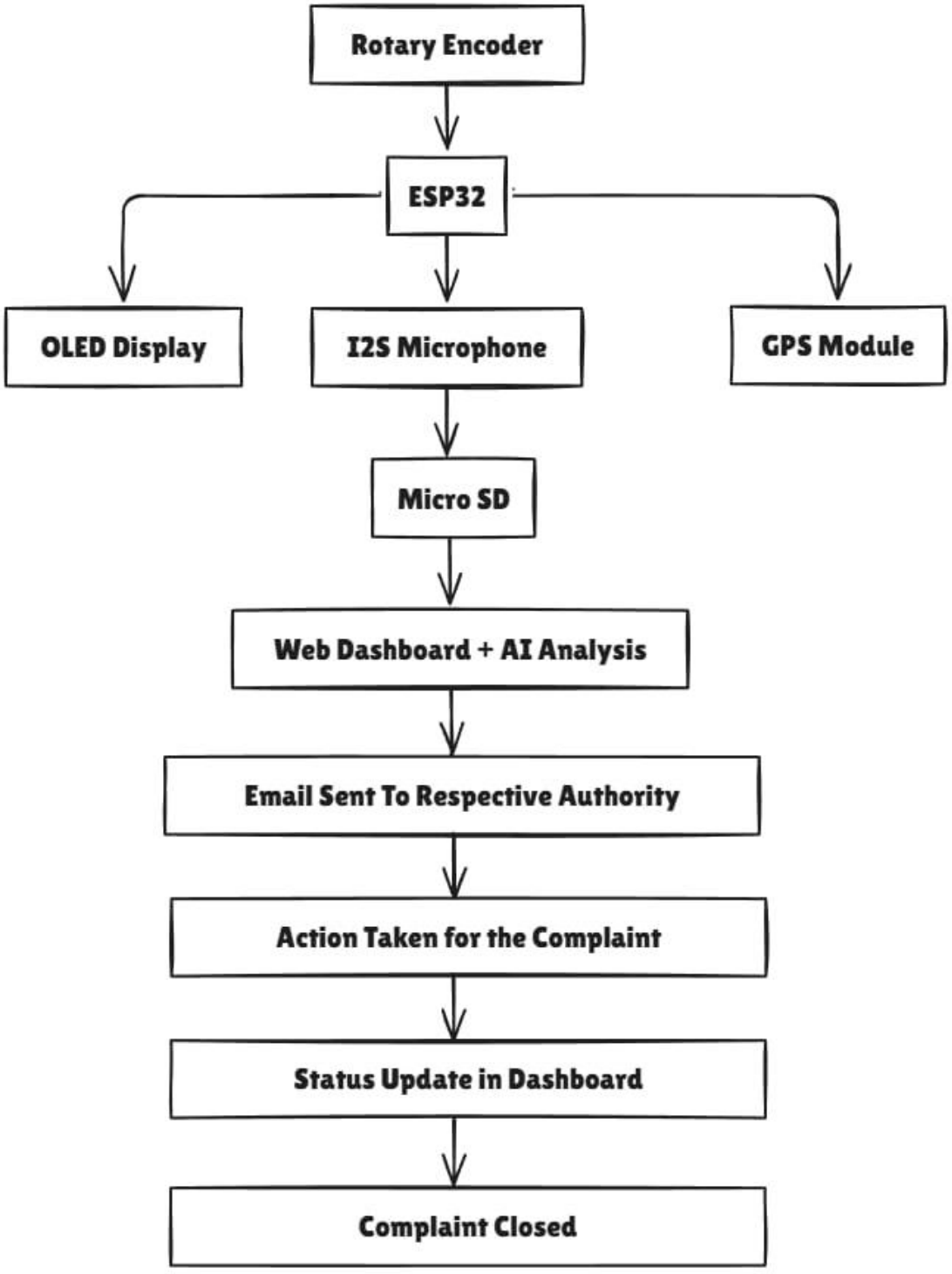

Figure 1 Methodology

3.1. Specifications

The CIVICMIND system is developed using an ESP32 microcontroller along with a digital microphone to capture voice complaints, a GPS module to record location details, an OLED display to show user prompts, and an SD card to store the

recorded audio. The device runs on a simple regulated power supply and uses built-in Wi-Fi to send complaint data to the server when connectivity is available. The software is written using Arduino IDE with supporting libraries for audio recording, GPS reading, display control, and storage. On the processing side, AI tools are used to convert speech into text and analyse the complaint content to assign priority. A simple web dashboard is used for monitoring complaints, and automated email alerts are sent to the concerned departments when urgent issues are detected.

3.2. Proposed Framework

The proposed CivicMind system is an AI-assisted embedded grievance logging platform designed to make complaint registration more accessible, secure, and reliable even in low-connectivity environments. Figure 2 shows Hardware Architecture

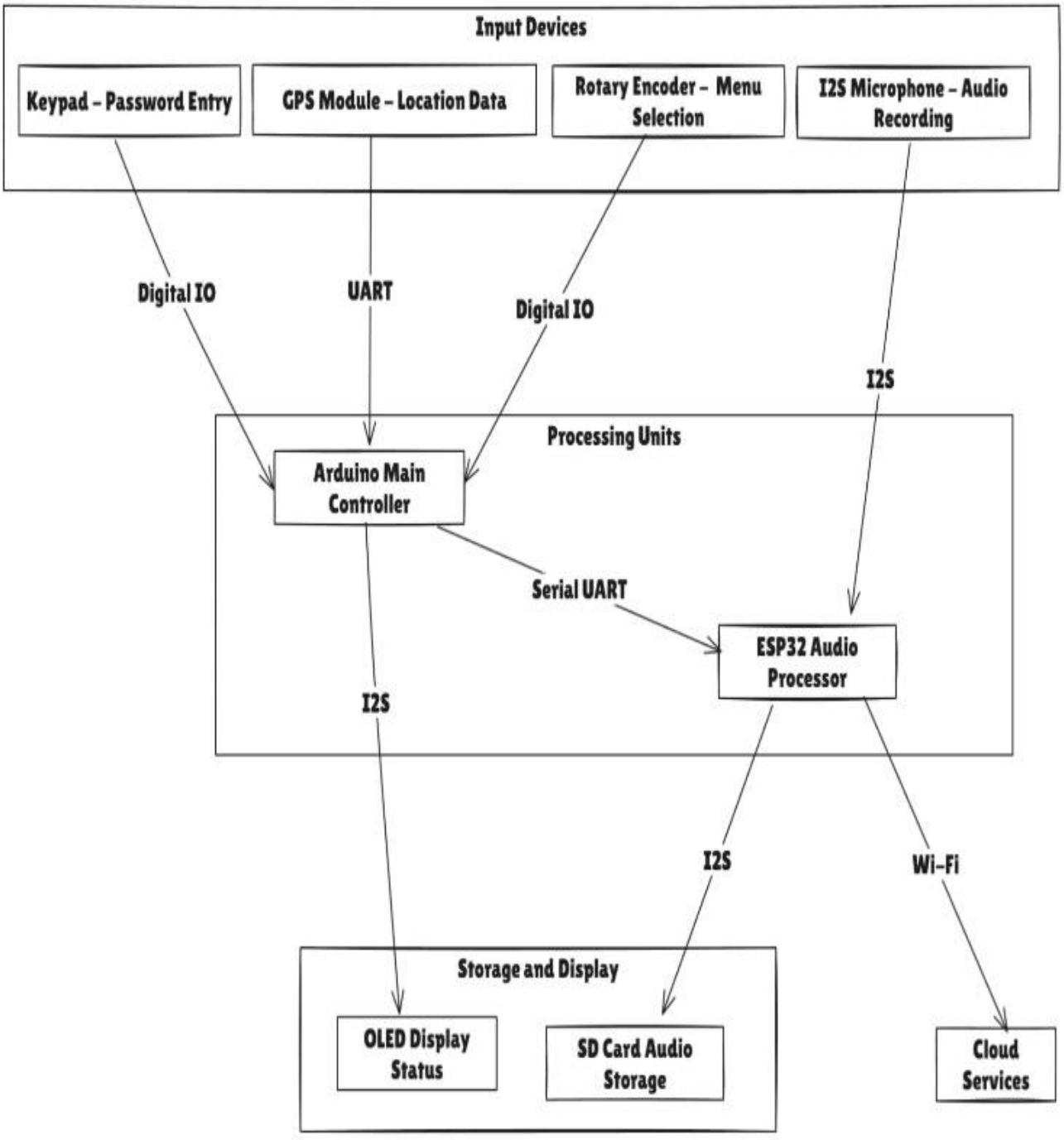

Figure 2 Hardware Architecture

Unlike traditional online-only grievance portals, this system combines dedicated hardware, voice-based input, contextual data capture, and intelligent back-end processing into a unified workflow that supports automated prioritization and routing. The system uses a microcontroller-based interface that guides users step by step through the complaint registration process. Instead of requiring typed input, complaints are captured through voice recording, which improves accessibility for users with limited literacy or low technical familiarity. A menu-driven interface displayed on an OLED screen allows users to select complaint categories using a rotary encoder, making interaction simple and structured. For public deployment scenarios, an optional keypad-based authentication mechanism is included to prevent misuse. During complaint registration, a GPS module captures the precise location coordinates and associates them with the complaint as metadata. Additional contextual information such as complaint category and device location ID is also attached. Voice input is captured using an I2S MEMS microphone and processed by an ESP32 controller, which stores the recorded audio locally on an SD card along with the related metadata. This offline-first design ensures that complaints can be recorded even during network outages and that original evidence remains safely stored on the device. When network connectivity becomes available, the stored complaints are automatically synchronized with a cloud database through the Wi-Fi module. A multilingual speech to-text AI model converts the recorded audio into structured text while preserving contextual meaning. The extracted complaint text and associated metadata are then analyzed using an AI-based prioritization model to estimate urgency and severity levels. Based on this analysis, the system automatically routes each complaint to the appropriate department and triggers alert notifications when required. A web-based dashboard provides administrators with facilities to view, track, and update complaint status, thereby enabling a complete, intelligent grievance management workflow from submission to resolution Figure 3 shows Arduino Workflow Architecture.

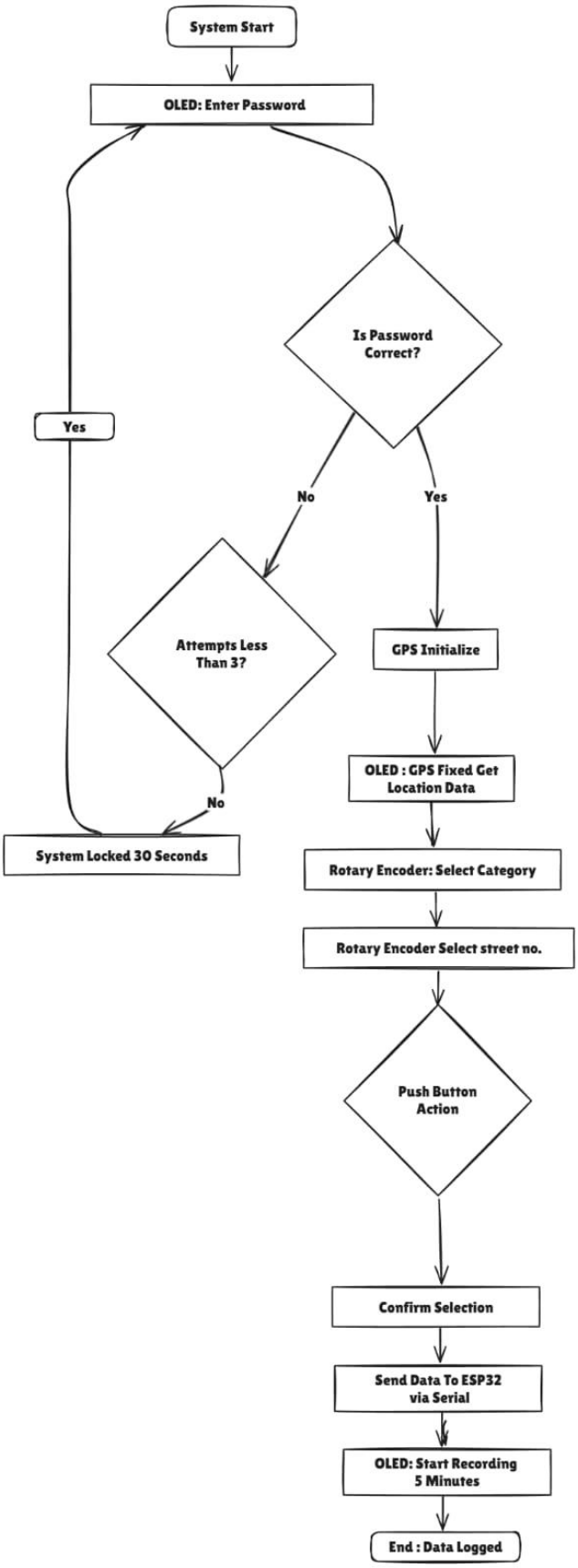

Figure 3 Arduino Workflow Architecture

4. Result and Discussion

The CivicMind system is implemented as an embedded, AI-assisted grievance recording and prioritization platform designed for reliable offline operation with cloud-enabled processing and notification support. The hardware architecture combines multiple controllers to distribute tasks efficiently. An Arduino Uno functions as the primary interface controller for user interaction and metadata handling, while an ESP32 microcontroller performs digital voice capture and local storage operations. An ESP8266 module provides Wi-Fi connectivity and manages cloud synchronization. The input and interface components include an I2S MEMS microphone for voice capture, a 128×64 OLED display for menu prompts and status messages, and a rotary encoder for complaint category selection. A NEO-6M GPS module is used to obtain geo-coordinates for complaint tagging. Audio recordings and related metadata are stored locally using a microSD card module to support offline first operation. A 4×4 matrix keypad can be optionally enabled for PIN-based access control in public deployments, and an RGB LED is used for visual status indication. On the software side, the embedded control layer is integrated with a cloud database, a multilingual speech-to-text AI transcription service, and an AI-based complaint prioritization engine. The processed complaints trigger automated SMTP email notifications to the responsible departments. A secure web-based dashboard is provided for authorized officials to monitor complaints, track status, and manage resolution workflows. Together, these components enable secure, accessible, and Grievance management Figure 4-14.

Figure 4 shows the OLED interface of the CivicMind system, including the welcome screen and secure password entry module used for authorized grievance logging.

Figure 5 illustrates the access control behavior when the correct password is entered, the system displays "Access Granted"; otherwise, it locks for 30 seconds to prevent unauthorized attempts.

Figure 6 Presents the GPS initialization process, where the system searches for satellite signals and captures location coordinates once a stable fix is obtained. These coordinates are stored along with the complaint record.

Figure 7 shows the complaint category selection menu, where the user chooses the complaint type and street number using the input controls

Figure 8 displays the summary screen that presents the selected category and captured location details for finaluser confirmation before submission. After confirmation, voice

recording begins.

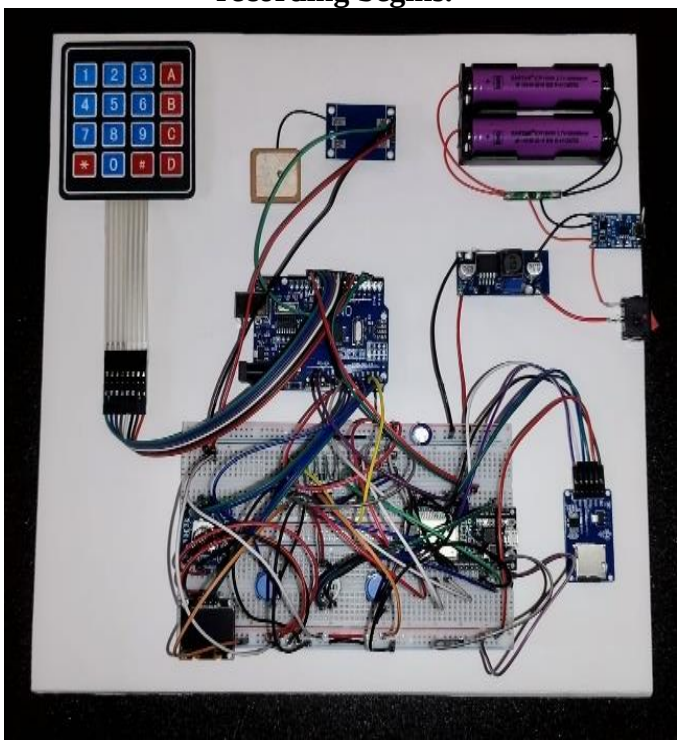

Figure 9 Hardware Module

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=== TRANSCRIPTION ===
எங்கள் பகுதியில் ரோடு மிகவும் கெட்ட நிலையில் உள்ளது. வாகனங்கள் செல்ல சிரமமாக உள்ளது.
====================

=== TRANSCRIPTION ===
हमारे क्षेत्र में पानी की सप्लाई बहुत कम है।
====================

=== TRANSCRIPTION ===
ഇവിടെ ഡ്രൈനേജ് സിസ്റ്റം തടസ്സപ്പെട്ടിരിക്കുന്നു.
==================

=== TRANSCRIPTION ===
వీధి లైట్స్ పని చేయడం లేదు, రాత్రి పరమడకరం
==================

=== TRANSCRIPTION ===
రాత్రి దీపాలు కాన్ని పనిస్తుంటాయి, రాత్రి అభయకరమైనది
==================
```

Figure 10 Demonstrates The Speech-To-Text Processing Stage, Where Recorded Voice Complaints Are Transcribed into Text in The Same Spoken Language To Ensure Accurate Grievance Documentation

Raw Complaints Data - Input Sheet

CivicMind

File Edit View Insert Format Data Tools Extensions Help

complaint_number	category	complaint	timestamp
C01	Fire	Fire accident near bus stand	07/01/2026 02:48:00
C02	Road	Huge pothole causing accidents	2026-01-07 05:29:00
C03	Health	Person collapsed on roadside	2026-01-07 07:01:00
C04	Water	Water pipeline burst	2026-01-07 07:56:00
C05	Electricity	Live wire hanging	2026-01-07 13:54:00
C06	Sanitation	Garbage not cleared	2026-01-08 04:16:00
C07	Traffic	Signal not working	2026-01-08 05:47:00
C08	Flood	Area flooded after rain	2026-01-08 12:53:00
C09	Police	Theft reported	2026-01-08 20:40:00
C10	Medical	Ambulance required urgently	2026-01-08 22:24:00

Complaints SortedComplaints

Figure 11 Raw Complaints Data - Input Sheet

Figure 12 Authorized users log in with their username and password to securely access the CivicMind grievance monitoring system.

Figure 13 Mail sent to respect authority

Figure 14 All recorded complaints are listed in one dashboard with category, location, and street details, along with priority indicators for quick action.

Conclusion

CivicMind provides an AI-driven embedded solution for grievance logging and risk prioritization, addressing key challenges in public and institutional complaint management. By combining offline voice-based complaint recording, GPS-based location tagging, category selection, and optional secure access, the system ensures accessibility, reliability, and data integrity across diverse environments. The multilingual speech-to-text AI model and automated prioritization framework enable timely identification of urgent complaints and facilitate efficient departmental notifications. The system operates effectively in both online and offline scenarios, supporting deployment in public spaces, NGOs, educational

institutions, and office campuses. Results indicate improved administrative efficiency, transparency, and accountability, while reducing reliance on manual or purely online complaint mechanisms. Future enhancements may include assisted GPS for improved location accuracy, optimized AI transcription for longer recordings, and integration of additional contextual sensors to further enrich complaint metadata. CivicMind offers a robust, adaptable, and intelligent platform for modern grievance management, bridging accessibility, automation, and decision support.

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Our sincere Thanks to Sri Ramakrishna Institute of Technology, Coimbatore, India for providing us the environment and support to complete our project in successful manner. Biography: Dr. L. Malathi, She received her Ph.D. in the field of VLSI under Faculty of Information and Communication Engineering (ICE) from Anna University, Chennai in the year 2023. She received her M.E. degree in Applied Electronics in the year 2008. She received her B.E. degree in Electronics and Communication Engineering in the year 2005. Currently she is working as Assistant Professor (Sr. Gr.) in Department of Electronics and Communication Engineering at Sri Ramakrishna Institute of Technology, Coimbatore, Tamilnadu, India. She is having 17 years of teaching experience. She has presented and published papers in various National and International Conferences, Journals and patents. Her field of interest is VLSI, Digital Signal Processing and Embedded Systems. She acted as resource person in seminar and workshop, session chair and reviewer in conferences. She is a lifetime member of professional bodies such as ISTE, IAENG and ACM. Ms. R. Dharshini, Ms. R. Kiruthika and Ms. K. Mounika are UG scholars in Department of Electronics and Communication Engineering at Sri Ramakrishna Institute of Technology, Coimbatore, Tamilnadu, India.

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