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(54) Title: **An offline-first, ai-enabled system for decentralized issue reporting, automated routing, and immutable resolution tracking**

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(57) Abstract:

The present invention discloses an Offline-First, AI-Enabled System for Decentralized Issue Reporting, Automated Routing, and Immutable Resolution Tracking, named SwarajDesk, designed to transform civic grievance redressal in India and similar developing-nation governance environments. The system integrates a local-first data architecture using Capacitor.js and IndexedDB to enable complaint capture without internet connectivity, an AI processing pipeline comprising computer vision-based image validation, multilingual NLP categorization across fifteen-plus Indian languages, abusive content moderation, and a generative AI agent for autoform-filling. Each complaint is stored immutably on an Ethereum-compatible permissioned blockchain with IPFS-based decentralized media storage, ensuring tamper-proof auditability and preventing administrative record manipulation. A 3-tier SLA enforcement mechanism encodes resolution timelines in smart contracts and automatically escalates unresolved complaints up the governance hierarchy. A RAG-based multilingual voice chatbot and an optional Drone-on-Demand verification module further enhance citizen accessibility and complaint authenticity validation respectively. The system is deployed on Google Cloud Platform with Kubernetes orchestration, providing role-based analytics dashboards with geospatial heatmaps and SLA compliance reporting for all stakeholder tiers, enabling transparent, accountable, and inclusive civic governance.

FORM 2
THE PATENT ACT 1970
(39 OF 1970)
AND
The patent rules, 2003
COMPLETE SPECIFICATION
(See section 10: rule 13)

1. TITLE OF THE INVENTION:

“AN OFFLINE-FIRST, AI-ENABLED SYSTEM FOR DECENTRALIZED ISSUE REPORTING, AUTOMATED ROUTING, AND IMMUTABLE RESOLUTION TRACKING”

2. APPLICANT(S):

| Name | Nationality | Address |
|--------------------------------------|--------------------|--|
| C. V. Raman Global University | INDIAN | Bidyanagar, Mahura, Janla, Bhubaneswar, Odisha 752054 |

3. PREAMBLE TO THE DESCRIPTION

The following specification particularly describes the invention and the manner in which it is to be performed.

4. DESCRIPTION

FIELD OF INVENTION:

[0001] The present invention pertains to the domain of software engineering, artificial intelligence, distributed ledger technology, and edge computing, and relates specifically to a decentralized, offline-first, AI-enabled civic issue reporting and resolution tracking system. The system is designed to empower citizens, field agents, supervisors, and government administrators to report, manage, and resolve public infrastructure and service-related grievances through a unified, technologically robust, and inclusive digital platform.

[0002] More particularly, the invention relates to a novel combination of blockchain-based immutable data storage using Ethereum-compatible smart contracts and IPFS-based decentralized file persistence, integrated with machine learning models for image-based complaint validation, natural language processing for multilingual complaint categorization, and a retrieval-augmented generation (RAG) chatbot for guided citizen interaction. These components work together in a cohesive pipeline that ensures each complaint is verified, categorized, routed, and tracked without human manipulation or administrative bias.

[0003] The field of this invention further encompasses the design and deployment of a local-first data architecture that allows complete operational functionality in the absence of continuous internet connectivity, enabling its effective use in rural, remote, and low-bandwidth environments across India and similar developing regions. The system synchronizes captured complaint data, including text descriptions, photographs, and voice inputs, to the cloud using intelligent background agents as soon as network availability is restored, ensuring zero data loss and maintaining audit trail integrity throughout the complaint lifecycle.

BACKGROUND:

[0004] Public grievance redressal is a critical function of governance in any democratic nation, and in India, millions of citizens daily encounter unresolved civic issues ranging from pothole-ridden roads and broken streetlights to waterlogging, illegal encroachments, and non-functional public utilities. Despite the proliferation of digital governance initiatives, the vast majority of citizens in rural and semi-urban areas are excluded from effective participation in civic reporting

due to limited internet access, language barriers, digital illiteracy, and the lack of accessible, user-friendly complaint interfaces. This exclusion results in grievances going unreported or being lost in bureaucratic pipelines with no transparent tracking or accountability.

[0005] Existing platforms such as CPGRAMS (Centralized Public Grievance Redress and Monitoring System) are nationally operated online portals that require stable internet connectivity, are available only in limited languages, and operate primarily as centralized repositories without any AI-based validation, automated routing, or real-time escalation mechanisms. These systems are susceptible to human manipulation, data suppression, and retroactive alteration of records, thereby creating a significant trust deficit between citizens and governance bodies. ServiceNow, while powerful for enterprise service management, is not designed for community-level civic engagement, lacks offline functionality, and does not support tamper-proof audit trails.

[0006] The current state of grievance management is further compounded by the absence of image-based complaint verification, which allows fraudulent or duplicate reports to flood administrative systems. Officials receiving such complaints have no automated means to verify whether an image submitted by a citizen genuinely corresponds to the reported issue and location, leading to wasted resources and delayed resolution of legitimate concerns. The supply chain of civic maintenance is opaque, with no mechanism for public auditability of complaint resolution timelines, assigned personnel, or action taken, which creates systemic inefficiencies and discourages citizen trust in digital grievance channels.

[0007] Furthermore, current systems fail to address the digital divide by supporting multilingual interaction, voice-based filing, or AI-assisted form filling for citizens with disabilities or low digital literacy. The hierarchical accountability structures within municipal corporations and state government bodies remain largely manual, with resolution authority being exercised at the discretion of individual officers rather than governed by enforceable, code-based service-level agreements. Escalation mechanisms are absent or informal, resulting in complaints stagnating at lower administrative tiers without being surfaced to higher authorities who could mandate resolution.

[0008] There thus exists a clear and pressing need in the art for a comprehensive, decentralized, offline-capable civic issue reporting system that integrates artificial intelligence for intelligent complaint processing, blockchain technology for immutable record-keeping and transparent

accountability, multilingual and multimodal interfaces for inclusive citizen participation, and automated SLA-based escalation for systemic enforcement of resolution timelines. The present invention addresses all of these critical gaps through a unified platform that combines offline-first architecture, AI-driven validation, blockchain immutability, and role-based governance in a single deployable solution that is purpose-built for the unique operational constraints and diversity of India's civic landscape.

OBJECTIVES OF THE INVENTION:

[0009] The primary objective of the present invention is to provide an offline-first, AI-enabled decentralized civic issue reporting and resolution tracking system that empowers citizens across all digital literacy levels, geographic locations, and language backgrounds to submit, monitor, and escalate public grievances through a single unified platform. The system is designed to function effectively in environments with intermittent or absent internet connectivity by capturing all complaint data locally on edge devices and synchronizing with the cloud backend once network access becomes available, thereby ensuring uninterrupted civic participation regardless of infrastructure limitations.

[0010] A further objective of the invention is to deploy a blockchain-based immutable governance layer using Ethereum-compatible smart contracts and IPFS decentralized storage, such that every complaint submission, status update, and resolution event is cryptographically recorded as an immutable transaction on a permissioned distributed ledger. This objective ensures that no administrative actor can retroactively alter, delete, or suppress complaint records, thereby creating an auditable, tamper-proof trail of civic accountability that can be inspected by citizens, oversight bodies, and judicial authorities alike.

[0011] Another objective of the invention is to incorporate multiple layers of artificial intelligence, including a computer vision module for validating complaint images against reported categories, a natural language processing module for multilingual complaint categorization and abuse detection across fifteen or more Indian languages, a generative AI-powered RAG chatbot for guided voice and text-based complaint submission, and an AI agent mode for automated form filling, pre-submission validation, and intelligent routing of complaints to the appropriate administrative authority based on department, geography, and workload balancing.

[0012] Yet another objective of the invention is to provide a granular, role-based analytics and transparency dashboard for all stakeholder tiers, including citizens, field agents, supervisory officers, municipal administrators, and state-level officials, enabling real-time visibility into complaint density through geospatial heatmaps, SLA compliance tracking, workload distribution across agents, and trending issue identification. The system further aims to include an optional autonomous UAV-based verification layer that dispatches drones to high-priority or high-stakes complaint locations to independently capture aerial footage and perform pixel-level semantic comparison to validate issue existence and severity prior to routing for resolution

SUMMARY:

[0013] The present invention provides an Offline-First, AI-Enabled System for Decentralized Issue Reporting, Automated Routing, and Immutable Resolution Tracking, hereinafter referred to as SwarajDesk, comprising a multi-layered software architecture that integrates edge computing, blockchain technology, artificial intelligence, and multimodal interaction interfaces into a single, coherent civic grievance management platform. The system enables citizens to report infrastructure and service-related issues through web, mobile, or voice interfaces, with the submitted data being validated, categorized, stored immutably, and routed to the appropriate authority for resolution, all with full transparency and zero susceptibility to administrative manipulation.

[0014] In a preferred embodiment, the system utilizes a local-first data architecture implemented using Capacitor.js and IndexedDB for on-device data capture and offline storage, enabling complaint data including text, images, and voice recordings to be recorded on the user's device without requiring an active internet connection. Intelligent background synchronization agents monitor network availability and automatically push locally stored complaints to the cloud backend upon connectivity restoration, leveraging Google Cloud Platform infrastructure including GKE, Pub/Sub messaging, and Redis-based event queues to handle high-volume asynchronous data ingestion with zero loss guarantee.

[0015] The invention further comprises an AI-driven complaint processing pipeline powered by Vertex AI and LangChain orchestration, wherein each submitted complaint passes through a sequence of automated stages including image validation using computer vision models, text

categorization using fine-tuned NLP classifiers, abuse and spam detection using a custom multilingual moderation API, and auto-form-fill using a generative AI agent that extracts structured metadata from unstructured citizen input. The blockchain component implemented on the Ethereum Solidity platform records every state transition of each complaint as a smart contract event, creating an immutable, auditable history stored redundantly on IPFS nodes for decentralized data persistence and tamper resistance.

[0016] The system additionally provides a 3-tier automated escalation mechanism governed by SLA timers encoded directly in smart contract logic, wherein complaints unresolved within defined time windows at the field agent tier are automatically escalated to the supervisory tier, and subsequently to the central authority tier, with all escalation events recorded on-chain. A RAG-based multilingual chatbot accessible via voice or text allows illiterate or visually impaired citizens to submit complaints conversationally without requiring any form-filling skills, while an optional UAV verification module dispatches Drone-on-Demand units to high-priority complaint sites for independent aerial validation of reported issues before resource deployment.

DETAILED DESCRIPTION OF EMBODIMENTS:

[0017] The system architecture of the present invention is organized into five primary functional layers: the Client Interaction Layer, the API Gateway and Microservices Layer, the AI Processing Pipeline, the Blockchain Governance and Storage Layer, and the Analytics and Administration Layer. Each layer is independently scalable and communicates through well-defined RESTful and event-driven interfaces, enabling modular deployment, horizontal scaling, and technology substitution without disrupting the overall system functionality. The client layer is implemented using Next.js for web and Capacitor.js for mobile, providing a responsive, cross-platform interface that supports fifteen-plus Indian languages with dynamic localization.

[0018] The offline-first data capture module operates by persisting all complaint data locally on the citizen's device using IndexedDB and Capacitor Storage APIs, enabling full complaint submission functionality in the complete absence of internet connectivity. Upon submission, the complaint record including the citizen's identity, issue description, category selection, geolocation coordinates, and any attached photographs or audio recordings is packaged into a structured JSON

payload and stored in the local database with a unique locally-generated UUID. A background synchronization worker implemented as a web worker continuously polls for network availability and, upon detection of connectivity, transmits all pending local payloads to the FastAPI backend gateway in prioritized order.

[0019] The AI-Driven Complaint Processing Pipeline comprises four sequential processing stages through which every submitted complaint passes before being committed to the database and blockchain. In the first stage, the Image Validation Module employs a PyTorch-based computer vision model served via Google Vertex AI to perform semantic similarity analysis between the user-submitted complaint photograph and a reference image corresponding to the user-selected complaint category, yielding a confidence score that determines whether the image is authentic and relevant. The second stage employs the NLP Categorization Module, a fine-tuned multilingual transformer model, to parse the complaint description text and auto-suggest or override the complaint category and sub-category.

[0020] The third processing stage invokes the SwarajDesk Abusive AI Detector, a custom NLP moderation service trained on multilingual civic complaint corpora in English, Hindi, Hinglish, and Odia, to identify and flag abusive, offensive, or irrelevant content within the complaint text prior to routing. Flagged complaints are quarantined for human review rather than rejected outright, ensuring that legitimate complaints submitted using emotionally charged language are not erroneously discarded. The fourth and final processing stage activates the Generative AI Agent Mode, powered by Google Vertex AI and LangChain, which analyzes any unstructured or incomplete complaint submission and automatically fills missing structured fields by inferring metadata from the available text, image, and voice inputs provided by the citizen.

[0021] The Blockchain Governance Layer is implemented on the Ethereum blockchain using Solidity smart contracts deployed on a permissioned network using the Sepolia testnet for development validation, with IPFS nodes configured via Cloudflare CDN providing decentralized content-addressed storage for all complaint records and media assets. Each complaint submission event triggers a write transaction to the smart contract, which encodes the complaint ID, submitting citizen's cryptographic wallet address, category, department routing code, and a SHA-256 hash of the complaint payload as an immutable on-chain record. Subsequent state changes including assignment, processing, resolution, and escalation each generate new blockchain events that

permanently extend the complaint's audit trail.

[0022] The SLA-Aware Auto-Assignment and Escalation System utilizes a distributed Redis-based complaint queue that dequeues incoming complaints and assigns them to available field agents using a workload-balanced distribution algorithm that considers agent availability, geographic proximity, department specialization, and current open complaint count. Service-level agreement timers are initialized at the moment of assignment and encoded as programmable constraints within the Ethereum smart contract governing each complaint. Upon timer expiry without a resolution event, the smart contract autonomously triggers an escalation transaction that promotes the complaint to the next supervisory tier and updates the on-chain record to reflect the escalation, sending real-time push notifications to all affected administrative stakeholders.

[0023] The Voice-Enabled RAG-Based Conversational Civic Assistance Module provides an accessible complaint submission interface for visually impaired, illiterate, or hands-free citizens by integrating Google Speech-to-Text for audio transcription, followed by semantic retrieval from a LangChain-managed FAISS vector database containing platform policy documents, complaint category definitions, and procedural guidance, enabling the system to generate contextually accurate and platform-specific responses to citizen queries and guide them through the complaint submission process in their preferred Indian language without requiring any text input or reading ability.

[0024] The Autonomous UAV Verification Layer is an optional, high-stakes module that can be activated for complaints categorized as critical severity or reporting dangerous infrastructure failures such as bridge collapses, major flooding, or electrical hazards. Upon activation, the system interfaces with a Drone-on-Demand API to dispatch an unmanned aerial vehicle to the GPS coordinates encoded in the complaint record. The UAV captures high-resolution photographs and video of the reported site, which are transmitted to the Computer Vision Semantic Comparison Module that performs pixel-level analysis between the drone-captured imagery and the citizen-submitted complaint photographs to verify the existence, scale, and location-consistency of the reported issue.

[0025] The Granular Role-Based Analytics Dashboard provides differentiated administrative interfaces for each of the five stakeholder tiers: citizens, field agents, municipal supervisors, district administrators, and state-level officials. The citizen-facing dashboard displays personal

complaint history, current status, assigned agent details, expected resolution date based on SLA parameters, and blockchain verification links for each complaint record. The administrative dashboards provide geospatial heatmaps of complaint density aggregated by ward, district, and state boundaries, SLA compliance rates by department and agent, trending issue categories by region, and workload distribution visualizations, all generated in real-time from the complaint database and supplemented by on-chain data for tamper-proof reporting.

[0026] The Community Transparency and Crowdsourced Validation Module enables registered community members, referred to as Swaraj Sahayaks, to view anonymized complaint records in their geographic vicinity, upvote issues they corroborate, add supporting photographic evidence, and participate in community-driven issue prioritization. The collective upvote count from verified community members feeds into the AI routing algorithm as an additional priority signal, enabling issues with broad community impact to be escalated to higher administrative tiers regardless of individual complaint severity scores. This democratic validation mechanism is recorded on-chain, ensuring that community consensus data is tamper-proof and auditable, preventing artificial inflation of complaint priority through organized upvote campaigns.

[0027] The system is deployed on Google Cloud Platform using a Kubernetes Engine cluster orchestrated via Terraform infrastructure-as-code, with continuous integration and deployment pipelines configured through GitHub Actions and Jenkins for automated testing, security scanning via OWASP ZAP and SonarQube, container image building via Docker, and deployment to GKE worker nodes. The backend API services are built in Node.js with Express.js and managed through Prisma ORM connected to a PostgreSQL primary database, while Redis serves as the event queue and caching layer. The frontend is served through Cloudflare CDN with WAF protection, ensuring global low-latency access and DDoS resilience for the citizen-facing complaint submission interface.

Date: 10-01-2026.

Signature: *nazeeruddin. s*

Nazeeruddin Baba Shaik

CLAIMS:

I/We claim:

1. A computer-implemented system for decentralized civic grievance management comprising an offline-first complaint capture module, an AI processing pipeline, and a blockchain governance layer integrated with IPFS-based immutable storage.
2. The system as claimed in claim 1, wherein the offline-first module persists complaint data locally using IndexedDB and Capacitor Storage and synchronizes asynchronously to the cloud upon network restoration.
3. The system as claimed in claim 1, wherein the AI processing pipeline comprises a computer vision image validation module, a multilingual NLP categorization module, an abusive content detection module, and a generative AI auto-fill agent.
4. The system as claimed in claim 1, wherein the blockchain governance layer records every complaint lifecycle event as an immutable Ethereum smart contract transaction, thereby preventing retroactive modification or suppression of civic complaint records.
5. The system as claimed in claim 1, further comprising a 3-tier automated SLA enforcement mechanism wherein smart contract-encoded timers trigger hierarchical escalation of unresolved complaints from field agents to supervisors and thereafter to central authorities.
6. The system as claimed in claim 1, further comprising a voice-enabled RAG-based multilingual chatbot that allows citizens to submit complaints conversationally in fifteen or more Indian languages via natural speech without requiring digital literacy or manual form entry.
7. The system as claimed in claim 1, further comprising an optional autonomous UAV verification module that dispatches Drone-on-Demand units to high-priority complaint coordinates and performs pixel-level semantic comparison of drone imagery against citizen-submitted complaint photographs.
8. A method for AI-enabled decentralized civic issue routing comprising capturing complaint data offline, processing the data through sequential AI validation and categorization stages, recording each complaint state transition on a permissioned blockchain ledger, and automatically escalating unresolved complaints through a coded hierarchical governance structure based on SLA timer expiry.

ABSTRACT:

The present invention discloses an Offline-First, AI-Enabled System for Decentralized Issue Reporting, Automated Routing, and Immutable Resolution Tracking, named SwarajDesk, designed to transform civic grievance redressal in India and similar developing-nation governance environments. The system integrates a local-first data architecture using Capacitor.js and IndexedDB to enable complaint capture without internet connectivity, an AI processing pipeline comprising computer vision-based image validation, multilingual NLP categorization across fifteen-plus Indian languages, abusive content moderation, and a generative AI agent for auto-form-filling. Each complaint is stored immutably on an Ethereum-compatible permissioned blockchain with IPFS-based decentralized media storage, ensuring tamper-proof auditability and preventing administrative record manipulation. A 3-tier SLA enforcement mechanism encodes resolution timelines in smart contracts and automatically escalates unresolved complaints up the governance hierarchy. A RAG-based multilingual voice chatbot and an optional Drone-on-Demand verification module further enhance citizen accessibility and complaint authenticity validation respectively. The system is deployed on Google Cloud Platform with Kubernetes orchestration, providing role-based analytics dashboards with geospatial heatmaps and SLA compliance reporting for all stakeholder tiers, enabling transparent, accountable, and inclusive civic governance.