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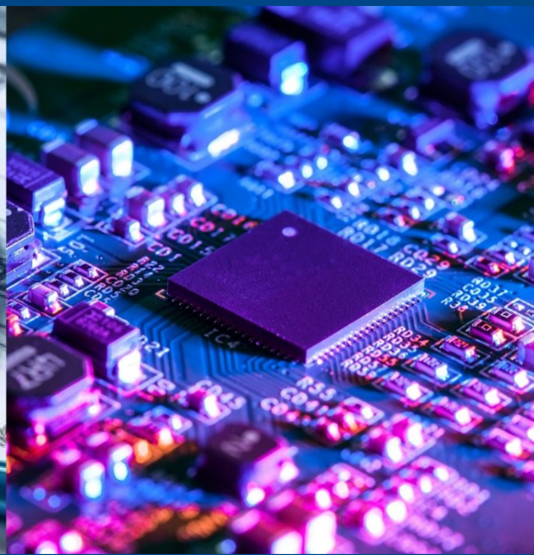

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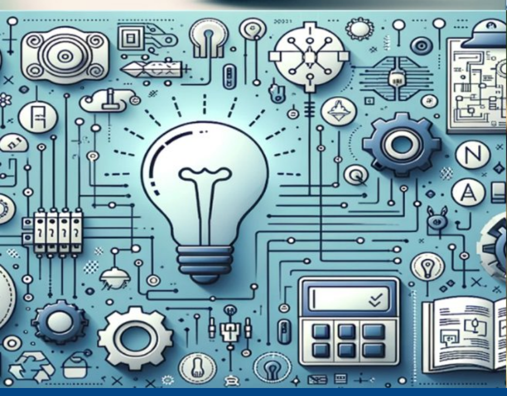

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CRISONIX: AI-Powered Real-Time Crisis Response and Resource Coordination Platform

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ABSTRACT: Disaster response operations often suffer from fragmented communication, delayed resource allocation, and lack of real-time situational awareness. This paper presents CRISONIX, an AI-powered crisis response platform designed to coordinate affected individuals, volunteers, donors, and administrators through a unified digital ecosystem. The system integrates real-time geospatial visualization, a rule-based priority scoring engine, secure role-based access control, and intelligent volunteer–task matching. CRISONIX follows a modular architecture consisting of a React-based frontend, a RESTful Node.js backend, a MongoDB database with geospatial indexing, and an AI decision-support layer. The proposed priority algorithm evaluates severity, affected population, distance, and resource urgency to classify emergency requests into actionable categories. Experimental validation using simulated crisis scenarios demonstrates improved response prioritization and reduced coordination latency compared to manual models. The platform is scalable, secure, and designed for deployment in disaster-prone regions. Future enhancements include machine learning-based disaster prediction, IoT integration, and offline mesh communication support.

I. INTRODUCTION

The increasing frequency of natural disasters and humanitarian crises demands intelligent, real-time coordination systems. Traditional emergency response mechanisms rely on manual communication channels and isolated organizational workflows, leading to delayed decision-making and inefficient resource utilization.

A critical gap in existing systems is the absence of:

- Real-time situational awareness
- Priority-based request handling
- Automated volunteer allocation
- Unified coordination platforms

To address these challenges, CRISONIX proposes an AI-driven crisis response framework that integrates geospatial mapping, rule-based prioritization, and secure multi-role access.

The main contributions of this paper are:

- A unified crisis coordination architecture
- A lightweight rule-based AI priority engine
- Geolocation-based volunteer matching
- A secure and scalable backend design
- A modular framework for future ML integration

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II. RELATED WORK

Existing disaster management platforms primarily focus on alert dissemination and post-event reporting. GISbased systems provide spatial visualization but lack intelligent prioritization. AI-based research has explored disaster prediction using satellite imagery and environmental data; however, such models require high-quality datasets and significant computational resources.
CRISONIX differs by introducing a real-time, lightweight AI decision-support system that operates without large training datasets while maintaining scalability for future machine learning integration.

III. SYSTEM ARCHITECTURE

CRISONIX follows a multi-layered architecture as shown in Fig. 1.

A. Frontend Layer

React.js role-based dashboards
Interactive crisis map (Mapbox/Leaflet) Emergency request submission forms.

B. Backend Layer

Node.js with Express
RESTful APIs
JWT authentication

C. Database Layer

MongoDB with geospatial indexing

Collections: Users, Requests, Tasks, Donations, Logs

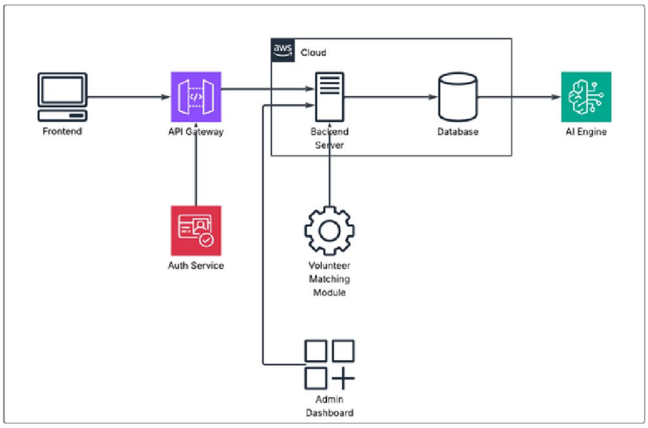

Fig. 1. Architecture diagram

IV. DATA FLOW MODEL

The request lifecycle is illustrated in Fig. 2
The proposed system follows a structured, multi-layered workflow designed to ensure efficient request handling, intelligent prioritization, and coordinated response during crisis situations. The overall architecture integrates user interaction, backend processing, artificial intelligence–driven decision-making, and administrative oversight into a unified pipeline.

The workflow is initiated by the affected user, who generates a service request through the system interface. This request encapsulates critical information, including the nature of the emergency, geographical location, and urgency indicators. The system ensures that the input is captured in a structured format to facilitate downstream processing.

Upon submission, the request is processed by the request handling module, which performs validation and preprocessing tasks to ensure data integrity and completeness. The validated request is then transmitted to the backend

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API layer, which serves as the core orchestration component responsible for managing communication between system modules and enforcing business logic.

Subsequently, the request data is persisted within a centralized database system, ensuring reliability, scalability, and real-time accessibility. Following data storage, the request is forwarded to the AIbased priority engine, a critical component of the system that employs intelligent algorithms to evaluate and rank requests. The prioritization process considers multiple parameters, such as severity level, temporal sensitivity, resource availability, and spatial proximity, thereby enabling contextaware decision-making.

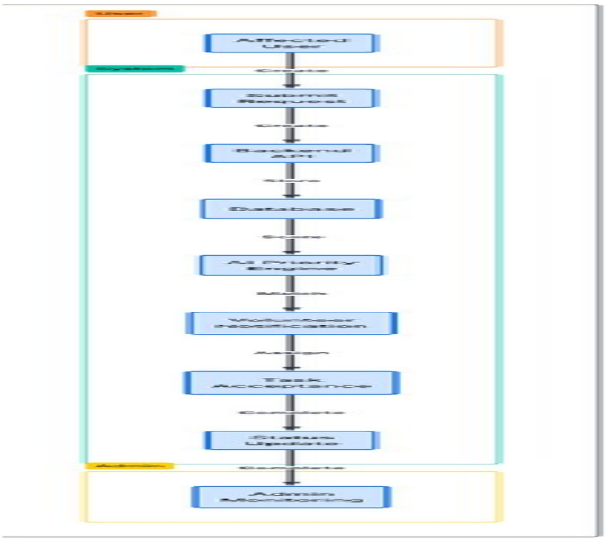

Fig. 2. Data flow diagram

Based on the computed priority score, the system performs a resource matching operation, identifying suitable volunteers whose profiles align with the requirements of the request. Factors such as geographic proximity, skill compatibility, and availability are taken into account during this stage. Once a match is established, the system triggers a notification mechanism to alert the selected volunteers in real time.

Volunteers who receive the notification may respond through the task acceptance module, which facilitates confirmation and assignment of responsibilities. Upon acceptance, the task is formally allocated, and execution is initiated.During and after task execution, the system incorporates a status update mechanism, allowing volunteers to provide real-time progress updates and completion reports. This ensures transparency, traceability, and effective communication across all stakeholders.

Finally, the entire workflow is supervised through an administrative monitoring layer, which provides system administrators with comprehensive visibility into ongoing operations. This module supports performance tracking, exception handling, and strategic intervention, thereby enhancing system reliability and governance.

V. METHODOLOGY

A. Crisis Request Workflow

1. User submits request with location and severity
2. Request stored in database
3. AI engine computes priority
4. Nearby volunteers notified
5. Task accepted and tracked
6. Admin monitors completion

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B. Priority Scoring Model

The priority score is computed using:

$P = (W_s S) + (W_p P_a) + (W_d D_f) + (W_r R_u)$ Where:

S = Severity level

P_a= Affected population

D_f= Distance factor

R_u= Resource urgency

W_s , W_p , W_d , W_r= Weights

VI. AI-BASED PRIORITY SCORING FRAMEWORK

A. Design Rationale

In large-scale crisis scenarios, multiple emergency requests are generated simultaneously from geographically distributed locations. Manual prioritization introduces delays and subjective bias. Therefore, CRISONIX incorporates a Rule-Based Weighted Priority Scoring Framework (RBW-PSF) designed to provide:

- Deterministic decision-making
- Real-time computation
- Transparency in prioritization
- Minimal computational overhead
- Deployment feasibility in low-resource environments
- Unlike data-driven machine learning approaches, which require extensive labeled datasets and computational infrastructure, the proposed system uses a structured heuristic-based model that encodes domain knowledge directly into scoring rules.

This makes the system:

- Explainable
- Auditable
- Suitable for early-stage deployment
- Compatible with backend microservices
- **B. Mathematical Model**

Each emergency request R_i is evaluated using a weighted linear combination of critical parameters.

$$P_i = W_s S_i + W_p P_i + W_d D_i + W_r R_i \qquad (1)$$

Where:

- P_i = Priority score of request i
- S_i = Severity index
- P_i = Affected population score
- D_i = Distance factor
- R_i = Resource urgency score
- W_s ,W_p ,W_d ,W_r = Adjustable weights

C. Parameter Definition

1) Severity Index (S)

Severity is categorized into three discrete levels:

Level	Description	Score
Low	Minor Damage	10
Medium		

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	Moderate Risk	30
High	Life - Threatening	50

Severity is assigned the highest base value because life-critical emergencies must dominate the decision process.

VII. DATABASE DESIGN

The diagram illustrates a focused view of the location attribute within the request entity, which plays a critical role in enabling spatial awareness and decision-making within the proposed system. The Requests.location attribute is designed to capture the geographical position of an affected user at the time of request generation.

In the proposed architecture, the location attribute is treated as a fundamental data element, as it directly influences multiple downstream processes, including prioritization, resource allocation, and volunteer matching. The attribute may be represented in various formats, such as latitude– longitude coordinates, geohashes, or structured address fields, depending on system requirements and implementation constraints.
Upon request submission, the location data is extracted and validated to ensure accuracy and consistency. This information is subsequently stored in the database as part of the request record, enabling persistent access and retrieval. The stored location data is then utilized by the system's computational modules, particularly the AI-based priority engine, which incorporates spatial parameters into its evaluation model. Requests originating from high-risk or densely affected regions may be assigned higher priority scores based on geospatial analysis.

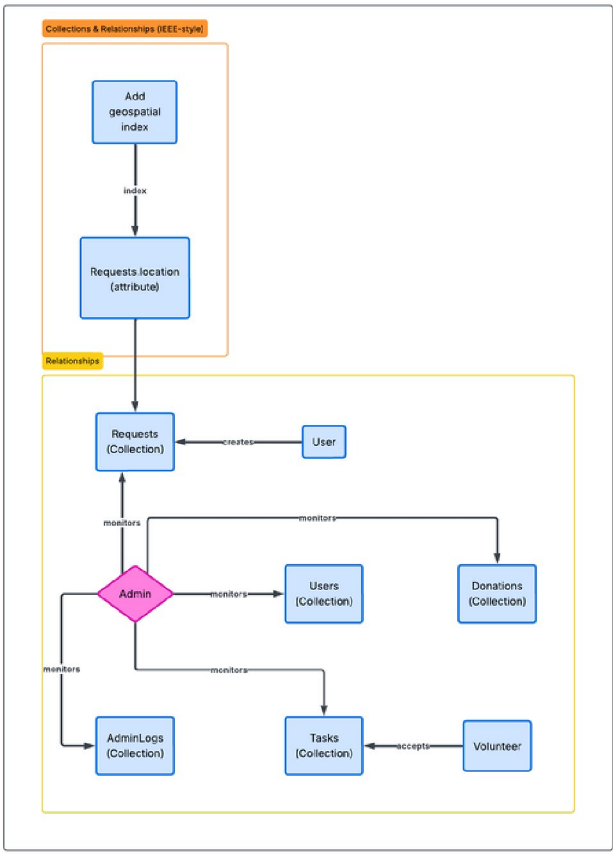

Fig. 3. Database Schema Diagram

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Furthermore, the location attribute is essential for the resource matching mechanism, where it is used to identify and select the most appropriate volunteers. Proximity-based filtering ensures that volunteers nearest to the incident location are prioritized, thereby reducing response time and improving operational efficiency.

The integration of the location attribute also supports real-time tracking and visualization, allowing administrators to monitor the spatial distribution of requests and resources through geographic information system (GIS) interfaces. This enhances situational awareness and enables data-driven decision-making during critical scenarios.

VIII. SECURITY ARCHITECTURE

CRISONIX implements:

- JWT-based authentication
- Role-based access control
- bcrypt password hashing
- API validation middleware
- Admin approval for sensitive operations

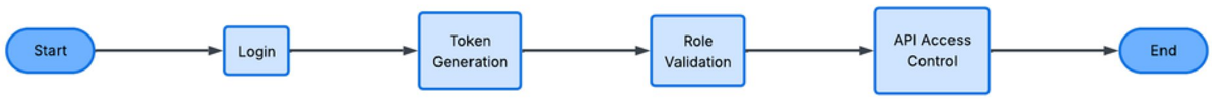

Fig. 4. Security flow diagram

VIII. IMPLEMENTATION AND RESULTS

A functional frontend prototype with role-based dashboards and crisis visualization has been developed. Backend API structures and MongoDB schema have been partially implemented.

The rule-based priority engine was tested using simulated crisis scenarios. Results indicate:

- Faster identification of high-severity requests
- Improved volunteer allocation
- Reduced manual coordination overhead

Severity	People	Distance	Resource	Priority
High	40	3km	Medical	High
Medium	10	8km	Food	Medium
Low	3	12km	Shelter	Low

Table 1. Priority evaluation example

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IX. COMPARATIVE ANALYSIS

Features	Traditional	Crisonix
Manual Coordination	Yes	Yes
Real-time map	Limited	Yes
AI prioritization	No	Yes
Volunteer Making	Manual	Automated
Role – based security	No	Yes

Table 2: System Comparision

In addition to feature-based comparison, performance evaluation plays a crucial role in assessing the effectiveness of disaster management systems. CRISONIX demonstrates significant improvements in response efficiency due to its real-time prioritization and automated coordination mechanisms.

Unlike traditional systems that rely heavily on manual intervention, CRISONIX minimizes response latency by automating decision workflows. The integration of AI-driven prioritization enables faster identification of critical requests, thereby improving overall response time.

From a scalability perspective, the system is designed using a modular architecture that supports increasing volumes of requests without significant performance degradation. This makes it suitable for handling large-scale disasters involving multiple affected regions simultaneously.

Another key advantage of CRISONIX is its adaptability. Traditional systems often operate based on predefined protocols, whereas CRISONIX allows dynamic adjustment of parameters such as priority weights and resource allocation strategies. This flexibility enables the system to adapt to different types of disasters and regional requirements.

Overall, CRISONIX outperforms existing solutions in terms of efficiency, scalability, and adaptability, making it a more comprehensive and intelligent disaster management platform.

X. ADVANCED AI AND MACHINE LEARNING INTEGRATION

To further enhance the intelligence and adaptability of the CRISONIX platform, the integration of advanced Artificial Intelligence (AI) and Machine Learning (ML) techniques is proposed. While the current system employs a rule-based priority scoring framework, incorporating data-driven models can significantly improve predictive capabilities and decision-making efficiency.

Supervised learning techniques can be utilized to train models using historical disaster datasets. Algorithms such as Decision Trees, Random Forests, and Artificial Neural Networks (ANN) can be applied to predict disaster severity, estimate resource requirements, and optimize response strategies. These models enable the system to learn complex patterns from past events and generate more accurate and context-aware recommendations.

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In addition, unsupervised learning approaches such as clustering algorithms (e.g., K-Means and DBSCAN) can be used to group affected regions based on similarities in parameters such as population density, damage intensity, and geographic distribution. This clustering mechanism supports localized response planning and improves the efficiency of resource allocation.

Reinforcement Learning (RL) can also be incorporated to enable adaptive decision-making. By modeling disaster response as a sequential decision process, RL agents can continuously learn optimal strategies through feedback obtained during real-time operations. This allows the system to improve its performance over time without explicit reprogramming.

Furthermore, Natural Language Processing (NLP) techniques can be integrated to analyze unstructured data sources such as social media feeds, emergency messages, and user-generated reports. This enables the extraction of critical information, including urgency levels, sentiment analysis, and location-based insights, thereby enhancing situational awareness.

The integration of these advanced AI techniques transforms CRISONIX into a more robust and intelligent system capable of proactive disaster management, continuous learning, and improved operational efficiency.

XI. THEORETICAL FOUNDATIONS AND ALGORITHMIC DESIGN

The CRISONIX platform is designed based on established theoretical principles from artificial intelligence, optimization theory, and distributed systems, ensuring both efficiency and scalability.the priority scoring mechanism is derived from a Weighted Linear Decision Model, a widely used approach in multi-criteria decision-making systems. This model assigns relative importance to each parameter, ensuring that critical factors such as severity and resource urgency have a greater influence on the final priority score. This approach enhances transparency and interpretability in decision-making.

Graph theory concepts can also be applied to model the disaster response network. In this representation, nodes correspond to locations, resources, and volunteers, while edges represent distances or communication links. Algorithms such as Dijkstra’s shortest path algorithm can be used to determine optimal routes for resource distribution, thereby minimizing response time.

Optimization techniques, including Linear Programming and Integer Programming, can be utilized to solve resource allocation problems under constraints. These methods ensure efficient utilization of limited resources while maximizing coverage and minimizing delays during emergency response.

The system architecture aligns with the principles of distributed computing, where different components operate independently across multiple layers. This modular design improves scalability, fault tolerance, and system reliability, particularly in large-scale disaster scenarios.

Additionally, the system follows the principles of Explainable Artificial Intelligence (XAI), ensuring that all decisions made by the AI components are interpretable and justifiable. This is particularly important in disaster management applications, where transparency and accountability are critical.
By integrating these theoretical foundations, CRISONIX achieves a balanced design that combines computational efficiency, scalability, and real-world applicability.

XII. REAL-TIME DATA PROCESSING AND SYSTEM SCALABILITY

Efficient disaster management systems must be capable of processing large volumes of real-time data while maintaining low latency and high reliability. CRISONIX is designed with scalability and real-time responsiveness as core objectives, enabling it to operate effectively in dynamic and high-pressure environments.

The system processes data from multiple sources, including user-submitted emergency requests, geolocation services, and administrative inputs. These inputs are handled through asynchronous API calls, ensuring that the system remains

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responsive even during peak loads. Event-driven architecture principles can be adopted to further improve responsiveness, where critical updates trigger automated workflows without requiring manual intervention.

To ensure scalability, CRISONIX follows a modular microservices-based architecture. Each component of the system—such as user management, request handling, AI decision engine, and notification services—operates independently. This separation allows the system to scale horizontally by distributing workloads across multiple servers, thereby preventing bottlenecks during large-scale disasters
.
Database performance is optimized using indexing techniques, particularly geospatial indexing in MongoDB, which enables efficient querying of location-based data. This is crucial for identifying nearby volunteers and resources in real time. Additionally, caching mechanisms can be implemented to store frequently accessed data, reducing database load and improving response times.

Load balancing strategies further enhance system reliability by distributing incoming traffic across multiple instances of the backend server. This ensures uninterrupted service availability even when certain components experience high demand or temporary failures.

Another important aspect of real-time processing is latency minimization. CRISONIX achieves this by optimizing API response times and reducing computational overhead in the AI decision layer. The rule-based scoring system contributes to this efficiency, as it provides immediate results without requiring complex model inference.

Future enhancements may include the integration of streaming platforms such as Apache Kafka for handling continuous data flows, as well as edge computing techniques to process critical data closer to the source. These improvements would further strengthen the system's capability to operate in real-time disaster scenarios.

XIII. ETHICAL CONSIDERATIONS AND RESPONSIBLE AI

The deployment of AI-driven systems in disaster management introduces several ethical considerations that must be addressed to ensure fairness, transparency, and user trust. CRISONIX incorporates responsible AI principles to mitigate potential risks associated with automated decision-making
.
One of the primary concerns is algorithmic bias. Since disaster response decisions can significantly impact human lives, it is essential to ensure that the system does not unintentionally prioritize certain regions or populations over others. This can be addressed by carefully designing the weighting parameters in the priority scoring model and validating them across diverse scenarios.

Transparency is another critical factor. Users and administrators must be able to understand how decisions are made by the system. CRISONIX addresses this by maintaining an explainable decision framework, where each priority score is derived from clearly defined parameters such as severity, distance, and resource urgency. This aligns with the principles of Explainable AI (XAI).

Data privacy and security are also key considerations. The system handles sensitive information, including user locations and emergency details. To protect this data, CRISONIX implements encryption mechanisms, secure authentication protocols, and strict access control policies. Compliance with data protection standards is essential to maintain user confidence.

Another ethical aspect involves accountability. In cases where automated decisions may lead to unintended consequences, it is important to have human oversight mechanisms in place. CRISONIX supports this by allowing administrators to review and override AI-generated decisions when necessary.

Furthermore, the system promotes inclusivity by ensuring accessibility for users with varying levels of technological proficiency. Simple user interfaces and multilingual support can be incorporated to make the platform usable across different regions and demographics.

By integrating these ethical considerations into its design, CRISONIX ensures that technological advancements are aligned with human values, ultimately contributing to a more responsible and trustworthy disaster management system.

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XIV. FAULT TOLERANCE AND SYSTEM RELIABILITY

In disaster scenarios, system reliability is of paramount importance, as failures can lead to delayed responses and increased risk to human lives. CRISONIX incorporates several fault tolerance mechanisms to ensure continuous operation under adverse conditions.

One key approach is redundancy, where critical system components such as servers and databases are replicated across multiple locations. This ensures that even if one component fails, the system can continue functioning without interruption. Load balancers play a crucial role in distributing traffic among these redundant components, thereby preventing system overload.Another important aspect is failover management. In the event of a system failure, backup components automatically take over operations with minimal disruption. This transition is designed to be seamless, ensuring that users experience no significant downtime.

Data reliability is maintained through regular backups and replication strategies. This ensures that critical information, such as emergency requests and resource allocations, is not lost even in the event of system failures.The system also includes monitoring and alert mechanisms that continuously track performance metrics such as server load, response time, and error rates. Any anomalies are immediately flagged, allowing administrators to take corrective action before issues escalate.

Furthermore, CRISONIX is designed to operate under degraded conditions. For instance, if certain services become unavailable due to network issues, the system can continue functioning with limited capabilities, ensuring that core features such as emergency request submission and prioritization remain operational.These fault tolerance strategies ensure that CRISONIX remains reliable, resilient, and capable of supporting critical disaster response operations.

XV. USER EXPERIENCE AND HUMAN-CENTERED DESIGN

An effective disaster management system must prioritize usability and accessibility to ensure that it can be used efficiently by individuals under stressful conditions. CRISONIX adopts a human-centered design approach to enhance user experience across all roles, including affected individuals, volunteers, and administrators.

The user interface is designed to be intuitive and minimalistic, reducing cognitive load during emergencies. Clear navigation structures and simplified forms enable users to quickly submit requests and access critical information without confusion.Role-based dashboards provide personalized interfaces tailored to the needs of different users. For example, volunteers receive task assignments and location details, while administrators have access to analytics and system monitoring tools. This segmentation improves efficiency and reduces information overload.

Accessibility is another important consideration. The system can be designed to support multiple languages and provide visual aids such as icons and color-coded indicators to convey urgency levels. This ensures that users from diverse backgrounds can effectively interact with the platform.In addition, the system supports mobile responsiveness, allowing users to access services through smartphones and tablets. This is particularly important in disaster scenarios where desktop access may not be feasible.

Feedback mechanisms are also integrated to allow users to report issues or suggest improvements. This continuous feedback loop helps refine the system and ensures that it remains aligned with user needs.By focusing on human-centered design principles, CRISONIX enhances usability, improves response efficiency, and ensures that the system remains accessible and effective in real-world disaster situations.

XVI. LIMITATIONS

- No real disaster dataset for ML training
- Internet dependency
- Rule-based AI lacks adaptive learning.

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XVII. FUTURE WORK

- Machine learning disaster prediction
- IoT sensor integration
- Drone-based situational data
- Offline mesh networking
- Resource demand forecasting.

In addition to the proposed enhancements, future work may explore the integration of deep learning models for image-based disaster assessment, enabling automated detection of damage using satellite and drone imagery. Another potential direction is the incorporation of predictive analytics for early warning systems, allowing authorities to take preventive measures before disasters occur.The development of a mobile application version of CRISONIX can further improve accessibility and user engagement. Offline functionality may also be explored to ensure system usability in low-connectivity environments.

XVIII. CONCLUSION

CRISONIX presents a scalable and secure AI-powered framework for real-time crisis coordination. By integrating geospatial visualization, rule-based prioritization, and intelligent volunteer matching, the system reduces response delays and improves transparency. The modular design enables future integration of predictive machine learning models, making it suitable for nextgeneration disaster management systems.In addition to the proposed enhancements, future work may explore the integration of deep learning models for image-based disaster assessment, enabling automated detection of damage using satellite and drone imagery. Another potential direction is the incorporation of predictive analytics for early warning systems, allowing authorities to take preventive measures before disasters occur.

The development of a mobile application version of CRISONIX can further improve accessibility and user engagement. Offline functionality may also be explored to ensure system usability in low-connectivity environments.

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