RESEARCH ARTICLE OPEN ACCESS

GEOPLIX: Smart Surplus Food Redistribution System Using AI and Geospatial Optimization

J. Jencewin *, C.Angelin Femi** , Y. Esther Venuka**, A.Jaifrin**
*Assistant Professor Computer Science and Engineering ,St Xaviers Catholic College Of Engineering, Chukankadai,
**UG Students -Computer Science and Engineering ,St Xaviers Catholic College Of Engineering, Chukankadai, India

ABSTRACT

Efficient redistribution of surplus food remains a major challenge due to fragmented coordination, lack of real-time visibility, absence of food safety assessment, and inefficient volunteer allocation, often resulting in food spoilage, delayed deliveries, and reduced impact in serving orphanages and old age homes. This paper presents a Smart Surplus Food Redistribution System Using GeoPlix, a real-time, AI-powered platform that connects donors, volunteers, and beneficiary organizations through a unified digital system, ensuring secure role-based access and dashboards tailored to user responsibilities. The system integrates a Food Analysis AI module that evaluates the safety and freshness of donated food based on preparation time, ambient temperature, perishability, and image-based or manual classification, allowing donations only when safety criteria are met. A Hybrid Adaptive GeoAI Optimization (HAGIO) model guides volunteer routes by considering distance, travel time, and food spoilage risk, while a volunteer assignment module uses the Haversine algorithm to select and rank eligible volunteers within a geographic radius. Real-time notifications alert volunteers, and an AI-powered chatbot provides context-aware assistance, enhancing user interaction. Built entirely with open-source tools and a cloud-based NoSQL database, the system ensures scalability, cost-effectiveness, and continuous integration of real time data. Experimental observations indicate reduced food wastage, faster deliveries, improved coordination, and enhanced decision-making, providing a comprehensive and intelligent solution for sustainable food redistribution.

KEYWORDS

Food Redistribution System; GeoPlix; Food Safety Analysis; Haversine Distance; Route Optimization; Real-Time System; Volunteer Assignment; AI Chatbot; Open-Source Platform; Food Wastage Reduction.

INTRODUCTION

1.1 Background

Food wastage is a persistent global issue, with millions of tons of surplus food being discarded annually, even as many orphanages, old age homes, and vulnerable communities face food scarcity. Efficient redistribution of surplus food is critical to addressing both environmental concerns and social welfare. Traditional donation practices often rely on manual coordination, informal communication channels, and unstructured logistics, which lead to delayed deliveries, food spoilage, and underutilization of available resources. A smart, technology-driven platform that integrates donors, volunteers, and beneficiary organizations is essential for ensuring timely, safe, and efficient food redistribution.

1.2 Challenges in Existing Food Redistribution Systems

Despite the emergence of digital donation platforms, many systems lack real-time decision-making, precise volunteer assignment, or integrated food safety assessment. Challenges include fragmented data storage, inability to track food freshness dynamically, inefficient routing of volunteers, and limited scalability. Manual or semi-digital approaches cannot prioritize donations based on perishability, distance, or volunteer availability, often resulting in unsafe or delayed deliveries and increased operational inefficiencies.

1.3 Need for Digital Transformation in Food Donation Digital transformation in food redistribution is necessary to enhance transparency, optimize resource allocation, and ensure food safety. Web-based platforms can provide real-time synchronization of donor and volunteer data, intelligent assignment, and automated route optimization. Integration of AI, geospatial algorithms, and cloud technologies can facilitate data-driven decision making, enhance operational efficiency, and minimize food wastage. **1.4 Importance of AI-Powered Food Safety and Volunteer Assignment**

Timely identification of safe-to-donate food and allocation of the nearest available volunteers are key to reducing spoilage and increasing delivery efficiency. Existing platforms often lack predictive or intelligent mechanisms to evaluate freshness or recommend hyperlocal volunteers. AI-driven food analysis, combined with geospatial modeling and routing optimization, can address these gaps, ensuring safe, timely, and efficient deliveries.

1.5 Research Gap

Although prior research has explored AI applications in food safety analysis, GIS-based volunteer routing, and vehicle optimization, many solutions remain isolated or focus on a single aspect of the redistribution process. Few systems integrate real-time freshness evaluation, geospatial volunteer assignment, route optimization, and intelligent user interaction within a unified, open-source framework. There is a need for a comprehensive platform that incorporates AI driven food safety analysis, GeoAI-based assignment, and route optimization to reduce food wastage effectively.

1.6 Contribution of the Paper

This paper proposes a Smart Surplus Food Redistribution System Using GeoPlix with the following contributions:

- Real-time, cloud-based platform connecting donors, volunteers, and beneficiary organizations.
- Food Analysis AI module for evaluating safety and remaining freshness based on preparation time, ambient temperature, and perishability.
- Hyperlocal volunteer assignment using Haversine distance and availability filtering.
- Hybrid Adaptive GeoAI Optimization (HAGIO) for route planning that considers distance, travel time, and food spoilage risk.

1.7 Significance of Data Integrity and Security in Redistribution Systems

Food redistribution platforms manage sensitive user information, including donor and volunteer details, as well as donation records. Ensuring data integrity, secure authentication, and controlled access is critical to maintain trust, prevent duplication of tasks, and track deliveries accurately. Centralized cloud-based systems with role based access control and audit trails enable reliable operations and ensure accountability across the donation workflow.

RELATED WORK

Food redistribution systems have evolved over recent years, moving from informal coordination and manual logistics to digital and AI assisted platforms. Prior research can be broadly categorized into AI driven food safety analysis, geospatial and GIS-enabled redistribution frameworks, optimization and vehicle routing approaches, and integrated open-source platforms for community food donation. **2.1 AI-Driven Food Safety Analysis**

Several studies have explored the use of artificial intelligence to ensure the safety and freshness of perishable food items. Hang Yang et al. (2022) utilized Support Vector Regression (SVR) and Gaussian Process

Regression (GPR) to estimate the freshness of apples using polarization imaging, demonstrating excellent predictive performance on small to medium datasets. Debapam Saha and Mrutyunjay Padhiary (2021) employed Convolutional Neural Networks (CNNs) to classify food items as fresh or spoiled, achieving superior accuracy through automated feature learning. Qingchuan Zhang et al. (2023) combined Transformer-based models with CNNs for risk assessment of food products, highlighting the potential of hybrid AI models in real-world food safety evaluation.

2.2 Geospatial and GIS-Enabled Redistribution Frameworks GIS and geospatial algorithms have been leveraged to match food donors with nearby recipients efficiently. Marcus Sammer et al. (2022) proposed AI-FEED, which combines Random Forest, SVM, K-means, and GIS for predictive identification of optimal food resource locations, integrating diverse datasets for sustainable community planning.

2.3 Optimization and Vehicle Routing Approaches

Routing optimization techniques such as CPVRP, Tabu Search, and Greedy algorithms to reduce travel time and improve workload balance in window constraints and reducing logistics costs. Malleswari Karanam et al. (2022) applied multi-objective evolutionary algorithms to optimize transportation time and cost simultaneously for surplus-to-deficit food transfers.While these optimization models improve efficiency, they are often computationally intensive, require predefined delivery schedules, and lack integration with AI-driven food safety evaluation. **2.4 Integrated Open-Source Platforms**

Some researchers have explored unified platforms that combine AI, GIS, and optimization. These platforms aim to enable real-time coordination, volunteer assignment, and route planning. However, many implementations rely on proprietary software or paid services, limiting scalability and cost-effectiveness for community-driven applications. Summary: Existing literature demonstrates advances in AI for food safety, GIS-enabled matching, and vehicle routing optimization. Yet, there is a clear gap in integrating AI-driven food analysis, hyperlocal volunteer assignment, dynamic route

optimization, and open-source, real-time deployment within a single framework-an aspect that the proposed Smart Surplus Food Redistribution System addresses.

2.5 Mobile, IoT, and Real-Time Delivery Systems

Mobile-first and IoT-enabled solutions have been explored to enhance real-time coordination in food donation and redistribution. For example, Helen Onyeaka et al. (2021) integrated AI-GIS to match food donors with recipients efficiently, while Marcus Sammer et al. (2022) used predictive GIS analytics for sustainable community planning. Mobile applications and notifications (via Android apps or push messaging) have been used to alert volunteers and donors about food availability and delivery schedules.

2.6 Security, Data Integrity, and Open-Source Constraints Food redistribution platforms require secure authentication, role based access, and reliable data management due to sensitive information such as donor details, volunteer locations, and delivery logs. While prior research emphasizes real-time tracking and coordination, many platforms rely on paid services, do not enforce structured role-based workflows, or lack audit trails for donation and volunteer activities.

2.7 Identified Research Gap

From the analysis of existing literature, it is evident that most proposed systems address specific aspects such as AI-based food Effective routing is critical for timely food delivery. Luz Helena Arroyo et al. (2021) applied K-means clustering and vehicle

safety, geospatial matching, or routing optimization independently. Few systems integrate:

- Centralized digital architecture with modular dashboards for donors, volunteers, and organizations
- AI-driven food safety analysis using classification

and freshness evaluation

- Hyperlocal volunteer assignment based on Haversine distance and availability
- Dynamic route optimization incorporating both distance and spoilage risk
- Secure role-based access control and real-time notifications
- Open-source, cost-effective implementation without reliance on paid APIs

PROPOSED SYSTEM

The proposed system, GeoPlix FoodBridge, is an intelligent and centralized web-based platform designed to minimize food wastage and enable the safe redistribution of surplus food to nearby orphanages, old age homes, and community kitchens. The system integrates donors, volunteers, and beneficiary organizations into a unified digital framework that ensures secure access, structured workflows, real-time food tracking, and AI-assisted decision support. The primary goal is to enhance operational efficiency, reduce food spoilage, and strengthen timely delivery through intelligent automation and contextual decision-making.

3.1 System Objectives

The proposed system aims to:

- Provide a centralized platform for donors, volunteers, and beneficiary coordination.
- Ensure real-time visibility of available food donations and delivery status.
- Implement structured approval and validation mechanisms for food suitability.
- Integrate AI-assisted food safety analysis and intelligent volunteer assignment.
- Optimize delivery routes considering distance, perishability, and ambient conditions.
- Provide analytical insights for administrative and operational decision-making.

By combining operational management with AI-driven decision making, GeoPlix FoodBridge seeks to modernize food donation workflows and reduce waste sustainably.

3.2 Overall System Architecture

1. **Donor Module** – Registration, food submission, and history tracking.
2. **Volunteer Module** – Registration, task assignment, and navigation.
3. **Admin Module** – Validation, safety checks, assignments, and reports.

3.3 Workflow Management

The system enforces structured workflows to maintain transparency and prevent misuse:

- **Pending** – Donation submitted; awaiting safety validation.
- **Approved** – Verified as safe; triggers volunteer assignment and delivery routing.
- **Rejected** – Deemed unsafe; donation is not processed.

3.4 Role-Based Access and Security Layer

Strict Role-Based Access Control (RBAC) is implemented:

- **Donor** – Submit, track donations, update profile.
- **Volunteer** – Accept tasks, track deliveries, navigate routes.
- **Administrator** – Approve/reject donations, manage inventory, view analytics.

3.5 Food Safety and Inventory Integrity Model

A centralized food inventory model maintains real-time records of donations. To ensure integrity:

- Food is added to the system only after passing AI-based safety assessment.

Donations are removed or marked delivered after successful completion.

faster delivery and reduces spoilage.

3.7 Route Optimization and Delivery Guidance

The system employs a Hybrid Adaptive GeoAI Optimization (HAGIO) algorithm for route selection:

- Combines distance, travel time, and food perishability in route planning.
- Utilizes open-source mapping tools like OpenStreetMap and OSRM for cost-effective navigation.
- Ensures volunteers follow the safest and fastest paths, minimizing spoilage risk.

3.8 Analytics and Visualization Module

The platform integrates a real-time analytics dashboard displaying: • Donation trends and volume distribution.

- Volunteer assignment and delivery efficiency.
- Food type and safety statistics. Dynamic filtering, chart switching, and map-based visualizations assist administrators in operational planning and resource allocation.

METHODOLOGY

The methodology of the proposed GeoPlix system follows a modular and rule-driven approach, integrating AI-based food safety assessment, geospatial volunteer assignment, route optimization, and secure data handling. The system is designed to reduce food wastage, ensure safe redistribution, and provide timely delivery using intelligent decision support and real-time data processing.

4.1 System Design Approach

GeoPlix is developed using a layered architecture that separates presentation, application, and data management layers. This layered approach ensures scalability, maintainability, and separation of concerns.

Layers:

1. **Presentation Layer:** Handles dashboards, notifications, and user interfaces for donors, volunteers, and administrators.
2. **Application Layer:** Implements business logic, AI algorithms, geospatial filtering, HAGIO route optimization, and workflow management.
3. **Data Layer:** Manages structured and cloud-based storage for users, donations, routes, and notifications (e.g., Firebase Firestore).

4.2 Role-Based Access and Workflow Management 4.2.1 User Roles

- **Donor:** Uploads food, inputs details, selects destination organizations.
- **Volunteer:** Receives nearby requests, accepts assignments, and delivers food.
- **Administrator:** Monitors system, reviews reports, and validates AI safety outputs.

Role-based access ensures security and usability, restricting users to functionalities relevant to their responsibilities.

4.2.2 Operational Workflow

1. Donor Workflow:

1. Donor registers and logs in.
2. Food item is submitted with either an image or textual details.
3. Food Analysis AI evaluates safety.
4. If safe, donor selects a nearby organization.
5. Notification is sent to eligible volunteers.

2. Volunteer Workflow:

1. Volunteer receives real-time notification of available requests.

2. Volunteer accepts request (first responder gets assignment). 3. Route optimization module guides delivery.

4. Status updates in real-time to prevent duplication. **3. Administrator Workflow:**

- Monitors food safety logs, volunteer assignments, and system performance analytics.

4.3 Food Safety Assessment

4.3.1 Freshness Score Calculation

Freshness_Score = (Max_Safe_Time − Time_Since_Prep − Estimated_Delivery_Time) ×

�� × ��

Where:

- ��= Temperature Factor based on ambient conditions • ��= Perishability Factor based on food type
- Units: Hours
- Ensures perishable foods degrade appropriately over time and temperature.

4.3.2 Food Classification

Status

Safe if Freshness_Score ≥ Safe_Threshold

The system uses a Hybrid Adaptive GeoAI Optimization (HAGIO) model to select delivery routes:

Route_Cost = �� · Distance + �� · Estimated_Time + �� · Spoilage_Risk

Where:

Spoilage_Risk = ��(Freshness_Threshold_Freshness_Score)

Risky if Warning_Threshold ≤ Freshness_Score < Safe_Threshold

= {

Unsafe if Freshness_Score < Warning_Threshold

- Delivery times and route efficiency

Interactive Features:

4.4 Geospatial Volunteer Assignment

4.4.1 Distance Calculation (Haversine Formula)

��= 2�� · arctan 2(√��√1 − ��), ��= sin 2Δ��2 + cos (��1)cos (��2)sin 2Δ��2 Where:

- ��= 6371 km(Earth radius)
- ��, ��= latitude and longitude in radians
- Δ��, Δ��= coordinate differences

4.4.2 Volunteer Eligibility Filter

Eligible = (Distance ≤ Max_Radius) ∧ (Status =′ ������������������′) ∧ (Current_Load < Max_Capacity)

Ensures only local and available volunteers are considered. **4.4.3 Weighted Scoring Model**

Volunteer_Score = ��1 · ��+ ��2 · ��+ ��3 · ��

Where:

- ��= 1 − Distance / Max_Radius (normalized, closer preferred)
- ��= 1if available, else 0
- ��= Completed_Tasks / Total_Tasks (reliability)
- ��1 + ��2 + ��3 = 1(weights tuned via historical data) **4.5 Route Optimization (HAGIO Model)**
- ��, ��, ��= tunable weights (sum = 1)
- Ensures the route minimizes travel time and spoilage risk. • Routing based on *OpenStreetMap + OSRM + A algorithm**. **4.6 Real-Time Notifications**
- Volunteers receive alerts using Socket.IO or Firebase Cloud Messaging.
- Notifications are hyperlocal and sent only to eligible volunteers to reduce clutter.
- First responder assignment updates the system in real-time to prevent duplication.

4.7 Analytics and Visualization

The dashboard provides:

- Donation trends and frequency
- Food type distribution
- Volunteer performance metrics
- Range-based filters
- Dynamic chart switching
- Temporal analysis for decision-making

4.8 Data Validation and Error Handling

- **Server-side validation:** food type, preparation time, location coordinates, duplicate entries
- **Error prevention:** ensures non-negative freshness, correct distance calculations, and consistent volunteer assignment • Maintains data integrity and reliability.

4.9 Performance and Scalability Considerations

- Modular architecture for easy integration with future AI models, predictive analytics, or mobile apps.
- Database optimization: minimizes redundant queries during assignment and route calculation.
- Containerized deployment ensures portability.

• Real-time GPS, routing, and weather integration for accurate and dynamic decision-making.

IMPLEMENTATION & RESULTS

5.1 Implementation Details

The proposed system, GeoPlix, is implemented as a web-based, AI powered platform for real-time surplus food redistribution using Python and Django, following the Model–View–Template (MVT) architecture. The backend manages business logic, authentication, workflow validation, food safety checks, volunteer assignment, and route optimization, while the frontend provides responsive dashboards and interactive interfaces for donors, volunteers, and beneficiary organizations.

5.1.1 Backend Implementation

The backend is developed using:

• Python 3.x

• Django 4.x

• Django ORM for structured database interaction • Firebase Firestore for real-time NoSQL data management The system is organized into three primary modules: Donor, Volunteer, and Donation Management, each maintaining dedicated database models to ensure modularity, maintainability, and separation of concerns.

5.1.2 Workflow and Food Assignment Implementation The system uses an approval-based workflow with controlled state transitions:

• All donations are initialized with a Pending status.

• Food safety approval triggers the eligibility of the food for redistribution.

• Volunteer acceptance triggers task assignment and route optimization.

• Rejected donations or declined volunteer requests do not affect the workflow or assignment queue.

Atomic transactions ensure data consistency during concurrent operations, avoiding duplicate assignments or miscalculations. **5.1.3 Food Analysis and Safety Evaluation Module** The food analysis mechanism is implemented as a service layer that:

• Accepts food input through image upload or manual entry (food type and preparation time).

• Performs food classification using lightweight AI models or predefined mappings.

• Calculates food freshness using the formula: Freshness = Maximum Safe Time – Time Since Preparation. • Incorporates contextual parameters such as ambient temperature (via weather APIs) and expected delivery duration.

• Categorizes food into safe, risky, or unsafe based on computed freshness values.

This module ensures that only safe and consumable food is approved for donation, thereby maintaining quality and preventing health risks.

5.1.4 Geo-based Volunteer Assignment and Routing

Implementation The volunteer assignment and routing module

is implemented using geospatial algorithms and open-source technologies. The module provides:

• Filtering of volunteers within a predefined geographic radius using GPS coordinates.

• Distance calculation using the Haversine formula for hyperlocal matching.

• Ranking of volunteers based on proximity and availability. • Real-time notification system using Socket.IO or Firebase Cloud Messaging.

• Route optimization using OpenStreetMap and OSRM.

• Shortest path computation using the A* algorithm. • Hybrid Adaptive GeoAI Optimization (HAGIO) considering distance, travel time, and food spoilage risk.

This module ensures efficient volunteer allocation and optimal route selection, enabling timely and safe delivery of food to beneficiaries

• Context-aware responses using natural language processing and retrieval-based techniques.

This module improves user engagement, provides actionable insights, and supports efficient system monitoring.

5.2 Experimental Evaluation

To evaluate system effectiveness, functional and operational testing was conducted using simulated datasets of donors, volunteers, and beneficiary organizations such as orphanages and old age homes.

5.2.1 Functional Testing

The following test cases were validated:

• Accurate food safety classification based on freshness calculation. • Prevention of unsafe food donations from being submitted. • Correct role-based access control for donors and volunteers. • Proper filtering and assignment of volunteers within geographic radius.

• Successful real-time notification delivery to relevant volunteers. • Accurate route generation between donor and destination. • Proper handling of invalid or incomplete input submissions. All test scenarios executed successfully without system failures or inconsistencies.

5.1.4 Geo-based Volunteer Assignment and Routing Implementation

The volunteer assignment and routing module is implemented using geospatial algorithms and open-source technologies. The module provides:

•Food analysis and classification time • Volunteer assignment response time

• System responsiveness under concurrent users

Compared to traditional food donation methods, the proposed system demonstrated:

5.2.3 Comparative Analysis

A comparative evaluation with traditional food donation systems is presented in Table 1.

Feature	Traditional System	GeoAI-Based System
Food Safety Verification	Manual / Not Assured	AI-Based Automated
Volunteer Assignment	Manual Coordination	Geo-Based Automated
Real-Time Tracking	Limited	Available
Route Optimization	Not Available	A* + HAGIO Optimization
Notification System	Delayed / Manual	Real-Time
Analytics Dashboard	Rare	Integrated
Decision Making	Human Dependent	AI-Assisted

The comparison demonstrates that the proposed system provides enhanced efficiency, improved food safety assurance, faster delivery coordination, and intelligent decision-making compared to conventional food redistribution approaches.

DISCUSSION

The results indicate that the integration of AI-based food safety analysis, geo-based volunteer assignment, and real-time route optimization significantly improves system efficiency and reliability. The use of freshness evaluation algorithms ensures that only safe food is redistributed, while geospatial filtering and HAGIO based routing enhance timely delivery and reduce spoilage risks.The modular architecture of the system supports scalability and flexibility, allowing seamless integration of additional features such as advanced analytics, extended geographic coverage, and improved AI models.

FUTURE WORK

Although the proposed system provides an intelligent and real-time solution for surplus food redistribution, several enhancements can further improve its scalability, intelligence, and real-world applicability.One major direction for future work is the integration of predictive analytics using advanced machine learning techniques. This would enhance trust, accountability, and traceability throughout the redistribution process.Further research can also focus on enhancing the AI models used for food analysis by incorporating computer vision techniques and real-time spoilage detection using IoT sensors. This would improve the accuracy of food safety evaluation under varying environmental conditions.These advancements would transform the proposed system into a comprehensive, scalable, and intelligent food redistribution ecosystem capable of addressing food wastage and hunger at a regional and national level.

CONCLUSION

This paper presented a GeoAI-based intelligent food redistribution system designed to address the critical issues of food wastage and inefficient surplus food management. The system integrates donors, volunteers, and beneficiary organizations within a unified and secure platform that ensures structured workflows, real-time coordination, and safe food delivery. By incorporating role-based access control and location-aware services, the platform enhances usability, security, and operational efficiency.An AI-powered food analysis module was introduced to evaluate food safety based on freshness, preparation time, and environmental conditions. Additionally, a geo-based volunteer assignment mechanism using the Haversine algorithm ensures efficient matching of nearby volunteers, while the Hybrid Adaptive GeoAI Optimization (HAGIO) model enhances route planning by considering both distance and food spoilage risk.

REFERNCES

[1] P. Garrone, M. Melacini, and A. Perego, “Surplus food management against food waste,” Politecnico di Milano, Milan, Italy, 2015.

[2] S. Sert, P. Garrone, and M. Melacini, “Keeping food alive: surplus food management,” European Journal of Sustainable Development, vol. 3, no. 4, pp. 339–339, 2014.

[3] E. Papargyropoulou, R. Lozano, J. K. Steinberger, N. Wright, and Z. Bin Ujang, “The food waste hierarchy as a framework for the management of food surplus and food waste,” Journal of Cleaner Production, vol. 76, pp. 106–115, 2014.

[4] F. D. A. Oroski, “Understanding food surplus: Challenges and strategies for reducing food waste – A mini-review,” Waste Management & Research, vol. 43, no. 9, pp. 1400–1409, 2025. [5] Z. Liu, S. Wang, Y. Zhang, Y. Feng, J. Liu, and H. Zhu, “Artificial intelligence in food safety: A decade review and bibliometric analysis,” Foods, vol. 12, no. 6, p. 1242, 2023.

[6] W. Yu, Z. Ouyang, Y. Zhang, Y. Lu, C. Wei, Y. Tu, and B. He, “Research progress on the artificial intelligence applications in food safety and quality management,” Trends in Food Science & Technology, vol. 156, p. 104855, 2025.

[7] C. Qian, S. I. Murphy, R. H. Orsi, and M. Wiedmann, “How can AI help improve food safety?,” Annual Review of Food Science and Technology, vol. 14, no. 1, pp. 517–538, 2023.

[8] R. Dhanare, K. K. Nagwanshi, and S. Varma, “A study to enhance the route optimization algorithm for the internet of vehicle,” Wireless Communications and Mobile Computing, vol. 2022, no. 1, p. 1453187, 2022.

[9] R. Beed, A. Roy, S. Sarkar, and D. Bhattacharya, “A hybrid multiobjective tour route optimization algorithm based on particle swarm optimization and artificial bee colony optimization,” Computational Intelligence, vol. 36, no. 3, pp. 884–909, 2020.

[10] L. Xin, P. Xu, and M. Guo, “Logistics distribution route optimization based on genetic algorithm,” Computational Intelligence and Neuroscience, vol. 2022, no. 1, p. 8468438, 2022.

[11] N. Haristiani, “Artificial Intelligence (AI) chatbot as language learning medium: An inquiry,” in Journal of Physics: Conference Series, vol. 1387, no. 1, p. 012020, Nov. 2019.

[12] S. Ayanouz, B. A. Abdelhakim, and M. Benhmed, “A smart chatbot architecture based on NLP and machine learning for health care assistance,” in Proc. 3rd Int. Conf. Networking, Information Systems & Security, pp. 1– 6, Mar. 2020.