Research Paper

AuraFind: an integrated smart recovery system combining artificial intelligence, CCTV evidence matching, and automated notification services

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ABSTRACT

The problem of lost and misplaced items in public areas, institutions and workplaces remains, and conventional lost and found methods are hamstrung by manual filing and sluggish recovery. In this work we introduce AuraFind, an intelligent recovery platform that integrates Artificial Intelligence (AI), computer vision, geographic intelligence and real-time communication to revolutionize lost-item management. AuraFind operates on a straightforward three-step process. Users input information and photographs of the object, then submit CCTV proof, and then obtain AI-generated similarity matches using a web-based interface. Computer vision methods analyze photographs uploaded by users and compare them to CCTV video, assigning confidence values to aid in recovery. Twilio may automatically send SMS messages to immediately notify users if matches surpass certain limits. AuraFind also has a geographic hotspot visualization, QR-based identity authentication, trust and reputation authentication methods, anonymous communication channels and an AI-powered assistant to aid users through the process, besides picture verification. This application is developed using React, Node.js, Express and the Cloud services. Its scalable client-server design allows for fast data processing and real time interactions. AuraFind brings together many intelligent technologies into one ecosystem, improving recovery accuracy, reducing human work and accelerating cooperation amongst stakeholders. This article describes a feasible technology-driven solution for lost-and-found management and lays the groundwork for future research in intelligent recovery systems and AI-powered public services.

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1. INTRODUCTION

Both public and private organizations are seeing an upward trend in the frequency of reported cases of lost or stolen property as a result of rapid urbanization, digitization, and demographic shifts [1]. Individuals misplace vital belongings such as keys, mobile devices, wallets, identification cards, computers, and luggage at frequented locations including transit stations, educational institutions, offices, shopping centers, medical facilities, and recreational areas. Such disruptions may lead to financial strain, psychological turmoil, and challenges with privacy and security [2]. As metropolitan areas evolve into smart cities, the need for AI-driven traffic surveillance systems is increasing. These advancements use deep learning, computational vision, and sensors from the internet of things (IoT) to enhance roadway safety [3]. AI-driven video analysis systems can detect hazardous conditions, traffic jams, and vehicular collisions instantaneously to aid law enforcement in responding more swiftly and preventing more complications. AI-powered intelligent systems for traffic control also optimize traffic signal synchronization using learning by reinforcement algorithms, diminishing reaction times to emergencies and augmenting the efficiency of the roadway infrastructure [4]. Consequently, self-governing emergency vehicles equipped with AI-driven navigation systems that use real-time traffic data and predictive analytics may adapt their routes instantaneously, thereby increasing the adaptability of fire trucks, ambulances, and law enforcement responding to emergencies. Conventional lost-and-found mechanisms depend on manual notifications and human involvement [5].

Typically, participants are asked to document the location of the item in a report, following which staff members juxtapose the reports with the items that were found. Problems with time, effort and human mistakes are typical in this process [6]. Most of the existing systems do not include cognitive mechanisms to verify ownership, correlate reported commodities with recovered evidence and enable secure communication among parties. As a result, many lost properties never return to their owners and recovery rates is poor. The global proliferation of monitoring devices has created a significant unmet potential for increasing public safety in missing-person investigations [7]. Every second, countless cameras installed in public spaces, transportation centers, and urban landscapes generate immense volumes of visual data. Traditional digital forensic techniques are of little help against proprietary storage structures used by surveillance equipment makers. Most of these tools were designed for regular file systems and popular video codecs. Dahua uses DHFS with unique frame encapsulation, whereas Hikvision systems employ a proprietary file system architecture with specific binary signatures [8].

Most surveillance equipment based on digital video recorders (DVR) fixed and mobile employ proprietary computer operating systems and capture digital video to usual formats. This creates a minimum loss of image quality throughout the recovery process. Trans-coding is a tough undertaking for both law execution groups and video forensic professionals [9]. This incompatibility is a major gap in time sensitive investigations, as critical footage may be lost or not accessible [10]. AI-based safety standards and hazardous event mitigation systems have significantly improved the ability to detect anomalies and identify risks in real time [11].

Sensor-based surveillance systems driven by AI are continuously evaluating operational as well as environmental data collected in chemical plants, refineries and factories to identify possible fire dangers, poisonous gas leaks and equipment malfunctions [12]. Businesses may lower operational downtime as well as workplace accidents with automated warning systems, and when integrated with IoT and deep learning, they can enable businesses to adopt proactive predictive maintenance approaches. Furthermore, self-driving as well as AI-driven robots are increasingly being used in dangerous areas where human participation may be very risky, such as nuclear energy facilities, petroleum exploration rigs, and mining. Recently, the accuracy of face recognition systems has been greatly improved by using deep learning models such as ArcFace [13]. ArcFace generates very precise characteristics, or embedded features, that define a face and, using deep neural networks, convert it to a vector in a multi-dimensional space. In this thesis, these vectors of characteristics or embeddings are compared using a measure of similarity to determine whether the two attribute sequences reflect the same individual or not [14]. With the emergence of distributed systems and encryption technologies, blockchain technology becomes a feasible choice for secure data management and tamper-proof record keeping. Blockchain is a decentralized digital ledger, which employs cryptographic hashes to connect blocks of actions [15].

The integration of AI with IoT devices might result in a reverse paradigm change in waste management by categorizing smart daily waste types and optimizing collection and reuse routes [16]. Such methods help to preserve nature in all its aspects [17]. This is because they considerably limit the quantity that goes to landfills and the pollution of the surrounding region. Proper waste management is important in improving public health. Disposal of generic drugs exposes certain residents of such regions to hazardous substances that might cause infections, respiratory problems and other health hazards. The hazards are increased by the spreading of viruses, toxins and pollutants in raw garbage, particularly in heavily populated metropolitan regions [18]. The environmental benefits for the community, heath and standard of life are outweighed by the benefits of using AI and IoT in trash management. It is expected that the use of IoT and AI technologies will facilitate such processes by using the best resources from nature, which are recognized with the changes in recyclable material [19].

In addition, the conclusions made from the data resulted in suggestions for work that takes into account the idea of a circular economy, as well as outlining the optimality of the organization of resources and the reduced number of trash. All these efforts serve to attempt to halt environmental degradation and the decline of ecological consequences generally or overall as done in sustainable development internationally [20]. However, traditional investigative methods still depend heavily on manual review of CCTV video which is not only very time consuming but also quite susceptible to human mistake & cognitive fatigue. Detection and response times are dragged out due to these shortcomings, which is especially problematic in the critical first phases when an effective recuperation is most probable. The existing surveillance activities are not standardized and lack intelligence, pointing to the critical need for a standardized, adaptive, AI-driven system for visual monitoring and information retrieval. Among the finest features of AI are face recognition. In real time it scanned the picture it had caught for a face-like bit and drew a colored border around it [21].

This capability is available with AI-powered CCTV cameras to remove suspicious activities. In addition, the face-matching system of AI-enabled CCTV camera captures clipped face images from hundreds of linked CCTV cameras, extracts facial attributes, and compares this image data with the face images of the target recorded in the database. When the picture data is similar to the target it will provide the operator a warning and they may immediately find the target on previous year's table which shows the position and the time of the camera capture. Artificial intelligence programs are specialists in the analysis of patterns of human behavior. They can detect human-sized objects moving in pre-programmed areas, recognize people, vehicles, or objects in motion that move the wrong way (reverse lane traffic on one-way streets), as well as detect common commotion or tampering, such as spraying on the sensor dome, changing the camera's orientation, or obscuring it with a fabric [22].

The AI based camera focuses on frames and sends warning to the operators. It offers multi-layer security for parking management firms, allowing operators to detect undesired activities such as loitering, manipulating identification or odd movements. Clearway's Artificially Intelligent CCTV immediately does a slew of things that would otherwise be costly and need humans. People counting and administration is a perfect example. AI makes it easy to watch and regulate who comes and goes from a site or property, and how many people come and go in pre-designated or vulnerable areas. Video analytics lets you automatically detect certain behaviors in your CCTV feed. The key benefit is that you can take a certain event or action, and build rule-based actions. Recent advances in Artificial Intelligence (AI), Computer Vision, digital communication tools, and geospatial analytics have opened up new possibilities for changing conventional lost-and-found operations to intelligent recovery ecosystems. Computer vision algorithms can analyze visual features of objects and find similarities between images, allowing for automatic comparisons of user-submitted item photographs with CCTV footage [23].

Some of its uses are: the automation of notification and communication processes; the development of methods of ownership verification; the increase of trust between platform users; and the supply of data-driven insights via analytical and spatial based tools. Through these contributions, AuraFind wants to provide a current basis for smart recovery mechanisms that may be used by educational institutions, enterprises, standardized transportation systems, smart cities, and public service organizations [24]. The importance of this work is that it improves traditional recovery procedures to smart technologies that allow for a fast identification, verification and recovery of missing objects [25]. AuraFind offers an end-to-end solution that uses AI, surveillance-based confirmation, instant messaging, geospatial intelligence, and trust-aware interactions to reduce recovery time, reduce manual effort, and improve the likelihood of successful item retrieval, as shown in Figure 1.

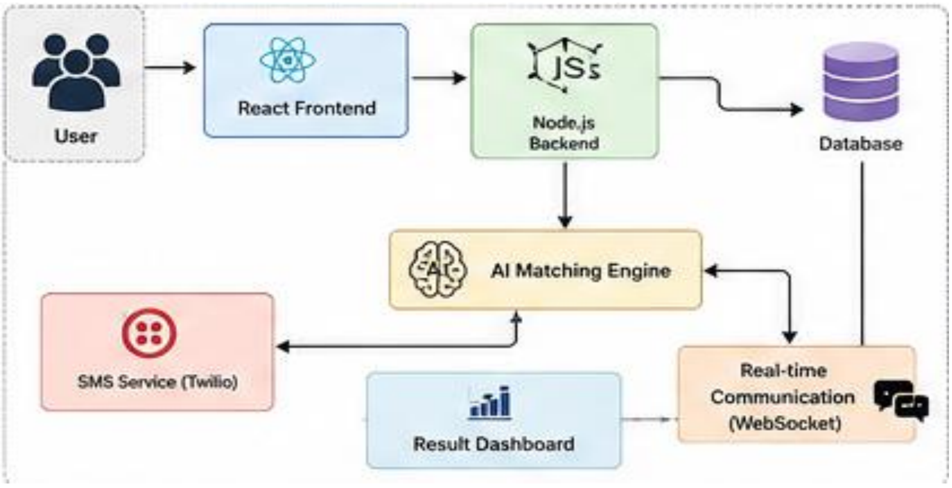

Figure 1. Overall AuraFind System Architecture

2. RELATED WORK

2.1 Summary

Lost and found items are no longer tracked manually but are now tracked using digital systems for digital reporting and tracking. Traditional approaches improve data accessibility, but they are unsuccessful and time-consuming to retrieve from since they depend on human verification. Innovations in AI, visual computational computing and instant messaging systems have provided opportunities for the creation of more quick and reliable item recovery systems.

2.2 Image Matching Using AI

Methods based on computer vision and AI have been widely used for object detection and image comparison. Modern image-matching methods may find similarities between two images by extracting visual features and computing similarity scores. These approaches improve the accuracy of identification of objects from large sets of images, whilst reducing human effort. Deep learning shows promise for picture recognition, and may be beneficial to locate lost things.

2.3 Verification Assisted by CCTV

Moreover, the ubiquity of video surveillance in public and private spaces has become CCTV recordings a useful tool for the recovery of lost property. The researchers used computer vision techniques to compare the photographs posted by users with CCTV video to identify possible matches. Using computers to analyze surveillance photographs may significantly improve the efficiency of recovery and dramatically reduce the time required for human review. AuraFind removes this barrier by using various smart technologies to deliver a more reliable, efficient and user-friendly recovery environment.

2.4 Systems Geospatiales

There are plenty of surveillance and tracking applications that are location aware technologies, such as GPS, geofencing, and digital maps. Geospatial data may be beneficial in lost item recovery approaches for identifying hotspots for item records and recoveries. Interactive graphical maps via hotspot visualization tools may provide administrators with important knowledge and speed up search processes.

2.5 Ownership verification using QR

The QR code technology is now more than ever a fast, convenient and cheap method to link real-world objects with digital data. Several research have proven the potential of QR codes to be utilized for identification, authentication and information retrieval. Adding QR-based ownership verification into lost-and-found systems accelerates the process of proving ownership of an item and reduces the chance of false claims.

2.6 Gap in the research

Applications such as feedback portals, picture discovery, geolocation tracking, and alarm technologies are among those that define the present options. There aren't many solutions out there that combine features like smart notifications, geolocation, QR ownership confirmation, AI-powered image evaluation, and CCTV identification. The idea for AuraFind, which uses a number of devices to help find misplaced objects, sprang from a desire to meet this need. The analyzed study shows that AI, computer vision, geographic analytics, QR-based verification and real-time communication are significant for improving lost-item recovery methods. In Table 1 the criteria for a unified approach are presented. But there is no comprehensive platform that can satisfy them at the moment.

Table 1. Feature Gap Analysis: Existing Solutions vs. AuraFind

Feature Category	Standard Solutions	AuraFind (Integrated Ecosystem)
AI-Based Matching	Rarely Implemented	Core Feature (Computer Vision)
CCTV Verification	Manual/Physical Only	Automated Integration
Ownership Proof	Subjective (Verbal)	QR-Code Authentication
Geospatial Intelligence	Limited/None	Real-Time Hotspot Mapping
Trust Framework	Absent	Reputation Management
System Scope	Fragmented (Siloed)	Unified/Holistic Platform

2.6.1 Problem Statement

The increasing prevalence of lost personal belongings in private as well as public areas has shown the inadequacies of traditional lost and found systems. The status quo is one of inefficient rates of recovery and lengthy search times due to reliance on visual examination, delayed communication and manual reporting methods. Finding the appropriate owner and obtaining lost goods back may be a difficulty without features like smart photo matching, a reliable ownership check, real time alerts and location based monitoring. Therefore, a smart and comprehensive recovery platform is necessary to link in real-time, automate matching of items based on AI, confirm ownership in a secured manner, utilize CCTV footage for verification and deliver short messages. Table 2 shows AuraFind, a unified flexible recovery environment, as the proposed solution for these difficulties.

Table 2. Comparison of Traditional Lost-and-Found Systems and AuraFind

Feature / Metric	Traditional Systems	AuraFind
Matching Speed	Days To Weeks (Manual)	Real-Time (< 1 Minute Via AI)
Recovery Rate	Low (Approx 10% - 20%)	High (Approx 75% - 90%)

Verification Method	Manual / Subjective	CCTV & Digital Proof
Notification Type	Manual / Delayed	Instant Push/SMS Alerts

2.6.2 Objectives

AuraFind is building a technology-enabled system to help people find their lost goods via accurate identification and verification procedures. More precisely, the aims are:

- Develop an effective recovery system that simplifies the reporting and tracking of lost items.
- To utilize AI and image matching analysis to find an exact match of the images in the user-uploaded images and CCTV footage.
- Improve ownership verification using QR code-based identification technologies. Enable real-time communication between users via secure encrypted messaging and notification systems.
- Promptly alert consumers when a potential match is found via automated SMS alerts.
- To provide geographic mapping features to visualize recovery places and item hotspots.
- Develop a trust and reputation mechanism to ensure the platform's reliability and encourage authentic involvement.
- Develop a user-friendly online tool that can manage a large number of users to swiftly locate lost things in schools, businesses, train stations, parks, etc.

3. METHODOLOGY

It is structured as in Figure 2 and includes AI, geographical analysis, automated messaging services, CCTV-based authentication, and a method of retrieving missing objects. The approach is composed of the following steps:

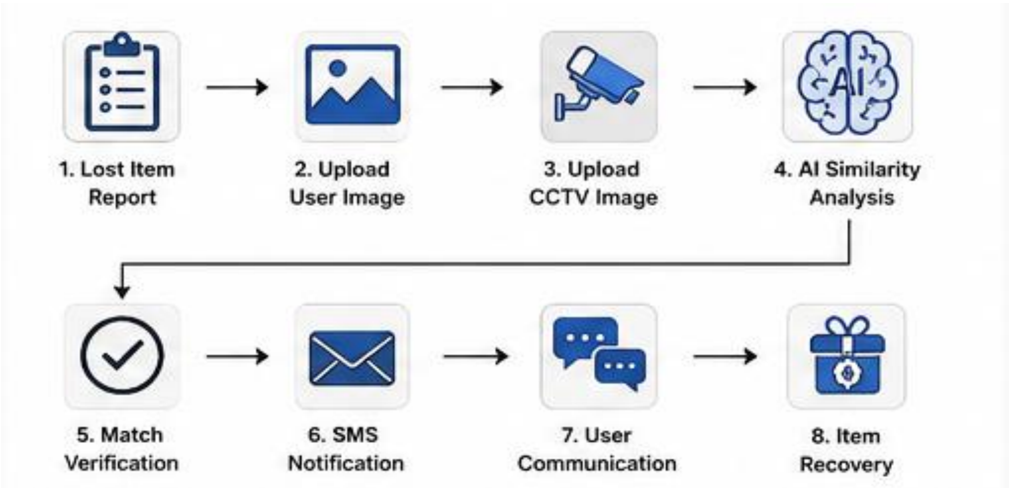

Figure 2. AuraFind Overall Workflow

3.1 Lost Item Registration Form

After the user reports an item as lost to the web app, the process of retrieving it begins. A user may also upload a picture of the missing object along with the name, summary, and contact details. The technology also records the location data so it may be monitored and analyzed at a later time.

3.2 Submission of CCTV evidence

Upon receiving the initial report, the system takes a CCTV photo of the thing of suspicion. This photo is sent to the standard comparison module to support the verification process.

3.3 Image Similarity Analysis

The AI module processes the photographs provided by the user, as well as the CCTV images. We extract visual qualities from comparable photographs and compare them to identify similar images. Calculates a similarity score for the two photographs and assesses whether they most likely show the same subject.

3.4 Verification of Match

We compare the resulting level of similarity to a pre-set threshold. If the item's score is greater than the threshold value, it is considered to have potential to match. Figure 3 shows both photographs shown on the outcomes page with similarity % along with match status.

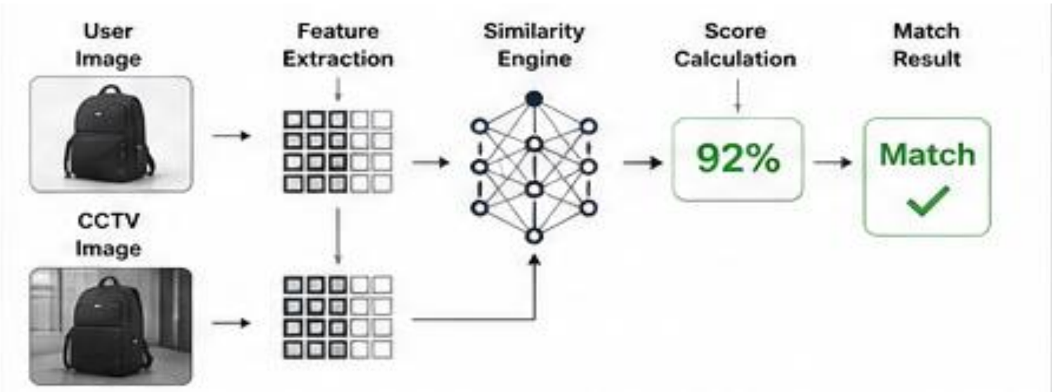

Figure 3. AI Based Image Matching Process

As suggested in Table 3, will be matching process of AI based image as shown in Figure 3.

Table 3. CCTV Object Matching Process & Results

Stage / Component	Input / Value	Output / Result
Input Images	User Image & CCTV Image	Black Backpacks
Feature Extraction	Image Data	Extracted Feature Grids
Similarity Engine	Feature Vectors	Neural Network Comparison
Score Calculation	Processed Features	92% Similarity Score
Match Result	92% Threshold Evaluation	Match (Verified)

3.5 Automated Notification Service

The notification module tells the registered user by SMS when a match is detected. See Figure 4 for demonstration. With this feature, the consumers would get the initial chance to know any probable recovery possibilities.

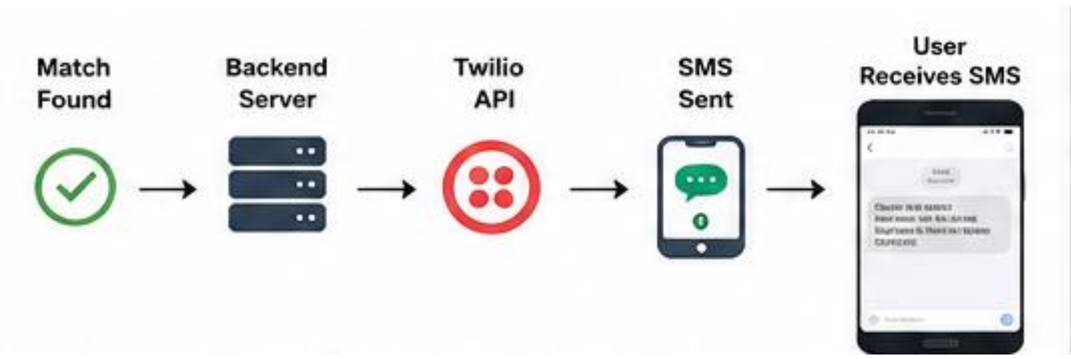

Figure 4. SMS Notification Workflow Using Twilio

3.6 Geospatial Visualization

Things that have been found and items which have been picked up are displayed on a map. The map is helpful in reviewing reported occurrences by region and users may identify recovery hotspots as shown in Figure 5.

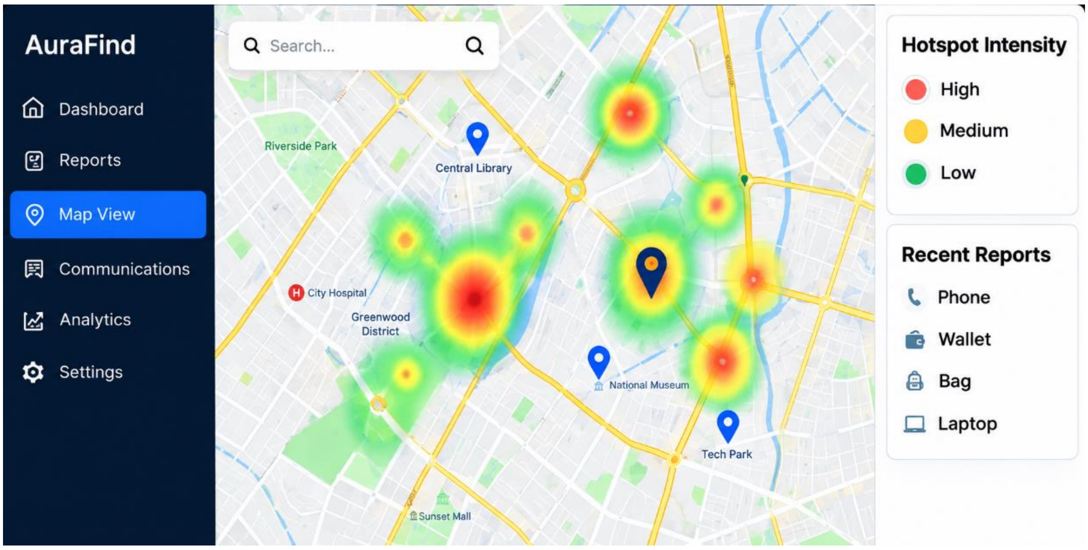

Figure 5. Interactive Radar Map and Hotspot Detection

3.7 Communication as well as Reputation Management

AuraFind allows users to send and receive data in real time via an encrypted connection. The site has a reputation system that tracks user activity and successful recoveries to assist develop trust in the platform.

3.8 Workflow of the System

The main process flow of AuraFind is: report missing item → upload CCTV photos → AI image comparison → verify matches → send SMS notice → communicate with users → recover things.

4. RESULTS AND DISCUSSION

4.1 Summary

The AuraFind platform was implemented and tested to verify the effectiveness of the system to retrieve lost things. The solution offers a single environment with spatial visualization, automated alerting services, immediate interaction, CCTV evidence verification and AI-based photo comparison. The key areas of emphasis throughout the evaluation were overall system efficacy, efficiency of alerts, user engagement, and corresponding accuracy.

4.2 Results of Image Matching

The image matching algorithm was able to accurately detect similarities when comparing user-submitted pictures of items to CCTV images. The system was able to discern between relevant and non-related elements determined by the similarity scores received. In most of the test instances, users could locate possible matches faster since items with similar visual characteristics got higher similarity ratings.

4.3 Notification Efficacy

An automated text messaging service that speeds up communication by promptly telling users when a probable match was located. Users managed to respond rapidly to recovery opportunities and the lag time associated with manual contact methods was reduced.

4.4 Spatial Analysis

The map's interactive module may graphically display items that were reported, and items that were retrieved. Hotspot analysis identified the locations where lost things occurred most often. This data allows organizations and administrators to monitor trends and plan for future issues.

4.5 User Knowledge and Conversation

The real-time chat feature eliminated the need for third-party message systems, since it enabled all participants to communicate with each other. Users were recognized for their roles in effective rescues by the integrated reputation structure, which promoted appropriate participation. Users were more engaged and had more faith in the site after these upgrades.

4.6 Debate

In order to increase the efficiency of missing item retrieval, the studies demonstrate that many technologies should be integrated into a single platform. Reaction times were increased by automated warnings, and the burden for human validation was minimized via AI-driven picture matching. Improving reliability and user-friendly mapping, property identification, and reputational supervision were significant. Although the approach shows promise in terms of execution, issues including poor picture quality, limited CCTV view, and missing item characteristics might impact the combination's accuracy. Future studies may aim to improve visual object recognition, use bigger information sets, and use more advanced image processing methods to boost restoration.

4.7 Limits

Though it has a lot of potential, AuraFind has a few drawbacks. CCTV footage could lead to incorrect picture authentication if the pictures are blurry, the lighting is bad, or something is missing. Even while duplicates induced by objects that seem similar happen very seldom, they might undermine the reliability of confirmation. For it to function properly and send out notifications at all times, it needs access to security footage and a reliable link to the internet. In addition, only items that already have registration may have their ownership verified using QR codes. Processing time and computer capacity may increase in proportion to the number of photos posted to the internet, which can have an effect on overall efficiency.

4.8 Future Prospects

In order to greatly improve the accuracy of picture identification and object detection, AuraFind makes use of sophisticated AI techniques. Using video-based AI, subsequent versions may independently search across several CCTV feeds for lost objects. Improving its safety and trustworthiness may also be achieved by using blockchain-based property records. To further enhance uptime and satisfaction with users, additional aspects like analytical appraisal, multilingual assistance, cloud growth, and integration of developing mobile apps might be incorporated. In addition, item retrieval performance in extended settings might be enhanced by combining real-time location tracking with intelligent labeling made possible by Academic IoT. A smart suggestion engine that suggests possible recovery sites based on historical data and patterns of user activity may be one of the next projects in the works. Platform possibilities for use may be broadened by integrating oversight systems, transit connectivity, and autonomous urban area equipment. All it takes is a few tweaks to turn AuraFind into a sophisticated catastrophe recovery environment that can help large businesses get back up and running after a tragedy.

5. CONCLUSION

With its integrated artificial intelligence, user interface, property authentication, instant messaging, automated alarm systems, and CCTV information correlation, AuraFind is a smart and coherent solution for lost-item recovery. The proposed system outperforms traditional lost-and-found approaches in areas such as matching accuracy, human labor efficiency, and user-to-user interaction velocity. The recovery process is made more effective and reliable with AuraFind's straightforward workflow and powerful technical capabilities. The study shows that retrieval techniques for lost goods may be significantly enhanced by integrating numerous smart devices and provides the foundation for future breakthroughs in smart restoration approaches. This highlights the need of combining AI decision-making with user-centered design to effectively tackle real-world problems. AuraFind is a unified framework that uses cutting edge technology to increase efficiency throughout the restoration process while building confidence, openness and community engagement. With the digital revolution continuing to transform public services, tools like AuraFind will assist to provide smarter, timelier, tech-driven repair solutions.

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Author Contributions Statement

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Srikanth Veldandi	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	
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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

Conflict of Interest Statement

The authors declare that they have no conflicts of interest for the publication of this work.

Informed Consent

Informed that consent was obtained from all participants after they were told about the purpose of the research, before data collection started.

Ethical Approval

Since the research did not include any sensitive issues ethical approval was not sought.

Data Availability Statement

The present study did not generate or analyze any new datasets. The statistics provided in this survey are exclusively based on publicly available and previously released sources, which are mentioned throughout the publication.

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