



गृह मंत्रालय
MINISTRY OF
HOME AFFAIRS



Project Report

On

Geo-Encoding of Police Stations in India

(Project No.12/MM:03)

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'Promoting Good Practices and Standards'



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Contents

1. Introduction.....	1
2. Problem Statement	1
3. Proposed Solution:	2
4. Proposed Technology:.....	4
5. System Diagram:	4
5. Performance Comparison of Various Geo-Encoding APIs:	5
6. Cost Analysis:.....	6
7. Implementation of the project:	7
7.1. Activity Workflow:	7
7.2. Components Hierarchy:	8
8. Geo-encoding combined with Artificial Intelligence & Machine Learning:	8
9. Key Benefits:.....	9
10. Conclusions:.....	10

1. Introduction

National e-Governance Plan (NeGP) of the Government of India is driving the change in every sphere of governance in India. This e-Governance policy has also introduced key changes in the domain of Policing and Law Enforcement in the country.

The success of future law enforcement strategies rests on the ability of law enforcement agencies to quickly and efficiently harness immense volumes of crime and criminal information to catalyze the investigations and enforcement actions. To gain deep insight of hidden patterns the Artificial Intelligence (AI) and Machine Learning (ML) tools along with efficient Geographic Information Systems (GIS) can be used. In an era, when police workforce is being asked to deliver more with scarce resources, AI and machine learning incorporated with Geographical Information can help in unearthing clues to target a patrol or drive an investigation.

Geographical Information along with AI/ML applications can facilitate police personnel with machine driven assistance and focus their efforts on the effective police work. AI/ML empowered with GIS is already demonstrating its value around the world by helping police. E.g., in western countries, many missing persons were found by analyzing CCTV footages & GIS systems. It signifies that analysis of patterns, sensor feed data, and databases of records, clubbed with GIS, AI and ML could help law enforcement agencies to identify critical places to be, key linkages between suspects, and explore other insights hidden in a sea of data.

2. Problem Statement

In law enforcement, address of a Scene of Crime (SOC) or Place of Incidence /accused or victim residence is vitally the foremost information about any crime & also the starting point of any investigation done by police or any other law enforcement agency. But, Location related data viz. Police stations coordinates, Place of Incident/Scene of Crime are unavailable in most of FIRs/Complaints being registered in India via the various police IT applications, location related information

consists only address field. Also, the legacy FIRs registered in previous years contains only address of place of incidence or SOC etc.

This SOC address & police station address, if converted to geospatial coordinates (latitude-longitude) and further analyzed using modern geo-spatial analysis techniques and tools can provide key information to investigating officers etc. eg. Geo-spatial analysis of a particular time of day or night can easily highlight the areas prone to that crime and can give us a significant idea about criminals and their safe houses based on their response time. This information can be used for further resource mobilization to that area for prevention of crime.

Presently, mechanism to convert address to corresponding coordinates is not integrated with Police IT applications due to unavailability of any efficient geo-coding tool / web based solution. Hence, geo-spatial coordinates viz. Longitudes and Latitudes are not being recorded in FIRs presently. Similarly, the address present in legacy FIRs which are fed to Police IT applications are also to be converted to corresponding coordinates & updated in police applications. Further, for effective crime management, prevention, forecasting police Stations locations (Address) are also to be converted to coordinates (lat-long) and their jurisdiction boundaries to be digitally drawn and updated in the applications.

Hence, an efficient Geo-encoding and reverse Geo-encoding solution (tool) or web-based service is needed to be integrated to Police IT applications.

3. Proposed Solution:

The purpose of geocoding is to convert location addresses to corresponding geographical coordinates (latitude, longitude) denoting a point on the digital map for visualization of spatial characteristics (location, area type, distance, terrain type, area type etc.) of the data. Reverse geo-encoding denotes the reverse that is conversion of coordinates to address.

For Geoencoding (Geocoding) and reverse geocoding, various location based services (LBS) API services are available on the internet which can be directly used

geo-encoding and reverse geo-encoding. These LBS APIs can also be easily integrated to our existing police applications using internet & with very minute changes in the existing applications. Some of well-known LBS APIs are google maps (most popular), Bing maps (Microsoft), HERE Maps, Openstreet Maps (open source), www.mapsofindia.com (India based company). Some of the modern high level computer programming languages viz Python, R, Scala etc. offer capabilities to perform geo-encoding and reverse geo-encoding and geospatial analysis like hotspot analysis etc. with the help of very few lines of code.

A feasibility study was performed for use of above mentioned APIs for Geo-encoding and reverse Geo-encoding and developed a working solution using python for the same under the exercise Geo-encoding of Police Stations in India. A performance comparison of these Geo-coding APIs was also drawn. Following deliverables were worked out during the exercise:

- a. Geo-Encoding of various Indian police stations i.e. conversion of Address of all Police Stations into respective Geographical coordinates (Latitude, Longitude pair) using popular mapping API services available in India viz. Google-maps / Bing Maps/ArcGIS/here maps etc.
- b. Calculating the crow-fly (Ariel) distance between the existing coordinates and coordinates fetched in the previous step.
- c. Matching of Existing Coordinates (Latitude, Longitude) from the fetched coordinates.
- d. Filtering the correct coordinates and replacing the wrong coordinates with the correct ones for each police station.
- e. Populating the Police IT core application software with the coordinates of each police station.
- f. Reverse Geocoding capabilities of these APIs i.e. conversion of Lat./Lon. pairs to respective address

- g. Drawing a comparison chart against various performance indicators such as execution time, response time, number of results produced, accuracy in geo-coding results etc. for each API and recommend a best result.
- h. Batch Geo-coding (batch processing) of multiple address given in a excel sheet & Vice –versa
- i. Addressing the Multi-Address Problem i.e. the situation where places with similar names exists with different Coordinates (Latitude-Longitude pair)

4. Proposed Technology:

- a. Mapping service APIs like Openstreet Maps, Bing Maps, Here Maps, and Google –Maps etc.
- b. Python and related libraries for coding purpose.
- c. Database technology (MySQL/MS-SQL/ NO-SQL databases like Mongo-DB) for storing the Location data (Optional).
- d. Microsoft Excel for data sharing and preliminary data filtration and correction.
- e. Medium to high speed Internet facility

5. System Diagram:

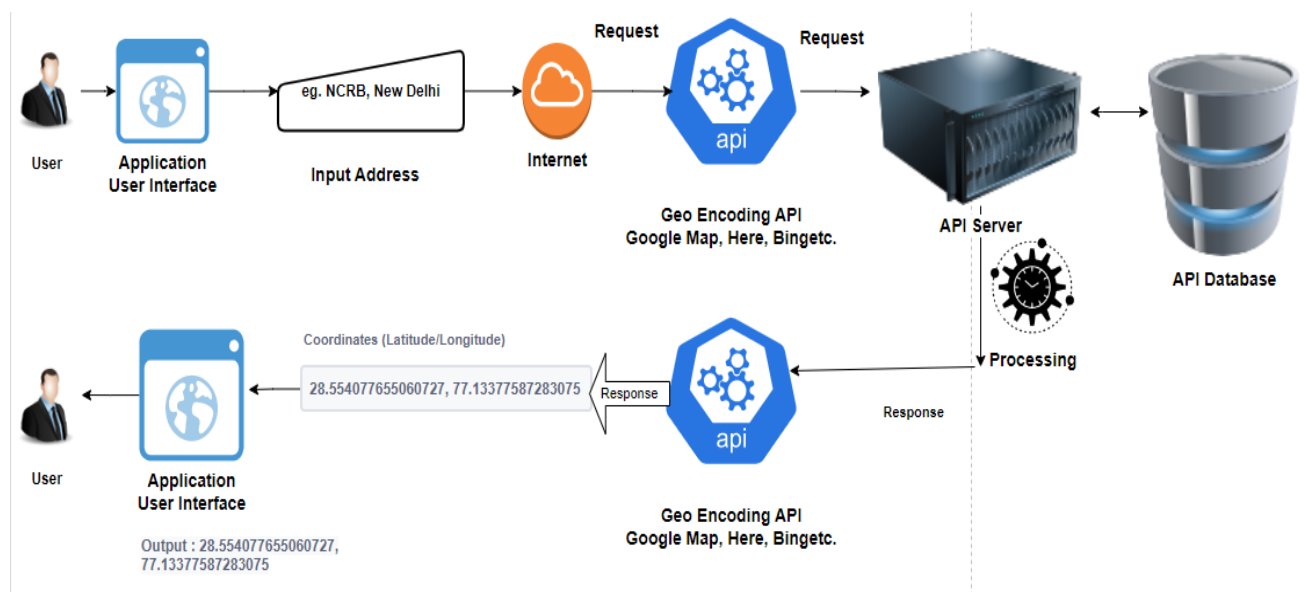


Fig.1 Geo-Encoding (Address ----> Lat./Lon. Pair) System Diagram

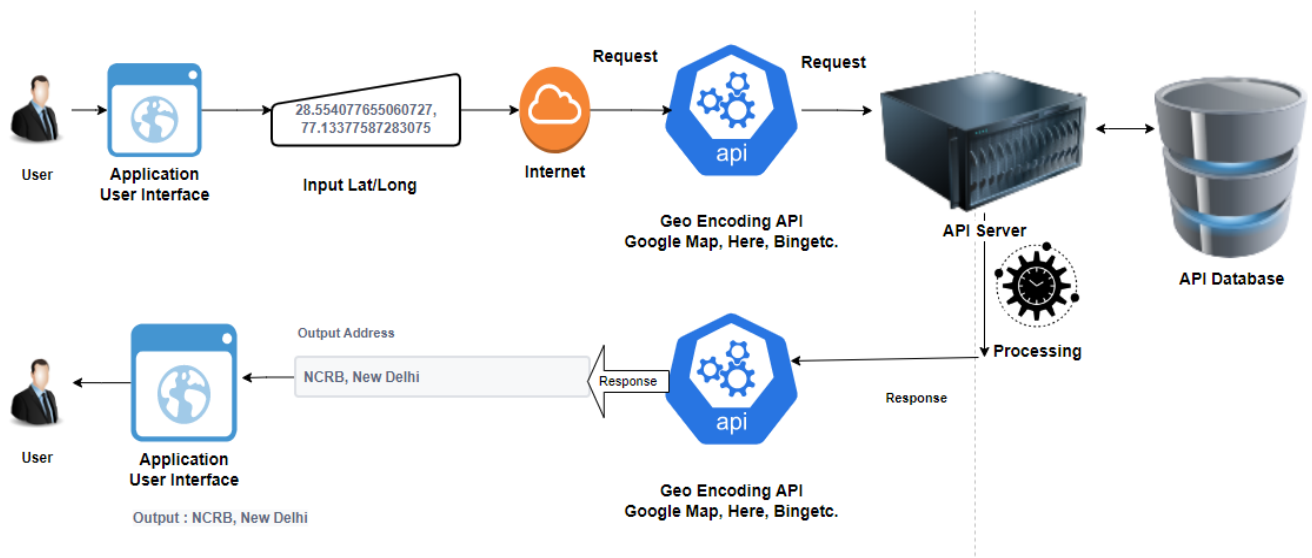


Fig.1 Reverse Geo-Encoding (Lat. /Lon. Pair to Address) System Diagram

5. Performance Comparison of Various Geo-Encoding APIs:

Total input address size : 5027

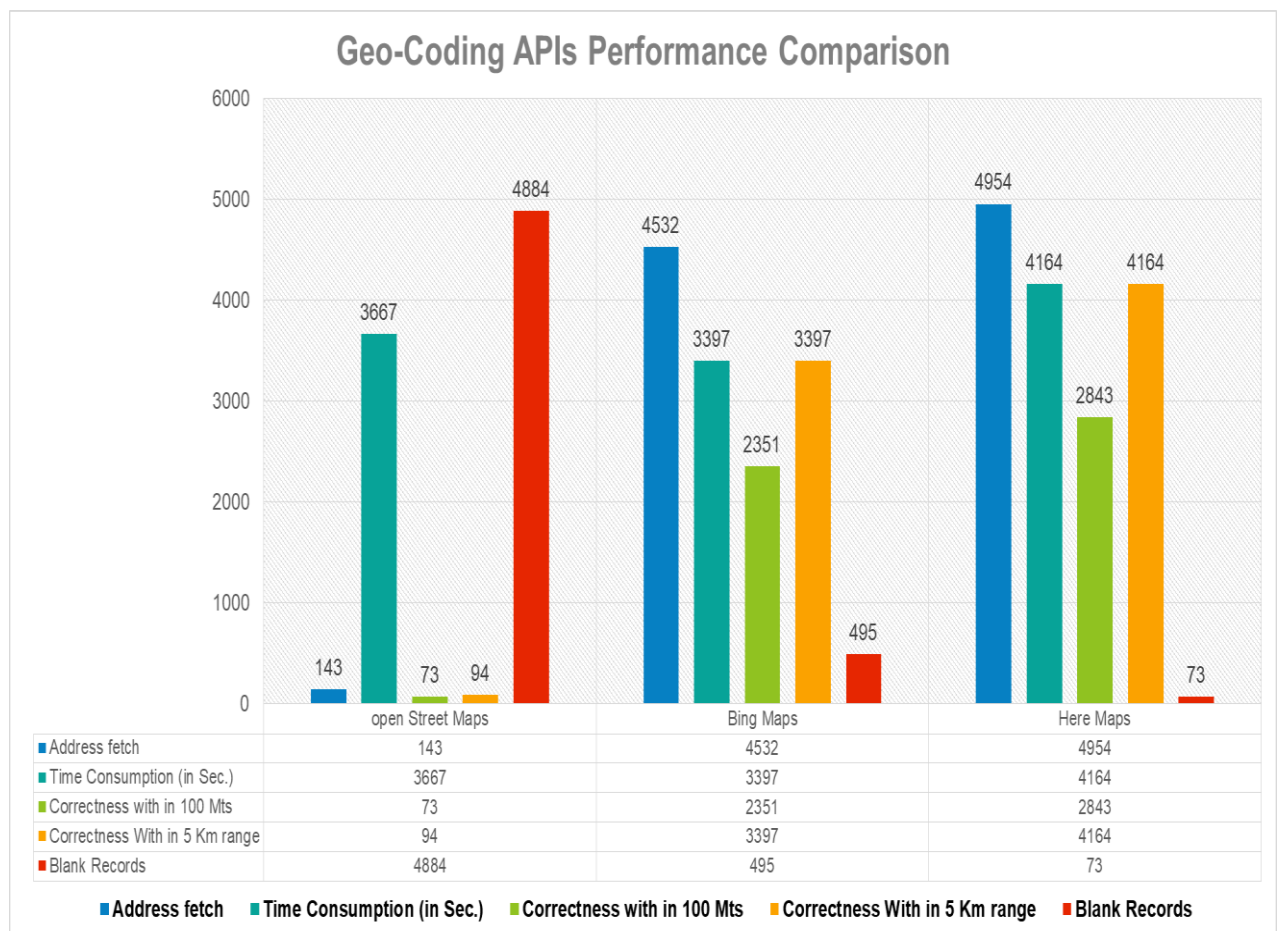


Fig.2 Geo-Coding APIs Performance Comparison Grap

Sl. no	API Name	Input Size	Fetched Lat/Lon	Blank Result	Correct Results (Lat/Lon within 100m tr. From actual coordinates)	Correct Results (Lat/Lon within 5kms. From actual coordinates)	Average Distance from Actual coordinates (in mtrs.)	Execution Time (In sec.)	Accuracy (in %) = (VII/IV) X 100
I	II	III	IV	V	VI	VII	VIII	IX	X
1.	Open street Maps	5027	143	4884	73	94	41.3	3667	65.73%
2.	Bing Maps	5027	4,532	493	2357	3397	67.8	4395	74.95%
3.	Here Maps	5027	4,954	73	2843	4164	14.3	2893	84.04%

Table 1. Geo-Coding APIs Performance Comparison Chart

6. Cost Analysis:

6.1.	Implementation Effort –	Low: Medium software coding skills required for implementation due to availability of ready to use libraries
6.2.	Capex Cost –	Medium: Requirement of annual subscription fee if any commercial Geocoding API (developed by a corporate company) is being used
6.3.	Operational Cost –	Medium: To ensure 24x7 uptime. Increased service cost in case of increase in data volume, user count etc.
6.4.	Maintenance Cost –	Low: Very minimal amount of maintenance is required for updating new police stations/ jurisdiction

7. Implementation of the project:

7.1. Activity Workflow:

A. Performance test of existing Geo-encoding APIs

- Fetching of the actual addresses & coordinates from the Police stations of India through state PHQs
- Testing of various mapping APIs against various parameters viz : Accuracy of geo-encoding, Crow fly distance between fetched coordinates & actual coordinates, response time etc.
- Performance comparison between all the APIs

B. Cost Estimation & Selection of best Mapping API

- Calculating the Implementation cost implication including recurring & non-recurring cost, Man power to be hired for development etc.
- Estimation of Complexity of Implementation i.e. Amount of coding required and changes in existing IT infrastructure

C. Integration of API

- Integration of mapping /Geo-encoding API with existing application as a service.
- Mark all the police stations coordinates (fetched)with their Jurisdiction maps.
- Conversion of legacy address (SOC) to coordinates and to be fed to the applications.
- Automation of converting future addresses (SOC, New police station) automatically converted to coordinates.
- Customization of existing reporting modules of the applications & integration of AI with GIS enabled capabilities.

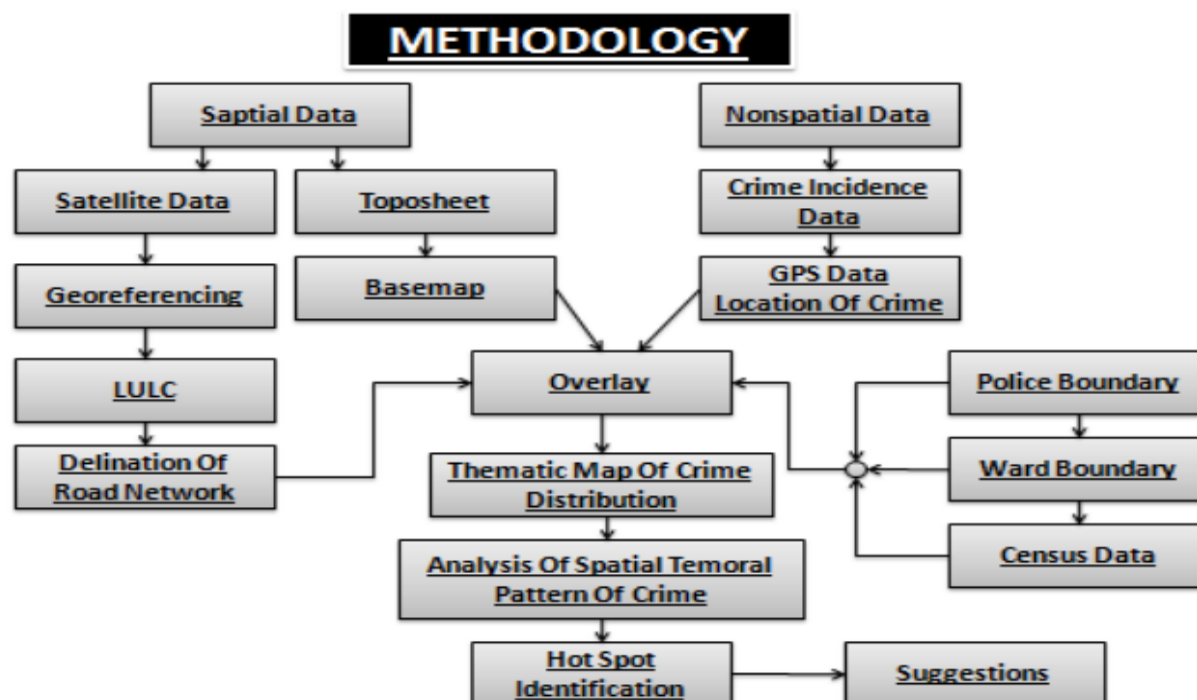
D. Report Generation & Hotspot Analysis

- AI based reporting module to existing application
- Report generation & Hotspot analysis
- Decision support & Crime prediction
- Resource Mobilization

E. Maintenance & Upgradation

- Maintenance of API & performance tuning
- Upgradation of portal according to the latest tools & techniques.

7.2. Components Hierarchy:



8. Geo-encoding combined with Artificial Intelligence & Machine Learning:

Combining Geographic Information Systems (GIS) with Artificial Intelligence (AI) and Machine Learning (ML) techniques can enable proactive, efficient, and effective policing. Combining spatial data and AI/ML algorithms can enhance law enforcement efforts with futuristic. Few applications of GIS clubbed with AI/ML can be further achieved:

i. Spatial Analysis for Crime Hotspot Identification:

One of the key applications of GIS in crime prevention is identifying crime hotspots. By overlaying crime incident data onto geographic maps, GIS can pinpoint areas with high crime rates. When coupled with AI and ML algorithms, these systems can predict future crime trends based on historical data. Law enforcement agencies can then allocate resources more efficiently, deploying officers and patrols to hotspot areas during peak crime times.

ii. Optimal patrol routing:

By incorporating location information with AI/ML algorithms, in monitoring systems can suggest optimal patrol routes and resource allocation strategies, leading to proactive crime prevention. Advanced surveillance systems equipped with GIS, AI, and ML capabilities can analyze live camera feeds and geospatial data to detect suspicious activities in real-time. If unusual patterns or anomalies are detected, automated alerts

iii. Enhanced Community Policing

GIS-based crime prevention efforts promote community policing by fostering better communication between law enforcement and the public. By mapping crime incidents and safety concerns, residents can provide valuable input, which, when integrated into AI/ML algorithms, helps in formulating more community-centric crime prevention strategies.

iv. Enhanced Emergency Response

Location-based services are vital for optimizing emergency response times. AI and ML can process incoming emergency calls and use geolocation data to dispatch first responders more efficiently. This not only saves precious time but also increases the chances of saving lives in critical situations.

9. Key Benefits:

Application of GIS tools and technology on the crime data can prove fruitful and provide following futuristic benefits to various stakeholders:

(i) Police Officers / IOs/officials:

- a. Geospatial /Hotspot Analysis of FIRs/ Complains for real time based on place of incidence and Modus-operandi etc.
- b. Implying various AI/ML algorithms for multidimensional analysis of crime data along with training datasets.
- c. Cost effective Resource deployments and effective strategy decision based on the analytical reports.

d. Increased speed of Investigation of Cases.

(ii) Senior Police Officers will be able to make Effective decision making and mobilization of resources based on real-time analysis of crime data in correlation with places and its nearby police stations.

(iii) Beat In-charge and Police Officials: Increase responsiveness and less action time of Police

(iv) Other Law enforcement Agencies:

a. Developing various Intelligent and predictive systems for early warnings etc. by use of AI/ML algorithms.

b. Real time search as required in investigating time sensitive cases

c. Public: Increased trust and feel safe due to decreased response time and presence of police in sensitive areas.

10. Conclusions:

Based on above Geo-Encoding APIs performance evaluation exercise done, few conclusions are submitted below:

(i) Filling up geographical information pertaining to scene of crime, criminal etc. is to be made mandatory to fill up in FIRs etc.

(ii) Police Officers / Officials may be trained to give emphasis upon GIS information