Continent Based Geo-Landmark Detection and Recognition Using CNN

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ABSTRACT

In the modern world, we need the development of an automated system that can accurately detect landmarks and provide essential services is important. The 'Continent-based Geo-Landmark Detection and Recognition using CNN" project develop the Continent-based Landmark Detection system using deep learning, specifically Convolutional neural network (CNNs). The system will be capable of identifying landmarks from uploaded images. It will provide a short summary about the identified landmarks, and extract geographic data such as landmark address, latitude and longitude and display them on the map. Additionally, the system will utilize location information (i.e. Latitude and Longitude) to locate 17 essential services such as Road Network, Hospitals, Bus Stops, Railway Station, ATM's, Religious Institutions (Temple, Masjid, Church and more) etc. around the identified landmark within a specified radius, such as 1000 meters (i.e. 1 kilometer).

Keywords: CNN; Continents; Geo-landmark; Detection and Recognition; Convolution neural network; Deep Learning; Python.

1. INTRODUCTION

Our project is centered around creating an intelligent system that can effectively recognize landmarks in images. We're leveraging advanced deep learning techniques, specifically Convolutional Neural Networks (CNNs), to develop this system. CNNs are powerful algorithms commonly used in image recognition tasks, and we're employing them to accurately identify landmarks from a wide range of images.

Once a landmark is identified, our system goes a step further by extracting important information such as the landmark's address and geographical coordinates (latitude and longitude). This information is then integrated into interactive maps, allowing users to visualize the location of the identified landmarks with ease.

But our system doesn't stop there. We're also incorporating location-based services to enhance user experience. By leveraging the geographical coordinates of the identified landmarks, users can easily discover nearby amenities such as hospitals, movie theaters, markets, and more. This integration of landmark detection and location-based services makes exploring new places and accessing essential facilities incredibly convenient.

Overall, our project aims to bridge the gap between advanced technology and practical utility. By seamlessly blending cutting-edge deep learning techniques with real-world geographic data, we're striving to create a system that revolutionizes the way people interact with their surroundings.

1.1 MOTIVATION

We see lots of pictures of a famous landmark and think where it is located? and also, we wanted to explore nearby facilities of that landmark but we don't have any idea where to start? so that’s why we think to create an application of landmark detection and recognition system.

Our project aims to address this need by developing a Continent-based Landmark Detection system using Convolutional Neural Networks (CNNs). By leveraging the power of deep learning, we seek to create a system capable of accurately identifying landmarks from uploaded images. This system has the potential to revolutionize the way people interact with and explore the world around them.

Also, by extracting address and location coordinates from images, our system can provide users valuable information about the geographical context of that landmarks which they are interested. This is not only increasing the user's experience but also opens up opportunities for applications in fields like tourism, cultural heritage preservation etc.

1.2 RESEARCH CONTRIBUTION

1. Breaking Technological Barriers: Previous attempts to develop landmark detection systems were hindered by limited computational resources and the complexity of image recognition algorithms. However, with the advent of Convolutional Neural Networks (CNNs) and improvements in hardware capabilities, we were able to surpass these limitations and develop a robust Continent-based Landmark Detection system.

2. Enhanced Accuracy and Performance: While earlier systems may have struggled with accuracy and performance issues, our project demonstrates notable improvements in both areas. By harnessing the power of CNNs, we achieved higher levels of accuracy in landmark

recognition, paving the way for more reliable and precise results.

3. Integration of Location-Based Services: In addition to advancing landmark detection technology, our project integrates location-based services to provide users with comprehensive information about nearby facilities. This integration enhances the practical utility of our system, enabling users to explore landmarks and access relevant services with ease.

4. Realizing the Full Potential: By overcoming previous technological limitations, our project realizes the full potential of landmark detection and exploration applications. We not only improve upon existing methods but also open up new possibilities for utilizing such technology in various domains, ranging from tourism and urban planning to cultural preservation and beyond.

2. LITERATURE REVIEW

In a paper titled "Lost Quantization: Improving Particular Object Retrieval in Large Scale Image Databases" by J. Philbin et al. in 2008, the authors explored ways to make it easier to find specific objects in huge collections of images. They focused on a small number of different landmarks, like famous buildings or monuments, to see how well their method worked. For example, they created a dataset with 6,412 pictures of 12 well-known landmarks in Paris. They wanted to see if their approach could accurately find these landmarks in the pictures, even if there were lots of other things in the background.[1]

In a paper titled "Landmark Classification in Large-Scale Image Collections" by Y. Li, D.J. Crandall, and D.P. Huttenlocher in 2010, the authors looked into how to classify landmarks in big collections of datasets. They wanted to figure out what landmarks were in the images, like famous buildings or natural landmarks. However, their study had a limitation they only used a dataset with images of 500 different landmarks. This means they couldn't test their method on a wide range of landmarks, which might limit how well it works in real-world situations with many different kinds of landmarks.[2]

In a paper called "Geo-Landmark Recognition and Detection" by Nishika Manira and others in 2010, the authors investigated into recognizing and detecting landmarks, which are famous places or buildings. However, their study didn't focus on helping tourists find their way around new places. While they could recognize landmarks in pictures, they didn't explore how to use this to guide people through unfamiliar locations. Even though they didn't cover these points, their work was still important because it helped us understand how computers can recognize landmarks. In the future, this could lead to systems that not only recognize landmarks but also help people navigate in new places by using those landmarks. [3]

In a paper titled "Automatic Landmark Extraction from Geo-tagged Social Media Photos using Deep Neural Network" by Najmeh Neysani Samany and others in 2010, the authors studied a method to automatically extract landmarks from photos shared on social media. They used a powerful computer program called a deep neural network to do this. However, their study encountered a limitation a technique they used called DBSCAN didn't work well when there were big differences in the number of photos in different areas. Despite this limitation, their research was important because it showed a new way to find landmarks in photos. In the future, this could help us better understand and explore the world around us through the photos people share online. [4]

Andrei Boiarov and Eduard Tyantov explored a method to recognize landmarks on a large scale using a technique called deep metric learning in their 2019 paper titled "Large Scale Landmark Recognition via Deep Metric Learning". They wanted to teach computers to recognize landmarks in lots of pictures. However, they found a limitation in their study the techniques they used, called triplet loss and contrastive loss, needed to be trained with carefully selected samples to work well. Despite this limitation, their research was important because it showed a new way to teach computers to recognize landmarks in many pictures. [5]

Guillaume Touya and Chaimaa Beladraoui explored a method for detecting landmarks on maps using deep learning in their paper titled "Deep Learning for Anchor Detection in Multi-scale Maps" published in 2022. They wanted to automatically extract landmarks from large geo-tagged photographs. However, their study encountered a limitation: while they used deep learning to analyze geo-tagged photographs for automatic landmark extraction, there were challenges in accurately identifying landmarks in this way. Despite this limitation, their research was significant because it introduced a new approach to automatically detecting landmarks on maps, which could have valuable applications in various fields such as navigation and urban planning.[6]

In their 2021 paper titled "Deep Learning for Cephalometric Landmark Detection: Systematic Review and Meta-analysis", Falk Schwendicke and Akhilanand Chaurasia conducted a study to review and analyze the effectiveness of deep learning in detecting landmarks on cephalometric images. They found that deep learning methods showed relatively high accuracy in detecting landmarks on these images. However, their study identified a limitation: while the results were consistent, they were also at high risk of bias. Despite this limitation, their research was important because it provided valuable insights into the potential of deep learning for improving landmark detection in cephalometric imaging, which could have significant implications for orthodontic diagnosis and treatment planning. [7]

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2.1 RESEARCH GAP:

1. There may be a lack of exploration into how well the developed landmark detection and recognition system performs across different continents. Further research is needed to understand the system's effectiveness in recognizing landmarks in diverse geographical settings beyond the initial continent studied.

2. While the project focuses on continent-based landmark detection, there may be gaps in understanding how the system scales to handle larger datasets encompassing numerous landmarks across various continents. More research is needed to evaluate the system's scalability and performance with extensive datasets.

3. The project may encounter challenges in effectively detecting and recognizing landmarks under different environmental conditions, such as varying lighting conditions, weather patterns, or seasonal changes. Further research is necessary to enhance the system's robustness to environmental variability and ensure consistent performance across different conditions.

4. Although the project aims to identify landmarks, there may be a gap in exploring how this technology can be integrated into practical navigation systems to assist users in navigating unfamiliar locations. More research is needed to develop and test navigation systems that leverage landmark recognition to provide accurate and intuitive navigation guidance.

5. There might be potential biases in the landmark detection and recognition system, such as biases in training data or algorithmic biases. Further research is required to identify and mitigate biases to ensure fairness and equity in the system's performance across different demographic groups and geographic regions.

6. The project may face challenges related to computational efficiency, particularly when processing large volumes of image data for landmark detection and recognition in real-time or near real-time applications. More research is needed to optimize the system's computational efficiency while maintaining high accuracy and reliability.

3. PROPOSED SYSTEM

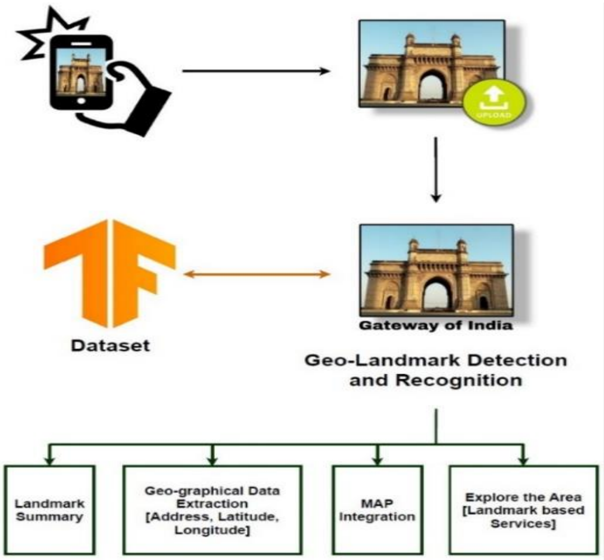

Figure 1: System Architecture of Geo-Landmark Detection and Recognition (GLDR)

The user interacts with the UI to upload an image or search for a recognized landmark. The Landmark Recognition Module processes the image using CNNs to identify the landmark. The Geographical Data Extraction Module extracts information about the recognized landmark, including address, latitude, and longitude. The system integrates with GIS data sources to retrieve real-time geographic data. Location-Based Services provide information about nearby amenities and facilities based on the geographic coordinates. Continent-specific recognition models adapt the recognition process for greater accuracy. Privacy and security measures ensure the protection of user-generated data.

3.1 IMPLEMENTATION METHOD:

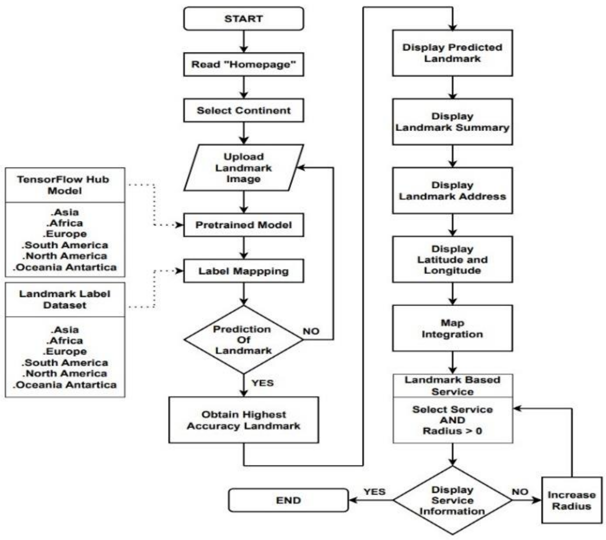

Figure 2: System Flow Chart of Geo-Landmark Detection and Recognition (GLDR)

1. The user interacts with the UI to upload an image or search for a recognized landmark.
2. The Landmark Recognition Module processes the image using CNNs to identify the landmark.
3. The Geographical Data Extraction Module extracts information about the recognized landmark, including address, latitude, and longitude.
4. The system integrates with GIS data sources to retrieve real-time geographic data.
5. Location-Based Services provide information about nearby amenities and facilities based on the geographic coordinates.

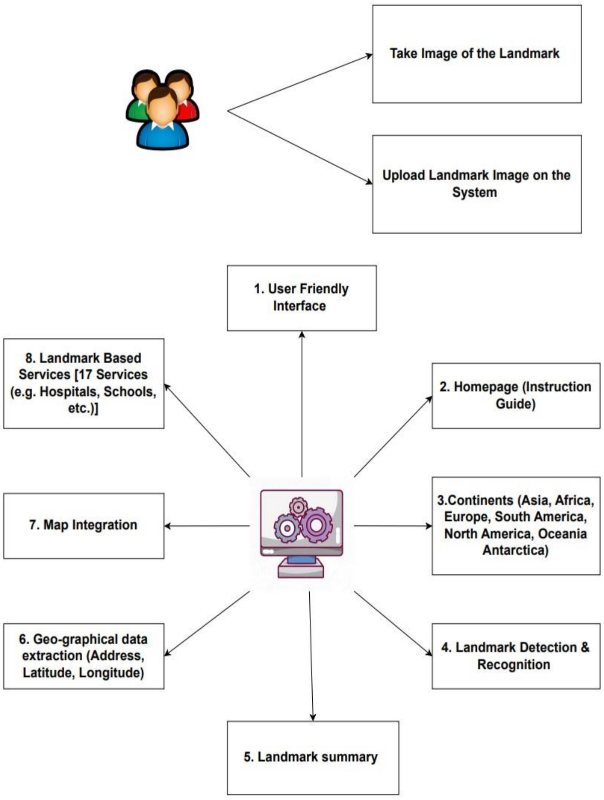

Figure 3: Use case diagram of Geo-Landmark Detection and Recognition (GLDR)

4. RESULTS AND DISCUSSIONS:

1. Data Collection: Gather a diverse and extensive dataset of images featuring landmarks from various continents. Ensure the dataset encompasses landmarks from urban and rural settings, capturing different lighting conditions and perspectives.

2. Data Preprocessing: Clean and preprocess the images to enhance quality and consistency. Resize images to a standard format suitable for CNN input. Label the dataset meticulously, associating each image with its corresponding continent, landmark name, and geographical coordinates.

3. Convolutional Neural Network (CNN) Architecture: Design a CNN architecture suitable for image recognition and feature extraction. Experiment with different CNN architectures, such as VGG, Reset, or custom-designed networks, to optimize landmark detection accuracy. Train the CNN model using the preprocessed dataset, employing techniques like transfer learning if applicable.

4. Landmark Recognition: Implement the trained CNN model to recognize landmarks from uploaded images. Extract landmark-specific details, including addresses, latitude, and longitude, using the recognized landmark names as queries in geolocation databases.

5. Interactive Mapping Integration: Integrate the geographical coordinates into interactive mapping APIs (e.g., Google Maps) to visualize recognized landmarks accurately. Develop an intuitive user interface that displays identified landmarks and nearby essential facilities on the map. Implement user-friendly controls allowing users to navigate the map and explore additional information about landmarks and facilities.

6. Location-Based Services Integration: Utilize location information (latitude, longitude, or pin-code) provided by users to identify nearby essential facilities. Implement algorithms to search for hospitals, movie theaters, markets, public transport hubs, shopping malls, schools, and colleges around the recognized landmarks. Display the results in a clear and organized manner, providing relevant details such as addresses, contact information, and distance from the landmark.

7. Testing and Evaluation: Conduct rigorous testing using diverse images to evaluate the accuracy and efficiency of landmark recognition and location-based services. Employ metrics such as precision, recall, and F1 score to quantify the system's performance. Gather feedback from users through usability testing, ensuring the system meets user expectations and provides a seamless experience.

8. Optimization and Scalability: Fine-tune the CNN model and algorithms based on testing results to optimize accuracy and speed. Ensure the system is scalable to handle a large number of users and diverse queries simultaneously. Implement caching mechanisms and other optimizations to enhance response times and user experience.

9. Documentation and Deployment: Document the entire development process, including datasets, methodologies, algorithms, and system architecture. Prepare user manuals and guides for seamless user adoption. Deploy the system on a reliable server infrastructure, ensuring high availability and minimal downtime.

10. Continuous Improvement: Monitor user interactions and system performance post-deployment. Gather user feedback and analyze user behavior to identify areas of improvement.

We successfully created a web-application for continent based geo-landmark detection and recognition using CNN. Check out the screenshot below to see the results.

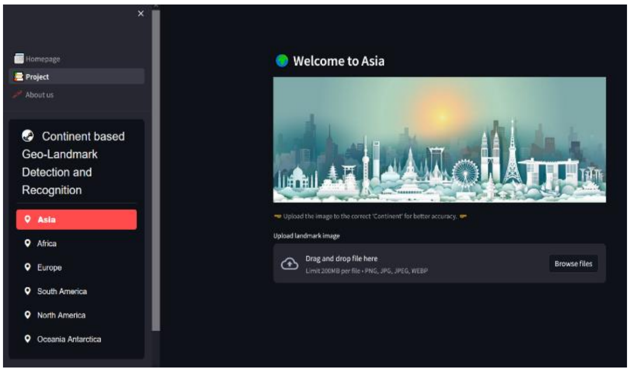

Figure 4: Homepage - Select Continent

After choosing the continent it will open that continents welcome page where user can drag or upload the image of the landmark

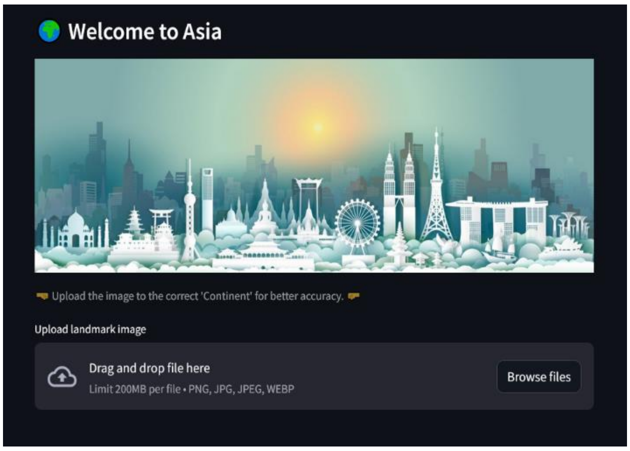

Figure 5: Upload Image of landmark

As soon as user upload the image it will quickly give the accurate prediction

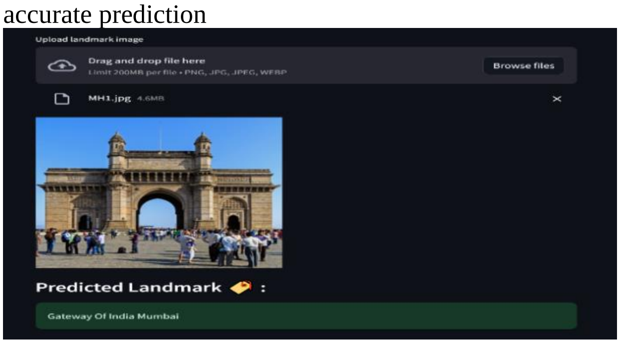

Figure 6: Display Predicted Landmark

After the prediction of the landmark, it will give the short summary of that landmark as well the proper address in any language and also Latitude and Longitude as well.

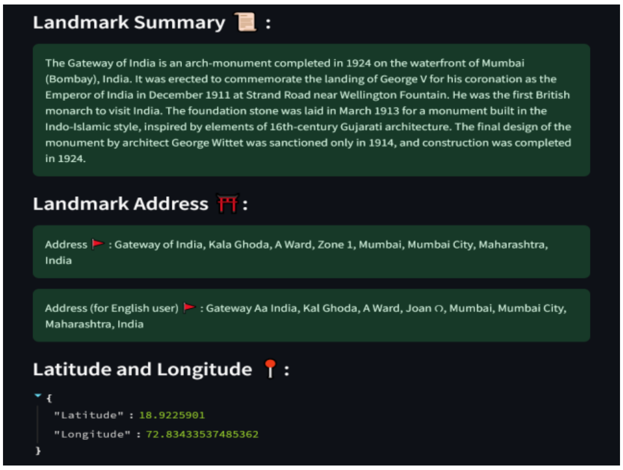

Figure 7: Display Landmark Summary and Geo-graphical Information (i.e. Address, Latitude - Longitude)

Then after that it will show the users live location on the map

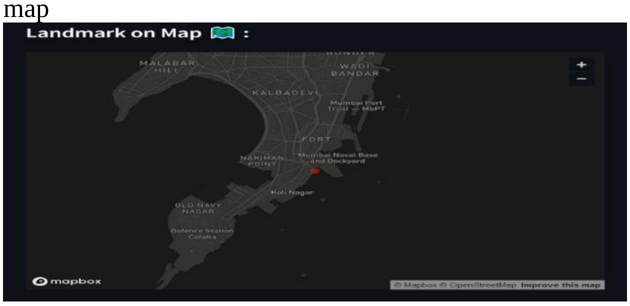

Figure 8: Map Integration

The most useful feature which help the user to explore the area independently without any help of other people, this feature will show the user Road Networks of the Area, Hospitals, Libraries, Police station, Bus Station, Railway Station, Parking Lots, Fuels, Hotels, Restaurants, Banks, ATM's, Supermarkets, Malls, Cinemas-Theater and Religious Institution (Temple, Masjid, Church and more…) etc.

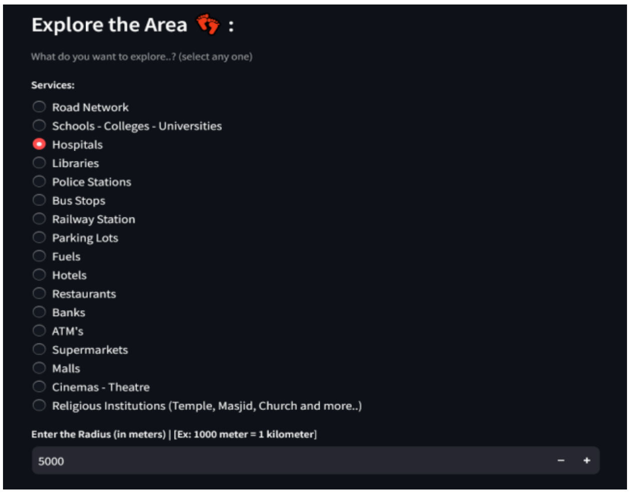

Figure 9: Landmark based Services (Select a Service and Enter Radius)

After choosing on of that feature firstly user need to define the radius to get nearby services.

	addr:district	addr:full	addr:postcode	addr:state	amenity	name	source
0	Mumbai	Near RC Church, Navy Nagar, Colaba, Mumbai	400,005	Maharashtra	hospital	INHS Asvini	OpenGovernmentData
1	None	None	None	None	hospital	Saifee Ambulance	GPS
2	None	None	None	None	hospital	None	None
3	Mumbai	(Dr Mangeshikar Clinic) Madhav Niwas , 8. Laburnum Road , Bombay	400,007	Maharashtra	hospital	Mangeshikar Access Gynecology and Infertility Center	OpenGovernmentData
4	Mumbai	9th Floor, Room No-91, Lady Ratan Tata Medical & Research Centre 31, Maharshi Karv	400,021	Maharashtra	hospital	Vinod Sharma Memorial Medical Centre	OpenGovernmentData
5	Mumbai	E -1st Floor, Bhaveshwar Vihar Svp Road, Prathna Samaj,Opposite Hurkiondas Hospi	400,004	Maharashtra	hospital	Dr. Yash Shah Total Eye Care	OpenGovernmentData
6	Mumbai	Hospital Address: Krishna Nivas, Junction Of Karve Road , & R R Roy Road, Girgaon	400,004	Maharashtra	hospital	Ursekar Laser and Microsurgery Eye Clinic	OpenGovernmentData
7	Mumbai	31 Surya Prakash Ground Floor, Babulnath Road, Chowpatty	400,007	Maharashtra	hospital	Eye-Q Vision Care	OpenGovernmentData
8	Mumbai	Navsari Bldg.240,Dr. D.N. Road	400,001	Maharashtra	hospital	Banaji Eyesurgery and Laser Center	OpenGovernmentData
9	Mumbai	105 A&C & 405 A Sukh Sagar, N.S. Patkar Marg, Opera House	400,007	Maharashtra	hospital	Foresight Eye Center	OpenGovernmentData
10	Mumbai	Modi Bhavan, Pandita Ramabai Road, Gamdevi, Grant Road (W)	400,007	Maharashtra	hospital	Dr. Nisars Eye Care Centre	OpenGovernmentData

Figure 10: Display the details of selected service within a specified radius

At the end user get the information that he needed like proper name, address postcode, state, amenity, source and latitude longitude.

	addr:district	addr:full	addr:postcode	addr:state	amenity	name	source	latitude	longitude
0	Mumbai	Near RC Church, Navy Nagar, Colaba, Mumbai	400,005	Maharashtra	hospital	INHS Asvini	OpenGovernmentData	18.9008	72.8161
1	None	None	None	None	hospital	Saifee Ambulance	GPS	18.9599	72.8315
2	None	None	None	None	hospital	None	None	18.9535	72.8371
3	Mumbai	(Dr Mangeshikar Clinic) Madhav Niwas , 8. Laburnum Road , Bombay	400,007	Maharashtra	hospital	Mangeshikar Access Gynecology and Infertility Center	OpenGovernmentData	18.9603	72.8102
4	Mumbai	9th Floor, Room No-91, Lady Ratan Tata Medical & Research Centre 31, Maharshi Karv	400,021	Maharashtra	hospital	Vinod Sharma Memorial Medical Centre	OpenGovernmentData	18.9231	72.8276
5	Mumbai	E -1st Floor, Bhaveshwar Vihar Svp Road, Prathna Samaj,Opposite Hurkiondas Hospi	400,004	Maharashtra	hospital	Dr. Yash Shah Total Eye Care	OpenGovernmentData	18.9577	72.8213
6	Mumbai	Hospital Address: Krishna Nivas, Junction Of Karve Road , & R R Roy Road, Girgaon	400,004	Maharashtra	hospital	Ursekar Laser and Microsurgery Eye Clinic	OpenGovernmentData	18.953	72.8177
7	Mumbai	31 Surya Prakash Ground Floor, Babulnath Road, Chowpatty	400,007	Maharashtra	hospital	Eye-Q Vision Care	OpenGovernmentData	18.9557	72.8083
8	Mumbai	Navsari Bldg.240,Dr. D.N. Road	400,001	Maharashtra	hospital	Banaji Eyesurgery and Laser Center	OpenGovernmentData	18.9358	72.8332
9	Mumbai	105 A&C & 405 A Sukh Sagar, N.S. Patkar Marg, Opera House	400,007	Maharashtra	hospital	Foresight Eye Center	OpenGovernmentData	18.9563	72.8134
10	Mumbai	Modi Bhavan, Pandita Ramabai Road, Gamdevi, Grant Road (W)	400,007	Maharashtra	hospital	Dr. Nisars Eye Care Centre	OpenGovernmentData	18.9591	72.8117
11	Mumbai	9,Dr, D.D. Sathe Marg	400,004	Maharashtra	hospital	Brahman Sabha, Mhaskar Gruh and General Nursing Ho	OpenGovernmentData	18.9568	72.819
12	Mumbai	58,Mohammedali Road	400,003	Maharashtra	hospital	Dholkawalla Maternity Home	OpenGovernmentData	18.9527	72.8338
13	Mumbai	Mahaprabhu Krupa, 1st Floor, Room No.5, Near Alankar Cinema, Girgaum -Charni Ro	400,004	Maharashtra	hospital	Yogeshwar Surgical Clinic and Nursing Home - Mumbai	OpenGovernmentData	18.9573	72.8248
14	Mumbai	Imamwada Road, Opposite Mughal Masjid	400,009	Maharashtra	hospital	M.H. Saboo Siddique Maternity and General Hospital - I	OpenGovernmentData	18.9596	72.8331
15	Mumbai	Apex centre, 5 Babulnath Road, OppositeBabulnath Temple, Grant Road	400,007	Maharashtra	hospital	Bombay City Eye Institute and Research Centre	OpenGovernmentData	18.958	72.8095
16	Mumbai	266 , Patel Bldg Opposite Central Cinema Girgaum	400,004	Maharashtra	hospital	Beramji's Hospital	OpenGovernmentData	18.9547	72.8183
17	Mumbai	81-84 Lady R.T.Med.&Research Cntre	400,049	Maharashtra	hospital	Spectrum Health Care	OpenGovernmentData	18.9231	72.8276

Figure 11: Expand screen to see more details regarding the selected service

4.1 COMPARATIVE ANALYSIS

1. Before, people used methods like looking at specific features or using basic computer programs to find landmarks. These methods worked okay but had trouble with different types of landmarks and places.
More recently, people started using fancy computer programs called CNNs to find landmarks. These programs are better at learning from lots of pictures and can recognize landmarks more accurately.

2. We used CNNs to find landmarks across whole continents. By training our program with lots of different landmark pictures, it got really good at recognizing landmarks from different places and conditions.
We didn't stop at just finding landmarks. Our program also tells you about nearby places like hospitals or schools, making it more useful for people exploring new areas.

3. Compared to older methods, our program is more accurate and faster at finding landmarks. This is because it can learn from lots of pictures and adapt to different situations better.
Our program can handle big datasets and different kinds of landmarks, unlike older methods that might only work in specific places or with certain types of landmarks.

4. Even though our program works well, we need more pictures of landmarks from all over the world to make it even better.
We also want to make our program faster so it can find landmarks in real-time without waiting.

5. CONCLUSIONS

• Our project "Continent-based Geo-Landmark Detection and Recognition using CNN" offers an innovative solution for identifying landmarks worldwide. Leveraging Convolutional Neural Networks (CNNs), our system accurately detects landmarks from user-uploaded images.
• By utilizing CNNs, our system can extract key details like addresses and coordinates, providing users with valuable information. With location-based features, users can effortlessly find nearby amenities, making exploration convenient.
• Our project's holistic approach, incorporating landmark detection, data extraction, and mapping services, ensures its practicality in real-world scenarios. Additionally, its scalability allows it to handle large volumes of data and user requests effectively.
• Overall, our project simplifies landmark identification and enhances geographic awareness. It exemplifies the potential of deep learning and geographic intelligence in improving our understanding of the world.

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