A

Synopsis

on

Restaurant Recommendation using geo-tagged image data generated hotmaps

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by

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1 Introduction

Hot Region detection plays a crucial role in urban traffic planning and analytics. Urban regions have more hot-regions i.e. higher density regions where the traffic is very high comparatively to other regions and this high traffic may lead to congestion and huge delays for the commute. These urban hot regions are not desired or preferred for day-to-day commutors.

Similar is the issue with the people going to restaurants. These days the restaurants are packed with people with a lot of restaurants being full on weekends and some even on the weekdays. This congestion and max capacity of the restaurants causes a huge booking line ranging from a couple minutes to hours which might not be the preferred situation always.

We live in a generation of people who click a lot of pictures and upload them online as well, a lot of these pictures are geotagged and contain the coordinates of the location they were taken at. We propose here, a study on these geotagged images to get the details of the density of the restaurant, to use these details to plot heat-maps to derive a hueristic whether to recommend the restaurant according to users needs or not.

Given a area of size X*Y, our goal is to plot heat maps for N restaurants (each restaurant would have its own images collected as a dataset and the geotags of them used to calculate the co-ordinates and ultimately the heat maps.) based on the number of images i.e. the density of people at the restaurant and clicking pictures there (Note that we have assumed here that images taken at a restaurant are a metric of density at the restaurant. This might not be always true.) We then use these images to calculate the heatmaps based on the frequency of co-ordinates of the particular restaurant N_i caclulated by taking distance Euler's distance between the restaurants centre co-ordinated (predecided) and comparing it with the geo-tagged values. If the distance is less than a particular threshold value t, then the co-ordinate is counted for the heat-mat value of the restaurant.

2 Motivation

In our modern era the way we discover and choose restaurants has undergone a massive transformation, going from word of mouth from our friends, neighbours and relatives to reviews on Google Maps from random peoples the restaurant recommendation market has evolved rapidly.

But this rapid growth led to a downside, with increasing amounts of people going to the restaurants, and more people going to high rated restaurants, there is an all-time high increase in congestion in these restaurants leading to waiting time and at worst cases not getting reservations at all as well.

The traditional restaurant recommendation systems primarily rely on structured data such as user ratings, reviews, and explicit preferences. Even though these sources are informative, they fall short in capturing the nuanced aspects of the dining experience.

Geo-tagged image data, often associated with location-specific ”hotmaps,” can bridge this gap. By tapping into this emerging source of information, we can create a more holistic and visually appealing restaurant recommendation system.

This project thesis aims to harness the power of geo-tagged image data to enhance the accuracy and relevance of restaurant recommendations. We aim to address the following key motivations:

1. Personalised Dining Experience - The ability to choose the threshold of how much crowd the user is okay with, does he want a highly crowded place or a quiet place. The user can thus set the heuristic of how dense or sparse he wants the restaurant crowd to be.

2. Exploration and Discovery: Users can discover new restaurants and places which are not so dense and close to them with great ambiance and environment.

3. Enhanced Decision Making: The incorporation of geo-tagged image data can empower users to make more informed and confident choices as the recommendation is guided by the photos clicked by past users themselves.

So, in short the motivation here is to streamline the restaurant and dining industry from the perspective of clients/users going to these eateries as a customer according to their time/crowd requirements.

3 Literature Review

Author, Year	**Algorithm Used**	**Advantages**	**Disadvantages**	**Accuracy**	**Data set used**	**Remarks**
Dahan Wang, Jianmin Li, Shunzhi Zhu, 2020	**Comprehensive Search**	Simpler Implementation, Full Coverage, Minimises Omissions, In-depth analysis	high complexity, Lack of Focus, Limited relevance	High accuracy because of full coverage and reduced bias	two road networks, Beijing Road Network (BRN) and North America Road Network (NRN)	Choosing Algorithm according to need and context is required for enhanced results.
	Region Search	Efficiency, Targeted Expertise, Contextual Insight	Reduced Generalizability, Potential Bias, Limited Scope	Higher when chosen region aligns with research context else limited in generalised scenarios		A promising approach for finding optimal way for rounting people to destination through crowded regions
Peter Hart, Nils Nilsson, Bertram Raphael, 1968	**A* Search**	Theoretical Foundation, Heuristic Guidance, Consistency Assumption	Theoretical Complexity, Heuristic Selection, Limited Discussion on Algorithm Variants	High accuracy due to solid theoretical foundations and formal mathematical proofs		Helpful for gaining insights above A* and choosing Heuristic for A*

Author, Year	**Algorithm Used**	**Advantages**	**Disadvantages**	**Accuracy**	**Data set used**	**Remarks**
Moataz Medhat ElQadi, Alan Dorin, Adrian Dyer, Martin Burd, Zoe Bukovac, Mani Shrestha, 2017	1) **Machine based image content filter** based on Google reverse image search, 2) **Human expert validation** to classify geo-tagged images	Simplifies the extensive process of data collection by instead using Geo-tagged images from Social Media	Use of common names to describe similar species and misclassification of uploaded images	dependent on the quality of the research methods and data sources, as well as the effectiveness of human validation for image classification.	geo-tagged images from Flickr	The paper provides a methodology for using social media images(Flickr) to supplement for Geo-tagged Images

3.1 COMPREHENSIVE SEARCH

Advantages:

- **Full Coverage:** A comprehensive search aims to cover all possible sources or areas of interest. This approach is essential when you need to ensure that you haven't missed any relevant information. It's often used in systematic reviews, academic research, and critical investigations.
- **Minimizes Omissions:** It helps reduce the risk of overlooking crucial data or information by including a wide range of sources, regions, or perspectives.
- **In-Depth Analysis:** In comprehensive searches, you can delve deep into each source or region to understand it thoroughly, which can be crucial for certain topics or research areas.

Disadvantages:

- **High Complexity:** (for Comprehensive Search) All region pairs have to be evaluated for comprehensive search. Total there are $|Q^2|$ region pairs in total for Q regions. This results in a very high computational complexity which is not really suitable for real-time implementation.
- **Lack of Focus:** A comprehensive search may lack the specificity and focus that a regional search offers.
- **Limited Relevance:** In certain cases, the information from outside a specific region may have limited relevance, making a regional search more efficient and effective.

3.2 The REGION SEARCH

Advantages:

- **Efficiency:** These searches are efficient, as they focus on a specific geographic area or context, reducing the volume of irrelevant data.

- **Targeted Expertise:** They allow experts in a particular region to focus on their specialized knowledge and resources.
- **Contextual Insight:** Region-specific searches often yield data that is particularly informative within a specific context or for localized decision-making.

Disadvantages:

- **Limited Scope:** Region-specific searches may miss out on valuable data from outside the specified region, potentially resulting in omissions or incomplete information.
- **Reduced Generalizability:** The data obtained from a region-specific search may not be easily generalizable to broader contexts, limiting its applicability.
- **Potential Bias:** Depending on the region chosen, there may be a risk of introducing bias into the search results, which can affect the accuracy of the information.

3.3 A* Search

Advantages:

- **Theoretical Foundation**: It provides a solid theoretical foundation for understanding the A* algorithm, including its properties, optimality, and admissibility.
- **Heuristic Guidance:** The article emphasizes the significance of choosing an appropriate heuristic function and how it guides the search efficiently.
- **Consistency Assumption:** The discussion of the consistency assumption helps researchers ensure the validity of their heuristic estimates.

Disadvantages

- **Theoretical Complexity:** The article is highly theoretical, which may make it challenging for readers without a strong mathematical or computer science background to fully grasp.
- **Heuristic Selection:** The article emphasizes the importance of choosing the right heuristic function but does not provide concrete guidance on how to select or design heuristics for specific problems.

- **Limited Discussion on Algorithm Variants:** While the article focuses on the basic A* algorithm, it does not delve into various algorithmic variants or improvements that have been developed over the years.

4 Research Gaps

I. Privacy and Ethical Concerns:

Using images from users to extract the Geo-tagged data raises a ethical concern regarding privacy, consent and security of the user's data. Striking a balance and maintaining the anonymity between the utility and use cases of the data set while maintaining the privacy of the user is a challenge for the research.

II. Bias of Data:

As we are using images to get the geo-tagged data, there might be a bias to a restaurant resulting into more/less image of them taken so that a desired heat-map is generated which wouldn't be ethical according to research standards. Maintaining an unbiased stature and being as fair as possible is necessary for the research.

III. Lack of Comprehensive Datasets:

Availability of diverse and comprehensive i.e. an all inclusive dataset sufficing to at least the minimum needs of the project containing Geo-tagged image samples from various restaurants and time periods is needed for the successful implementation of the project.

IV. Threshold Selection:

Selecting a value that would act as the threshold for guiding the user to the nearest restaurant based on the crowd can turn out to be a hinderance as we would have to figure out if the user should be allowed to have open-ended values or be limited a set of options to select from (i.e. less crowd, medium crowd, highly crowded restaurants).

5 Problem Statement and Objectives

I. The problem lies in the modern dining and restaurant industry. These days the restaurants are heavily rushed and it is next to impossible to find tables at well known restaurants during weekends and some on weekdays as well. While there are other restaurnts which might not have so much crowd. The congested restaurants and the immense associated customer waiting times result in a bad experience for some people while others who go to restaurants to explore and spend time might enjoy being in a somewhat crowded but not congested place. The problem is to guide users to the restaurants near them with approximately the crowd the users would prefer, and to do this in an optimal way.

Objectives:

(a) Develop an adaptable and robust restaurant recommendation system capable of determining and recommending a path from user's present location to the nearest *desired category* of restaurant.

(b) Allow users to contribute data/Geo-tagged images to the dataset to increase the capability and accuracy of the system and the algorithm.

(c) Establish some standardized benchmarks for evaluating the performance of the recognition system, ensuring a consistent and objective measure of its efficiency and reliability.

(d) Intergrate the solution with the current existing research-work to streamline and integrate the research to make the research project more user-friendly thus more usable.

II. Challenges:

(a) Creating the data-set with adequate amount of clear non-noisy images with Geo-tagged information

(b) Choosing the appropriate configuration distances when deciding whether to count the current image in a restaurant' heatmap or not.

(c) Minimizing the overall time requirement, reducing the response time and give users response faster is also a considerable challenge.

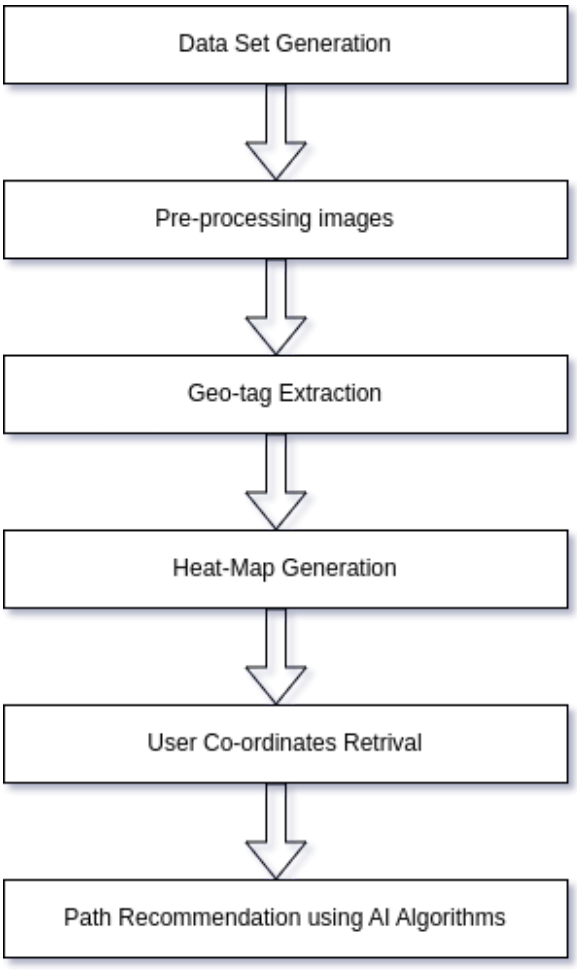

Figure 1: Implementation Steps

6 Methodology

A restaurant recommendation system's development would consist of the following stages (Refer Figure 1):

1. Data-set Genration

   As there is not any database available with the Geo-tagged images of restaurants we had to manually generate the dataset

2. Pre-processing

   Out of all the collected images, we have to remove the not-required images, filter out the noisy data, fill the images which for some reasons do not have the geo tag but are from the restaurant, etc.

3. Geo-tag Extraction

The Geo-tags from all the images are extract here based on the distance from the restaurants they are used to calculate points for heatmaps for the nearest restaurant to them.

4. Heat-Map Generation

   The heat map is generated by using python library. The heat map in this project will have most likely three levels according to the congestion and crowd i.e. Low crowd, medium crowd, highly crowded.

5. User Co-ordinates retrival

   The user will have to give their location permissions from which their co-ordinates would be acquired which will be used to create a path from user to the recommended restaurant.

6. Path Recommendation using AI Algorithms via user specified heuristic

   An AI Algorithm such as A* would be used to determine the good-enough path from the user's location to the recommended destination restaurant.

7 Hardware and Software Requirements

7.1 Hardware Components

- Modern Smartphone with GPS services and Geo-tagging enabled for images.
- Computing Hardware with enough processing power to support Geo-tag processing of large number of images and Heat-map generation based on their frequency distribution.
- Hard Disks and storage devices with ample capacity to store and manage extensive datasets of Geo-tagged images of the restaurants and their locations and also to store user's current location temporarily.

7.2 Software Components

- Programming Language : Python
- Python's libraries :
  - Matplotlib(Genrating Heatmaps)
  - exif(GPS Coordinates extraction)
- Development Tools : Jupyter Notebook
- Version Control Systems: Git and Github for effection Versioning and Collaboration and keeping track of code changes

8 Conclusion

In conclusion, this research project successfully tackles the challenges of restaurant selection in crowded cities like Pune where getting a table can be a nascence. Our comprehensive approach towards the recommendation system of Restaurants based on the crowd preference will help in managing and making better use of people's time by suggesting restaurants which aren't rushed but are good alternatives.

The implementation of this project is significant for saving time of users stuck in commute and waiting due to restaurant congestion. The integration of our system can streamline the process of restaurant table reservation and crowd management in metropolitian regions like Pune city.

In conclusion, the identification of high-density areas within urban landscapes is essential for optimizing traffic flow and improving the dining experience for patrons. The presence of these hot regions, characterized by exceptionally heavy traffic or fully occupied restaurants, can lead to congestion and long wait times, often inconveniencing commuters and diners alike.

This study proposed an innovative approach to tackle these challenges by harnessing the power of geotagged images. In today's era of prolific image sharing, a wealth of user-generated content contains valuable location data. Leveraging this information, we aimed to gauge restaurant density and create heat maps that would serve as a heuristic tool for recommending restaurants based on the preferences and needs of users.

The methodology involved collecting geotagged images from various restaurants, using their location data to determine the frequency of coordinates, and ultimately generating heat maps. The heat maps were computed based on the proximity of the geotagged coordinates to predefined restaurant centers, as determined by the Euclidean distance metric. If a coordinate fell within a specified threshold distance, it contributed to the heat map value for the corresponding restaurant.

This innovative approach has the potential to provide valuable insights into restaurant congestion and traffic patterns, allowing for more informed decision-making when choosing a dining establishment. However, it's important to note that the correlation between image

density and restaurant occupancy is a key assumption in this approach and should be further validated through empirical studies.

9 Timeline Chart

References

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