Introduction

Traffic management is the organization, arrangement, guidance and control of both stationary and moving traffic, including pedestrians, bicyclists and all types of vehicles.

Its aim is to provide for the safe, orderly and efficient movement of persons and goods, and to protect and, where possible, enhance the quality of the local environment on and adjacent to traffic facilities.

This book is an introduction to traffic management, written in laypersons' language, and assuming no background knowledge of the subject.

Various basic traffic characteristics relating to road users, vehicles and roads, and traffic regulation and control, are discussed, including some traffic volume and traffic flow considerations relevant to traffic management.

What is traffic prediction, who needs it, and why is it important?

Traffic prediction means forecasting the volume and density of traffic flow, usually for the purpose of managing vehicle movement, reducing congestion, and generating the optimal (least time- or energy-consuming) route.

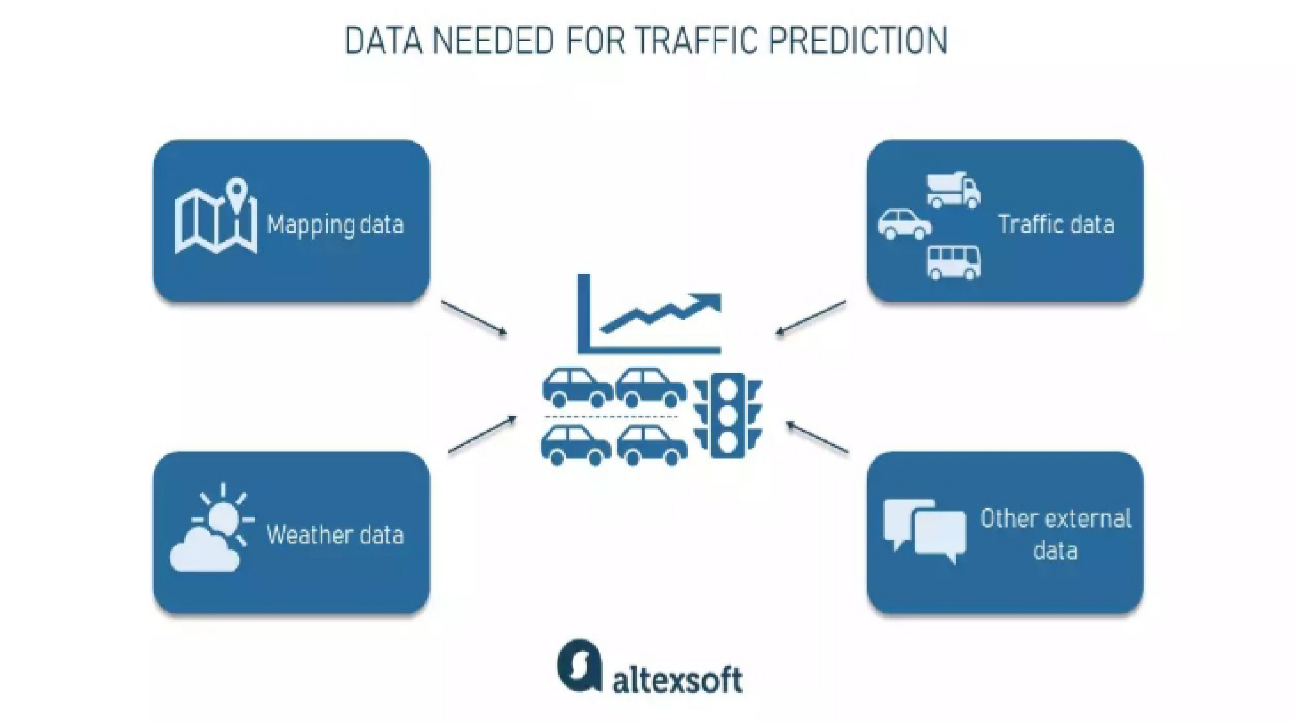
Traffic prediction is mainly important for two groups of organizations (we're not talking about folks planning a weekend getaway, you know).

1. National/local authorities. In the last ten to twenty years, many cities adopted intelligent transportation systems (ITS) that support urban transportation network planning and traffic management. These systems use current traffic information as well as generated predictions to improve transport efficiency and safety by informing users of current road conditions and adjusting road infrastructure (e.g., street lights).

Data types and sources

Traffic is influenced by many factors, and you should consider all of them to make accurate predictions. So, there are several main groups of data that you'll have to obtain.

Mapping data. First of all, you need to have a detailed map with road networks and related attributes. Connecting to such global mapping data providers as Google Maps, TomTom, HERE, or OSM is a great way to obtain complete and up-to-date information.



Traffic information

Then, you'll have to collect both historical and current traffic-related information such as the number of vehicles passing at a certain point, their speed, and type (trucks, light vehicles, etc.). Devices used to collect this data are

- Loop detectors,
- Cameras,
- Weigh in motion sensors, and
- Radars, or other sensor technologies.

Weather information

Weather data (historical, current, and forecasted) is also necessary as meteorological conditions impact the road situation and driving speed. There are lots of weather data providers you can connect to — such as Open Weather.

Additional data on road conditions

There are external data sources that can provide important information that impacts traffic. Think social media posts about sports events in the area, local news about civil protests, or even police scanners about crime scenes, accidents, or road blockages.

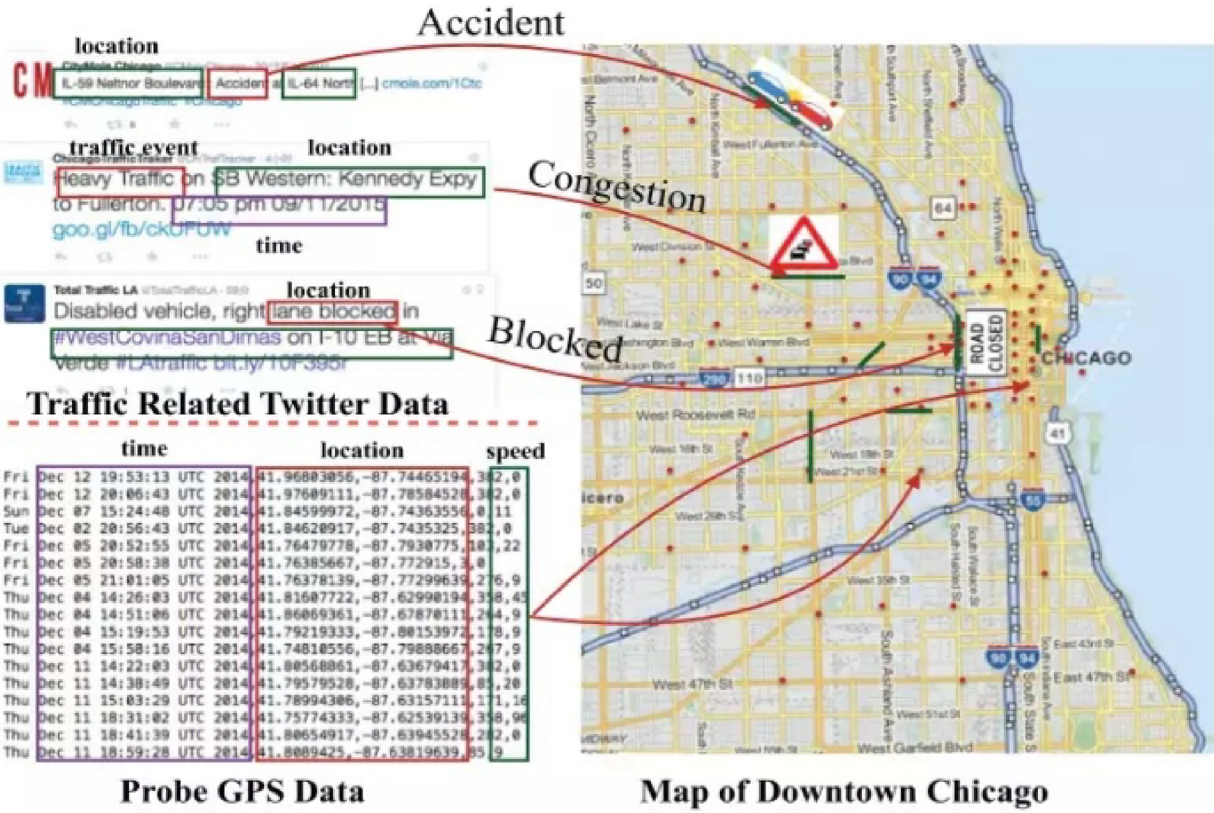


Fig. 1. Illustration of probe GPS data and social media data for traffic monitoring.

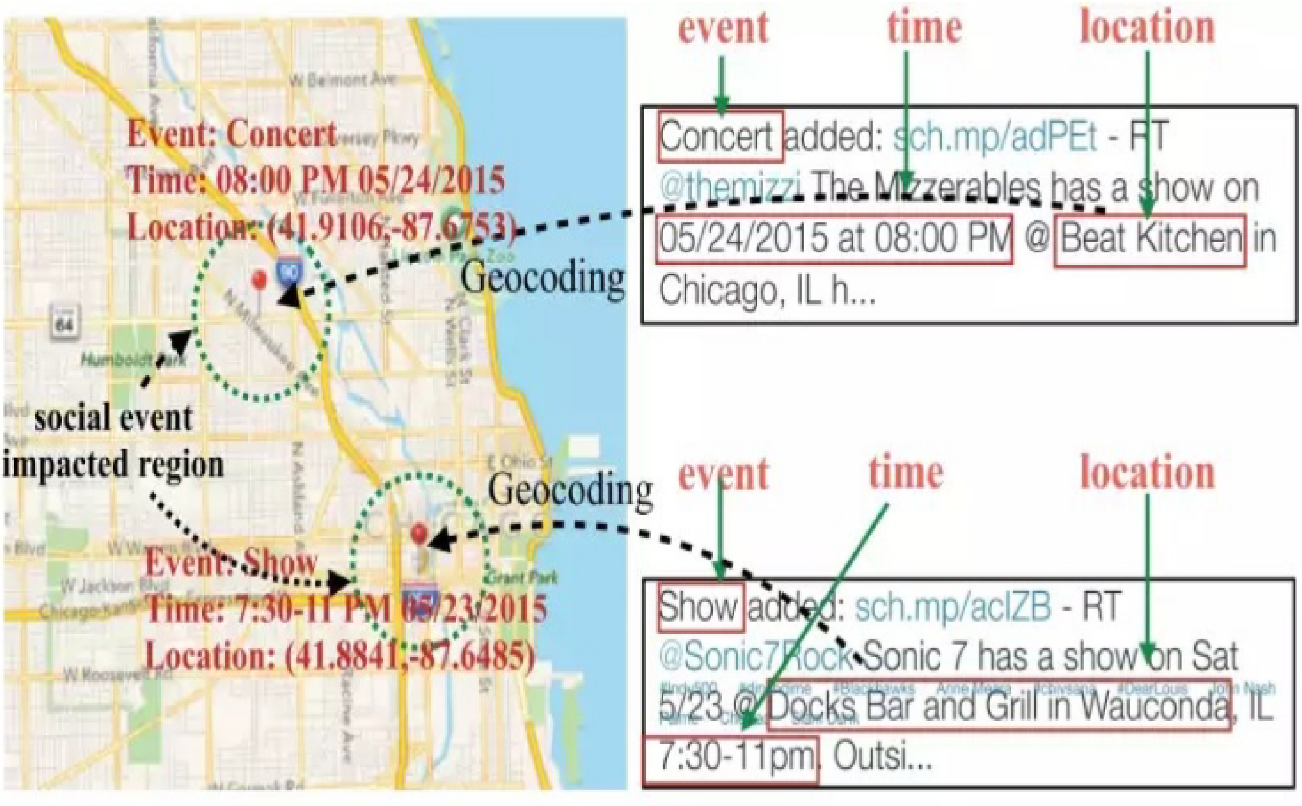
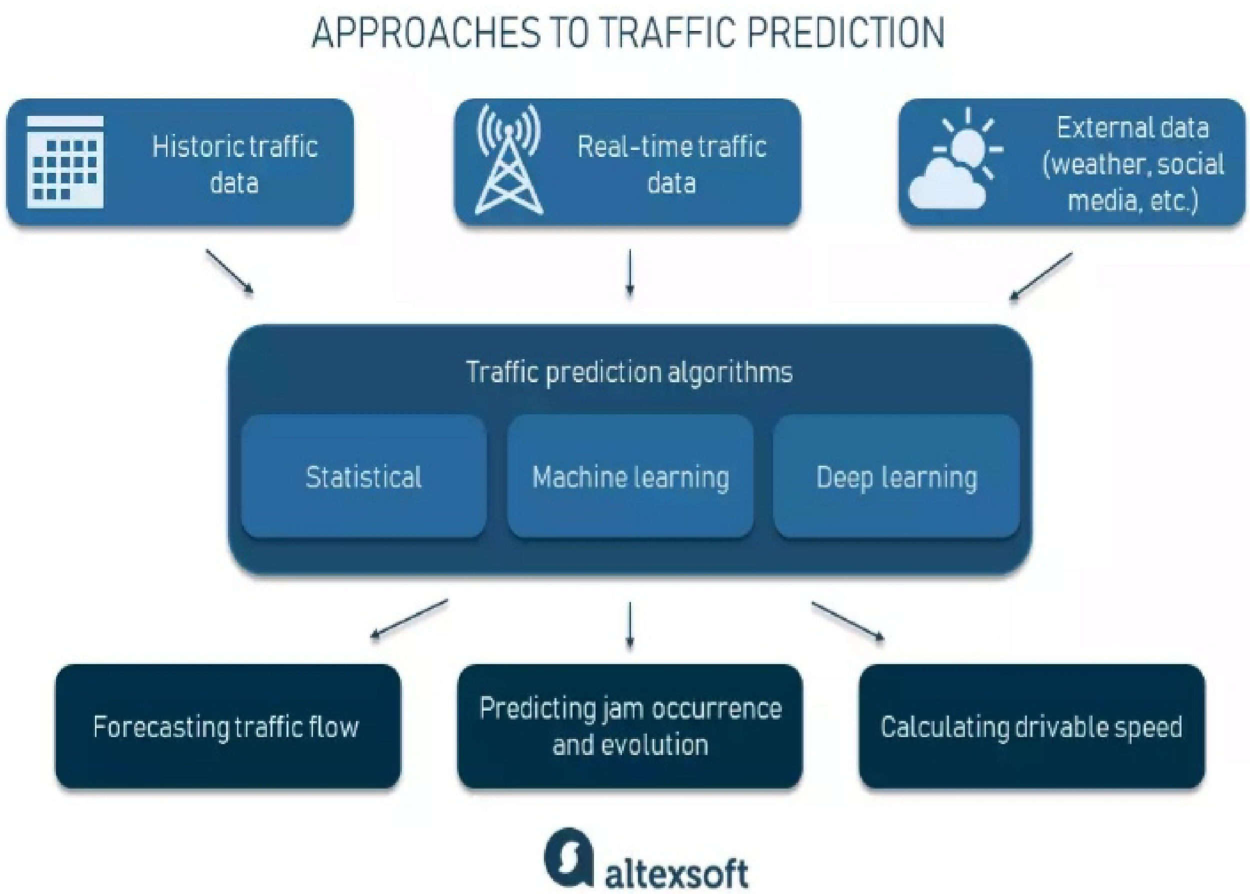


Fig. 3. Social events extraction and geocoding.

Algorithms for generating traffic predictions

Traffic prediction involves forecasting drivable speed on particular road segments, as well as jam occurrence and evolution. Let’s take a look at different approaches to this task.



Statistical approach

Statistical methods allow you to identify traffic patterns at a different scale: during the day, on different days of the week, seasonal, etc. They are usually easier, faster, and cheaper to implement than machine learning ones. However, they are less accurate since they can’t process as much multivariate data.

How to implement traffic prediction

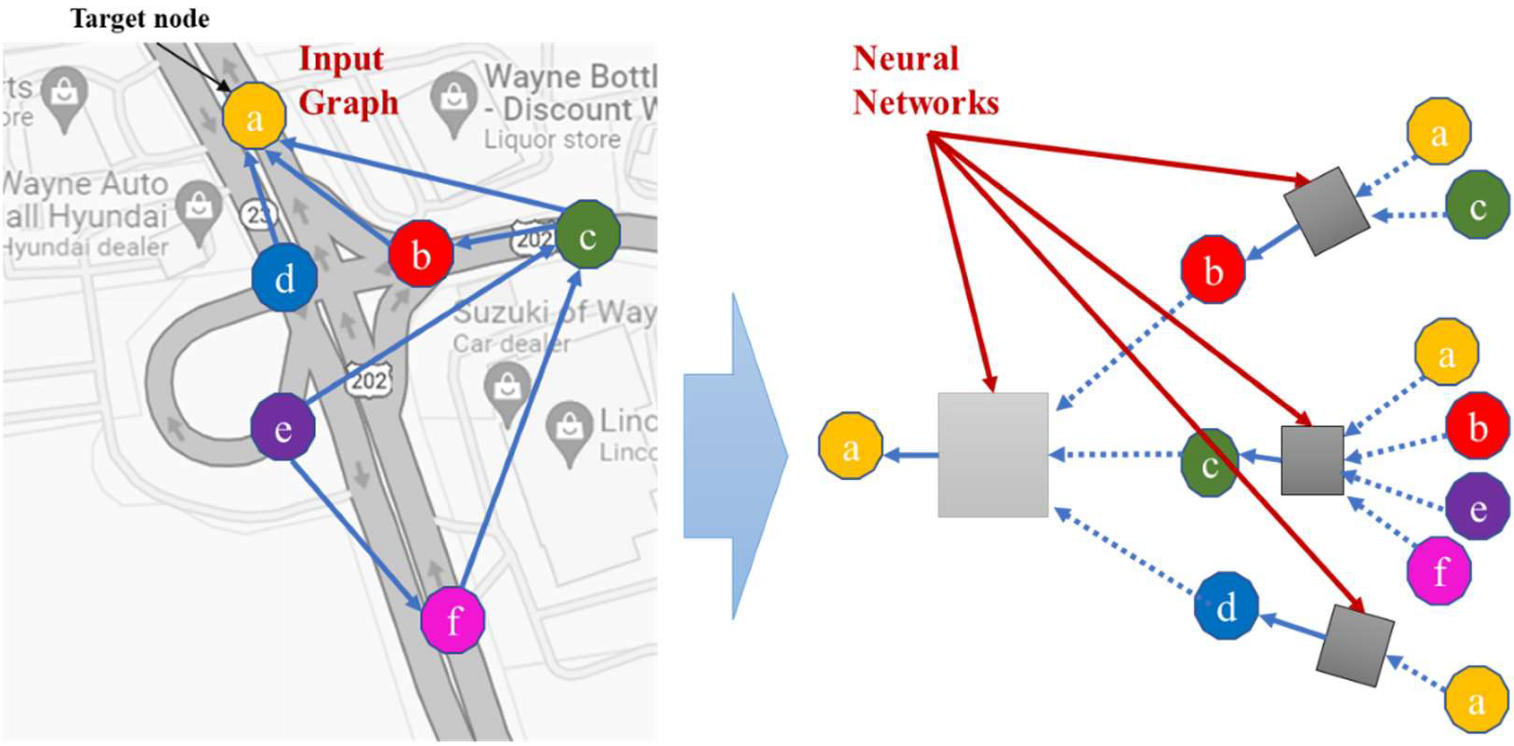
If you run a logistics business, most likely you don't need traffic prediction by itself, but rather its impact on your operations. As we've already mentioned, accurate prediction is important for routing and scheduling purposes. If this is the case, there are three main ways to get those forecasts and build optimal routes (check our related article for more ideas and information).

Off-the-shelf solutions

There are lots of ready-made software solutions on the market developed for any type of business. If your company is small or medium-sized and your operations (be it field service, last-mile delivery, taxi, moving, or long-haul transportation) are more or less standardized, you can find a tool that meets your needs and has routing capabilities to support your business activities.

HMM-based map matching
Input: taxi trajectory point sequence, $O=(o_1,o_2,\dots,o_N)$�=(�1,�2,…,��)
Output: optimal matching point sequence, $\text{optimal path}=(r_1,r_2,\dots,r_N)$optimal path=(�1,�2,…,��)
1. Use a list V� to store information for each state, including joint probability, parent node number, and node coordinates corresponding to the parent node number
2. Use optimalpathoptimalpath to store the set of optimal matching points after backtracking
3. Use $\text{radic}$and set to store the observation probability and the corresponding candidate matching point coordinates and obtain and initialize the candicandi set when i equals 0
4. For $i=1$�=1 to $N-1$�−1
5. Obtain a set of first candidate lastcandilastcandi matching points corresponding to o_{i-1}��−1 and calculate an observation probability

HMM-based map matching
6. Obtain a set of second candidate $candi$candi matching points corresponding to o_i�� and calculate an observation probability
7. For each matching point r_j�� in $candi$candi
8. For each matching point r_k�� in $lastcandi$lastcandi
9. Calculate the transition probability $P_t(r_k,r_j)$��(��,��)
10. Calculate $V[i][j][prob]=P_j(o_i/r_j)\max_{r_j\in lastcandi}\{P_t(r_k,r_j)\cdot V[i-1][k]["prob"]\}$�[�][�][prob]=��(��/��)max��∈lastcandi{��(��,��)·�[�−1][�]["prob"]}
11. $r=\mathrm{argmax}_{r_j\in candi}\{P_t(r_k,r_j)\cdot V[i-1][k]["prob"]\}$�=argmax��∈candi{��(��,��)·�[�−1][�]["prob"]}
12. $V[i][j]["prev"]=r$�[�][�]["prev"]=� // Save the point with the highest joint probability to list *V*
13. $optimalpath[N-1]=\mathrm{argmax}_{1\leqslant l\leqslant len(V[N-1])}\{V[N-1][l]["prob"]\}$optimalpath[�−1]=argmax1⩽�⩽len(�[�−1]){�[�−1][�]["prob"]} // Find the matching point with the highest joint probability and trace back from that point
14. For $i=N-2$�=�−2 to $1$1
15. $optimalpath[i]=V[i+1][optimalpath[i+$


Target node
Input Graph
Neural Networks
Liquor store
Car dealer