Travel demand corridors: Modelling approach and relevance in the planning process

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A B S T R A C T

In an ideal world, transportation networks and services would be adapted to the specific travel needs of each individual and would perfectly fit the corresponding desire lines (direct lines between origin and destination points). However, in practice, networks cannot be designed to accommodate each individual trip. Still, it is possible to optimize transportation systems from a collective demand point of view. To move from an individual to a collective scale, individual demands need to be encapsulated into demand corridors. Although current spatial tools and data mining techniques are able to identify corridors from numerous movements by using linear or non-linear trajectory data, their limitations—from a transportation point of view—include the use of non-intuitive parameters and the application of some aggregation processes that make it difficult to retrace the attributes of individual input data that could benefit the richness of the available data after processing. For that reason, we propose a new algorithm called Trajectory Clustering for Desire Lines (TraClus-DL), which can identify corridors from Origin-Destination (OD) information with simple parameters, such as spatial location, angles between lines, and sampling weights. The functionality of TraClus-DL as a diagnostic tool for transportation supply was assessed and tested using data from the 2013 OD travel survey conducted in the Montreal area. The sensitivity of the results, with respect to parameter settings, was evaluated, and a comparison with an existing algorithm was proposed. The results of this study demonstrate that transportation specialists can benefit from the convenience of using TraClus-DL as a corridor identification tool, which includes its potential to perform deep analyses at the corridor level. In addition, this study provides new insights into the possible uses of demand corridors as relevant tools for transportation planning, and in the decision-making processes in which a neutral reference is needed to evaluate how much the transportation supply differs from the collective travel demand.

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1. Introduction

In a historical review of urban transportation planning, Weiner (2012) has noted that in the early 1950s network characteristics and travel volume became insufficient for effective transportation planning in complex areas such as urban zones. As a result, data collection methods were developed—for example, Origin-Destination (OD) surveys—and the collected information was analyzed to recognize travel patterns and factors that affected urban movements. By the mid-1950s, >100 OD surveys already had been conducted in American metropolitan areas (Weiner, 2012). Since then, OD data have become valuable resources for providing a clear picture of mobility patterns at both the individual and collective scale, and a great deal of research has been carried out in transportation planning and decision the making processes using the OD survey data. In the past, a lot of research relied solely on aggregated data due to the complexity of data processing with the available tools and the time required; consequently, the methods used did not benefit from the richness of the available data, and the results were limited accordingly. Nevertheless, powerful tools and methods were proposed to handle large sets of micro-data, such as spatial analysis tools (Morency, 2006) and data mining methods (Rao et al., 2011; Guo and Zhu, 2014).

Many researchers have benefited from these advances to better understand mobility and improve their studies using OD data. Some have aimed to improve transportation services (Jara-Díaz et al., 2008) and to assess service accessibility (Jiang et al., 2012), whereas others have used OD data to simply visualize large amounts of disaggregated data (Bahbouh and Morency, 2014).

Any OD survey set carries basic information about individual trips through the origin and destination points. The direct line connecting the origin and destination points represents the theoretical shortest

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path for an individual, which is called a desire line (Weiner, 2012). Since
the transportation supply usually is designed to fulfill collective de-
mand, individual travels need to be synthesized to a collective scale.
Methodologically speaking, this means that desire lines need to be ag-
gregated into corridors in which a corridor can be seen as a “watershed”
gathering together similar individual trips (Smith, 1999). Therefore, the
identification of corridors from desire lines is a way to identify optimal
collective axes where desire lines are encapsulated to form what we
can call demand corridors.

Since most of the research regarding corridor definition relies on the
presence of physical infrastructures and land use (Chapman et al., 2003;
Priemus and Zonneveld, 2003; Reggiani et al., 1995), the optimal mobi-
licity axes that reflect collective demand may not always be
detected. Only a few studies on identifying corridors using the observed
demand are included in the literature. For example, Liu et al. (1996) pro-
posed a model to identify rail corridor locations based on pre-defined
paths and OD data using an optimization cost approach to adjust corri-
dor locations. Other studies (Clark and Oxley, 1991; Moorethy, 1997)
have used an OD matrix and a predefined intra-zonal spider web net-
work to identify corridors. In more recent studies, to minimize costs
for both users and operators, Verma et al. (2011) proposed a framework
to identify transit corridors based on OD data, road networks, Geograph-
ic Information Systems (GIS), and optimization algorithms; whereas
Rao et al. (2011) identified urban transportation corridors using aggre-
gated OD data and a data-mining method.

In the available literature, we observed two recurring elements: the
use of processed data to simplify the complexity of OD sets, and the use
of a pre-identified network and optimization techniques to adjust corri-
dor location. Most of those optimization techniques rely on operational
concepts such as optimizing travel distance or travel time.

In a different context, Lee et al. (2007) proposed a framework called
Trajectory Clustering (TraClus) to identify animal and hurricane corridors.
Bahbouh and Morency (2014) tested the potential of using TraClus to
identify corridors from desire lines only, and although they proposed
some interesting results, they also highlighted the difficulties inherent
in the direct application of TraClus to transportation problems. These
difficulties are related to parameter definitions and the mismatch of
the TraClus process to desire line features. In fact, TraClus parameters
are not easy to select and interpret, since they are formulated using com-
posite distance equations. In addition, the framework does not directly sup-
port some of the desire line features, such as direction or sampling weight.

One of the main objectives of the present study is to contribute to the
limited existing literature by proposing a well-defined method and prac-
tice to define and identify corridors from demand. Furthermore, this
study highlights some of the potential benefits of using demand corridors
to assess the adequacy of transportation supply with respect to demand.

To identify demand corridors, we propose an improved process of
trajectory clustering called Trajectory Clustering for Desire Lines
(TraClus-DL), which has been adapted to identify demand corridors from
desire lines. The functionality of TraClus-DL as a diagnostic tool
for transportation needs was tested using a set of data from the greater
Montreal OD survey.

The remainder of this study is organized as follows. Section 2 pro-
vides a general corridor classification and a brief definition of some cor-
rridor features that were used to design the TraClus-DL algorithm.
Section 3 presents the demand corridor identification algorithm
(TraClus-DL), and Section 4 demonstrates the functionality of TraClus-
DL and the possible implementation of the demand corridor concept
through two case studies. Section 5 examines the impacts of various pa-
rameters, and Sections 6 and 7 discuss the advantages and limitations of
using TraClus-DL, and provide a general conclusion.

2. Transportation corridors

Transportation corridors can be classified mainly into supply corri-
dors and demand corridors. Whereas supply corridors are identified
based on transportation supply elements and characteristics such as
services, location, and capacity; demand corridors typically are identi-
fied based on transportation demand elements, without the direct influ-
ence of any administrative or environmental constraints. Supply
corridors can be used in long-range transportation planning and the de-
cision-making processes (Carr et al., 2010; Smith, 1999), and demand
corridors can be used as a reference comparison unit in decision-making
processes to diagnose and evaluate how much the transportation sup-
ply differs from the travel demand.

Desire lines are a simple way to represent demand; therefore, direct-
ly identifying corridors from desire lines leads to identifying the corri-
dors that most closely match the demand.

A summary of the main corridor features is an essential step in de-
signing an algorithm that can identify corridors from desire lines. We
build on the transportation literature (Carr et al., 2010; Smith, 1999;
Reiss et al., 2006) that describes corridors as dynamic and linear zones
with a high trip concentration. In the following paragraphs, we clarify
the main corridor features used in the proposed algorithm.

As a starting point, a minimum number of trips is required to identify
the corridor zone that is characterized by a high trip concentration. This
minimum requirement is highly associated with the study objectives and
corridor typology. For example, identifying demand corridors for poten-
tial transit services may require more trips than identifying pedestrian
demand corridors.

The dynamic feature of a corridor refers to the possibility of changing
the corridor structure (direction, length, position, etc.) based on mobility
variables, such as trip distance, start time, commuter’s gender, income,
etc. Consequently, it is possible, based on these variables, to identify dif-
f erent corridors from the same data set in the same territory (e.g., rush
hour or nighttime corridors, students and professionals’ corridors, etc.).

The linearity feature is defined by Reiss et al. (2006) as “the sense of a
particular cardinal direction.” With respect to a demand corridor derived
from desire lines, a variable or an equation can be used to measure the
similarity of the directions. We propose to use the angle of desire lines
to determine if two lines belong to the same corridor or not. Our hy-
pothesis, illustrated in Fig. 1, presumes that two lines with angles dif-
fering by 90° or more absolutely belong to different corridors. Corridors act
as travel-sheds and tend to gather desire lines from each side of their axes,
so the maximum angle between the travel-shed axis and desire lines
should not be >22.5°.

Finally, corridors are seen as zones in which similar trips (desire
lines) are encapsulated together. These zones are defined by their lo-
cation, length and width. Thus, a corridor will continue as long as a suffi-
cient number of similar trips are present, and it may be characterized
by a minimum length. The width of a zone, called the influence width,
may vary depending on many factors such as topographical or commut-
er characteristics. The literature provides various examples linking corri-
dor widths to trip modes; for example, pedestrian or cycling corridors
can have widths up to 100 m, transit corridors can have widths up to
2 km, and international trade corridors can have widths in the 10s of
kilometers. Furthermore, some studies have proposed assigning an ap-
proximate width instead of a fixed one, since corridor width should be
able to increase slightly to include nearby similar trips (Reiss et al.,
2006; Vermont Agency of Transportation, 2005).

![Fig. 1. Maximum angle between the main corridor path and desire lines.](image-url)
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