**The Original Huff Model**

The original Huff Model (Huff, 1964) is designed to estimate the probability of customers at each origin patronizing a given store among all stores as their destination choices. Two factors into account: **1. Attractiveness 2. Distance.** Attractiveness can be computed as a function of many attributes of a store, including the store size, number of parking spaces, customer reviews,

etc.

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**Pij** represents the probability of a customer at location **i** visiting store **j**; **Aj** is the measure of attractiveness of store **j**;**Dij** is the distance between location **i** and store **j**; and **n** indicates the total number of stores in the data set. The parameters **α** and ***β*** (**α** >0, ***β*** <0) are associated with the attractiveness and distance factors.

**Socially Aware Huff Model**

A socially aware Huff model include **social factor and neighboring effect**, based on the assumptions that: (1) People tend to choose more attractive travel destinations; (2) People tend to

choose closer travel destinations; (3) People tend to choose travel destinations with more beneficial future choices.

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where **Pijt** represents the probability of a tourist at location **i** visiting attraction **j** at time t; **Ajt** is the attractiveness of attraction **j** at time t; **Dij** is the distance between origin **i** and attraction **j**; **Cjt** is the term used to describe the neighboring effect of attraction **j**, relative to other attractions at time **t**; and **n** indicates the total number of attractions in the area. The parameters **α, β**

and **Ө** are associated with the attractiveness, distance, and neighboring effect factors, respectively.

Here is how we will quantify the three terms, i.e., **Ajt, Djt, and Cjt**, mathematically. The three types of attractiveness A(l)jt , l = 1;2;3, can be expressed as below. In our case, we will mainly use the second equation as we have number of users from SafeGraph dataset. The other two ways of getting data from social media photos could be considered as complementary solutions.

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where Mjt is the number of photos at attraction j at time t.

Text

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where **Ujt** is the number of unique users at attraction j at time t.

Diagram, text, schematic

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where Vkjt is the number of views for photo k at attraction j at time t. We use the product of the number of photos and the average number of photo views per user at attraction j to include a social influence factor. Given the fact that social media influencers (SMIs) have more

followers than others, thus the photos they post would have more views and greater social impact, we include photo views per user here to account for potential existence of SMIs who upload photos at an attraction. We hypothesize that the attraction with more photo views per user is more attractive.

The term **Cjt**, measuring the neighboring effect, can be modeled as:

A picture containing text, antenna

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where **K** is the total number of nearest neighboring attractions being considered. **Cjt** reflects the assumption that people tend to travel to places with more promising future choices in a multi-destination trip. We consider **K-nearest** neighbors of attraction **j**, calculating their attractiveness **A(l) kt** at time period t, and weight **A(l) kt** by their distance to attraction **j,Dkj** . A higher **Cjt**

value is assigned to attractions with closer and more attractive neighbors. Finally, we define the term **Dij** as the estimated distance from SafeGraph dataset.

**Calibration Method**

Parameters of the Huff model need to be calibrated before further studying the travel patterns. We can use the linear regression calibration method – **Ordinary Least Squares (OLS), which estimates one set of parameters α, β and Ө, that best fit the model based on observations.**

To conduct OLS, the socially aware Huff model in Eq. 2 is rewritten in a log-transformed-centered form, according to Nakanishi and Cooper (1974**), in order to obtain the least square estimate of parameters.**

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where P~it, A~jt, D~i and, C~t are the means of Pijt; Ajt; Dij and Cjt over attraction j, respectively. **For each origin attraction i, the model will estimate one best fit parameter set (α, β and Ө).**

To examine the overall performance of the temporal factor and neighboring effect in the **socially aware Huff model (SA model**), we compare it with SA model without the neighboring effect (**SA model w/o N**), SA model without the temporal factor (**SA model w/o T**), and the original Huff model (**Huff model**), whose results are shown in Tab.

Table

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**Visualizing Visitation Data from SafeGraph**

**Figure 1.** Daily visitation at six U.S. national parks in 2019 (blue) and 2020 (gold) based on data from SafeGraph’s Social Distancing Metric dataset.

**Chart, histogram

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**Figure 2**. Correlation between monthly visitation estimates (2019 and 2020) of U.S. National Park Service data and values

derived from the SafeGraph Social Distancing Metrics dataset.

**Chart, scatter chart

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**Figure 5**. Comparison of visitation flows for three months in 2019 and 2020 at Zion NP and Grand Canyon NP. The maps

were generated using Kepler.gl.

**Background pattern

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