Agent Based Modeling For Optimization in Retail Store Layout

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Introduction

Despite the fact that online retail prevails even rapidly due to the pandemic, according to the public survey, real experience in store is nonetheless popular. To keep its popularity and offers the satisfying experience to customers, data science is inevitable in retail industry too. Many companies and startups use Artificial Intelligence to augments edge devices such as web camera beyond its image capturing capacity to face detection, attribute analysis, object tracking etc… These features allows retail companies to collect various data to be used for customer segmentation.

However, numerous obstacles still remains for this approach such as computational power and its accuracy to fully harness Artificial Intelligence. Moreover, Algorithm bias is widely known as a controversial subject. Therefore, expanding data science ability and find an alternative solution is the reasonable decision at this moment.

Based on these background, I decided to make a simulation of customer behavior in the store. I start by making an simulation of people in the store. Then I focus on the optimization for store's layout as a common practice of data science for the retail industry.

Main motivation is to observe the potential usage of the simulation model in addition to the logical rule base-model.

Purpose

As I've explained little in the introduction, the main motivation is to see the usage of the agent based modeling for the retail insight. This study strives to incorporate popularity of real retail experiences by analyzing customer's purchasing behavior to find the best layout in store. This study is an agent based modeling simulation and practical usage can be possible after the verification with real data.

Entities, state variables, and scales

Agents (Who): Customer in the store
Environments (Where): Store
Major variables (What): Store shelve, POP, Pickup&Exit Point, Agent attributes, global factors
Major rules (How): Customer behavior, step size

Definition:

Customers

1000 customers with various attributes such as age, gender, occupations. This information can be retrieved from the real *POS data

*POS(point) of sales refer to the information collected from a store's payment system. This could be anything from data regarding repeat sales, time of sale, merchandise purchased and even geographic location and demographic data.

Store

This can be any setting although in my study, I make an assumption that the store is the pharmacy. As many of stores run by big companies has its similarity to some extent, I suppose this study can be applicable to any sort of retail stores with small modification of parameters in each variable.

Store Shelve
Shelve where products are placed.

The point of purchase(POP)
The area in which marketers and retailers plan promotional activities surrounding the consumer products. POP can be placed on the store either by random or by manual

Pickup&Exit Point
These points are scattered with respect to the layout of store shelve. Pickup is the point where the purchasing also occurs with the certain probability given.

Agent Attribute
Agent attribute can be one's age, gender, occupation etc…

Global factors
This is the external variable which influences customer's purchasing. Global factors give one deeper dimension which allows our model have parallel scenario based on their external force. As an example, recent pandemic causes the new norm which is wearing a mask. This skyrocket the demand for mask in stores and therefore, it is obvious to incorporate this trend in the model.

Time
Time can be one of the measurement to evaluate each model's performance. It goes until all agents reach their respective pickup&exit point.

Process overview and scheduling
Categories dealt in the study range from medicine, health food, Hygiene products, cosmetics, hair care, body care products, deodorant, snacks, alcohol, Tabaco, etc.. This is based on the assumption that this study is implemented in a pharmacy.
Customer attributes, POP, and Global factors increase the certain probability of one's purchasing products. This seems rather arbitrary but the empirical study such as purchasing history could be utilized to measure the magnitude of increase of probability of each product. Every step can also incorporate the notion of time by approximately making a inference from real data.

Emergence What emerges from the model rather than being imposed?
Measurement time and the total amount of purchased products(and its categories).
The potential emergence could be the empirical pattern of customer behavior based on the environment and respective conditions.

Objectives Do agents have objectives?
Agent objective is reaching their assigned pickup&exit points where they pickup(purchase) a product with certain probability. Once the agent do the pickup action they start moving toward next pickup&exit position. If agent have no more subsequent pickup&exit point, they exit the simulation at the last pickup&exit point

Adaptation How do agents adapt to reach their objective?
Agents with stochastically assigned pickup&exit points walk around store by talking different path which is again stochastically decided.

Learning
Memory, Environmental ques, Embedded assumption
Agent encountered with POP increases its probability of purchasing(pickup)

Prediction How agents predict consequences of their decisions?
There is no prediction ability in the agent.

Sensing What agents need to know for making decision?
Sensing other agents and environment
Agent can spot POP on their track of in the store. Those who have recognized POP are subject to the increase of its purchasing probability

Interactions How agent interact with other agents and environment?
Each agent is independent, therefore no interaction between agent.

Stochasticity What is stochastic and why?
The number of spots agent visits and their probability of purchasing can be stochastically decided. As for the probability of purchasing, this stochastic probability become the baseline and would be increased or decreased based on the additional effect from variables.

Collectives What are specific groups of agents?
People are individual visitor and therefore, no specific collectiveness among the agent. However, there are some possibilities to inject the notion of collectiveness as variables such as trend of products or some phenomenon at a large scale such as earthquake and pandemic.

Observation Which data is collected and how?
Time and total amount of purchased products are observed in each simulation.
Potential data which can be obtained is the customer's purchasing behavior based on the layout of the store. For example, the interest can be the duration of shopping and customer's purchasing. As POP increases the probability of purchasing, the purchasing rate must increase accordingly. This rate can be used again to analyze the trade-off with total duration of simulation time(time customers take to finish their purchase).

Initialization

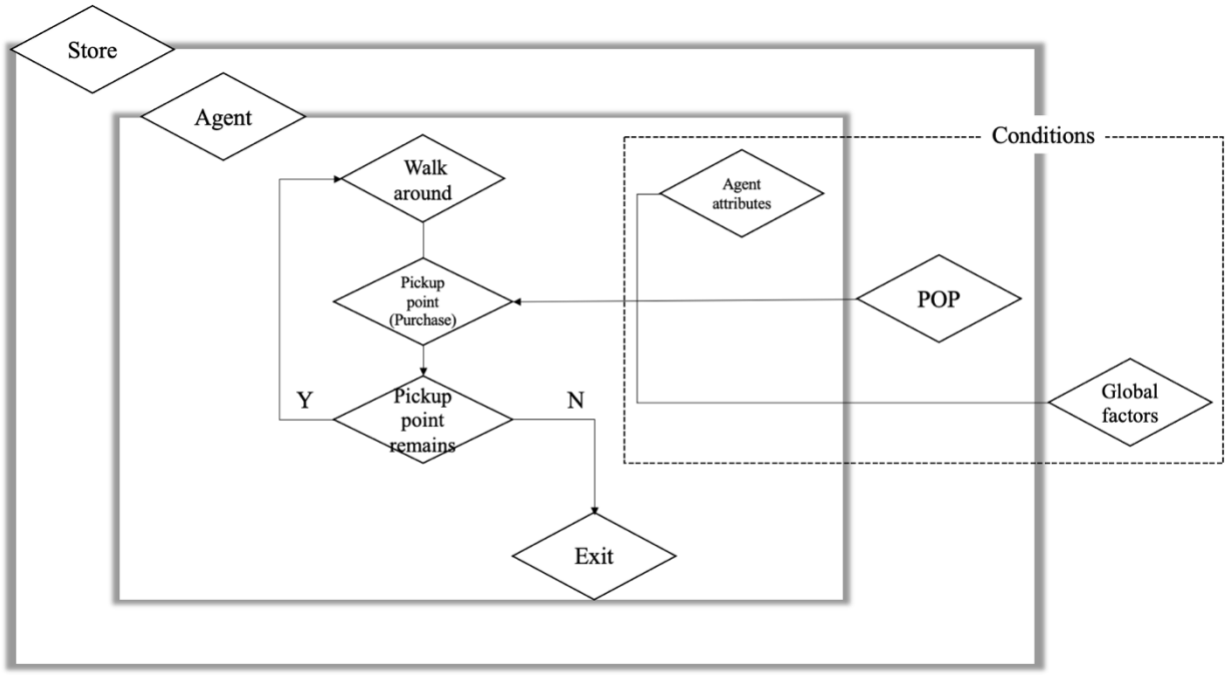
1. Prepare 1000 customers with various attributes such as age, gender, occupations ,which are ideally normally distributed or at least obtained from real observations.
2. Deploy store's shelve in a way that layout is distinct each other in every time.
3. Give each customer around 1 to 4 pickup&exit points randomly. After that, set the global factor that might increase or decrease the probability of purchasing of certain products and assign those probabilities on top of the baseline accordingly
4. Randomly or manually set arbitrary number of POP on the store
5. Set step size(usually 1) and simulate until all customers exit store(finish pickup)

Analysis

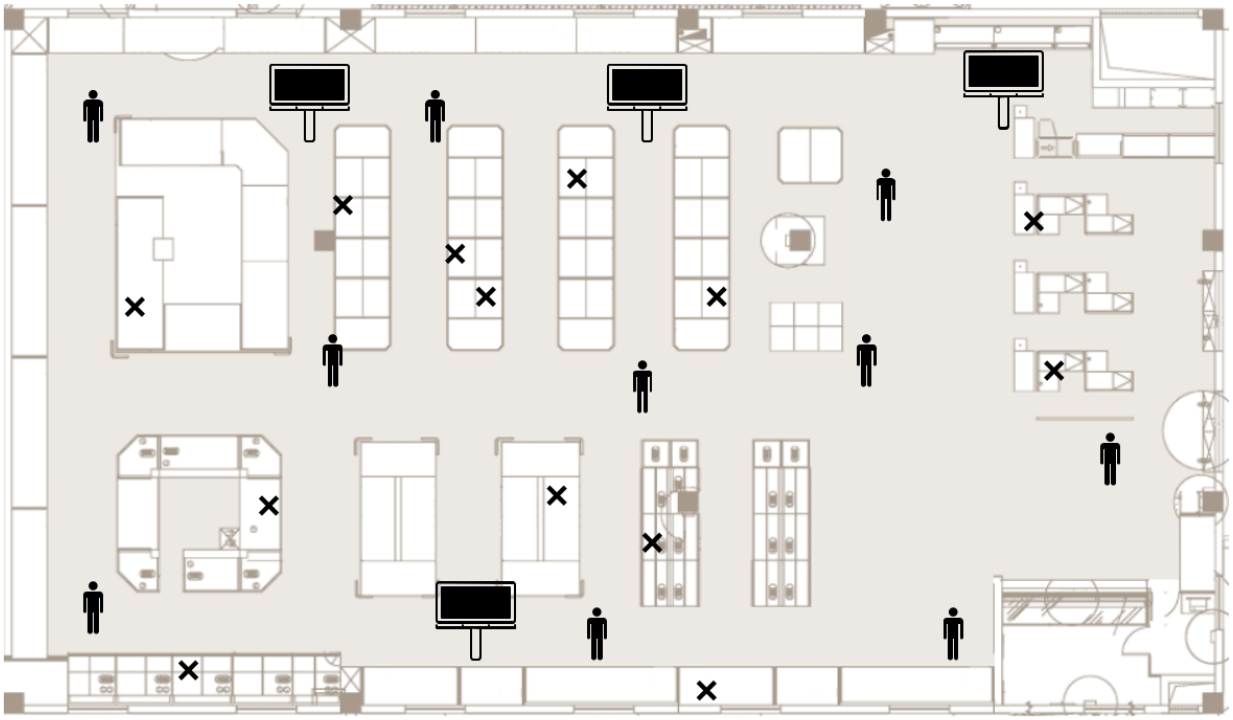
6. Prepare the real data obtained from the survey or previous history data in the store
7. Evaluate time and the number of purchasing products(categories of them)
8. Try with the different layout and conditions and compare the evaluation results

I make tons of explicit and implicit assumptions to facilitate this model, some of which are quite deterministic. This is against the goal of the estimation which is the expected value of the outcome given various choices as too many assumptions narrows down the range of choices. With less variable, this model can potentially work as good as the one with more variables.

Flow Chart



2D Map



Agent

POP(Point of Purchase)

× Pickup&Exit Point