Demand Forecasting at Alabama Food Pantries Using Machine Learning Methods

Yin Sun

Dept. ECE, Auburn University
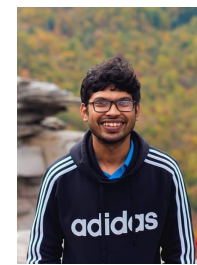
Joint work with

Rui Chen
Tuskegee

Thomas Orrison
Auburn

Md Kamran Chowdhury Shisher
Auburn

Auburn United Methodist Church (AUMC) Food Pantry

- Each client will get
  - Two boxes: perishable and non-perishable food
  - More choices: cans, snacks, bread, fruit, vegetable
  - Even more: toothpaste, roll paper, second-hand clothes
  - Volunteers help to bring food to car (50-70 lbs)
- Warm-hearted people! Strive to provide the best experience to clients!

# Concerns of Alabama Food Pantries: How Many People Will Come?

- Staff and volunteers of the food pantries shared two key concerns
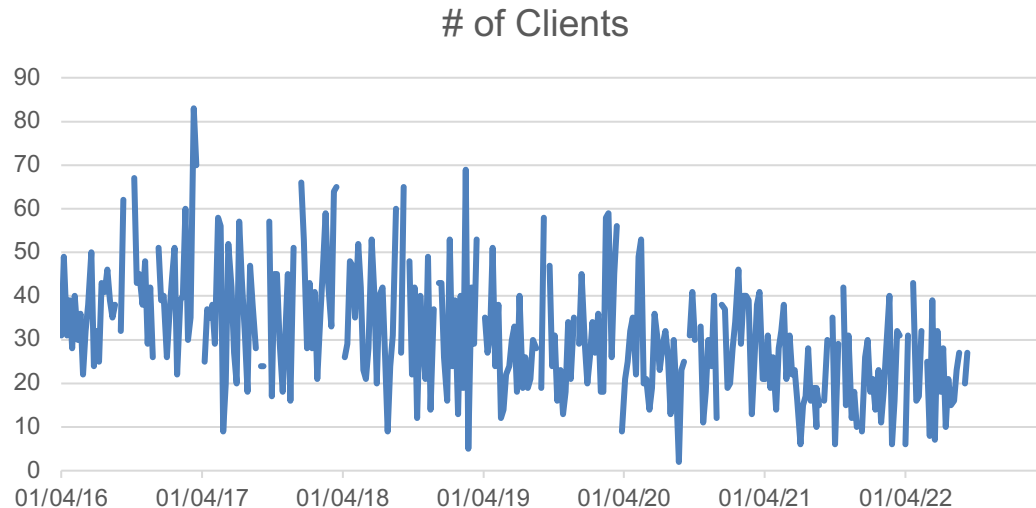
# of Clients

# of Clients at Lakeview Baptist Food Pantry

- **Concern 1:** Number of client visits varies dynamically week by week
  - Food waste and food shortage
  - Difficult to manage food supply chain (order, ship, storage)
  - Difficult to provide fresh, nutritional food

Concerns of Alabama Food Pantries: Fewer People are Coming

of Clients

Pre-Covid | Post-Covid

Lakeview Baptist Food Pantry

# of Clients

Pre-Covid | Post-Covid
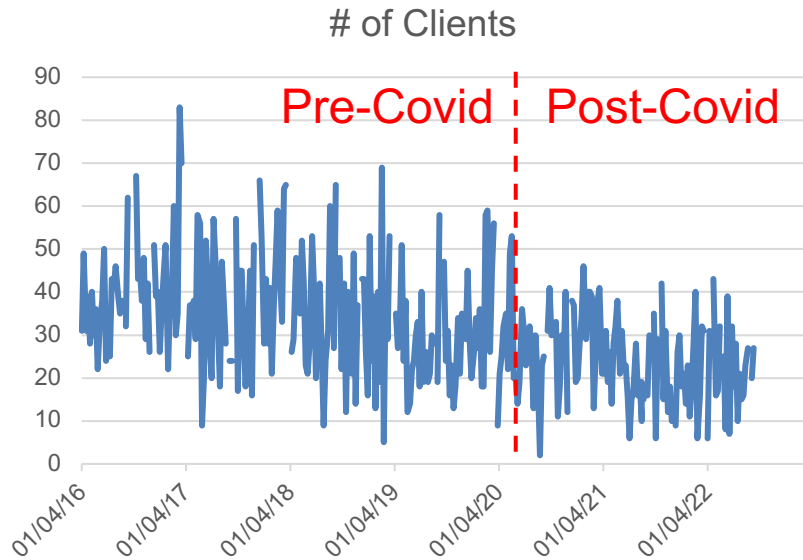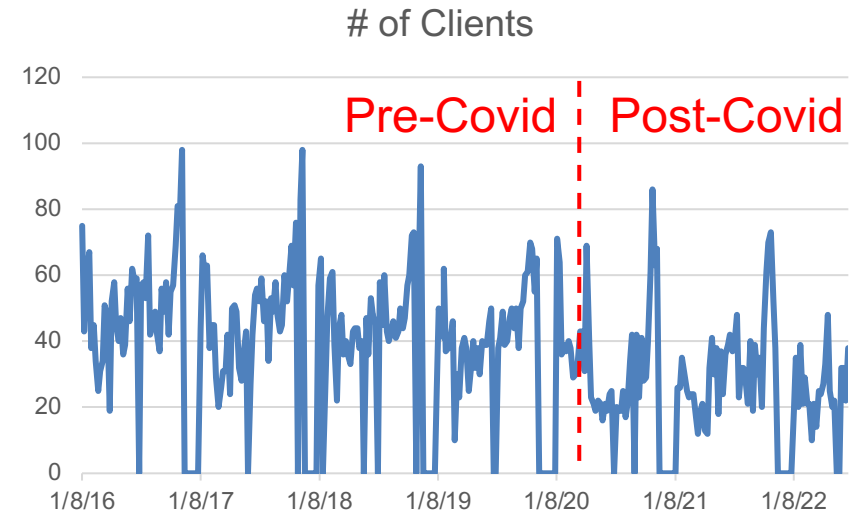
AUMC Food Pantry

- **Concern 2**: Average Visits have dropped 30%-50% since the Covid-19 pandemic started
  - Service facilities, human resources, and funds are underutilized
  - This drop has been continuing …

Our Initial Efforts to Help Food Pantries

- Develop machine learning algorithms to predict weekly food demand (# of client visits)

  - Data Collection
  - Machine Learning Algorithms
  - Performance Improvement

Data Collection

- Goal: Predict the number of client visits next week, based on data from 4 most recent weeks

- Data from food pantries (with IRB): Weekly # Client Visits
  - Lakeview: 1/8/16 - 6/24/22, AUMC: 1/4/16 - 6/27/22
  - 336 data points (336 weeks)

- Socioeconomic data:
  - Unemployment rate
  - # School opening days in a week
  - Average personal income
  - # SNAP Benefits Recipients
  - Consumer Price Index (CPI)
  - Weather (Temperature, Rain)
  - …

Seven Machine Learning Algorithms

- Linear Regression

- LASSO

- Neural Network

- Gradient Boosting

- Decision Tree

- Bayesian Ridge Regression

- Ridge Regression

Two Baseline Algorithms

- Baseline 1: # of client visits 2 months ago
  - Used by Lakeview Baptist Food Pantry

- Baseline 2: Average # of client visits during the last 2 months

Performance Comparison

Algorithm	Training Error	Inference Error
Linear Regression	38.06%	45.08%
LASSO	40.16%	43.35%
Neural Network	33.91%	44.13%
Gradient Boosting	0%	**38.44%**
Decision Tree	0%	41.98%
Bayesian Ridge	43.07%	42.36%
Ridge Regression	41.8%	41.6%
Baseline 1 (Lakeview)		**71.4%**
Baseline 2		57%

- Dataset (Lakeview): 80% training, 20% inference
- Inference error reduces from 71.4% (~17 visits) to 38.44% (~9 visits)

Reasons for High Inference Error

- Small dataset
  - Only 336 data points

- Time-varying data probability distribution
  - Pre-covid vs. post-covid
  - Employment rate
  - CPI

Data Augmentation

- Enlarge the dataset by generating additional synthetic data that is similar to the original data.

  - Method: Variational Auto Encoder (VAE)

  - Dataset size: 336 datapoints ➜ 1171 datapoints

Improved Performance

Algorithm	Training Error	Inference Error	Training Error with VAE	Inference Error with VAE
Linear Regression	38.06%	45.08%	25.45%	26.4%
LASSO	40.16%	43.35%	24.7%	26.6%
Neural Network	33.91%	44.13%	24.5%	**25.67%**
Gradient Boosting	0%	**38.44%**	19.11%	26.6 %
Decision Tree	0%	41.98 %	25.42%	26.51%
Bayesian Ridge	43.07%	42.36%	25.43%	26.4%
Ridge Regression	41.8%	41.6%	25.4%	26.62%
Baseline 1 (Lakeview)		**71.4%**		
Baseline 2		57%		

- By data augmentation, inference error drops to 25.67% (~6 visits)

Future Work

- Machine Learning:
  - Improve Algorithm Stability and Robustness
    - Advanced optimization techniques for Variational Autoencoder (VAE)
  - Maintain good performance for time-varying data distribution
    - Refine the model with an updated dataset
  - Other food pantries with little or no data
    - Transfer learning, Bayesian learning
  - Provide the algorithm to food pantries

- Economics, Social and Nutrition Sciences
  - Collaboration with Tuskegee University

- Educational efforts

EVSC 595 (Tuskegee University)
# Applied Statistics and Machine Learning

- Instructors:
  - Dr. Rui Chen (Tuskegee)
  - Dr. Yin Sun (Auburn)
- Features:
  - Applied statistics
    - Data Collection, Cleansing, and Visualization
    - Experimental Design
    - Statistical Hypothesis Testing
  - Machine learning
    - Regression, classification, and computer vision
  - Python Programming skills
  - Field visits (food pantry + ??)
  - Real-world applications
- Stipend: A stipend of $700-$1100 will be offered upon funding availability.
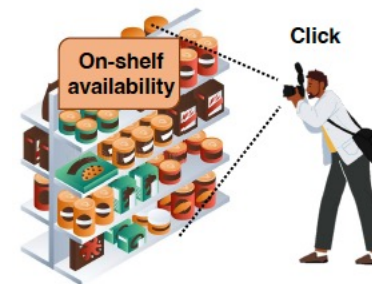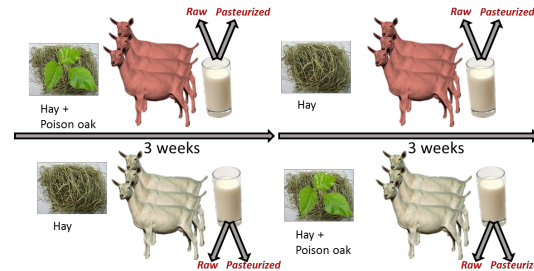
(a) Image capture using mobile devices

(b) Shelf image w/ and w/o bound boxing on food items

Yin Sun, Auburn University, yzs0078@auburn.edu

Rui Chen, Tuskegee University, rchen@tuskegee.edu