AI-POWERED SOLUTIONS FOR THE

RESTAURANT INDUSTRY

Leveraging LLMs for enhanced product categorization.

THE ERDÖS INSTITUTE
DEEP LEARNING BOOTCAMP

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Agenda

I. Problem Statement
II. Data Collection & Cleaning
III. EDA
IV. Model Selection for multi-label classification
V. Model Predictions
VI. Conclusions & Perspectives

Problem Statement:
Restaurants have thin margins

- ❌ Food Wastage:
  > 25 bn lb/year

- ❌ Old School recipe/inventory management
- ❌ 500 Hrs/year on admin

- ❌ No Big-Picture insights
- ❌ Lack of data-driven forecasts

Problem Statement:
Restaurants have thin margins

Burnt
Reimagining back of house operations

- Inventory demand forecast
- Automated inventory management
- Automated payment scheduling
- Budgeting
- Live food cost analysis
- Posinegrations
- Menu profitability
- GP Alerts

Problem Statement:
Restaurants have thin margins

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Reimagining back of house operations

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Problem Statement:
Classifying Inventory Items

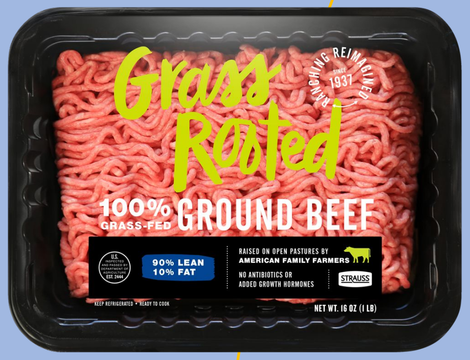
- Restaurants have on average 5-10 different suppliers with different ways to describing their products

High-quality organic tomatoes on the vine, cultivated in a controlled greenhouse

Premium greenhouse-grown organic tomatoes on the vine

Greenhouse-raised organic tomatoes on the vine

Problem Statement:
Multi-Label Classification



Laura's Lean Beef 92% Lean 8% Fat Ground Beef

American Foods 80/20 Ground Beef

- Food
  - Meat
    - Beef

Optimized search-bar engine

Nestlé NESQUIK Chocolate Lowfat Milk Ready to Drink

fairlife 2% Chocolate Ultra-Filtered Milk, Lactose Free

- Beverages
  - Non-alocholic
    - Dairy

Minimized wastage

Automated inventory management

NatureSweet Heavenly Salad Tomatoes

Produce organic Roma tomatoes

- Food
  - Fresh produce
    - Tomato

Problem Statement: Approach

American Foods 80/20 Ground Beef

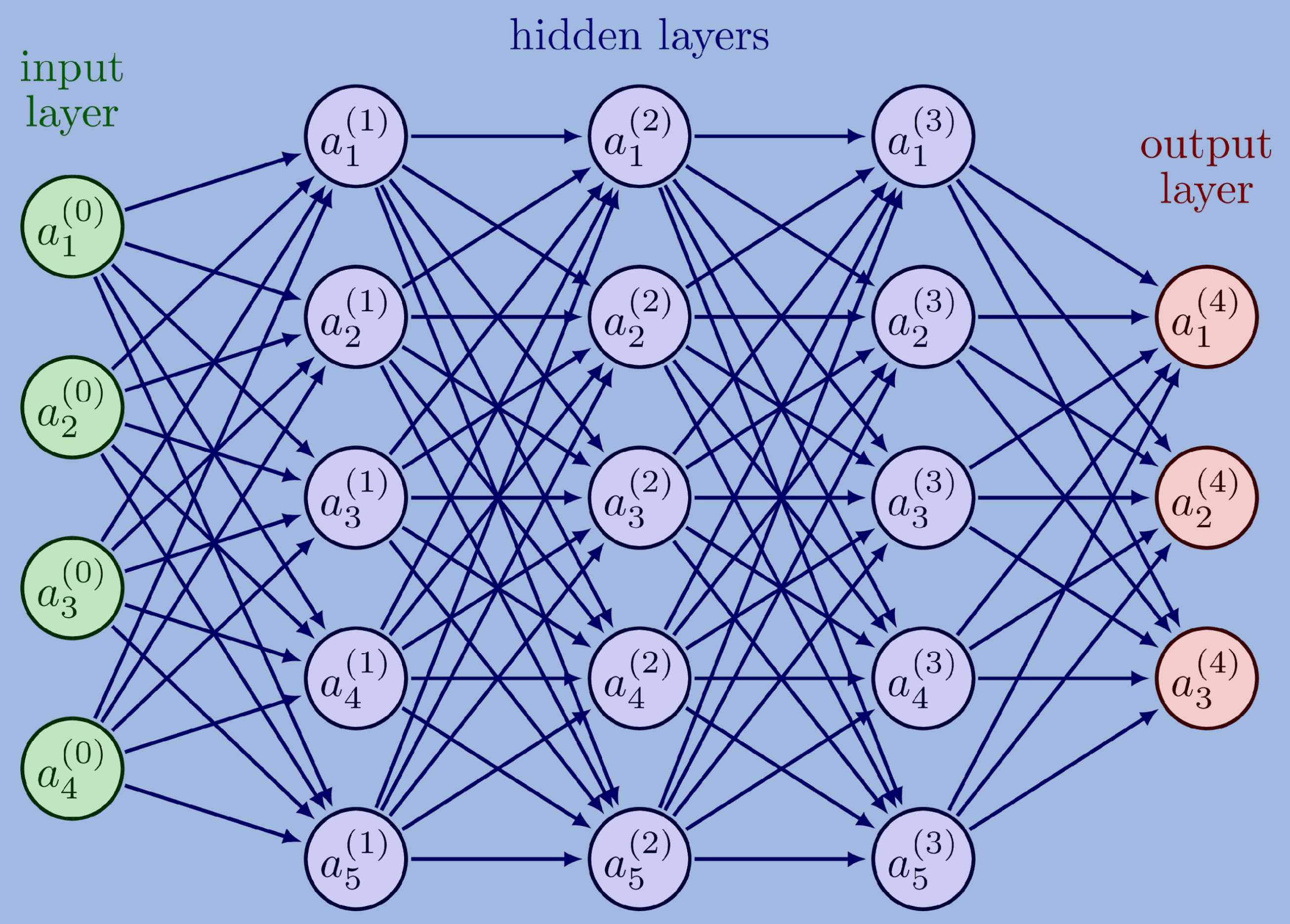
Laura's Lean Beef 92% Lean 8% Fat Ground Beef

fairlife 2% Chocolate Ultra-Filtered Milk, Lactose Free

Nestlé NESQUIK Chocolate Lowfat Milk Ready to Drink

Produce organic Roma tomatoes

NatureSweet Cherubs Heavenly Salad Tomatoes



Fine-tuned LLMs

- Food
  - Meat
    - Beef

- Beverages
  - Non-alocholic
    - Dairy

- Food
  - Fresh produce
    - Fruits

Data Collection & Cleaning

- Need hierarchical categories
- Need labeled data
  - Scrape data from Instacart

product	label
New Belgium Brewing Fat Tire Ale12 fl oz	alcohol/beer/ales/amber red ale
Yuengling Beer, Traditional Lager, 24 Pack12 fl oz	alcohol/beer/ales/amber red ale
George Killian's Irish Red Lager Beer12 fl oz	alcohol/beer/ales/amber red ale
Dragon's Milk Crimson Keep, Bourbon Barrel-Aged Red Ale, 11% ABV12 fl oz	alcohol/beer/ales/amber red ale
Smithwick's Red Ale Beer14.9 fl oz	alcohol/beer/ales/amber red ale
Bell's Amber Ale12 fl oz	alcohol/beer/ales/amber red ale
Alaskan Brewing Co. Amber12 fl oz	alcohol/beer/ales/amber red ale
Alaskan Brewing Co. Beer, Alt Style Ale, Amber, 6 Pack12 fl oz	alcohol/beer/ales/amber red ale
Classic Touch 3 Leaf Dish, Gold1 each	alcohol/beer/ales/amber red ale
Karl Strauss Brewing Company Red Trolley Ale12 fl oz	alcohol/beer/ales/amber red ale

- Alcohol
- Beverages
- Food
  - Fresh Produce
  - Frozen Food
  - Meat Alternatives
  - Pantry
  - Deli
  - Baked Goods
  - Dairy
  - Meat
  - Seafood
  - Ready to Cook Meals

instacart

Food / Meat / Beef

American Foods Group 80% Lean 20% Fat Ground Beef
16 oz

Skylark Beef Liver, Sliced
16 fl oz

Laura's Lean Beef 92% Lean 8% Fat Ground Beef
16 oz

```
<!DOCTYPE html>
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  <head>
    <title>Beef Products Delivery or Pickup Near Me | Instacart</title>
    <link href="https://www.instacart.com/categories/316-food/1807-meat/703-beef" rel="canonical">

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    <meta content="Get Beef products you love delivered to you &lt;b&gt;in as fast as 1 hour&lt;/b&gt; vi

    <meta content="Beef Products Delivery or Pickup Near Me | Instacart" property="og:title">
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    <meta content="Get Beef products you love delivered to you &lt;b&gt;in as fast as 1 hour&lt;/b&gt; vi
    <meta content="width=device-width,initial-scale=1,user-scalable=yes" name="viewport">
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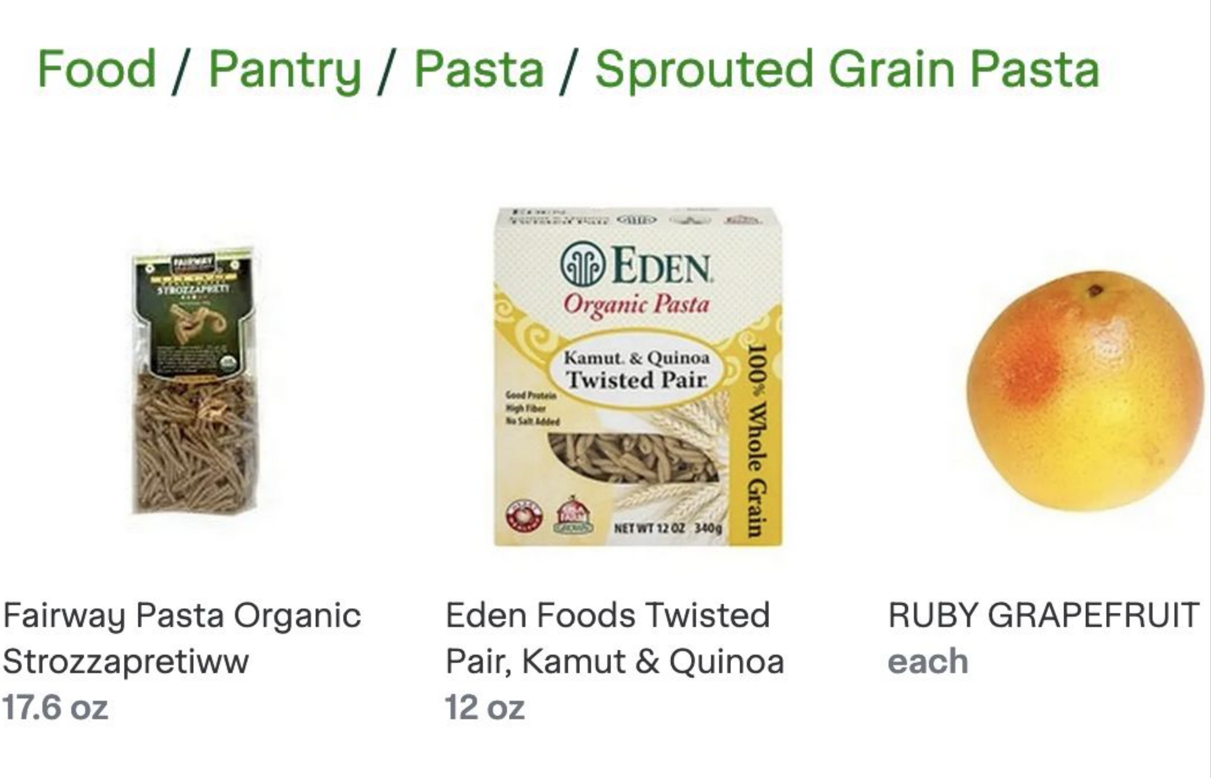
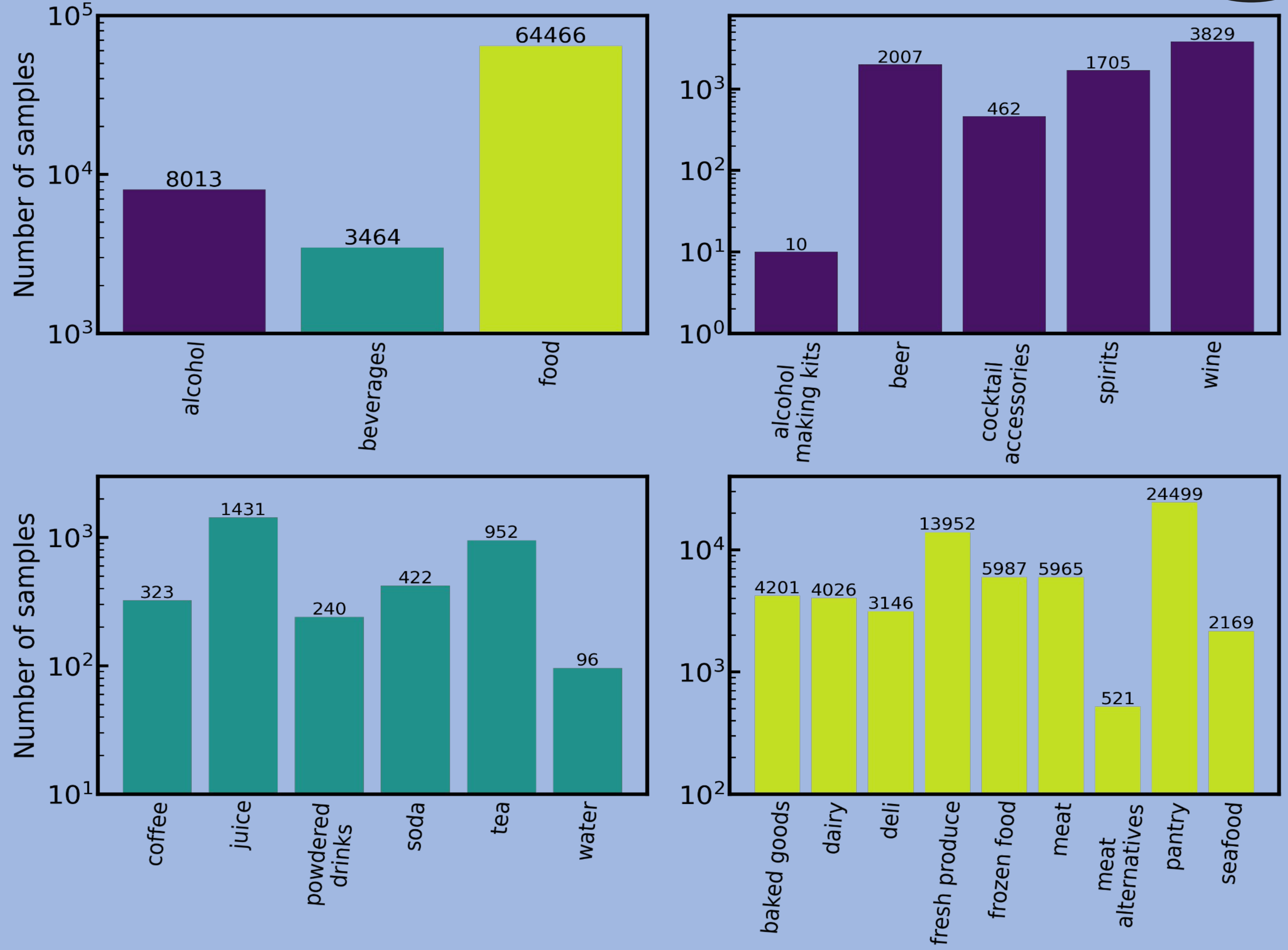
Exploratory Data Analysis

- Uneven product distribution
- Some instances of mis-labeling





Model Selection
LLMs

Meta

Llama 2-7b-hf
(7 billion parameters)

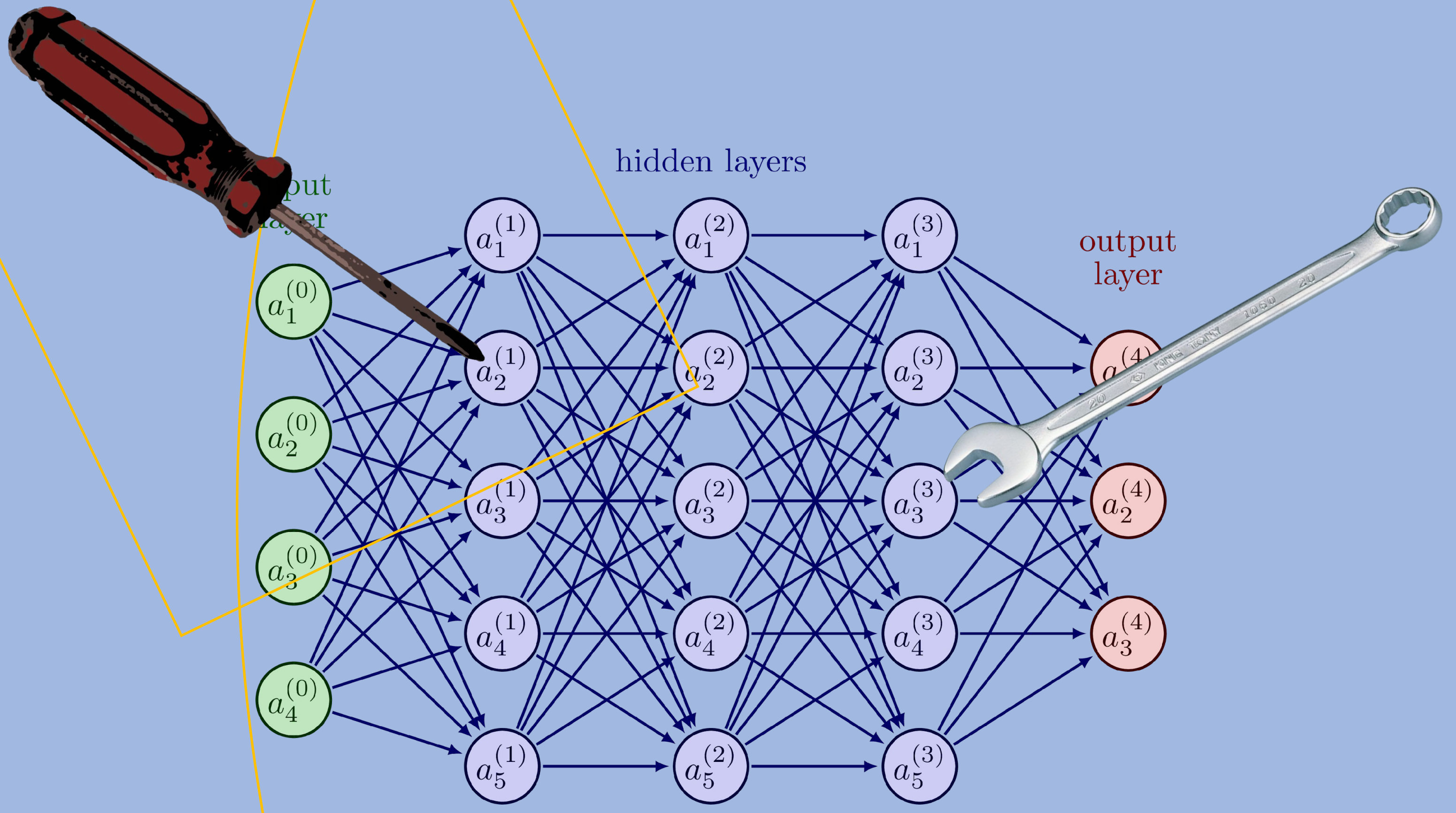
OpenAI

GPT-2
(1.5 billion parameters)

Google

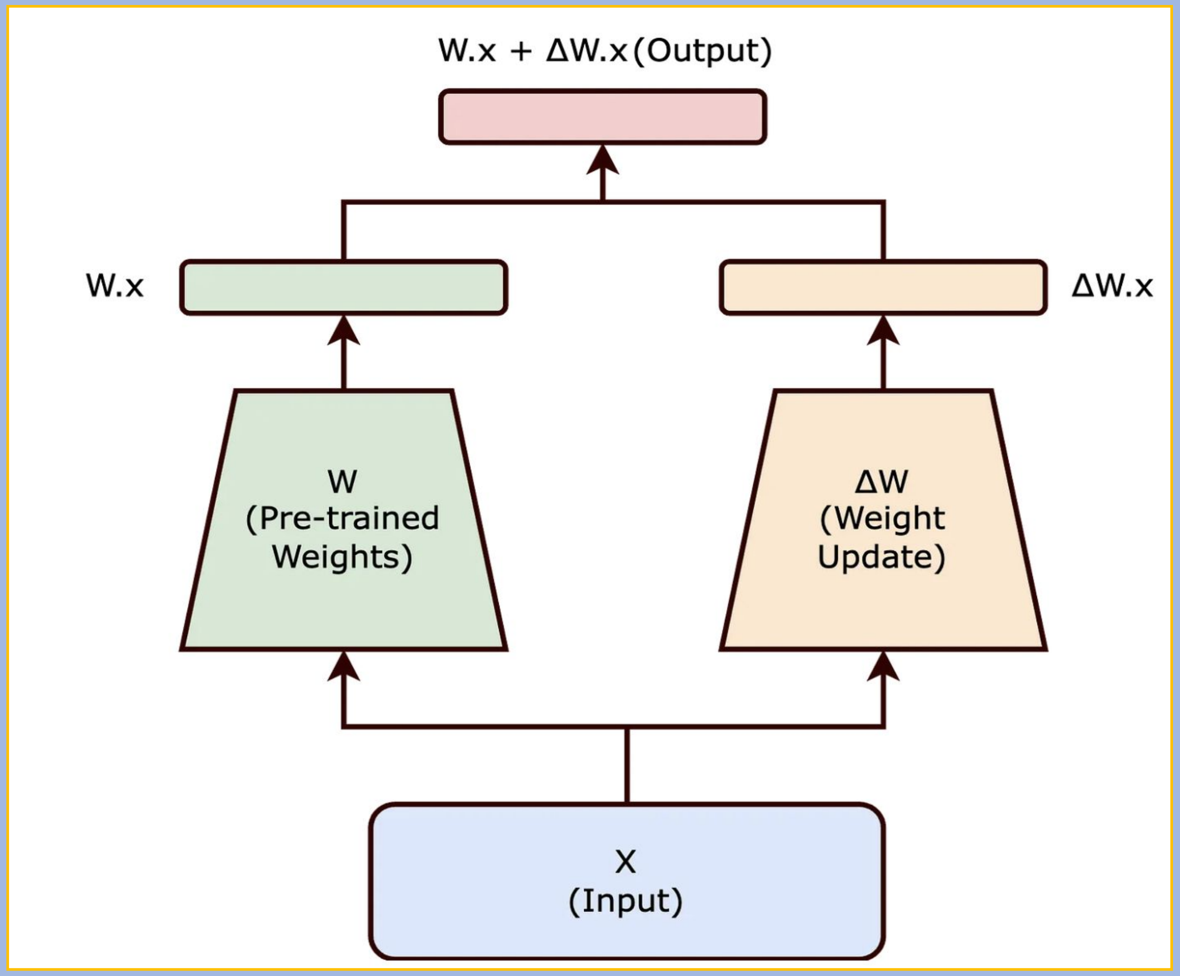
BERT
(110 million parameters)

Model Selection
LLM finetuning

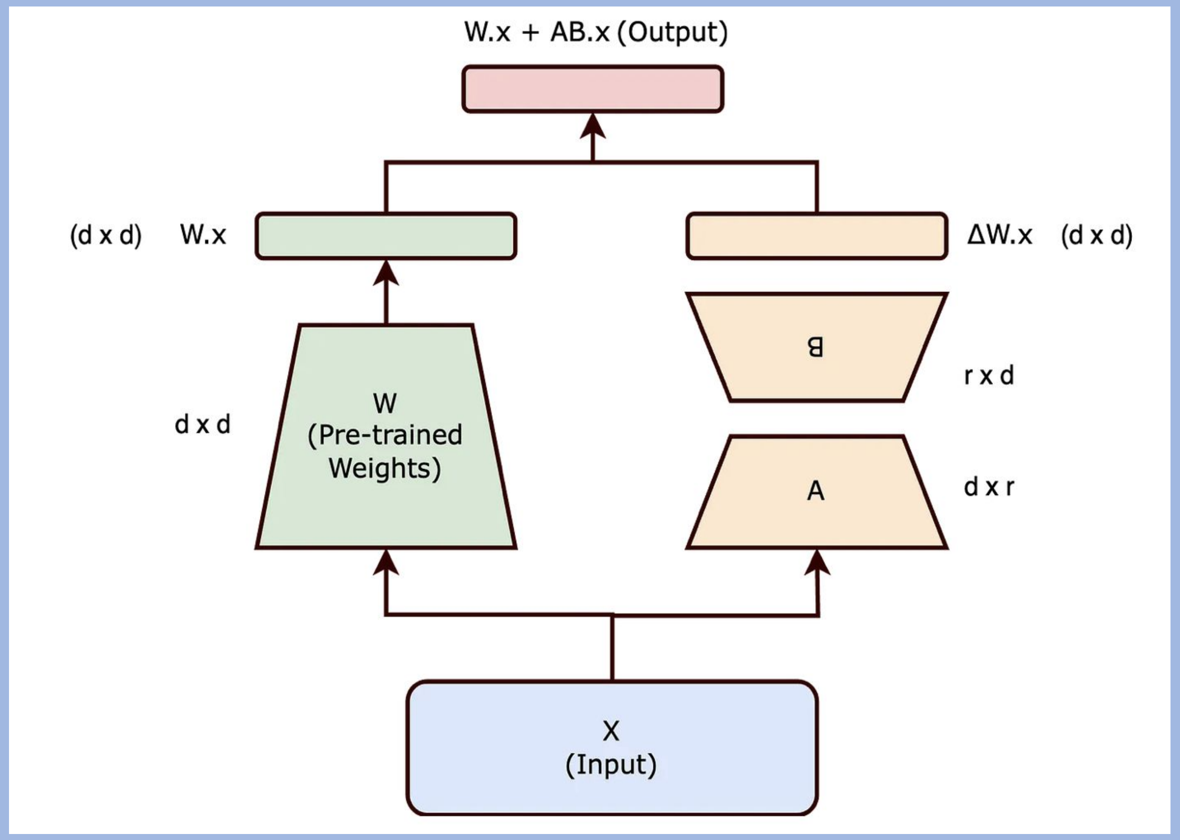


Different approaches:
- Prompt fine-tuning
- Full parameter fine-tuning
- Partial parameter fine-tuning
- Adapter layers
- LoRA (low rank adaptation)

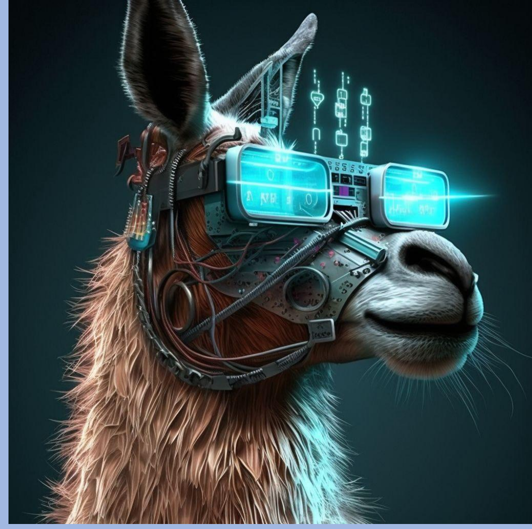
Traditional fine-tuning



LoRA fine-tuning



Model Selection
Llama finetuning



Llama-2: Auto-regressive language model with optimized transformers.

Fine-tuning method:

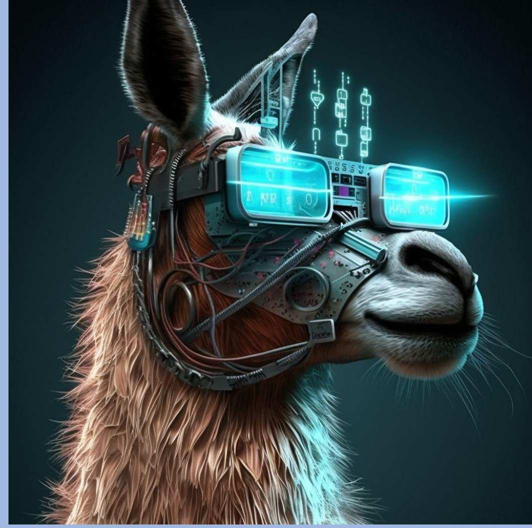
- Create a prompt to get category by autocompletion

> *Classify the text into food, beverages or alcohol and return the answer as the corresponding label.*
> *text: Signature Farms Tomatoes, Campari*
> *label:*

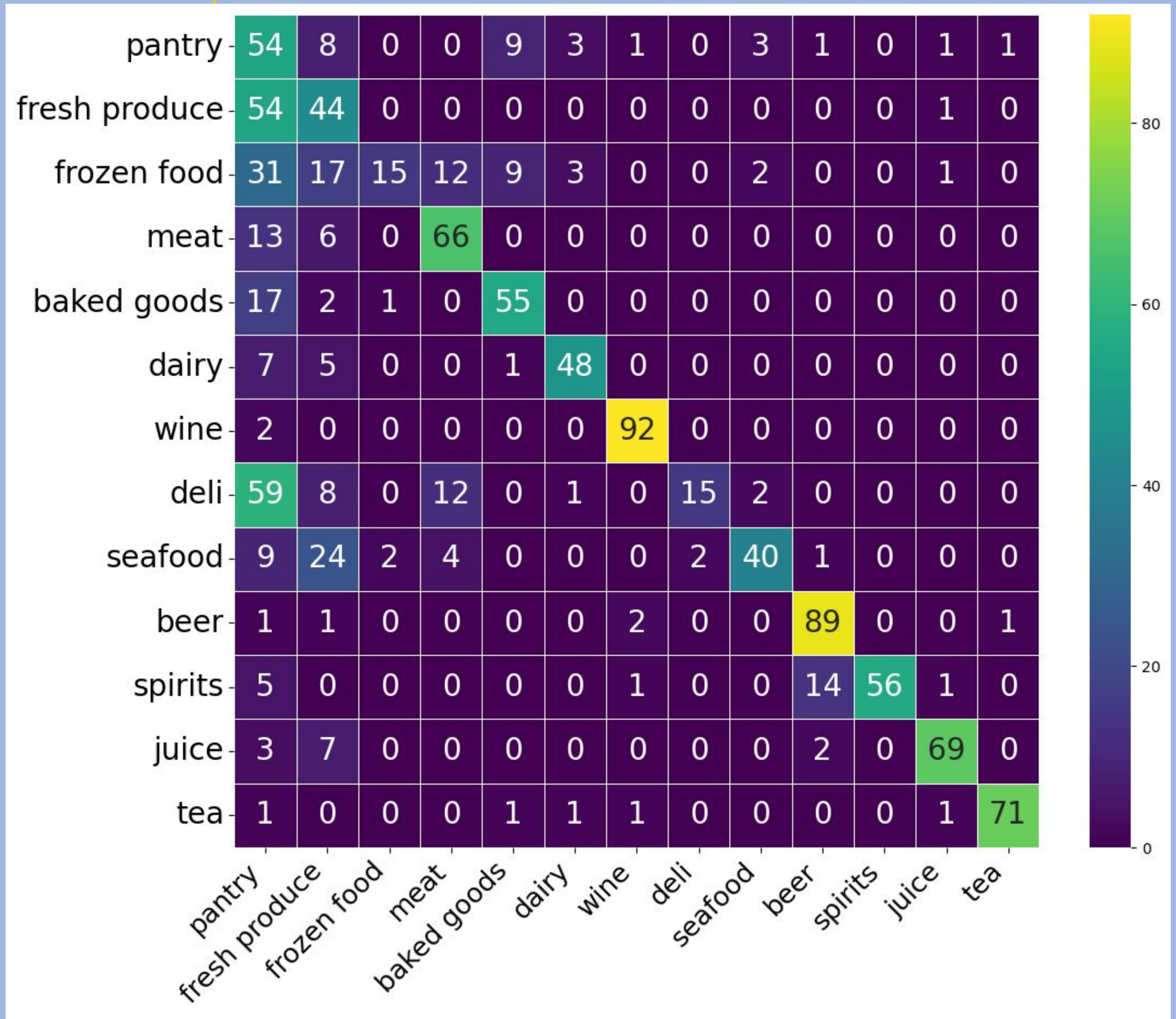
- Fine-tune using LoRA
  - Loss function: cross-entropy loss
  - Hyperparameters from literature

Qlora: Efficient finetuning of quantized llms. *T Dettmers, A Pagnoni, A Holtzman, L Zettlemoyer. Advances in Neural Information Processing Systems, 2024*

Model Selection
Llama finetuning

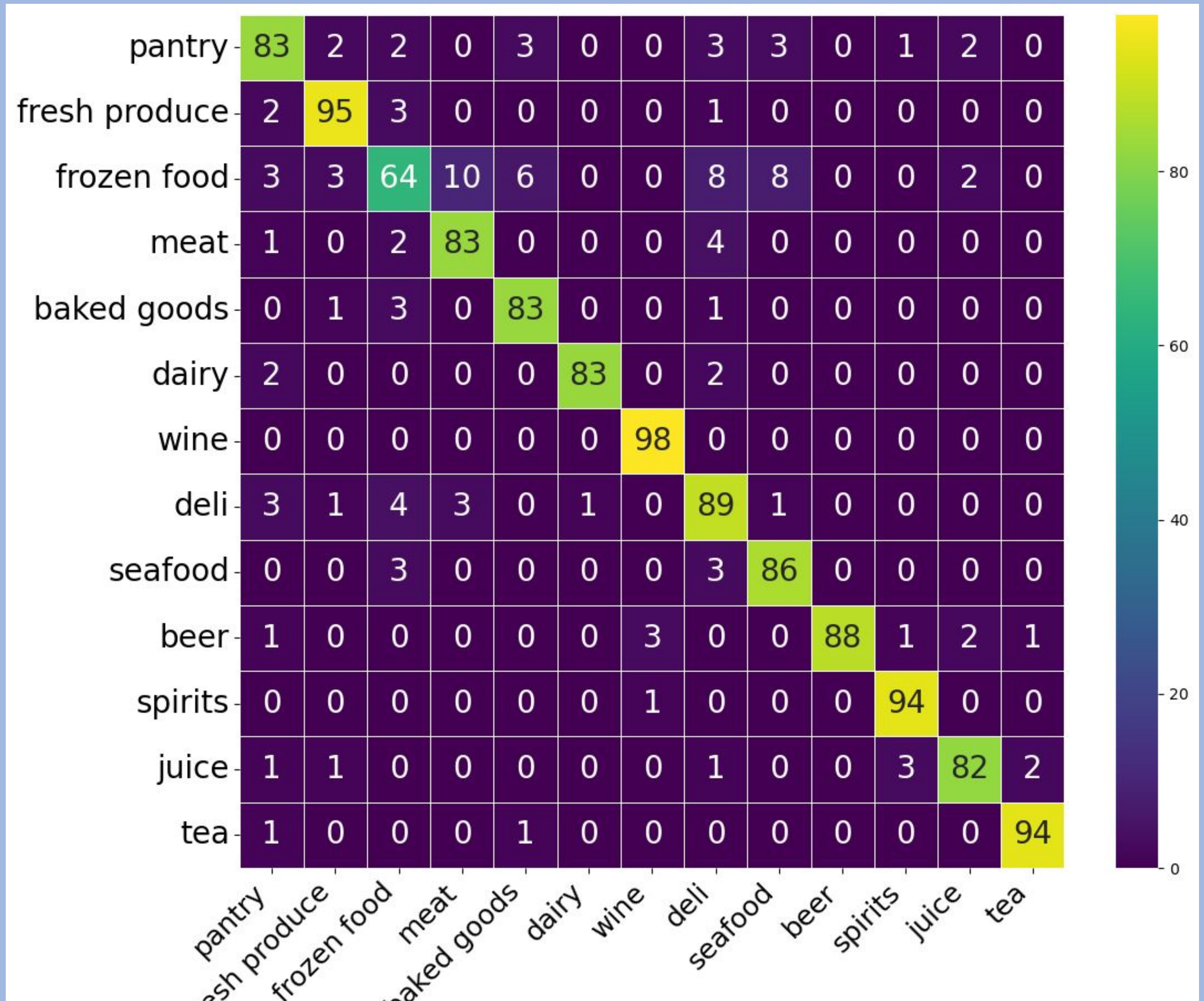


- Base model

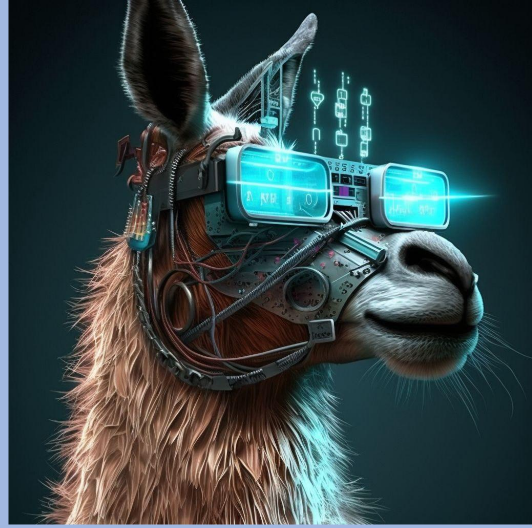


E

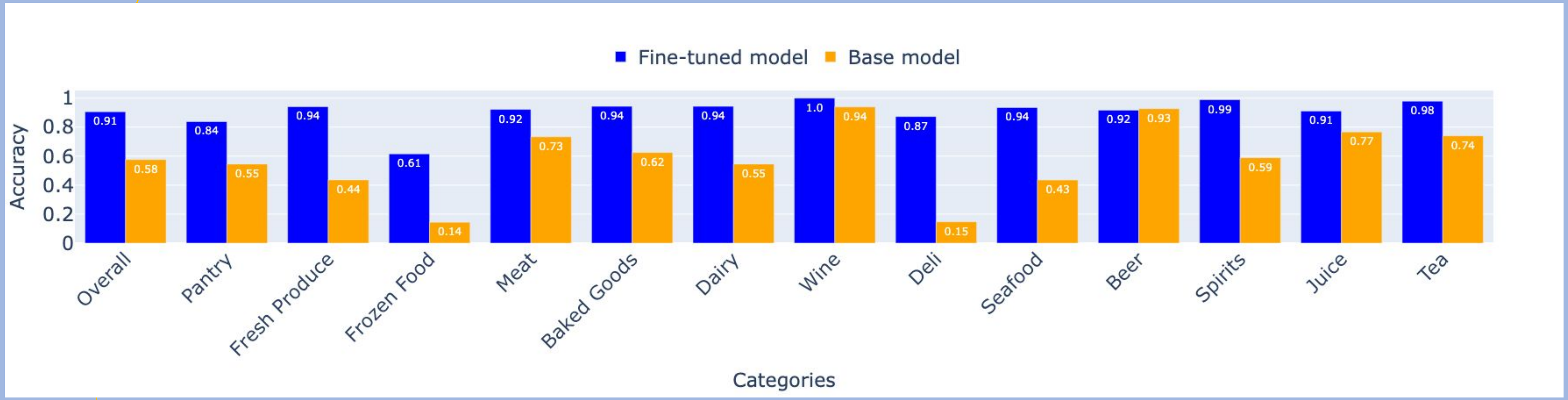
- Fine-tuned model



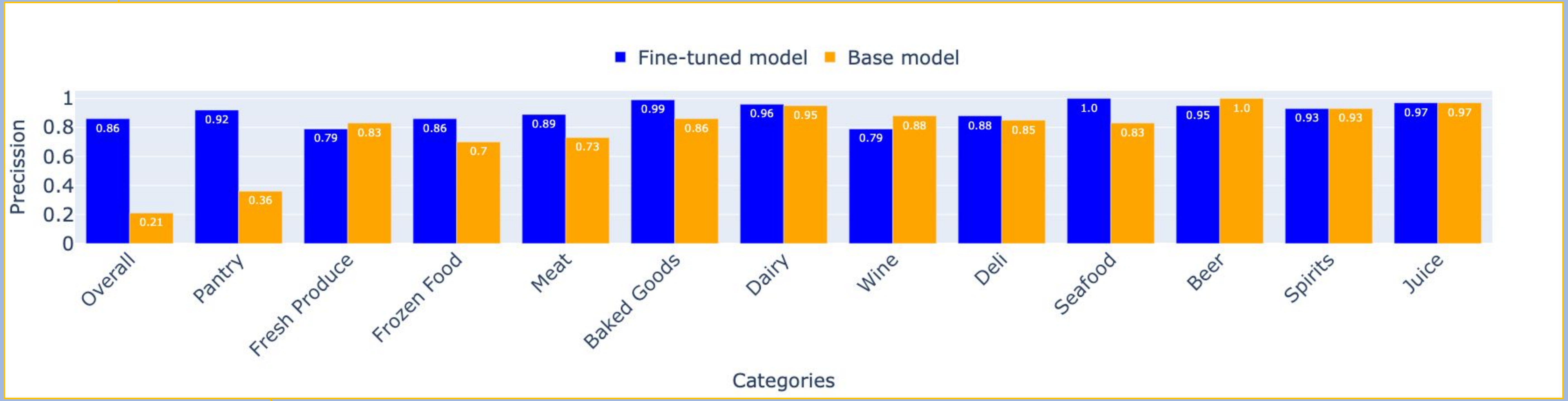
Model Selection
Llama finetuning



Accuracy



Precision

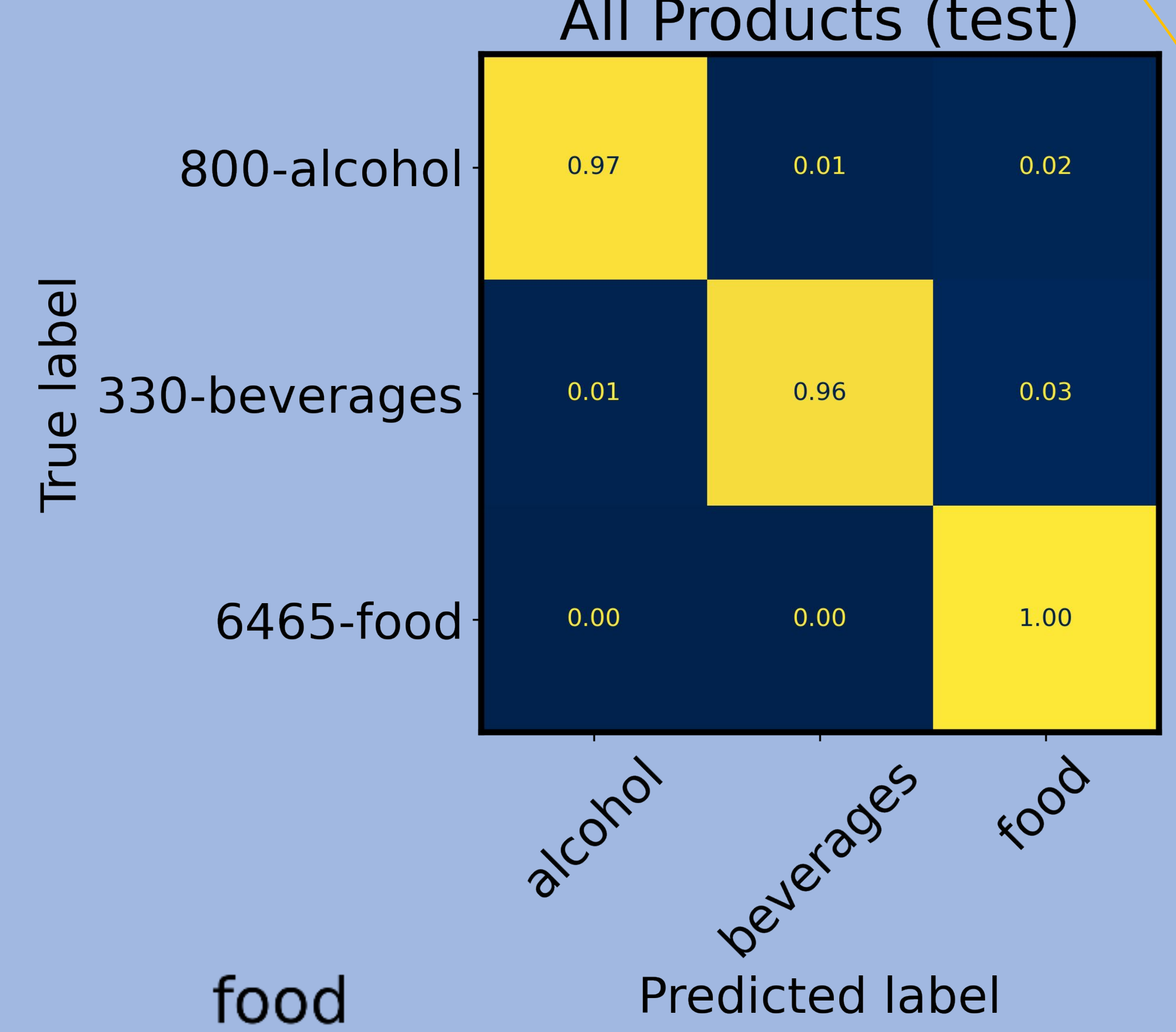


Model Selection
Bert finetuning

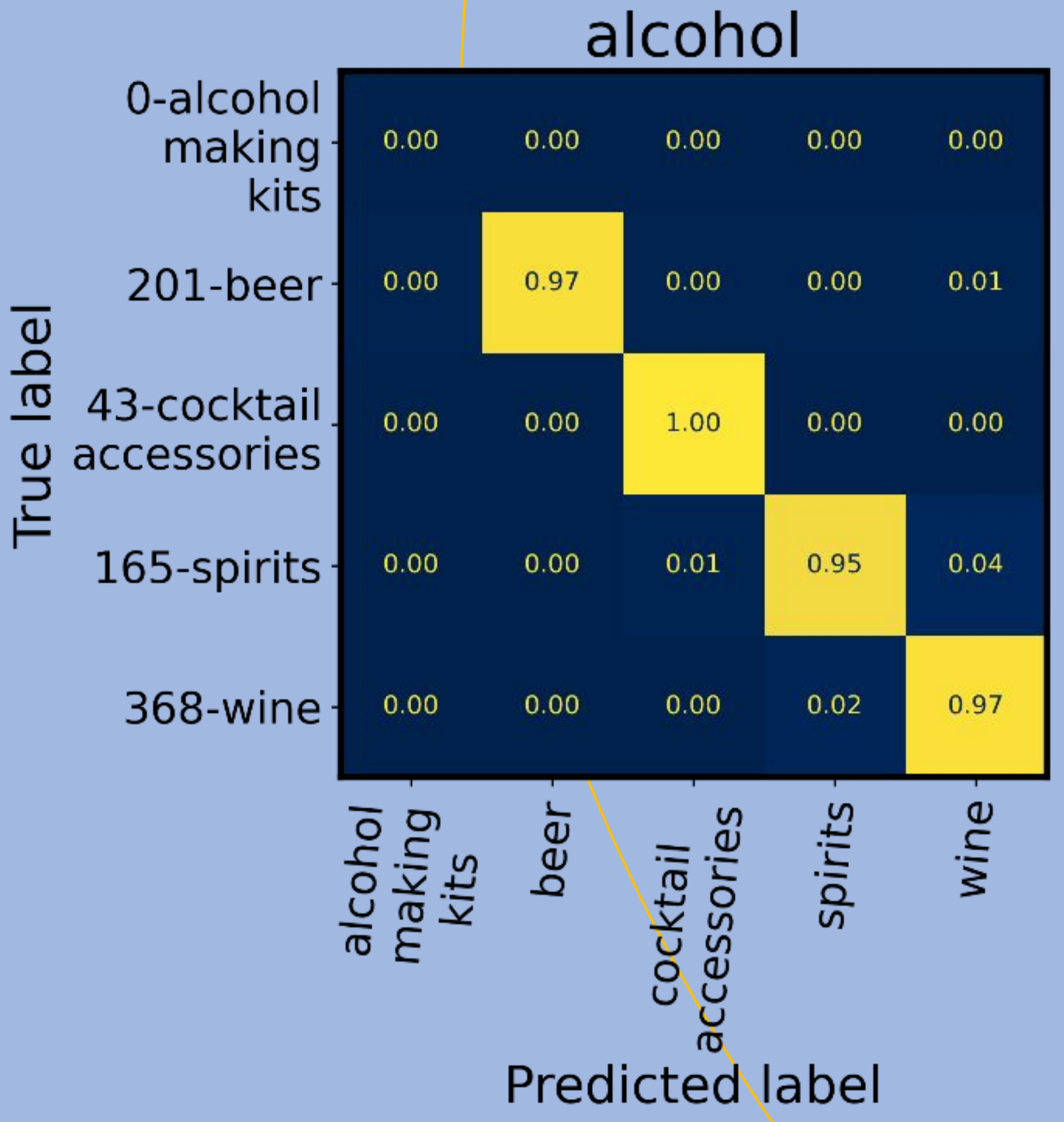
- Create vectors to represent hierarchical categorization for each product
- Assign a unique number (label) to each unique vector
- Add a classification layer to the `bert-base-cased` model from HF

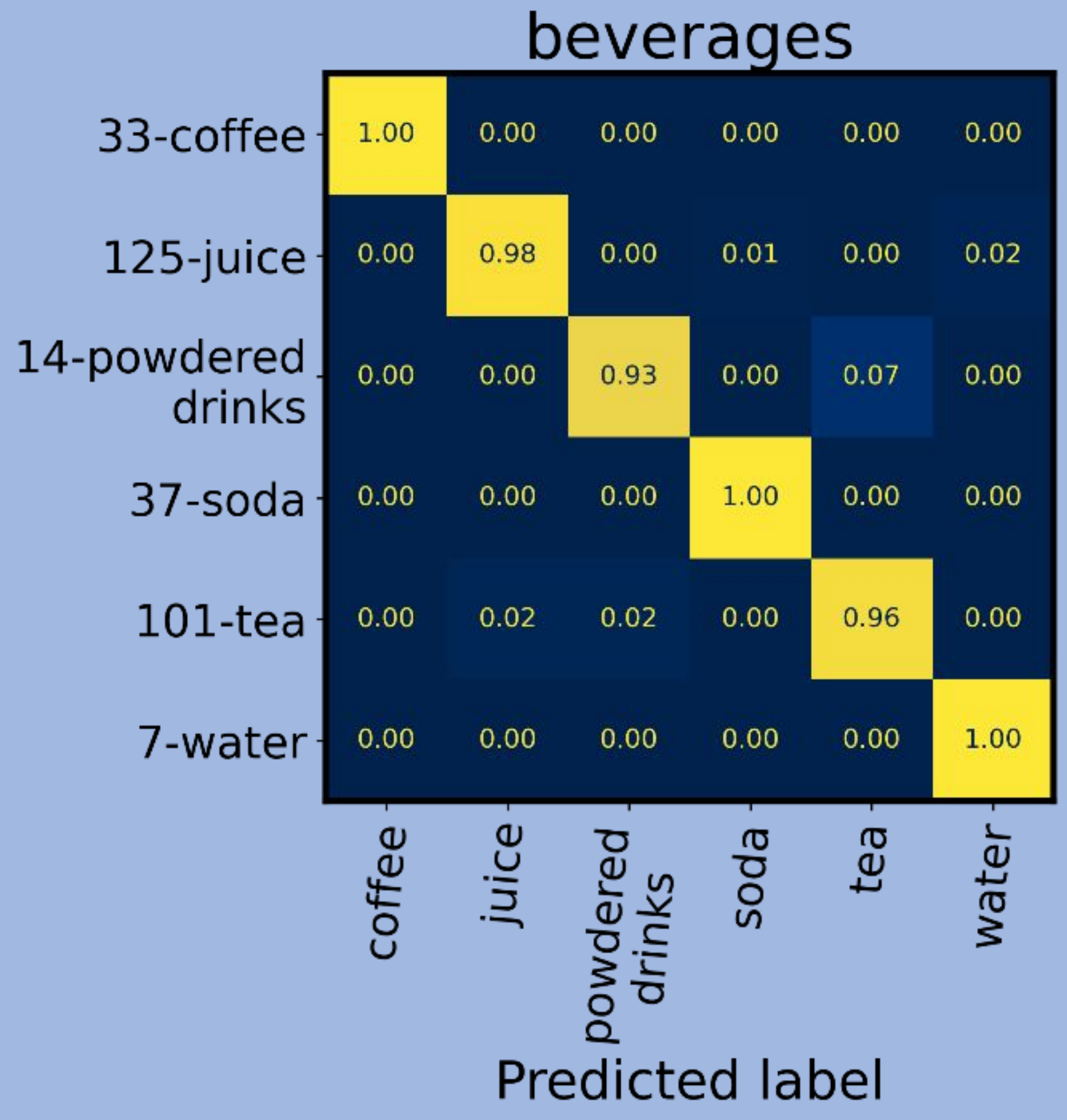
product	label	lab_0	lab_1	lab_2	lab_3	lab_4	lab_5	base_label
New Belgium Brewing Fat Tire Ale12 fl oz	alcohol/beer/ales/amber red ale	0	1	0	0	0	0	1
Bud Light Hard Seltzer Iced Tea Variety Pack, Slim12 fl oz	alcohol/beer/beer variety packs	0	1	1	0	0	0	23
Guastaferro Taurasi Primum Riserva750 ml	alcohol/wine/red wine/aglianico	0	4	5	1	0	0	196
Signature SELECT Blue Cheese Crumbles5 oz	food/dairy/cheese/blue cheese	2	1	0	3	0	0	335
Driscoll's Organic Blackberries6 oz	food/fresh produce/fresh fruit/berries/blackberries	2	3	0	5	0	0	1410

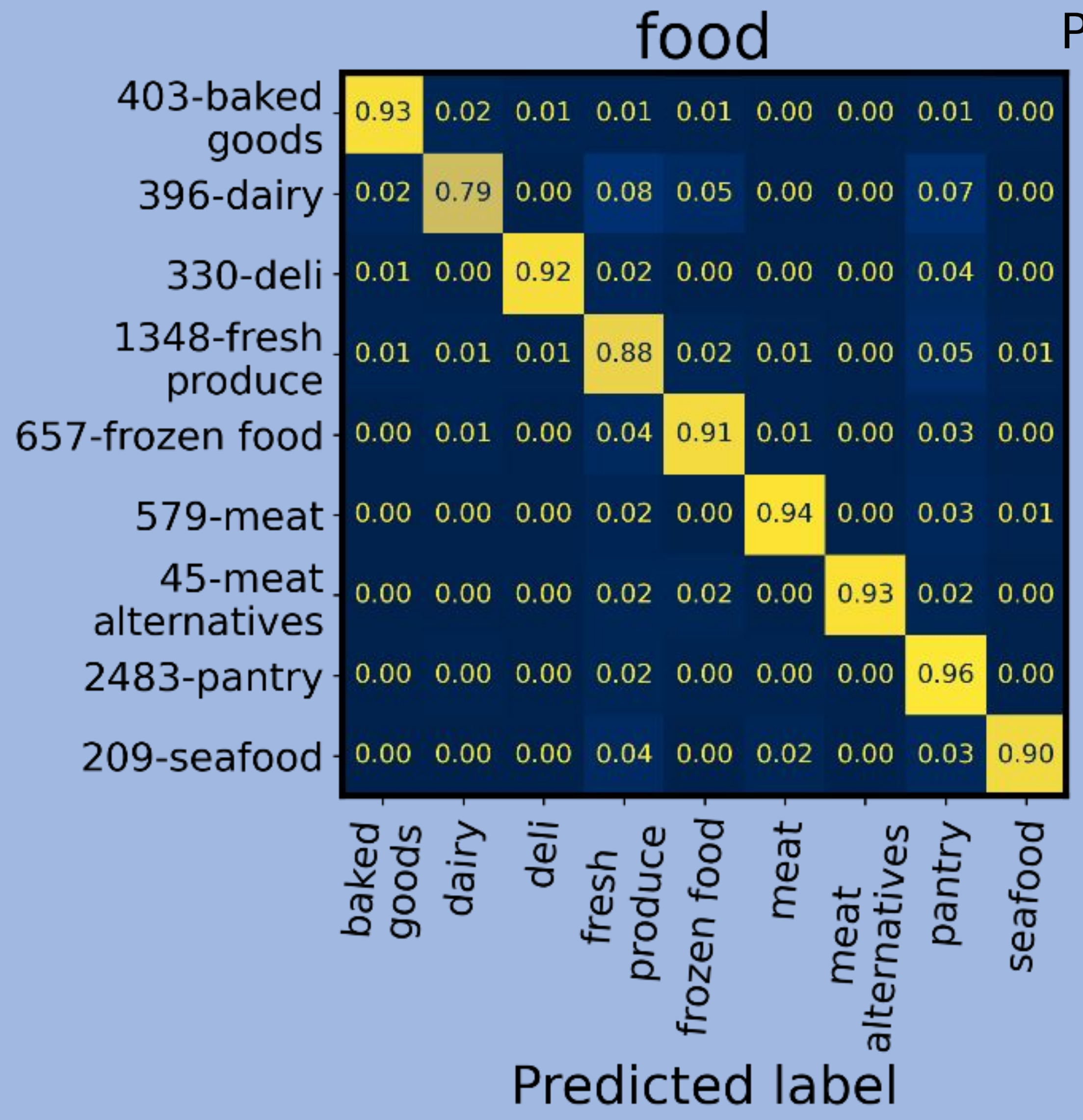
Model Selection
Bert finetuning



- Excellent performance for the two top levels

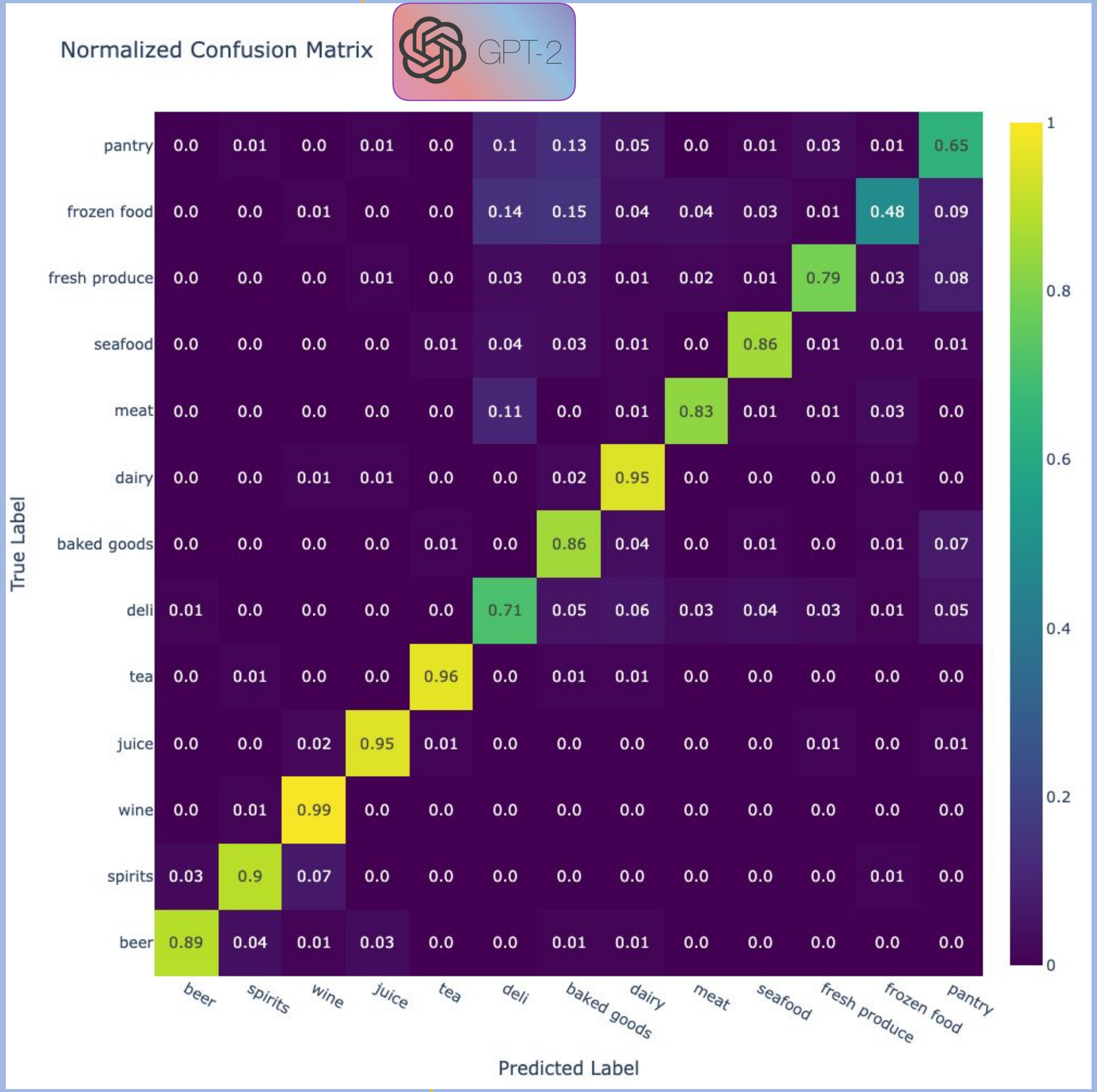


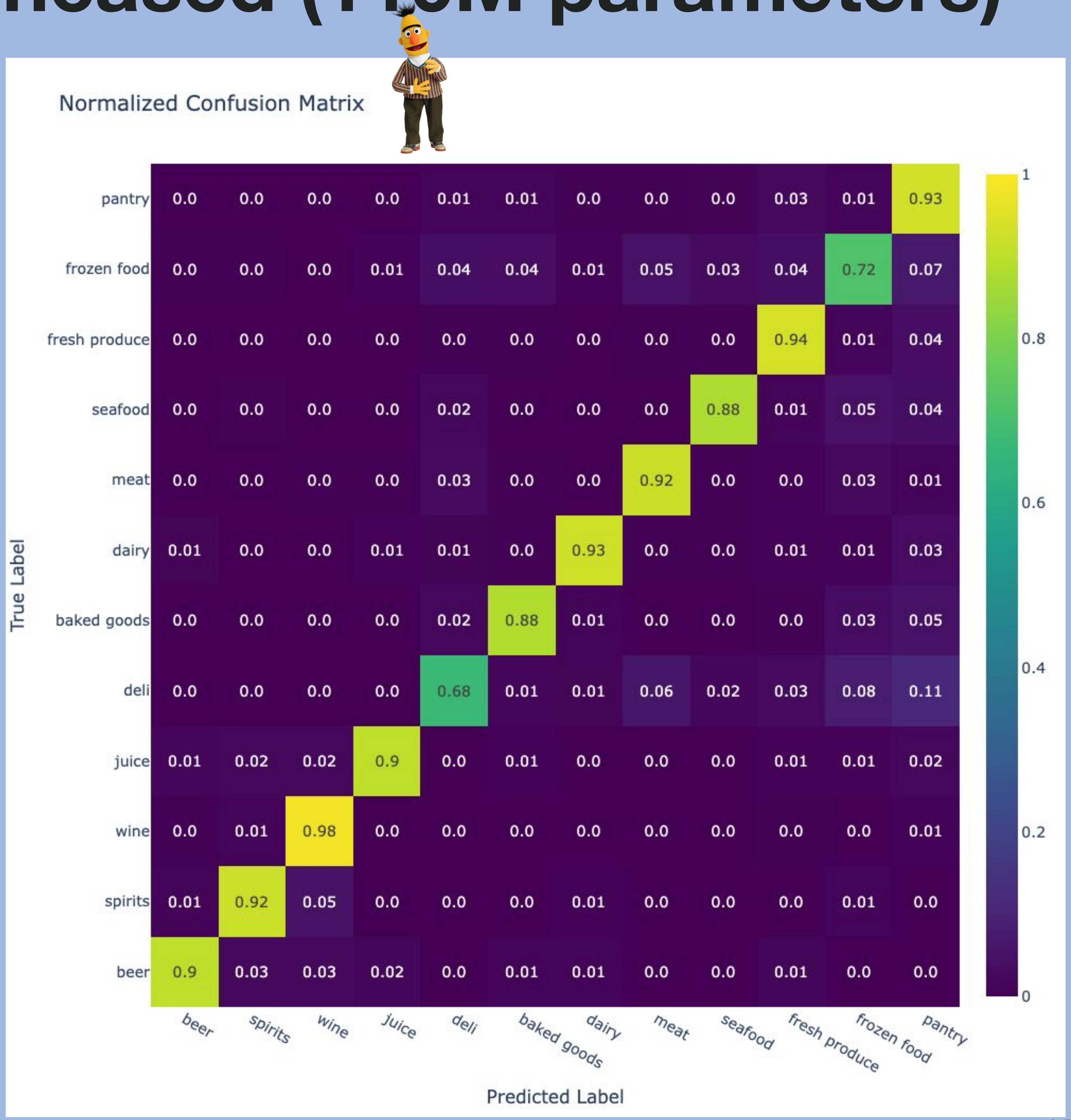


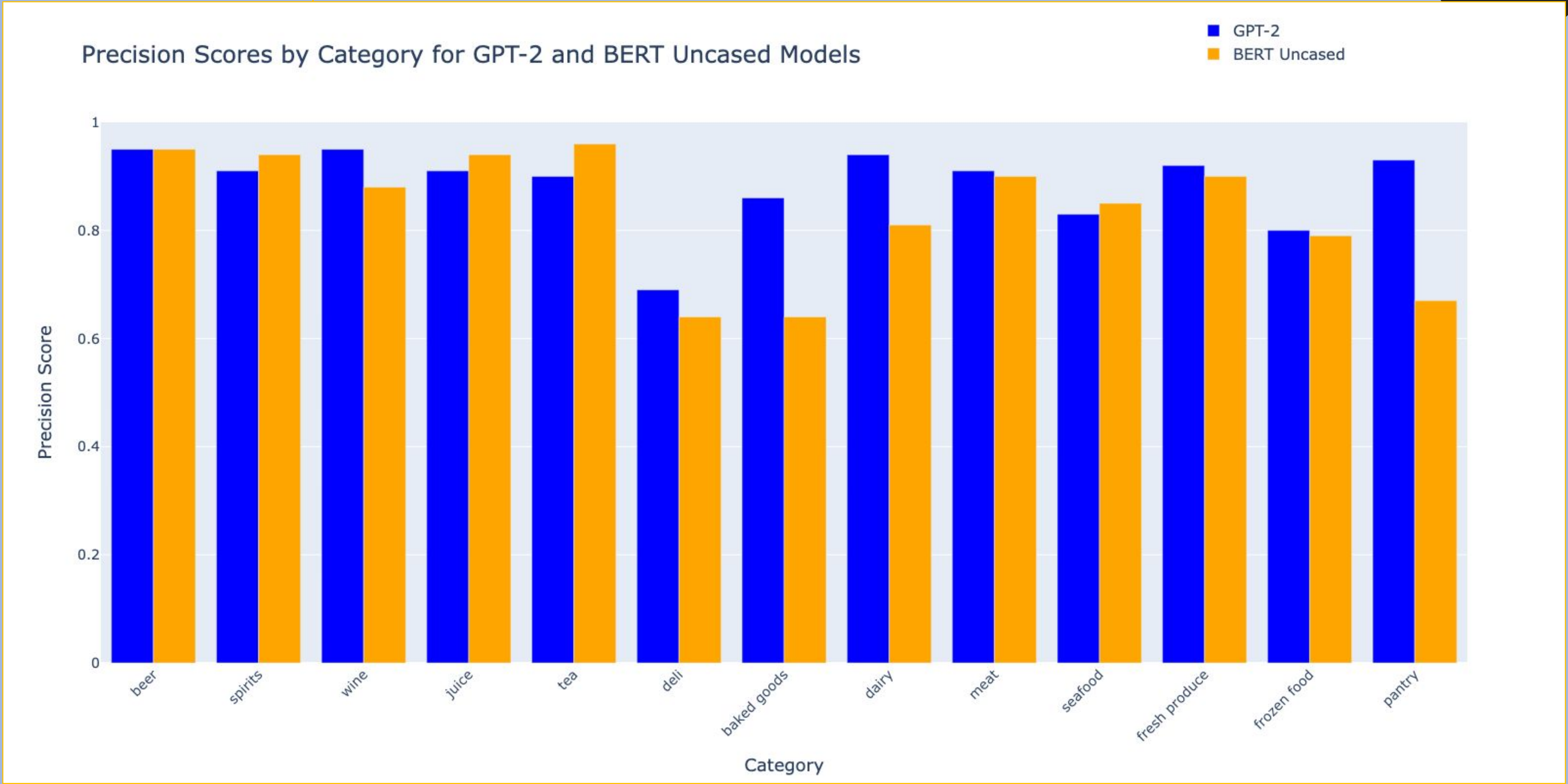


Model comparison

GPT2(1.5 billion) Vs Bert-Uncased (110M parameters)






Precision Scores by Category for GPT-2 and BERT Uncased Models
GPT-2
BERT Uncased
Precision Score
1
0.8
0.6
0.4
0.2
0
beer
spirits
wine
juice
tea
deli
baked goods
dairy
meat
seafood
fresh produce
frozen food
pantry
Category

Common model issues

- Caught a few mislabeled products
- Mostly confused hard-to-label products

Mislabeled

Model labeled correctly as food

Model labeled as alcohol

Conclusions & Perspectives

Key findings:

- Successfully categorized products with different open source LLMs.
- Implemented efficient approaches of fine tuning.
- Identified some mis-labeled cases in the existing labelled dataset (from Instacart)
- Gained insights into improving classification models by investigating mis-classified products

Conclusions & Perspectives

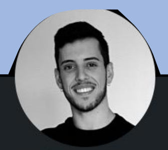
Future perspectives:

- Deeper hierarchical classification
  - Need more data
  - Define a loss that takes the hierarchical structure into account
- Combine insights from the two projects to build a personalized AI-assistant for each restaurant’s business analytics

THANK YOU

Let's Connect

Davood B. Dar
Student at Rutgers University



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Amir Kazemi-Moridani, PhD
Astrophysicist | Data Scientist

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Burnt

Hugginface

Instacart