Food Classification

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Purpose

People like to taste different cuisine and choose the most appealing food. They often are concerned about diet restrictions such as gluten-free, vegan, ketosis, peanut-allergy, and calorie count. I would like to provide an easy solution to making health and good looking foods that fit your daily calorie consumption limit.

Problem Statements

The project focuses on three major problem statements:

1. Food Classification.
2. Recipe Generation.
3. Calorie Estimation.

From the image of food captured, I determine the classification of food (such as donut, samosa, red curry), identify the calorie count and describe the cooking procedure of the food. With this information, an informed decision can be made on making the item or not.

Datasets

1. Food Classification: iFood. This dataset has 251 fine-grained (prepared) food categories with 118475 training images, 11994 validation images and 28377 test images.
2. Recipe Generation: Recipe1M. This dataset has training images of size 94GB, validation images of size 21GB, and test images of size 20GB.
3. Calorie Estimation: Recipe with Nutritional Info. This contains nutritional information scraped from Recipe websites which includes the ingredients present in the dish, nutrition per ingredient, values per 100g, title, units, URL, and weights per ingredients.

Food Classification

Food classification is a challenging problem due to the large number of food categories, high visual similarity between different food categories.

It’s multi-class classification problem to predict the 251 fine-grained food-category label given a food image.

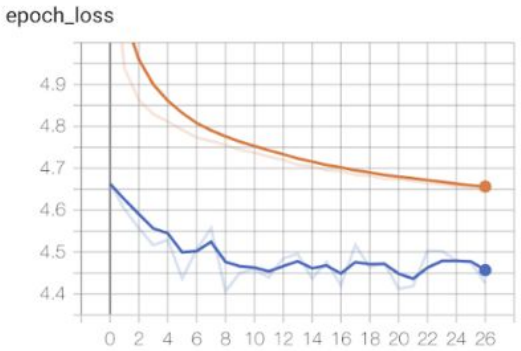
```
0 macaron
1 beignet
2 cruller
3 cockle_food
4 samosa
5 tiramisu
6 tostada
7 moussaka
8 dumpling
9 sashimi
10 knish
11 croquette
12 couscous
13 porridge
14 stuffed_cabbage
15 seaweed_salad
16 chow_mein
17 rigatoni
18 beef_tartare
19 cannoli
20 foie_gras
21 cupcake
22 osso_buco
23 pad_thai
24 poutine
25 ramen
26 pulled_pork_sandwich
27 bibimbap
28 chicken_kiev
29 apple_pie
30 risotto
```

Various Alternatives Explored

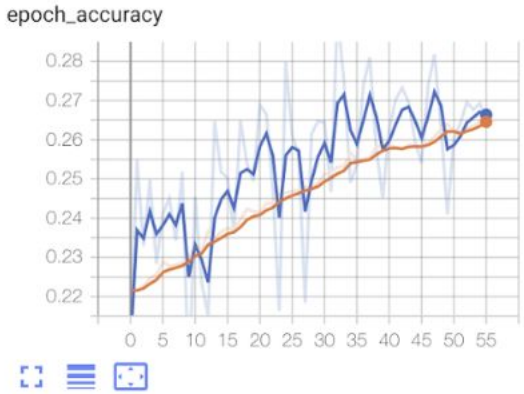
1. Transfer Learning involving VGG16 model trained with ImageNet weights and changing the output layer with the custom CNN architecture with adam optimizer. The model performed poorly after 24 epochs.
2. Since VGG16 needs an SGD optimizer. VGG16 pre-trained model was trained with SGD optimizer. The results were similar to that of the model trained with Adam.
3. Train all the layers of VGG16 with appropriate layers on top. The model gave better results but didn't provide substantial change in the accuracy after 60 epochs.
4. Finetune Inceptionv3 pretrained model with L2 kernel regularizer with a penalty of 0.05 in FC layer, SGD optimizer with learning rate of 0.0001 and 0.9 momentum.

epoch_accuracy

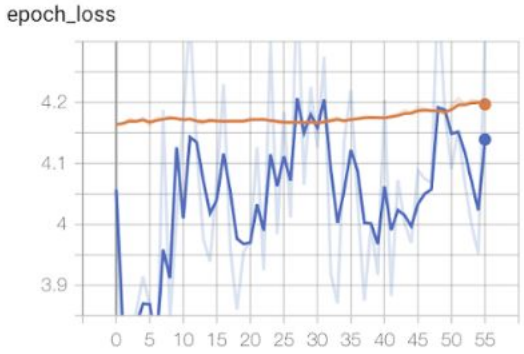
epoch_loss



epoch_accuracy



epoch_loss



Recipe Generation

Recipe Generation problem is resolved by three major sub-networks -

- Food understanding (Extracting ingredients)
- Multi-label classification (Detecting the food title)
- conditional text generation (NLP). (Preparing recipe)

  The pipeline extracts the image representation with resnet-50 encoder and obtain the ingredients.

  Recipes are generated with identified ingredients into human readable format.

Recipe1M

Downloads

README
Layers (381 MiB)
Ingredient detections (102 MiB)
Recipe1M images
- training (94 GiB)
- validation (21 GiB)
- test (20 GiB)

Recipe1M+ images
- 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f (approx. 210 Gib each tar file)

Layer2+
- layer2+.json (2.5 GiB)

Model training files
- data.h5.gz (89 GiB, recipe1M)
- vocab.bin.gz (33 MiB)
- classes1M.pkl (26 MiB)
- train.tar (24 GiB, recipe1M)
- val.tar (5 GiB, recipe1M)
- test.tar (5 GiB, recipe1M)
- encs_train_1024.t7 (29 GiB)
- encs_val_1024.t7 (6 GiB)
- encs_test_1024.t7 (6 GiB)
- remove1M.txt (133 KiB)

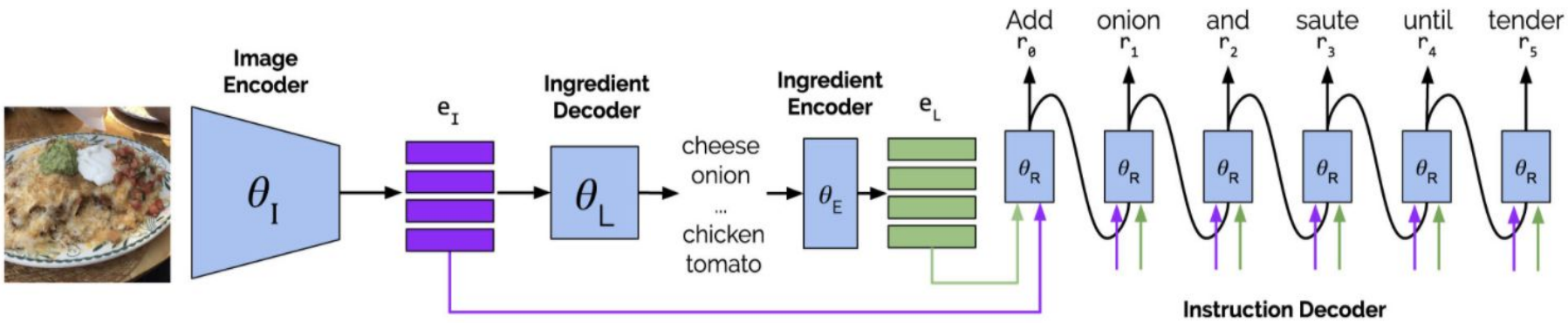
Recipes with nutritional information
- recipes_with_nutritional_info.json (213 MiB)

Terms of Use:

By downloading the data from the above URLs, you agree to the following terms:

1. You acknowledge that MIT CSAIL does not own the copyright to the recipes or images.

Architecture Diagram

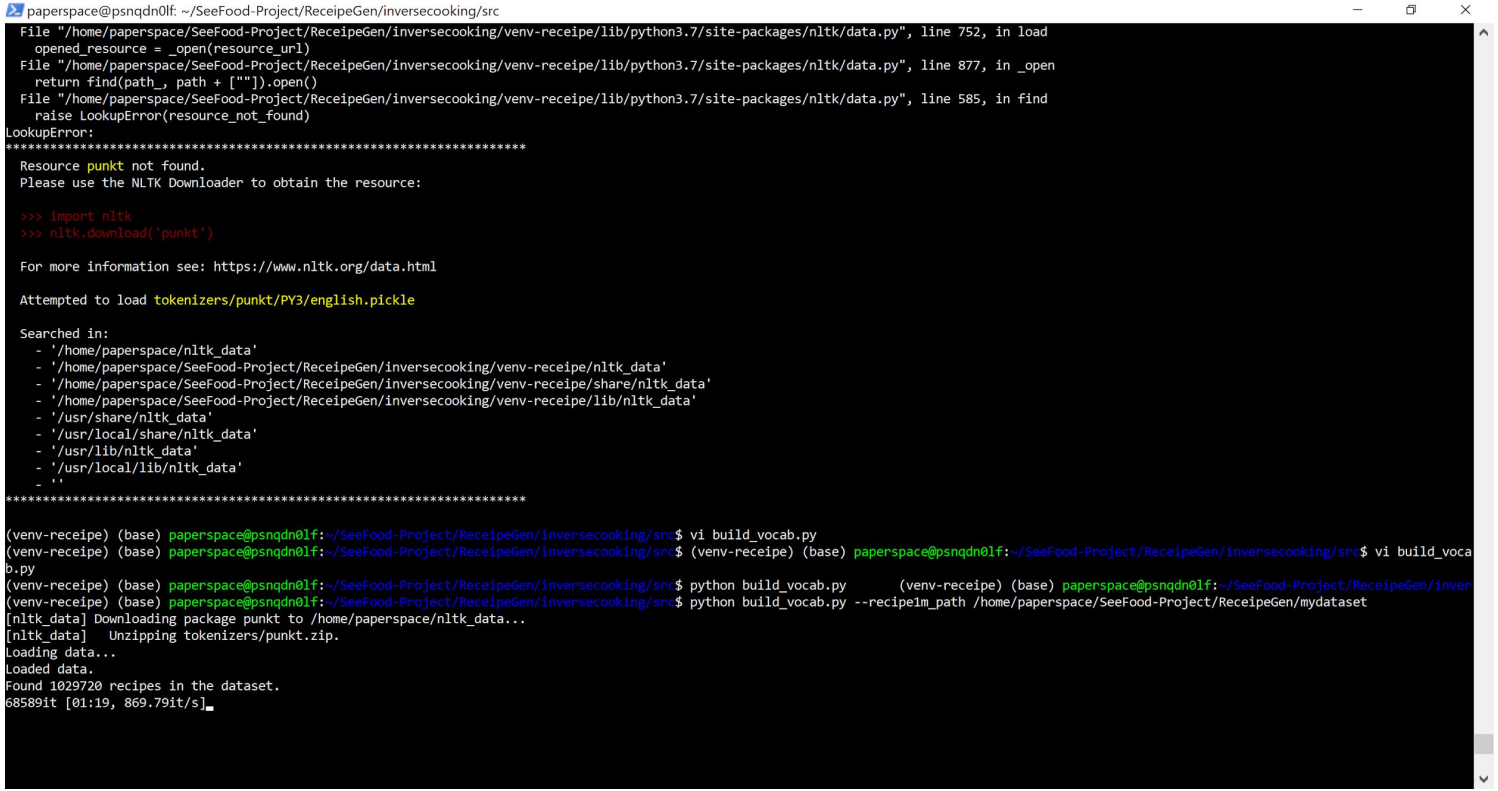


Receipe Generation modules - Training stages

1. Build Vocabulary
2. Ingredient Prediction from image
3. Recipe generation from ingredients and images

Cloud machine in Paperspace

Stage 1


paperspace@psnqdn0lf: ~/SeeFood-Project/ReceipeGen/inversecooking/src
File "/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/lib/python3.7/site-packages/nltk/data.py", line 752, in load
opened_resource = _open(resource_url)
File "/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/lib/python3.7/site-packages/nltk/data.py", line 877, in _open
return find(path_, path + [""]).open()
File "/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/lib/python3.7/site-packages/nltk/data.py", line 585, in find
raise LookupError(resource_not_found)
LookupError:
****
Resource punkt not found.
Please use the NLTK Downloader to obtain the resource:
>>> import nltk
>>> nltk.download('punkt')
For more information see: https://www.nltk.org/data.html
Attempted to load tokenizers/punkt/PY3/english.pickle
Searched in:
- '/home/paperspace/nltk_data'
- '/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/nltk_data'
- '/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/share/nltk_data'
- '/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/lib/nltk_data'
- '/usr/share/nltk_data'
- '/usr/local/share/nltk_data'
- '/usr/lib/nltk_data'
- '/usr/local/lib/nltk_data'
- ''
****
(venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ vi build_vocab.py
(venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ (venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ vi build_vocab.py
(venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ python build_vocab.py (venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inver
(venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ python build_vocab.py --recipe1m_path /home/paperspace/SeeFood-Project/ReceipeGen/mydataset
[nltk_data] Downloading package punkt to /home/paperspace/nltk_data...
[nltk_data] Unzipping tokenizers/punkt.zip.
Loading data...
Loaded data.
Found 1029720 recipes in the dataset.
68589it [01:19, 869.79it/s]

Stage 2

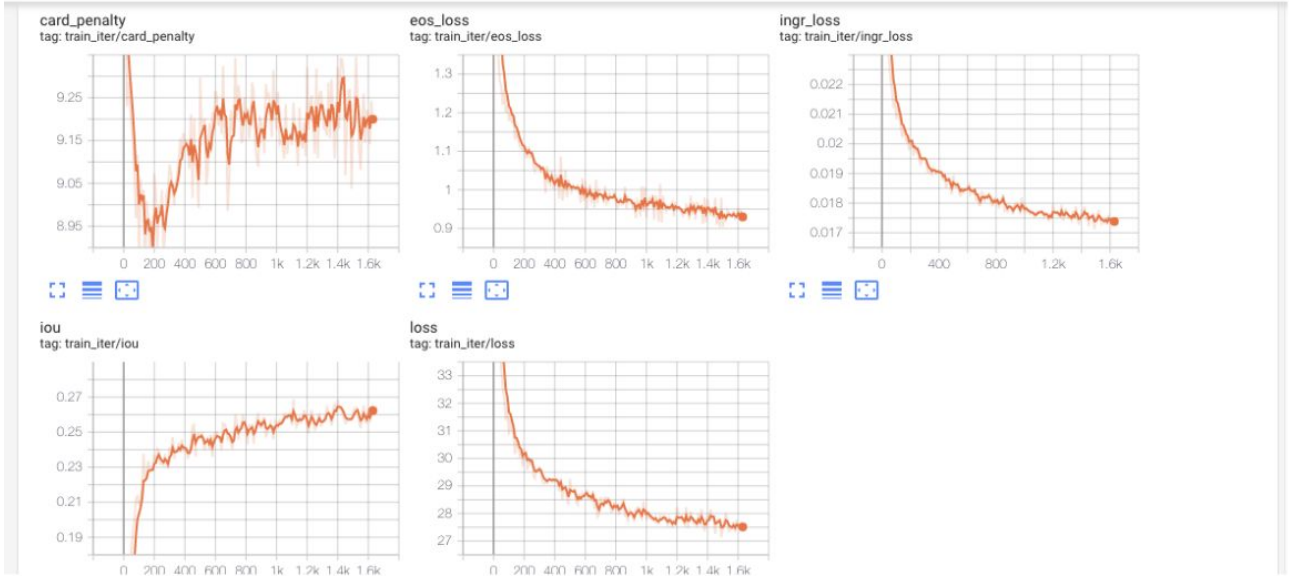
paperspace@psnqdn0lf: ~/SeeFood-Project/ReceipeGen/inversecooking/src

```
  File "/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/lib/python3.7/site-packages/nltk/data.py", line 752, in load
    opened_resource = _open(resource_url)
  File "/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/lib/python3.7/site-packages/nltk/data.py", line 877, in _open
    return find(path_, path + [""]).open()
  File "/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/lib/python3.7/site-packages/nltk/data.py", line 585, in find
    raise LookupError(resource_not_found)
LookupError:
**********************************************************************
  Resource punkt not found.
  Please use the NLTK Downloader to obtain the resource:

  >>> import nltk
  >>> nltk.download('punkt')

  For more information see: https://www.nltk.org/data.html

  Attempted to load tokenizers/punkt/PY3/english.pickle

  Searched in:
    - '/home/paperspace/nltk_data'
    - '/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/nltk_data'
    - '/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/share/nltk_data'
    - '/home/paperspace/SeeFood-Project/ReceipeGen/inversecooking/venv-receipe/lib/nltk_data'
    - '/usr/share/nltk_data'
    - '/usr/local/share/nltk_data'
    - '/usr/lib/nltk_data'
    - '/usr/local/lib/nltk_data'
    - ''
**********************************************************************

(venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ vi build_vocab.py
(venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ (venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ vi build_voca
b.py
(venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ python build_vocab.py       (venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inver
(venv-receipe) (base) paperspace@psnqdn0lf:~/SeeFood-Project/ReceipeGen/inversecooking/src$ python build_vocab.py --recipe1m_path /home/paperspace/SeeFood-Project/ReceipeGen/mydataset
[nltk_data] Downloading package punkt to /home/paperspace/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt.zip.
Loading data...
Loaded data.
Found 1029720 recipes in the dataset.
236937it [04:33, 922.74it/s]
```

Training stage 3

PID	USER	PRI	NI	VIRT	RES	SHR	S	CPU%	MEM%	TIME+	Command
1524	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1523	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1522	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1521	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1520	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1519	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1518	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1517	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1516	paperspac	20	0	19.5G	9462M	117M	R	86.6	31.4	0:03.58	python train.py --model_name im2ingr --batch_size 150 -
1515	paperspac	20	0	19.5G	9462M	117M	R	87.9	31.4	0:03.52	python train.py --model_name im2ingr --batch_size 150 -
1514	paperspac	20	0	19.5G	9462M	117M	R	88.6	31.4	0:03.68	python train.py --model_name im2ingr --batch_size 150 -
1513	paperspac	20	0	19.5G	9430M	117M	D	85.3	31.3	0:03.48	python train.py --model_name im2ingr --batch_size 150 -
1512	paperspac	20	0	19.5G	9454M	117M	R	79.9	31.4	0:03.61	python train.py --model_name im2ingr --batch_size 150 -
1511	paperspac	20	0	19.5G	9461M	117M	R	85.3	31.4	0:03.59	python train.py --model_name im2ingr --batch_size 150 -
1510	paperspac	20	0	19.5G	9454M	117M	R	91.3	31.4	0:03.62	python train.py --model_name im2ingr --batch_size 150 -
1509	paperspac	20	0	19.5G	9462M	117M	D	86.6	31.4	0:03.54	python train.py --model_name im2ingr --batch_size 150 -
1508	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1499	root	20	0	10088	5144	1460	S	0.0	0.0	0:00.00	/usr/sbin/xe-daemon -p /var/run/xe-daemon.pid
1498	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1497	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1496	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -
1495	paperspac	20	0	20.0G	9732M	388M	S	0.0	32.3	0:00.00	python train.py --model_name im2ingr --batch_size 150 -

Tensorboard with loss metrics



Performance metrics

Stages	IoU	F Score
Ingredient Prediction	32.11	48.61
Receipe Generation	32.52	49.08

Training time:
Each Epoch takes 16 minutes
We have evaluated with 400 epoches

Calorie Estimation:

- From the ingredients generated from Recipe module, I have computed the Calorie for the dish
- Each recipe provided me the nutritional value for every 100 grams
  - Fat/ Saturation
    - Every gram of fat has 37 kilojoules
  - Protein
    - Every gram of protein has 17 kilojoules
  - Sodium
    - Every gram of sodium has 8 kilojoules
  - Sugar
    - Every gram of sugar has 17 kilojoules
- Every kilojoule has 0.239006 calories
- Using that information I used the following formula to estimate calories
  - 0.24((fat * 37) + (protein*17) + (sodium *8) + (sugar * 17)) = total calories

```
[
    {
        "fsa_lights_per100g":{
            "fat":"green",
            "salt":"green",
            "saturates":"green",
            "sugars":"orange"
        },
        "id":"000095fc1d",
        "ingredients":[
            {
                "text":"yogurt, greek, plain, nonfat"
            },
            {
                "text":"strawberries, raw"
            },
            {
                "text":"cereals ready-to-eat, granola, homemade"
            }
        ],
        "instructions":[
            {
                "text":"Layer all ingredients in a serving dish."
            }
        ],
        "nutr_per_ingredient":[
            {
                "fat":0.8845044000000001,
                "nrg":133.80964,
                "pro":23.110512399999998,
                "sat":0.26535132,
                "sod":81.64656,
                "sug":7.348190400000001
            },
            {
                "fat":0.46,
                "nrg":49.0,
                "pro":1.02,
                "sat":0.023,
                "sod":2.0,
                "sug":7.43
            },
            {
                "fat":7.415,
                "nrg":149.25,
                "pro":4.17,
                "sat":1.207,
                "sod":8.0,
                "sug":6.04
            }
        ],
        "nutr_values_per100g":{
```

Technical challenges

- Food Classification multi-class classification weights tuning
- Receipe generation pipeline setup was difficult with tensorflow, pytorch and Cuda dependencies version
- Calorie estimation is computed on Raw vegetables which we fixed for cooking ingredients
- Merging the inference pipeline for three different modules

WebApp Demo

- Read an image
- Classify food category
- Generate Recipe
- Calculate Calorie

Thank you