Estimating Parking Capacity in Somerville

Milestone 3
November 13, 2019

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City of **Somerville**

IACS

Problem Statement

Inventory of all parking in Somerville

Non-residential parking
Street parking
Parking garages
Parking lots

✅ Handled by city of Somerville

Residential parking
Driveways
Garages

Primary Goal: Estimate location of driveways
Secondary Goal: Estimate parking capacity of each land parcel

Problem Statement

Inventory of all parking in Somerville

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Residential parking
Driveways
Garages

Primary Goal: Estimate location of driveways
Secondary Goal: Estimate parking capacity of each land parcel (likely out of scope)

Last Time

1. Google Street View

2. Created a dataset of 527 street view images and corresponding aerial satellite photos of parcels

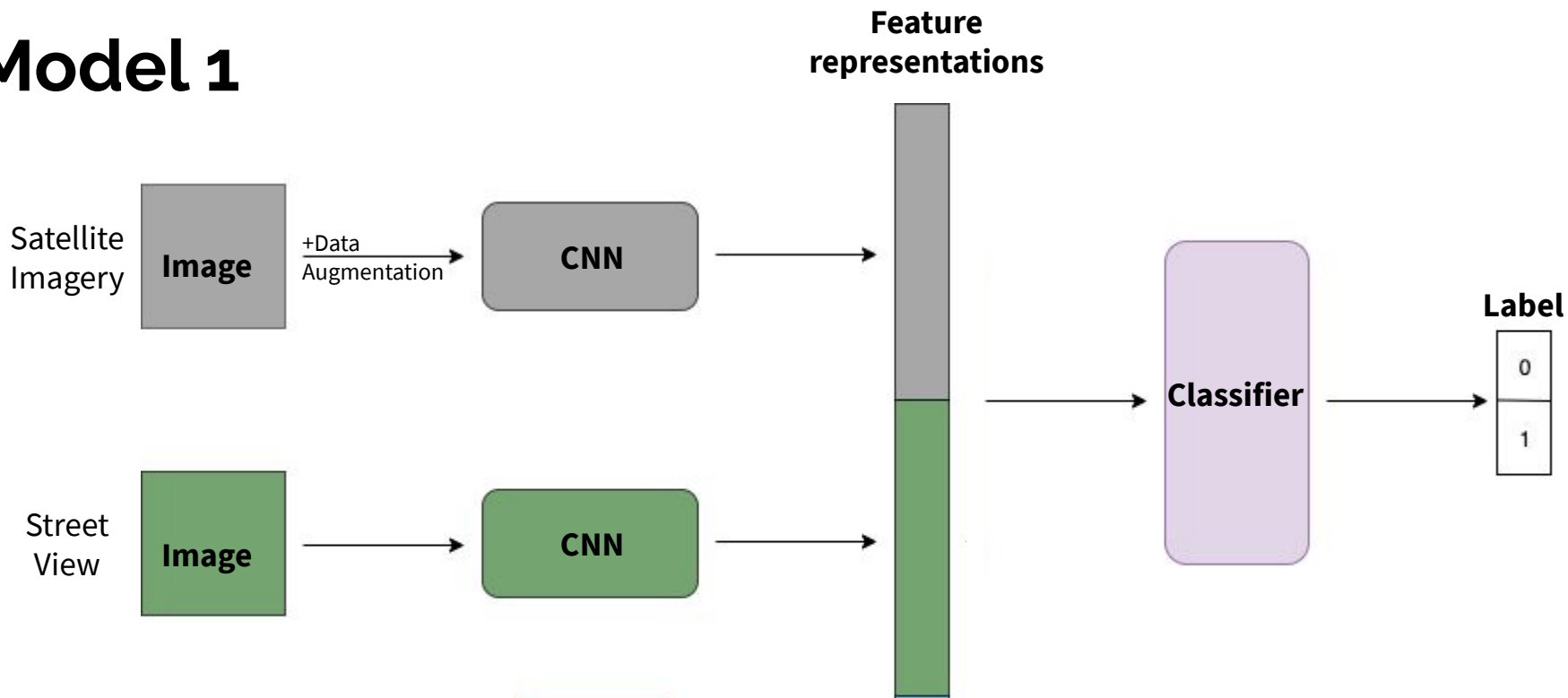3. Labelled all 287 of these paired images

What's New

1. Created a dataset of 527 street view images, corresponding aerial satellite photos of parcels, and tabular data from tax assessment information

2. Labelled all of these paired images

3. Trained model on both images and tabular data

4. Added upsampling instead of downsampling

Tabular Data Features

- ❏ BLDG_VAL:Current assessed value for the main building(s) on the property
- ❏ LAND_VAL: Current assessed value for land
- ❏ OTHER_VAL:Other structures or physical improvements that are separately valued
- ❏ LOT_SIZE: Deed area in EITHER square feet OR acres, but not both, to two decimal places
- ❏ LS_PRICE: Last sale price
- ❏ LS_YEAR: Last year of sale
- ❏ YEAR_BUILT
- ❏ BLD_AREA: Applies primarily to apartment buildings and commercial/industrial properties; assessor's data is based on exterior building measurements.
- ❏ UNITS: Number of living/dwelling units and also other units, for example, commercial condos and storage units in a warehouse.

- ❏ RES_AREA: Applies primarily to 1, 2 & 3 family dwellings based on exterior building measurements or residential condominiums based on deeded unit areas.
- ❏ STORIES: Story height is typically recorded as a full story for each floor, except under roof-line floors, which are adjusted by factors ranging from 10% to 90% of a full story depending on roof slope and wall height
- ❏ NUM_ROOMS: Total room count as determined by the assessor; primarily applied to residential properties.
- ❏ LOT_UNITS: S (sq. ft.) or A (acres) (Added by vendor, not from assessor database)
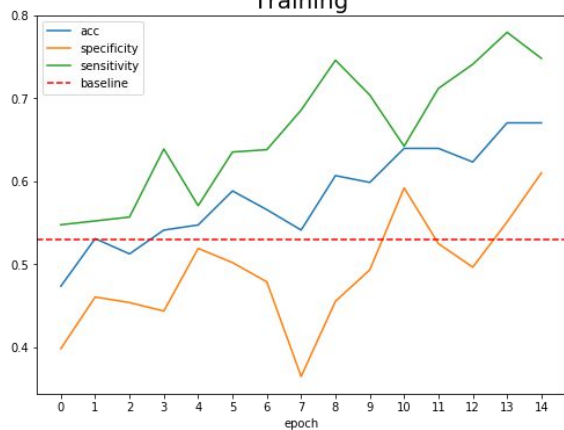- ❏ BLD_AREA_MISSING:
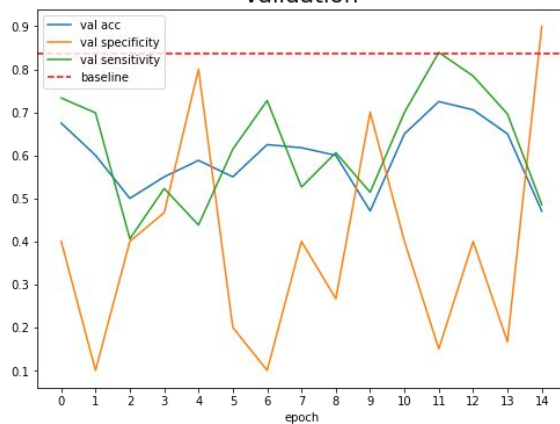- ❏ BLDG_VAL_MISSING,
- ❏ LOT_SIZE_MISSING,

Model 1
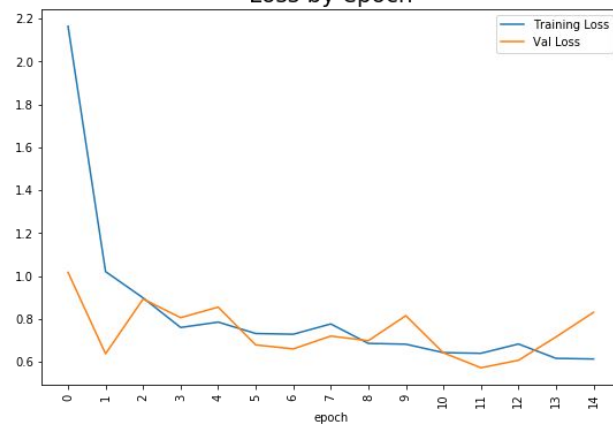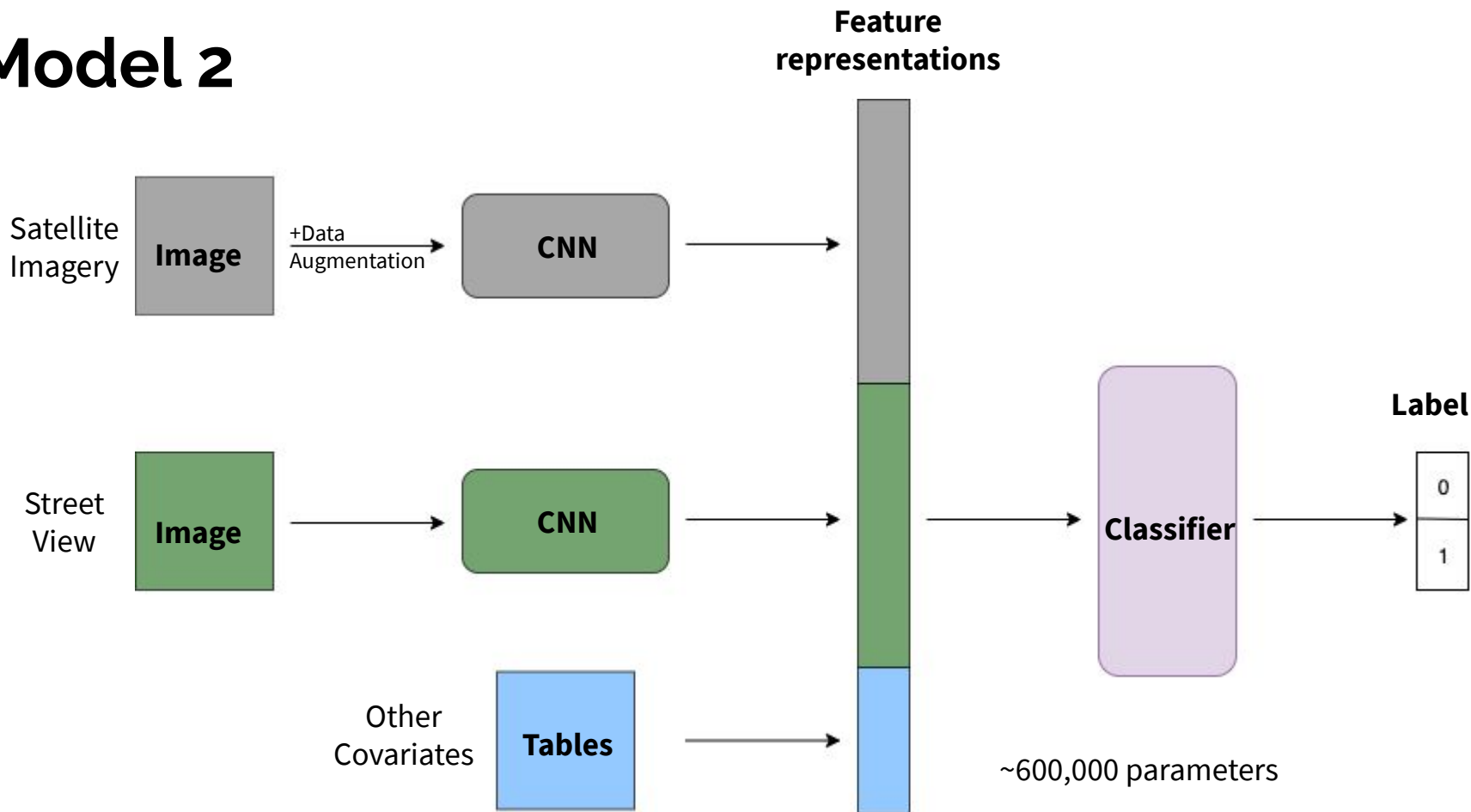
Feature representations

Satellite Imagery — **Image** — +Data Augmentation → **CNN** →

Street View — **Image** → **CNN** →

Classifier → **Label**

| 0 |
| 1 |

~500,000 parameters

Model 1

Model 2

Feature representations

Satellite Imagery — **Image** — +Data Augmentation → **CNN** →

Street View — **Image** → **CNN** →

Other Covariates — **Tables** →

→ **Classifier** → **Label**

0
1

~600,000 parameters

Model 2

Image labels

Model 1 prediction	Model 2 prediction
0.63	0

Not sure

Yes
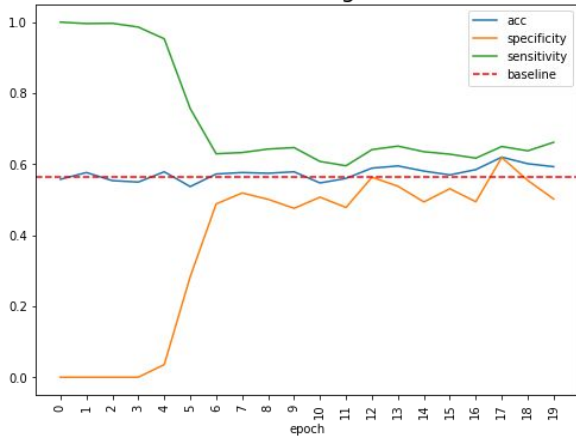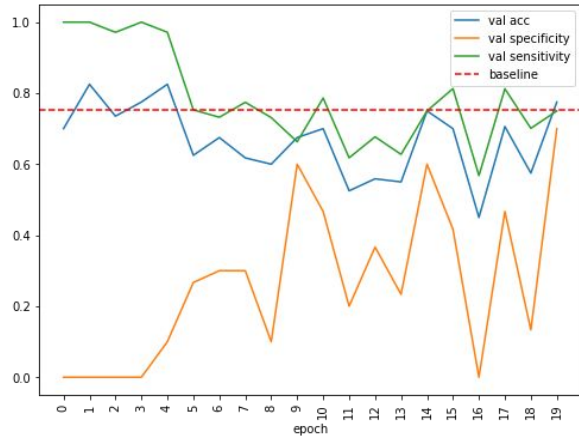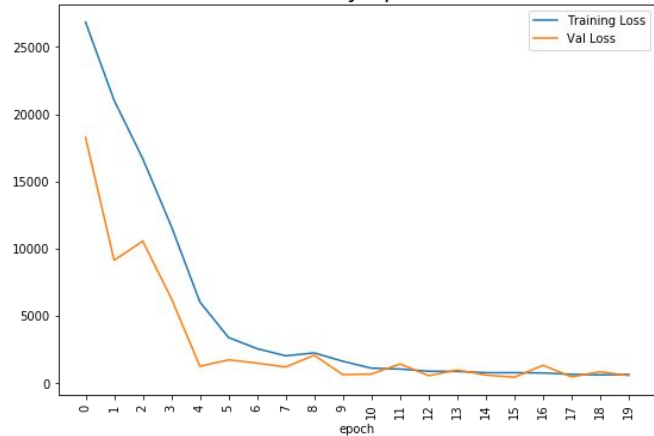
Image labels
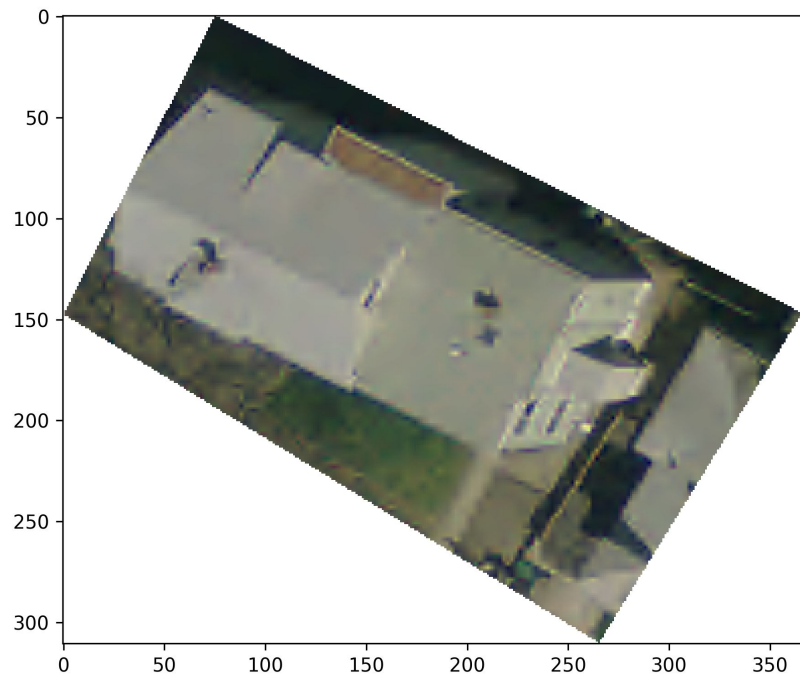
Model 1 prediction	Model 2 prediction
0.31	1

Unsure

Yes
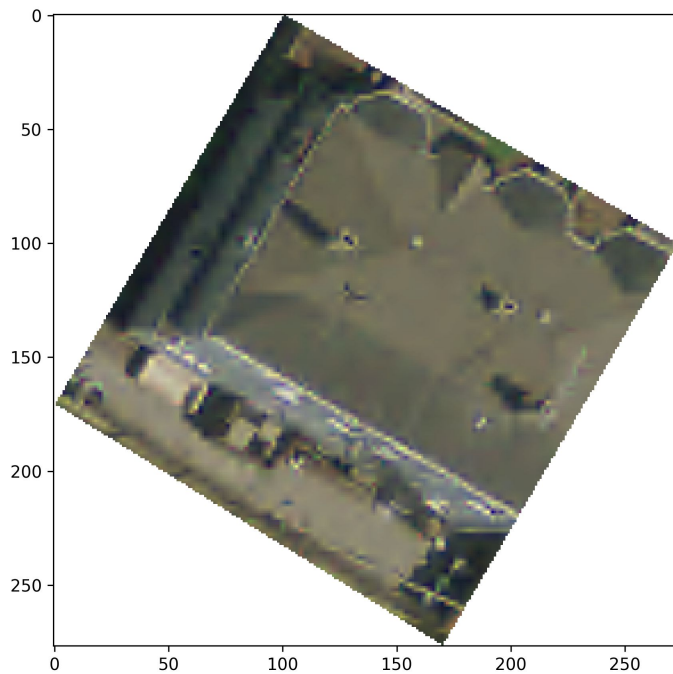
Image labels

Yes

Model 1 prediction	Model 2 prediction
0.47	1
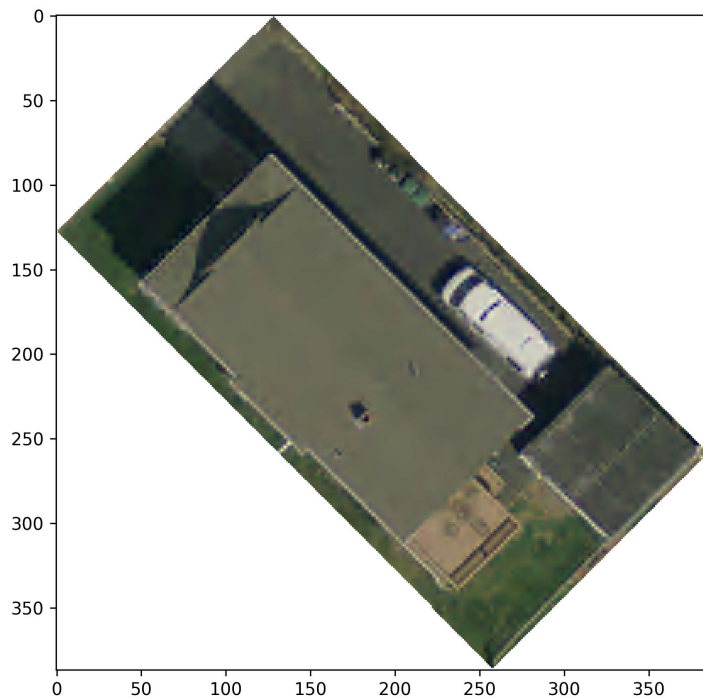
Yes

Image labels

Model 1 prediction	Model 2 prediction
0.43	1

No
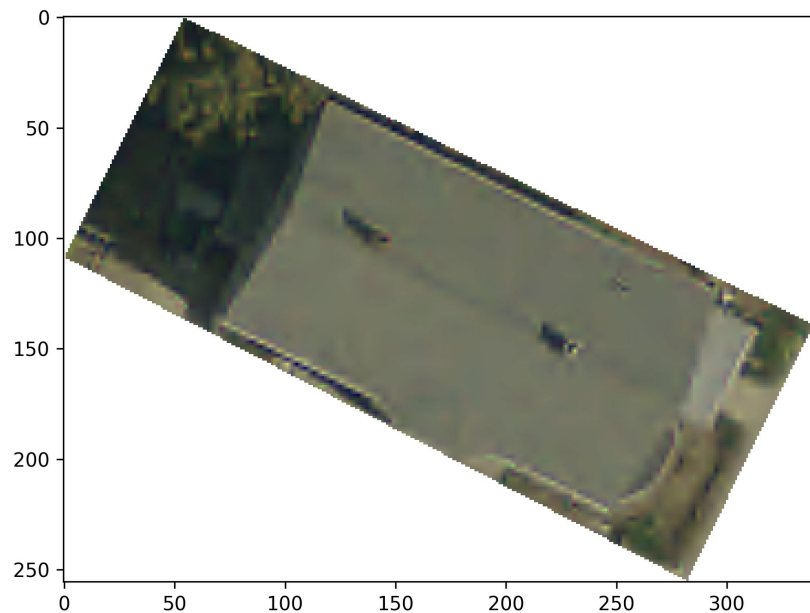
No
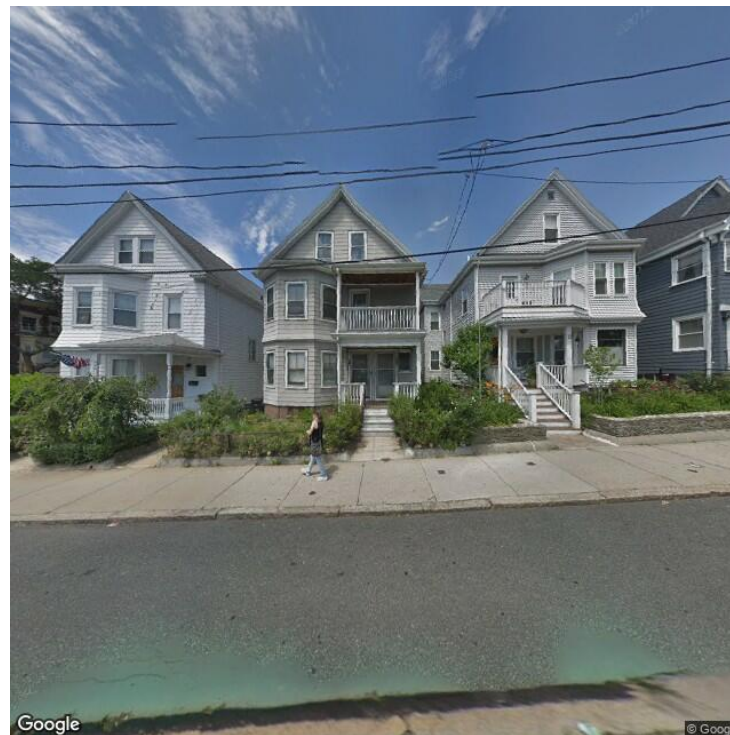
Image labels

Model 1 prediction	Model 2 prediction
0.56	0

Not sure

Not sure
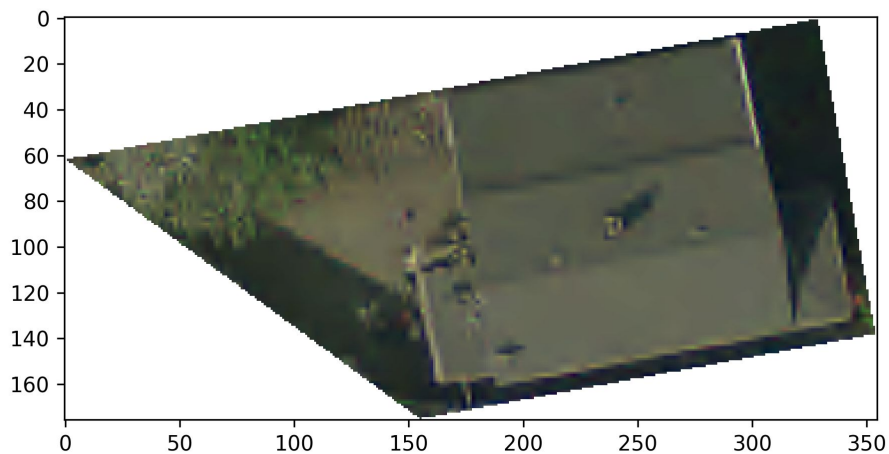
Modelling next steps

1. Data
   a. Add more predictors such as distance between buildings in adjacent parcels
2. Model tuning
   a. **Transfer learning**
   b. **Label smoothing**
   c. Hyperparameter tuning
   d. Different model architectures
3. Apply model to all data to produce driveway location estimates

Model 1 Predictions

```
In [29]: addresses_gsv_filename = ['1_ESSEX_ST.jpg', '8_GILMAN_ST.jpg', '9_MELVILLE_RD.jpg','10_CENTRAL_ST.jpg',
                                   '14_MANSFIELD_ST.jpg']
         pred_sample = sample[sample.gsv_filename.isin(addresses_gsv_filename)]
         pred_sample
```

Out[29]:

| M	FULL_STR	MBL	ADDRESS_FOR_STREET_VIEW	AERIAL_Driveway	GSV_Driveway	final_label	aerial_filename	gsv_filename	temp_label
14	MANSFIELD ST	81-B-16	14 MANSFIELD ST, SOMERVILLE, MA	2.0	2.0	0.5	14_MANSFIELD_ST_aerial.png	14_MANSFIELD_ST.jpg	0
8	GILMAN ST	92-J-10	8 GILMAN ST, SOMERVILLE, MA	1.0	2.0	0.9	8_GILMAN_ST_aerial.png	8_GILMAN_ST.jpg	1
1	ESSEX ST	50-B-12	1 ESSEX ST, SOMERVILLE, MA	2.0	1.0	0.9	1_ESSEX_ST_aerial.png	1_ESSEX_ST.jpg	1
9	MELVILLE RD	55-C-13	9 MELVILLE RD, SOMERVILLE, MA	1.0	1.0	1.0	9_MELVILLE_RD_aerial.png	9_MELVILLE_RD.jpg	1
10	CENTRAL ST	44-F-8	10 CENTRAL ST, SOMERVILLE, MA	0.0	0.0	0.0	10_CENTRAL_ST_aerial.png	10_CENTRAL_ST.jpg	0

```
In [30]: model.predict_generator(generator_two_inputs(pred_sample, aerial_dir = '../data/training/aerial_images/',
                     gsv_dir ='../data/training/sv_images/', batch_size = batch_size,
                     gsv_image_dim = (128,128, 3), aer_image_dim = (128,128, 4), y_column = 'temp_label'),
                     steps = 1)
```

```
Found 5 validated image filenames belonging to 2 classes.
Found 5 validated image filenames belonging to 2 classes.
```

```
Out[30]: array([[0.56627464],
                [0.31721202],
                [0.6378035 ],
                [0.47309566],
                [0.4315741 ]], dtype=float32)
```

Model 2 Predictions

M	FULL_STR	MBL	ADDRESS_FOR_STREET_VIEW	AERIAL_Driveway	GSV_Driveway	final_label	aerial_filename	gsv_filename	temp_label
14	MANSFIELD ST	81-B-16	14 MANSFIELD ST, SOMERVILLE, MA	2.0	2.0	0.5	14_MANSFIELD_ST_aerial.png	14_MANSFIELD_ST.jpg	0
8	GILMAN ST	92-J-10	8 GILMAN ST, SOMERVILLE, MA	1.0	2.0	0.9	8_GILMAN_ST_aerial.png	8_GILMAN_ST.jpg	1
1	ESSEX ST	50-B-12	1 ESSEX ST, SOMERVILLE, MA	2.0	1.0	0.9	1_ESSEX_ST_aerial.png	1_ESSEX_ST.jpg	1
9	MELVILLE RD	55-C-13	9 MELVILLE RD, SOMERVILLE, MA	1.0	1.0	1.0	9_MELVILLE_RD_aerial.png	9_MELVILLE_RD.jpg	1
10	CENTRAL ST	44-F-8	10 CENTRAL ST, SOMERVILLE, MA	0.0	0.0	0.0	10_CENTRAL_ST_aerial.png	10_CENTRAL_ST.jpg	0

```
[25]: sample_check = sample.copy()
```

```
[28]: model.predict_generator(
          generator_three_inputs(pred_sample, tabular_df,
                                 tabular_predictor_cols = tabular_predictor_cols,
                          aerial_dir = '../data/training/aerial_images/',
                          gsv_dir ='../data/training/sv_images/',
                          batch_size = pred_sample.shape[0],
                          gsv_image_dim = (128,128, 3), aer_image_dim = (128,128, 4) ,
                          y_column = 'temp_label'), steps = 1)
```

```
Found 5 validated image filenames.
Found 5 validated image filenames belonging to 2 classes.
```

```
[28]: array([[0.],
             [1.],
             [0.],
             [1.],
             [1.]], dtype=float32)
```