Estimating Parking Capacity in Somerville

Midterm Presentation
October 15, 2019

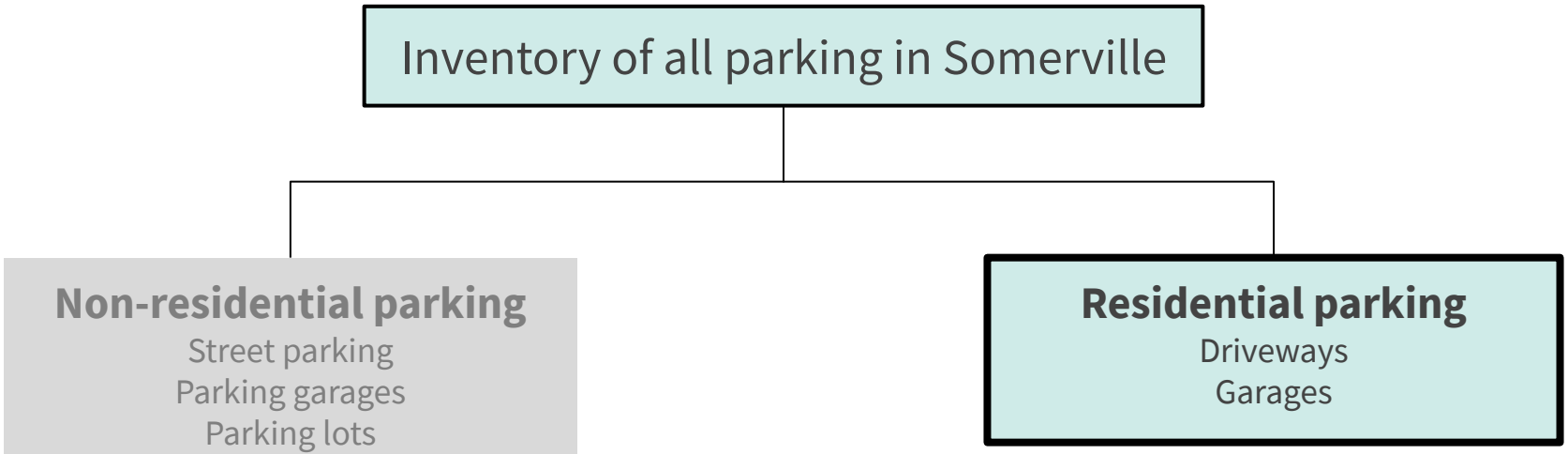
Anthony Rentsch, Joshua Feldman, Lipika Ramaswamy

City of **Somerville**

IACS

Background + Problem Statement

Problem Statement



✔ Handled by city of Somerville

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

Approach

1. Use satellite imagery to predict whether a house has a driveway
2. For labels - use a combination of tabular data sources and manual tagging
3. After predicting whether a house has parking, tackle the capacity estimation problem if time left in semester

Related Work

Lots of people have taken similar approaches for identifying swimming pools in backyards [1, 2].

Takeaways

- Choose a “smart” set of channels based on receptive field
- Augment training (and test) data by applying transformations to the image
- Use auxiliary data to identify which images are allowed to have the feature of interest (e.g., only residential parcels can have driveways)
- Use transfer learning + Single Shot MultiBox Detector (SSD) approach

Data

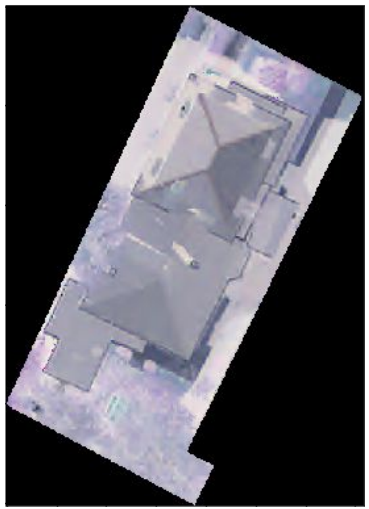
Data: Satellite Imagery

- Source: Massachusetts Orthoimagery Consortium, Spring 2015
- Best quality available; other years' data is license-restricted
- Geotagged raster data
- .TIFF (Tagged Image Format File)
- 5 channels: RGB, near infrared, and one unknown channel

Data: Satellite Imagery

Cleaning

- Extracted 14GB from proprietary ArcMap format
- Separated each parcel into a standalone .TIFF
- Exported to over 14,000 individual images
- Different sizes, different orientations
- Residences are only one type of parcel



Tabular Data

- Parcel Information
  - Information for each parcel exported from satellite imagery
  - Lot size, address, building area, residence area, # stories, # rooms, style (single family, apartment, office, school, etc.)

- Residential Parking Permits
  - Permits for Somerville residents to utilize street parking
  - Used to determine number of permits per street address (parcel)

- Registered Vehicles
  - Information on each garaged vehicle in the city of Somerville
  - Unique by license plate
  - Used to determine number of cars to be parked by street address (parcel)

- Curb Cuts Requests
  - Information on curb cuts requested by residents
  - Indicates that they intend to build a driveway
  - Data forthcoming

Parcel information

	ID	SITE_ADDR	ADDR_NUM	FULL_STR	SITE_CITY	SITE_ZIP	YEAR_BUILT	BLD_AREA	UNITS	RES_AREA	STYLE	STORIES	NUM_ROOMS
0	1	67 BROADWAY	67	BROADWAY	SOMERVILLE	NaN	1900.0	6842.0	0	4073.0	Office/Apts	2.3	0
1	2	9 PENNSYLVANIA AVE	9	PENNSYLVANIA AVE	SOMERVILLE	NaN	1900.0	4740.0	0	3002.0	2-Decker	2.8	13
2	3	11 MAINE AVE	11	MAINE AVE	SOMERVILLE	NaN	1900.0	4628.0	0	3120.0	3-Decker	3.0	15
3	4	13 PENNSYLVANIA AVE	13	PENNSYLVANIA AVE	SOMERVILLE	NaN	1900.0	4769.0	0	3206.0	3 fam Conv	2.8	14
4	5	17 PENNSYLVANIA AVE	17	PENNSYLVANIA AVE	SOMERVILLE	NaN	1900.0	5389.0	0	3142.0	3 fam Conv	2.8	14
5	6	21 PENNSYLVANIA AVE	21	PENNSYLVANIA AVE	SOMERVILLE	NaN	1900.0	5000.0	0	3151.0	Two Family	2.8	11
6	7	25 PENNSYLVANIA AVE	25	PENNSYLVANIA AVE	SOMERVILLE	NaN	1915.0	4991.0	0	3288.0	Two Family	2.8	15
7	8	29 PENNSYLVANIA AVE	29	PENNSYLVANIA AVE	SOMERVILLE	NaN	1900.0	4900.0	0	3204.0	3 fam Conv	2.8	15
8	9	33 PENNSYLVANIA AVE	33	PENNSYLVANIA AVE	SOMERVILLE	NaN	1900.0	4564.0	0	2912.0	Two Family	2.5	11
9	10	37 PENNSYLVANIA AVE	37	PENNSYLVANIA AVE	SOMERVILLE	NaN	1900.0	4600.0	0	2895.0	Two Family	2.8	12

Tabular Data

- Parcel Information
  - Information for each parcel exported from satellite imagery
  - Lot size, address, building area, residence area, # stories, # rooms, style (single family, apartment, office, school, etc.)

- Residential Parking Permits
  - Permits for Somerville residents to utilize street parking
  - Used to determine number of permits per street address (parcel)

- Registered Vehicles
  - Information on each garaged vehicle in the city of Somerville
  - Unique by license plate
  - Used to determine number of cars to be parked by street address (parcel)

- Curb Cuts Requests
  - Information on curb cuts requested by residents
  - Indicates that they intend to build a driveway
  - Data forthcoming

Residential parking permits by street address

Original Data

	type_code	type_name	issued	effective	expiration	st_addr	unit_num	city	state	zip_code
0	WD	Moving Van	02/23/2017 12:00:00 AM	03/01/2017 12:00:00 AM	03/01/2017 12:00:00 AM	69 ADAMS ST	1	SOMERVILLE	MA	2145.0
1	G	Visitor	05/22/2017 12:00:00 AM	04/01/2017 12:00:00 AM	04/30/2018 12:00:00 AM	37 SEWALL ST		SOMERVILLE	MA	2145.0
2	G	Visitor	05/22/2017 12:00:00 AM	04/01/2017 12:00:00 AM	04/30/2018 12:00:00 AM	37 SEWALL ST		SOMERVILLE	MA	2145.0
3	G	Visitor	07/07/2017 12:00:00 AM	07/06/2017 12:00:00 AM	06/30/2018 12:00:00 AM	25 BEACON ST	5	SOMERVILLE	MA	2143.0
4	G	Visitor	07/07/2017 12:00:00 AM	07/06/2017 12:00:00 AM	06/30/2018 12:00:00 AM	25 BEACON ST	5	SOMERVILLE	MA	2143.0

Aggregated Data

	st_addr	residential_permits_issued
0	1 ALDERSEY ST	1
1	1 AVON ST	3
2	1 BEACON ST	1
3	1 BELMONT SQ	3
4	1 BENTON RD	3
5	1 BRADLEY ST	5
6	1 CAPEN CAP	2
7	1 CAPEN ST	14
8	1 CARVER ST	4
9	1 CEDAR ST	2

Tabular Data

- Parcel Information
  - Information for each parcel exported from satellite imagery
  - Lot size, address, building area, residence area, # stories, # rooms, style (single family, apartment, office, school, etc.)

- Residential Parking Permits
  - Permits for Somerville residents to utilize street parking
  - Used to determine number of permits per street address (parcel)

- Registered Vehicles
  - Information on each garaged vehicle in the city of Somerville
  - Unique by license plate
  - Used to determine number of cars to be parked by street address (parcel)

- Curb Cuts Requests
  - Information on curb cuts requested by residents
  - Indicates that they intend to build a driveway
  - Data forthcoming

Registered vehicles by street address

Original Data

	Address	Unit	City	State	Zip	Plate.Type	Year	PlateID	EV
0	67 CONCORD AVE		SOMERVILLE	MA	2143	PAN	2017	COS_1	No
1	67 CONCORD AVE		SOMERVILLE	MA	2143	PAN	2016	COS_1	No
2	46 BOW ST		SOMERVILLE	MA	2143	PAN	2016	COS_2	No
3	46 BOW ST		SOMERVILLE	MA	2143	PAN	2017	COS_2	No
4	77 NEWBURY ST	1	SOMERVILLE	MA	2144	PAR	2016	COS_3	No

Aggregated Data

	Address	City	num_registered_vehicles
1	08 GEORGE ST	SOMERVILLE	1
2	1 ALDERSEY ST	SOMERVILLE	2
4	1 AVON ST	SOMERVILLE	3
5	1 BANKS ST	SOMERVILLE	2
6	1 BEACON ST	E SOMERVILLE	1
7	1 BEACON ST	SOMERVILLE	1
8	1 BELMONT SQ UNIT 1	SOMERVILLE	1
9	1 BELMONT SQUARE	SOMERVILLE	2
10	1 BENTON RD	SOMERVILLE	4
11	1 BENTON RD 2	SOMERVILLE	1

Tabular Data

- Parcel Information
  - Information for each parcel exported from satellite imagery
  - Lot size, address, building area, residence area, # stories, # rooms, style (single family, apartment, office, school, etc.)

- Residential Parking Permits
  - Permits for Somerville residents to utilize street parking
  - Used to determine number of permits per street address (parcel)

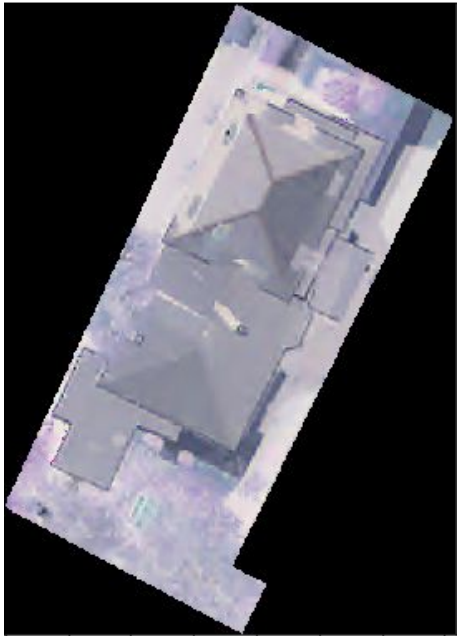
- Registered Vehicles
  - Information on each garaged vehicle in the city of Somerville
  - Unique by license plate
  - Used to determine number of cars to be parked by street address (parcel)

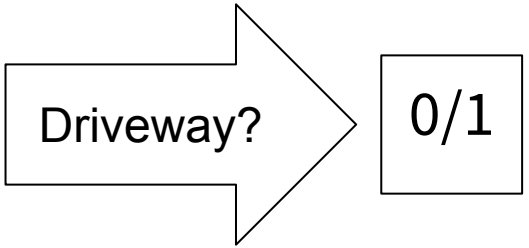
- Historical Curb Cuts Requests
  - Information on curb cuts requested by residents
  - Indicates that they intend to build a driveway
  - Data forthcoming

Modelling

Modelling Step 1:
Does a parcel have a driveway or not?

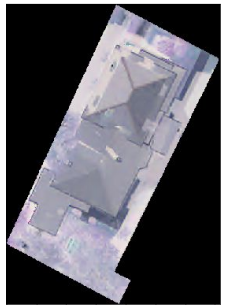
- Formulate as image binary classification

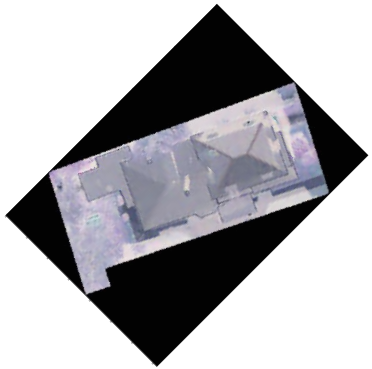




Modelling Step 1:
Does a parcel have a driveway or not?

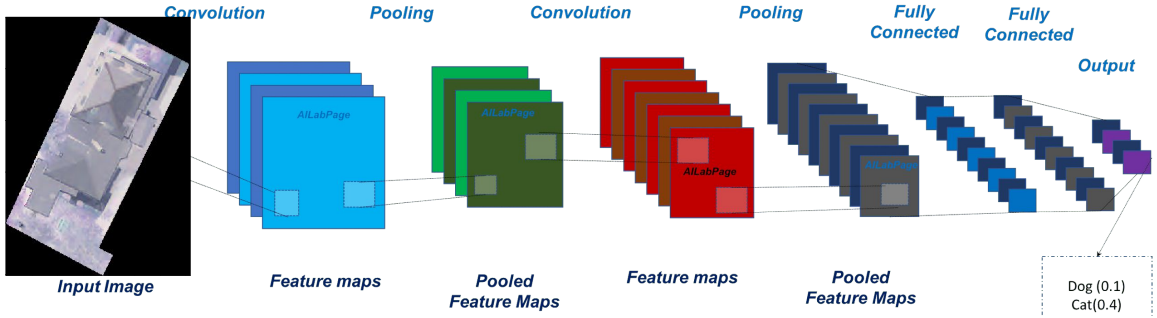
- Formulate as image binary classification
- Augment training data with transformed images



Modelling Step 1:
Does a parcel have a driveway or not?

- Formulate as image binary classification
- Augment training data with transformed images
- Train basic CNN (for now)



Modelling Step 1:
Does a parcel have a driveway or not?

- Formulate as image binary classification
- Augment training data with transformed images
- Train basic CNN (for now)
- Experiment with methods for small datasets

Transfer Learning

Disentangled Representations

Active Learning

Modelling Step 2:
What is the capacity of a driveway?

Initial ideas

- Hand-label estimates for driveway capacity for parcels with driveways
- Use tabular data to estimate based on area and type of house (single-family, apartment, etc.)
- Look for images with cars and compute their size (average or max) in pixels and estimate how many would fit within the shape of a parcel's driveway

Early Results

Results, the good

Manual label

Yes, driveway

Model score

0.9992046

Manual label

No driveway

Model score

0.01251887

Results, the bad

Looking Ahead...

Timeline

October 30	Extract new data sample from LandSat and manually label in ArcGIS
November 6	Implement transfer learning (VGG16, Resnet-34) + SSD into model
November 15	Milestone 3: Preliminary results for location of driveways sent to partner
November 20	Capacity estimation models
December 9-12	IACS Showcase; final presentation + deliverables

References

[1] Jha D and Singh R. Swimming pool detection and classification using deep learning. https://medium.com/geoai/swimming-pool-detection-and-classification-using-deep-learning-aaf4a3a5e652.

[2] Pool Detection Using Deep Learning. https://github.com/DigitalGlobe/mltools/blob/master/examples/polygon_classify_cnn/README.md.