Automated Road Network Extraction and Route Travel Time Estimation from Satellite Imagery

Data prep:

AOI_7_Moscow: total length: 2252.3 km, 1353 chip tiff files
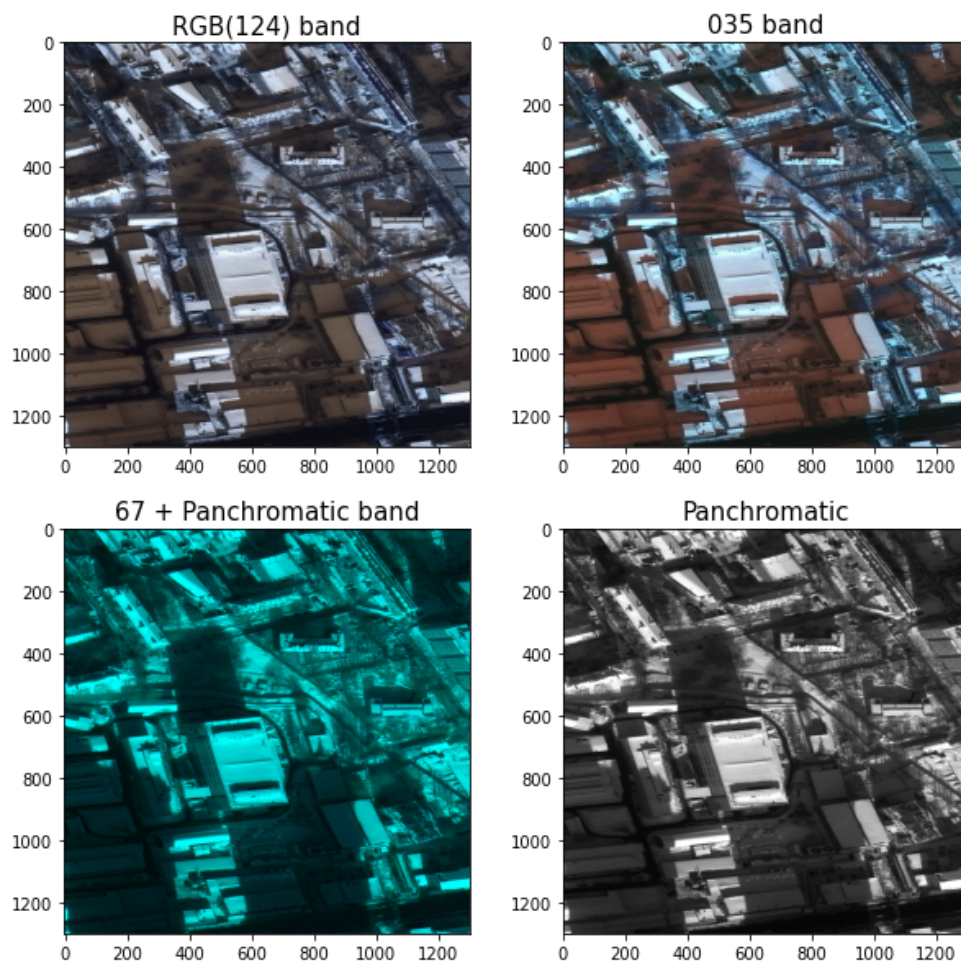AOI_8_Mumbai: total length: 1391.6 km, 1016 chip tiff files

Tiff file:
PS-MS: 1300*1300*8 files, PAN: 1300*1300*1 files
Pan-sharpenned 8-channel multispectral image with value 0~2000+
Panchromatic image

We stored the 9 channels of one chip image into 3 png files, as shown below.

Moscow chip 178

Speed mask creation

The roads length, coordinates and travel time data are stored in csv files.

```
df_simp[(df_simp['ImageId']=='SN5_roads_train_AOI_7_Moscow_chip1300')][:5]
```
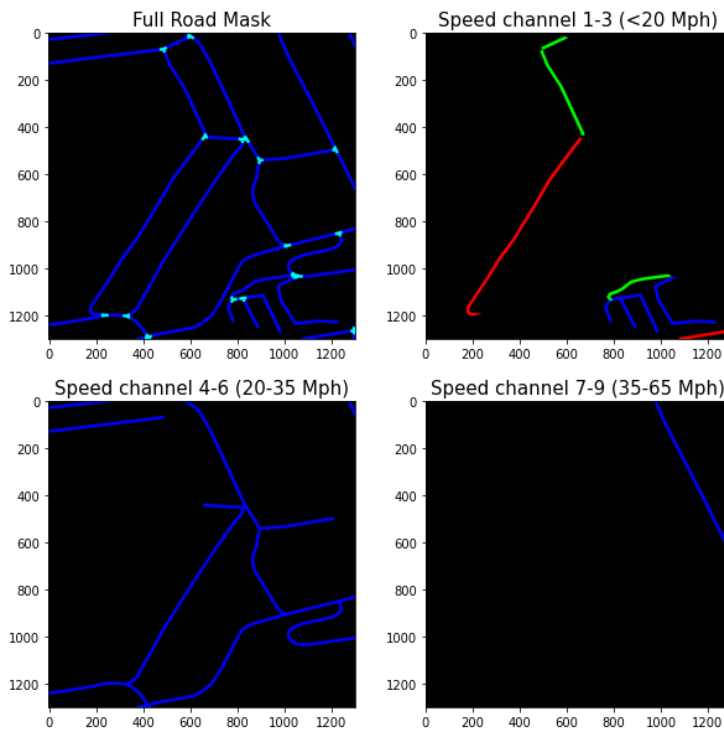
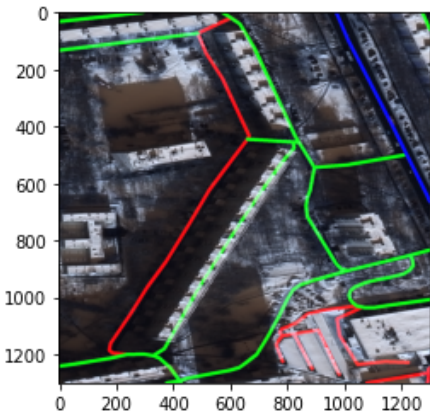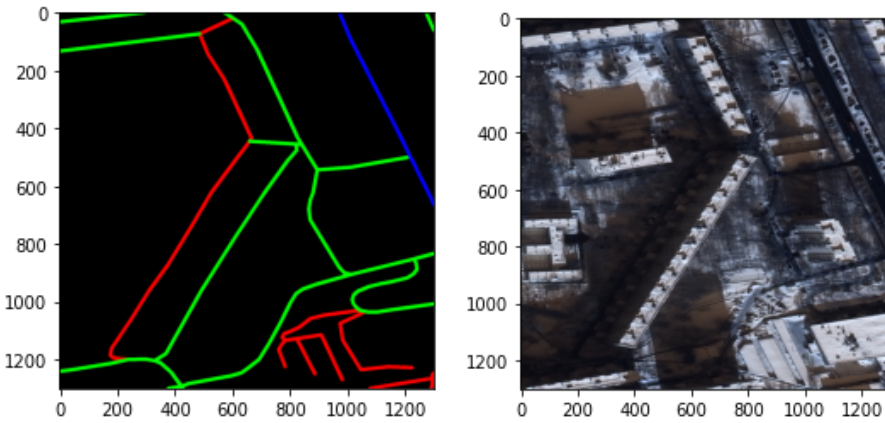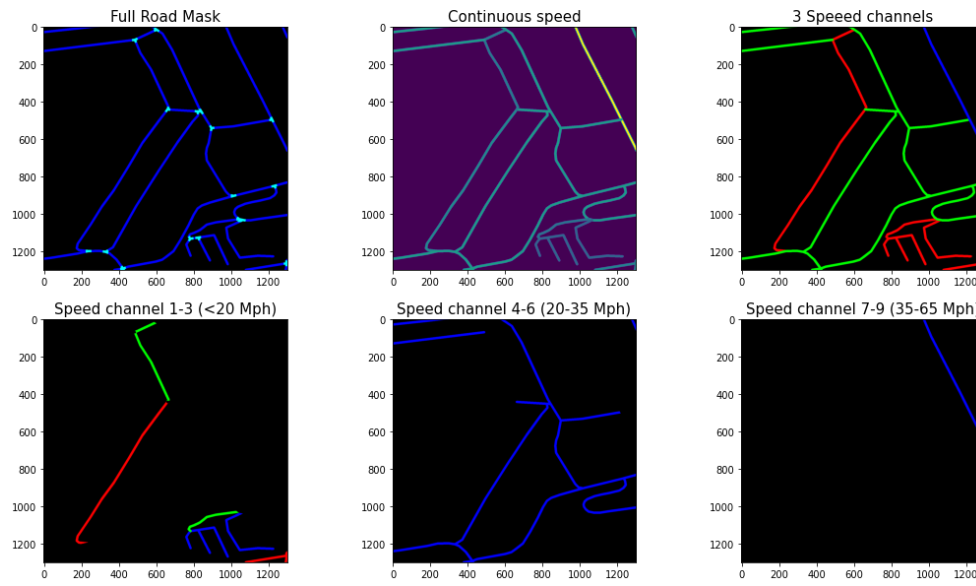|	ImageId	WKT_Pix	length_m	travel_time_s	speed
8593	SN5_roads_train_AOI_7_Moscow_chip1300	LINESTRING (1218.921328015625 499.127116709947...	59.492	2.957329	45.0
8594	SN5_roads_train_AOI_7_Moscow_chip1300	LINESTRING (1295.024837473407 1264.24377623200...	12.418	1.388914	20.0
8595	SN5_roads_train_AOI_7_Moscow_chip1300	LINESTRING (1078.604571962729 1299.99495349079...	44.062	4.928194	20.0
8596	SN5_roads_train_AOI_7_Moscow_chip1300	LINESTRING (1299.994953490794 1246.84674017503...	6.326	0.707543	20.0
8597	SN5_roads_train_AOI_7_Moscow_chip1300	LINESTRING (1062.504190951586 1033.84425793215...	47.759	4.273354	25.0

WKT_Pix to geometrical shapes:

We extracted these road information and draw them on corresponding chips to creat the speed masks

Moscow chip 1300

Full Road Mask

Continuous speed

3 Speeed channels

Speed channel 1-3 (<20 Mph)

Speed channel 4-6 (20-35 Mph)

Speed channel 7-9 (35-65 Mph)

Image Augmentation

Before feeding the images and masks to the machine learning models, we did some image augmentation operations:

Shift, rotate, crop, gaussian noise, contrast/ brightness/ saturation….

Modeling

11 channels: full road shape, 9 speed channels, 1 continuous speed channel
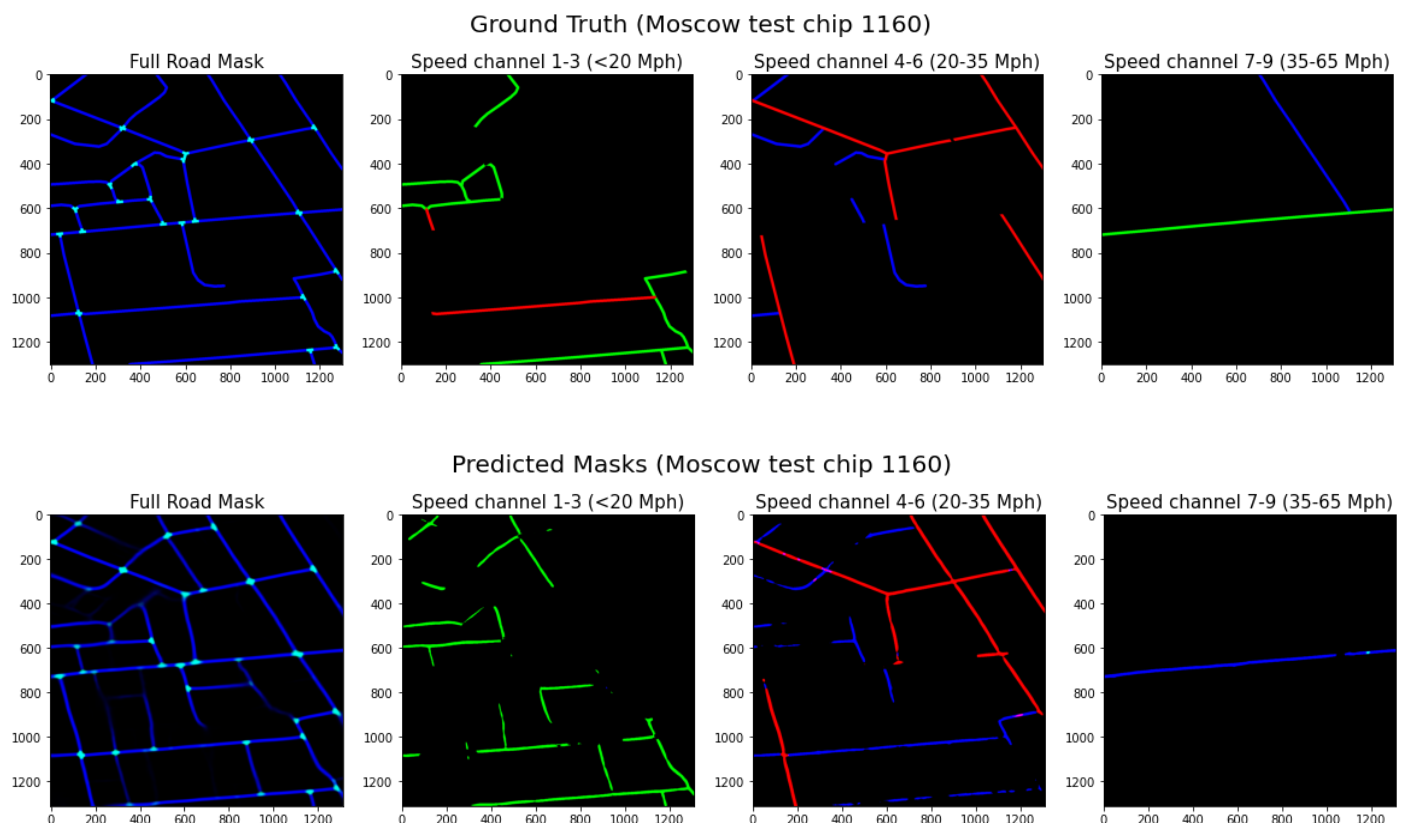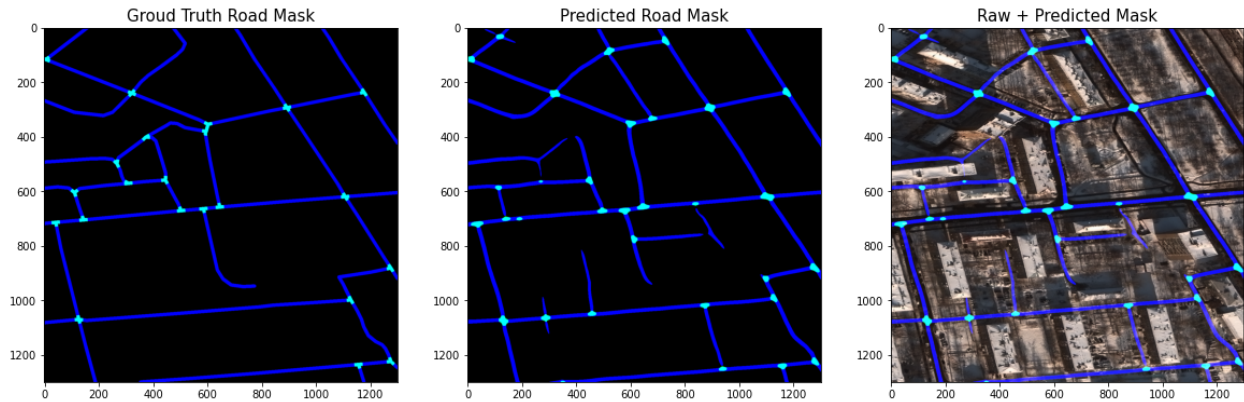
Combo loss with different weights:
- 1 Dice + 3 Focal for road mask
- Cross Entropy for speed mask
- MSE for continuous speed mask

Ensembled 8 pretrained models and trained on our dataset:
- 4 ResNet50 + Unet
- 4 SeResNeXt + Unet

Predictions

Ground Truth (Moscow test chip 1160)

Predicted Masks (Moscow test chip 1160)

Ground Truth Road Mask   Predicted Road Mask   Raw + Predicted Mask

Metrics Evaluation

Dice score

Road mask: 0.68
Speed channel 1-3 : 0.39
Speed channel 4-6: 0.46
Speed channel 7-9: 0.60

Implications and Future

- Dataset with better annotation will improve the training models
- Include other released SpaceNet dataset in training could improve our models
- Tune the losses function weight to enhance predictions for speed channels
- Try various encoder structures for Unet backbone