USING PUBLICLY AVAILABLE SATELLITE IMAGERY AND NEURAL NETS TO ADDRESS DATA SCARCITY IN DEVELOPING ECONOMIES

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DATA POOR DEVELOPING ECONOMIES

- Developing economies lacking official economic measures
- Satellite data is widely available
  - Higher resolution than other economic statistics
  - Worldwide coverage
  - Low marginal cost
- Modern computer vision techniques to analyze images
- Jean et al (2016) "Combining satellite imagery and machine learning to predict poverty"

SATELLITE DATA – LANDSAT

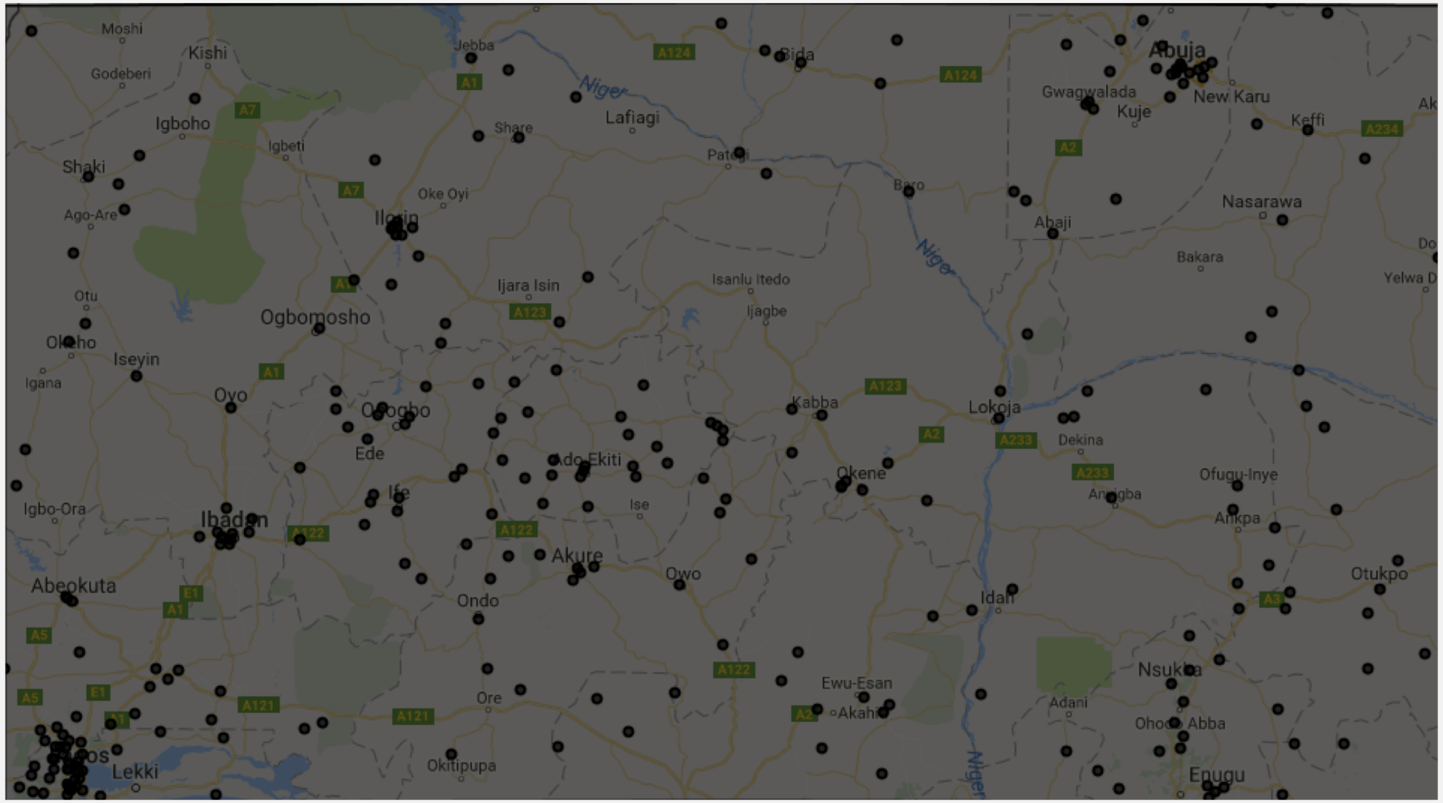
- Available from 1972 to today
- 30 meter resolution (medium resolution)
- Cover entire Earth's surface every two weeks
- Access through Google Earth Engine API
  - Goldblatt et al, 2016

GROUND TRUTH DATA – DHS SURVEY

- “Demographic and Health Survey”
- Includes Wealth Index, composite index
- Nigeria

DHS SURVEY LOCATIONS

- DHS survey locations across Nigeria
  - The wealth index is the “Y” variable
- The corresponding satellite image above is the “X” variable



NOT ENOUGH DATA FOR MODEL TRAINING

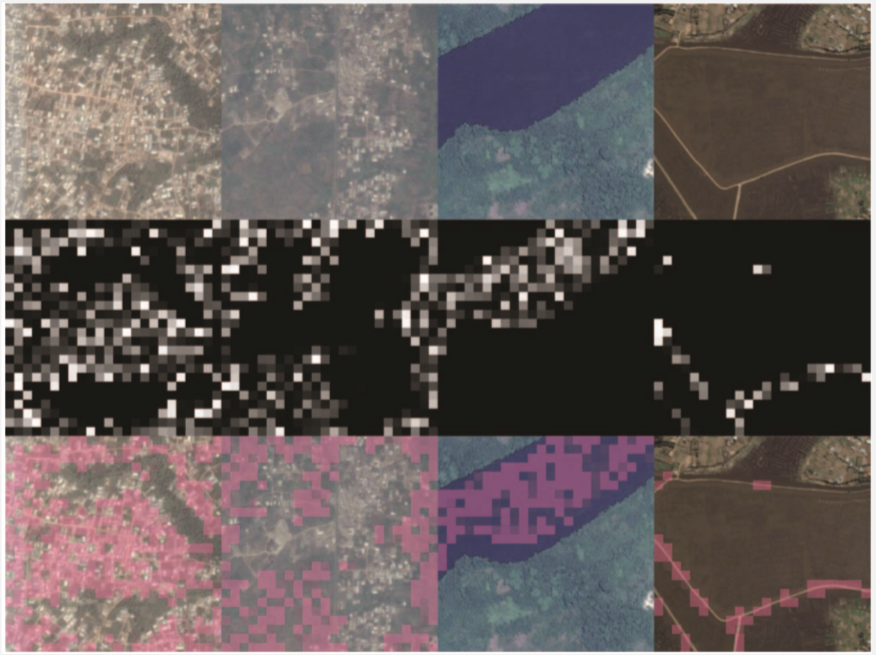
- Use convolutional neural nets to identify features in the satellite image
- Models have > 1 million parameters
- We have 279 survey locations ☹
- NEED INTERMEDIARY STEP WITH LOTS OF DATA

SOLUTION?? => TRANSFER LEARNING

- Essentially transitive property
- Learn A~B and B~C, where A~B is data rich
- The intermediary is to train CNN to identify ***nighttime luminosity*** given satellite images

CONVOLUTIONAL NEURAL NETWORK

- Deep neural network used in computer vision
- Learns to identify image features relevant to economic activity
- Transfer learning from ImageNet
- Jean et al (2016) “Combining satellite imagery and machine learning to predict poverty”
- Banerjee et al (2017) “On monitoring development using high resolution satellite images”



TRANSFER LEARNING STEPS

- Step #1: CNN learns to predict luminosity given satellite images
- Step #2: Use the ‘features’ (essentially a low-dimensional summary of the image) as regressors in a ridge regression on the wealth index

RESULTS TO DATE

- 3 CNN
  - Small (34 x 34) pixel images trained from scratch
  - Large (128 x 128) pixel images trained from scratch
  - Transfer (128 x 128) pixel images based on weights from ImageNet
- Run on Google Cloud Computing ft 3 NDVIDIA tesla K80 GPU’s
- Ridge regression has cross-validated R2 of .4

PROBLEMS, CAVEATS, FUTURE, ETC

- I (basically) don’t know how to train neural nets (yet)
- Data is highly imbalanced
- Medium resolution images complicate transfer learning from typical high-resolution image detection
- To expand to time-series, you have multiple image frames per sequence – essentially this is now a video classification task