Identifying Area of Rooftops in Denver, CO, for Solar Policy

Project Proposal

Problem Statement

Climate change as a crisis that decisive action. Now. A huge part of that solution involves shifting our productions of energy away from fossil fuels and towards renewable sources of energy. Paul Hawken's famous Project Drawdown lists rooftop solar as a key strategy of meeting our ambitious climate goals. Their analysis suggests that rooftop solar can grow from 0.4% of global electricity generation to 7% by 2050, and "that growth can avoid 24.6 gigatons of emissions."

Rooftop solar is an increasingly appealing option for those looking to not only contribute to building a better world, but those hoping to save money in the long term through reduced energy bills and net metering. Policies exist to incentivize the application of rooftop solar, including several in Denver: City and County of Denver Elevation Loans, Solar* Rewards through Xcel, and the RENU Loan through the Colorado Energy Office.

But how would rooftop solar would it take to essentially "run" Colorado, the state where the sun shines 300 days a year? What about just single-family residential electricity needs?

In true engineering fashion, we can begin to estimate this answer by taking it to the extreme: if every rooftop in Denver was outfitted with PVs, how much electricity could we produce?

Since this is a data science project and not an engineering project, our process will be simplified. We'll use a standard rate of electricity produced per area of PV on a rooftop. One (very basic) rule of thumb is to say that every square foot of roof space generates 15 watts of solar energy (based on a solar panel with 15.8% efficiency).

According to the US Energy Information Administration, Coloradans use an average of 706 kilowatt hours in their homes each month. According to the U.S. Census, there are 320,545 houses in Denver County. With some basic math, we can estimate that the residential sector of Denver County uses roughly 225 GW of solar energy.

Therefore, we're looking to identify roughly 1.5 x 10^10 square feet of rooftops in Denver, or 538 square miles.

Solution

Given satellite imagery of Denver, we can train a convolutional neural network to correctly identify rooftop area. The steps in the project are based in the research presented in two white papers (1,2) and a project from Akash Kumar's Github (thank you, Akash!).

Preprocessing the data

1. Aerial Rooftop Detection Methods
    a. Hough Transforms
        i. Using this code from OpenCV
    b. Watershed Segmentation
        i. Using this code with OpenCV
        ii. Adopting code from here as well
    c. Adaptive Canny Edge Detection
        i. Using this code with OpenCV
        ii. Adopting code from here as well
2. Foreground Background Separation (Gabor Filter)
    a. Adopting code from
3. Building Rooftop Extraction Methods:
    a. Edge Sharpening
        i. Adopting code from here
    b. Active Contours

Neural Net

I plan to work in Tensorflow to build a CNN with the preprocessed images above.

Data

The City and County of Denver generously provides open source data via https://www.denvergov.org/opendata. For this project, I am using their 2004 dataset of satellite imagery of Denver County. These data consist of almost 3,000 JP2 files.

For the benefit of the analysis, I converted these JP2 files into JPEGs using XnConverter for Linux.

Deliverables

What are your deliverables? Typically, this includes code, a paper, or a slide deck

References

1.Novel Approach for Rooftop Detection Using Support Vector Machine
https://www.hindawi.com/journals/isrn/2013/819768/

(2) Automatic Rooftop Detection Using a Two-stage Classification
http://ijssst.info/Vol-15/No-4/data/4923a285.pdf