Residential Photovoltaic system detection by convolutional neural network in heterogeneous urban and rural areas: Application to France.

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To better understand the mechanisms behind the deployment of residential PV systems, and to guide future development, it is important to identify where existing PV systems are installed. Convolutional neural networks (CNNs) applied to aerial images have shown promising results in this regard. However, European studies using CNNs often rely on limited training datasets, typically focused on restricted areas, making the models less robust when applied to 'unseen' regions. This limitation is particularly relevant in countries with rich architectural diversity.

In this work, we present an alternative methodology that shifts from the traditional tile-based approach to a building-by-building analysis. The metropolitan French territory is used as a case study, and its architectural diversity is carefully considered.

The model is trained on high-resolution aerial imagery of buildings, with the images cropped according to the building footprints provided by cadastral data. A set of roofs equipped with PV systems was manually labeled across different departments in France (departments 22, 34, 67, and 73), chosen to represent the diversity of roof types and building typologies found in the country.

The model is validated using national datasets from grid operators (ENEDIS). For each municipality, the number of PV systems identified by the model is compared to the actual number of registered PV systems, as recorded by the grid operator. The results demonstrate high accuracy, particularly in regions using roof tiles. The analysis also investigates the influence of roof materials on detection performance, revealing reduced accuracy in areas with slate roofs due to lower color contrast and shading effects. The prediction model is applied to the entire metropolitan French territory.

The model and associated datasets, including both the training dataset and the predicted dataset, are made available as open-access resources.

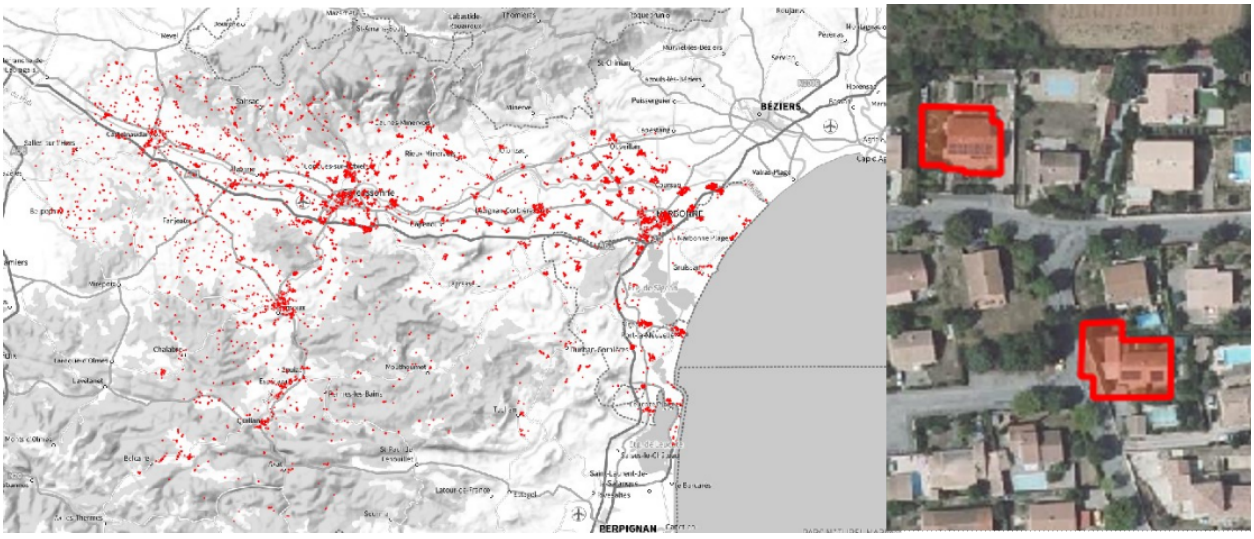

Figure 1: Residential PV system locations in the Aude department (11) as predicted by the model. On the right-hand side, two buildings equipped with PV systems are identified.