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From geospatial observations of ocean currents to causal predictors of spatio-economic activity using computer vision and machine learning

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The big data transformation currently revolutionizing science and industry forges novel possibilities in multimodal analysis scarcely imaginable only a decade ago. One of the important economic and industrial problems that stand to benefit from the recent expansion of data availability and computational prowess is the prediction of electricity demand and renewable energy generation. Both are correlates of human activity: spatiotemporal energy consumption patterns in society are a factor of both demand (weather dependent) and supply, which determine cost - a relation expected to strengthen along with increasing renewable energy dependence.

One of the main drivers of European weather patterns is the activity of the Atlantic Ocean and in particular its dominant Northern Hemisphere current: the Gulf Stream. We choose this particular current as a test case in part due to larger amount of relevant data and scientific literature available for refinement of analysis techniques. This data richness is due not only to its economic importance but also to its size being clearly visible in radar and infrared satellite imagery, which makes it easier to detect using Computer Vision (CV). The power of CV techniques makes basic analysis thus developed scalable to other smaller and less known, but still influential, currents, which are not just curves on a map, but complex, evolving, moving branching trees in 3D projected onto a 2D image.

We investigate means of extracting, from several image modalities (including recently available Copernicus radar and earlier Infrared satellites), a parameterized representation of the state of the Gulf Stream and its environment that is useful as feature space representation in a machine learning context, in this case with the EC's H2020-sponsored 'See.4C' project, in the context of which data scientists may find novel predictors of spatiotemporal energy flow. Although automated extractors of Gulf Stream position exist, they differ in methodology and result. We shall attempt to extract more complex feature representation including branching points, eddies and parameterized changes in transport and velocity. Other related predictive features will be similarly developed, such as inference of deep water flux long the current path and wider spatial scale features such as Hough transform, surface turbulence indicators and temperature gradient indexes along with multi-time scale analysis of ocean height and temperature dynamics. The geospatial imaging and ML community may therefore benefit from a baseline of open-source techniques useful and expandable to other related prediction and/or scientific analysis tasks.