EMS Annual Meeting Abstracts
Vol. 11, EMS2014-316, 2014
14th EMS / 10th ECAC

Short-term forecasting of cloud movement & irradiance changes using ground-based sky cameras

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Accurate short-term solar forecasts, with horizons of 5-20 minutes, are difficult to obtain using traditional satellite imagery, statistical or numerical weather prediction (NWP) techniques. Ground-based whole-sky imagery using digital cameras with 180° fisheye lenses ('skycams') are emerging as a promising data-acquisition platform for estimating and predicting cloud movement, and deriving shading and irradiance forecasts. These forecasts are particularly useful for the operation of large solar generators and improving the energy market's effective utilisation of solar power.

CSIRO is developing a skycam-based solar forecasting platform as part of the government-funded Australian Solar Energy Forecasting System (ASEFS) project. ASEFS will provide irradiance and power predictions at timescales from minutes to months, to assist the Australian Energy Market Operator (AEMO) to better dispatch solar plants alongside traditional non-renewable generation during each 5-minute market resolution interval. Skycam-based techniques will fill the gap in the 5-20 minute forecast range, where traditional techniques are unable to provide sufficient resolution and accuracy.

A system is presented which analyses sequences of sky images to identify clouds and extract movement vectors to estimate future cloud movement. This system improves upon previous approaches by performing per-pixel analysis, enabling prediction of multiple cloud layers moving with distinct speeds and directions; by using a novel cloud identification technique, combining multiple pixel features with a neural network to give up to a 95% classification accuracy; and by projecting movement inside distorted fisheye-space, avoiding cropping the image and lowering forecast horizon.

Results show the skycam forecaster's ability to provide an attenuation coefficient, which provides a forecast of the available irradiance at a solar farm as a percentage of clear sky irradiance; and a ramp-event forecast, which warns operators of large upcoming irradiance drops, for which compensatory measures can be taken to avoid power quality and grid stability issues near large solar farms, or at times of high solar grid penetration.