SKYCam:
A Dataset of Sky Images and Their Irradiance Values

ABSTRACT
Recent advances in Computer Vision and Deep Learning have enabled astonishing results in a variety of fields and applications. Motivated by this success, the SkyCam Dataset aims to enable image-based Deep Learning solutions for short-term, precise prediction of solar radiation on a local level. For the span of a year, three different cameras in three topographically different locations in Switzerland are acquiring images of the sky every 10 seconds. Thirteen high resolution images with different exposure times are captured and used to create an additional HDR image. The images are paired with highly precise irradiance values gathered from a high-accuracy pyranometer.

Keywords Sky Images · Irradiance Prediction · Photovoltaic Systems

1 Introduction
Recent years have seen the rise of Photovoltaic (PV) energy as a solution to the problem of sustainable energy. Moreover, a move to local producers of energy is observed compared to the traditional centralized production systems. Thus, it is important to be able to predict the energy yield of a PV system especially in stand-alone solutions.

Stand-alone PV systems operate independently of a central electric grid. When a PV system is used in conjunction with an engine-generator or utility power it is referred as a photovoltaic-hybrid-system. In such cases it is important to be able to forecast with high accuracy the solar radiance and thus the energy output of the PV system in order to predict the need to switch to the alternative energy generator.

The motivation behind the preparation of the SkyCam dataset is to gauge the effectiveness of a low-cost and camera-based solution on predicting the solar irradiance values on a local scale. This information would potentially improve the energy-performance of stand-alone solutions, where PV panels are used in conjunction with diesel generators to generate power. Since the generator would not have to run permanently on standby, a more accurate forecast could greatly reduce the consumption of fossil fuels.

The dataset offers:
- Data from 3 topographically diverse locations
- Collection of images over the span of a whole year
- A sample every 10 seconds
- 13 images of different exposure times and a High-Dynamic-Range post-process image
- Precise solar radiance measurements

2 Collection of the data
Switzerland is a perfect testing ground for creating a dataset that aims to tackle the problem of short-term solar radiation prediction due to its diverse topographical features and highly variable meteorological conditions. To this extend...
image and solar radiance capturing equipment was set to three topographically distinct locations, acquiring observations over the span of a year.

2.1 Camera Locations

The variable topography of Switzerland results in diverse hydro-meteorological conditions and the locations where the images are acquired are diverse and characterized by a unique topology compared to one another. Neuchâtel is in the region of Jura, Bern is the Swiss Plateau and Alpnach is in the Pre-Alps area (Fig. 1b). Their first difference is in elevation: Alps and Jura regions has high elevations but the Swiss Plateau has low.

![Image of camera and pyranometer](image)

(a) (b)

Figure 1: (a) The equipment used for the data acquisition: a high accuracy pyranometer(left) and a fish-eye camera (right) (b) The image capturing sites. The three different locations across Switzerland are characterized by different topological conditions.

2.2 Collection Times

The data was collected across the span of the year 2018. Consequently, we aim to capture the diverse seasonal effects created by the topographical differences between the collections sites. On each day of the year the equipment starts acquiring pictures and measurements at the time of dawn and stops at dusk. As the three locations have different longitudes and thus different times for dawn, peak sun point and dusk. This can be observed in Figure 2. The samples were collected with a frequency of 10 seconds.

2.3 Equipment

In all three locations a single industrial camera was used. In all sites a high-accuracy pyranometer was deployed in order to acquire the irradiance values with high precision. All cameras are industrial-grade CMOS cameras with an appropriate protective casing. The pyranometer is a Hukseflux SR30 designed for for Photovoltaic system performance monitoring and meteorological networks. At the start of the measurements the pyranometer has been calibrated. The solar radiation is received by a horizontal surface and measured in $W/m^2$, from a 180° field of view angle.

Table 1: Specifications table

| Subject area                      | Computer Vision, Renewable Energy, Meteorology |
|----------------------------------|-----------------------------------------------|
| More specific subject area       | Irradiance prediction, Cloud movement prediction, Weather prediction |
| Type of data                     | 13 concurrent images with different exposure times, 1 HDR post-processed image, 1 irradiance value per 10 secs |
| How data was acquired            | 1 camera sensor and 1 pyranometer pointing to the sky, at each of the three different locations |
| Data format                      | Png and XML files |
| Data source location             | The images were acquired by cameras on three locations across Switzerland: CSEN Alpnach, University Hospital Bern, CSEM Neuchâtel |
| Data accessibility               | The data is available for download at: [https://github.com/vglsd/SkyCam](https://github.com/vglsd/SkyCam) |
Figure 2: Irradiance measurements at the three different locations on the same day. A lag of approximately 3 minutes can be observed between the Bern and Alpnach sites. As it is shown in the graph the three different locations can have vastly different weather conditions with one having a very cloudy sky while the others a clear one. This results in great difference in the levels of the irradiance values.

3 SkyCam Dataset

Figure 3: All images produced by the system on the 29th of January 2018 at 11:09:20 on Alpnach site. The 13 first images were captured sequentially with increasing exposure times. The last is the HDR image produced post-capture. The irradiance value of the timestamp is 452.94 W/m²

The SkyCam dataset is a collection of images from 365 days from three different locations and three cameras. Each day has on average 12 hours between dawn and dusk and images are captures with a frequency of 10 seconds. That means that we have approximately 1576800 timestamps per camera. The total size of the dataset is approximately 16 TeraBytes.

3.1 Data description of each timestamp

For each time stamp each camera acquires a series of 13 photographs with different exposure times as well. After the collection the images are post-processed in order to generate a High-Dynamic-Range (HDR) image. At the same time the solar irradiance value is measured by the pyranometer. The measurements were not quality proofed. A description
of the 13 photographs along with the irradiance values are included in a XML file. In Figure 3 we can observe how a particular timestamp looks like. The original resolution of each captured image is $1200 \times 1200$ pixels while the generated HDR image has a resolution of $600 \times 600$ pixels.

### 3.2 Missing and Erroneous Data

During the span of one year various problems lead to temporary disruptions of the sampling. These disruptions lead to the samples of certain timestamps to be missing in one of the locations. Moreover, in some cases, as seen in Figure 4, birds have occluded the view of the sky. These images are still in the dataset. In both cases this is left to the user to handle.

![Figure 4: Example cases of problematic timestamps where part of the sky is occluded](image)

### 4 Conclusion

In this article we present a description of the SkyCam dataset, its acquisition process and its characteristics. It offers a variety of locations with diverse topographical characteristics (Swiss Jura, Plateau and Pre-Alps regions), where a camera with a high-accuracy pyranometer are deployed. The dataset is collected with a high frequency rate, a data sample is generated every 10 seconds. 13 images with different exposures times are generated along with a post-processed HDR images and a solar radiance values for each of the locations. SkyCam dataset will enable future works to tackle the problem of short-term local camera-based solar radiance prediction.

### 5 Acknowledgements

The development of the SkyCam dataset was funded by the Swiss Federal Office of Energy under grant SI/50151 as a collaborative project between CSEM and Meteotest.

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