Using solar panels to deduce weather

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1 Introduction

Photovoltaic modules (PV), commonly known as solar panels, works by having two silicon based semiconductors, namely a n-type and a p-type. The two semiconductors react when exposed to photons which is used to create electricity [Nea12].

It has already been found that weather data to is relevant for PV generating systems, when maximum power point tracking is used to maximize the power output, mainly temperature and radiation [MOI04].

►BAsed on this we want to try to correlate power generated with cloud conditions◄

2 Related work

There has already been some research in measuring weather data by utilizing some of the sensor capabilities that arises from the increasing amount of technology in use.

OpenSignal have created the app WeatherSignal that utilized phone battery temperatures [ORL$^+$13] to deduce information about the air temperature in heavily populated areas. They proved a strong relation between the temperature of a the phone batteries and the outside temperatures. The authors believe that the data can be further improved, if the data can be calibrated according to phone models and if the phone is inside or outside, as heating and air conditions bias the data.

A correlation between the radio signals used for phones and rain measurements has also been proved [LUS07]. The radio signals can be used to measure the amount of rain in between two points. The measurements is fairly accurate, and it's assumed that they can be further improved if improved for the signal loss due to wet antennas.

It is believe that the combination of various weather sensing techniques such as [LUS07], [ORL$^+$13] and measurement of clouds by PV systems, such as proposed in this article, is likely to have some useful potential. For instance the maximum power point tracking units of PV systems can be improved with weather data [MOI04].

3 Data analysis

The expected data is to see a clear connection between the output of a PV and clouds[SCS+14]. The aparant view of things the data also seem to have a correlation as can be seen on figure 2. It seems likely from the graph that there is some correlation, between the clouds and the PV system, as there's a tendency for the effect to drop when there's more clouds.

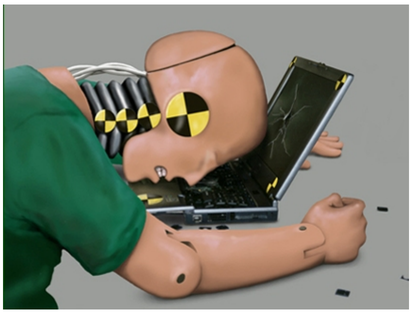

Figure 1: Noisy unfiltered data

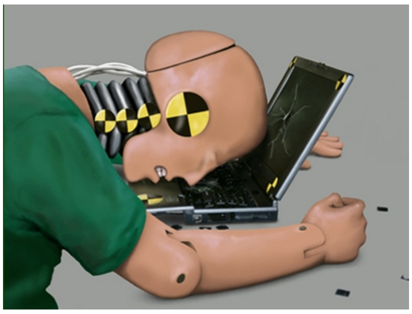

Figure 2: Cloud cover and averages of power generated (10 minute intervals)

However further analysis puts some doubt to that. The blue line in figure 2 shows the optimal effect measured at a given point of time in the day. To test that hypothesis a scatter plot comparing how far from the optimal the power generation is compared to the cloud coverage.

►Boxplot comments, more analysis◄

That a single PV system is very sensitive to even small changes can easily be seen following the green curve on figure 1. It's apparent from the amount of fluctuations that even small things can influence the effect. Both [Bar11] and [SCS+14] has data confirming that small scale PV systems are easily affected by things such as clouds, they still look at large systems in comparison with a personal system. Thus it is likely that even a flock of birds can influence it.

A larger area of PV systems and bigger PV systems can smooth out noise in the data [SCS+14, Bar11] and it is thus likely that having an area with more panels would even out the data in meaningful way. Since it's still determining cloud information that is interesting, it has to be local areas, such as a small village or similar. The reasoning behind this is that if we have for instance

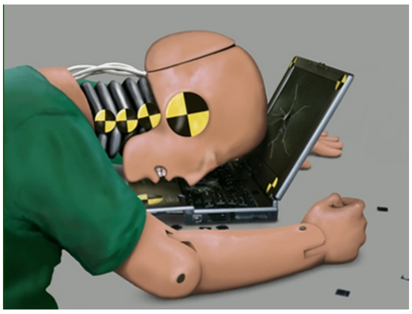

Figure 3: Scatter plot from comparing effect, cloud coverage and optimal effect

a cloud coverage of 30% we may be so unfortunate that the PV system is completely covered, even though there's no cover next to it, having multiple systems will increase the chance that the data is representative.

4 Conclusion

▶Write a proper conclusion◀

5 Acknowledgments

▶Lynderup senior - dad, Bouvin - computer scientist, supervisor, Karl Fischer - chemist◀

6 Conclusion

▶. . . ◀

References

[Bar11] D.A. Barber. Tracking cloud cover effects on large-scale pv plants. `http://pv.energytrend.com/knowledge/Tracking_Cloud_20110929.html`, 2011. [Online; accessed April-2015].

[LUS07] H. Leijnse, R. Uijlenhoet, and J. N. M. Stricker. Rainfall measurement using radio links from cellular communication networks. *Water Resources Research*, 43(3), 2007.

[MOI04] Nobuyoshi Mutoh, Masahiro Ohno, and Takayoshi Inoue. A method for mppt control while searching for parameters corresponding to weather conditions for pv generation systems. In *The 30th Annual Conference of the IEEE Industrial Electronics Society, November 2 - 6, 2004, Busan, Korea*, 2004.

[Nea12] Donald A. Neamen. *Semiconductor Physics And Devices*. McGraw Hill, 4 edition, 2012.

[ORL+13] A. Overeem, J. C. R. Robinson, H. Leijnse, G. J. Steeneveld, B. K. P. Horn, and R. Uijlenhoet. Crowdsourcing urban air temperatures from smartphone battery temperatures. *Geophysical Research Letters*, 40, 2013.

[SCS+14] Marcel Suri, Tomas Cebecauer, Artur Skoczek, Ronald Marais, Crescent Mushwana, Josh Reinecke, and Riaan Meyer. Cloud cover impact on photovoltaic power production in south africa. *http://geomodelsolar.eu/*, 2014.