Using solar panels to deduce weather

Kasper Lynderup - 20105319
Timothi Hansen - 201303516
Rohde Fischer - 20052356

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Advisor: Niels Olof Bouvin

AARHUS UNIVERSITY
DEPARTMENT OF COMPUTER SCIENCE

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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

PV systems work by having two silicon parts (N-type and P-type) that when exposed to photons have an electron reaction used to produce power. The fact that photons are needed to produce electricity indicates that things that affects the amount of light reaching the earth (apart from light vs no light) is likely to have an effect. When the silicon is doped to produce the N-type and P-type parts it is doped with materials that react with the longer wavelengths of light, i.e. closer to the infrared wavelengths, to minimize the impact from clouds [Nea12]. The fact that it's only minimizing however indicates that there is at least some effect.

That this suspicion is true is further supported by research done to smooth out the impact from cloud coverage on large scale systems [SCS+14, Bar11].

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.

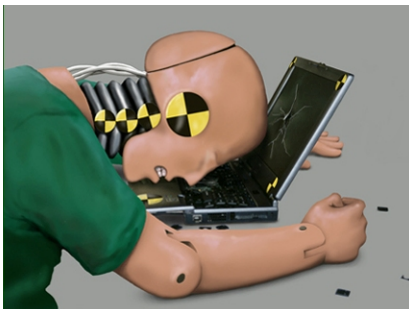

Figure 1: Noisy unfiltered data

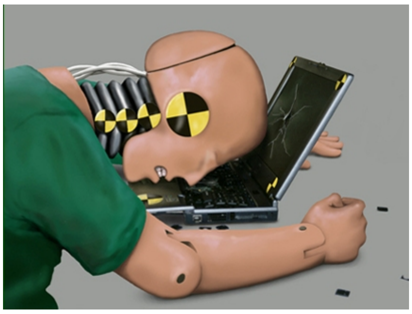

Figure 2: Cloud cover and averages of power generated (10 minute intervals)

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

From the fact that PV systems is sensitive to the amount of photons reaching them and that research has shown that larger scale PV systems and areas can be used to smooth out weather data the expected results show a clear connection [SCS+14, Bar11, Nea12]. The approach will be to first off confirm that it's likely to be true and then refining the data for the purpose to confirm or refute this hypothesis.

By plotting the raw data The apparent 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.

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.

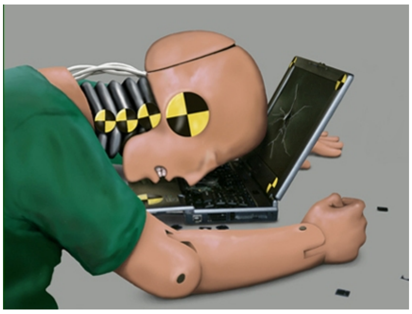

Figure 3: Scatter plot from comparing effect, cloud coverage and optimal effect

►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]. The effect of larger systems could be interesting if they can be accessed, for the approach of this project it would be an interesting addition to get access to more systems. The approach to have a larger area of PV systems is used is used to try and even out all noise caused from clouds [SCS+14], where the intend here would be to even out some, such that conclusions about correlation about the weather and effect can be made. The fact that the weather impact can be smoothed a lot, when it's done over areas of 250x250 and 500x500 km squares, but weather data is still quite apparent on 50x50 km squares [SCS+14], indicates both that a larger area than a single PV system will smooth the data, but without loosing the stronger connection with weather data as long as the area is relatively small.

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.