Predicting Water Usage for Automated Irrigation System

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Objectives

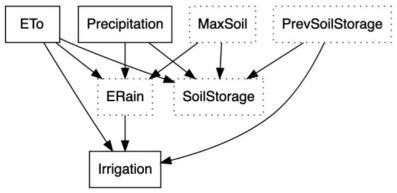
- Evaluate the performance of neural networks in predicting irrigation.
- Test if neural networks can uncover the underlying process.
- Identify variables whose measurement accuracy are important.

Evapotranspiration Process

Equations

$$NIR = Max[ETo - ERain - PrevSoilStorage, 0]$$
$$ERain = Min[Precip, MaxSoil + ETo - PrevSoilStorage]$$
$$SoilStorage = Min[MaxSoil, (Precip - ETo + PrevSoilStorage)]$$

Visualization



Challenge: Data Availability

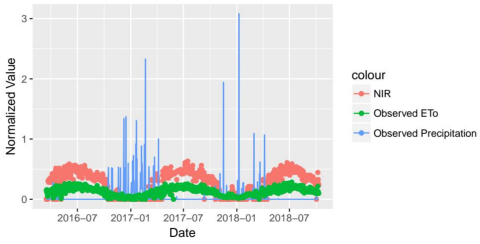
Measurment	Variable	Definition
Accurate	NIR	Net irrigation requirement on a given day
Inaccurate	Precip	Precipitation (regional average)
	ETo	evapotranspiration rate (regional average)
Unobserved	MaxSoil	Maximum water the soil can store
	SoilStorage	Water left in the soil
	ERain	Effective rainfall

Simulation

Why simulation?

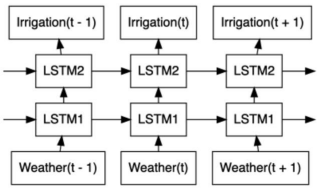
- Limited data size; expensive to collect
- Uncertain what variables and their measurement are important
- Data generating process known, making simulation possible
- Provide guidance on what data to collect

Simulated Examples



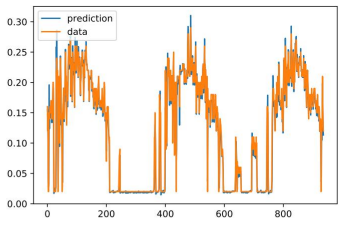
Model

We start with the basic LSTM model and then try the stacked version. Stacking LSTM twice turns out to perform the best. **This number of levels coincides with that of the actual data generating process**



Results

Data vs Prediction



Noise vs Accuracy

	RMSE
Soil Noise	0.010* (0.005)
Precipitaion Bias	−0.001 (0.012)
Evaporation Bias	−0.005 (0.012)
Precipitation Noise	0.003 (0.012)
Evaporation Noise	0.025** (0.012)
R^2	0.333
Residual Std. Error	0.006 (df = 19)
Note:	*p<0.1; **p<0.05; ***p<0.01

Conclusion

- A stacked LSTM does an excellent job in predicting the irrigation.
- The prediction works best when the network structure is closest to the actual DGP, which has two levels.
- The network can fix constant weather bias, but the soil characteristics and time-varying noise in the evapotranspiration process can still significantly affect the prediction.