Forecasting Evapotranspiration using RNN - LSTM

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Evapotranspiration

According to USGS:

“In general, evapotranspiration is the sum of evaporation and transpiration.”

Some applications of Evapotranspiration:

• Climate and cloud formation
  (Shukla and Mintz, 1982; Rabin et al., 1990; Mölders and Raabe, 1996)
• Agricultural management
  (Allen et al., 1998; Farahani et al., 2007; Allen et al., 2011)
• Water resources management
  (Bastiaanssen et al., 2005; Anderson et al., 2012)
• Detection of drought and heat waves
  (Rind et al., 1990; Vicente-Serrano et al., 2010; Miralles et al., 2014; Otkin et al., 2010)

Source: www.usgs.gov
Penman Monteith Equation

\[ ET_0 = \frac{0.408\Delta(R_n - G) + \gamma(900/(T + 273)U(e_s - e_a))}{\Delta + \gamma(1 + 0.34U)} \]

- \( ET_0 \) = Reference Evapotranspiration (mm/day)
- \( \Delta \) = Slope Vapor Pressure Curve (kPa°C\(^{-1}\))
- \( R_n \) = Net radiation at the crop surface (MJ m\(^{-2}\) day\(^{-1}\))
- \( G \) = Soil Heat Flux (MJ m\(^{-2}\) day\(^{-1}\))
- \( \gamma \) = Psychrometric Constant (kPa°C\(^{-1}\))
- \( T \) = Mean Daily Air Temperature at the reference height of 2 m (°C)
- \( U \) = Wind Speed at 2 m height (m s\(^{-1}\))
- \( e_s \) = Saturation Vapor Pressure (kPa)
- \( e_a \) = Actual Vapor Pressure (kPa)

Allen et al., 1998
RNN - LSTM

https://colab.research.google.com/drive/1B1vvZMdLjEwxsxrNjrMx4viNctib6go

```python
# define timesteps and features
ntimesteps = 30
nfeatures = 6

model = Sequential()
model.add(LSTM(units=30, return_sequences=True, input_shape=(ntimesteps, nfeatures)))
model.add(Dropout(0.1))
model.add(LSTM(units=30, return_sequences=True))
model.add(Dropout(0.1))
model.add(LSTM(units=30, activation = 'sigmoid'))
model.add(Dropout(0.1))
model.add(Dense(6))
model.compile(loss='mean_squared_error', optimizer='adam')
model.summary()

[ ] hist = model.fit(x_train,y_train, epochs=100, batch_size=32, verbose=1)

Epoch 98/100
6668/6668 [==============================] - 31s 5ms/sample - loss: 0.0123
Epoch 99/100
6668/6668 [==============================] - 31s 5ms/sample - loss: 0.0124
Epoch 100/100
6668/6668 [==============================] - 31s 5ms/sample - loss: 0.0122

```

Model: "sequential"
Layer (type)        Output Shape       Param #
=================================================================
dropout (Dropout)  (None, 30, 30)   0
lstm_1 (LSTM)      (None, 30, 30)   7320
dropout_1 (Dropout) (None, 30, 30)  0
lstm_2 (LSTM)      (None, 30, 30)   7320
dropout_2 (Dropout) (None, 30)      0
dense (Dense)      (None, 6)        186
=================================================================
Total params: 19,266
Trainable params: 19,266
Non-trainable params: 0

```
```
Results
Results

Solar Radiation

Average Air Temperature

Mean Wind Speed

Average Soil Temperature

Ave % Relative Humidity

Real Solar Radiation

Predicted Solar Radiation

Real Average Air Temperature

Predicted Average Air Temperature

Real Mean Wind Speed

Predicted Mean Wind Speed

Real Average Soil Temperature

Predicted Average Soil Temperature

Real Ave % Relative Humidity

Predicted Ave % Relative Humidity
Conclusions and Recommendation

- RNN - LSTM can be an effective program in predicting or forecasting the mean values of evapotranspiration and other time-series data.
- Improving the program via training it to detect the anomalies in data for more accurate results.
- Develop a more accurate RNN - LSTM program in order to use for weather/rainfall, drought forecast, and for agricultural practices.
References

