LSTM’s and Corn Price Elasticity derived from Supply Factors within the USA

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Agenda

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- Thesis
- Application in Quant Finance
- Long Term Goal
- Data
- Model Assumptions
- RNN capabilities
- What is an LSTM?
- Code
- Key Findings
- Model Issues

Thesis

Weather patterns within the top 10 corn producing states in the US can be used to derive corn spot price fluctuations by using a Recurrent Neural Network Architecture to detect temporal relationships varying through time.

Thought Process

- The US produces 32% of the Worlds Corn.
- The top 10 corn producing states (primarily from the Midwest) are responsible for all of this corn production.
- Linear/polynomial regression would oversimplify relationship missing key details.

Application In Quant Finance

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Pairs Trading

- Find detect the divergence of corn and wheat.
- When corn prices diverge from wheat, short the overvalued asset and go long on the undervalued asset.
- Assets prices will converge in the future.

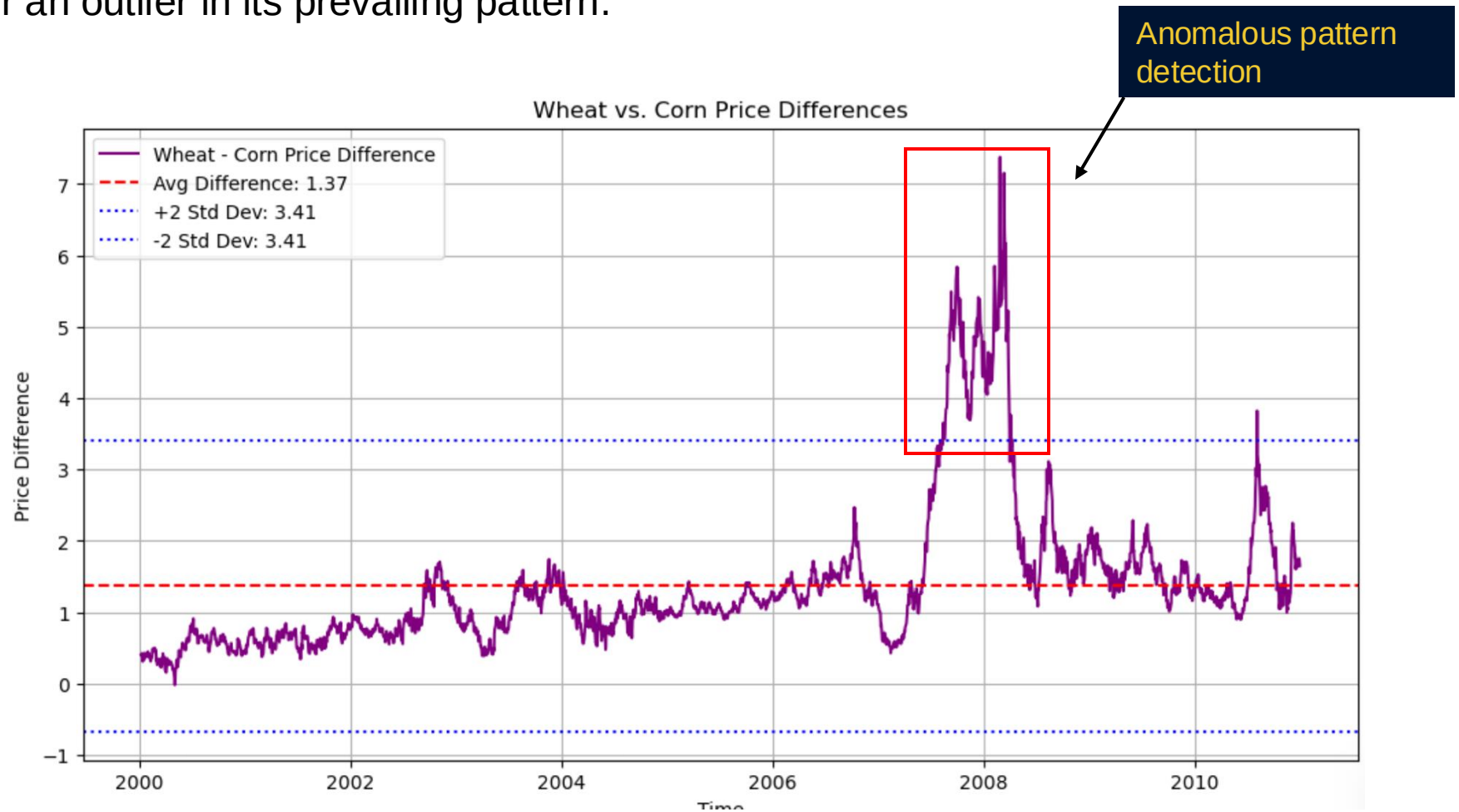
Agriculture Indexes

- S&P GSCI Agriculture Index
- S&P/ASX Agribusiness Index

Ultimate Long-Term Goal

Detect price divergence of wheat and corn

When the difference between wheat and corn passes confidence interval threshold (+/- 2SD), it is counted as an anomalous or an outlier in its prevailing pattern.



Data

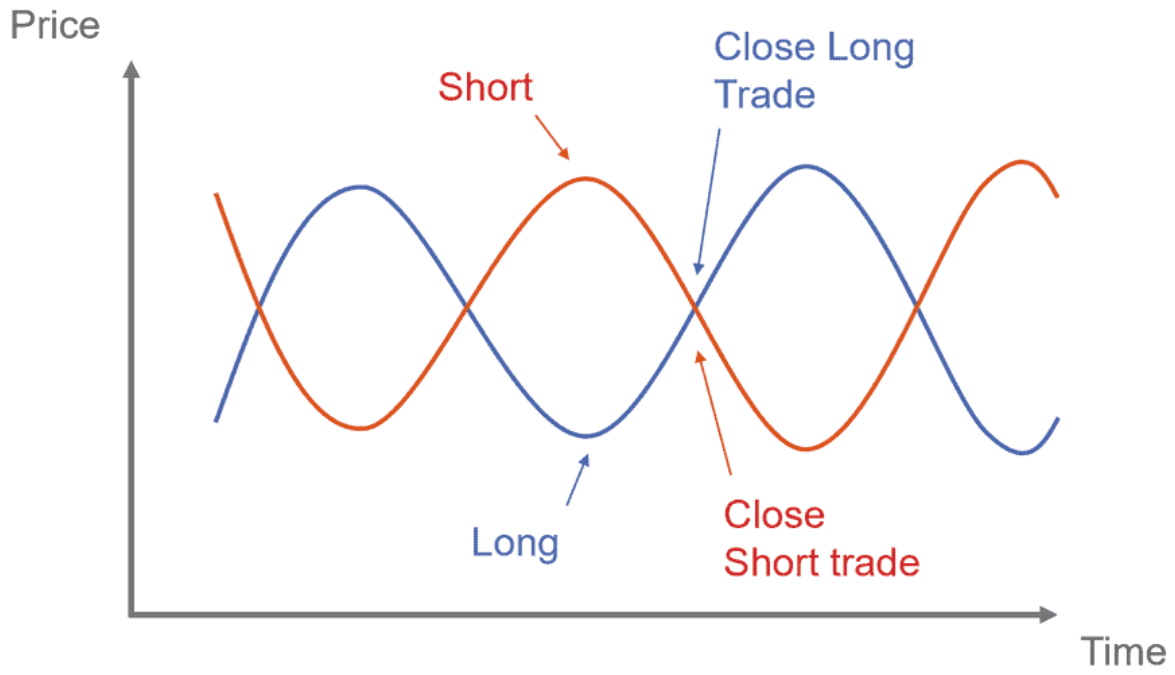
	time	wheat_price	corn_price	lat	lon	max_day_temp	effective_degree_days	ice_days	heavy_rain_days
0	2000-01-05	2.4975	2.0300	36.75	-103.75	293.35178	6.794754	1.0	0.0
1	2000-01-05	2.4975	2.0300	36.75	-103.25	295.86730	10.660324	1.0	0.0
2	2000-01-05	2.4975	2.0300	36.75	-102.75	297.86926	12.471822	1.0	0.0
3	2000-01-05	2.4975	2.0300	36.75	-102.25	298.21940	13.270727	1.0	0.0
4	2000-01-05	2.4975	2.0300	36.75	-101.75	298.43073	14.187780	2.0	0.0
...	...	...	...	...	...	...	...	...	...
311370	2010-12-15	7.6475	5.8425	48.75	-82.75	274.35205	0.000000	9.0	0.0
311371	2010-12-15	7.6475	5.8425	48.75	-82.25	274.23660	0.000000	9.0	0.0
311372	2010-12-15	7.6475	5.8425	48.75	-81.75	274.08870	0.000000	9.0	0.0
311373	2010-12-15	7.6475	5.8425	48.75	-81.25	274.41687	0.000000	9.0	0.0
311374	2010-12-15	7.6475	5.8425	48.75	-80.75	274.77618	0.000000	9.0	0.0

311375 rows × 9 columns

Equation Representation: *corn_price = wheat_price + lat + lon + max_day_temp + effective_degree_days + ice_days + heavy_rain_days + bias*

Model Assumptions

- Supply factors influence pricing of commodities
- Certain relationships between securities tend to revert to their mean or exhibit predictable patterns over time
- The top 10 US corn producing states have a substantial outcome on corn prices
- Severe weather events influence corn supply
- Agriculture is an efficient market

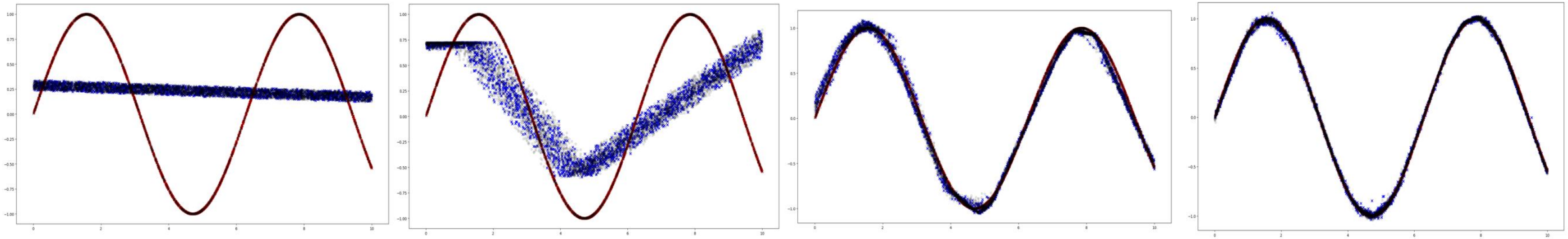


Recurrent Neural Network Capabilities

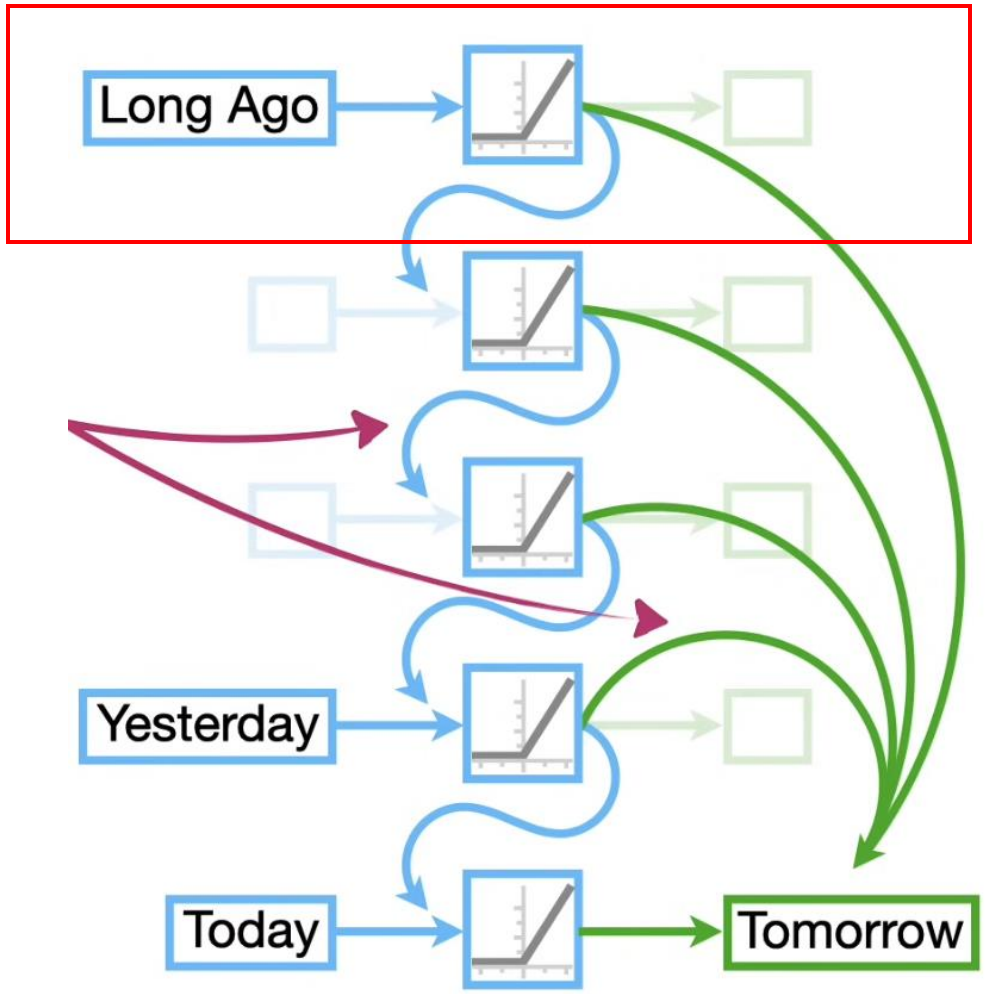
- Universal Function Approximator
- Through many training iterations and a large dataset, it can very accurately detect nonlinear patterns

Training iterations with nonlinear activation layers

Start → **Result**



How does an LSTM work?

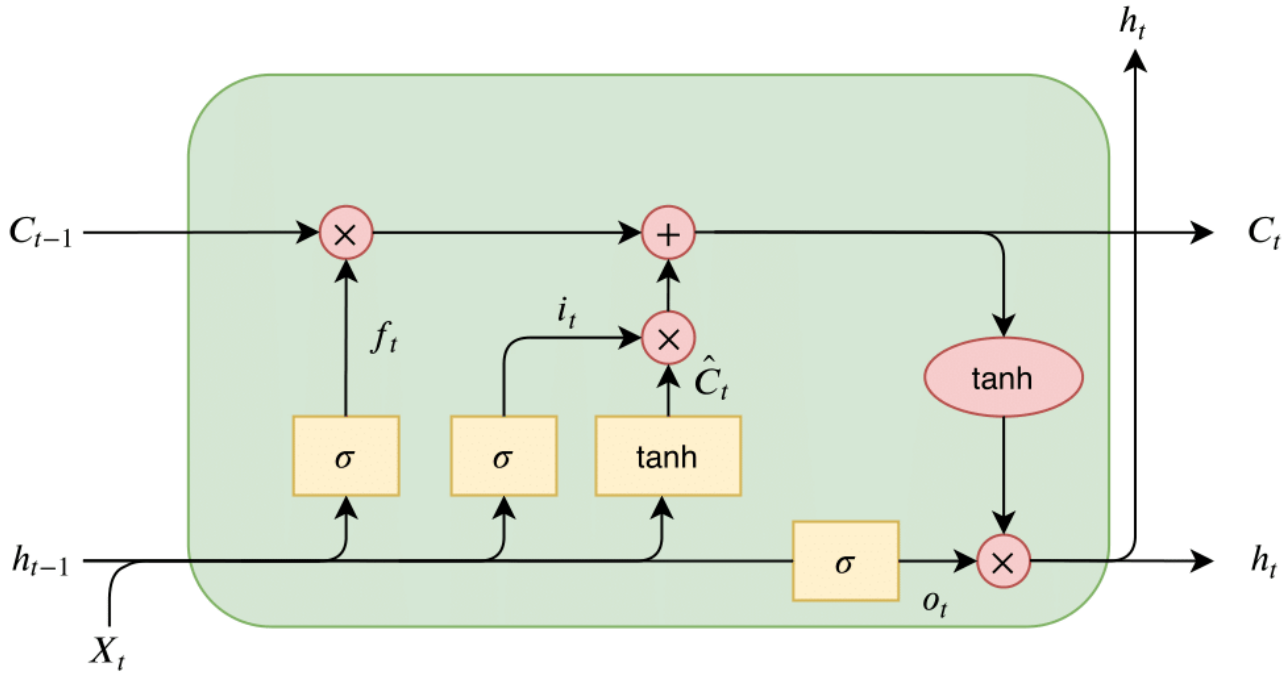


Type of Recurrent Neural Network

Utilizes a gated architecture to determine relevance of long term and short-term data

Output today can depend on data from long ago or data from yesterday

Model Architecture

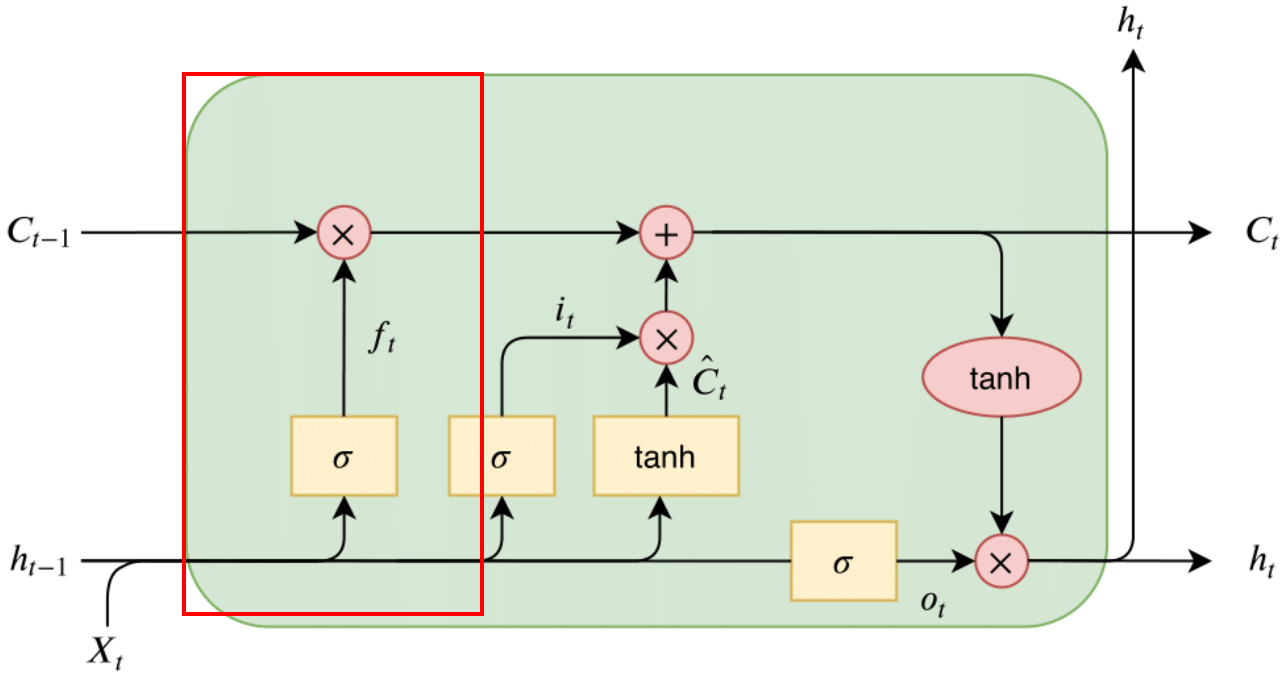


$$Tanh$$

$$f(x) = \frac{\left(e^{x} - e^{-x}\right)}{\left(e^{x} + e^{-x}\right)}$$ **= range[-1,1]**

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$ **= range[0,1]**

Model Architecture



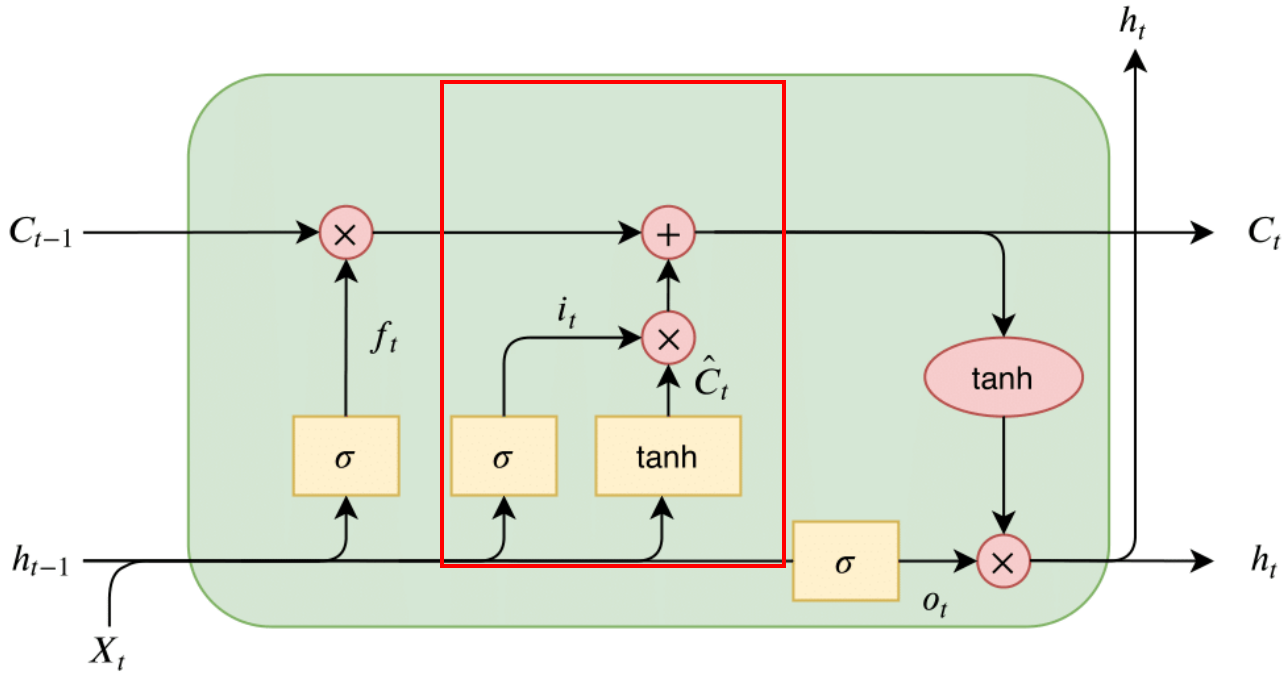
Forget gate – Short term memory determines percentage of long term memory relevant
To make new prediction

$$Tanh$$

$$f(x) = \frac{\left(e^{x} - e^{-x}\right)}{\left(e^{x} + e^{-x}\right)}$$ **= range[-1,1]**

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$ **= range[0,1]**

Model Architecture



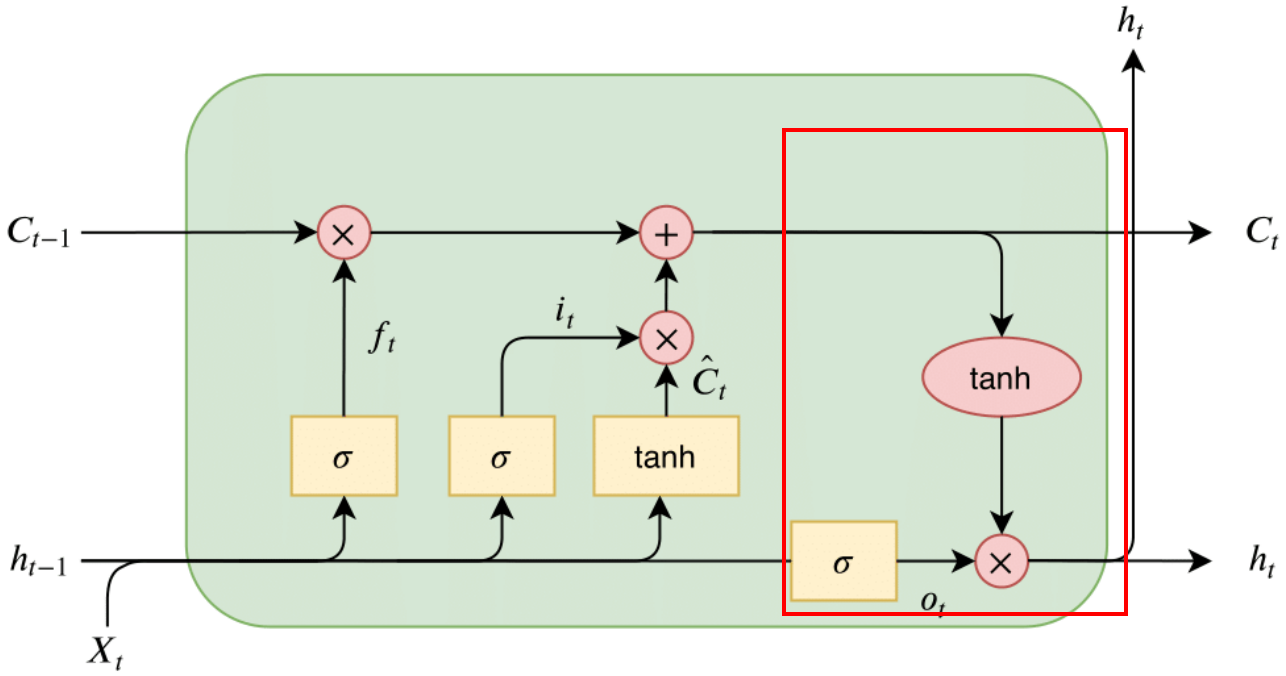
Input gate – Short term memory determines newly updated long-term memory

$$Tanh$$

$$f(x) = \frac{\left(e^{x} - e^{-x}\right)}{\left(e^{x} + e^{-x}\right)}$$ **= range[-1,1]**

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$ **= range[0,1]**

Model Architecture



Output gate – Long term memory determines newly updated short-term memory (which is the output)

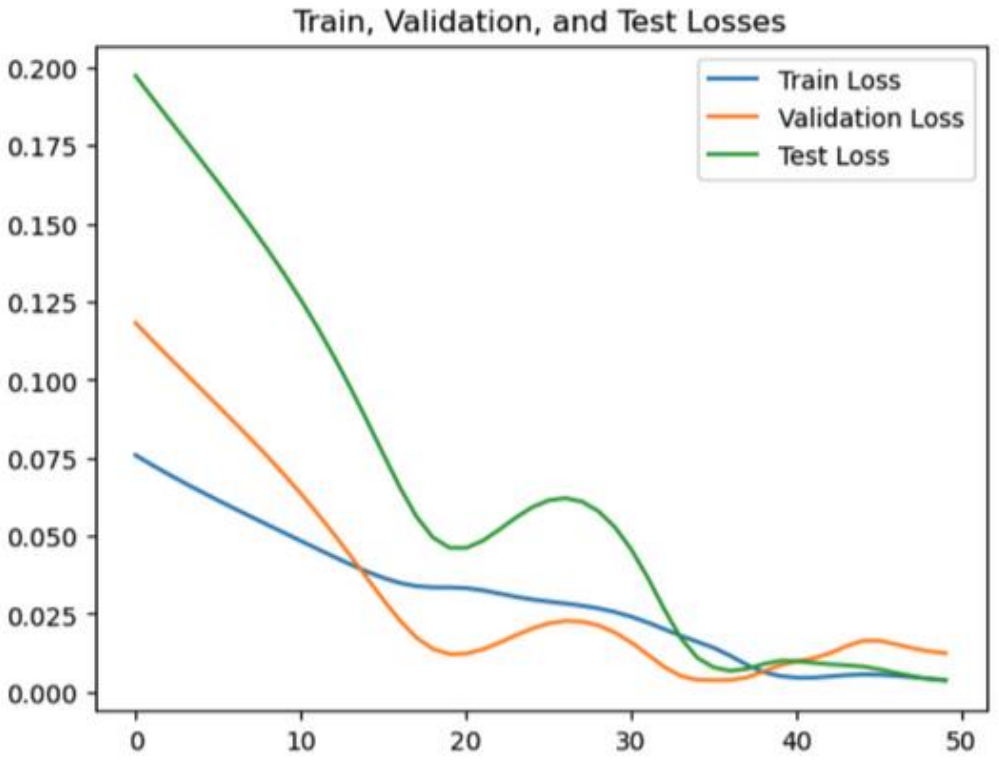
$$Tanh$$

$$f(x) = \frac{\left(e^{x} - e^{-x}\right)}{\left(e^{x} + e^{-x}\right)}$$ **= range[-1,1]**

$$\sigma(x) = \frac{1}{1 + e^{-x}}$$ **= range[0,1]**

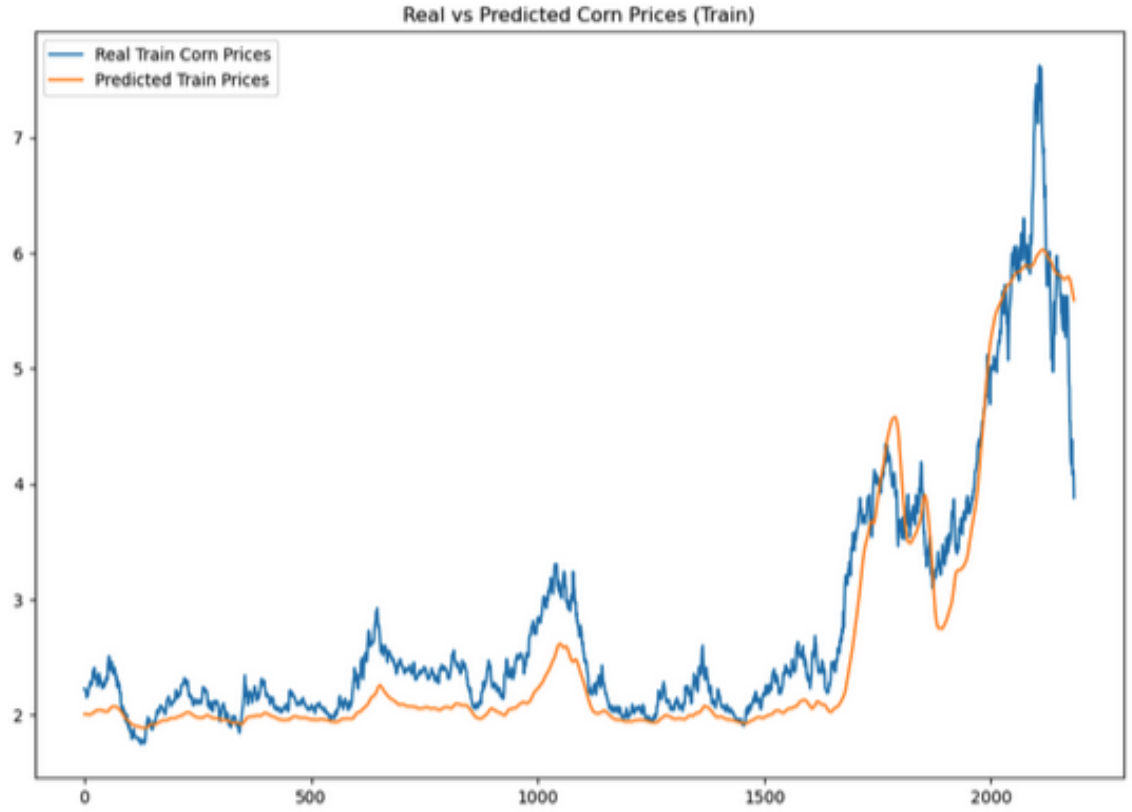
Results & Code

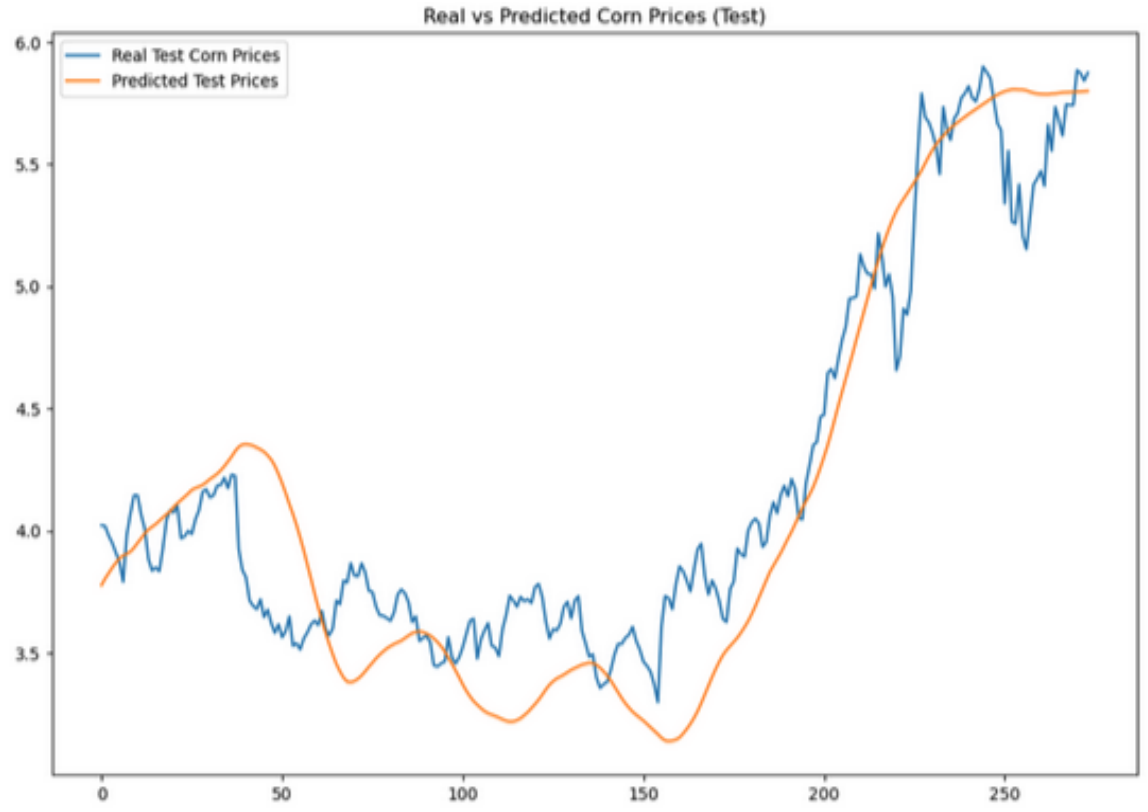
- Convergence of train, test and validation RMSE through 50 training epochs
- Low model error (accurate predictions)
- Not too overfit but predictions are slightly lagged



Github Repository: https://github.com/kenjic1/Corn-Spot-Price-LSTM

Results & Code

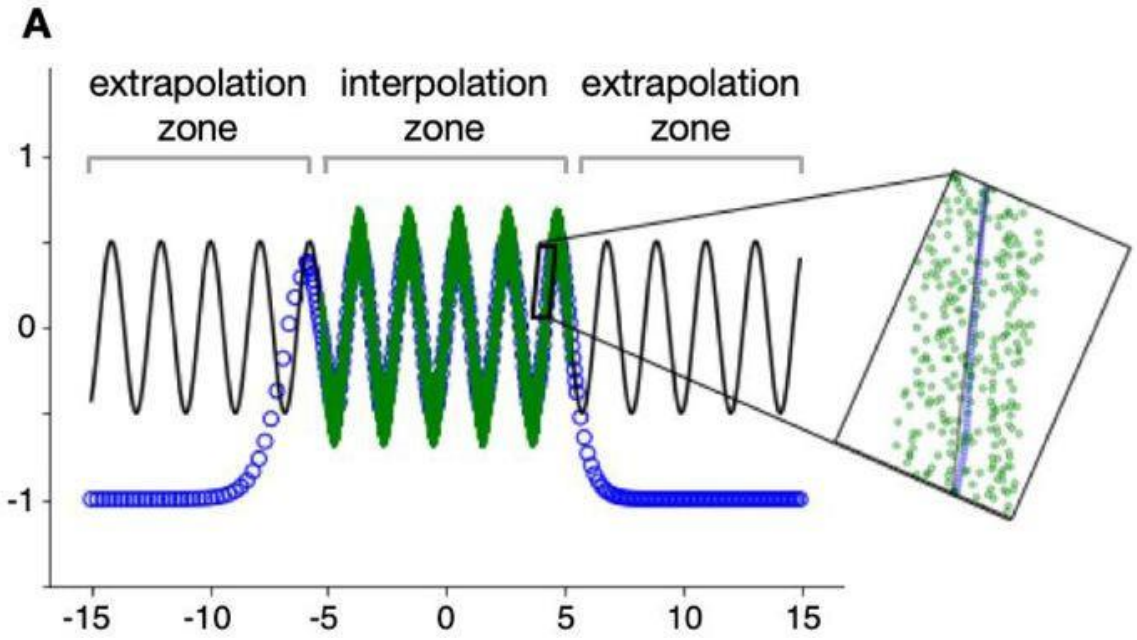




Key Findings

- Model can very accurately predict corn prices between 2000-2010
- If overfit, not a problem (can be tested for)

- **Evaluation Metric - Root Mean Square Error (RMSE)**
- Low test, validation and training RMSE (implies model accuracy)
- Convergence of train, test, validation RMSE (not overfit)



Issues to be considered

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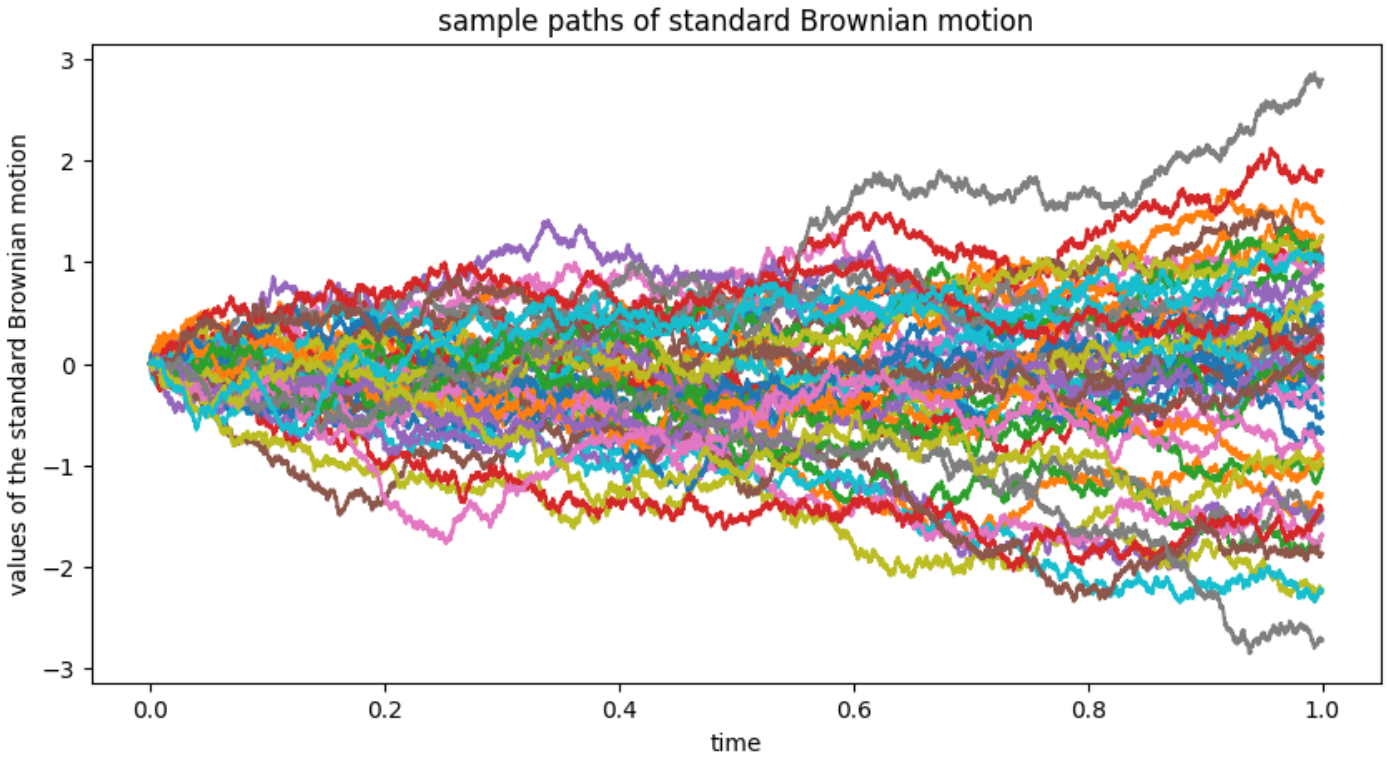
Violation of Brownian Motion



AB Testing to compare models: Select corn prices through Wiener process sampling within price range -> compared to LSTM output to see which model is more accurate

Next Steps

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To prevent overfitting:

- Further fine tune model
- Incorporate more data that accounts for other supply factors other than weather (business cycles, market conditions)
- Incorporate wheat price prediction model to predict divergence more accurately
- Need to account for lagged predictionsa

Thank You