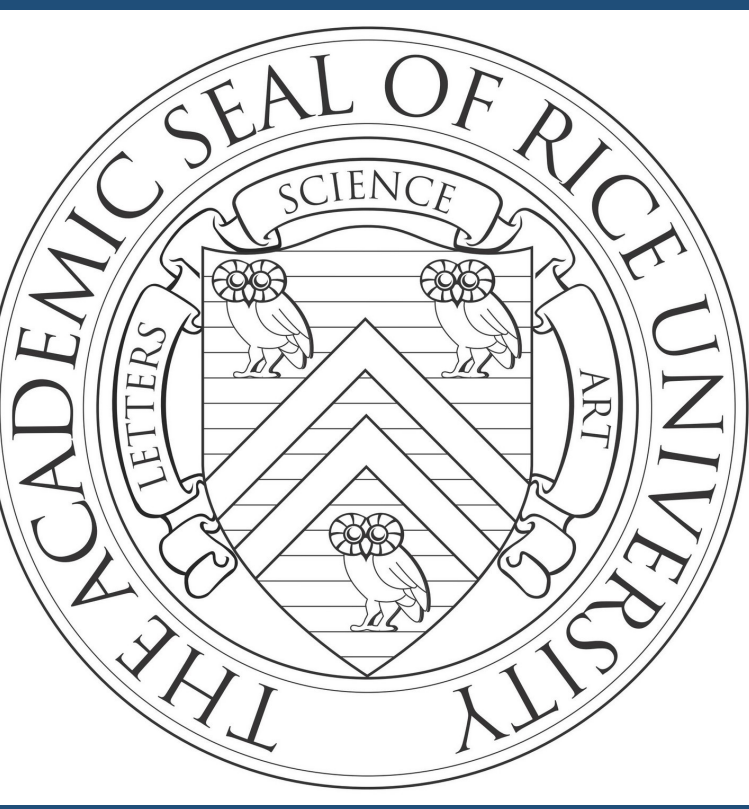


Forecasting Daily Returns of American Index Future Contracts via Wavelets Thresholding & Recurrent Neural Networks



Michael Jackson, Yifan Zhang

Advisor: Dr. Kathy Ensor

Hypothesis

Investigate how different wavelet thresholding techniques affect the accuracy of a RNN based prediction of the one day ahead return of American Index Futures and the profitability of two trading algorithm based on the predictions.

Thresholding Techniques

Universal Hard:

$$W_i^{hard} = \begin{cases} 0 & |W_i| \leq \lambda \\ W_i & |W_i| > \lambda \end{cases}$$

Universal Soft:

$$W_i^{soft} = \begin{cases} 0 & |W_i| \leq \lambda \\ W_i - \lambda & W_i > \lambda \\ \lambda - W_i & W_i < -\lambda \end{cases}$$

• Where $\lambda = (2 \cdot \ln(n))^{1/2} \sigma$

Empirical Bayesian: $t(\hat{w})$

• Where \hat{w} is estimated via maximizing the marginal log-likelihood given the appropriate prior that has a mixture distribution

WaveL₂E

$$\lambda_{WaveL_2E} = \hat{\omega}_t M$$

• Where $\hat{\omega}_t$ is estimated by minimizing the L₂E Criteria and M is the number of wavelet coefficients.

WaveL₂E χ^2

$$\lambda_{WaveL_2E\chi^2} =$$

95% critical value of the squared wavelet coefficient distribution

Trading Algorithm

- Denoise the OHLC signal Price Series
- Calculate 1-Day return of the Denoised Close series
- $x = \{\text{Denoised HLC} + 8 \text{ Momentum Technical Indicators}\}$
- $y = \{\text{1Day_Return_Denoised_Close}\}$
- Use 3 years (x,y) to train NARX Neural Network to predict 3 months of \hat{y}
- If $\begin{cases} long, & \text{if } \hat{y} > 0 \\ short, & \text{if } \hat{y} < 0 \end{cases}$

Model	Method	Dow Jones	S&P 400	S&P 500	Nasdaq
Wave L ₂ E	Long/Short	11.03	12.56	12.58	12.43
Wave L ₂ E χ^2	Long/Short	7.58	10.16	8.57	9.34
Universal Hard	Long/Short	8.15	5.27	8.27	12.26
Universal Soft	Long/Short	14.50	14.83	15.99	19.26
EBayes	Long/Short	11.01	5.46	11.34	11.41
Wave L ₂ E	Long only	10.89	11.62	12.42	15.98
Wave L ₂ E χ^2	Long only	9.26	10.58	10.48	14.44
Universal Hard	Long only	9.62	8.09	10.37	15.90
Universal Soft	Long only	12.61	12.70	14.08	19.40
EBayes	Long only	10.95	7.88	11.85	15.47
Buy and Hold		10.74	10.57	12.18	20.29

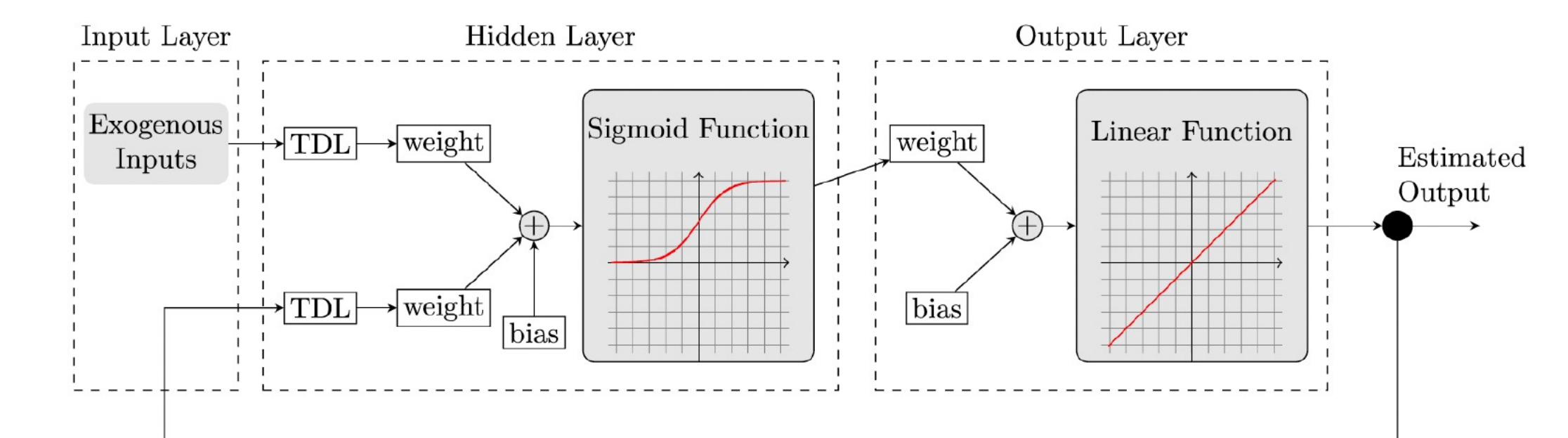
(2011-2020) Average Yearly Accuracy				
Model	Dow Jones	S&P 400	S&P 500	Nasdaq
Wave L ₂ E	0.541	0.535	0.538	0.540
Wave L ₂ E χ^2	0.537	0.533	0.535	0.545
Universal Hard	0.529	0.516	0.519	0.541
Universal Soft	0.547	0.543	0.542	0.559
EBayes	0.536	0.517	0.524	0.533

(2011-2020) Average Yearly Precision				
Model	Dow Jones	S&P 400	S&P 500	Nasdaq
Wave L ₂ E	0.554	0.548	0.556	0.562
Wave L ₂ E χ^2	0.549	0.545	0.552	0.560
Universal Hard	0.550	0.538	0.548	0.566
Universal Soft	0.556	0.551	0.557	0.567
EBayes	0.556	0.540	0.552	0.565

(2011-2020) Average Yearly Recall				
Model	Dow Jones	S&P 400	S&P 500	Nasdaq
Wave L ₂ E	0.877	0.877	0.879	0.894
Wave L ₂ E χ^2	0.914	0.912	0.916	0.949
Universal Hard	0.821	0.824	0.828	0.857
Universal Soft	0.906	0.904	0.909	0.947
EBayes	0.809	0.816	0.815	0.825

NARX Neural Network

$$y[t] = \phi(x[t - d_x], \dots, x[t - 1], x[t], y[t - d_y], \dots, y[t - l], \Theta)$$



Technical Indicators

Momentum Indicators: Bull Market Search

- **(RSI) Relative Strength Index**
 - Price oscillator/price momentum indicator
- **(MACD) Moving Average Convergence-Divergence**
 - Price Velocity
- **MACD Signal**
 - Moving average of MACD
- **MACD Histogram**
 - Price Acceleration
- **Stochastics:** short term price velocity indicators
 - Stochastic Fast %K
 - Stochastic Slow %K
 - Stochastic %D
- **Ultimate Oscillator:** time weighted price momentum oscillator

Futures Contracts

- S&P 400 Mini Futures Contracts
- S&P 500 Mini Futures Contracts
- Dow Jones Mini Futures Contracts
- NASDAQ Mini Futures Contract

Data

- Source: **Bloomberg**
- DAILY OHLCV, 8 technical indicators, & hurst coefficient
- (2008-2020)