Forecasting stock market short – term trends using a neuro-fuzzy based methodology

Goal

- Predict short-term stock up-down movements purely using short-term historical stock prices.
- $y(k+n) = F(y(k), U)$, where U is a control action (factor), y is stock returns. U is important because it determines the changes from y(k) to y(k+n).
- $U = G\big(y(k), y(k+n)\big)$. We first estimate how to generate U by the mapping G using y(k) and y(k+n) first and then using y(k) and U to predict future return y(k+n).
- There are 2 steps in the process. The first step is to generate U first (CON-ANFIS). The second step is to use U to predict y(k+n) (PR-ANFIS).

CON-ANFIS

- The goal of this step is find a mapping G, which can drive the stock price y(k) to y(k+n) in n time steps. $U = G\left(y(k), y(k+n)\right)$.

- U could be generated by 5^2 rules from the form: $if\ y(k +$

CON-ANFIS

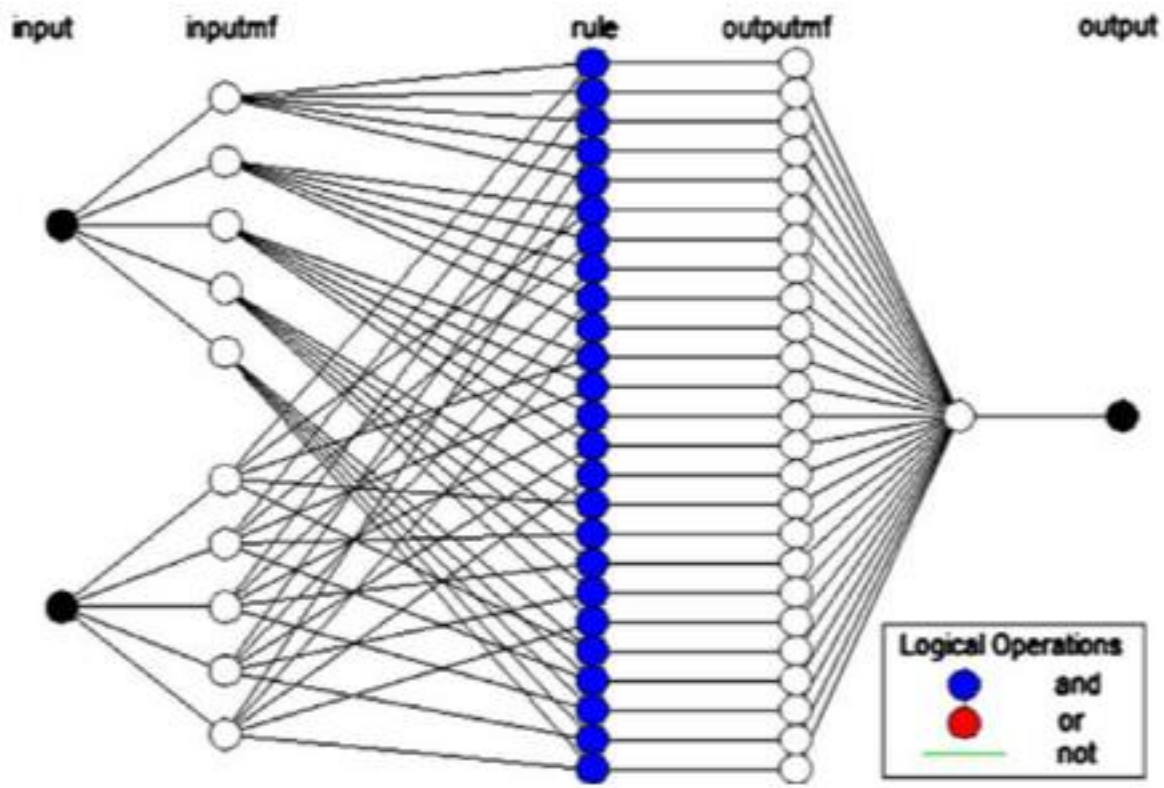

Fig. 2. Graphical representation of the structure of the CON-ANFIS controller using MATLAB (Jang & Gulley, 1995).

- Training data is $[y(k), y(k+1); u(k)]$
- $SMA(k) = \frac{sum\ of\ close\ price\ , day\ k\ , k-1, k-2}{3}$,

  $$y(\widetilde{k+1}) = \frac{SMA(k) - SMA(k-1)}{SMA(k-1)}$$

- We also do not know the true $u(k)$. Because $u(k)$ is the driver of stock price from k to k+1, we use change of stock return to approximate.
- $\widetilde{u(k)} = \sqrt{\left(y(k) - y(k+1)\right)^2}$

CON-ANFIS

- We could estimate u(k) using the above neural network. The fuzzy logic is Sugeno type.

- $u_1 = p_1\big(y(k)\big) + q_1\big(y(k+1)\big) + r_1$

  $u_2 = p_2\big(y(k)\big) + q_2\big(y(k+1)\big) + r_2$

  ……

- $w_1 = \min(MF_1\big(y(k)\big), MF_1(y(k+1)))$

  $w_2 = \min(MF_2\big(y(k)\big), MF_2(y(k+1)))$

  ……

- $u(k) = \frac{\sum_{i=1}^{25} u_i w_i}{\sum_{i=1}^{25} w_i}$

- The parameters $\{p_1, q_1, r_1, \ldots\ldots\}$ and the parameters within the membership function of y(k) and y(k+1) is trained by OLS and backpropagation.

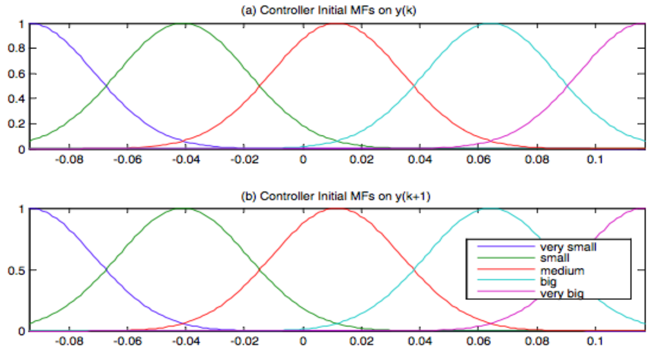

Fig. 5. The membership functions before the training of the CON-ANFIS controller.

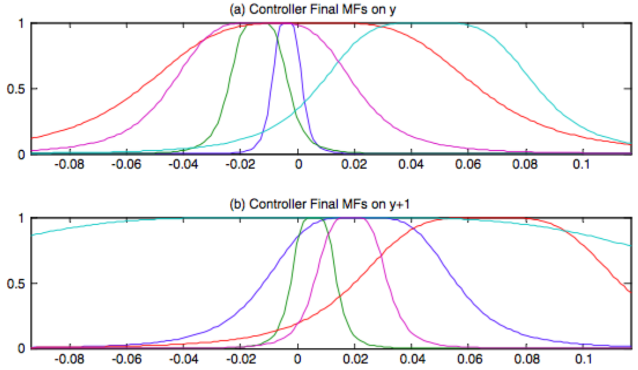

Fig. 6. The membership functions after the training of the CON-ANFIS controller.

CON-ANFIS

- We could see that the predicted u(k) is very close to the actual stock return changes, indicating that it could be a good driver of stock return changes. But actually it is not a strictly an estimate of stock return changes because we are using the approximates $y(\widetilde{k+1}) = \frac{SMA(k)-SMA(k-1)}{SMA(k-1)}$, which is not the true value.

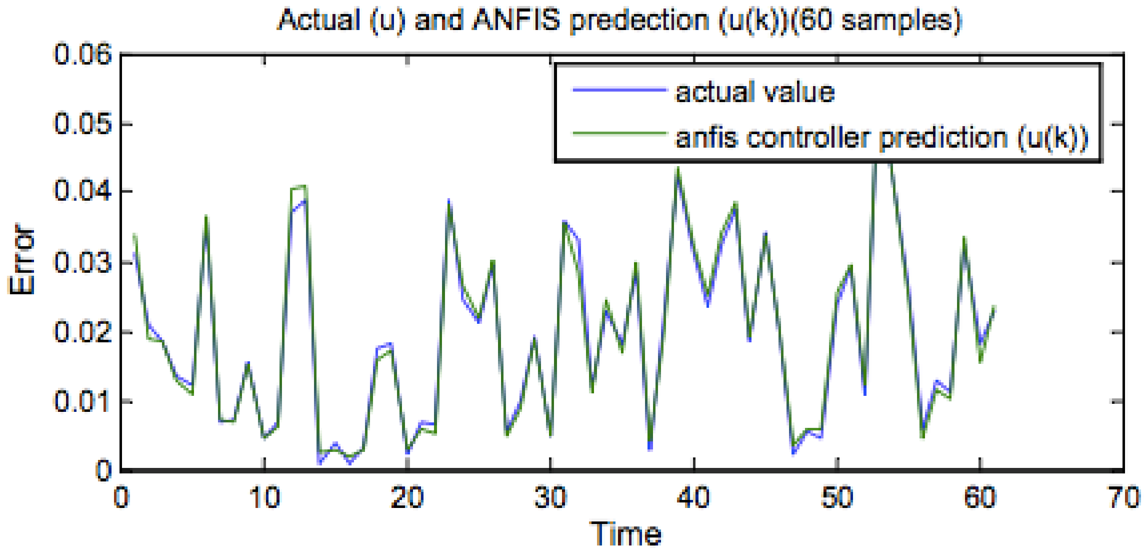

Fig. 9. Actual value and CON-ANFIS controller value of u(k) for 60 observations.

PR-ANFIS

- Under this step we want to predict $y(k+1) = f(y(k), y(k-1), u(k))$ using the training data $[y(k-1), y(k), u(k); y(k+1)]$, where $y(\widetilde{k+1}) = \frac{SMA(k)-SMA(k-1)}{SMA(k-1)}$.
- The rule is 3^3: $if\ y(k-1)\ is\ small\ and\ y(k)\ is\ small\ and\ u(k) is\ small, then\ y(k+1)\ is\ f_1 = p_1 y(k+1) + q_1 y(k) + s_1 u(k\ ) + r_1$.
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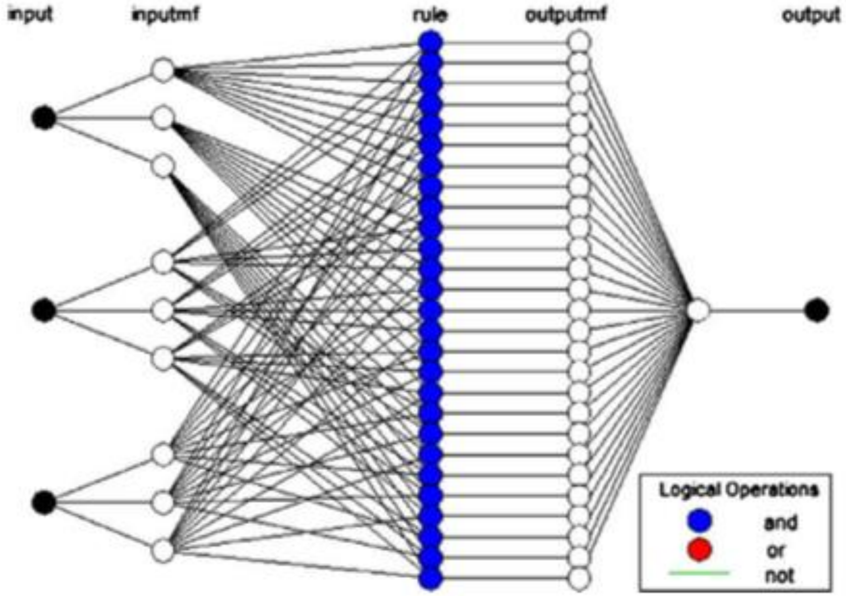

Fig. 10. The structure of the PR-ANFIS using MATLAB (Jang & Gulley, 1995).

Prediction Evaluation

- Test set: 3 60-day windows. 4/5/2016-6/30-2016; 11/4/2015-1/31/2016; 2/28/2016 – 5/31/2016. 10 large stocks in Greece and U.S.

- Forecasting accuracy varies between 56.50% to 68.33% with an average 62.32%.
- Buy if predicted up-trend, sell if predicted down-trend.

- Compared with B&H strategy and other forecasting methods.

Table 3
Comparison of the ROR with the B&H strategy, ASE stocks.

	NBG	ALPHA	CB	TITAN	ALGR
Time period	5/4/05–30/6/05				
Proposed System ROR %	**12.48**	**15.97**	**45.31**	**10.07**	**25.69**
B&H strategy ROR %	1.29	−3.03	22.43	−3.84	13.72
Performance difference %	11.19	19.00	22.88	13.91	11.97

Table 4
Comparison of various models that forecast the trend in the stock market.

Author	Model	Hit rate (%) next day
Lin et al. (2002)	REG	52.47
Lin et al. (2002)	GM	52.83
Lin et al. (2002)	NN	55.77
Lin et al. (2002)	NF	58.03
Fernandez-Rodriguez et al. (2000)	ANN	58.00
Harvey et al. (2000)	NN	59.00
Perez-Cruz et al. (2003)	MLP	57.00
Lendasse et al. (2000)	RBFN	57.20
Zhang et al. (1998)	NN	56.30
Doesken et al. (2005)	M-FIS	53.31
Doesken et al. (2005)	TS-FIS	56.00
Halliday (2004)	NN	55.57
Atsalakis (2006)	ATS-Anfis	60.00
Atsalakis, (proposed)	Neuro-Fuzzy	68.33

Ensemble Average

- What is loss function: squared loss function
- Control action
- Membership Constraints: do not require constraint.
- Membership Freedom: 2/3 parameters in each membership function.
- In the test process. We need $y(k+1)$ first to obtain $u(k)$. Because we do not know $y(k+1)$ at time k, we use the rate of change of 3-day stock price moving average to approximate because of trail-error analysis. $y(k+1) = SMA(k) = \frac{sum\ of\ close\ price\ ,day\ k\ ,k-1,k-2}{3}$,

$$y(\widetilde{k+1}) = \frac{SMA(k) - SMA(k-1)}{SMA(k-1)}$$