Universal Forecasting Model {Version-2}

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Abstract

In this research investigation, the author has presented '*Universal Forecasting Model - A Locally Parameter Element Wise Linear Transformations Based Forecasting Model For Dynamic State Systems With Large Number Of Parameters*'.

Theory

Firstly, we represent any *Dynamic State System* using a *State Vector* (*Row Vector*) of a specified size, say

$$V_i = [V_i(1) \quad V_i(2) \quad V_i(3) \quad . \quad . \quad . \quad V_i(n-2) \quad V_i(n-1) \quad V_i(n)]$$

That is,

$$\overline{V_i} = [V_i(1) \quad V_i(2) \quad V_i(3) \quad . \quad . \quad . \quad V_i(n-2) \quad V_i(n-1) \quad V_i(n)]$$

$$\overline{V_i} = \sum_{j=1}^{n} \{[V_{ij}]\hat{e}_j\}$$

Here, the *State Vector* has n parameters that are Evolving with time.

For the time instant $i = k$, we have the *State Vector* given by

$$\overline{V_k} = [V_k(1) \quad V_k(2) \quad V_k(3) \quad . \quad . \quad . \quad V_k(n-2) \quad V_k(n-1) \quad V_k(n)]$$

Let the *State Vector* be defined for $i = 1$ to $i = m$ instants.

We now *Normalize* all $\overline{V_i}$ for $i = 1$ to $i = m$.

The *Normalization* is given by

$$\hat{V_i} = \frac{\overline{V_i}}{\left\{\sum_{j=1}^{n} [V_{ij}]^2\right\}^{1/2}}$$

That is,

$$\hat{V}_i = \frac{\sum_{j=1}^{n} \{[V_{ij}]\hat{e}_j\}}{\left\{\sum_{j=1}^{n} [V_{ij}]^2\right\}^{1/2}}$$

We now define $T_{s\to(s+1)}(j) = \frac{\hat{V}_{(s+1)j}}{\hat{V}_{sj}}$

If $\hat{V}_{mj}$ is closest to some $\hat{V}_{(u_j)j}$ when we run u_j through $1 \le u_j \le m$

***Case 1*:**

$$\hat{V}_{mj} > \hat{V}_{(u_j)j}$$

We define

$$\hat{V}_{(m+1)j} = \{\hat{V}_{mj}\}\left[\frac{\hat{V}_{mj}}{\hat{V}_{(u_j)j}}\{T_{u\to(u+1)}(j)\}\right]$$

We now have

$$\hat{V}_{m+1} = [\hat{V}_{m+1}(1) \quad \hat{V}_{m+1}(2) \quad \hat{V}_{m+1}(3) \quad . \quad . \quad . \quad \hat{V}_{m+1}(n-2) \quad \hat{V}_{m+1}(n-1) \quad \hat{V}_{m+1}(n)]$$

We now write n Equations

$$\hat{V}_{(m+1)j} = \frac{\overline{V}_{(m+1)j}}{\left\{\sum_{j=1}^{n} \{\overline{V}_{(m+1)j}\}^2\right\}^{1/2}}$$

for $j = 1 \; to \; n$

and solve for $\overline{V}_{(m+1)j}$ for $j = 1 \; to \; n$.

$$\overline{V}_{m+1} = \left\{\sum_{j=1}^{n} \{\overline{V}_{(m+1)j}\}^2\right\}^{1/2}$$

Finally, we have

$\overline{V}_{m+1} = \left|\overline{V}_{m+1}\right| \hat{V}_{m+1}$.

Case 2:

$\hat{V}_{mj} < \hat{V}_{(u_j)j}$

We define

$$\hat{V}_{(m+1)j} = \left\{\hat{V}_{mj}\right\} \left[\frac{\hat{V}_{(u_j)j}}{\hat{V}_{mj}} \left\{T_{u \to (u+1)}(j)\right\} \right]$$

We now have

$$\hat{V}_{m+1} = \left[\hat{V}_{m+1}(1) \quad \hat{V}_{m+1}(2) \quad \hat{V}_{m+1}(3) \quad . \quad . \quad . \quad \hat{V}_{m+1}(n-2) \quad \hat{V}_{m+1}(n-1) \quad \hat{V}_{m+1}(n)\right]$$

We now write n Equations

$$\hat{V}_{(m+1)j} = \frac{\overline{V}_{(m+1)j}}{\left\{ \sum_{j=1}^{n} \left\{\overline{V}_{(m+1)j}\right\}^2 \right\}^{1/2}}$$

for $j = 1 \; to \; n$

and solve for $\overline{V}_{(m+1)j}$ for $j = 1 \; to \; n$.

Solution Scheme

We consider the equation $\hat{V}_{(m+1)j} = \dfrac{\overline{V}_{(m+1)j}}{\left\{ \sum_{j=1}^{n} \left\{\overline{V}_{(m+1)j}\right\}^2 \right\}^{1/2}}$ and square it

$$\left(\hat{V}_{(m+1)j}\right)^2 \left\{ \sum_{j=1}^{n} \left\{\overline{V}_{(m+1)j}\right\}^2 \right\} = \left(\overline{V}_{(m+1)j}\right)^2$$

We re-write the above as n equations

$$\left(\hat{V}_{(m+1)1}\right)^2 \left\{\left\{\overline{V}_{(m+1)1}\right\}^2 + \left\{\overline{V}_{(m+1)2}\right\}^2 + \ldots\ldots\ldots + \left\{\overline{V}_{(m+1)n}\right\}^2\right\} = \left(\overline{V}_{(m+1)1}\right)^2$$

$$\left(\hat{V}_{(m+1)2}\right)^2\left\{\left\{\overline{V}_{(m+1)1}\right\}^2+\left\{\overline{V}_{(m+1)2}\right\}^2+\dots\dots+\left\{\overline{V}_{(m+1)n}\right\}^2\right\}=\left(\overline{V}_{(m+1)2}\right)^2$$

....

....

....

$$\left(\hat{V}_{(m+1)n}\right)^2\left\{\left\{\overline{V}_{(m+1)1}\right\}^2+\left\{\overline{V}_{(m+1)2}\right\}^2+\dots\dots+\left\{\overline{V}_{(m+1)n}\right\}^2\right\}=\left(\overline{V}_{(m+1)n}\right)^2$$

We re-write the above n equations as

$$\underbrace{\begin{bmatrix} \alpha_1 & -a_1^2 & -a_1^2 & \cdot\ \cdot\ \cdot & -a_1^2 & -a_1^2 \\ -a_2^2 & \alpha_2 & -a_2^2 & \cdot\ \cdot\ \cdot & -a_2^2 & -a_2^2 \\ -a_3^2 & -a_3^2 & \alpha_3 & \cdot\ \cdot\ \cdot & -a_3^2 & -a_3^2 \\ \cdot & \cdot & \cdot & \cdot\ \cdot\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot\ \cdot\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot\ \cdot\ \cdot & \cdot & \cdot \\ -a_{(n-1)}^2 & -a_{(n-1)}^2 & -a_{(n-1)}^2 & \cdot\ \cdot\ \cdot & \alpha_{(n-1)} & -a_{(n-1)}^2 \\ -a_n^2 & -a_n^2 & -a_n^2 & \cdot\ \cdot\ \cdot & -a_n^2 & \alpha_n \end{bmatrix}}_{A} \underbrace{\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ \cdot \\ \cdot \\ \cdot \\ x_{(n-1)} \\ x_n \end{bmatrix}}_{X} = \underbrace{\begin{bmatrix} 0 \\ 0 \\ 0 \\ \cdot \\ \cdot \\ \cdot \\ 0 \\ 0 \end{bmatrix}}_{D}$$

(These are n equations in n variables)

where

$$\overline{V}_{(m+1)j}=\sqrt{x_j}$$

$$\hat{V}_{(m+1)j}=a_j$$

$$\left(1-a_j^2\right)=\alpha_j$$

We can solve the above slated Consistent System Of Equations in *MATLAB* in the category *Symbolic Math Toolbox→Solving Equations→Several Algebraic Equations.*

We now have

$$\left|\overline{V}_{(m+1)}\right| = \left\{\sum_{j=1}^{n}\left\{\overline{V}_{(m+1)j}\right\}^{2}\right\}^{1/2}$$

Finally, we have

$$\overline{V}_{m+1} = \left|\overline{V}_{m+1}\right|\hat{V}_{m+1}.$$

Conclusion

This Scheme can be used to predict the *One Step Evolution* of any *Dynamic State System* with Large Number of Parameters.

Moral

Clear Waters Run Deep.

References

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Dedication

*All of the aforementioned Research Works, inclusive of this One are **Dedicated to Lord Shiva**.*