Fuzzification of Newton's Forward Interpolation Method and Exploring its Application in Stock Market

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Article Info
Page Number: 857 – 866
Publication Issue:
Vol. 71 No. 3s (2022)

Article History
Article Received: 22 April 2022
Revised: 10 May 2022
Accepted: 15 June 2022
Publication: 19 July 2022

Abstract

Numerical methods always give approximate results. On the other hand fuzzification of any number gives a result which falls within a range and it enhances the level of accuracy and therefore in this paper an attempt has made to fuzzify Newton's Forward Interpolation Formula a0nd also developed computer programs for the Classical and the Fuzzified Newton's Forward Interpolation Formula. The results of Fuzzified Newton's Forward Interpolation Formula and Classical Newton's Forward Interpolation Formula have been compared. Fifteen examples are taken under consideration for comparison. It has been seen that the methods provide more or less same results in classical and fuzzified form. The application of Interpolation method in the field of stock market is also discussed in this paper.

Keywords: Fuzzification, Fuzzy number, Interpolation, Stock Market,

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INTRODUCTION:

Numerical methods always give approximate results that mean it is inaccurate. On the other hand fuzzification of any number gives a result which falls within a range and it enhances the level of accuracy and therefore in this paper an attempt has made to fuzzify Newton's Forward Interpolation Formula in anticipation of better results and also developed computer program. Fifteen examples are taken under consideration for comparison of the fuzzified and the classical methods. The results of fuzzified Newton's Forward Interpolation Formula and classical Newton's Forward Interpolation Formula have been compared using statistical tools.

The main objectives of the study are

1. Fuzzification of Newton's Forward Interpolation Formula.
2. To develop computer programs for the Fuzzified Newton's Forward Interpolation Formula and Classical Newton's Forward Interpolation Formula.
3. To compare the results obtained from the computer programs developed for Fuzzified Newton's Forward Interpolation Formula and Classical Newton's Forward Interpolation Formula.
4. To explore the scope of application of Fuzzified Newton's Interpolation Method in Stock Market:

FUZZY FINITE DIFFERENCES:

Finite differences are involved in interpolation formulas. Therefore it is needed to know the about finite differences when the question of interpolation formulae arises. Finite differences have been used to produce the classical Newton's Forward Interpolation Formula. These differences have been also involved in the expression of the formula. Therefore a brief idea of finite differences has been given.

Let Y=F(X) be a fuzzy function of X. Let Y_0, Y_1, Y_2,…….Y_n be the values of Y corresponding to the values X_0,X_1,X_2,…….,X_n of the independent fuzzy variable X.

Then the first differences of Y are

$\Delta Y_0 = Y_1 - Y_0$, $\Delta Y_1 = Y_2 - Y_1$ ....

Similarly the second differences of Y are

$\Delta^2 Y_0 = \Delta Y_1 - \Delta Y_0$, $\Delta^2 Y_1 = \Delta Y_2 - \Delta Y_1$,.......

Continuing this way

$\Delta^r Y_n = \Delta^{r-1} Y_{n+1} - \Delta^{r-1} Y_n$

The successive differences of a function have been prominently displayed by constructing a difference table, which is known as Forward Difference Table. Since the values that have been discussed are in fuzzy form so in this study the table has been considered as Fuzzified Forward Difference Table which is as follows:

Fuzzified Forward Difference table

X	**Y**	ΔY	$\Delta^2 Y$	$\Delta^3 Y$	$\Delta^4 Y$
X_0	Y_0				
		ΔY_0			
X_1	Y_1	ΔY_1	$\Delta^2 Y_0$	$\Delta^3 Y_0$	
X_2	Y_2		$\Delta^2 Y_1$		$\Delta^4 Y_0$
X_3	Y_3	---		$\Delta^3 Y_1$	
X_4	Y_4	ΔY_3	$\Delta^2 Y_2$		

FUZZIFICATION OF NEWTON'S FORWARD INTERPOLATION FORMULA:

Let Y=F(X) be a fuzzy function which takes the values Y_0, Y_1, Y_2,……Y_n corresponding to the values X_0,X_1,X_2,…….,X_n of the independent fuzzy variable X. Let the values of X be at equidistant intervals i.e. X_i-X_{i-1}=H, i=1,2,3….Here H is a fuzzy number. In this study S has been considered as the Universal set of the fuzzy triangular numbers.

Then

$$F(X)= Y_0+\frac{U}{[1,1,1]}\Delta Y_0+\frac{U(U-[1,1,1])}{[2,2,2]}\Delta^2 Y_0+\frac{U(U-[1,1,1])(U-[2,2,2])}{[6,6,6]}\Delta^3 Y_0+\ldots\ldots$$

Where $U=\frac{X-X_0}{H}$, U is a fuzzy number such that U=[U', U'', U'''] and f.m.f. of U is

$$\mu_U(S)=\begin{cases}\dfrac{S-U'}{U''-U'} & \text{where } U'\le S\le U''\\ \dfrac{S-U'''}{U''-U'''} & \text{where } U''\le S\le U'''\\ 0 & \text{otherwise}\end{cases}$$

Here ΔY_0 represents first difference of Y such that $\Delta Y_0=Y_1-Y_0$ where $Y_1=[Y_1', \quad Y_1'', \quad Y_1''']$ and $Y_0=[Y_0', \quad Y_0'', \quad Y_0''']$

$\Delta^2 Y_0$ represents second order difference of Y such that $\Delta^2 Y_0=\Delta Y_1-\Delta Y_0$,

$\Delta Y_1=Y_2-Y_1$ and $\Delta Y_0=Y_1-Y_0$

and so on.

Example From the following data, let us find Y at X=[.24,.25,.26]

X	Y
[.09, 0.10, 0.11]	[1.39, 1.40, 1.41]
[0.19, 0.20, 0.21]	[1.55, 1.56, 1.57]
[0.29, 0.30, 0.31]	[1.75, 1.76, 1.77]
[0.39, 0.40, 0.41]	[1.99, 2.00, 2.01]
[0.49, 0.50, 0.51]	[2.27, 2.28, 2.29]

Solution

The forward difference table has given below

X	Y
[.09, 0.10, 0.11]	[1.39, 1.40, 1.41]
[0.19, 0.20, 0.21]	[1.55, 1.56, 1.57]
[0.29, 0.30, 0.31]	[1.75, 1.76, 1.77]
[0.39, 0.40, 0.41]	[1.99, 2.00, 2.01]
[0.49, 0.50, 0.51]	[2.27, 2.28, 2.29]

ΔY	$\Delta^2 Y$
[0.14, 0.16, 0.18]	[0, 0.04, 0.08]

[0.18, 0.2, 0.22] [0, 0.04, 0.08]

[0.22, 0.24, 0.26] [0, 0.04, 0.08]

[0.26, 0.28, 0.30]

Here, $H = X_i - X_{i-1} = [0.08\ \ 0.10\ \ 0.12]$

f.m.f. of H is

$$\mu_H(S) = \begin{cases} \dfrac{S-0.08}{0.10-0.08} & \text{where } 0.08 \le S \le 0.10 \\ \dfrac{S-0.12}{0.10-0.12} & \text{where } 0.10 \le S \le 0.12 \\ 0 & \text{otherwise} \end{cases}$$

and $U = \frac{X - X_0}{H} = \frac{[0.24\ 0.25\ 0.26]-[0.09\ 0.10\ 0.11]}{[0.08\ \ 0.10\ \ 0.12]} = \frac{[0.13\ \ 0.15\ \ 0.17]}{[0.08\ \ 0.10\ \ 0.12]} = [0.25\ 0.50\ 0.88]$

f.m.f. of U is

$$\mu_U(S) = \begin{cases} \dfrac{S-0.25}{0.50-0.25} & \text{where } 0.25 \le S \le 0.50 \\ \dfrac{S-0.88}{0.50-0.88} & \text{where } 0.50 \le S \le 0.88 \\ 0 & \text{otherwise} \end{cases}$$

$$Y = Y_0 + \frac{U}{[1,1,1]}\Delta Y_0 + \frac{U(U-[1,1,1])}{[2,2,2]}\Delta^2 Y_0$$

$$= [1.39\ 1.40\ 1.41] + \frac{[0.25\ \ 0.50\ 0.88]}{[1\ 1\ 1]} \times [0.14\ 0.16\ 0.18] + \frac{[0.25\ 0.50\ 0.88]([0.25\ 0.50\ 0.88] - [1\ 1\ 1])}{[2\ 2\ 2]} \times [0.00\ 0.04\ 0.08]$$

$$= [1.55171\ 1.6555\ 1.78201] = [1.55\ 1.66\ 1.78]$$

f.m.f. of Y is $\mu_Y(S) = \begin{cases} \frac{S-1.55}{1.66-1.55} & \text{where } 1.55 \le S \le 1.66 \\ \frac{S-1.78}{1.66-1.78} & \text{where } 1.66 \le S \le 1.78 \\ 0 & \text{otherwise} \end{cases}$

and α cut is $[Y\ \ ]^\alpha = [1.55 + (1.66 - 1.55)\alpha, 1.78 - (1.78 - 1.66)]$

FUZZIFIED NEWTON'S FORWARD INTERPOLATION FORMULA VS CLASSICAL NEWTON'S FORWARD INTERPOLATION:

In this section fifteen examples have been considered for comparison purpose. C++ programs have been developed for Fuzzified Newton's Forward Interpolation Formula and Classical Newton's Forward Interpolation Formula. The solutions of these examples have been calculated through these programs. The solutions have been recorded in the Table 1.

Table - 1
Showing the Output of the C++ Program Developed for the Fuzzified Newton's Forward Interpolation Formula and Classical Newton's Forward Interpolation Formula

SL No.	x	Y	X			Y		
			Left	Mid	Right	Left	Mid	Right
1	0.1	0.01	0.99	0.1	0.11	-2.41500	0.00910	2.78432
2	9	1405.86	8.99	9.00	9.01	1376.30	1401.72	1436.21
3	47	106.52	46.99	47.00	47.01	109.215	109.401	109.766
4	0.5	-1.25	0.49	0.50	0.51	-1.49171	-1.23	-1.0248
5	1.5	15.12	1.49	1.50	1.51	15.05950	15.010	15.174
6	0.3	77.04	0.29	0.30	0.31	76.6773	77.012	77.3816
7	2.8	22.83	2.79	2.80	2.81	22.6053	22.840	23.0319
8	.25	1.655	0.24	0.25	0.26	1.55171	1.650	1.78201
9	43	189.79	42.99	43.00	43.01	189.582	188.90	190.003
10	21	0.3583	20.99	21.00	21.01	0.33124	0.3523	0.386075
11	1.02	1.851	1.01	1.02	1.03	1.831	2.1330	2.91116
12	0.12	0.1205	0.11	0.12	0.13	-0.0281114	0.1214	0.323976
13	12	34.22	11.99	12.00	12.01	34.1366	34.202	34.2914
14	1.02	.3461	1.01	1.02	1.03	0.202664	0.34618	0.512855
15	1.85	6.3598	1.84	1.85	1.86	6.14315	6.3977	6.81766

The Table 2 shows the defuzzified values of X and Y for each fuzzified problem and corresponding x and y values in crisp form for the same problem.

Table - 2
Showing the defuzzified values of X and Y and their Corresponding crisp values in reference to Table 1

Sl. No	X	Defuzzified value of X	y	Defuzzified value of Y
1	0.1	0.101	0.010	0.0094
2	9	9.001	1405.86	1404.58
3	47	47.002	106.52	108.98
4	0.5	0.501	-1.250	-1.246
5	1.5	1.41	15.120	15.001
6	0.3	0.291	77.040	76.78
7	2.8	2.78	22.830	22.78
8	.25	0.245	1.655	1.646
9	43	43.001	189.79	189.67

10	21	20.991	0.3583	0.3578
11	1.02	1.021	1.851	2.1278
12	0.12	0.123	0.1205	0.12004
13	12	12.001	34.22	34.1920
14	1.02	1.022	0.3461	0.3471
15	1.85	1.844	6.3598	6.3978

Comparison of Solutions obtained from Fuzzified Newton's Forward Interpolation formula and Classical Newton's Forward Interpolation formula:

For comparing whether the results obtained by Fuzzified Newton's Forward Interpolation formula are significantly different with the results obtained by the Classical method on the same randomly selected set of problems, appropriate statistical test is used. The null hypothesis considered.

The null hypothesis for comparing the results is as follows,

H_{01} : The Results obtained by Fuzzified Newton's Forward Interpolation formula and Classical Newton's Forward Interpolation formula are same

Against the two-sided alternative hypothesis

H_{A1}: The Results obtained by Fuzzified Newton's Forward Interpolation formula and Classical Newton's Forward Interpolation formula are not same.

To choose the proper statistical test the normality of the results on the same set of randomly selected problems obtained by both the method are tested by using box-plot and K-S test. The box-plot of the results is presented in Figure 1,

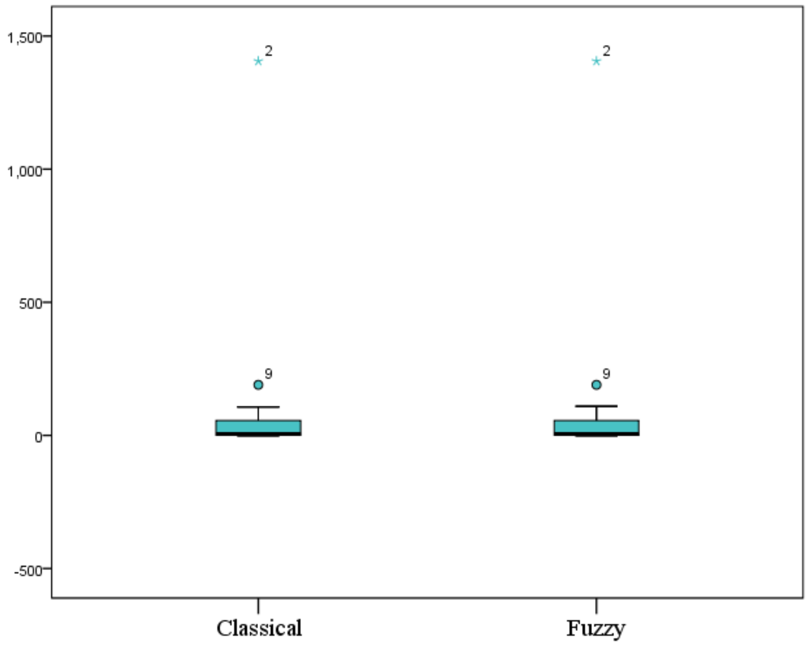

Figure 1 : box-plot of the results of Newton's Forward Interpolation formula

By observing the position of median and also occurrence of extreme observation in the box-plot on the results of both classical and fuzzy methods one can conclude that it is less likely that the results follow normal distribution and this can be confirmed by applying K-S test. The null hypothesis for the K-S test is H_{02}: data follows normal distribution Vs H_{A2}: the data do not follow normal distribution. The results of the K-S test are presented in Table 3.

Table - 3

Results of K-S test for the Solutions of Classical Newton's Forward Interpolation formula and Fuzzified Newton's Forward Interpolation formula

	Kolmogorov-Smirnov		
	Statistic	Df	p-value
Classical	.386	15	<0.01
Fuzzy	.383	15	<0.01

From the results of the K-S test it can be observed that the results obtained by both the classical and fuzzy methods are statistically significant i.e., they do not follow normal distribution (p-value<0.01, reject H_{02})

As the results do not follow normal distribution, non-parametric statistical test viz., Wilcoxon-signed rank test is used to compare whether the results obtained by both the methods are statistically significant. The results are presented in the Table 4.

Table -4

Showing the Results of Descriptive Statistics and Wilcoxon-signed rank test for Newton's Forward Interpolation formula

	Classical	Fuzzy	Z-value	p-value
Mean	124.0554	124.2750		
Median	6.3598	6.3989		
Std. Deviation	358.6550	358.6377		
Minimum	-1.2500	-1.2500		
Maximum	1405.8600	1405.8600	-1.778	0.075

Table 4, shows the descriptive statistics on the results obtained by classical and fuzzified Newton's forward interpolation formula. The results of the Wilcoxon-signed-rank test shows that the results obtained by both the methods are not statistically significant (p-value<0.05) i.e. H_{01} may be accepted. Thus, it can be concluded that the result of a mathematical problem obtained by newly developed fuzzified Newton's forward interpolation formula is more or less same with the classical method.

EXPLORING THE SCOPE OF APPLICATION OF FUZZIFIED NEWTON'S INTERPOLATION METHOD

Dong Ming and Zhou Shen Xu in the paper entitled" Exploring the Fuzzy Nature of Technical Patterns of U.S. Stock Market" proposed a Fuzzy logic based approach for Technical Analysis. They have introduced the inter & intra fuzzification into an automatic pattern detection and analysis process and incorporated human cognitive uncertainty into the Technical Analysis domain[1].

In the paper titled "Stock Technical Analysis using Multi Agent and Fuzzy Logic" Gamil. A. Ahmed et al proposed a multi agent and fuzzy logic based DSS for Stock Market. This system will help investors of the stock market to take/sell/hold decisions[2].

Govindasamy V. and Thambidurai P. in the paper titled "Probabilistic Fuzzy Logic based Stock Price Prediction" proposed an innovative probabilistic approach for Stock Price Prediction that minimises the Investors Risk while investing money in the Stock Market[3].

Homayouni Nassim and Amiri Ali in the paper titled "Stock Price Prediction using a Fusion Model of Wavelet, Fuzzy Logic and ANN" proposed a fusion model for predicting of Stock Prices. They have used the Tehran Stock Market Prices as a sample[4].

A common problem that the investors face is to make the accurate choices at the right moment in the Stock market. The paper entitled "A New Fuzzy Logic Controller for Trading on the Stock market" by R. M. Francesco et al provided a Fuzzy Trading System. This system has been compared with the Trading System to find out accuracy level[5].

Ijegwa david Acheme et al in their paper " A Predictive Stock Market Technical Analysis Using Fuzzy Logic " deployed Fuzzy inference to Stock market with four indicators used in Technical Analysis to aid in the decision making process in order to deal with probability[6].

The managing of the investment portfolio is very important to outperform in the stock market. The paper "Dual Time Frame Relative Strength Stock Selection Using Fuzzy Logic" authored by Peachavanish Ratchata proposed a stock selection method that applies Mamdani type Fuzzy rule based inference on Dual Time Frame Relative Strength Index momentum technical indicators[7].

.Stock Market is the most attractive place for investors, but it is difficult to make trading decisions. This paper entitled "Stock market Analysis and Prediction System Using Fuzzy Logic Type 2" by I. N. Davis et al presented a system which predicts variable stock using historical stock prices and Fuzzy Logic. Four technical indicators were used as input variable to the fuzzy predictive system in the study. This system achieved 92 % accuracy level and can be implemented in decisions of buying, holding and selling of stocks[8].

Roy Partha et al in the paper titled ": A Fuzzy Logic Model to Forecast Stock Market Momentum" proposed a Fuzzy model that helps in identifying the momentum of the index. The results of the study results suggested that the Fuzzy modeling is very accurate in predicting bullish, neutral or bearish trends[9].

B. Amutha and G. Uthra in the paper entitled "Defuzzification of Symmetric Octagonal Intuitionistic Fuzzy Number" obtained an optimal solution for the Intuitionistic Fuzzy

Assignment Problem using Symmetric Octagonal Intuitionistic Fuzzy Number. The costs of the Intuitionistic Fuzzy Assignment Problem are taken as Symmetric Octagonal Intuitionistic Fuzzy Numbers. The costs are defuzzified into crisp values using the proposed ranking[10].

From the above mentioned literature, it has been observed that the Fuzzy Logic has been found by the researchers as an effective tool in predicting the stock prices and taking the trading decisions accurately.

The Classical Newton's Forward Interpolation Method is helpful finding unknown value approximately from a given set of data. Since Fuzzifiied Newton's Forward Interpolation Method gives a range of values for the unknown value, there is possibility of getting more accurate results than classical methods. In this paper, a computer program has also been developed which enhance level of accuracy of the method and also reduces burden of handling huge data set which is common in case of stock market data.

Therefore, there is a scope of using this Computerized Fuzzified Interpolation method in predicting future stock prices.

CONCLUSION

In this research study Newton's Forward interpolation method has been fuzzified. In the present study efforts have been made to fuzzify interpolation method using triangular fuzzy number and also computer programs have been developed for the classical and the fuzzified methods. Fifteen mathematical examples have been considered and the solution of these examples has been attained from the respective computer programs. Comparison has been made been between the outcome of the classical and fuzzified methods

With the help of descriptive and inferential statistical tool, various tests have been performed and it has been seen that the methods provide more or less same results in classical and fuzzified form.

This paper opens up a scope of developing a model using Computerized Fuzzified Interpolation method for predicting future stock prices.

References:

1. Dong Ming and Zhou Shen Xu "Exploring the Fuzzy Nature of Technical Patterns of U.S. Stock Market" ICONIP'02-SEAL'02-FSKD'02, Nov 18-22, 2002, Singapore.
2. Gamil. A. Ahmed, El-fouly S Raafat and Darwish M. Nevin "Stock Technical Analysis using Multi Agent and Fuzzy Logic" Proceedings of the World Congress on Engineering 2007 Vol I, WCE 2007, July 2 - 4, 2007, London, U.K.
3. Govindasamy V. and Thambidurai P. "Probabilistic Fuzzy Logic based Stock Price Prediction" International Journal of Computer Applications (0975 – 8887) Volume 71– No.5, May 2013,pp 28-31.
4. Homayouni Nassim and Amiri Ali "Stock Price Prediction using a Fusion Model of Wavelet, Fuzzy Logic and ANN", International Conference on E-business, Management and Economics, IPEDR Vol.25 , IACSIT Press, Singapore.

5. R. M. Francesco, Pennacchio S., Via P. and Mulè M. “A New Fuzzy Logic Controller for Trading on the Stock market”, In Proceedings of the Ninth International Conference on Enterprise Information Systems - AIDSS, pages 322-329.
6. Ijegwa David Acheme, Rebecca Olufunke Vincent, Olusegun Folorunso and Isaac Olasunkanmi Olusola“ A Predictive Stock Market Technical Analysis Using Fuzzy Logic, Computer and Information Science; Vol. 7, No. 3; 2014, ISSN 1913-8989 E-ISSN 1913-8997.
7. Peachavanish Ratchata, “Dual Time Frame Relative Strength Stock Selection Using Fuzzy Logic”, Proceedings of the International MultiConference of Engineers and Computer Scientists 2018 Vol II IMECS 2018, March 14-16, 2018, Hong Kong
8. I. N. ,Davis., “Stock Market Analysis and Prediction System Using Fuzzy Logic Type 2” Journal of Advances in Mathematical & Computational Sciences, Vol. 7, No. 2. Pp. 33-46
9. Roy Partha, Kumar Ramesh and Sharma Sanjay,“: A Fuzzy Logic Model to Forecast Stock Market Momentum” International Journal of Advanced Engineering Research and Studies IV/II/Jan.-March,2015/98-101 E-ISSN2249–8974.
10. B. Amutha and G. Uthra, “Defuzzification of Symmetric Octagonal Intuitionistic Fuzzy Number” Advances and Applications in Mathematical Sciences Volume 20, Issue 9, July 2021, Pages 1719-1728