

## Implementation Fuzzy and Extended Kalman Filter for Estimation of High and Low Stock Price Travel Company

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### ABSTRACT

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Competition in the business world is getting tougher from year to year both within a country and abroad. There are a large number of companies competing with one another, especially entering the free market share in Asia, namely the ASEAN Economic Community (AEC). In the current development of modern economy, Indonesia is making efforts to increase its economic growth. For this, developments in any fields are made. Among others is the service industry such as accommodation, travel, and transportation services. Considering that Indonesia is a country comprised of many islands with a variety of natural beauty, it has the very potential for tourist resort attraction. This kind of thing leads to the growth of the Travel, tourism and hotel industry to support development of tourism. With such rapid service industry development, supported by promising business opportunities, investors for such sector are encouraged. The right way to reduce risk for investors interested is to develop a system for estimating the stock prices. Therefore, in this study, the high and low stock price estimation method applied for travel companies adopted developed Kalman Filter, a comparison of two Kalman Filter development methods, namely Extended Kalman Filter (EKF) and Fuzzy Kalman Filter (FKF) as a chart for investors to take into consideration in their investment decision making. The simulation results showed that the EKF method had higher accuracy than the FKF method with an error by the EKF of 3.5% and that by the FKF of 8.9%.



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## 1. Introduction

Investments in financial instruments attractive to investors today are stock investments. In addition to the opportunity to obtain dividends, investors can also get capital gains. Even so, stock investment is known as a high risk high return investment, with a big risk tolerance. Investors are likely to get a high rate of return as well, and vice versa [1].

Shares are securities as proof of someone's ownership in a company, especially a public company trading its shares. Currently, investment in shares is preferred by many investors because they give attractive benefits in the future. In daily stock trading activities, stock prices fluctuate either in term of increases or decreases. Stock / share price analysis is needed by investors to determine the value of these shares, so that they can determine an investment portfolio strategy that can provide optimal returns. Fundamental and technical analysis is a analysis that can be used by investors [2].

Competition in the business and travel world is getting tougher from year to year both within a country and abroad. Business competition is a condition in which business people in relatively the same field compete with each other to achieve their respective business goals. There are a large number of companies competing with one another, especially entering the free market share in Asia, namely the Asean Economic Community (AEC). In the current development of modern economy, Indonesia is making efforts to increase its economic growth. For this, developments in any fields are made. Among others is the service industry such as accommodation, travel, and transportation services. With such rapid service industry development, supported by promising business opportunities, investors for such sector are encouraged. Economic development, especially in the tourism sector, can improve the economy of the lower community, So that investment by investors can help increase the acceleration of economic rotation

Several studies, beside those on economics and business, applied estimation and forecasting algorithms, among others, the implementation of estimation and forecasting methods on tourism ships [3], and in the military field the application of estimation algorithms for position of AUV [4,5] and missile and mobile robot position estimation to determine the trajectory to be followed by the intelligence vehicle [6,7]. Many intelligent system algorithms and Artificial intelligence to support a rapidly growing economy. With the existence of AI can help investors in finding and measuring opportunities in investing [8]

To minimize the risk of loss from investors and shareholders, numeric computation related to stock predictions is needed. Therefore, in this study, the high and low stock price estimation method applied for travel companies adopted developed Kalman Filter, a comparison of two Kalman Filter development methods, namely Extended Kalman Filter (EKF) and Fuzzy Kalman Filter (FKF) as a chart for investors to take into consideration in their investment decision making.

## 2. Research Method

The EKF algorithm can be seen in **Figure 1** and FKF algorithm can be seen in the next paragraph after **Figure 1**.

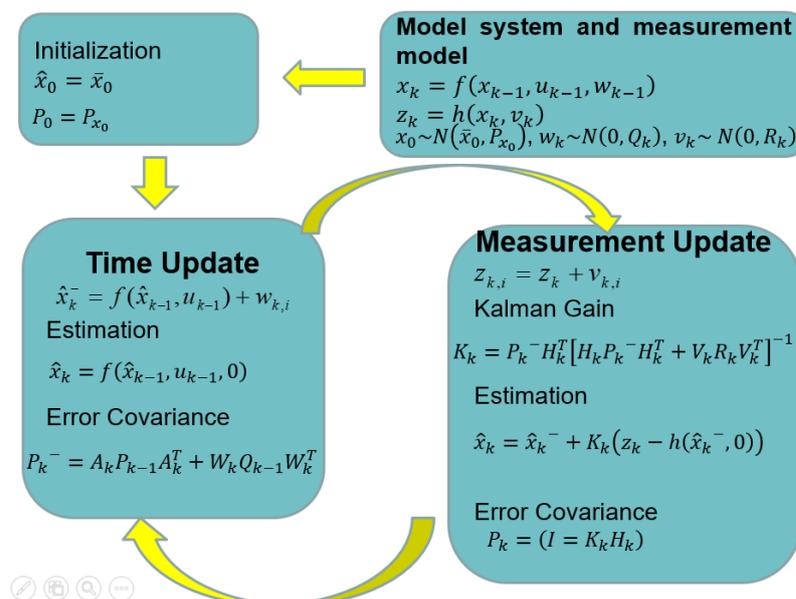


Figure 1. Extended Kalman Filter Algorithm [9,10]

Fuzzy Kalman Filter (FKF) is an estimation method that combines the fuzzy set with the Kalman Filter. We generate the variable state of crude oil using the Fuzzy set, and the Kalman Filter is applied to estimate that variable state. Lotfi A. Zahde is the person who first introduced the fuzzy set as a mathematical way to represent inaccuracies.

If  $S$  is a collection of objects denoted by  $s$ , then the fuzzy set  $E$  is a set of sequential pairs that can be denoted as follows [11,12]

$$E = \{(s, \mu E(s)) | s \in S\}$$

### 3. Simulation Result

The main purpose of this research is to minimize the risk of loss from investors and shareholders, so a numeric computation related to stock predictions is needed. This numeric simulation made by applying the EKF and Fuzzy KF algorithms to the high and low stock of travel company functions obtained from Mathematical Software Computation showed the stock data for high and low price as in **Table 1**. The simulation results were evaluated and compared to the established stock functions, and the stock functions for high and low prices in **Equation (1)-(2)** are as follows:

$$\begin{aligned} f_{high}(x) &= 209.81 - 6.51218x + 0.294136x^2 - 0.00445185x^3 \\ f'_{high}(x) &= -6.51218 + 0.588272x - 0.01335555x^2 \end{aligned} \tag{1}$$

$$\begin{aligned} g_{low}(x) &= 147.696 - 4.2972x + 0.185122x^2 - 0.00262836x^3 \\ g'_{low}(x) &= -4.2972 + 0.370244x - 0.00788508x^2 \end{aligned} \tag{2}$$

From **Equation (1)** and **(2)** the modified the stock functions model in **Equation (1)** and **(2)** are obtained as follows.

$$\begin{bmatrix} f_{high_{k+1}} \\ f_{low_{k+1}} \end{bmatrix} = \begin{bmatrix} -6.51218 + 0.588272x_k - 0.01335555x_k^2 \Delta t \\ (-4.2972 + 0.370244x_k - 0.00788508x_k^2) \Delta t \end{bmatrix} \tag{3}$$

**Table 1.** High and low stock price of Eka Sari Lorena Transport Company

Month	Closing Price		
	High	Low	Close
Jan 2015	210	183	188
Feb 2015	195	139	140
Mar 2015	194	127	150
Apr 2015	163	130	137
May 2015	166	124	164
June 2015	282	135	271
July 2015	280	151	160
Aug 2015	165	100	122
Sept 2015	140	112	120
Oct 2015	134	111	119
Nov 2015	128	108	113
Dec 2015	130	104	122
Jan 2016	120	100	113
Feb 2016	127	100	105
Mar 2016	123	101	110
Apr 2016	135	105	111
May 2016	121	103	110
June 2016	148	100	125
July 2016	158	110	150
Aug 2016	155	110	118
Sept 2016	156	110	140
Oct 2016	232	138	184
Nov 2016	200	167	187
Dec 2016	220	163	220
Jan 2017	208	165	189
Feb 2017	192	106	145
Mar 2017	188	140	187
Apr 2017	214	126	178
May 2017	206	117	138
June 2017	206	128	130

Month	Closing Price		
	High	Low	Close
July 2017	145	120	127
Aug 2017	158	122	127
Sept 2017	127	105	105
Oct 2017	112	95	96
Nov 2017	129	85	97
Dec 2017	102	85	94
Jan 2018	109	88	95
Feb 2018	112	92	98
Mar 2018	111	94	103
Apr 2018	117	93	112
May 2018	120	93	97
June 2018	118	80	106
July 2018	112	95	104
Aug 2018	130	98	103
Sept 2018	110	91	103
Oct 2018	107	98	98
Nov 2018	112	93	103
Dec 2018	113	100	107

The implementation of the Fuzzy KF algorithm and Extended KF algorithm on the highest and lowest stock price functions. the purpose of implementing the FKF and EKF algorithm is to determine the accuracy of both methods The resulted of running the Mathematica software seen in Equations (1) and (2) is to produce the highest and lowest price estimates for a company's shares and can be seen result of Mathematica software in Figure 1 and Figure 2.

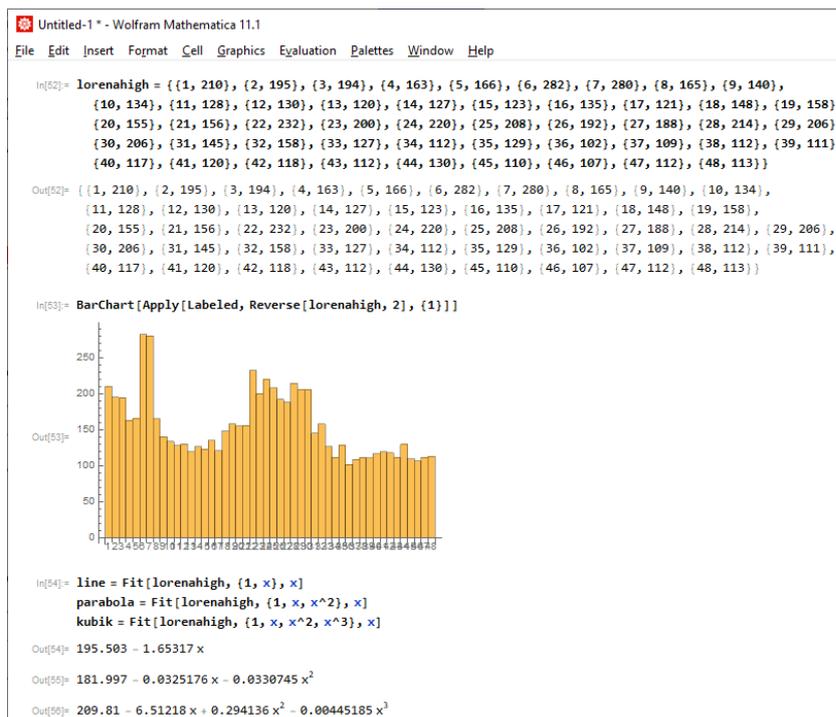


Figure 2. Simulation Travel company's high stock using Mathematica Software

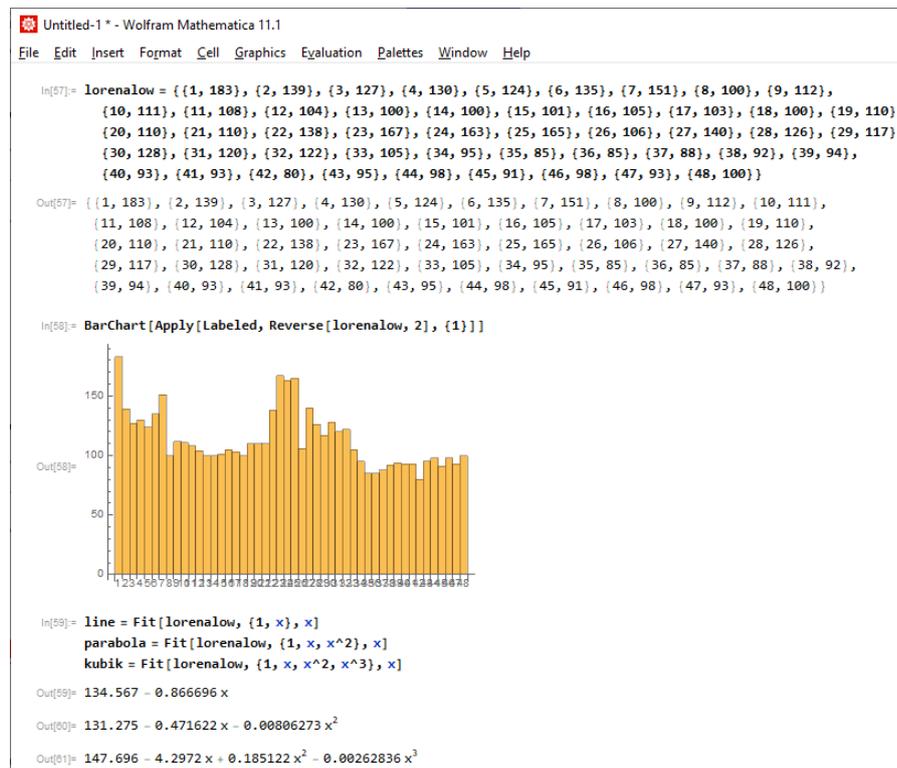


Figure 3. Simulation Travel company's low stock using Mathematica Software

The purpose of this paper was to compare numerical simulations on the FKF and EKF algorithm with 200 and 300 iterations to estimate the highest and lowest stock prices of travel company. This was conducted as an initial study to determine the stability of stock prices that tend to fluctuate (rise and fall). Along with the development of numerical computing science can also increase industrial development With such rapid service industry development, supported by promising business opportunities, investors for such sector are encouraged. Economic development, especially in the tourism sector, can improve the economy of the lower community, So that investment by investors can help increase the acceleration of economic rotation

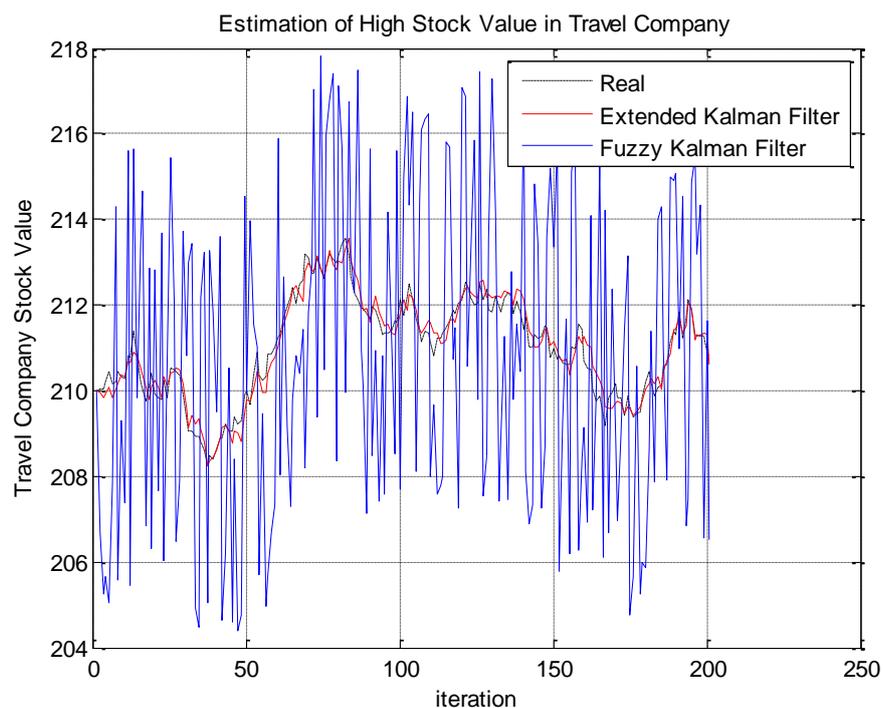
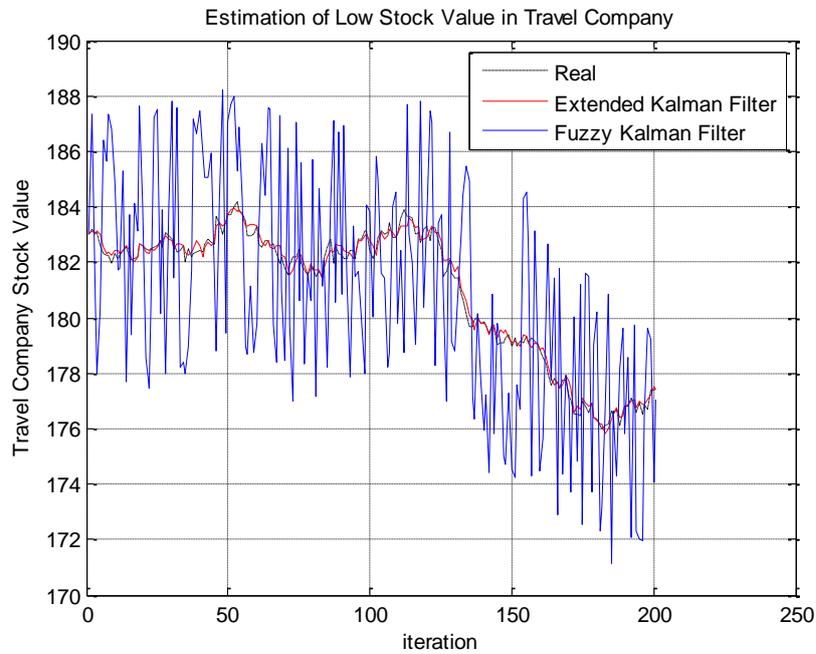


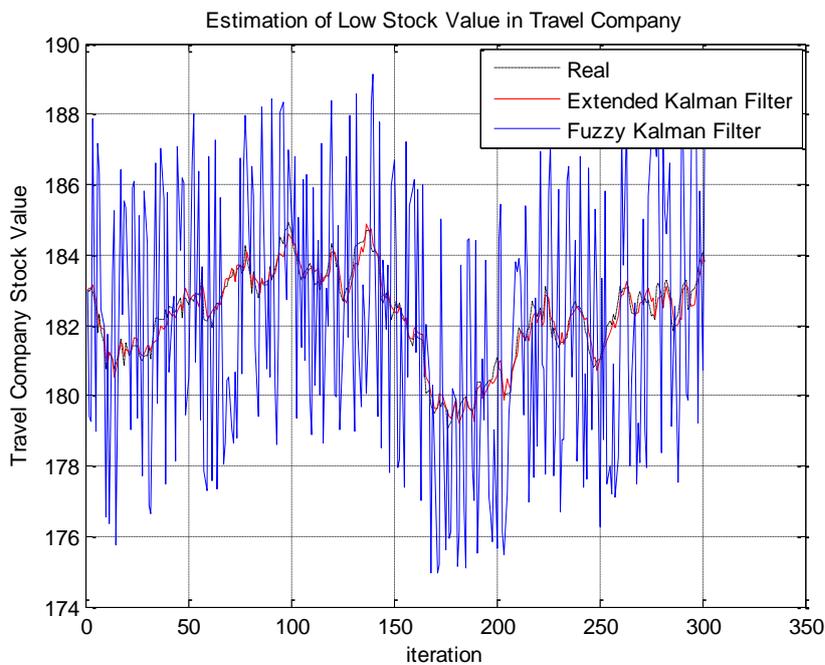
Figure 5. Estimation of Travel Company's high stock price using EKF and FKF with 300 iteration

**Figure 4** and **Figure 5** describe the numeric and science computation results of the highest stock prices using 200 and 300 iterations. It can be seen that the FKF and EKF algorithm can produce a small error of around 3-8%, this can also be observed in the error comparison in **Table 2**.

Likewise in **Figure 6** and **Figure 8**, it shows that the EKF and FKF algorithm with 200 and 300 iterations can be applied to predict the lowest stock prices of travel company in **Table 2**, that the more looping iterations with prediction and correction step, so can produce small error. Along with the development of numerical computing science can also increase industrial development. Many intelligent system algorithms and Artificial intelligence to support a rapidly growing economy. With the existence of AI can help investors in finding and measuring opportunities in investing



**Figure 6.** Estimation of Travel Company’s low stock price using EKF and FKF with 200 iteration



**Figure 7.** Estimation of Travel Company’s low stock price using EKF and FKF with 300 iterations

**Table 2.** Simulation Comparison of the RMSE values by the EKF and FKF based on 200 and 300 iterations

	High Price Stock				Low Price Stock			
	200 Iteration		300 Iteration		200 Iteration		300 Iteration	
	EKF	FKF	EKF	FKF	EKF	FKF	EKF	FKF
RMSE	0.00593 (95,21%)	0.00988 (90,21%)	0.00512 (95,86%)	0.0089 (91,56%)	0.00461 (96,32%)	0.00821 (92,63%)	0.00387 (97,44%)	0.00754 (93,45%)
Simulation Time	6.47 s	7.47 s	7.27 s	8.54 s	8.69 s	9.97 s	8.77 s	10.22 s

In general, with the study and development related to the EKF method, FKF can contribute to the development of AI to the economy. A small contribution can help investors in helping the economic turnover in the lower middle class community and using EKF and Fuzzy Kalman Filter (FKF) methods as the basis of investor considerations for investment making

#### 4. Conclusion

Based on the results of the simulation analysis, the results of estimated close price stock using EKF and FKF have good accuracy with an error of less than 3 -10%. So that the numerical study in this study can be a reference that in investing it is necessary to require proper calculations in order to minimize the risk of loss from investors. Along with the development of numerical computing science can also increase industrial development. Many intelligent system algorithms and Artificial intelligence to support a rapidly growing economy. With the existence of AI can help investors in finding and measuring opportunities in investing

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