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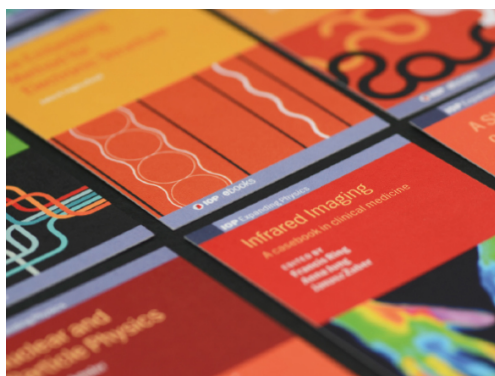
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Estimation of Thrombocyte Concentrate (TC) in PMI Gresik using unscented and square root Ensemble Kalman Filter

A Muhith[1], T Herlambang[2], D Rahmalia[3], Irhamah[4], D F Karya[5]

[1]Department of Nursing Science, Universitas Nahdlatul Ulama Surabaya
[2]Department of Information System, Universitas Nahdlatul Ulama Surabaya
[3]Department of Mathematics, Universitas Islam Darul Ulum Lamongan.
[4]Department of Statistic, Institut Teknologi Sepuluh Nopember, Indonesia.
[5]Department of Management, Universitas Nahdlatul Ulama Surabaya

E-mail : abdulmuhith@unusa.ac.id

Abstract. Ministry of Health established the Indonesian Red Cross (PMI) as an organization to anticipate the need for blood by obligation to provide enough proper blood for use. Its process of delivering information related to blood donation requires the public always come to PMI. In such way it is less efficient and effective. In addition, there is no system for estimating blood stock to anticipate the blood supply needed in the next period. Blood transfusion is needed in terms of both quality and quantity by patients suffering from various health problems. Due to the urgency of blood transfusion, maintaining the stability of blood stock is a must so as not to cause blood loss due to excessive of the blood stock. To minimize such loss, blood stock prediction is needed. The objective of this study was to estimated the blood demand for blood type of Thrombocyte Concentrate (TC) or concentrated red blood cells at PMI Gresik by applying the method of Unscented Kalman Filter (UKF) and Square Root Ensemble Kalman Filter (SR-EnKF). The simulation results showed that both methods have high accuracy with an error of less than 3%..The best simulation showed that the error between the real data and the simulation with SR-EnKF was in the order of 0.0023574 with generated 300 ensembles. Where as that with UKF was some 0.025566.

1. Introduction

The Indonesian Red Cross often called PMI is a member of the Indonesia national association engaged in the social and humanitarian field. In performing its humanitarian duties, PMI provides its services without discrimination among political groups, races, ethnicities, or religions. PMI prioritizes victims in the most need for immediate help to save their souls. The purpose of PMI itself is to alleviate the suffering of fellow human beings. One typical activity often carried out by PMI is blood transfusion. The blood donation activity is done voluntarily without any compensation through the blood donor programs [1].

The blood distribution to hospitals by the PMI Blood Donor Unit is a pick-up system if it is carried out in the same PMI area concerned [2]. Therefore, the demand for blood by recipients to the hospital or PMI Blood Donor Unit may take place before the hospital makes a blood request to the PMI Blood Donor Unit. The hospital made an offer to the recipient or his family, stating that the patient is in need of blood, and for that purpose the blood for the patient is from either the PMI Blood Donor Unit or the family [3]. Beside giving the offer, the hospital also explains that if the blood comes from the family, it will take a long process. PMI has an obligation to assist in the establishment of a Hospital Blood

Bank under Hospital management. One of the tasks of the blood bank is to plan blood needs and daily or weekly monitor blood supplies at the hospital concerned [4].

One way to lower the risk of excess and shortage of blood supply and demand is by applying an estimation algorithm to determine the future blood supply. Several cases, beside those in the health sector, applied estimation algorithms, including the application of estimation methods in the economic field, namely to estimate the crude oil [5] and stock price of a company [6], and that in the technical field, to estimate steam drum water height [7], as well as those utilized to estimate the missile position [8] and ASV [9,10], widely applied to determine the trajectory for the vehicle to follow. Those all cases utilized an estimation algorithm. And in this study the methods used in estimating blood supply in hospital blood bank were Square Root Ensemble Kalman Filter (SR-EKF) and Unscented Kalman Filter (UKF), serving as a chart for the hospital to take into consideration in the blood supply and demand management.

2. TC Blood Data

TC is a blood component containing platelets, to be provided with the aim of increasing blood platelet concentration level. The number of requests for TC ranks second after PRC. It usually the demand increases as the number of dengue cases increases. TC is a risky blood component therefore it needs component that needs watching since its storage condition in the refrigerator is at a temperature of 20-24°C which allows for a rapid growth of bacteria. The data of the TC blood is shown as follows:

Table 1. Blood Data of TC type in Gresik Blood Bank.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2013	113	154	128	85	122	180	32	82	103	60	143	238
2014	165	173	242	189	226	276	121	259	259	2231	274	279
2015	274	332	254	288	301	288	220	712	316	304	344	291
2016	354	449	405	391	522	361	320	561	433	465	476	445
2017	472	512	427	381	416	219	397	324	161	307	308	286
2018	505	458	314	303	301	256	400	242	279	304	235	394
2019	248	344	302	177	216	366	285	300	361	316	262	324

3. Unscented Kalman Filter and Square Root Ensemble Kalman Filter Algorithm

The implementation of the Unscented Kalman Filter (UKF) and Square Root Ensemble Kalman Filter (EnKF-SR) algorithms covered 3 stages, that is, the initialization process, the prediction stage, and the correction stage. Before the initialization process, the system modeling was done first. The UKF algorithm can be seen in Figure 1 and SR-EnKF algorithm can be seen in Figure 2.
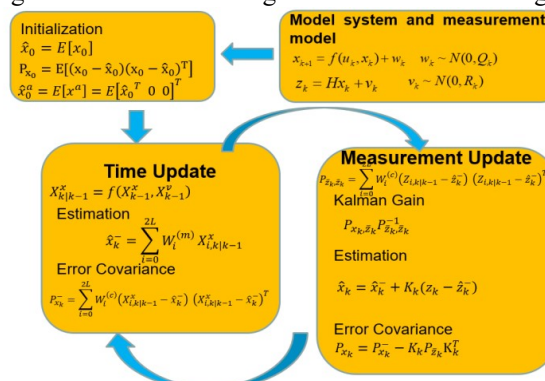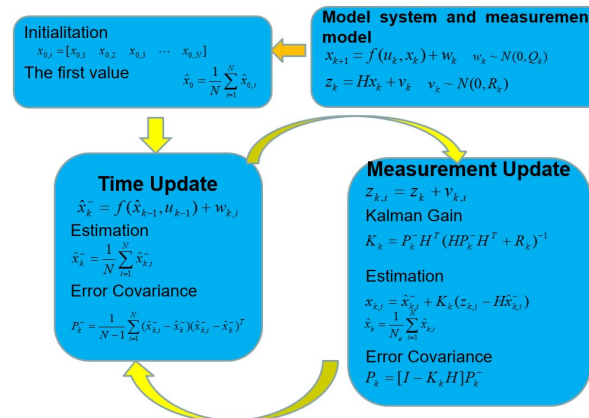

Figure 1. Unsented Kalman Filter Algotihm [4].

Figure 2. Square Root Ensemble Kalman Filter Algorithm [11].

4. Results and Discussion

The application of the UKF and EnKF-SR methods to the functions generated in Table 1 uses Mathematica software. Here are the functions of TC blood:

$$h(x) = 38.995 + 13.6913 - 0.135306x^2$$
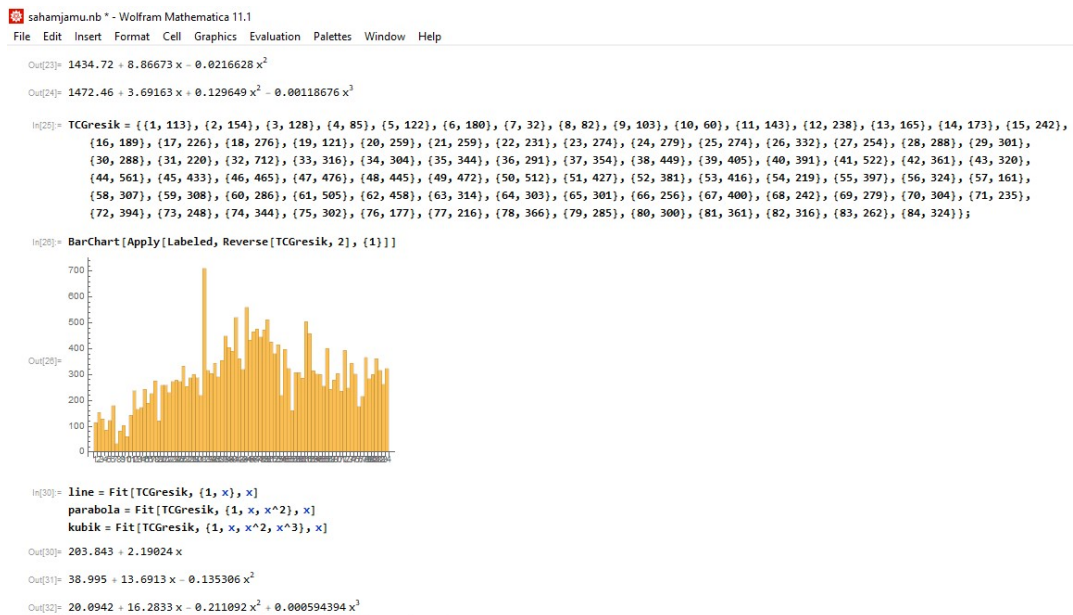$$h'(x) = 13.6913 - 0.270612x \tag{1}$$

With x is month

Figure 3. Simulation TC Blood Data in Gresik Blood Bank using Mathematica Software.

From equation (1), the function of TC blood is discretized through a discretization process so that equation (2) is obtained.

$$h_{k+1} = (13.6913 - 0.270612x_k)\Delta \tag{2}$$

The application of the UKF and EnKF-SR algorithms covered 3 stages, that is, the initialization process, the prediction stage, and the correction stage. Before the initialization process, the system

modeling was done first. Then it was followed by starting substituting equation (2) as the platform to estimate. This paper aimed to compare the numerical computation results of the UKF and EnKF-SR methods by generating 100 and 200 ensembles and using 300 and 400 iterations, as represented by the four simulation results in Figures 4–Figure 7.
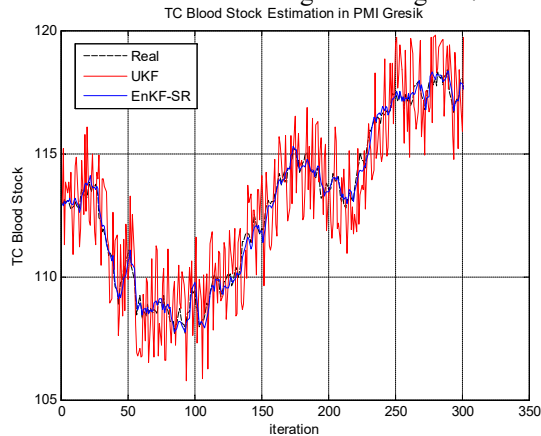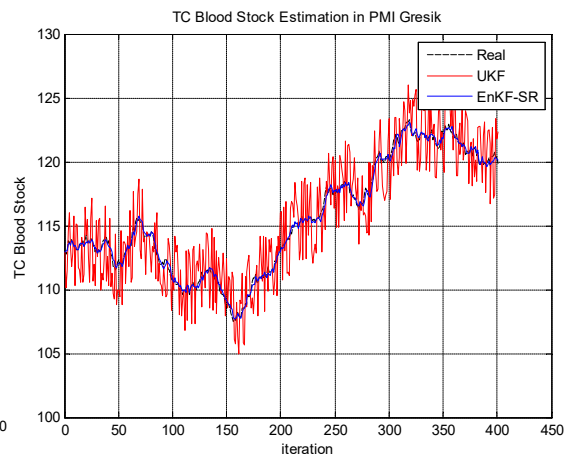

Figure 4. TC blood Estimation using UKF and EnKF-SR methods using 100 ensemble and with 300 iteration.
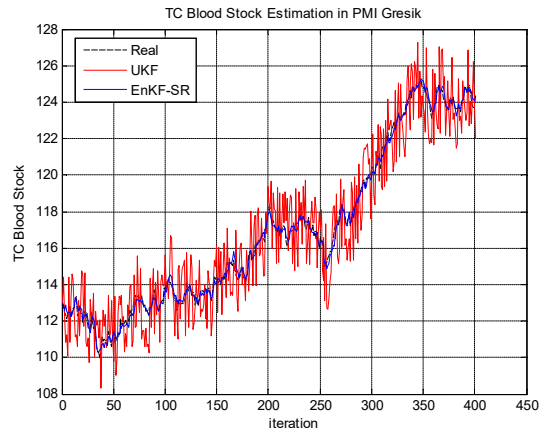
Figure 5. TC blood Estimation using UKF and EnKF-SR methods using 100 ensemble and with 400 iteration.
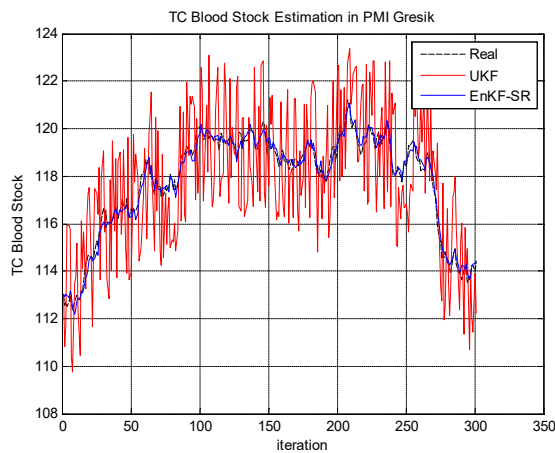
Figure 6. TC blood Estimation using UKF and EnKF-SR methods using 200 ensemble and with 300 iteration.

Figure 7. TC blood Estimation using UKF and EnKF-SR methods using 200 ensemble and with 400 iteration.

Based on the discussion above, it can be said that Figures 4, 5, 6 and 7 show that the results of the estimation of TC blood at PMI Gresik by the EnKF-SR method had a small error of about 3%, but those by the UKF had a bigger error, than that by EnKF-SR, of around 15 -20%.

Table 2. Value of RMSE by the UKF and EnKF-SRbased on 100 ensemble.

	300 iteration		400 iteration	
	EnKF-SR	**UKF**	**EnKF-SR**	**UKF**
RMSE	0.00793	0,0912	0.00812	0,0924
Simulation Time	7.218 s		8,421 s	

Table 2 and Table 3 illustrate the comparison of the simulations with different numbers of ensembles. Table 2 and 3 show that by generating more ensembles, an error can be minimized.

Table 3. Value of RMSE by the UKF and EnKF-SR based on 200 ensemble.

	300 iteration		400 iteration	
	EnKF-SR	**UKF**	**EnKF-SR**	**UKF**
RMSE	0.00867	0,0978	0.00904	0,1154
Simulation Time	9.447s		11,931 s	

In general, the EnKF-SR method was effective applicable for TC blood supply estimation at PMI Gresik, while the UKF needs reviewing because it had a big error of above 15%. So, with the development of the EnKF-SR method as the blood supply and demand estimation, it is expected to effectively support the management of blood distribution at Gresik blood bank.

5. Conclusion

Based on the results of the discussion analysis, EnKF-SR method can be used as a method to estimate mathematics function of Thrombocyte Concentrate (TC) bloodstock with excellent accuracy and errors of less than 3%, but UKF has errors of 15-20% of bloodstock function, so it can support the work of Gresik blood bank management.

Acknowledgment

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