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Fuzzy Mewma Control Chart with Median Transformation for Manufacturing Multivariate Process Control

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Abstract

The Multivariate Exponentially Weighted Moving Average (MEWMA) control chart is developed with the advantage of detecting small shifts in the mean vector and is robust. Conventional control charts have limitations in handling ambiguity in a process. The fuzzy MEWMA control chart is proposed to detect small shifts under uncertain conditions. When the fuzzy data distribution is asymmetric, the median transformation method is used. Quality control is crucial for the convection industry. Clothing designs tailored to human body proportions indicate that ambiguity in the process and small measurement shifts can affect measurement accuracy. This study will utilize the Fuzzy MEWMA control chart with median transformation for quality control in the multivariate manufacturing process, particularly in the convection industry. The purpose of this study is to determine the UCL value, obtain performance evaluation results and implement the Fuzzy MEWMA control chart with median transformation. The research findings show that the UCL with an alpha level cut of 0.6 for three quality characteristics increases as the lambda value decreases. Performance evaluation results indicate that when small process shifts occur, lambda 0.05 and lambda 0.1 provide better performance than other lambda values. The production control results for uniform manufacturing in a convection company in Palu City show two observations outside the UCL, which can serve as an early warning for the company.

Keywords: *Control chart, fuzzy MEWMA, Median Transformation, Convection industry*.

1. INTRODUCTION

Statistical Process Control (SPC) is a statistical-based approach to continuously controlling and improving process quality through systematic monitoring [12]. One of the tools in SPC that can be used in production process management is the control chart [11]. A control chart functions to identify

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deviations from the expected conditions. It can illustrate the upper and lower control limits as well as the average of a process [10].

The $\bar{X} - R$ control chart was first developed by Walter A. Shewhart in 1924. A drawback of the $\bar{X} - R$ control chart is its low sensitivity in detecting small shifts in the process mean and variance and its lack of robustness. Therefore, several control charts have been developed, including the Exponentially Weighted Moving Average (EWMA) control chart. EWMA has the advantage of detecting small shifts in the mean and is robust [11].

Univariate control charts are difficult to interpret when a process involves two or more interrelated categories. According to Ahsan and Khusna [2], multivariate control charts will be more effective when the number of quality characteristics involved is not too large. In monitoring process quality with multiple interconnected categories, multivariate control charts have a higher sensitivity level than univariate control charts [5]. Several multivariate control charts have been developed, one of which is the Multivariate Exponentially Weighted Moving Average (MEWMA) control chart. MEWMA control chart is a powerful tool for detecting minor shifts in the mean vector of multiple interrelated variables over time and is robust to the assumption of normal distribution [13]. It applies an exponentially weighted movement pattern and integrates past and present information, making it more efficient in identifying small process shifts [11].

Monitoring shifts in the mean and variability of the production process is a crucial aspect. If measurement results are influenced by human judgment, the decisions made tend to be subjective and unclear. Conventional control charts have limitations in handling uncertainty in a process [6]. To address this issue, fuzzy set theory has been developed to represent uncertainty or ambiguity. The fuzzy set theory is a suitable tool for handling situations with uncertainty [1]. Fuzzy control charts utilize fuzzy numbers, membership functions, and fuzzy control limits, making them more realistic than conventional charts [4]. The combination of conventional control charts and fuzzy set theory produces a more accurate tool for process quality control under uncertain conditions [8].

Fuzzy control charts are developed based on the fuzzy set concept. The fuzzy set was first introduced by Lotfi A. Zadeh in 1965. Fuzzy control charts become more efficient when an $\alpha - level\ cut$ is applied. Gülbay, et al., [7] developed a control chart with an $\alpha - level\ cut$ to regulate the monitoring process stringency in fuzzy control charts. Şentürk, et al., [14] proposed a univariate fuzzy exponentially weighted moving average (FEWMA) control chart with an $\alpha - level\ cut$ to detect small shifts under uncertain or ambiguous conditions while reducing the potential for false alarms. Additionally, Alipour & Noorossana [3] developed a fuzzy MEWMA control chart to monitor multivariate quality and detect mean shifts in uncertain data.

In fuzzy data analysis, it is necessary to represent fuzzy sets associated with linguistic data in scalar values through a transformation process to support further calculations. The literature identifies four common fuzzy central tendency measures used in data transformation: (1) fuzzy mean, (2) fuzzy median, (3) fuzzy mode, and (4) fuzzy midrange [9]. When the fuzzy data distribution is asymmetric, the fuzzy median transformation method is applied. The median represents the midpoint of a distribution and is not affected by extreme values [3].

Quality control is essential in the manufacturing industry, including the convection industry. Competition in the convection industry is becoming increasingly intense with technological advancements, leading to a growing demand for high-quality products [15]. Production outcomes are highly influenced by workers accuracy and skills. The production process includes checking measurements such as chest width, sleeve length, and body length. Clothing designs tailored to human body proportions indicate that ambiguity in the process and small measurement shifts can affect measurement accuracy. If sample inspection results fall outside the control limits, the company will implement specific policy measures.

An analysis of these three quality characteristics can be conducted using statistical quality control through the Fuzzy MEWMA control chart. This study will use the Fuzzy MEWMA control chart with median transformation for quality control in the multivariate manufacturing process, specifically in the convection industry. This approach serves as an early preventive measure before serious issues arise in the company due to inadequate quality control in production results.

2. MAIN RESULTS

2.1. Fuzzy MEWMA

The fuzzy MEWMA control chart is an extension of the MEWMA control chart. The difference between MEWMA and fuzzy MEWMA is that before statistical control is applied, the data is transformed into fuzzy values. If the same weighting factor is applied to the m-component vector of FMEWMA, $\lambda_k = \lambda$, $k = 1,2,\ldots,m$, the fuzzy MEWMA vector is defined as follows:

$$\tilde{\boldsymbol{z}}_k = \boldsymbol{\Lambda}\boldsymbol{R}_k + (\boldsymbol{I} - \boldsymbol{\Lambda})\tilde{\boldsymbol{z}}_{k-1}, \tag{2.1}$$

with:

$\tilde{\boldsymbol{z}}_k$ = Fuzzy MEWMA vector on the kth subgroup; $k = 1,2,\ldots,m$,

$\boldsymbol{R}_k$ = The mean vector of observations after being transformed with the median transformation on the kth subgroup; $k = 1,2,\ldots,m$,

$\boldsymbol{\Lambda}$ =Diagonal matrix of weighting parameters, with the main diagonal being λ, where $0 < \lambda \leq 1$.

When the process is in control, the mean vector $\boldsymbol{\mu}_k$ is assumed to be equal to $(0,0,\ldots,0)^T$, so that $\boldsymbol{z}_0 = \boldsymbol{0}$, with size $(p \times 1)$. The controlling statistic used in the fuzzy MEWMA graph is defined as $\tilde{F}_k^2$ which is constructed by the vector $\tilde{\boldsymbol{z}}_k$ with size $(p \times 1)$ and the fuzzy MEWMA covariance matrix $\tilde{\boldsymbol{\Sigma}}_{Z_k}$ with size $(p \times p)$. The fuzzy covariance matrix $\tilde{\boldsymbol{\Sigma}}_{Z_k}$ is obtained from the multiplication of the weighting by the covariance $\tilde{\boldsymbol{\Sigma}}_F$ between the fuzzy quality characteristics to be controlled with the matrix size $(p \times p)$. The parameter $\tilde{\boldsymbol{\Sigma}}_F$ is estimated from the analysis of the initial data average of each subgroup that has been converted into triangular fuzzy and written in the $\tilde{\boldsymbol{S}}$ matrix. The controlling statistic used in the fuzzy MEWMA control chart is defined as follows:

$$\tilde{F}_k^2 = \tilde{\boldsymbol{z}}_k^T \tilde{\boldsymbol{\Sigma}}_{Z_k}^{-1} \tilde{\boldsymbol{z}}_k, \tag{2.2}$$

with:

$$\tilde{\boldsymbol{\Sigma}}_{Z_k} = \frac{\lambda}{2-\lambda}\left[1 - (1-\lambda)^{2k}\right] \tilde{\boldsymbol{\Sigma}}_F. \tag{2.3}$$

A process is said to be out of control if $\tilde{F}_k^2 > h_F$, where h_F is the standard limit generated based on the in-control ARL.

Basically, the triangular curve representation is a combination of two linear lines going up and down. The membership function of a fuzzy set can be said to be a triangular membership function if it has three points, namely a is the smallest value with a membership value of 0, b is a value with a membership value of 1, and c is the largest value with a membership degree of 0 or can be written $a \leq b \leq c$ and x which is the input value that will be converted into a fuzzy number with a certain membership degree. The membership function of the triangular curve representation is as follows:

$$\mu(x) = \begin{cases} 0 & ; x \leq a \text{ atau } x \geq c \\ \frac{x-a}{b-a} & ; a \leq x \leq b \\ \frac{c-x}{c-b} & ; b \leq x \leq c. \end{cases} \quad (2.4)$$

The triangular curve representation is a curve that shows the mapping of input data points x (horizontal axis) on the fuzzy membership degree value $\mu(x)$ (vertical axis) which has an interval value of 0 to 1. is as follows:

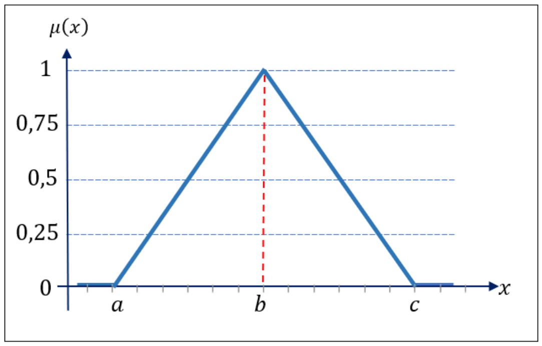

Figure 2.1. Illustration of Triangular Curve Representation Membership Function

According to [16], triangular fuzzy numbers can be formed by transforming data x_{jmin}, x_j and x_{jmax}, where in the Figure 2.1, $x_{jmin}$is a, x_j is b and x_{jmax} is c. x_{jmax} can be formed by adding the observation value with the estimated variance of the observation ($\hat{\sigma}^2$) and x_{jmin} can be formed by subtracting the observation value with the estimated variance of the observation ($\hat{\sigma}^2$) as follows:

$$x_{jmin} = x_j - \hat{\sigma}^2, \quad (2.5)$$
$$x_{jmax} = x_j + \hat{\sigma}^2. \quad (2.6)$$

After being formed into x_{jmin}, x_j and x_{jmax}, the average observation of each subgroup will be calculated. The $\alpha - level\ cut$ in the fuzzy control chart can be defined as $\bar{x}_{kj(min)}(\alpha_{cut})$ and $\bar{x}_{kj(max)}(\alpha_{cut})$, where:

$$\bar{x}_{kj(min)}(\alpha_{cut}) = \bar{x}_{kj(min)} + \alpha_{cut}(\bar{x}_{kj} - \bar{x}_{kj(min)}), \quad (2.7)$$
$$\bar{x}_{kj(max)}(\alpha_{cut}) = \bar{x}_{kj(max)} - \alpha_{cut}(\bar{x}_{kj(max)} - \bar{x}_{kj}). \quad (2.8)$$

There are four measures of fuzzy central tendency frequently used in data transformation, namely: (1) fuzzy mean, (2) fuzzy median, (3) fuzzy mode, and (4) fuzzy midrange [9]. If the fuzzy data distribution is asymmetric, the fuzzy median transformation method is an option that can be used. The median is the middle value in a distribution and is not affected by extreme values. Defuzzyfication using median transformation can be done with equation (2.9) as follows:

$$R_{kj} = \begin{cases} \bar{x}_{kj(max)}(\alpha_{cut}) - \left[\frac{(\bar{x}_{kj(max)}(\alpha_{cut}) - \bar{x}_{kj(min)}(\alpha_{cut}))((\bar{x}_{kj(max)}(\alpha_{cut}) - \bar{x}_{kj})}{2}\right]^{\frac{1}{2}}, for\ \bar{x}_{kj} < \frac{\bar{x}_{kj(max)}(\alpha_{cut}) + \bar{x}_{kj(min)}(\alpha_{cut}))}{2} \\ \bar{x}_{kj(min)}(\alpha_{cut}) - \left[\frac{\left(\bar{x}_{kj(max)}(\alpha_{cut}) - \bar{x}_{kj(min)}(\alpha_{cut})\right)\left(\bar{x}_{kj} - \bar{x}_{kj(min)}(\alpha_{cut})\right)}{2}\right]^{\frac{1}{2}}, for\ \bar{x}_{kj} > \frac{\bar{x}_{kj(max)}(\alpha_{cut}) + \bar{x}_{kj(min)}(\alpha_{cut}))}{2} \end{cases} \quad (2.9)$$

2.2. Research Methods

This study uses 2 types of data, namely generation data with the help of the R program and primary data on the precision size of uniforms in one of the convection company in Palu City. The research variables used in this study are the characteristics of uniform sizes in one of the convection company in Palu City. The characteristics of the uniform sizes that will be used in this study are chest width, sleeve length, and body length.

This study uses the help of R software with analysis steps divided into 3 parts, namely determining the UCL of the MEWMA fuzzy control chart with median transformation, obtaining performance evaluation results for the MEWMA fuzzy control chart with median transformation and applying the fuzzy MEWMA control chart with median transformation. The flow chart of the analysis steps in this study is as follows:

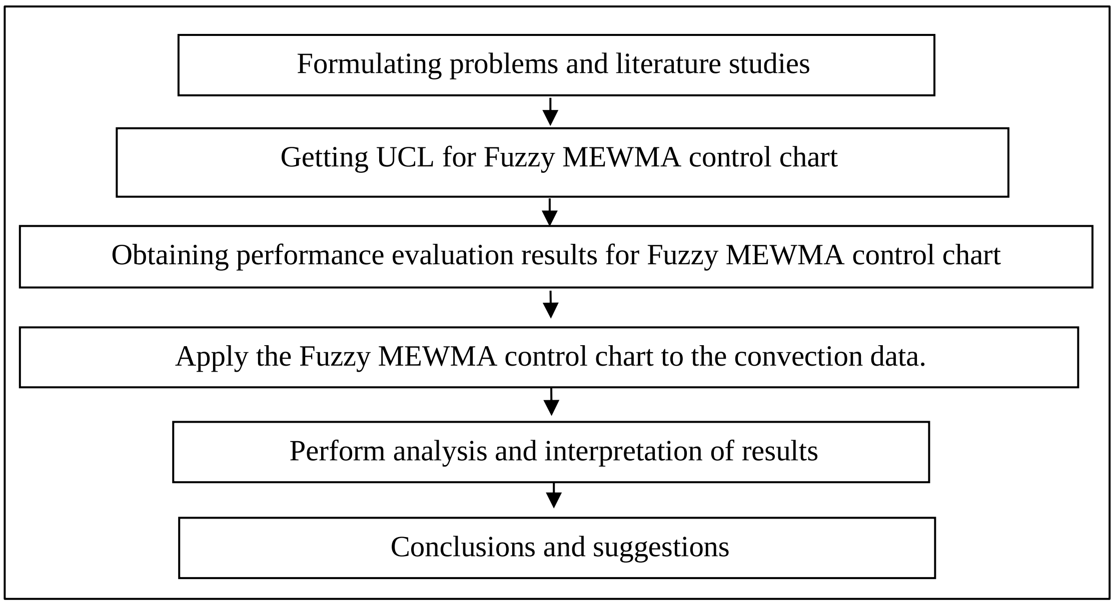

Figure 2.2. Research Flow Chart

2.2.1 Steps to Determine UCL from Fuzzy MEWMA Control Chart with Median Transformation

Determination of UCL from MEWMA fuzzy control chart with median transformation is by conducting ARL Monte Carlo simulation for the in control process. Simulation will be conducted at λ = (0.01; 0.05; 0.1; 0.25; 0.5) for quality characteristics of 3 and α_{cut}= 0.6. The steps for determining UCL from MEWMA fuzzy control chart with median transformation are as follows:

a. Establishing the initial UCL. Determination of the initial UCL for h_F is determined based on the MEWMA UCL value, which is guided by α=0.0027.
b. Performing iterations
   i. Generating 1000 samples of multivariate normal distribution simulation data with a mean vector **μ**=**0** and a covariance **Σ** with a diagonal matrix element of 1.
   i. Performing fuzzyfication with triangular fuzzy numbers on the data and performing calculations with α-*level cut*.
   ii. Performing defuzzyfication with median transformation.
   iii. Calculating the $\tilde{F}_k^2$ statistical value

iv. Determining the Run Length (RL), which is the number of observations that must be plotted until the first observation that passes the control limit is obtained.
v. Calculating ARL_0, which is the average of RL for 1000 iterations.

c. If ARL_0 is around 370, then the iteration is complete. If ARL0 is not yet around 370, then the iteration is repeated.
d. The iteration is repeated by shifting the UCL value based on the ARL_0 value obtained in the previous stage (c). If the previous simulation was too quick to detect the out of control point (ARL_0 is smaller than the target), the UCL will be shifted by adding a certain value to the UCL of 0.001. If the previous simulation was too slow to detect the out of control point (ARL_0 is greater than the target), the UCL will be shifted by reducing the UCL value by 0.001. UCL can be recorded when the iteration result of the ARL_0 value is around 370.

2.2.2 Performance Evaluation Steps of Fuzzy MEWMA Control Chart with Median Transformation

Evaluation is carried out based on the UCL value obtained in the previous stage f. The steps for performance evaluation can be described as follows:
1. Carry out steps a to f in the previous stage 2.2.1.
2. Calculate ARL_1 by shifting $\boldsymbol{\mu}$ by 0.1 where the shift starts from 0.1 to 3.0. The shift of $\boldsymbol{\mu}$ is carried out when the ARL_0 value of around 370 has been obtained.

2.2.3 Steps for Implementing Fuzzy MEWMA Control Chart with Median Transformation

The last part of this research is to implement the MEWMA fuzzy control chart with median transformation to monitor the quality characteristic data of uniforms in one of the convection company in Palu City. The steps to be taken are as follows:
1. Perform fuzzyfication with triangular fuzzy numbers on the data and perform calculations with α-level cut.
2. Perform defuzzyfication with median transformation.
3. Calculate the $\boldsymbol{Z}_k$value for each characteristic variable from the representative values that have been obtained previously.
4. Calculate the $\tilde{F}_k^2$ value.
5. Plot the MEWMA fuzzy statistics with the UCL value.
6. Analyze and interpret the results.
7. Draw conclusions and suggestions.

2.3 Method Implementation

In this section, the results of the UCL simulation of the MEWMA fuzzy control chart with median transformation to monitor the process average, performance evaluation and application of the control diagram to convection data will be described.

2.3.1 UCL *Fuzzy* MEWMA Control Chart with *Median Transformation*

UCL of MEWMA fuzzy control chart with median transformation is obtained by conducting ARL simulation. ARL simulation in this study was conducted using Monte Carlo simulation with ARL target of around 370. Simulation was conducted at α_{cut} of 0.6 with λ = (0.01; 0.05; 0.1; 0.25; 0.5) for quality characteristics of 3. UCL value of MEWMA fuzzy control chart with median transformation is written in Table 2.1 below:

Table 2.1. Fuzzy MEWMA UCL Simulation Value with Median Transformation

λ	**0.01**	**0.05**	**0.1**	**0.25**	**0.5**
UCL ($\tilde{h}_F$)	83.82	36.07	27.67	20.03	17.97

Based on Table 2.1, it can be seen that the UCL fuzzy MEWMA control chart value with median transformation $\tilde{h}_F$ with α_{cut} of 0.6 on quality characteristics of 3 shows an increasing $\tilde{h}_F$ value along with the decrease in the λ value. So that the $\tilde{h}_F$ value is the largest at λ = 0.01 and decreases at λ = 0.5.

The simulation of UCL values for this fuzzy MEWMA has previously been conducted by [5], but the calculation did not incorporate median transformation. In the study [5], UCL simulation was conducted at α_{cut}=0.5 and α_{cut}= 0.9, with the results showing an increasing $\tilde{h}_F$ value along with a decrease in the λ value at α_{cut}=0.5. while α_{cut}=0.9 showed a decreasing $\tilde{h}_F$ value along with a decrease in the λ value. The addition of median transformation to the previous study, at α_{cut}=0.6, showed results that were analogous to α_{cut}=0.5 in the previous study without median transformation.

2.3.2 Performance Evaluation of Fuzzy MEWMA Control Chart with Median Transformation

The performance evaluation of MEWMA fuzzy control chart with median transformation is carried out by Monte Carlo simulation based on ARL criteria and λ = (0.01; 0.05; 0.1; 0.25; 0.5) for 3 quality characteristics at α_{cut} of 0.6 and UCL value based on Table 2.1. The performance evaluation of MEWMA fuzzy control chart with median transformation is visually shown in Figure 2.3 as follows:

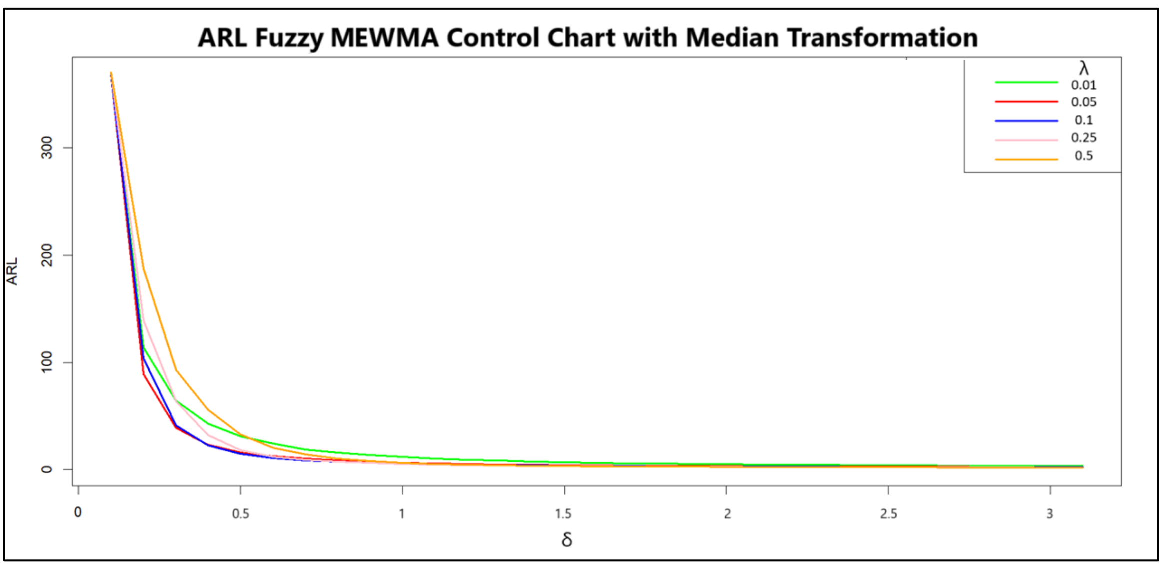

Figure 2.3. ARL *Fuzzy* MEWMA Control Chart with *Median Transformation*

Based on the visualization of the ARL value of the fuzzy MEWMA control chart with median transformation with λ = (0.01; 0.05; 0.1; 0.25; 0.5) for quality characteristics of 3 at α_{cut} of 0.6 and the UCL value based on Table 2.1 at the average process shift condition together shows that when a small process shift occurs, the fuzzy MEWMA control chart with median transformation at λ = 0.05 and λ = 0.1 provides better performance than other λ, this is indicated by the red and blue lines. When the process shift is towards a moderate shift, λ = 0.25 and λ = 0.5 have slightly better performance than other λ, this is indicated by the orange and pink lines.

The performance evaluation of this fuzzy MEWMA using median transformation was conducted by [3], but it was only performed for UCL = 2566 and λ = 0.5. Another study that evaluated the performance of fuzzy MEWMA has previously been conducted by [5], but the calculation did not incorporate median transformation. In the study [5], it was shown that the smaller the value of λ, the better the performance of the fuzzy MEWMA control chart. After adding median transformation in this study, the best performance evaluation results were obtained at λ = 0.05 and λ = 0.1.

2.3.3 Implementation of Fuzzy MEWMA Control Chart with Median Transformation

The last part of this research is to implement the fuzzy MEWMA control chart with median transformation to monitor the quality characteristic data of uniforms in one of the convection company in Palu City. The data used in the calculation in this study is the difference between the monitoring data and the target specification values offered by the company. Control begins by forming a membership function matrix for each quality characteristic variable according to the triangular membership function using equations (2.5) and (2.6). The calculation results can be seen in Table 2.2.

Table 2.2. Representative Average Data of Triangular Fuzzy Number

Sub Group	Chest Width			Sleeve Length			Body Length		
	$\bar{x}_{1(min)}$	$\bar{x}_1$	$\bar{x}_{1(max)}$	$\bar{x}_{2(min)}$	$\bar{x}_2$	$\bar{x}_{2(max)}$	$\bar{x}_{3(min)}$	$\bar{x}_3$	$\bar{x}_{3(max)}$
1	0.18	1.16	2.14	-0.28	0.73	1.74	0.23	1.26	2.29
2	-0.61	0.37	1.35	-0.91	0.10	1.11	-0.65	0.38	1.41
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
49	-1.63	-0.65	0.33	-2.18	-1.17	-0.16	-1.56	-0.53	0.50
50	-0.66	0.32	1.30	-0.95	0.06	1.07	-0.59	0.44	1.47

The values of $\bar{x}_{kj(min)}$ and $\bar{x}_{kj(max)}$ on the triangular curve are recalculated with $\alpha -level$ *cut* and defined as $\bar{x}_{kj(min)}(\alpha_{cut})$ and $\bar{x}_{kj(max)}(\alpha_{cut})$ according to equations (2.7) and (2.8), then the calculation results are obtained according to Table 2.3.

Table 2.3. Representative Average Data of Triangular Fuzzy Number with α-level cut

Sub Group	Chest Width			Sleeve Length			Body Length		
	$\bar{x}_{1(min)}(\alpha_{cut})$	$\bar{x}_1$	$\bar{x}_{1(max)}(\alpha_{cut})$	$\bar{x}_{2(min)}(\alpha_{cut})$	$\bar{x}_2$	$\bar{x}_{2(max)}(\alpha_{cut})$	$\bar{x}_{3(min)}(\alpha_{cut})$	$\bar{x}_3$	$\bar{x}_{3(max)}(\alpha_{cut})$
1	0.18	1.16	2.14	-0.28	0.73	1.74	0.23	1.26	2.29
2	-0.61	0.37	1.35	-0.91	0.10	1.11	-0.65	0.38	1.41
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
49	-1.63	-0.65	0.33	-2.18	-1.17	-0.16	-1.56	-0.53	0.50
50	-0.66	0.32	1.30	-0.95	0.06	1.07	-0.59	0.44	1.47

The representative average data of Triangular Fuzzy Number with α-level cut will then be defuzzified using median transformation according to equation (2.9), so that the calculation results are obtained in Table 2.4.

Table 2.4. Defuzzyfication Data Using Media Transformation

Sub Grub	R_{k1}	R_{k2}	R_{k3}
1	1.21	0.78	1.31
2	0.42	0.15	0.43
⋮	⋮	⋮	⋮
49	-0.60	-1.12	-0.48
50	0.37	0.11	0.49

The defuzzyfication data using median transformation will then be calculated using Fuzzy MEWMA statistics according to equations (2.1) to (2.3). By using λ = 0.1, the calculation results are obtained in table 2.5 as follows:

Table 2.5. The Value of Z_k and $\tilde{F}_k^2$

Sub Grub	Z_{k1}	Z_{k2}	Z_{k3}	$\tilde{F}_k^2$
1	0.12	0.08	0.13	3.32
2	0.15	0.09	0.16	3.32
⋮	⋮	⋮	⋮	⋮
49	0.03	-0.14	0.20	18.16
50	0.06	-0.12	0.23	18.31

The fuzzy MEWMA statistical value ($\tilde{F}_k^2$) will be plotted together with the UCL fuzzy MEWMA value ($\tilde{h}_F$) that has been simulated in Table 2.1, where if $\tilde{F}_k^2 \geq \tilde{h}_F$, then the observation result is said to be out of control. The results of controlling the characteristics of uniforms in one of the convections in Palu City using the MEWMA fuzzy control chart with median transformation are as follows:

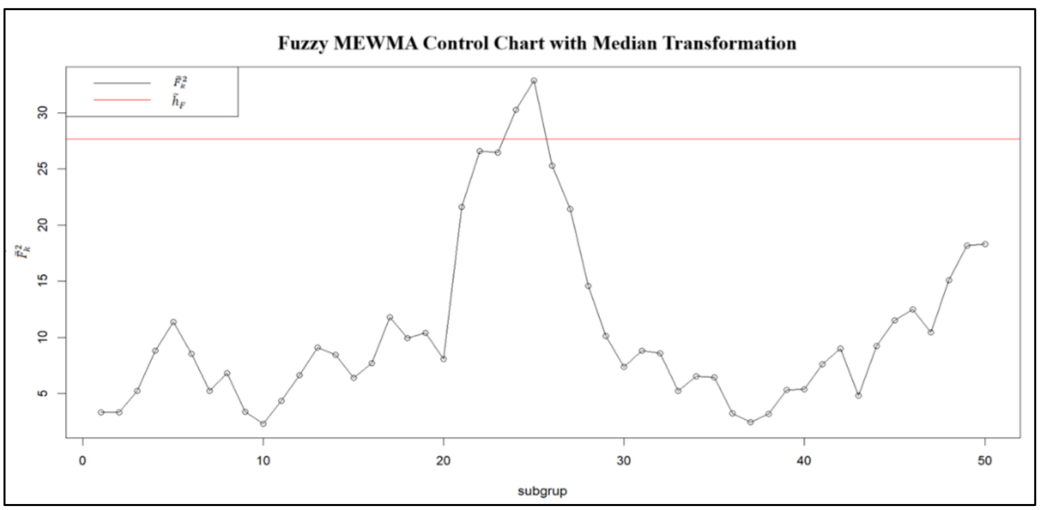

Figure 2.4. Fuzzy MEWMA Control Chart with Median Transformation

Based on Figure 2.4 with α_{cut} = 0.6 and λ = 0.1, it can be seen that there are 2 observations that are outside the $\tilde{h}_F$ value or out of control. This can be seen from the 2 observations that are above the red line. A process is said to be uncontrolled if $\tilde{F}_k^2 > \tilde{h}_F$, where $\tilde{h}_F$ is the UCL generated based on the in-control ARL. This shows that the MEWMA fuzzy control chart with median transformation is able to detect uncontrolled observations in data in a vague state. This can be an early warning for the company to start identifying the causes or factors that may result in indicated out of control observations and to make improvements to the production process so that these defects do not increase.

Control with the same method was also performed by [3], but with λ = 0.5 and applied to food process data. Control using this data was previously conducted by [5] on some α_{cut}, without incorporating median transformation. In the study, out of control could not be detected at α_{cut} = 0.6, out of control was detected at α_{cut} = 0.9. However, after adding median transformation to this study, 2 data were obtained that were out of control at α_{cut} = 0.6.

3 Conclusion

Based on the results and discussion, the following conclusions are obtained:

1. The UCL value of fuzzy MEWMA with median transformation $\tilde{h}_F$ with α_{cut} of 0.6 on quality characteristics of 3 shows the value of $\tilde{h}_F$ which increases along with the decrease in the value of λ. So that the value of $\tilde{h}_F$ is the largest at λ = 0.01 and decreases at λ = 0.5.
2. Evaluation of the performance of the fuzzy MEWMA control chart with median transformation with λ = (0.01; 0.05; 0.1; 0.25; 0.5) for quality characteristics of 3 at an α_{cut} of 0.6 shows that when a small process shift occurs, λ = 0.05 and λ = 0.1 provide better performance compared to other λ, while when the process shift is towards a medium shift, λ = 0.25 and λ = 0.5 have slightly better performance than other λ.
3. The results of controlling the production of uniforms in one of the convection company in Palu City using the fuzzy MEWMA control chart with median transformation at α_{cut}= 0.6 and λ = 0.1 show 2 observations that are outside the $\tilde{h}_F$ value or out of control. This can be an early warning for the company to start identifying the causes or factors that may result in indicated out of control observations.

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