SEMARAK ILMU PUBLISHING

Semarak Engineering Journal

Journal homepage:
https://semarakilmu.com/
ISSN: 3036-0145



Development of Graphical User Interface Based Taguchi's T-Method

Faten Nur Izati Hassan[1], Nolia Harudin[1,*], Farah Elida Selamat[1], Zulkifli Marlah@Marlan[2]

[1] College of Engineering, Universiti Tenaga Nasional, Jalan Ikram-Uniten, 43000 Kajang, Selangor, Malaysia
[2] Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia (UTM), Kuala Lumpur, Malaysia

ABSTRACT

Taguchi's T-Method is a technique developed explicitly for multivariate data predictions under Mahalanobis-Taguchi System. This prediction tool implements an excellent and efficient yield of data that will produce a good forecasting result. However, its limitation in this new era of technology incorporates different computational methods. The analysis result in Excel was limited depending upon the purchased time of the current product specifications and could not be used widely. The development of Graphical User Interphase (GUI) as a medium of the Taguchi's T-Method data analysis using MATLAB interphase can help users forecast data with visualization and user-friendly apps. From the result, an application by MATLAB was designed to forecast the estimation output value, and error estimation was calculated in the GUI. The system requires users to insert an Excel file into the MATLAB GUI, and all calculations can be done by just a few simple clicks on the GUI programmed.

Keywords:
Graphical user interphase; MATLAB;
prediction; Taguchi's T-Method;
Mahalanobis-Taguchi System

1. Introduction

The Taguchi's T-Method is a technique explicitly developed for multivariate data predictions under the Mahalanobis-Taguchi System [1,2]. In an effort to evaluate the best levels of control variables, the Taguchi's T-Method, also known as the Robust Design principle, is used for optimization by preparing, performing, and analyzing the results of experiments [3]. It is used when the parameters of interest are needed, not just for production processes. Therefore, in many areas, such as environmental sciences [4], agricultural sciences [5,6], medicine and chemical processes [7,8], statistics, physics, industry [9,10], and management, the Taguchi's T-Method is also used. The most common tool used in statistics to perform data analysis is multiple regression analysis. However, most people find it too complicated to understand and apply. In order to deal with multiple equations, it requires a list of techniques and knowledge, especially in calculation [11]. For each predictor variable with the least frequent result, a guideline for the minimum data is required in most real-life scenarios. It may disrupt the production runs, especially in big industrial companies. This

* *Corresponding author.*
E-mail address: Nolia@uniten.edu.my

method uses insufficient data and may wrongly summarize that a correlation is the leading cause [12].

The main objective of the Taguchi's T-Method is to improve the quality standard so that it has a more negligible effect on cost factor. It provides the optimum process settings that can enhance efficiency, and these Taguchi's T-Method reached settings are often insensitive to the variance of noise factors. Essentially, the design of process parameters is complex and hard to use, and the Taguchi approach, on the other hand, is user-friendly [13,14].

2. Methodology

This chapter defines the research methodologies in detail and divides them into four phases, as shown in Figure 1. Phase 1 defines the scopes and general analysis requirements of the project, and problem in Teshima software. Phase 2 provides an overview of the Taguchi's T-Method and applications. To ensure that the work is within the scopes, the aims were established. General analytical criteria are required to determine the relevant tools to be used. Phase 3 consists of data analysis, which uses MATLAB coding to develop virtual data using GUI. Finally, Phase 4 expresses the overall conclusion to analyze and conclude the findings.

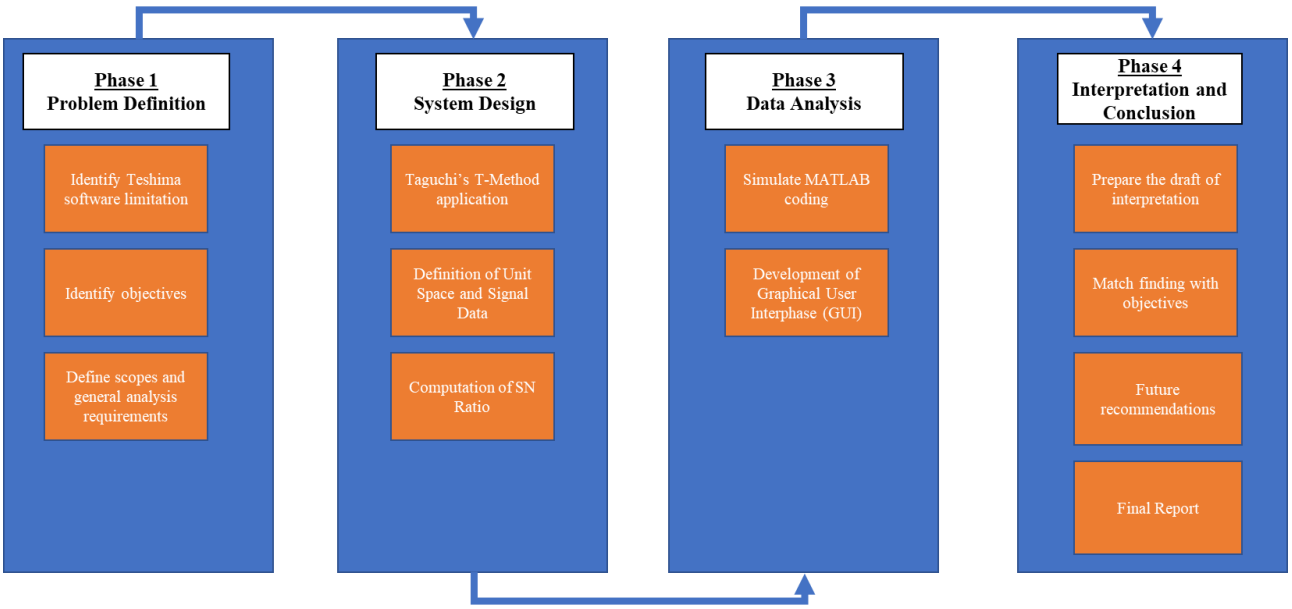


Fig. 1. Research flowchart

2.1 Data Analysis

The main aim of the Taguchi's T-Method is to satisfy Eq. (1) to evaluate the integrated estimated output [7].

$$Integrated\ estimated\ output\ value, M_i = \frac{\eta_1 \times (\frac{X_{i1}}{\beta_1}) + \eta_2 \times (\frac{X_{i2}}{\beta_2}) + \cdots + \eta_j \times (\frac{X_{ij}}{\beta_j})}{\eta_1 + \eta_2 + \cdots + \eta_j} \quad (1)$$

Next, the proportional coefficient (β) and SNR ratio (η) were computed on an item-by-item basis using normalized data (X_{ij}, M_O) calculated from Eq. (1). The unit space data was obtained from the

raw data taken and excluded and averaged out from the raw data. The remaining data were treated as signal data. This is how Eq. (2) can be applied.

Normalized data $8X_{ij}, M_0 := signal\ data - average\ of\ unit\ spac$ (2)

Effective Divider, $r = M_1{}^2 + M_2{}^2 + \cdots + M_i{}^2$ (3)

Total Variation, $S_T = X_1{}^2 + X_2{}^2 + \cdots + X_i{}^2$ (4)

Variation of Proportional Term, $S_\beta = \frac{(M_1X_{11}+M_2X_{21}+\cdots+M_lX_{l1})^2}{r}$ (5)

Error Variation, $S_e = S_T - S_\beta$ (6)

Error Variance, $V = \frac{Se}{\blacksquare\blacksquare 1}$ (7)

Duplicate SN Ratio,
$\eta = (\frac{(S_\beta - V_e)}{rV_e}$ (8)

$$\beta_m = \frac{M_1X_{11} + M_2X_{21} + \cdots + M_lX_{l1}}{r} \quad (9)$$

Linear Equation, $L = M_1 M\hat{}_1 + M_2 M\hat{}_2 + \cdots + M_i M\hat{}_i$ (10)

Effective Divider, $r = M_1{}^2 + M_2{}^2 + \cdots +$ (11)

Total Variation, $S_{\blacksquare\blacksquare} = M\hat{}_1{}^2 + M\hat{}_2{}^2 + \cdots + M\hat{}_{\blacksquare}{}^2$, (12)

Variation of Proportional Term, $S_\beta = \frac{L^2}{r}$ (13)

Error Variation, $S_e = S_r - S_\beta$ (14)

Error Variance, $V_e = \frac{Se}{\blacksquare\blacksquare 1}$ (15)

SN ratio, $\eta = 10\ log(\frac{(S_\beta - V_e)}{rV_e})$ (16)

Based on the computations performed so far, the yields (output values) were normalized in terms of the average Unit Space values. Therefore, to find the integrated estimate value ŷ of the actual yield, the average value M of the yield of the Unit Space was added to the normalized value $\hat{M}\ i$.

$\hat{Y} = M\hat{}_1 + M_0$ (17)

3. Result

This chapter encompasses pattern recognition to focus on GUI that includes a visual representation of the available commands and functions of the operating system that enable users to access and manipulate the available functions easily. Throughout this chapter, the GUI design will be shown and explained in detail.

3.1 Raw Material Mixing

In this project, the Raw Material Mixing data from the Quality Recognition and Prediction e-book [15] were used as reference data to compare the actual and estimated yield data between the e-book and Taguchi's T-Method in MATLAB application. The data were in a single Excel file and imported into the MATLAB application for execution. In this case study, the Taguchi's T-Method was used as the analytical tool, while the tensile strength was used as the output. However, the assessment must include tensile strength and other output parameters, such as flexural strength and impact strength. Following the studies mentioned above, the final mixing ratio was calculated by considering the findings of numerous output characteristic assessments.

3.1.1 Raw material mixing known data

Going further, data in Table Proportional Coefficient and SN Ratio were used, separately for each variable, the integrated estimated value of strength of each instance of the Signal Data was found. Calculation for the table in Figure 2 was based on the formula given in the Quality Recognition and Prediction e-book [15] in Eq. (1). The first column shows the actual value of the output, the second column shows the estimated value of the output, the third column shows the output value in the Excel file, and the fourth column shows the actual estimated value. This table enables users to determine the output value and compare the actual and estimated values.

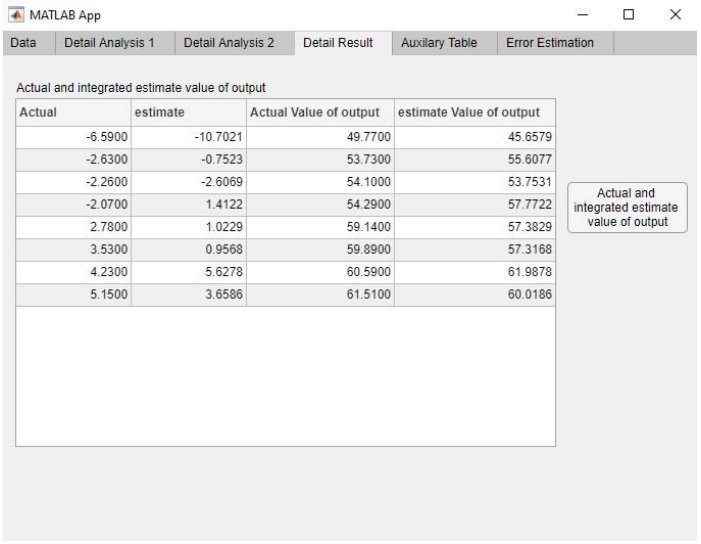


Fig. 2. Table of actual and integrated estimated values of output of raw material mixing known data

Figure 3 shows a factorial graph. It demonstrates how the variables, with steeply descending inclines from Level 1 to Level 2, play essential roles in yield estimation. Based on Figure 3, the larger the SNR, the closure of the straight line, and the less significant contributors the item is. Furthermore,

Raw Material 1, 4, and Additives 2 have a steeper line, giving a significant contribution to the data, if included.

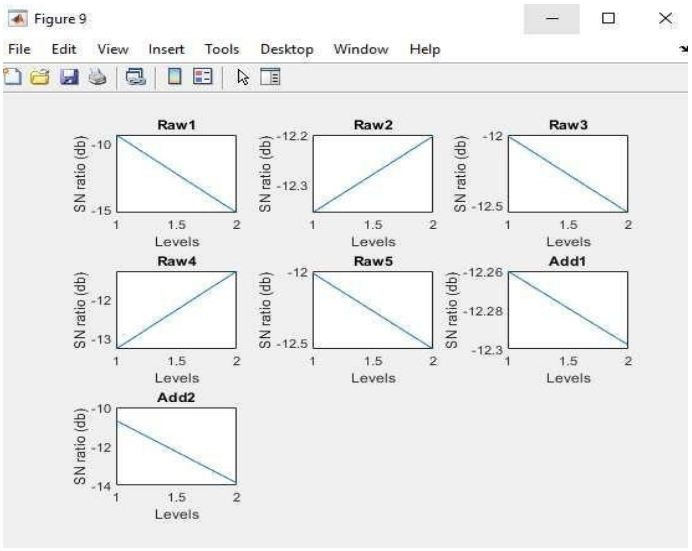


Fig. 3. Scatter of output value yields and items (normalized data) of raw material mixing known data

3.1.2 Raw material mixing unknown data

In this section, users can forecast their estimated output value using the Unknown Data type selection. The actual output value for the Raw Material Mixing Unknown Data type is provided for this project's testing purpose (refer to Figure 4). The step for importing the Unknown Data type is similar to that of the Known Data, which is by importing a single Excel file into the MATLAB application.

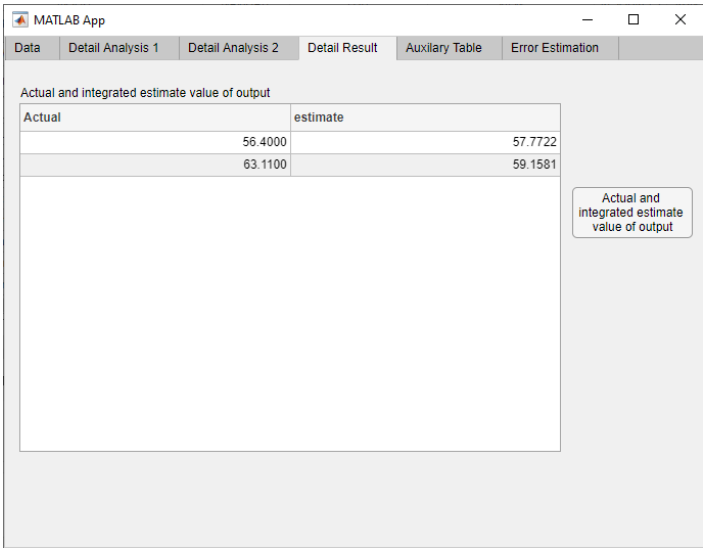


Fig. 4. Table of actual and integrated estimate value of output of raw material mixing unknown data

3.2 Manufacturing Production (Testing Data)

Based on this case study, the Taguchi's T-Method is described with an illustrated case of "yield prediction in the context of industrial production operations". It predicts the production yield based on the process data obtained from the day-to-day manufacturing procedures, such as temperature, pressure, and other measurements.

In most circumstances, interrupting and inserting testing within production run intervals are challenging in an ongoing manufacturing process. If daily production data or data relevant to production under changing circumstances are available, the application of the Taguchi's T-Method may allow the conditions for improvement to be identified.

3.2.1 Manufacturing production known data

In this section, a new case study will be conducted to ensure that the MATLAB application can be used in various data applications. Since the case study will be taken from the same source [15], the GUI program will apply the same steps and calculation as those of the previous case study (refer to Figure 5 and 6).

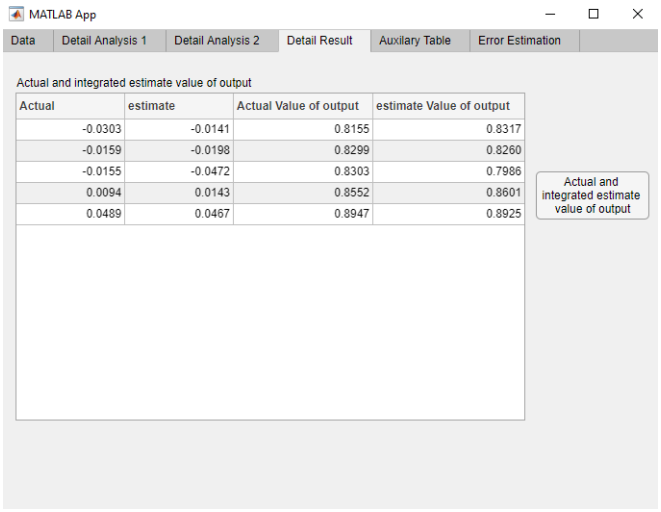


Fig. 5. Table of actual and integrated estimate value of output of manufacturing production known data

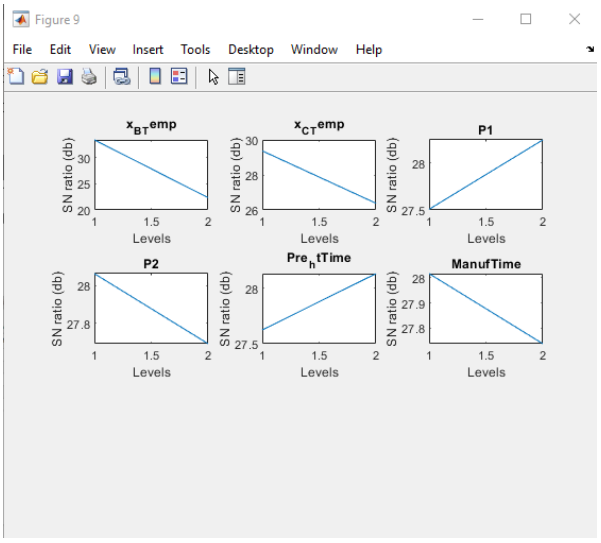


Fig. 6. Scatter of output value yields and items (normalized data) of manufacturing production known data

3.2.2 Manufacturing production unknown data

In this section, users can forecast their estimated output value using the Unknown Data type selection. Based on the actual output value for Raw Material Mixing, Unknown Data type is provided as it is for this project testing purpose (refer to Figure 7). The step for importing the Unknown Data type is similar with that of the Known Data, which is by importing a single Excel file into the MATLAB application.

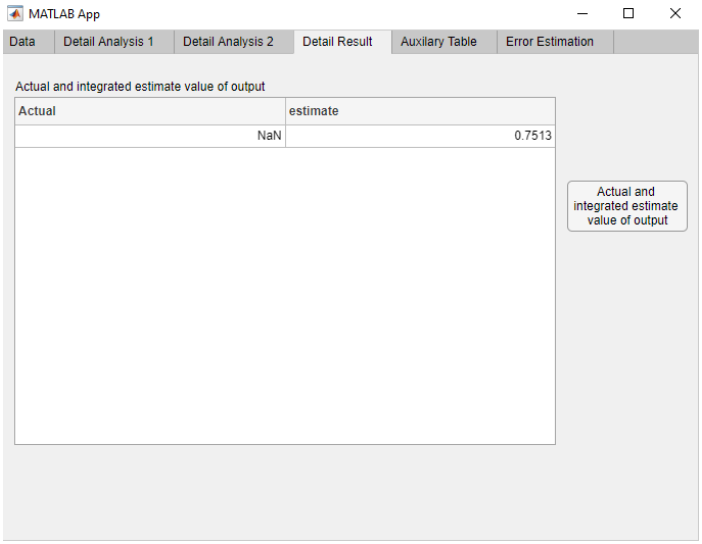


Fig. 7. Table of actual and integrated estimate value of output of manufacturing production unknown data

4. Conclusion

The research successfully developed a GUI based on the Taguchi's T-Method. The main objective is to develop a GUI as a medium of Taguchi's T-Method data analysis using MATLAB interphase. The objective was achieved as the estimated output value and error calculation were able to be calculated using the GUI. The system requires users to insert an Excel file into the MATLAB GUI, and all calculations can be done through simple clicks on the GUI programmed.

The second objective is to investigate the functionality and effectiveness of the Taguchi's T-Method in predicting data. The results showed that it overcame the weaknesses of the Teshima software. Therefore, all users can use this method without limitations by using many resources, such as MATLAB software. The Taguchi's T-Method can also be compared with other prediction methods by calculating the error estimation.

Lastly, the GUI can be applied in various engineering problems. Users with engineering backgrounds can perform their forecasting using the Taguchi's T-Method and make it simpler by using this MATLAB GUI. The system will generate and conclude the output value and calculate the error estimation for the users.

Acknowledgement
I would like to express my deepest gratitude to UNITEN and Yayasan Peneraju for giving me the chance, and for their involvement in this project. I am also extremely grateful to my supervisor, Dr. Nolia Binti Harudin and team for guidance and persistent helps. Thank you to my family and friends for the moral support. Lastly, thanks should also go to the people who contributed directly or indirectly in helping me throughout the completion of this paper.

References
[1] Nakayama, Shota, Suguru Sekine, and Yasushi Nagata. "A study of MT systems applied to multivariate regression." *Total Quality Science* 7, no. 1 (2021): 10-22.
[2] Matsui, Shushiro, and Yasushi Nagata. "Proposal for a univariate time series analysis method based on Taguchi's T-method." *Total Quality Science* 5, no. 1 (2019): 1-10.
[3] Freddi, Alessandro, Mario Salmon, Alessandro Freddi, and Mario Salmon. "Introduction to the Taguchi method." *Design principles and methodologies: from conceptualization to first prototyping with examples and case studies* (2019): 159-180.
[4] Mohamed, Zamri. "Tire cavity resonance mitigation using acoustic absorbent materials." *Journal of Vibration and Control* 23, no. 10 (2017): 1607-1622.
[5] Sosa-Martínez, Jazel, Nagamani Balagurusamy, Juan Roberto Benavente-Valdés, Julio Montanez, and Lourdes Morales-Oyervides. "Process performance improvement for the simultaneous production of ligninolytic enzymes in solid culture using agricultural wastes through the Taguchi method." *Journal of Environmental Management* 293 (2021): 112966.
[6] Ajmal, Muhammad, Shi Aiping, Muhammad Awais, Muhammad Saif Ullah, Rehan Saeed, Saad Uddin, Ibrar Ahmad, Bingliang Zhou, and Xu Zihao. "Optimization of pilot-scale in-vessel composting process for various agricultural wastes on elevated temperature by using Taguchi technique and compost quality assessment." *Process Safety and Environmental Protection* 140 (2020): 34-45.
[7] Khajeheian, Datis, Amir Mohammad Colabi, Nordiana Binti Ahmad Kharman Shah, Che Wan Jasimah Bt Wan Mohamed Radzi, and Hashem Salarzadeh Jenatabadi. "Effect of social media on child obesity: Application of structural equation modeling with the Taguchi method." *International journal of environmental research and public health* 15, no. 7 (2018): 1343.
[8] Meena, Anoj, Harlal S. Mali, Amar Patnaik, and Shiv Ranjan Kumar. "Investigation of wear characteristics of dental composites filled with nanohydroxyapatite and mineral trioxide aggregate." In *Fundamental Biomaterials: Polymers*, pp. 287-305. Woodhead Publishing, 2018.
[9] Ragab, Tamer IM, Fahad M. Alminderej, Wael A. El-Sayed, Sayed M. Saleh, and Al Shimaa Gamal Shalaby. "Enhanced Optimization of Bioethanol Production from Palm Waste Using the Taguchi Method." *Sustainability* 13, no. 24 (2021): 13660.
[10] Mia, Mozammel. "Mathematical modeling and optimization of MQL assisted end milling characteristics based on RSM and Taguchi method." *Measurement* 121 (2018): 249-260.
[11] Harudin, Nolia, Khairur Rijal Jamaludin, Faizir Ramlie, Mohd Nabil Muhtazaruddin, Che Munira Che Razali, and Wan Zuki Azman Wan Muhamad. "Binary particle swarm optimization for variables selection optimization in Taguchi's T-Method." *MATEMATIKA: Malaysian Journal of Industrial and Applied Mathematics* (2020): 69-84.
[12] Taguchi, Genichi. 1997. Method for pattern recognition. US Patent 5,684,892, fi led Aug. 22, 1995, and issued Nov. 4."
[13] Keçeci, Bariş, Yusuf Tansel Iç, and Ergün Eraslan. "Development of a spreadsheet DSS for multi-response taguchi parameter optimization problems using the TOPSIS, VIKOR, and GRA methods." *International Journal of Information Technology & Decision Making* 18, no. 05 (2019): 1501-1531.
[14] Dutta, Sunil, and Suresh Kumar Reddy Narala. "Optimizing turning parameters in the machining of AM alloy using Taguchi methodology." *Measurement* 169 (2021): 108340.
[15] Teshima, Shoichi. *Quality recognition & prediction: Smarter pattern technology with the Mahalanobis-Taguchi system*. Momentum Press, 2012.