Department of Inter Disciplinary Studies,
Faculty of Engineering,
University of Jaffna, Sri Lanka
ID1021 - Assignment

Submission Deadline: *The assignment must be submitted as a single PDF file by 06-07-2023 at 5:00 PM. It is important to ensure that your submission is received prior to the designated deadline.*

1. A manufacturing company produces electronic components that need to meet precise dimensional specifications. The company uses a coordinate measuring machine (CMM) to measure the dimensions of the components. As part of a metrology project, a student is tasked with calibrating the CMM and ensuring accurate measurements. The student collects 100 measurements data by comparing the CMM's readings with reference measurements obtained from a high-precision standard. You can retrieve the data by accessing the provided web page using your registration number. Please note that while any group member's registration number can be used, it is essential to specify in the report which registration number was utilized to generate the data.

   Data link: calibration data for question 1

   Using simple linear regression analysis, perform a calibration analysis for the CMM. Determine the calibration equation and evaluate the accuracy and precision of the calibration. To order to perform a calibration analysis for the CMM, please answer following questions,

   (a) What is the objective of the metrology project in calibrating the CMM using regression analysis?

   (b) What type of data is collected for the calibration analysis, and what are the variables involved?

   (c) How can a scatter plot be used to visualize the relationship between CMM readings and reference measurements?

   (d) What are the steps involved in performing a regression analysis for calibrating the CMM?

   (e) How can the calibration equation be determined using regression coefficients?

   (f) What statistical measures can be used to assess the accuracy and precision of the calibration model?

   (g) How can the coefficient of determination (R-squared) provide insights into the goodness of fit of the calibration equation?

   (h) What is the significance of evaluating the residuals and checking for linearity in the calibration analysis?

   (i) What are the implications of the mean squared error (MSE) and mean absolute error (MAE) in evaluating the accuracy and precision of the calibration model?

   (j) How can the calibration equation be used to predict reference measurements for new CMM readings, and what factors should be considered in assessing the reliability of the predictions?

2. You are conducting a metrology study to determine the relationship between the diameter (X) and the weight (Y) of a specific type of ball bearing. You have collected 100 observations of the diameter and weight of the ball bearings. Using simple linear regression, estimate the uncertainty in predicting the weight of a ball bearing given its diameter. You can retrieve the data by accessing the provided web page using your registration number. Please note that while any group member's registration number can be used, it is essential to specify in the report which registration number was utilized to generate the data.

Data link: uncertainty data for question 2

To order to perform an uncertainty analysis for specific type of ball bearing, please answer following questions,

(a) What is the equation of the regression line that models the relationship between diameter and weight?

(b) How well does the regression model fit the data? Calculate the R-squared value and interpret its meaning.

(c) Are there any outliers or influential data points that significantly affect the regression model and its uncertainty estimation?

(d) Estimate the uncertainty (confidence interval) in predicting the weight of a ball bearing for a given diameter. Calculate the confidence interval at a specific confidence level, such as 95% or 99%.

(e) Does the uncertainty in weight prediction vary across different diameter ranges? Analyze whether there are specific diameter values where the uncertainty is higher or lower.

(f) Conduct residual analysis to evaluate the assumptions of the linear regression model, including normality, constant variance, and independence of residuals.

(g) Check for any violations of assumptions and assess the impact on uncertainty estimation.

(h) Interpret the estimated uncertainty in weight prediction in the context of the ball bearing metrology study. Discuss the implications for the accuracy and reliability of weight measurements.

(i) Compare the estimated uncertainty with the tolerance limits or specifications for the weight of the ball bearings. Assess whether the uncertainty meets the required criteria.

(j) Discuss any limitations or assumptions associated with the regression analysis and how they may affect the uncertainty estimation and its applicability.

Summary of guidelines:

1. Group will be formed with 10 students per group to complete this assignment. Any group member's registration number can be used, but it is essential to specify in the report which registration number was utilized to generate the data.

2. Each group should prepare their report for **one** of the given questions (calibration analysis or uncertainty analysis) and ensure that the report is not more than five pages.

3. It is important to clearly report every member's contributions to the assignment.

4. To submit your work, please ensure that it is in a single PDF file format. Submissions should be sent via email. If you require assistance in saving your work as a PDF file, please let us know, and we will be happy to help.

5. For question 1, you can obtain your datasets from the following link: calibration data for question 1

6. For question 2, you can obtain your datasets from the following link: uncertainty data for question 2

7. The assignment must be submitted in a single PDF format by 5:00 PM on 06 - 07 - 2023. Kindly ensure that your submission is received before the specified deadline. You can send this assignment to the following email addresses: mayooran@eng.jfn.ac.lk or thawsika@eng.jfn.ac.lk.