The Use of Statistics in Engineering and Food Industry

Norazah Umar and Zuraira Libasin
norazah191@uitm.edu.my, zuraira946@uitm.edu.my

Jabatan Sains Komputer & Matematik (JSKM), Universiti Teknologi MARA Cawangan Pulau Pinang, Malaysia

Introduction

Statistics is an important tool for robustness analysis, measurement system error analysis, test data analysis and it is extremely important in our daily life. In this article we will discuss some examples of the importance of statistics in engineering and food industry as these are the two main programs available in UiTM Permatang Pauh.

Statistics in Engineering

An engineer is someone who solves problems of interest in society by either refining an existing product or design a new product that meets customers' needs. The steps to accomplish this are as shown in figure 1.

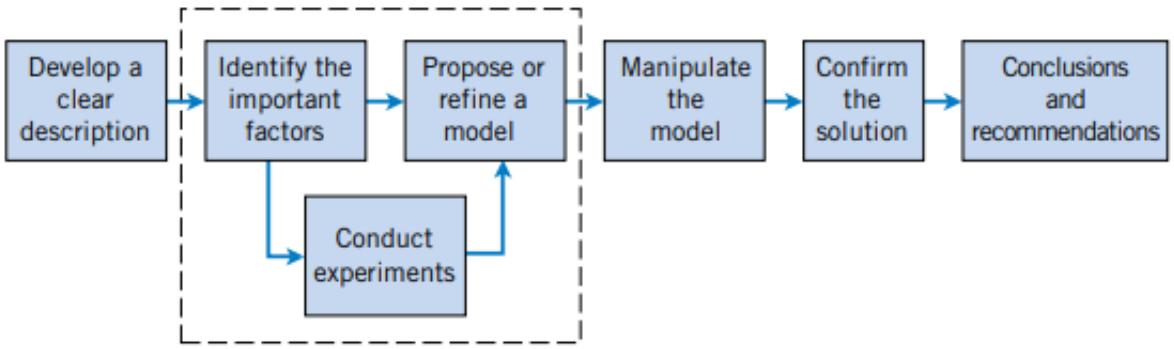

Figure 1: The engineering method

Knowledge of statistics is important to engineers because some statistical techniques can be a powerful aid in designing new products and systems, improving existing designs, developing new design and improving production processes. Some of the most important statistics applications in the field of engineering are Probability Application, Experimental Design, Hypothesis Testing, Quality Control and Regression Analysis

Probability Application

The study of probability is very important to engineers as it can helps them to examine how likely events could happen so the risk could be determined and solve professionally. Another significant application of probability theory in everyday life is reliability. Many consumer products such as automobiles and consumer electronics use reliability theory to reduce the probability of failure in product design.

Experimental Design

The design of experiments (DoE) methodology is a tool that has been applied for years in industry for process performance and product quality improvement such as for solar technologies. In this example DOE such as two-way analysis of variance is applied on injection-molding process with the aim of improving product quality such as excessive flash. Factors considered as affecting for flash formation are: pack pressure , pack time , injection speed, and screw RPM,while clamping pressure, injection pressure and melting temperature were under control. Each factor affecting flash formation is considered at low and high levels.

Table1: Factors contributing to flash formation

Factors	**Low**	**High**
pack pressure	10	30
pack time	1	5
injection speed	12	50
screw RPM	100	200

(Source: Benjamin Durakovic,2017)

Hypothesis Testing

The decision an engineer takes regarding which factor to change or what are the variables that need to experimented are made using statistical hypothesis testing. Both parametric test (t-test and z-test) and nonparametric test (sign test and Wilcoxon rank-sum test) are appropriate for use in a manufacturing environment. The parametric is used when the sample is taken from a population with a Normal distribution whereas the nonparametric test does not require the population to conform to a normal distribution. For example, a voltage measurement will always measure as 5 volts under ideal conditions. A hypothesis testing can be used to help an engineer decide whether the same measurement in a high humidity environment will significantly affect the measurement average.

Quality Control

In modern manufacturing plants, engineering quality control is use to ensure that a product's quality meets a specified standard and that rejection rates are minimised. For instance in producing a resistor to a specified value, the process will invariably produce a range of values and those that are closer to the nominal specification will have a higher sale price. The Shewhart's statistical process control model can be used in distinguishing assignable cause variation from common cause variation. In the case of monitoring vibration levels in steam turbines, statistical models are used to set alarms which detect changes in vibration above normal values. The alarms highlight that something is changing and allow action to be taken before a major failure takes place, or the machine has to be taken out of service for investigation, thus avoiding major loss of revenue.

Regression Analysis

Regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modelling and analyzing several variables and the focus is on the relationship between a dependent variable and one or more independent variables. For example, an engineer in aquaculture development might be interested to see the relation between the dissolve oxygen and the depth of water in a pool. Dissolved oxygen is necessary to many forms of life including fish, invertebrates, bacteria and plants. Therefore the result will

help the engineer in planning the size and location of the pool and the suitable aquatic life for the pool.

Statistics in Food Industry

Basic statistical concepts such as population size, sample size, sample space, variance, distribution, standard deviation, T-tests, hypothesis and so on are much needed in food technology to provide safe and quality food for consumers and people. There are many applications of statistics in the field of food technology and some are as mentioned in table 1.

Table 1. Application of statistics in the food technology.

Method	Year
Summaries of results	Tables, graphs and descriptive statistics and instrumental, sensory and consumer measures of food characteristics
Analysis of difference and relationships	Research and applications on differences in food properties due to processing and storage, correlation studies of instrumental and sensory properties
Monitoring of results	Statistical control of food quality and parameters such as net filled weight
Measurement system integrity	Uncertainty of estimates for pesticides and additives levels in food
Experimental design	Development and applications of balanced order designs in sensory research

(Ellendersen et al,2012)

The process of producing new product have many stages which are developing innovation strategy, understanding consumers, formulation development, instrument measurement, sensory test and food product processing. It is essential to identify a formula that will optimized the levels of ingredients for sensory acceptability with minimum cost

Food sensory is the analysis that used human senses to analyse foods in term of taste, flavour and texture. Some important statistical analysis in food sensory are such as hypothesis testing

and Analysis of variance. Using an efficient experiment design can save a lot of time and helps in achieving the best results.

Analysis of Variance

Analysis of variance is the most common statistical test performed in descriptive analysis and other sensory tests where more than two products are compared using scaled responses. It provides a very sensitive tool for seeing whether treatment variables such as changes in ingredients, processes, or packaging had an effect on the sensory properties of products. As in the story above, it is a method for finding variation that can be attributed to some specific cause, against the background of existing variation due to other causes. Depending on the number of factors to be analysed. We can have:

- *A one-way ANOVA* in which only one factor is assessed. For example, five samples of apple are analyzed for its' catechin content. Other example is the investigation on the rheological behaviour of honeys from Spain under different temperatures (25 °C, 30 °C, 35 °C, 40 °C, 45 °C, and 50 °C)
- *The 2-way ANOVA* determines the differences and possible interactions when response variables are from two or more can be employed in sensory evaluation when both panelists and samples are sources of variation(Granato, Ribeiro, & Masson, 2012) or when the consistency of the panelists needs to be assessed.
- *A factorial ANOVA* for n factors, that analyzes the main and the interaction effects is the most usual approach for many experiments, such as in a descriptive sensory or microbiological evaluation of foods and beverages (Ellendersen, Granato, Guergoletto, & Wosiacki, 2012; Jarvis, 2008; Mon & Li-Chan, 2007). For example, two sweeteners, sucrose and high-fructose corn syrup (HFCS), being blended in a food (say, a breakfast cereal), and we would like to understand the impact of each on the sweetness of the product. Each sweetener is added to the product in 3 levels (2%, 4%, and 6% of each) and four individuals panel are selected to rate the product for its sweetness. Using the factorial design we will be able to know whether these levels of sucrose had any effect, whether the levels of HCFS had any effect and whether there is an interaction between the two sweeteners.

- *A repeated-measures (RM) ANOVA* has been used to examine results from assessments of different instrumental color attributes for a mixture of juices from yacón (Peruvian ground apple) tubers and yellow passion conditions

Regression and Correlation

Sensory scientists are frequently faced with the situation where they need to know whether there is a significant association between two sets of data. For example, the sensory specialist wants to know if the perceived brown-color intensity (dependent variable) of a series of cocoa powder-icing sugar mixtures increased as the amount of cocoa (independent variable) in the mixture increased. In another example, the sensory scientist wants to know if the perceived sweetness of grape juice (dependent variable) is related to the total concentration of fructose and glucose (independent variable) in the juice, as determined by high-pressure liquid chromatography.

Conclusion

Statistics are an important part of our lives. The role of statistics in engineering and food industry is indispensable. Starting from designing a product, making a finished one and making it work, at every step an engineer and food practitioner needs help of statistics in some form or other to get the best solution.

References:

Bereket Abraha Gherezgihier et al. 2017. "Methods and Application of Statistical Analysis in Food Technology."*Journal of Academia and Industrial Research (JAIR), Volume 6, Issue 5.*

Daniel Granato et al. 2014. "Observations on the use of statistical methods in Food Science and Technology." *Food Research International 55 (2014) 137–149.*

Benjamin Durakovic. 2018. " Design of Experiments Application, Concepts, Examples:State of the Art." *Periodicals of Engineering and Natural Sciences ISSN 2303-4521,Vol 5, No 3, December 2017, pp. 421–439.*