Errors and Their Computation in Numerical Method

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Abstract- The objective of this review paper is to review the concept of errors and their computation including different types of errors such as absolute error, relative error, random error, percentage error, etc. Errors play an important role in measurements or any calculations. Any measurement that we make is just an approximation, 100% accuracy is not possible. If we measure the same thing two times, there will be some variation between their values and this variation introduces an unwanted but unavoidable uncertainty in our measurements. So, here we discuss a new approach of error calculation & how to overcome from drawback of errors.

Indexed Terms- Systematic error, gross error, random error, absolute error, relative error, percentage error etc.

I. INTRODUCTION

Error may be classified as the difference between the measured value and the actual value. When we are measuring the values of an unknown quantity using the measuring instrument the value which we are getting is called the measured value. This measured value is different from the actual value of unknown quantity [1]. For example, if we have done any practical measurements two times, then we get two different results both the time, there must be small error or sometimes large error between these two values. Sometimes the measured values are the same but it is an exception, theresults don't need to be the same at both the time. After the measurement, the difference that occurs between the measured value and the actual value is termed as error [2]. It is just one example but there are several examples regarding error. Errors may occur in any calculations such as mathematical, digital, technical, measurement, computational, etc. In general words, we can say that errors occur everywhere in every sector. Let's take an example, as we all know computers are one of the advanced result of our advanced technology, but even several errors occur in computational calculations. While performing experiments with industrial instruments, it is very important to operate these instrumentscarefully for reducing the presence of errors. Some errors are constant while some are random. We can't predict where errors occur, it occurs anywhere. Evolution of accuracy measures are used in major comparative studies of forecasting method. There are some early and most popular accuracy measures such as Root mean square error (RMSE)andMean absolute percentage error (MAPE). These methods are widely used for well-known issues such as higher sensitivity to outliers. When we use these accuracy measures, there must be some errors but these errors are small and seems to be good. Errors occur due to RMSE is 0.1% while errors occur due to MAPE is 1 %. A similar case can be found regarding MAPE with an error of 1.3% which seems to be good, but the error of 1.3% is larger than the average error. When we compare MAPE error concerning average error/fluctuation of stock price, MAPE error is larger than error occurred in stock price. Here poor interpretation occurs mainly due to lack of comparable benchmark used by the accuracy measures during any measurements or calculations.

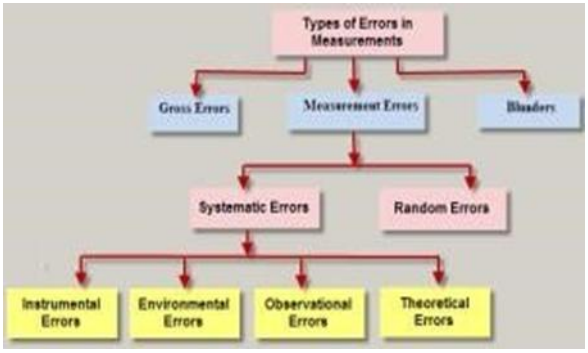

Fig 1.1 Types of errors in measurement

II. ERRORS

2.1 DEFINITION: Errors may be classified as difference between measured value and actual value.
Error= Actual value- Approximate value

2.2 TYPES OF ERRORS: The errors are broadly classified into three categories:

1. Gross errors
2. Systematic errors
3. Random errors

1. GROSS ERRORS: Gross errors are caused due to human mistake. When the observer is reading the instrument then at the time of reading the instrument if, the observer has mistakenly written different reading, or he does not have correctly taken the reading. So, the errors which is occurring due to human mistake is termed as gross error

- Errors caused by human mistakes are:

a) Reading of the instruments value before it reaches steady state.
b) Mistakes during reading of data.

- How to eliminate gross errors?
- Careful reading and recording of the data can reduce gross errors.

2. SYSTEMATIC ERROR

Systematic errors are those errors which occur due to the fault in the measuring instrument. If the measuring instrument is not calibrated or the pointer of measuring instrument is not accurate then error can occur [1]. These errors may be classified into different categories. Ex:-Suppose, if the ammeter pointer is at 0.1 A position so when we are measuring the current of 1A, it will give us a reading of 1.1A instead of 1A. So error has occurred because actual value was 1A but we are reading it as 1.1A. So due to the pointer of the ammeter, this error has occurred in the measurements.

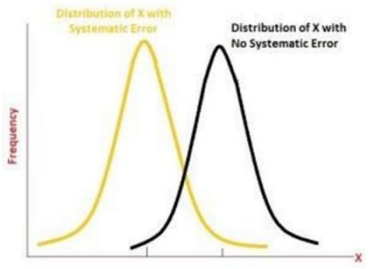

Fig 2.2.1 Systematic error

- Instrumental Errors
- Environmental Errors
- Observational Errors

- Instrumental errors: Instrumental errors are those errors which occur due to the wrong correction of the measuring instrument. At the time of constructing the measuring instrument if any error or any default has occurred, due to that default the errors occur are termed as instrumental errors. Instrumental errors occur due to hysteresis or friction. It also occurs due to the loading effect & misuse of instruments [2].

  Ex: - when we are carrying the instruments from one place to another place. During this transportation of instrument if some damage has occurred to any part of that instrument or if it's internal circuit has been damaged. So, due to that, the errors will occur in the measurement.

- Environmental errors: Environmental error occurred due to the environment. If any external changes in the external environment of the instrument. So, due to that if there is any effect in reading then an environmental error can occur. External environment means, like if the surrounding temperature of the instrument is changing then also it can have some effect on the readings such as humidity, pressure, temperature, etc.
- How to eliminate environmental errors?
  - Maintain the humidity and temperature as constant.
  - Avoid presence of electrostatic & magnetic field.

- Observational errors: Observational errors occur due to the wrong observation or reading which are taken from the instrument by the observer. When

the observer is taking the reading and at that time if he has done any mistake then it will cause observational errors [1].

3. Random errors: Random errors occur due to sudden change in the experimental condition like when we are taking the reading from the instrument at that time the temperature was different, pressure was different and humidity around instrument is different. So, due to some random/sudden change in experimental condition can occur random errors.

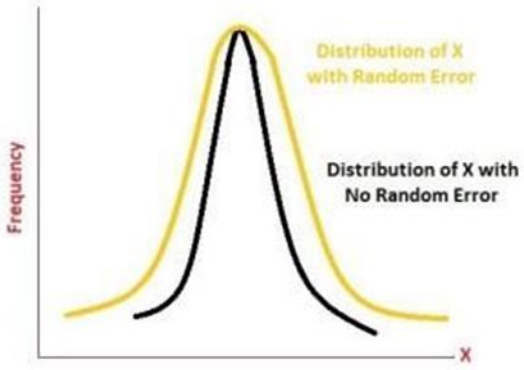

Fig 3.1 Random errors

There are some different types of errors used in numerical method are:

1. Absolute error: - It is defined as magnitude of error. It is denoted by E_aEa= |error| = |Actual value – Approx. value| = $|E_t|$, where $e_{t\ is}$ true error [1].

The absolute error depends upon the magnitude of the actual & approximate values. Hence only absolute error does not provide complete information.

Ex: - The height of an observation tower was estimated to be 49m whereas, its actual height was 47m. Calculate its absolute error? Sol: - Absolute error= |Actual value –
Approx. value|
= |47-49|
= |-2| = 2

2. Relative error: - when the absolute value is normalized with respect to actual value then it is called as relative error.

E_r = Absolute value/ True value

$$Relative\ error = \frac{Absolute\ error}{Actual\ price} x\ 100$$

Ex: - The height of an observation tower was estimated to be 49m whereas its actual height was 47m. Calculate its relative error?
Sol: - Absolute error =|47-49|
=|-2| =2
Hence, relative error= |2|/|47|
= 0.04553

3. Percentage error :- Percentage error is obtained from the relative error by expressing it in terms of percentage i.e.

Percentage error=Relative error*100%

CONCLUSION

In my views errors play an important role in measurements or any mathematical calculations. Here we discuss different types of errors such as gross, systematic, random, absolute, and relative and percentage error. In this paper, we discuss how to eliminate errors and what are the issues related to errors. By presenting some examples regarding different types of errors we can easily understand it. The basic ideas in my view is that everyone should know about errors, issues related to errors and how to overcome from it.

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