Evaluation of Proficiency Testing Results and the elimination of Statistical Outliers.

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Statistical Outliers

Introduction

Various statistical tools are available for the analysis of measurement results against assigned values.

Statistical Outliers

Introduction

An analysis needs to be performed in order to ensure that the assigned or consensus values are themselves not adversely affected, or tainted by poor measurements results.

Statistical Outliers

Introduction

The most common statistical tools used to evaluate measurements results are those that were included in the ISO Guide 43 these being z Scores and En values.

Statistical Outliers

Introduction

The basis of the z score is a measure of the number of SD's that the participants measurement results differ from the assigned value which may be a consensus mean.

$$z = \frac{x - X}{s}$$

Statistical Outliers

Introduction

En numbers are typically used in the evaluation of proficiency testing measurement results originating from calibration or metrology laboratories.

$$E_n = \frac{x - X}{\sqrt{U_{lab}^2 + U_{ref}^2}}$$

Statistical Outliers

Introduction

The En number makes provision for consideration of the uncertainty of measurement of both the reference value and the participant's measurement results.

$$E_n = \frac{x - X}{\sqrt{U_{lab}^2 + U_{ref}^2}}$$

Statistical Outliers

Introduction

In both of the above examples a very simple method of eliminating potential outliers is the same criteria used to consider if the measurement results are acceptable

i.e. $z \leq 3$ or $En \leq 1$, and then to exclude these from the set of data.

Statistical Outliers

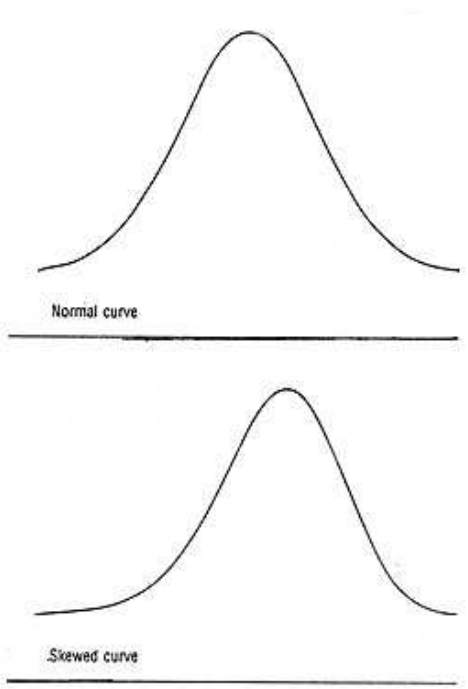
Introduction

This of course will have little effect when the reference value is not a consensus value, and is derived from a single ‘reference’ measurement value or a select group of ‘expert’ laboratories.

Statistical Outliers

Outliers

An outlier has the potential to skew the mean value of the data set, however not all statistical outliers are necessarily poor measurement results.



Statistical Outliers

Outliers

In an analytical laboratory measurement results may be skewed where different factors have been introduced into the measurement process, such as an alternative method, or measurement platform.

In such cases it may be necessary to treat the data differently or separately.

Statistical Outliers

Outliers

Example of the above is the size distribution of a particulate material may be determined using either round or square holed sieves.

If a laboratory uses a different method to that used to determine the assigned value, their results may show a bias although no fault in execution is present.

Statistical Outliers ISO CD 17043:

The ISO is due to release ISO 17043 in the near future. This standard requires

4.4.4.1 Statistical designs shall be developed to meet the goals of the scheme, based on the nature of the scheme.

The statistical designs could vary from being very simple to the very complex.

4.4.4.2 The PT provider shall document the statistical model and data analysis techniques used to identify the assigned value.

Statistical Outliers ISO CD 17043:

4.4.4.3 Careful consideration shall be given to:

a) Accuracy, Trueness and/or precision as well as the uncertainty required or expected;

b) Minimum number of participants to produce statistically valid results;

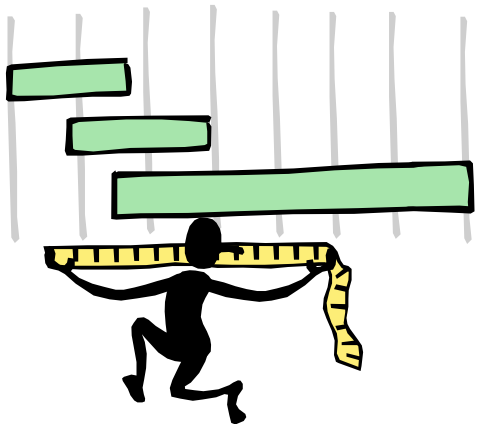
d) The procedures used to establish the SD for PT assessment & other evaluation criteria;

Statistical Outliers
ISO CD 17043

4.4.4.3 Careful consideration shall be given to:

e) Procedures to identify and/or handle outliers;

f) where appropriate the statistical procedure for the evaluation of excluded values;



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ISO CD 17043

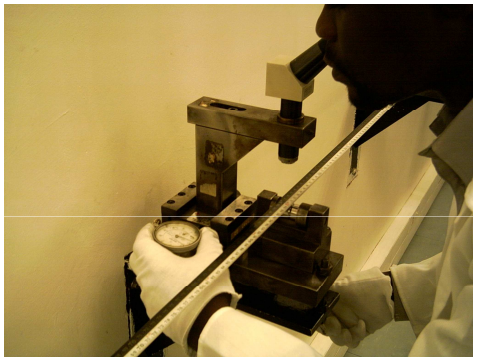
4.4.5.1 The PT provider shall document the procedure for determining the assigned values. This procedure shall take into account traceability & measurement uncertainty to demonstrate that the scheme is fit for purpose.

Statistical Outliers
ISO CD 17043

4.4.5.2 PT schemes in Calibration/Metrology shall have assigned values with traceability including measurement uncertainty.

4.4.5.4 The PT provider shall document the justification for the procedure used to determine the assigned values.

If a consensus value is used as the assigned value the PT provider shall document the reason for it's selection and shall estimate the uncertainty of the assigned value.



Statistical Outliers Definitions:

Robust Statistical Methods

Statistical methods insensitive to small departures from underlying assumptions surrounding an underlying probabilistic model.

[ISO CD 17043 Definitions 3.12]

Statistical Outliers Definitions

Outlier(s)

Observation(s) in a set of data that appear to be inconsistent with the remainder of the set.

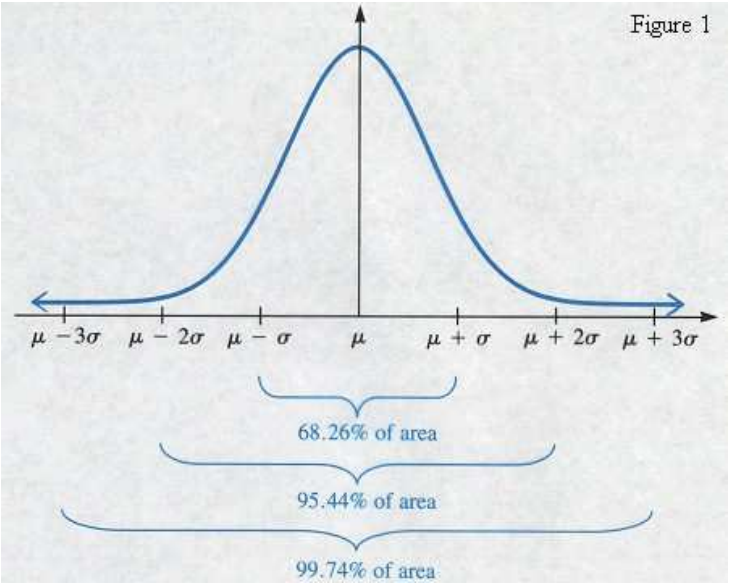
NOTE: Outlier(s) may originate from a different population or be the result of incorrect recording or gross measurement error.

[ISO CD 17043 Definitions 3.5]

Statistical Outliers
Proceed with Caution

It should be noted that before applying any of the tests for the determination of statistical data the following should be noted:

Many of the tests assume a normal or bell-shaped distribution, and available data may not be subject to any particular distribution function;



Statistical Outliers
Proceed with Caution

It should be noted that before applying any of the tests for the determination of statistical data the following should be noted:

Statistical tests for Multivariate outliers are not necessarily suitable for Univariate outliers.

Multivariate - relating to or used to describe a statistical distribution that involves a number of random but often related variables;

Statistical Outliers
Proceed with Caution

Prior to commencing with any statistical analysis review the data and either correct or remove obvious blunders.

Examples of blunders:

Results reported in the incorrect units (mm instead of cm, etc.)

Decimal point or comma in the incorrect place (Typo etc.)

Statistical Outliers
Grubbs Test

The Grubbs Test is used to detect outliers in a Univariate data set.

The data should approximate a normal distribution.

It detects one outlier at a time, the data eliminated, and the test repeated until no more outliers are detected.

It should not be used on sample sizes of 6 or less.

The Critical Value is determined as

$$C = \frac{(n-1)}{\sqrt{n}} \sqrt{\frac{t^2_{(\alpha/2n,n-2)}}{n-2+t^2_{\alpha/2n,n-2}}}$$

Statistical Outliers
Grubbs Test

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$$G = \frac{|y_o - \bar{y}|}{s}$$

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$$C = \frac{(n-1)}{\sqrt{n}} \sqrt{\frac{t^2_{(\alpha/2n,n-2)}}{n-2+t^2_{\alpha/2n,n-2}}}$$

CHAUVENET'S CRITERION : CRITERION FOR THE ELIMINATION OF STATISTICAL OUTLIERS

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What is the Chauvenet's Criterion?

Chauvenet's Criterion is a means of assessing whether one piece of experimental data — an outlier — from a set of observations, is spurious. Data is the plural of datum. ...

CHAUVENET'S CRITERION : CRITERION FOR THE ELIMINATION OF STATISTICAL OUTLIERS

What is the Chauvenet's Criterion?

Chauvenet's Criterion states that the probability of an outlier being included in any data set is less than 50%, therefore in a set of 5 measurements/results, a outlier may be discarded if it's probability of being in the parent population is less than 1/(2*N) = 1/(2*5) = 0.1 or 10%

CHAUVENET'S CRITERION : CRITERION FOR THE ELIMINATION OF STATISTICAL OUTLIERS

What is the Chauvenet's Criterion?

Chauvenet's Criterion is based on an assumption that the population is normally distributed.

The criterion is not recommended on a sample size of 4 or less.

Before the data is analyzed remove the obvious blunders from the data set.

CHAUVENET'S CRITERION : CRITERION FOR THE ELIMINATION OF STATISTICAL OUTLIERS

What is the Chauvenet's Criterion?

Calculate the deviation from the mean, as a function of the standard deviation for each data point or measurement.

$$\left| \frac{|x_i - \bar{x}|}{\sigma} \right|_j$$

From the table look up the Critical Value compare with the deviation, if the deviation deviates by more than the critical value the data point may be rejected.

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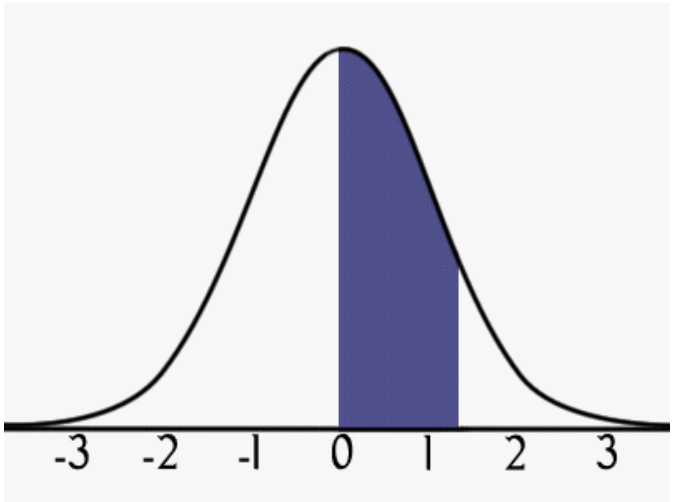
N (number of data points)	d/σ (deviation/std. dev. of distribution)
5	1.65
6	1.73
7	1.81
8	1.86
9	1.91
10	1.96
12	2.04
14	2.10
16	2.15
18	2.20
20	2.24
25	2.33
30	2.39
40	2.49
50	2.57
60	2.64
80	2.74
100	2.81
150	2.93
200	3.02
300	3.14
400	3.23
500	3.29
1000	3.48

Maximum Deviation for Chauvenet's Criterion.

Probability adjusts with N the number of observations, by 1/(2N)



CHAUVENET'S CRITERION : CRITERION FOR THE ELIMINATION OF STATISTICAL OUTLIERS

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N=5 1 / (2N) = 1 / (2·5) = 1/10 = 10/100 = 0.10 1-p = 0.10

p = 0.90 ⟶ table look-up ⟶ z = 1.65

N=10 1 / (2N) = 1 / (2·10) = 1/20 = 5/100 = 0.05 1-p = 0.05

p = 0.95 ⟶ table look-up ⟶ z = 1.96

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1.4	0.8385	0.8415	0.8444	0.8473	0.8501	0.8529	0.8557	0.8584	0.8611	0.8638
1.5	0.8664	0.869	0.8715	0.874	0.8764	0.8789	0.8812	0.8836	0.8859	0.8882
1.6	0.8904	0.8926	0.8948	0.8969	0.899	0.9011	0.9031	0.9051	0.907	0.909
1.7	0.9109	0.9127	0.9146	0.9164	0.9181	0.9199	0.9216	0.9233	0.9249	0.9265
1.8	0.9281	0.9297	0.9312	0.9328	0.9342	0.9357	0.9371	0.9385	0.9399	0.9412
1.9	0.9426	0.9439	0.9451	0.9464	0.9476	0.9488	0.95	0.9512	0.9523	0.9534
2.0	0.9545	0.9556	0.9566	0.9576	0.9586	0.9596	0.9606	0.9615	0.9625	0.9634

Chauvenet's Criterion: Example

Sample	Deviation (SD)	Criterion
10.0180	-0.1220	ACCEPT
10.1276	0.7389	ACCEPT
9.9000	-1.0499	ACCEPT
9.8928	-1.1067	ACCEPT
10.1154	0.6434	ACCEPT
9.6955	-2.6569	REJECT
10.2322	1.5616	ACCEPT
10.1375	0.8171	ACCEPT
10.0128	-0.1635	ACCEPT
9.9657	-0.5337	ACCEPT
9.9402	-0.7335	ACCEPT
10.1403	0.8391	ACCEPT
10.1021	0.5388	ACCEPT
9.9975	-0.2832	ACCEPT
10.0126	-0.1651	ACCEPT
9.9485	-0.6687	ACCEPT
10.0492	0.1228	ACCEPT
10.0042	-0.2308	ACCEPT
10.2114	1.3979	ACCEPT
10.1677	1.0544	ACCEPT
N =	20	
Mean	10.0336	
SD ±	0.1272	
	2.24	

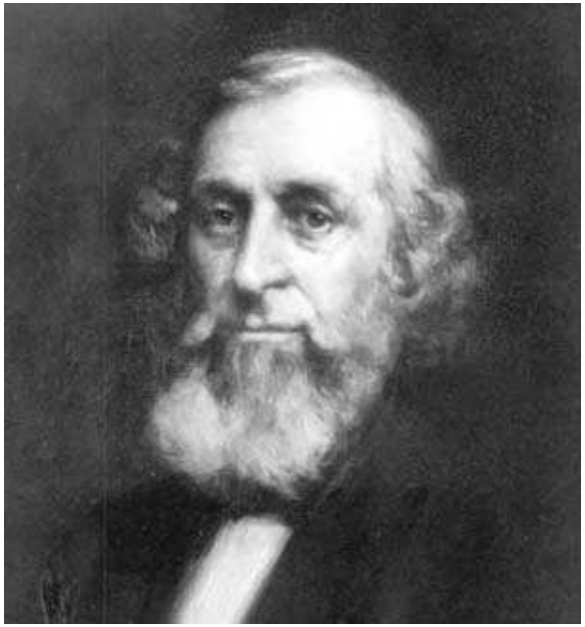
So who was Chauvenet?

William Chauvenet was born in Pennsylvania in 1820. He graduated from Yale in 1840.

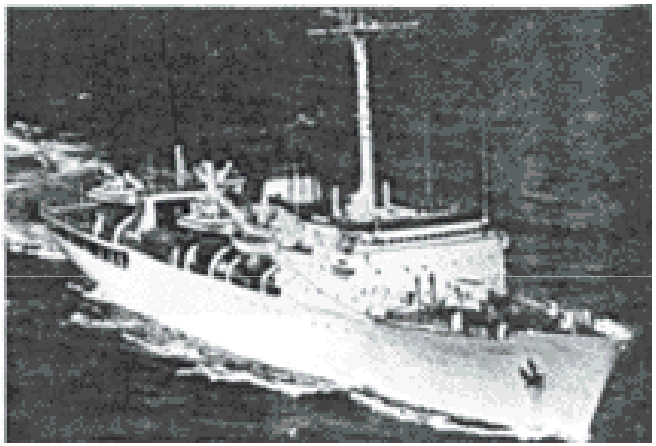
So who was Chauvenet?

William Chauvenet was active in the establishment of the United States Naval Academy, where he taught mathematics and astronomical navigation.

In 1859 he was elected to the chair of Mathematics at the Washington University. He was the author of numerous publications.



So who was Chauvenet?



USNS Chauvenet

Built by Upper Clyde Shipbuilders of Glasgow, Scotland in 1970.

Converted in a Maritime school ship in 1996.

The End

Thank you

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