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# A STUDY ON SOFTWAR EQUALITY AND RELIABILITY

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***Abstract***
*Software reliability is the probability of failure-free operation of software in a specified environment during specified time duration. Relatively little research work is, however, available on their use to monitor failure process of software. The control scheme adopted for our study is based on the inter failure cumulative data between observations of failure. It is proposed that the said control scheme can be easily and fruitfully applied to monitor the software failure process for Half Logistic Distribution based Non-Homogeneous Poisson Process (NHPP).*

***Key Words: Software, Reliability, Equality.***

## Introduction

There are a number of views as to what software reliability is and how it should be quantified. Some believe that this measure should be binary in nature so that an imperfect program would have zero reliability while a perfect one would have a reliability value of one. This view parallels that of program proving whereby the program is either correct or incorrect. Others, however, feel that software reliability should be defined as the relative frequency of the times that the program works as intended by the user. This view is similar to that taken in testing where a percentage of the successful cases are used as a measure of program quality.

Software reliability is a probabilistic measure and can be defined as the probability that software faults do not cause a failure during a specified exposure period in a specified use environment. The probabilistic nature of this measure is due to the uncertainty in the usage of the various software functions and the specified exposure period, that may mean a single run, a number of runs, or time expressed in calendar or execution time units.

Software reliability is a useful measure in planning and controlling resources during the development process so that high quality software can be developed. It is also a useful measure for giving the user confidence about software correctness. Planning and controlling the testing resources via the software reliability measure can be done by balancing the additional cost of testing and the corresponding improvement in software reliability. Thus, there is a point beyond which continuation of testing to further improve the quality of software can be justified only if such improvement is cost effective. An objective measure like software reliability can be used to study such a tradeoff (Daniel Galin, 2009).

Reliability of a product as a metric has universal relevance and generally obtained using meantime between Failure (MTBF); however, its expected standard may vary. For example reliability of a critical transaction handling system in a stock exchange needs to be very high whereas the same can be afforded to be average for a small or medium size manufacturer using software accounts handling (Pressman, 2010).

**Discussions, Materials and Methods**

The run chart becomes a control chart if decision lines are added. The chart contains sacenter line that represents heaverage value of real or assumed set of fluctuating observations. It may or may not pass through the actual plotted points. This is so because the average is affected by extreme observations. Two horizontal lines, called the upper control limit and the lower control limit, are also shown on the chart. Control limits are mathematical limits used to interpret the pattern on a control chart. They are derived from knowledge of distribution theory and are calculated numbers in relationship to the data. They are boundaries of expected or common variation. These control limits are chosen so that if the process is in control, nearly all of the sample points will fall between them. As long as the points plot within the control limits, the process is assumed to be in control, and no action is necessary. On the other hand, a point that plots outside of the control limits is interpreted as evidence that the process is out of control and that corrective action is required to find and eliminate the assignable causes responsible for this behaviour. A statistically controlled process will oscillate fairly evenly about the mean.

Control charts are widely used for process monitoring. A control chart illustrates the dynamic performance of the process. Software reliability process can be monitored efficiently by using SPC. It assists the software development team to identify failures and actions to be taken during software failure process and hence, assures better software reliability. If not many, few researchers proposed SPC based software reliability monitoring techniques to improve Software Reliability Process.

To identify and eliminate human errors in software development process and also to improve software reliability, the SPC concepts and methods are the best choice. They are used to monitor the performance of a software process over time in order to verify that the process remains in the state of statistical control. It helps in finding assignable causes, long term improvements in the software process.Softwarequalityandreliabilitycanbeachievedbyeliminatingthe causes or improving the software process or its operating procedures (Kimura *et al.*,1995).

Software process control is used to secure the quality of the final product which will conform to predefined standards. In any process, regardless of how carefully it is maintained, a certain amount of natural variability will always exist. A process is said to be statistically "in-control" when it operates with only chance causes of variation. On the other hand, when assignable causes are present, then we say that the process is statistically "out-of-control."

The control charts can be classified into several categories, as per several distinct criteria. Depending on the number of quality characteristics under investigation, charts can be divided into univariate control charts and multivariate control charts. Furthermore, the quality characteristic of interest may be a continuous random variable or alternatively a discrete attribute. Control charts should be capable to create an alarm when a shift in the level of one or more parameters of the underlying distribution or a non-random behavior occurs. Normally, such a situation will be reflected in the control chart by points plotted outside the control limits or by the presence of specific patterns. The most common non-random patterns are cycles, trends, mixtures and stratification Koutras *et al.,* (2007). For a process to be in control the control chart should not have any trend or nonrandom pattern.

SPC is a powerful tool to optimize the amount of information needed for use in making management decisions. Statistical techniques provide an understanding of the baselines, insights for process improvements, communication of value and results of processes, and active and visible involvement.SPC provides real time analysis to establish controllable process baselines; learn, set, and dynamically improves process capabilities; and focus areas which need improvement. The selection of proper SPC charts is essential to effective statistical process control implementation and use. The SPC chart selection is based on data, situation and need MacGregor and Kourti (1995).Many factors influence the process, resulting in variability. The causes of process variability can be broadly classified into two categories, viz., assignable causes and chance causes (Shewhart, 1931; Deming, 1986; Montgomery, 1997).

At the basis of the theory of statistical process control is differentiation of the causes of variation during the operation of any process. Certain variations belong to the category of chance or random variations, about which little may be done, other than to revise the process. When only common causes of variations are present in a process, the process is considered to be „*stable*", „*in statistical control*" or „*in control*". Causes of variation which are relatively large in magnitude and readily identified are classified as„ assignable"or„*special*"causes. When special causes of variation are present, variation will be excessive and the process is classified as„*unstable*",„„*out of statistical control*"or„*out-of control*".

The control limits can then be utilized to monitor the failure times. After each failure, the data can be plotted on the chart. If the plotted point falls between the calculated control limits, it indicates that the process is in the state of statistical control and no action is warranted. If the point falls above the UCL, it indicates that the process average, or the failure occurrence rate, may have decreased which results in an increase in the time between failures. This is an important indication of possible process improvement. If this happens, the management should look for possible causes for this improvement and if the causes are discovered then action should be taken to maintain them. If the plotted point falls below the LCL, It indicates that the process average, or the failure occurrence rate, may have increased which results in a decrease in the failure time. This means that process may have deteriorated and thus actions should be taken to identify and the causes may be removed.

**Conclusion**
Data forms the basis for analysis, decision and action, and their form and presentation will obviously differ from process to process. Information is collected to discover the actual situation. After data is collected, they are analysed and useful information is extracted through the use of statistical methods. If data are not carefully and systematically recorded, especially at the point of operation, they cannot be analysed and put to use. Information recorded in a suitable way enables the magnitude of variations and trends to be observed. This allows conclusions to be drawn concerning errors, process capability, etc.

SPC is a methodology of collecting data, arranging the data in a chart or graph form, and interpreting the data to reduce variations in the process. It is a method of monitoring the behaviour of the process and determining the cause of variation based on statistical analysis of the problem. SPC uses probability theory to control and improve processes. It has been empirically found that SPC is indeed an effective methodology for problem solving and for improving performance of any process. It helps identify problems quickly and accurately. It also provides quantifiable data analysis, provides a reference baseline, and promotes participation and decision making by people closest to the job.

A process is said to be in a state of statistical control when assignable or special causes of variation have been detected, identified and eliminated. It is of subsequent interest to determine any change in the process, either in the mean level or in the variation about the mean. Control charts are used to detect changes from a target level or changes in the variability of the process.

If analysis of the control chart indicates that the process is currently under control then data from the process can be used to predict the future performance of the process. If the chart indicates that the process being monitored is not in control, analysis of the chart can help determine the sources of variation, which can then be eliminated to bring the process back into control. The control chart can be seen as part of an objective and disciplined approach that enables correct decisions regarding control of the process, including whether or not to change process control parameters.

Common causes of variation are always present and influence the performance of the process. They are innate to the production process. Variation due to only common causes should not be reacted to, unless it is to fundamentally improve the process. Unnecessary intervention may induce extra variation and result in economic loss.

A process that is affected by common causes only is said to be in-control. Observations from a process that is in-control vary within limits around a central value. Special causes are occasional disturbances to the process that interfere with its common cause operation. They may arise periodically in a somewhat unpredictable fashion and cause problems. Special causes should be detected and removed to bring the process back in its most economic state. A process that is affected by special causes is said to be out-of-control. People often interpret observations poorly without the help of proper aids (Hogarth 1975).

An SPC chart signals a change in performance when an observation falls outside the control limits or observations exhibit a systematic pattern. The original Shewhart charts are mostly useful for larger changes in performance. Additional supplementary runs rules have been developed to detect smaller changes. They test patterns of observations within the control limits. Supplementary runs rules are found in Wheeler (1995) and Montgomery (1997). SPC charts have several different functions (Kolesar, 1993; Wheeler, 1995; Woodall 2000).

Shewhart charts have been developed for all well-known probability distributions. Many have received their own name. The X-chart and Xbar-charts are respectively for individual observations and means of subgroups of normally distributed data. These charts are also suggested for data with unknown distributions (Wheeler 1995). The R-chart, MR-chart, and S-chart are Shewhart charts for the dispersion of normally distributed data. The NP-chart and P chart are for binomially distributed data. The U-chart and C-chart are for Poisson distributed data. Other types of SPC charts are the cumulative sum and exponentially weighted moving average control charts. These charts have been developed for normal, binomial, and Poisson distributions and others. They are better at detecting smaller changes in performance than the supplementary runs rules (Montgomery, 1997; Hawkins and Olwell 1998).

Success of SPC charts depends also for a large part on the use of rational subgroups (Wheeler 1995). A rational subgroup is set of observations that were generated under rather identical conditions. Sometimes a rational subgroup may be 1 observation at a time. Out-of control situations are more likely to appear between rational subgroups and therefore typically affect allorn one of the observations in a rational subgroup. SPC charts should be used with observations that are closely related to the origins of variation (Montgomery 1997). The performance of SPC charts can be exactly determined when all assumptions about the distribution of the observations hold. This is usually not the case. Most processes are never exactly in-control (Montgomery1997). Wheeler (1995) points out that observations do not follow exactly the assumed probability distribution and other assumptions such as independence or constant variance may not hold.

It is typically recommend for a Shewhart Xbar-chart to have at least 25 to 30 subgroups of 4 or 5 observations each to obtain reliable estimates of the variability and hence to set up control limits (Quesenberry, 1997). This is considerably more for Shewhart individuals charts (Quesenberry, 1993) and cusum charts (Hawkins and Olwell 1998).

A type I decision error (false alarm or false positive) is made when the process is judged to be out-of-control when in fact it is in-control. A type II decision error (false negative) is made when the process is judged to be in-control when in fact it is out-of-control. Both types of errors are typically associated with economic loss. SPC charts help to correctly judge the state of the process through the use of properly calculated control limits. Control limits should be based on the distribution of the rationally sampled observations and the cost of type I and II decision errors.

The control limits for the chart are defined in such a manner that the process is considered to be out of control when the time to observe exactly one failure is less than LCL or greater than UCL. Our aim is to monitor the failure process and detect any change of the intensity parameter. When the process is normal, there is a chance for this to happen and it is commonly known as false alarm. The traditional false alarm probability is to set to be 0.27% although any other false alarm probability can be used. The actual acceptable false alarm probability should in fact depend on the actual product or process (Swapna et al., 1998).

Most people think that the essence of SPC is to generate "Some “charts and then relax. That is the furthest from the truth. Problem solving is a continual issue of improvement.

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