CHAPTER 7

SUMMARY & CONCLUSION

7.1 SUMMARY

The probability that software faults do not cause a failure during a specified exposure period in a specified environment is called software reliability. In this thesis, we prepare and analyze an array of different procedures related to software reliability based on SPC & SPRT methods. Software reliability growth model can be provide a good prediction from the number of failure at time(t) and the number of remaining failure can be found out. Reliability models are a powerful tool for predict controlling and assessing software reliability. In this thesis we discuss concepts related to the areas of Non-Homogeneous Poisson Process (NHPP), Software Reliability Growth models (SRGM), Statistical Process Control (SPC), Maximum Likelihood Estimation (MLE) and Sequential Probability Ratio Test (SPRT) which are extensively used in carrying out this thesis.

A perfect program is said to be reliable while an imperfect one is said to be unreliable. Many models have been developed with different mathematical techniques to adapt to different testing environments. Generally these models can be categorized into two groups: data-driven software reliability models and analytical software reliability models. Data-driven models focus on the failure data generated through the software testing process. They consider software reliability prediction as a time-series analysis problem. These models are developed from past software failure data and have less restrictive assumptions. Analytical software reliability models describe the software failure behaviour during the software testing process and take this process as a stochastic process. For these models, some restrictive assumptions are made such as perfect and immediate fault correction. NHPP models are applied extensively, which are the main concern for the present thesis.

A reliability growth model is needed to estimate the current reliability level, the time and resources required to achieve the objective reliability level. During this phase, reliability estimation is based on the analysis of failure data. The number of failures experienced can be denoted as a stochastic counting process characterized by its mean value function. This process can be represented by a Poisson model.
Research activities in software reliability engineering have been conducted and a number of NHPP software reliability growth models have been proposed to assess the reliability of software. Software reliability can be estimated once the mean value function is determined. The technique of control chart has been used in the software engineering so as to improve the quality of software products. The software failure process which follows a Non-Homogeneous Poisson is monitored on Interval domain data.

The data analysis can be done depending on the format in which test data are available, there are two common types of failure data: time-domain (i.e., ungrouped) data and interval domain (i.e., grouped) data. The time-domain approach involves recording the individual times at which failure occurred. The interval-domain approach is characterized by counting the number of failures occurring during a fixed period (e.g., hour, week, day). These data are usually used by practitioners when analyzing, assessing and predicting reliability applications. Some software reliability models can handle both types of data.

Data forms are the basis for analysis, decision and action. Their form and presentation will obviously differ from process to process. After the data is collected, they are analyzed and useful information is extracted through the use of statistical methods. If data is not carefully and systematically recorded, especially at the point of operation, they cannot be analyzed and put to use. The control limits are utilized to monitor the failure times. 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 failure occurrence rate, may have decreased which results in the increase of TBFs. This is an important indication of possible process improvement. If the plotted point falls below the \( LCL \), it indicates that the failure occurrence rate, may have increased which results in the decrease of failure time. This means that process may have deteriorated. This has been discussed in Chapter 5.

Software reliability assessment is increasingly important in developing and testing new software products. Software reliability is the commonly used quality metric. This is estimated by the use of an analytical model whose unknown parameters are estimated from the available failure data. There are a number of views to quantify
software reliability. Parameter estimation is of primary importance in software reliability estimation. In this thesis, the parameters are estimated by MLE technique for the Interval domain data. The idea behind maximum likelihood parameter estimation is to determine the parameters that maximize the probability of the sample data. A MLE method is versatile and applies to many models and to different types of data. This is discussed in Chapter 4 with a Numerical illustration.

The SPRT was initially developed for quality control problems to reformulate it as a sequential analysis problem. SPRT is used as a statistical device to decide which of two simple hypotheses is more correct. It has been formulated for use in the computerized testing of human examinees as a termination criterion. This is been discussed with numerical illustration in Chapter 6.

7.2 CONCLUSIONS

Chapters 1, 2 and 3 of this thesis are usual format of introduction, focuses problems, review of literature and methodology to be adopted to the proposed research problems. The results of each investigation are given in the form of conclusion at the end of Chapters 4, 5 and 6. The broad conclusion arrived at in Chapters 4 to 6 are briefly listed below.

Chapter 4 Software reliability is an important quality measure that quantifies the operational profile of computer systems. This model is primarily useful in estimating and monitoring software reliability, viewed as a measure of software quality. In this thesis the fault detection rate is calculated with the number of faults remaining in the software. Considering the two factors jointly the fault detection rate is more realistic and accurate. we have discussed the performances of 6 datasets by using our new Burr type XII SRGM. The experiment result shows that the Phase 1 data set can provide a better goodness-of-fit compared with other datasets. The reliability of the model over Release #4 data is high among the data sets which were considered. This is a simple method for model validation and is very convenient for practitioners of software reliability.

Chapter 5 The parameter estimation is carried out by Newton Raphson Iterative method. Dataset #1b, Dataset #3b, Dataset #4b, Release #1, Release #2 and Release
#3 have shown that, some of the mean value successive differences have gone out of control limits i.e., below LCL at different instant of time. Datasets #2b and #5b has shown that all the mean value successive differences are within the control limits i.e., in between UCL and LCL, which indicates a stable process control. Hence it is concluded that the proposed method of estimation and the control chart are giving a positive recommendation for their use in finding out preferable control process or desirable out of control signal. When the successive differences of failure counts are less than LCL, it is likely that there are assignable causes leading to significant process deterioration and it should be investigated. On the other hand, when the successive differences of failure counts have exceeded the UCL, there are probably reasons that have lead to significant improvement.

Chapter 6 The Table 6.4.2 of Interval domain data as exemplified for 11 Data Sets shows that Burr Type XII model is performing well in arriving at a decision. Out of 11 Datasets the procedure applied on the model has given a decision of rejection for 8 datasets, acceptance for 3 datasets and continue for none at various time instant of the data. The datasets Phase1, Release #4 and Dataset #2a are accepted at 1st instance of time whereas remaining datasets are rejected at different instances of time. Therefore, by applying SPRT on data sets it can be concluded that we can come to an early conclusion of reliable or unreliable software.

7.3 DISCUSSION

Though our findings given in terms of above conclusion, it is customary in the research study that the proposed problems are investigated in a restricted frame work in order to achieve satisfactory results. We therefore may say that our findings are not insensitive to relaxations of above quoted limitations. Our future research is based on relaxing one/some/all of the stated limitations and verify how robust our results would be. The work in this directions is our future research plans and are marked for outside the scope of the thesis.