SRGMs

Barbara Russo

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Mean function of a point process

- The mean function of a point process is the expected value

$$\mu(t)=E(N(t))$$

- Note that t is the global time!
- It is an increasing function

Rate of Occurrence of Failures

- When μ (t) is differentiable (I can derivate it) then the Rate of Occurence of Failure is defined as

$$\lambda(t) = \frac{d}{dt}\mu(t)$$

- It is the istantaneous rate of change in the expected number of failures

Theorem

- If simultaneous failures do not occur intensity function and ROCOF are equal

$$\lambda(t)=\lambda\_(t)$$

Software Reliability Growth models

- The problem to model the failures occurrences shifts to determine $\lambda(t)$ or $\mu(t)$

Reliability growth

- In mathematical terms in order to have a good description of a failures detection process, we need:

$$\mu(0) = 0$$

$$\lambda(t)=\mu'\geq 0$$

$$\lambda(t)'<0 \text{ when } t>>o$$

Reliability growth

- If moreover, exists t such that $\lambda' > 0$ the curve is S-shaped, otherwise is concave.
- The flex of $\mu(t)$ identifies the end of the learning period and the starting moment in which it becomes harder to detect new failures

Identifying the failure intensity

- In reliability growth models we are assuming some effort of fault removal. Thus, ROCOF is variable over time

$$\lambda(t)$$

- Every reliability growth model is based on specific assumptions concerning the change of failure intensity $\lambda(t)$ through the process of fault removal

Model	E(N[(t)])	Interpretation of Parameters
Goel-Okumoto [1] (**GO**) *Concave*	$a(1-e^{-bt})$ $a>0, b>0$	*a* – expected cumulative total number of MRs *b* – MRs-detection rate per MR NHPP
GO S-shaped [2] (**GO-S**) *S-shaped*	$a(1-(1+bt)e^{-bt})$ $a>0, b>0$	*a* – expected cumulative total number of MR *b* – MR removal: defect detection rate, defect isolation rate NHPP
Gompertz [3] (**G**) *S-shaped for* $b>e^{-1}$	$a\cdot b^{c^t}$ $a>0, 0<b<1, 0<c<1$	*a* – expected cumulative total number of MRs *b, c* – no physical meaning TREND
Hossain-Dahiya/GO [4] (**HD**) *S-shaped for c>1*	$a(1-e^{-bt})/(1+ce^{-bt})$ $a\geq 0, b>0, c>0$	*a* – expected cumulative total number of MRs c – inflection parameter : $c(r)=(1-r)/r \geq 1$, $0<r<1/2$ *r* – inflection rate indicating the ratio of detectable MRs to the total number of MRs in the software NHPP
Logistic [3] (**L**) *S-shaped for b>1*	$a/(1+be^{-ct})$ $a>0, b>0, c>0$	*a* – expected cumulative total number of MRs *b* – inflection parameter TREND
Weibull [6] (**W**) *S-shaped*	$a(1-e^{-b\cdot t^c})$ $a>0, b>0, c>0$	*a* – expected cumulative total number of MRs *b* – error-detection rate *c* – parameter that changes error detection rate NHPP
Weibull *more* S-shaped [7] (**W-S**) *S-shaped*	$a(1-(1+b\cdot t^c)\cdot e^{-b\cdot t^c})$ $a>0, b>0, c>0$	*a* – expected cumulative total number of MRs *b* – error-detection rate, error-isolation rate *c* – parameter that changes error detection rate NHPP
Yamada Exponential [8] (**YE**) *Concave*	$a(1-e^{-b(1-e^{-c\cdot t})})$ $a>0, b>0, c>0$	*a* – expected cumulative total number of MRs $b\cdot(1-e^{-c\cdot t})$ – cumulative testing effort based on Exponential model NHPP
Yamada Raleigh [8] (**YR**) *S-shaped*	$a(1-e^{-b(1-e^{-c\frac{t^2}{2}})})$ $a>0, b>0, c>0$	*a* – expected cumulative total number of MRs $b\cdot(1-e^{-c\cdot\frac{t^2}{2}})$ – cumulative testing effort based on Weibull model NHPP