Extracting characteristic functions from growing populations
– examples from reliability, epidemiology, climate and traffic safety research.

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Abstract

Object: To predict the future outcome based on reported response to growing populations. By population is here meant a measure of any physical object or activity capable of causing an effect.

Methods: A statistical distribution was assumed able to characterize the response to a stepwise increase of the activity causing the effect. The parameters characterizing this distribution were varied to best fit reported data. Finally, the same distribution was used to estimate the future response to historic and future population increases. The distribution could be assumed representative to either the whole population or just to part of it (e.g. a sub-population of weak parts causing early failures)

Background: In 1978 the author published a paper describing how log-normal distributions of weak parts could explain early failures among electronic devices, [1]. The principles of extracting such characteristics from reported field use data were first outlined in 1987, [2], addressing field reliability analysis of electronic components and also traffic safety issues. In 1995 a project started to develop modern computer methods for the analysis of field failure data, and in 1997 the result was presented at a conference in Lisbon, [3]. These methods became successfully used in the daily reliability surveillance of telecommunication products based on installation volumes and repair statistics from all around the world.

The principles used for reliabilty analysis of electronics were also deployed for use in other quite different areas, that will be presented.

Results
Reliability

Most of field reliability reports generated by this method were indicating failure rates declining by time, e.g. due to the detection and removal of inherently weak parts. Sometimes, fortunately quite seldom, also cases where the failure rate started to increase after some years of use, were found. Examples will be shown.

The Mad Cow disease

In 1996 the author took a close look at data from the outbreak of the Mad Cow disease called BSE in England. In a two step analysis the number of BSE-infected cows that were slaughtered for food consumption each year was first estimated by this method. Second, the response to this infected meat in terms of people hit by the human version of the disease, nvCJD, was successfully estimated based on the few cases reported at the time, see [4].

Traffic deaths

Already in the report from 1987 [2] the use of the methods for analyzing and projecting traffic accident trends were highlighted. Later on it turned out that the characteristic parameters describing the risk of lethal accidents in the traffic between 1975-1985 also very accurately prognosed future death numbers year by year in the Swedish traffic. This was first highlighted in the report of 1997, [3]. Since the model has shown to fit very well to reported data until today, the Swedish Road Administration recently requested an indepth presentation for the management and their experts, [5].

Global heating

The global climate change is a challenge to all of us. One very important question is to what extent and how fast the global temperature will increase due to the sudden (in geological terms) increase of atmospheric contents of carbon dioxide (CO_2) and other green house gases (GHG). Since data on the global temperature and CO_2 contents were available since 1850 it was possible to extract the characteristic parameters of a temperature response function. Future temperatures can then easily be estimated by the method. In the same way it was possible to use data from predictions done by the Intergouvernmental Panel on Climate Change (IPCC) to extract corresponding parameters they have been using. We found that reported data indicate that the temperature increase will become substantially higher than what IPCC currently are projecting, [6].

Melanoma epidemic

Within the science of epidemiology cancer incidence trends are often characterized by age and birth year. The models used are regression models where many parameters are varied to fit reported data. There is, however, no physical background to these models so the relevance for extrapolation into future trends may be limited. We designed a physical model of the risk that an initial skin damage develops into melanoma based on a cancer risk over time combatted by a skin repair probability over time. Our general model was then used to calculate the melanoma risk by age and calendar time fo all birth cohorts of interest. Only two model parameters were varied to fit calculated age-standardized rates with reported data. A remarkably good fit to age-specific data was arrived at, both vs. calendar time and vs. birth year, [7]. A more detailed description of the model work and results is given in ref. [8]. A competing model assumed that the main reason for increasing melanoma rates was increasing sun tanning habits. This model could, however, not be made to fit both reported age-standardized and age-specific data.

Conclusions Physical models can easily be tested against reported data and become very useful for prediction purpose. Models based on wrong physical assumptions will have difficulties to pass theoretical and practical tests and will in the end not fit future data.

Biography

Örjan Hallberg, born 1942, received a Master of Science degree in Electrical Engineering from the Technical University of Chalmers in 1966. After heading a component engineering group within the Swedish Administration of Telecommunication he worked from 1971 to 1981 as manager of the component reliability unit within ELLEMTEL Development AB. In 1981 he was appointed quality manager within an Ericsson company. From 1987 to 2003 Hallberg worked within Ericsson as Qualification and Vendor assessment Manager, Product Improvement Manager and finally since 1998 as Environmental Manager for two business areas within Ericsson. From 2003 onwards Hallberg has been managing his own research company, Hallberg Independent Research.

Hallberg has co-authored one book about long term reliability of technical systems, authored 17 publications in reliability journals and conferences and, so far, authored 26 publications in medical journals and conferences. In 1996 Hallberg was appointed Expert Reliability Engineering within the Ericsson Corporation.

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