Société de Calcul Mathématique SA
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Risks analysis

To evaluate a "risk" means, from existing data, to compute the probability that a similar event may occur in the future. It might be, for instance, the breakdown of some component, a human error, a severe earthquake, and so on. We distinguish between two types of risks: ordinary (usually covered by insurance or guaranty) and extreme.

1. Ordinary risks

If the risk deals with the failure of an industrial object, typical questions are:

– How many tests are necessary in order to evaluate the number of returns, after the product has been put on the market?
– How much will the guaranty cost?
– What preventive maintenance is necessary, and how frequent should it be?

These are "ordinary risks" in the sense that one must balance the number of occurrences and the cost of each occurrence.

Our specialty here is the critical analysis of the models. Quite often, indeed, in most accepted situations, the probabilistic laws are oversimplified. People admit that the variables follow a Gaussian law, or a uniform distribution. Or, quite commonly also, people take the data gathered in some situation and use them in another, which is not correctly related. The same way, in many cases, people consider as independent the events which may occur, and they are not in practice. Therefore, the computation of the cost is often wrong, since it is made from improper laws, or improper assumptions.

We analyze the existing models and revise the probabilistic evaluations which were made. We look at possible dependences and artificial assumptions. Also, we consider the uncertainties. The result is a model which is much more robust than the initial one, meaning a better estimate of the cost, as well as a better estimate of the probability of the event.

Books:

[1] Bernard Beauzamy: Nouvelles Méthodes Probabilistes pour l'évaluation des risques. SCM SA. ISBN 978-2-9521458-4-8. ISSN 1767-1175, April 2010 (in French).

[2] Olga Zeydina and Bernard Beauzamy: Probabilistic Information Transfer. SCM SA. ISBN: 978-2-9521458-6-2, ISSN: 1767-1175, May 2013 (in English).

Recent contracts:

- 2005-2006, CEA, Saclay (French Atomic Energy): Probabilistic evaluation of risks associated with transportation of dangerous materials near the site and with the flight of planes above the site
- 2006-2012, Espaces Ferroviaires: Analysis of the risks connected with real estate operations
- 2006, Direction Générale de l'Energie et des Matières Premières: Probabilistic study dealing with the security of supplies for natural gas
- 2007, CEA, Saclay: Probabilistic Methods in Seismology

Report 1: Probabilistic Methods in Seismology; Critical Analysis of the Models
http://www.scmsa.eu/archives/CEA_SCM_Seismes_1.pdf
Report 2: Critical analysis of deterministic formulas.
http://www.scmsa.eu/archives/CEA_SCM_Seismes_2.pdf
Report 3: Using a probabilistic method.
http://www.scmsa.eu/archives/CEA_SCM_Seismes_3.pdf
Report 4: Building a probability law, taking the uncertainties into account.
http://www.scmsa.eu/archives/CEA_SCM_seismes_4.pdf

- 2008, Agence Nationale des Titres Sécurisés, Ministère de l'Intérieur : Search for vulnerabilities in the new biometric passport.
- 2008, Société GPN: Critical analysis in seismology.
- Réseau Ferré de France, 2008-2013: Analysis of the causes of train delays and investment decisions.
- Snecma Propulsion Solide, 2009: Probabilistic methods for reliability.
- Réseau de Transport d'Electricité, 2009: Critical analysis of epidemiological studies.
- Institut de Radioprotection et de Sûreté Nucléaire, 2009: Probabilistic safety analyses.
- Institut de Radioprotection et de Sûreté Nucléaire, 2010: Mathematical analysis of the surveillance equipment in a nuclear reactor.
- Groupe Total, 2010: Probabilistic methods for the evaluation of a pollution.
- IRSN, 2011: Probabilistic studies concerning reactors safety.
- Réseau de Transport d'Electricité, 2012: Comparison between a connected network and an isolated network, in terms of reliability.
- Aéroports de Paris, 2012: Critical analysis of epidemiological studies, relating airplanes noise to sanitary consequences in the nearby housing.
- Areva, 2012: Probabilistic methods for the evaluation of mechanical properties of components.

- Agence Nationale des Titres Sécurisés, 2013: Analysis of the data about the biometric passport and analysis of frauds.
- DCNS, 2013: Probabilistic methods for the improvement of an industrial process.
- Espaces Ferroviaires, 2013: Probabilistic analysis of the risks connected with real estate.
- Monceau Assurances, 2014: Redefining the policy associated to some risks.
- L'Oréal, 2016: Study of the risks associated to commuting accidents.
- Monceau Assurances, 2016: Analysis of the excessive amount of accidents in some categories.
- ANDRA, 2016: Analysis of the risks associated with a site for nuclear waste deposit.
- RATP (Paris Underground Railways), 2016, 2017, 2018: Analysis of the behavior of the trains in the situation of an emergency braking.
- RATP, 2018: Probabilistic analysis of the risks associated with some structural deformations.
- Groupe Atlantic, 2019: Probabilistic analysis of the calls to the Consumer Service.
- PSA, 2020: Critical analysis of reinsurance thresholds.

2. Extreme phenomena

A risk is called "extreme" if it is quite rare, but with high consequences; there is no precise definition for that. It may concern natural disasters, such as severe storms, flooding, earthquakes, and so on: the usual insurance is covered by a reinsurance when the cost is above a certain limit. The evaluation of the probability of such events is difficult to make, because the occurrences are rare and quite often the data are imprecise.

For such extreme events, we developed specific methods, in the framework of contracts with the French "Caisse Centrale de Réassurance" (2009-2011). They are described in our book [1] below.

Such probabilities were previously evaluated by means of artificial and arbitrary laws, such as the Gumbel laws, chosen because they use only a small number of parameters, easy to set when the data are not numerous. This may be acceptable in an academic setting but should be forbidden when we deal with real life phenomena: to use an artificial law is just as unacceptable as to use artificial data. Moreover, the adjustment by Gumbel laws is very sensitive to the uncertainties upon the data, and in all such cases the data are very uncertain: one has no precise knowledge of the intensity of the earthquakes, a hundred years ago.

Our method simply requires a sample, consisting in any number of observations. Here are some examples:

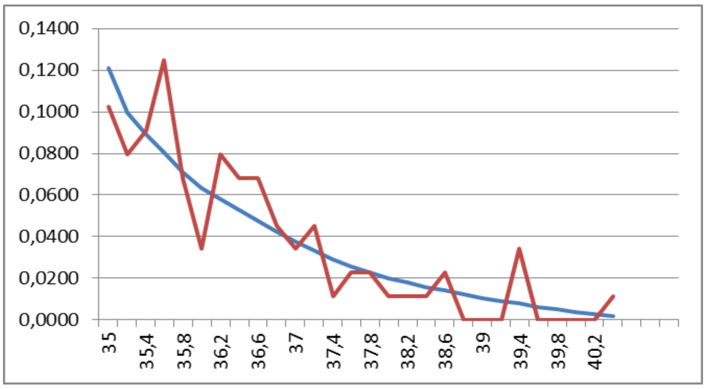
- Temperatures $\geq 35°C$ in Paris, precision $0.2°C$, number of days where each temperature was observed.
- Ocean water height ≥ 90 cm, in Marseilles, precision 5 cm, number of days where each height was observed.
- Delays of the trains, Paris region, number of trains affected by a given event, in a year.

Of course, the number of occurrences depends on the observation period. It may be since the origin of the measurements (for instance, meteorology) or upon a year (for the trains).

The output of our method is a probability law for each possible value: for each temperature, for each water height, for each number of trains. They are conditional probabilities; the information is given by the observations. Such laws are valid even if the observations are not frequent (this is usually the case with extreme phenomena).

The only assumption which is made in our method is that the more extreme the phenomenon is, the lower its probability.

Here is an example of what our method gives, dealing with extreme temperatures in Paris. In red, the observed values (upon 137 years), in blue, the probability computed from our method.



Our method also gives confidence intervals for each estimate, and not only a precise value for the probability. It also covers the so-called "joint laws", that is to say, simultaneous occurrences of two or more extreme phenomena, perhaps in different locations (article [3] below).

During the fall 2013, we applied these methods, as part of a contract with Vinci Construction Grands Projets (COSEA), about the construction of the fast train TGV Sud Europe Atlantique. The question was about the value of the centennial debit which should be considered for the rivers Vienne and Creuse: their confluent occurs just where the train passes.

The French Authorities, using ajustments with the Gumbel laws, came to an estimate of 3 150 m3/second for the river Vienne, and COSEA, using other ajustments, came to 2 700 m3/s. Our methods showed that this last value in fact had an average return time of 160 years, so it was a conservative value.

Our studies are written in order to be directly communicated to the Safety Authorities, in all domains. We take full responsibility of the results we obtain and of the methods we use.

References

Book

[1] Bernard Beauzamy :Méthodes probabilistes pour la gestion des risques extrêmes. SCM SA. ISBN: 978-2-9521458-9-3, ISSN: 1767-1175. June 2015 (in French).

Articles

[1] 2009, SCM SA, Bernard Beauzamy : Robust Mathematical Methods for Extremely Rare Events : http://www.scmsa.eu/RMM/BB_rare_events_2009_08.pdf

[2] 2009, Peter Robinson, Quintessa Limited: Efficient Calculation of Certain Integrals for Modelling Extremely Rare Events:
http://www.scmsa.eu/RMM/ART_2010_Peter_Robinson_Efficient_Integration.pdf

[3] 2011, SCM SA, Bernard Beauzamy and Olga Zeydina: The joint probability law of extreme events:
http://www.scmsa.eu/RMM/BB_OZ_Joint_Law_Extreme_Events_2011_04_16.pdf

[4] 2012, SCM SA, Bernard Beauzamy: The probability of extreme events: Explicit computations
http://www.scmsa.eu/RMM/BB_closed_form_extreme_events_2012_09.pdf

Recent contracts

- 2004-2005, CNES (French Space Agency): Probabilistic maps related to the fall of space debris
- 2006-2011, Institut de Radioprotection et de Sûreté Nucléaire: Probabilistic methods for nuclear safety; definition of the Experimental Probabilistic Hypersurface
- 2007-2008, Délégation à la Sûreté Nucléaire et à la radioprotection pour les activités et installations intéressant la Défense : About the precise definition of probabilistic studies for nuclear safety
- IRSN, 2012: Computing economic indicators in case of a severe accident
- Vinci Construction Grands Projets (Ligne à Grande Vitesse Sud Europe Atlantique), 2013: Estimates for the return period of extreme flooding

http://www.scmsa.eu/archives/SCM_COSEA_Rapport_Crues_Vienne_2013_10_01.pdf

- EDF (French Electricity), 2015: Risk analysis and recommendations in order to improve the quality of safety procedures.
- IRSN, 2015-2016: Analysis of the risks associated with the malfunction of sensors
- Monceau Assurances, 2017, 2018: Modelling natural hazards and their impact on the insurance portfolio.
- PSA, 2020: Critical analysis of reinsurance thresholds.