Société de Calcul Mathématique SA
Mathematical Modelling Company, Corp.
Tools for decision help
since 1995

Malfunctions of sensors

- Our working program -

The information which is collected, in order to ensure the surveillance of a system, usually comes from one or several sensors. It may deal with the measurement of a temperature, of a number of cars, of a radioactivity level, and so on. Before taking a decision, before acting on the system, one should wonder if the information received is correct or not: this is common sense.

This is quite obvious if the system is supposed to be "autonomous", such as a vehicle without any driver, because then the behaviour of the system depends directly upon the perceptions gathered by the sensors.

But, unfortunately, common sense is not so common. Many organizations, companies, have a blind faith in their data, take a decision from these data, and discover later that the data were not correct.

I. Types of malfunctions

There are three types of malfunctions:

- Complete failure: the sensor indicates nothing;
- Excessive uncertainty: the precision is so poor that the information is rather useless;
- False alarm: the sensor indicates situations which have no reality.

II. The need for a validation

Usually, one can check and validate the information, from the comparison between different sensors or from the history of a given sensor. If, for instance, the measurement deals with a pollution in a river, downstream should indicate more than upstream. If it deals with a fire, it should be detected by several sensors, not just one.

Such a validation may be made on statistical grounds, with some delay. For instance, after a year, we would compare the recordings and find that a station did not work correctly. The validation is also possible in real time, but this assumes that the sensors are close enough one from the other, so that there are non-empty intersections of their surveillance zones. This requires that the network of sensors has been designed with this preoccupation in mind. If every surveillance point is monitored by two sensors at least, when these sensors do not agree, one can say that there is something wrong with one of the sensors at least.

SCM has conceived methods in order to detect aberrant data and methods in order to reconstruct missing data; please see our books [RDM] (in French) and [PIT] (in English) and our competence sheet "Quality of Information" :
http://www.scmsa.eu/fiches/SCM_Quality_Information.pdf

III. The conception of a robust network

This is obviously a preoccupation that one should have before the installation. It means that the malfunction of any sensor will be detected and recognized. Contrarily to what people often believe, having too many sensors is not a good idea, due to false alarms. The more numerous the sensors are, the more frequent the false alarms will be. If this happens in critical situations (fires, radioactivity), then immediate verifications are necessary and they are costly. In such cases, it is better to use sensors that are less sensitive, but more reliable.

As a general statement, a network using several simple sensors will be more robust, and finally more precise, than a unique sensor, supposed to be more sophisticated. Please see our book [MPPR] (second edition, chapter 13 : fusion multicapteurs) about this topic.

IV. Working program

Many organisations, companies, institutions, have simulators in order to properly analyze the behaviour of complex systems. These simulators, usually, are not properly equipped in order to reproduce all possible anomalies of the sensors (failures, uncertainties, false alarms). Our working program aims therefore to complete the simulators so that they can take into account these difficulties. Each of them should be given a proper probability law. The question of independence of events should be addressed.

A second element of importance is the possible presence of a human being in the decision process. In some cases, the sensors provide the information, and the decision is taken by a human being. In other cases, one considers that human beings are not reliable enough, and that some automatic system should take the final decision (and, in particular, prohibit some actions). Our role is here to provide simulations of both modes, so that one can analyze correctly the advantages and disadvantages of each of them.

V. Our publications

1. Books

[MPPR] Bernard Beauzamy : Méthodes Probabilistes pour l'étude des phénomènes réels. SCM SA, ISBN 2-9521458-0-6, ISSN 1767-1175, mars 2004 ; seconde édition, juin 2016 (in French)

[RDM] Bernard Beauzamy et Olga Zeydina : Méthodes probabilistes pour la reconstruction de données manquantes. SCM SA, ISBN : 2-9521458-2-2, ISSN : 1767 – 1175, avril 2007 (in French).

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

2. Articles

[1] Emmeric Dupont (NEA), Bernard Beauzamy (SCM), Hélène Bickert (SCM), M. Bossant (NEA), Carmen Rodriguez (SCM), N. Soppera (NEA) : Statistical Methods for the verification of databases. Publication de la Nuclear Energy Agency de l'OCDE, 2011. http://www.oecd-nea.org/nea-news/2011/29-1/29-1-int-e.pdf#page=32

[2] O. Zeydina (SCM), A.J. Koning (NEA), N. Soppera (NEA), D. Raffanel (SCM), M. Bossant (NEA), E. Dupont (NEA), and B. Beauzamy (SCM): Cross-checking of large evaluated and experimental databases, Science Direct, Nuclear Data Sheets 120 (2014) 277–280. http://www.scmsa.eu/archives/NEA_SCM_2014.pdf

[3] Emmeric Dupont (NEA) : Exfor : Improving the quality of International Databases. NEA News, 2014, 32.1, page 28. http://www.scmsa.eu/archives/EXFOR_NEA_News_2014_32.pdf

[4] V. Khalipova (SCM), G. Damart (SCM), B. Beauzamy (SCM), G. B. Bruna (IRSN) : Malfunctions in radioactivity sensor's network. Submitted for publication.

[5] Gottfried Berton (SCM) : Verification of the databases EXFOR and ENDF. Nuclear Energy Agency, JEFF Meetings - Session JEFF Experiments, November 28 - December 1, 2016. http://www.scmsa.eu/archives/SCM_NEA_JEFF_Meeting_2016_11.pdf

VI. Recent contracts

Quite generally, all contracts treated by SCM since 1995 showed anomalies in the available information, resulting usually from malfunctions of sensors. We indicate the most recent ones.

– Agence Européenne de l'Environnement, 2006-2013 : Méthodes probabilistes pour la qualité de l'eau
– Veolia Environnement, Région Ouest, 2007 : Détection de dysfonctionnements dans les réseaux de capteurs
– Veolia Environnement, Région Ouest, 2007-2009 : Constitution d'un panel de consommateurs et prévision des consommations d'eau potable

- Institut de Radioprotection et de Sûreté Nucléaire, 2007-2011 : Applications de l'Hypersurface Probabiliste aux problèmes de sûreté des réacteurs nucléaires
- International Stainless Steel Forum, 2008 : Analyse générale du système d'information et préconisations relatives au traitement statistique des données
- Agence de l'Eau Artois-Picardie, 2008 : Etude probabiliste concernant la qualité des eaux de rivière et caractérisation des situations de bonne qualité
- Areva, 2010 : Méthodes probabilistes pour l'étude d'un stockage de déchets radioactifs
- Nuclear Energy Agency (OCDE), 2010, 2012, 2014, 2015, 2016 : Detection of aberrant data in nuclear databases
- Air Liquide, 2011 : Construction d'un "indice de proximité" entre pipe-lines
- ArcelorMittal, 2011-2012: Méthodes probabilistes pour la hiérarchisation des paramètres dans un process industriel
- GDF-SUEZ, 2012-2013 : Analyse générale de la qualité des données, distribution du gaz
- Areva, 2012-2013 : Analyse des incertitudes dans un process industriel
- Air Liquide, 2012 : Analyse générale de fiabilité ; interopérabilité de plusieurs bases de données
- IRSN, 2012 : Analyse statistique préliminaire de données de radioactivité dans l'environnement
- DCNS, 2013 : Méthodes probabilistes pour l'amélioration d'un procédé de soudage
- RFF, 2013 : Amélioration de l'outil de mesure de criticité des lignes Transilien
- COSEA (Ligne à Grande Vitesse Sud Europe Atlantique), 2013 : Estimation de la durée de retour de crues extrêmes
- IRSN, 2013-2014 : Analyse du fonctionnement du réseau TELERAY : surveillance de la radioactivité ambiante.
- IRSN, 2014 : Analyse du "risque résiduel" en sûreté nucléaire.
- IRSN, 2014-2015 : Outil d'aide à la vérification des comptes de matière nucléaire
- EDF/SEPTEN, 2015 : Prise en compte des incertitudes dans les Etudes Probabilistes de Sûreté.
- IRSN, 2015 : Analyse dynamique du réseau TELERAY, en cas de déplacement d'un panache de radioactivité.
- IRSN, 2015-2016 : Dysfonctionnements dans les réseaux de capteurs.
- RATP, 2016 : Planning de remplacement d'équipements critiques.
- ANDRA, 2016 (French Agency for Nuclear Waste Management): Best position of sensors in order to monitor a site for nuclear waste.