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VALORISATION

# FROM TALLY TO FORETELLING

The exact prediction of time, date and location of future fire incidents will remain beyond the reach of ICT. But the project Data-Driven Risk Management for Fire Services intends to inch closer to that situation. For example, the indication of the seasonal incidence of chimney fires in 1930s neighbourhoods has become within reach. This allows fire services to optimise their capacity deployment and address prevention activities.

**By Leendert van der Ent**
Images WAT ontwerpers

'Timely, measured response based on expectancy will go hand in hand with effective prevention'

Data science student Tineke School dedicated her master's thesis to the prediction of chimney fires in the operational territory of Brandweer Twente (Twente Fire Service). Ron de Wit, deputy commander at Brandweer Twente: 'The result was a successful web application. The topic became quite a hit in regional media.' It also gave rise to a sequel; the data allow for further elaboration. The fourteen municipalities of Twente have kept records on categorised fire incidents since 2004. De Wit: 'This database is now proving its value. Scientific analysis also lays bare some flaws. This new project allows us to underline the need for high-quality registration and enriched data. Once you know what the data can bring you, awareness grows about the importance of correctness and completeness.'

The leader of the present project is Marie-Colette van Lieshout, Professor of Spatial Stochastics at the University of Twente and staff member at Centrum voor Wiskunde & Informatica (CWI) in Amsterdam. The research is done by a PhD Student under the operational supervision of associate professor Maurits de Graaf from Mathematics of Operations Research at University of Twente and who is also active for Thales Nederland.
Van Lieshout: 'Can the data support preliminary assumptions? Analysis will tell. This asks for the handling of unstructured, complex data. That is where machine learning comes in. And when it comes to interpreting underlying mechanisms, stochastic statistical models are used. The most important aspect is the integration of both technologies.'

## Scientific challenge

The project's biggest scientific challenge is finding patterns in space and time without inappropriate stationary assumptions, says Van Lieshout. 'The data consist of a single realisation of a point process. Classic spatial stochastics relies on certain assumptions that do not hold for our data, as information from long ago and far away does not tell as much about the risk of a chimney fire as data from here and now. In these cases, classic assumptions do not lead to valid outcomes.'
De Graaf: 'Working with the arithmetic mean is not an option with the datasets. In order to predict the confidence interval, you have to model the uncertainty. Bayesian inversion is the way to go.' Alternatives have to be carefully weighed and combined. Van Lieshout: 'You need to deploy Bayesian hierarchical models, alongside Monte-Carlo simulation-based statistical inference.'

Bayesian mathematics turn out to be an important ingredient in the project approach. Van Lieshout explains: 'Risk is something you cannot observe. Datasets contain information on incidents that did actually happen. Bayesian statistics can be used for inversion because it is able to translate observed incidents reliably into unobserved risks.'
The risks depend on sometimes quite logical and, in other instances, more surprising explanatory variables. Variables such as "the house has a chimney" and "it's autumn" can be expected to heighten the incidence of chimney fires. 'But the fact that houses from 1920 to 1945 ran a higher risk of chimney fires was quite surprising. We don't have an explanation yet, but we will look into it. Could it be the construction of the chimney?', De Wit wonders.

There are all kinds of variables: the weather, the type of house (detached, semi-detached), the building period and more. Machine learning techniques will bring unclear explanatory variables to the surface and Bayesian statistics will quantify the risk.

## Clear benefits

With the project a year underway now, De Wit can already highlight practical benefits from predictions. 'We now have the same capacity stand-by at all times: 24/7, the whole year long. That is because we cannot match capacity to risk yet. The operational guarantees are the same at all times and locations, but the idea is that this could be differentiated in accordance with the predicted risk. Once we have a careful, elaborate and accurate expectancy of incidents over time and space, we will be able to adjust preparation of capacity of staff and equipment to actual risk.'
That means more capacity will be available when it is really needed. De Wit: 'Once we know what a "code yellow storm" means in terms of specific capacity demand, we will be able to scale up beforehand. Of course, we were always able to act on the basis of educated guesses. But now, for the first time, we will be able to anticipate on a scientific basis. That makes a big difference. Being able to turn intuitive knowledge into a rock solid assessment is a relief.'

There is a second important benefit, De Wit emphasises. 'The project will show us patterns. It will hand us the required insights to approach specific target groups in our prevention policy. Timely, measured response based on expectancy will go hand in hand with effective prevention. A targeted message to owners of specific risks connected to specific types of houses works far better than a generic message to all.'
It is clear that the project benefits are not limited to fire services, nor to Twente. De Graaf: 'Police forces, which are included in the user group, can equally benefit from the approach, as could other first responders.' De Wit: 'With Twente, we now get a risk profile of one safety region. This approach can be easily scaled up to all 25 safety regions – hence the participation of Brandweer Nederland [Dutch Fire Service].'

*'We cannot match capacity to risk yet'*

## DATA-DRIVEN RISK MANAGEMENT FOR FIRE SERVICES

Project duration:
**1 September 2020 to 1 September 2024**

Budget:
**400,000 euros**

Knowledge institutions:
**CWI and University of Twente**

Partners:
**Amsterdam-Amstelland Fire Service, Dutch Fire Service, Twente Fire Service, Datacadabra, Institute for Safety, Amsterdam Police, Enschede Police, Thales**