SPIRIT: Interactive Prediction of Sewer Conditions Based on Expert-opinions, Classifications conform EN13508-2 and Geo-information

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Abstract

Management of operation and maintenance (O&M) includes planning of inspections, (long term) planning of rehabilitation and (short term) decisions on combining the replacement of sewers with other works on the infrastructure. These planning schemes are often based on a poor insight in the urgency of the specific actions needed. Even if the actual state of the sewers has been assessed with visual inspections, the future development of the conditional aspects can hardly be taken into account for an accurate planning of O&M activities. With a model called SPIRIT the Dutch RIONED Foundation aims at filling this information gap. SPIRIT will be a practical prediction tool that combines the expertise of senior sewer experts with inspection results and geo-information.

Introduction

Asset management based on reliable predictions of the sewer quality can be called predictive asset management and will be the next step in the ongoing professionalisation of sewer system management.
A reliable prediction, with an indication of the accuracy, supports a better planning of O&M as well as a more sound argumentation for financial reservations and depreciation of assets.

So far a prototype of SPIRIT has been developed (Beenen et. al., 2005), the statistical methodology is designed (Korving et. al., 2006) and a roadmap has been made for the practical implementation of predictive asset management for sewer systems (Rabenort et. al., 2005). This abstract deals with the further development of the prototype.

SPIRIT

SPIRIT is a Dutch acronym for software plug-in in sewer management software packages for interactive prediction of sewer conditions. SPIRIT is an interactive model to assist the sewer system managers in planning operation and maintenance. SPIRIT will be implemented in existing sewer management software packages (see figure 1). In this manner the needed data is at hand and the users don't need to get acquainted with a new interface. Once SPIRIT is implemented the users wont notice any difference in their day to day working routing but a better prediction of sewer conditions.

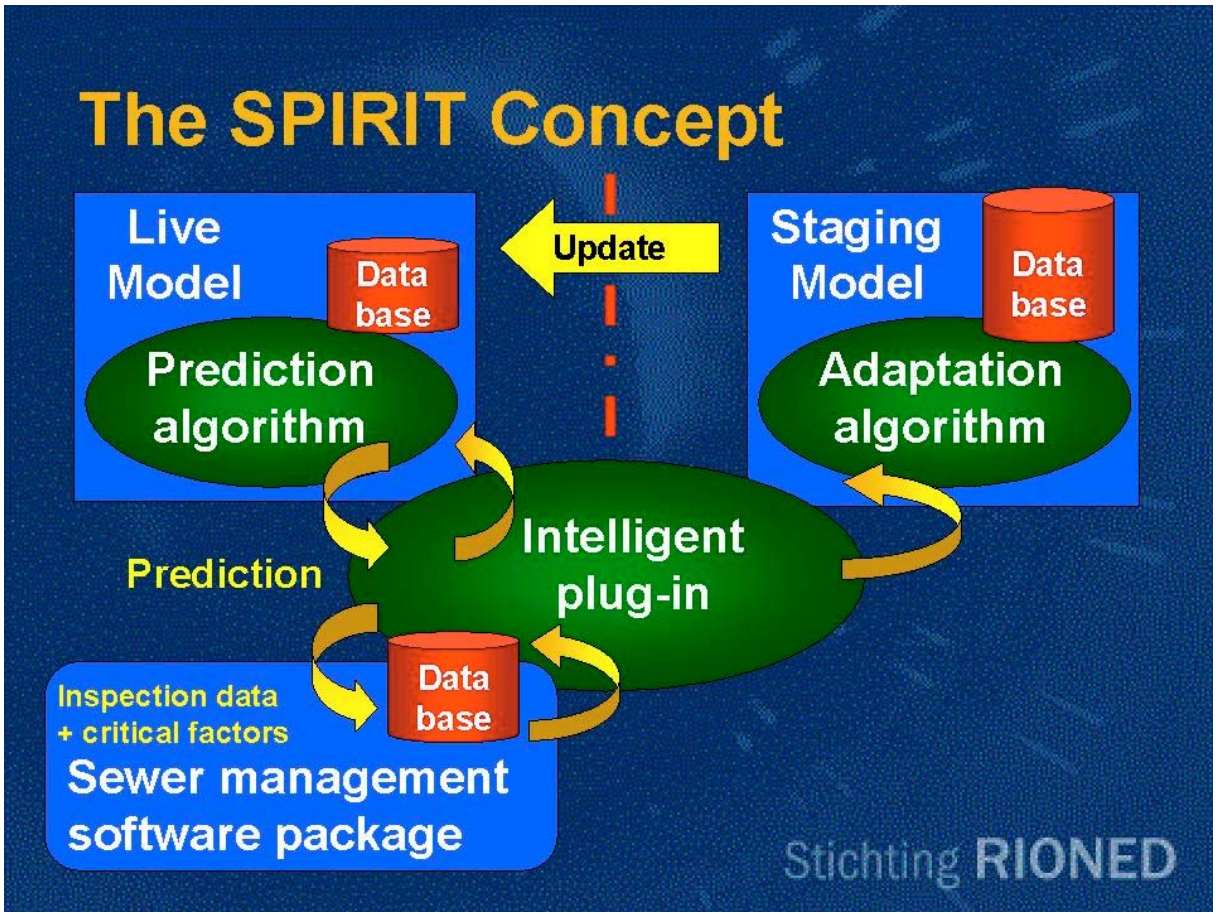

Figure 1. SPIRIT: Plug-in for sewer management software packages

SPIRIT predicts the degradation of sewers with the statistical relations based on a large database containing condition assessments of sewers combined with relevant geo-information.

Internet technology provides the data communication between the central model and the local users. The sewer system managers can upload the characteristics of a sewer section to SPIRIT. Geo-information will be added from existing geo-information gateways. SPIRIT calculates a prediction of the quality of that sewer section and downloads this prediction towards the locally used sewer system management software.

Every time SPIRIT is used the uploaded data is captured to extend the underlying database. An adaptation routine based on Bayesian statistics improves the accuracy of the calculated predictions. This interactivity makes the model self learning and completes the puzzle of sewer degradation processes by combining the scattered pieces of information.

SPIRIT will be implemented as an Internet application with an intelligent software plug-in for sewer system management software packages currently used by the municipalities. The plug-in organizes the data communication between the local databases with the inspection results, the central database of SPIRIT and the distributed databases with geo-information (see figure 2). Implementing SPIRIT in the existing software packages the sewer system manager can use a familiar interface. In this manner the manager doesn't have to learn how to use SPIRIT. Behind the

screens SPIRIT will just combine the needed data and downloads the calculated predictions to the locally used sewer system management software package. At the same time the uploaded data will be captured into the central database. This new data will adapt the model and in the long term a national database on sewer quality in The Netherlands will be developed.

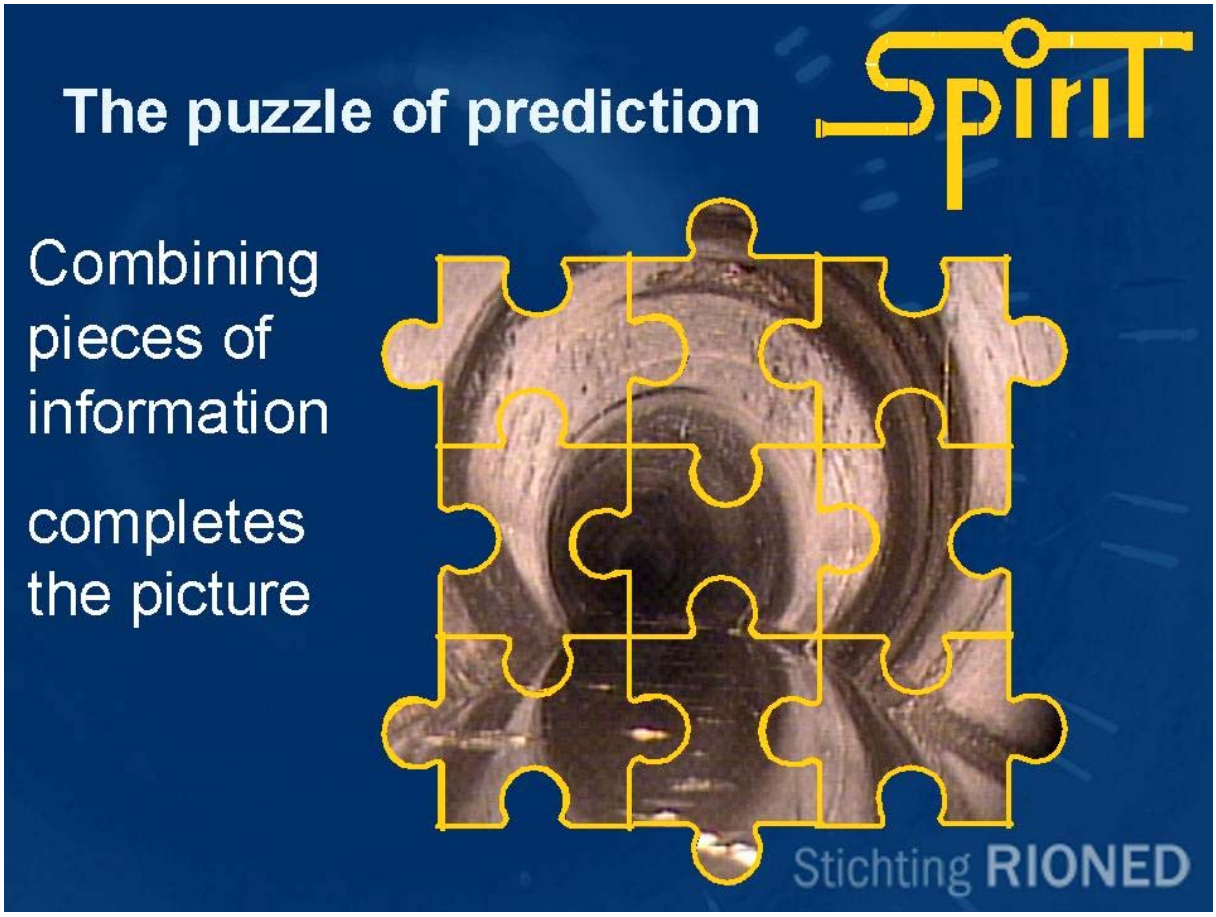

Figure 2. Solving the puzzle by combining pieces of information

Interactive use of Geo-Information

SPIRIT takes several circumstances of the sewer in account such as type of sewer, depth of sewer, year of construction, material, diameter, type of sub-soil, groundwater tables and traffic load. Some of these critical factors are not recorded in the sewer system management software and thus can be hard to provide. SPIRIT will fill eventual information gaps using data from existing geo-information gateways to supply the model with the needed data. On the other hand it is possible that a local sewer system manager has better, more detailed geo-information than yet available in the national databases. In this case it should be possible to extend and/or update these national databases in return for using them.

Research

One of the goals in the current phase is combining local information on the quality of sewers with geo-information available from existing gateways. A win-win situation can be created. Sewer system managers can improve their asset management and

with the same effort improve the databases on geo-information. Another goal of the SPIRIT project in the long term is a national database on the quality of sewer systems in The Netherlands. This database can offer great opportunities for research, for instance on the topic of which influence is most critical for sewer degradation.

Some questions need to be answered before reliable implementation of SPIRIT as an interactive tool with strong win-win potential becomes possible.
Inconsistencies could arise between central stored global geo-information and local available detailed data. The question is how to decide what data-source is most reliable and how this influences the updating process. A decision strategy has to be made on how to deal with possible contradictions.
SPIRIT uses Bayesian statistics as well for defining the relations between historical field data and expert expectations of degradation as well for updating the self learning algorithm. Proper use of the Bayes theorem needs an estimated prior. In the project we need to investigate what a realistic prior is for the adaptation algorithm.

Data acquisition

The statistical relations used in SPIRIT are based on three types of information:

1. Expert opinions;
2. Single records of a sewer condition, a certain classification and a set of critical factors;
3. Double records of sewer sections that have been inspected twice with a specified number of years between those two inspections.

Each group of information is used for a special group of conditional aspects from EN13508-2. These groups are characterised as specified below (see figure 3).

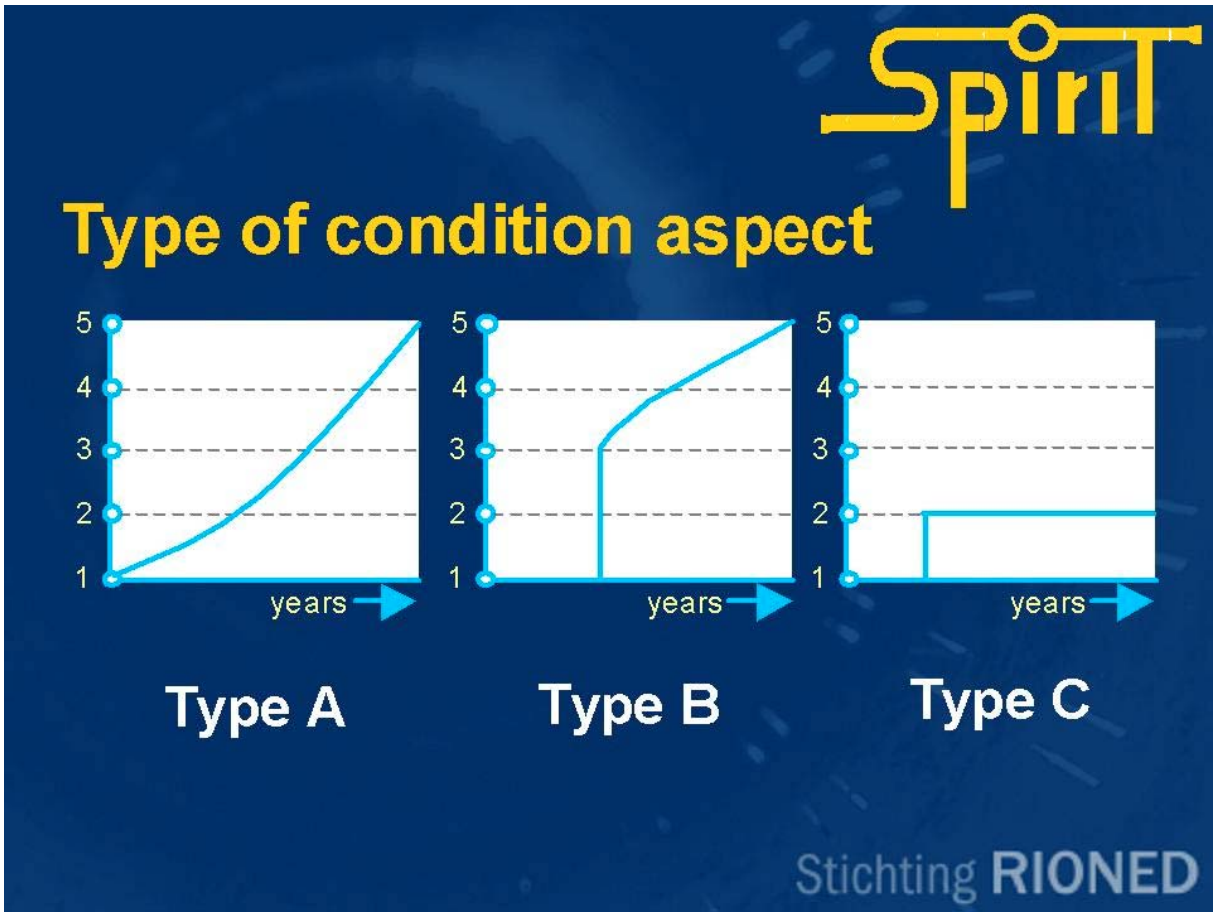

Figure 3: Different behaviour of conditional aspects need in time

Type a.: Aspects that show a gradual degradation through the years passing by (e.g. corrosion of concrete pipes (code BAF));

Type b.: Aspects that appears suddenly and from that moment show a gradual degradation (e.g. cracks (code BAB));

Type c.: Aspects that don't have a development in the classification with increasing time (e.g. objects (code BBE)).

'Type-c' aspects are not useful to predict as they don't have any development at all. 'Type-b' aspects can be predicted with statistical relations based on historical data as formed by double records. These aspects can also be predicted with expert judgement. Type-a' aspects can be predicted with statistical relations based on all three kinds of information.

Information types 1 and 3 are the most difficult to obtain. For that reason some efforts have been made to make an efficient combination of information sources and types of aspects. Furthermore it is obvious that not all possible combinations of condition aspects and critical factors are relevant. Expert consultation resulted in a reduction from 306.720 combinations to 162 combinations that will be presented to a group of 16 experts to give their opinion on the probability of increase of the classification respectively 5 or 10 years after the date of inspection.

Conclusions and outlook

Information and expertise needed to predict the condition of sewers is scattered among several databases and senior experts. SPIRIT will be an intelligent software plug-in in sewer system management software packages that combines local and national stored information. SPIRIT calculates a prediction of the sewer quality and extends the underlying database every time it is used. SPIRIT supports predictive asset management of sewer systems and generates a valuable database on the state of the art of the Dutch sewer systems.

Keywords

Asset management; Database; Geo-Information; Internet; Sewer systems; Urban drainage; Prediction.

Literature

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