WAPUG MAY 2003

THE ISAAC PROJECT

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Background

The ISAAC project came out of WRc's business relationship with 2 organisations with substantial expertise in digital images, The Czech Technical University in Prague, and the IMK Fraunhofer Institute in Bonn. All parties felt there was scope for applying image technology to sewer inspection and a project was formed which fitted the EC's 'Information Society' programme under Framework 5. The project was to be a trial of existing methods applied in a new way rather than complete new techniques, and 5 methods to be tested were listed in the proposal. It was a 12 month project completed in December 2002. The other partners with WRc were Pearpoint-Telespec, Anglian Water and the Prague Water Company.

Scope of the project

The project consisted of 4 stages:

1. A specification stage where the end users set out in detail what they wanted from the technologies in the trial.

2. A laboratory stage, where the techniques were adapted in the lab using mock-ups of pipelines and inspection systems.

3. A sewer trial.

4. An evaluation and dissemination stage.

User requirement specification

The user requirement specification was intended to give direction to the technology providers. It helped to focus resources on how the project could deliver faster and hence cheaper inspection, and on ways of increasing the value of the data to engineers. The specification also considered the needs of inspection tasks other than the inspection of existing sewers. For example, the acceptance inspection of new sewers is concerned largely with joints, and potentially could use a different device from the standard forward-looking camera. There is a growing market for 'quick' survey information where the operators of a sewer network are to change. This might use a different inspection system and mode of use from that used for standard surveys.

Technology

The 3 most interesting techniques used in the trial will be discussed here, the 'omni-directional camera', mosaicing and laser-based orientation.

Omni-directional camera. The omni-directional camera is illustrated in figure 1. It comprises 2 steps:

- Recording an image of the pipe which includes an annular section of the pipe wall;

- Using a transformation to convert this into a 2 dimensional strip as though the pipe ring had been spread out flat – a process we called ‘unwarping’.

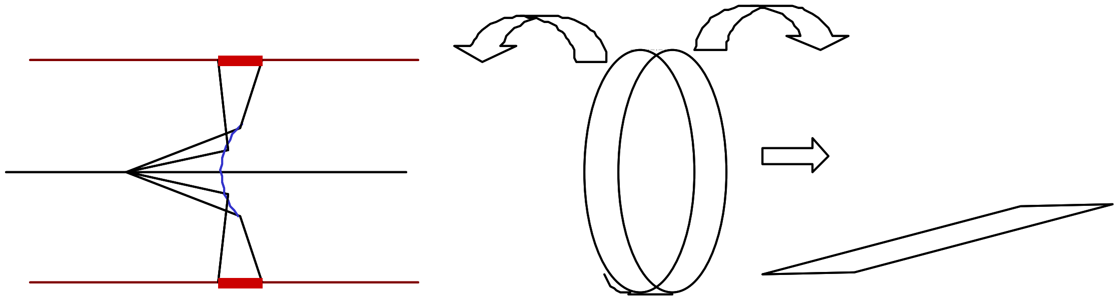

Figure 1 Schematic of the omni-directional camera

In the ISAAC project a parabolic mirror was used to generate the annular pipe image rather than a fish eye lens. A very fast technique was developed so that the camera could show the 2 dimensional ‘unwarped’ image in real time. The technique also includes dealing with data collected with the camera off-centre which would otherwise distort the images.

The omni-directional camera is a complex procedure, but it has several benefits:

- cracks and displaced joint defects are much easier to size;

- A metric scale can easily be applied to the unwarped images and this can be done both live and on stored images. This enables slowly changing defects to be reinspected and the change to be measured;

- Where at the moment a pan-and-tilt survey is needed, it may be possible to replace this with the omni-directional camera and save the time spent moving the camera head.

- For defects in the plane of the pipe wall, it is much easier to perform automatic defect recognition on an unwarped image than on conventional video images.

Mosaicing. Once the pipe images are in the unwarped format, it is possible to string them together to make one huge image of the pipe, a process known as mosaicing. There are inherent difficulties in doing this:

- The camera is subject to the usual movement of a survey, so the successive images may not line up properly;

- The lighting is never perfectly uniform and so successive strips of pipe show as bands in the combined image.

Effective solutions for these difficulties have been found and excellent quality mosaiced images were produced in the project. The benefits of mosaicing are:

- A live mosaiced image can be produced showing the data in the context of a good-sized area of pipe which improves viewing;

- The mosaiced image offers much more economical storage than conventional pipe video images. The file sizes are small enough to make direct computer access to full archived data readily achievable.

Laser orientation. A third technique trialled by the ISAAC project is a method for measuring the orientation of the camera in the pipe. This technique was originally designed to be used with a sewer robot to help it to steer its way through a pipe. It uses laser light to project a X into the pipe. The projections of the 2 lines of the X on the circular surface of the pipe appear as 2 intersecting parabolas. By analysing the position of the intersection of the parabolas in the field of view, the camera displacement from the centre line of the pipe can be deduced. If the camera is not pointing parallel to the pipe axis, this can appear as a displacement of the camera, hence it is also necessary to know the inclination of the camera in the pipe from an on board inclinometer.

There was initially some scepticism about whether this technique would be robust in the full range of sewer pipes, where the pipe surfaces can be wet or dry, rough or smooth and may be coated with fats and other debris. Within the scope of the sewers tested the technique worked very well and no problems were encountered in detecting the laser lines.

The main applications for this technique are:

1. to have an automatically centring camera, which would improve the viewing quality of sewer images and would assist in automated defect recognition

2. to use the orientation data to assist in launching and guiding a satellite camera, that is a camera which is pushed into side connections of the main sewer.

At present application (1) is seen as too advanced, and (2) may be a valuable method, depending upon the satellite camera mechanical design.

The future

Sewer inspection is a strongly price-sensitive market, and nothing will gain acceptance in that market if it cannot hold its own on economic grounds. New technology therefore must produce cheaper surveys, or deliver data of greater value. Survey prices will not fall further using existing equipment and methods, it requires a major technical step.

The omni-directional camera could be that step as it can score both by adding value to the data and potentially by making surveys cheaper. The greater value comes through the improved accuracy of crack and joint defect measurement, and the possibility of monitoring sewer deterioration. Reduced inspection costs may be achieved by driving the tractor through a sewer non-stop (apart from obstructions) and analysing for defects automatically.

The X laser device may play its part in ensuring good data from the omni-directional camera, but it also demonstrates that laser patterns, so called ‘structured light’ can be used effectively in sewers. The original structured light technique is the light ring, valuable especially for measuring deformation. The use of this and other laser light patterns are being researched at present for use in sewer inspection. It is likely that they will be used, probably together with both a forward-looking and omni-directional camera, to provide reliable automatic detection and sizing of defects. This may seem like a lot of technology to drive around our sewers, however the parts required are now robust, reliable, and low cost. This is the way forward for both cheaper and better inspection data.