ROBO-SPECT NEWS

ROBotic System with Intelligent Vision and Control for Tunnel Structural INSPECTion and Evaluation

ROBO-SPECT

Issue 1 May 2014

Editorial

Welcome to the first newsletter of the ROBO-SPECT project!

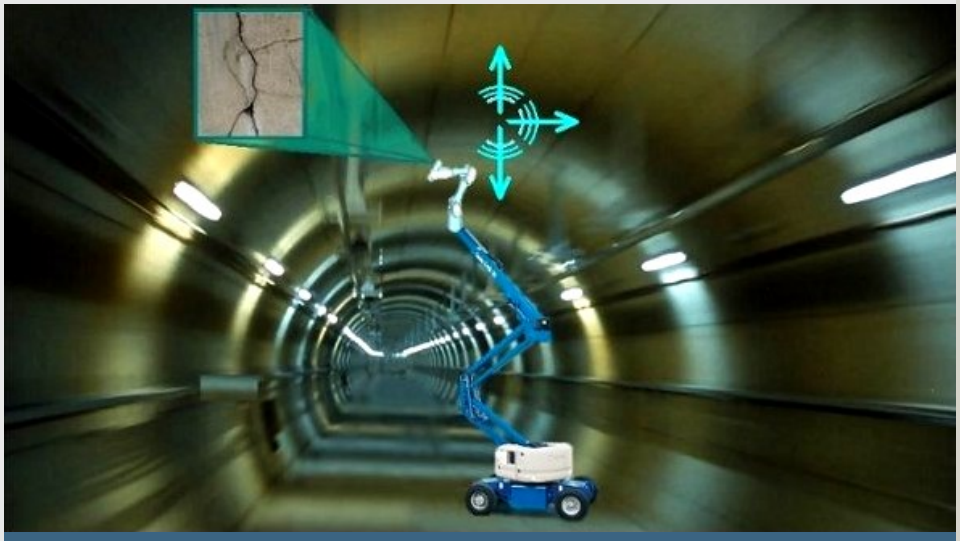
ROBO-SPECT is a European 7th Framework project funded under the ICT programme on Robotics Use Cases (contract No. 611145), implemented by 10 partners from 6 European countries.

The main objective of the project consortium is to provide an automated, speedy and reliable tunnel inspection and assessment solution that can combine in one pass both inspection and detailed structural assessment and that does not, or only minimally interfere with tunnel traffic.. The proposed robotic system will be evaluated at the research infrastructure of VSH in Switzerland, at London Underground and at the tunnels of Egnatia Motorway in Greece.

The project officially launched its activities in October 2013. During the first six months of the project the partners identified an extended group of end-users, derived user requirements and based on these determined the system architecture.

Inside this issue you will find what are the tunnel inspection problems that this project attempts to solve, what the end users need from ROBO-SPECT, an overview of the ROBO-SPECT robotic system and partners' participation in conferences and workshops.

Angelos Amditis
Project Coordinator



ROBO-SPECT

PROJECT FACTS

Duration:
1 October 2013 –
30 September 2016

Total Cost:
4.592.196,00€

EU contribution:
3.306.599,00€

www.robo-spect.eu

In This Issue

Common Practice

Presently, structural tunnel inspection is predominantly performed through scheduled, periodic, tunnel-wide visual observations by inspectors who identify structural defects, rate these defects and then, based on the identified defects and their severity, categorize the condition of the tunnel liner into one of various categories such as critical, serious, poor, fair, good, excellent. When areas of concern are identified, more detailed measurements of the defects are taken, in a subsequent step, through non-destructive or destructive means, to provide the required input for structural analysis. Both steps above are slow and labour intensive while the inspector is working in an unpleasant environment due to dust, absence of natural light and uncomfortable conditions. Moreover, the second step relies on expensive equipment and often needs to be done at 'touching distance' which may necessitate scaffold access which further slows down the process and necessitates closure of at least one lane.

Cracks in tunnels

Spalling

Tunnel Inspection and Assessment Problem

Most of the existing tunnels in Europe and the rest of the developed world are many decades old and have had prolonged exposure to harsh environments and loads. As a result, there are widespread signs of deterioration, evidenced by an increase in the proportion of budgets spent on inspection and assessment. Things are bad to the point that there have been a number of failures resulting in collapses in tunnels in recent years which highlighted the need for better ways to inspect and assess stability of in service tunnels. For instance, well known are failures of the Hanekleiv road tunnel in Norway or the Bosruck railway tunnel in Austria. Similar is the situation abroad: In 2006, a concrete ceiling panel fell in Boston's Fort Point Channel Tunnel killing a person and injuring another one, while in Japan, nine people have died on 2/12/2012 when the ceiling of the Sasago motorway tunnel collapsed, crushing three vehicles with concrete panels.

Additional difficulties

To the above one should add that

(a) the cost of new tunnel construction is very high (120-160 million Euros per km) and, thus, inspection, assessment and repair of the existing tunnel infrastructure is of utmost importance,

(b) the expected high growth in transport demand will be accommodated primarily by existing tunnels, which places greater demands on these structures for inspection and assessment,

(c) the inspection and assessment should be speedy in order to minimise tunnel closures or partial closures, and

(d) the effectiveness of tunnel inspection and assessment is limited by manpower and funding while the increasing need for inspection and assessment only places a greater strain on these two factors.

General View of Tunnel

The ROBO-SPECT Robotic Solution

ROBO-SPECT aims at the development and validation of the prototype of an innovative, automated, intelligent, robotic system for the inspection and structural assessment of transportation tunnels in one pass, speedily and reliably that has the potential to be commercialised in the short to medium term.

Such an automated tunnel inspection system will include:

- A robotic system with navigation and positioning capabilities
- An integrated intelligent control component that should define the orientation and lighting conditions for the cameras and command the robotic system so as to receive “good visual features” while simultaneously determining the movement step needed to inspect the tunnel (e.g., coarser steps for undeteriorated parts of the intrados, finer steps for problematic regions).
- A computer vision system that will combine state-of-the-art machine learning tools to automatically detect defective performance of the lining intrados through visual inspection.
- Sensing capability to provide the required measurements in the identified areas of concern (e.g., structural cracks) with the required accuracy
- And finally, a module that based on inspection results will automatically assess the structural condition of the tunnel lining through the use of civil engineering algorithms

Implementation

The technology in ROBO-SPECT will be implemented in the case of structural inspection and assessment of cast-in-place concrete linings and segmental precast concrete linings for transportation tunnels which will serve as reference structures to demonstrate and field validate and benchmark a practical adoption of this technology. After a successful conclusion of this project, this work will be extended to cover additional tunnel lining materials (e.g., metallic segmental linings).

Expected Results

This work will:

increase the available tunnel capacity by drastically reducing congestion bottlenecks and delays in tunnels due to inspection.

minimise the required inspectors' and engineers' time for structural inspection and assessment of tunnels.

optimise the timing for tunnel maintenance

minimise exposure of tunnel inspectors to dangerous situations.

What Tunnel Management Needs from the Inspection Robot

The identification of the Users' requirements is very important task in the framework of the ROBO-SPECT project as it will help to identify the exact end-user needs and will certainly lead to the system specifications. The Users' requirements have been derived in the domains of the solutions proposed in ROBO-SPECT. Accordingly, these requirements involve transportation tunnels whose lining is made of cast-in-place or segmental concrete and structural inspection and assessment.

The derived **users' requirements** are based on:

- The cases (scenarios) that have been studied
- The background of ROBO-SPECT partners in the domain.
- Questions that were grouped and put into a first draft that was discussed with the users internally and updated several times
- A review of the literature on methods for tunnel inspection and assessment and their shortfalls and misfits

The analysis of user requirements has been performed for the following **frameworks**:

- Requirements for the sensors and computer vision;
- Requirements for the robot;
- Requirements for the structural assessment system;
- Requirements for the integrated robotic system

Crack Growth

Included were requirements for:

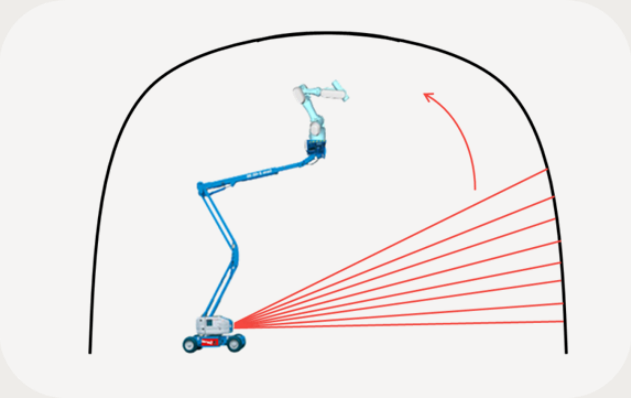
- tunnel geometries and clearance to be covered
- access requirements for metros
- type of material deterioration to be inspected (e.g., corrosion, cracking, opening of joints, missing of connecting bolts, etc.) and the required accuracy of inspection.
- accuracy in the assessment of the deformed shape of the internal face of the permanent lining
- type of structural assessment (deterministic, stochastic)
- control modalities (autonomous, human interaction possible)
- capabilities of the vehicle (be able to move on road and rail, move forward on its own, 'see' and avoid obstacles, control the vehicle position and minimise vibration)
- capabilities of the crane and manipulator (the crane will move the manipulator and the sensors attached to it to the desired position on the lining and will be able to stand forces and torques caused by the manipulator, the manipulator will be able to reach critical lining areas, etc.)
- type of inspection to be performed (fast, coarse inspection with low precision; fine inspection with medium precision and velocity and accurate inspection for structural assessment, where required, with high precision and at low velocity).
- capabilities of the robot (it will be able to perform three types of movements: along the tunnel, around the vehicle and around the primary movements arm once it has reached its final position, etc.).

The ROBO-SPECT Robotic System

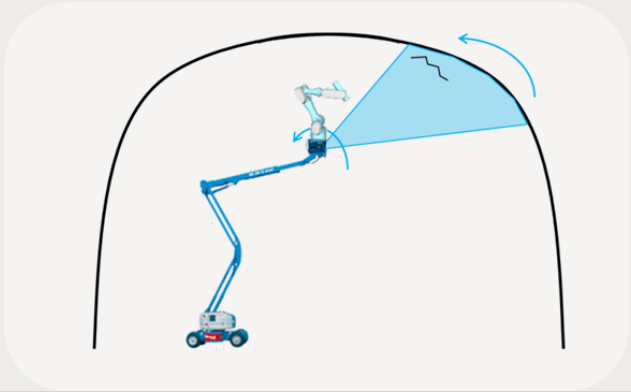
The ROBO-SPECT Robotic System has been designed to be adaptable to various types of end-users and especially to their inspection procedures.

The system is based on 3 major components:

- The **robot** itself described in the previous paragraph "Robotic solutions", composed of the robotic platform, the articulated arm encompassing the sensors and the local processing capabilities comprising the navigation system and the local sensor processing modules;
- The robot **Ground Control Station (GCS)**, used to prepare the missions of the robots, monitor the missions for safety purpose or to re-define the mission if needed and finally to enable the robot to download the data gathered during the inspection for further analyses (analyses of detected anomalies and structural assessment);
- The **control room or the safety room** in the headquarters of the end-user equipped with a central system which supervises the overall safety of the works of engineering. After the inspection missions, the GCS will download the data of the inspections to enable deeper analyses of the anomalies and more detailed structural assessments in order to define the needed curative actions and to eventually update the tunnel 3D model and maps.



Coarse Inspection



Fine detection

These three components can communicate through smart communications solutions defined for the project. Depending on the modes of operation defined by the end-user, the communications can be permanently established or activated on demand by the operator.

For safety reasons, the GCS will be permanently linked to the robot through indoor wireless solutions. The link between the control room and the GCS might not be permanent, especially if the inspections take place far from the control room.

The end-user is therefore provided with a **flexible system** that can be adapted to the configuration of the network and to the specific requirements in terms of *modus operandi.*

High Precision Inspection for structural assessment

News and Events

The official kick-off meeting of the ROBO-SPECT project was held in Athens (Greece) from 9th to 10th of October 2013. As coordinating partner of the consortium, ICCS invited all project partners to this two-day-meeting at Athens where a successful start of the project was ensured.

Upcoming events

ROBO-SPECT presentation during the ISARC 2014 event

The ROBO-SPECT project will be described in the key note speech by C. Balaguer (UC3M) in the ISARC 2014 conference. The title of the speech is 'Towards Fully Automated Tunnel Inspection: A Survey and Future Needs.'
More information for the conference can be found here: www.isarc2014.org/

ROBO-SPECT organizes a special session in the framework of World Tunnel Congress 2015

ROBO-SPECT is organizing a special session at the 2015 World Tunnel Congress in Dubrovnik, Croatia, on "Emerging Technologies for Tunnel Inspection.'

Consortium

- Institute of Communications and Computer Systems (ICCS)
- CASSIDIAN (CAS)
- University Carlos III, Madrid Dpto. De Ingeniera de Sistemas y Automatica Robotics Laboratory(UC3M)
- VSH Hagerbach Test Gallery Ltd. (VSH)
- Egnatia Motorway S.A. (EOAE)
- Institute of Microelectronics and Microsystems, National Research Council of Italy (CNR)
- RISA Sicherheitsanalysen GmbH (RISA)
- Techniche e Consulenze Nell' Ingegneria Civile S.p.A - Consulting Engineers S.p.A (TECNIC)
- D. Bairaktaris & Associates Structural Design Office Ltd. (DBA)
- Ecole des Ponts ParisTech (ENPC)
- ROBOTNIK (ROB)

Contact Us

Project Coordinator:
Angelos Amditis
(a.amditis@iccs.gr)

Dissemination Manager:
Stephanos Camarinopoulos
(s.camarinoloulos@risa.de)

Visit us on the web at
www.robo-spect.eu

Join us on robo_spect
Twittter group

Join us on ROBO-SPECT
LinkedIN group

This project has received funding from the European Union's Seventh Framework Programme under grant agreement no [611145]

END USERS IN THE GROUP

End users that participate as partners, associate partners, subcontractors or members of an extended users' group that has been formed are: EUROTUNNEL, London Underground, RATP (Parisian metro), Attico Metro (Athinean metro), Harcrow Group Ltd., Egnatia Metorway S.A., Aegean Motorway S.A., SITAF, and CETU (in the French Public Roads Administration).