sewer **i**nspection **a**utonomous **r**obot

Paulo Alvito, IDMind
PDTI - SIAR Consortium

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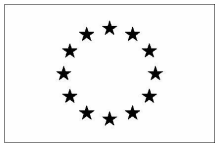

Background / motivation

ECHORD++: Public end-user Driven Technological Innovation (PDTI)

Ajuntament de Barcelona

Barcelona Cicle de l'Aigua SA

"Utility infrastructures and condition monitoring for sewer network. Robots for the inspection and the clearance of the sewer network in cities."

Background / motivation

TYPE OF SEWER	LENGTH (m)	PERCENTAGE
Non visitable sewers	541.000	35%
Semi visitable sewers	148.000	10%
Visitable sewers	843.000	55%
TOTAL	**1.532.000**	**100%**

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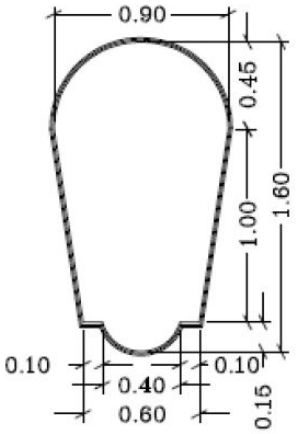

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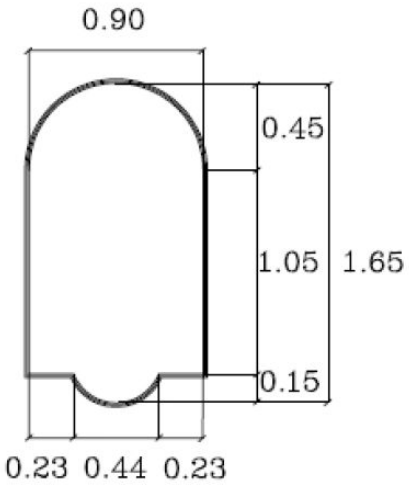


Background / motivation

Sewers' inspection requires special **health and safety** measures

risks like **slippery sections, obstacles or biological risks** from the potential contact with wastewater.

Serviceability inspection (cracks, floor obstructions, air quality, etc)

Background / motivation

Consortium

IDMind (IDM), PT
Universidad de Sevilla (USE), ES
Universidad Pablo de Olavide (UPO), ES

Main Roles

IDM (Coord.) - Platform development and Commercial exploitation

USE - Perception and communications

UPO - Navigation

SIAR Goals

- robust IP67 robot frame designed to work in the hardest environmental conditions;
- increased power autonomy and flexible inspection capabilities;
- robust and increased communication capabilities;
- increased onboard autonomous navigation and inspection capabilities;
- usability and cost effectiveness of the developed solution.

Development Phases

Phase I

Jan 2016 June 2016
Design. Proof of concept.

Phase II

Sep 2016 Sep 2017
Prototyping. Main developments.

Phase III

Dec 2017 Dec 2018
Usability improvement. Exploitation definition.

Developed Solution

Locomotion Platform

- six-wheeled differential kinematic configuration with an axle track width adjustment mechanism
- The axle track mechanism increases the adaptability of the robot to the sewer configuration
- Main features:
  - Weight: 60 Kg
  - Payload capability: 30 Kg
  - Battery autonomy: up to 5 hours
  - Maximum Velocity: 0.8 m/s
  - Height x Max_Width x Length : 44 x 85 x 88 cm
  - Height x Min_Width x Length : 44 x 52 x 1080 cm

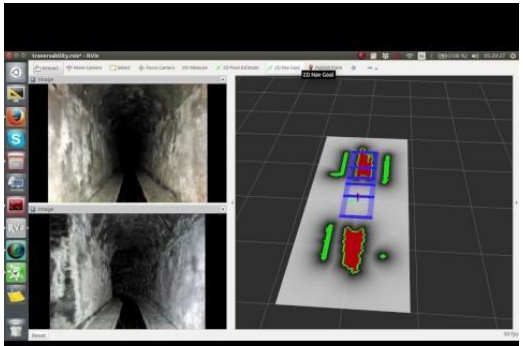
Communications

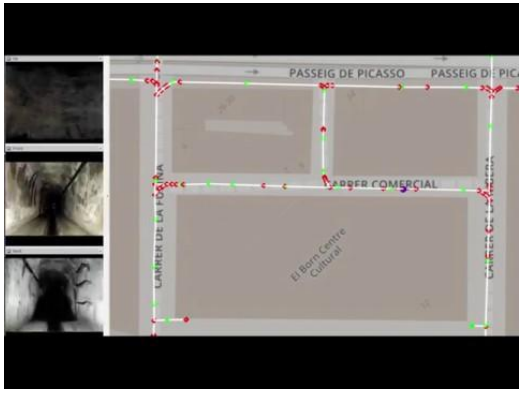
- deployment of self-powered wireless repeaters
- high bandwidth connection used for robot commanding, video streaming and additional information such as 3D

Developed Solution

Navigation

- strategy: let the robot solve the navigation so that the operator can focus in the inspection task
- array of low-cost RGB-D sensors provides fully environment awareness => automatically navigate through the center of the sewer
- system is able to traverse the gutter when needed, i. e., whenever a fork is found; the operator is allowed to choose the new direction to follow
- fusion of onboard sensors and given prior geometric information of the structure of the sewer => self-localization in real-time with an absolute error below 1m

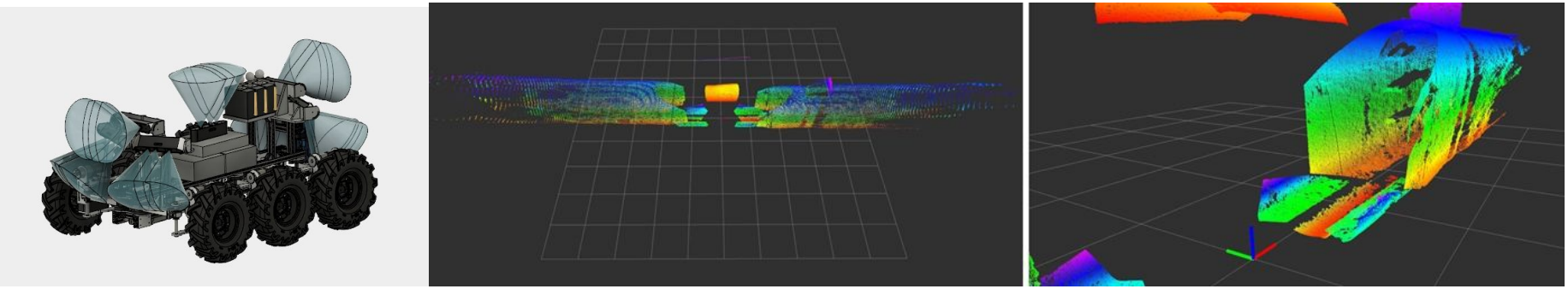




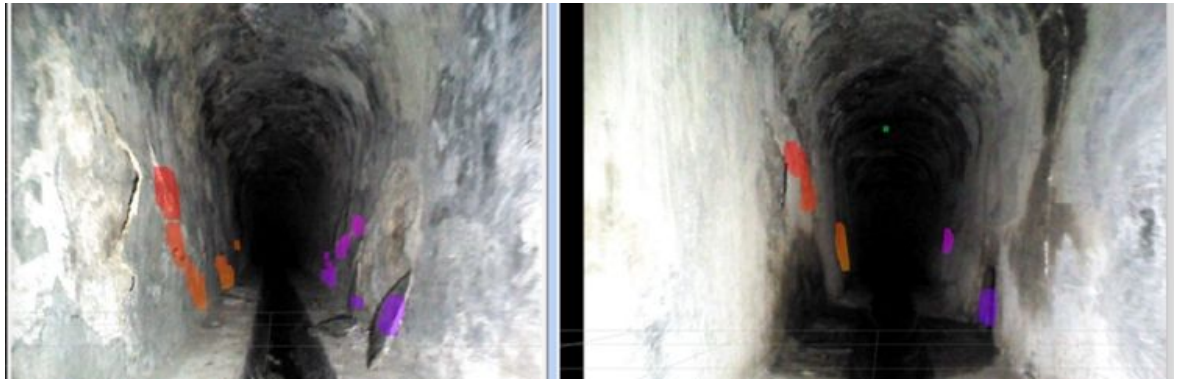
Developed Solution

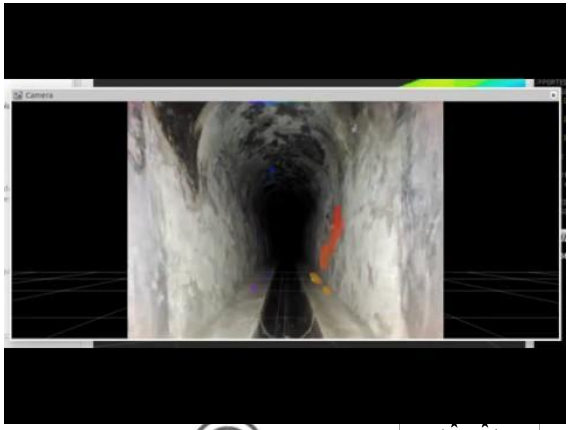
Perception

- 7 RGB-D camera sensors enable metric 3D scanning of the environment



- automatically detect inlets, manholes or structural defects on the sewers, given prior information about the section of the sewer gallery





Being part of PDTI in ECHORD++

Benefit from participation in the PDTI

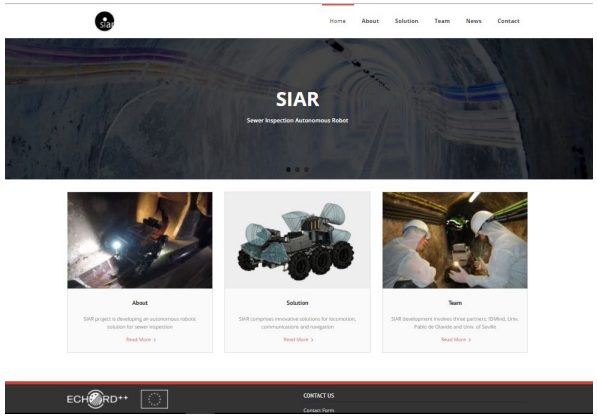
- Directly addressing end user needs
- Application driven R&D
- Collaborative work at an operational level

Development Process

- multi-stage, iterative development process, with permanent dialog with evaluators and end-users, had a positive impact on the outcomes.

Impact

- Develop a close to market solution (TRL 7)
- Generating good contacts and business opportunities either directly related to the inspection scenario of the project or to the use of its technologies in other scenarios of operation



SIAR website: siar.idmind.pt

SMART CITY 2017

Achieved TRL

TRL 1 – basic principles observed

TRL 2 – technology concept formulated

TRL 3 – experimental proof of concept

TRL 4 – technology validated in lab

TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 7 – system prototype demonstration in operational environment

TRL 8 – system complete and qualified

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Achieved TRL

Improvements in view of commercialization:

- **Additional experiments**. For a better characterization of the platform, its specifications and its limits.
- **Software**. Packaging of software modules and improvement of usability.
- **Certification**. CE marking in accordance with the applicable directives.

Off-the-shelf product version onto the market 18 months after the project end

Marketing

Product

SIAR is not only a robot for the inspection of sewers, it is also a robot with **potential for use in a large number of underground galleries and other scenarios** where its specifications will be a differentiating factor.

Price

- IDMind estimates a target price of about 50,000.00€ for the complete SIAR solution at the beginning of its commercialization (presented in D28.8, section 4.3)
- Expected improvements in cost/benefit for the sewer inspection in the city of Barcelona were discussed in D28.4 (section 3):
  - Assuming a **lifespan of 5 years** for the product, with an annual maintenance cost of 15% of the initial value, the Consortium estimated a reachable goal of a unitary cost of **0,20 €/m** for the SIAR inspection solution in comparison with the current **0,75 €/m**, i.e., a reduction of 73% in the inspection costs (TBC based on real-use scenarios).

Place

- Business to Business (**B2B**) model
  - **target clients**: organizations (private or public) providing sewer inspection **services**
  - **IDMind** will be providing:
    - the **technological solution** while these organizations will provide locally the service
    - **technical support** and **maintenance** (advanced) of the robots
    - **expertise** for the **customization** of the solution in some specific use case scenarios.

Promotion

key promotion slogans

- Improving Efficiency
- Reducing Risks

SWOT Analysis

Thank you

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