Autonomous Robot System for Monitoring and Cleaning of Bridges

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TECHTRANSFER AWARD
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MECSPE
Bologna (Italy) 2022

Autonomous Robot System for Monitoring and Cleaning of Bridges

Opened: September 4, 1967 (**Construction started:** 1963)
Total length: 1,012 m, (0.629 mi)
Width: 18 m (59 ft)
Height: Piers 90 metres (300 ft), Road Deck 45 metres (148 ft)
Engineer: Riccardo Morandi

Morandi's bridge collapse

Morandi's Bridge before and after the collapse of the Pillar 9
(14th August 2018 at 11:36am with 43 victims and 16 injuries)

Autonomous Robot System for Monitoring and Cleaning of Bridges

Opened: August 4, 2020 (**Construction started:** June 25, 2019)
Total length: 1,067 m, (0.663 mi)
Width: 31 m (103 ft)
Height: Piers 45 metres (150 ft), Road Deck 50 metres (151 ft)
Architect: Renzo Piano

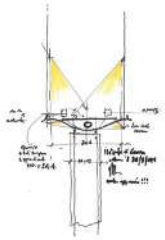
San Giorgio's bridge building

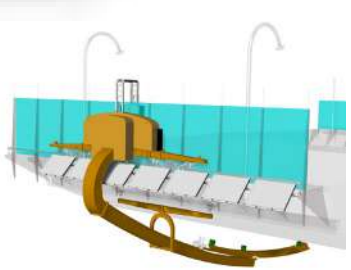
High Tech Structure: >240 sensors!!!

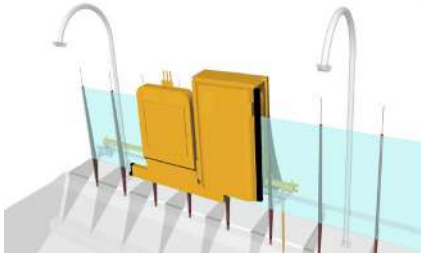
Very Efficiency in Building: <24 months!

"Simple but not trivial. A steel bridge, safe and durable. Because bridges do not have to collapse."
[Renzo Piano]

Autonomous Robot System for Monitoring and Cleaning of Bridges







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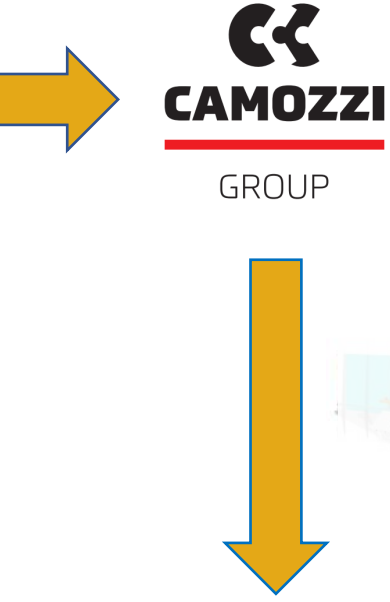


Autonomous Robot System for Monitoring and Cleaning of Bridges

Monitoring and Maintenance

Current Scenario

https://www.youtube.com/watch?v=-LmAcL2WFFo

Traditional bridge inspections

- Time consuming
- Dangerous
- Expensive
- Imprecise
- Imperfect record keeping
- Lack of comparison data to previous year

(ALMOST) NO MONITORING!!!

https://www.flyability.com/articles-and-media/drones-bridge-inspection

Advanced bridge inspections

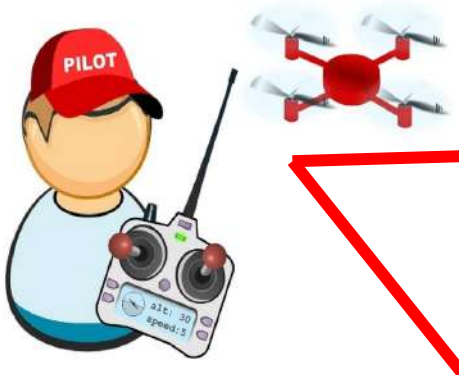
- Inspection road and highway damage due to environmental impact and natural erosion.
- Maintain bridges, tunnels and other critical infrastructure to help reduce the cost of on-demand maintenance. Perform railway inspections frequently and efficiently to avoid damage and derailment.
- View seaports, canals, and waterways in superior detail and accuracy.
- Faster Inspection
- No road partial/total closure and traffic issues
- Repeatability is not guaranteed and then there will be lack of comparison with data to previous years.

Autonomous Robot System for Monitoring and Cleaning of Bridges

Monitoring and Maintenance

Current Scenario

NEEDS AN OPERATOR!!!



Autonomous Robot System for Monitoring and Cleaning of Bridges

High Tech Structure!!!!

Monitoring and Maintenance Robotic System for San Giorgio Bridge

(Genoa, Italy)

Monitoring and Maintenance Robotic System for San Giorgio Bridge

Partners

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Monitoring and Maintenance Robotic System for San Giorgio Bridge

(Genoa, Italy)

https://www.youtube.com/watch?v=WmQ1bQNgKds

Monitoring and Maintenance Robotic System for San Giorgio Bridge

MECHATRONICS

Monitoring :

- Underside of the deck
- Head of piers

Maintenance:

- Sound barriers
- Solar panels

Contact: first tentative for a fully autonomous I&M robot to interact with the environment

- Sensors (ultra-sound, magneto-scope, etc.)
- Brushes for cleaning

Cognitive Mechatronics: be aware about the environmental parameters in order to make decisions

- Autonomy: batteries management
- Navigation: trajectories planner
- Self-Diagnosis: fault management

Inspection and Maintenance Robotic System for San Giorgio Bridge

Monitoring

San Giorgio Bridge (Genoa): Robots Structures

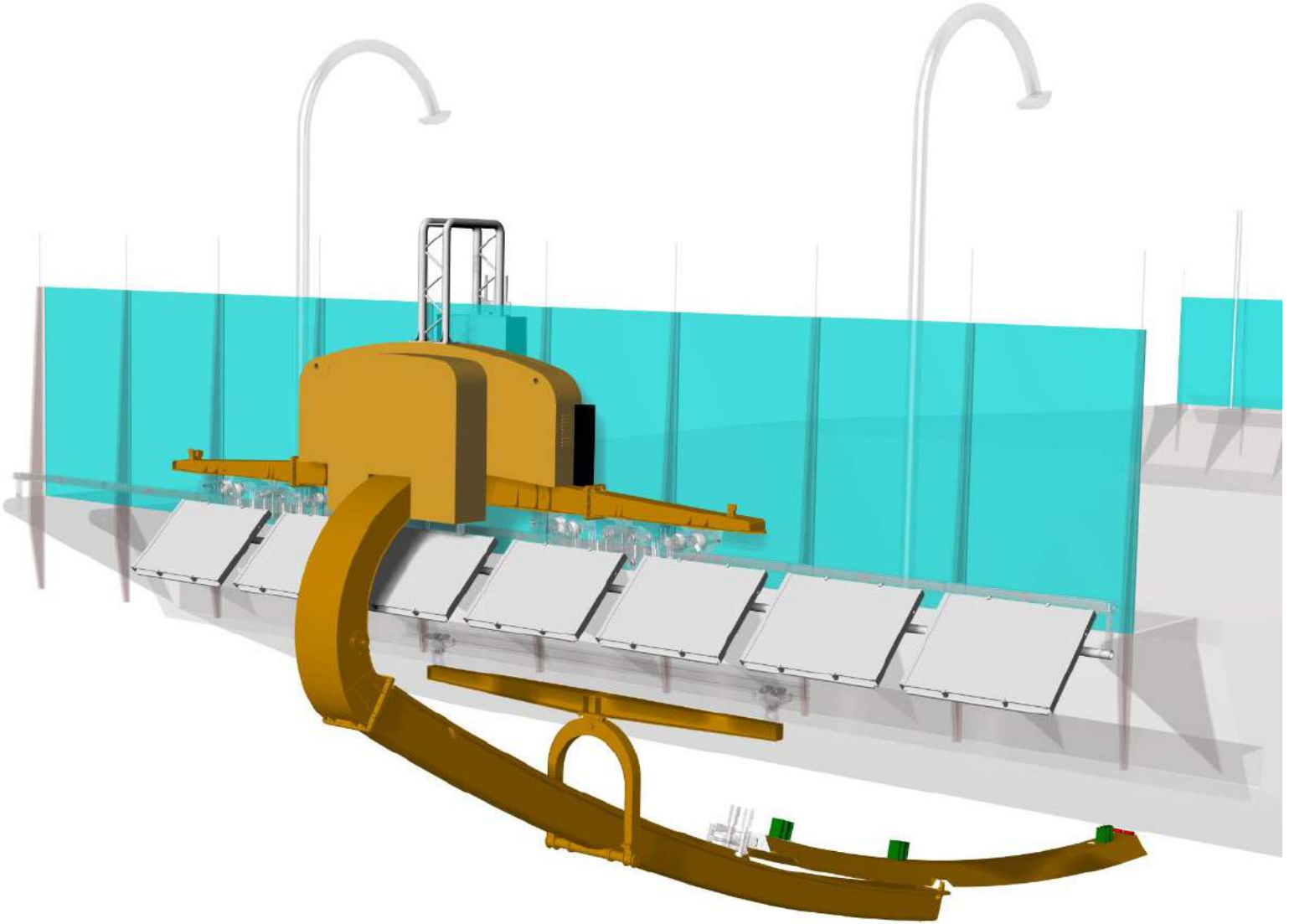
Cognitive Mechatronics

MODELLING OF KINEMATICS AND DYNAMICS OF THE ROBOT

Monitoring and Maintenance Robotic System for San Giorgio Bridge

Robots Structures

Robot Monitoring

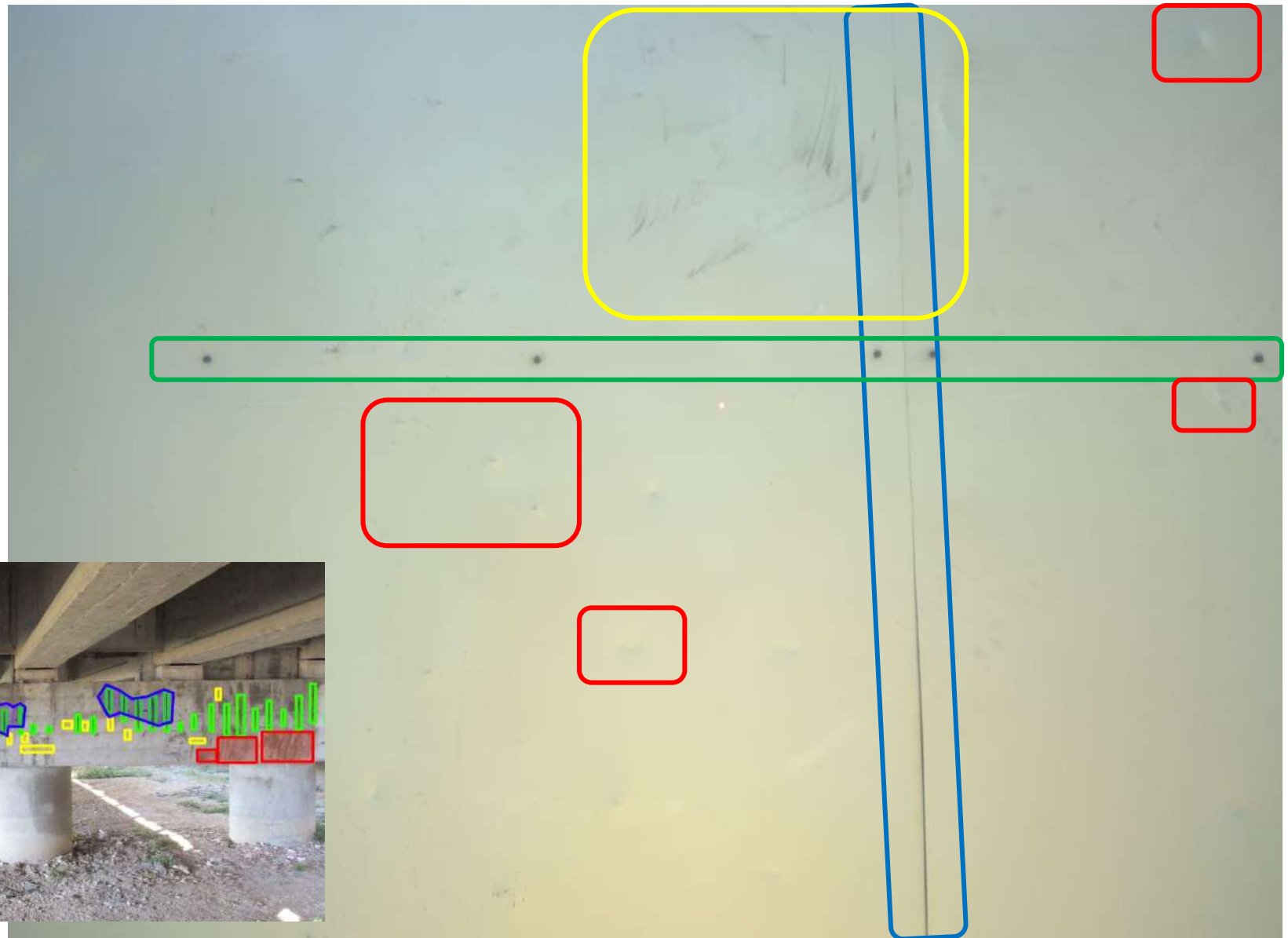


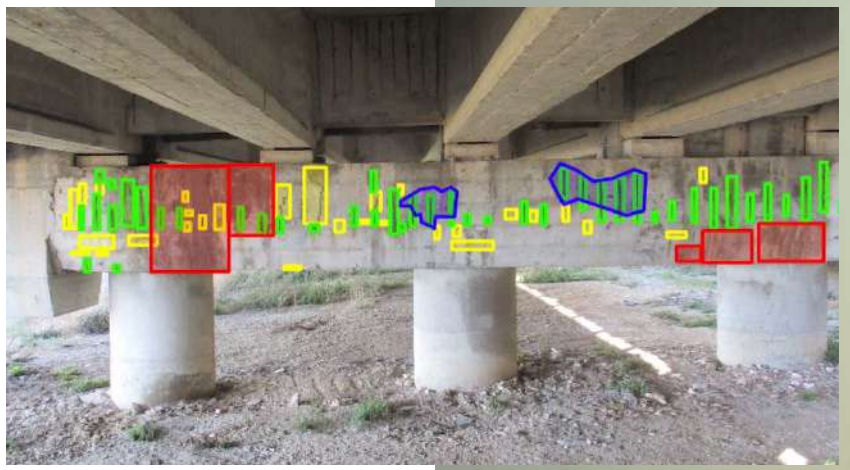
Inspection and Maintenance Robotic System for San Giorgio Bridge

Monitoring

Monitoring and Maintenance Robotic System for San Giorgio Bridge

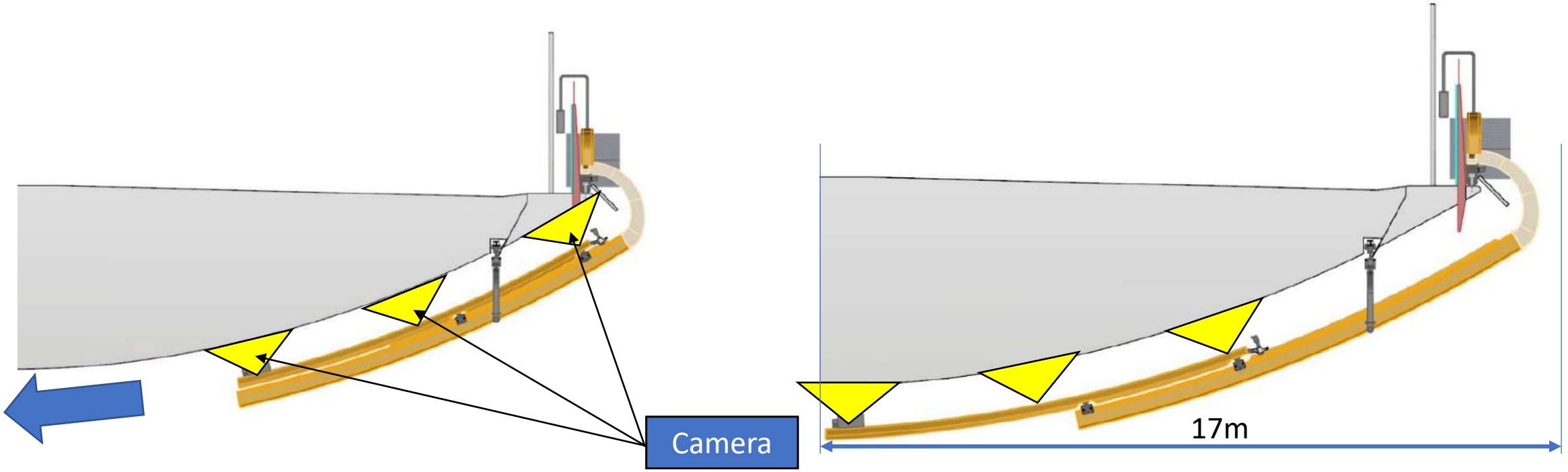
CHANGE DETECTION





Monitoring and Maintenance Robotic System for San Giorgio Bridge

Monitoring

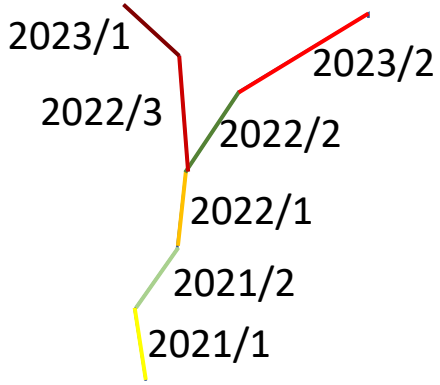


The vision will be moved by the sliding beam and the images will be processed with Pattern Analysis in order to detect potential «anomalies» that will be reported to the human operators.

The surface Monitoring will investigate:

1) Painting degrading
2) Corrosion of metallic parts
3) Joint status
4) Welded status
5) Crack detection

Monitoring of the evolution along the months and years!



Monitoring and Maintenance Robotic System for San Giorgio Bridge

Monitoring

FULLY AUTONOMOUS Robot for inspecting the Genova San Giorgio bridge

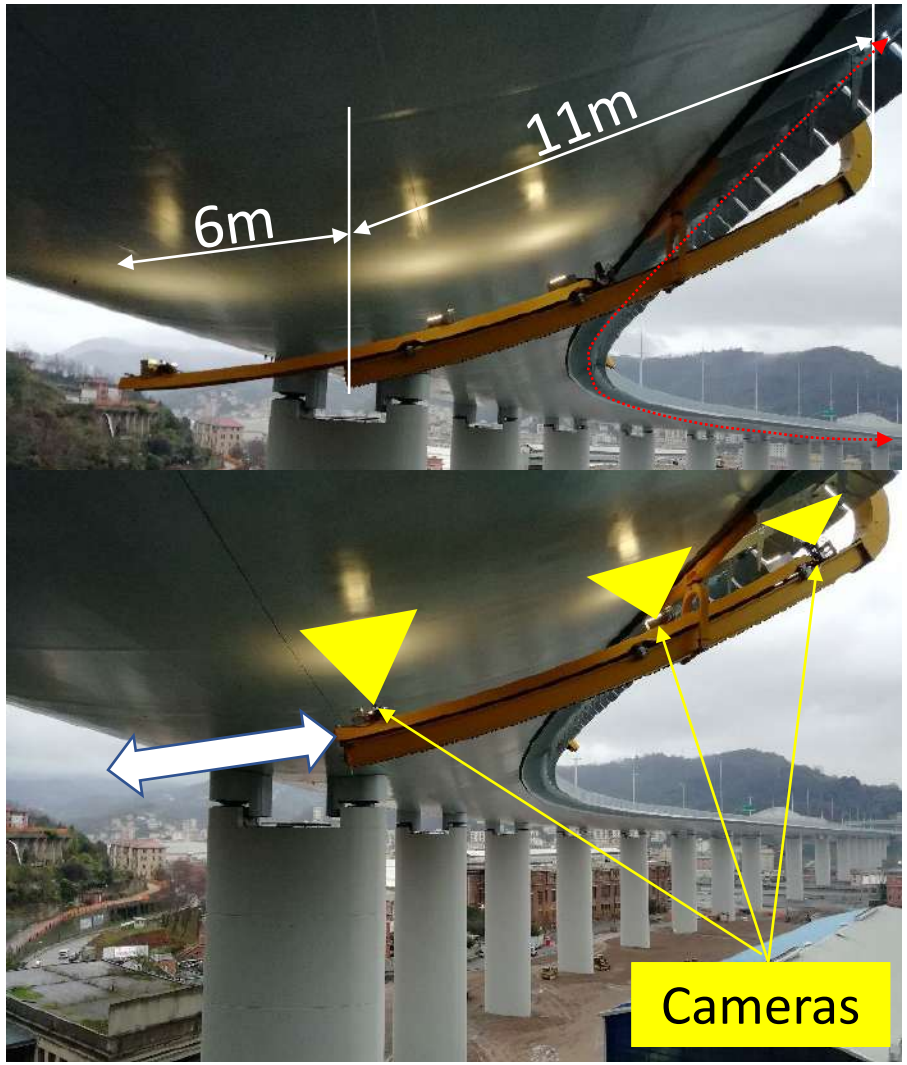
Weight: 2400 kg
(arm: 300kg of carbon fiber structure)

Payload of the arm:
On the tip: 80 kg
Distributed: 250 kg

Size:
Arm length: 11+6 m
Length: 7 m
High: 10 m

Speed: 0.15 m/s
Span: 1100 m

+/- 25mm vibrations



Monitoring and Maintenance Robotic System for San Giorgio Bridge

The RESULTS

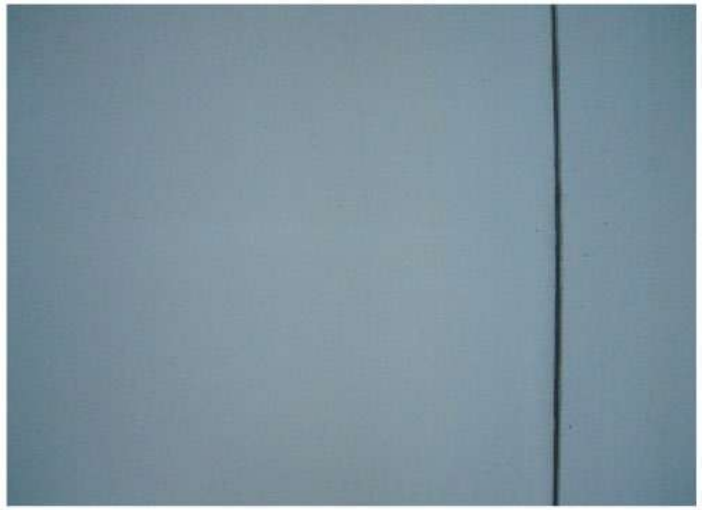
Monitoring and Maintenance Robotic System for San Giorgio Bridge

Results

FIRST DEFECT DETECTION (2021, February)

The first scanning the whole bridge was covered and more than 30000 pictures were taken. A couple of them are shown in the following. THIS IS THE BRIDGE PATTERN «REFERENCE»

Not defects DETECTED by the algorithm, because the bridge was new!

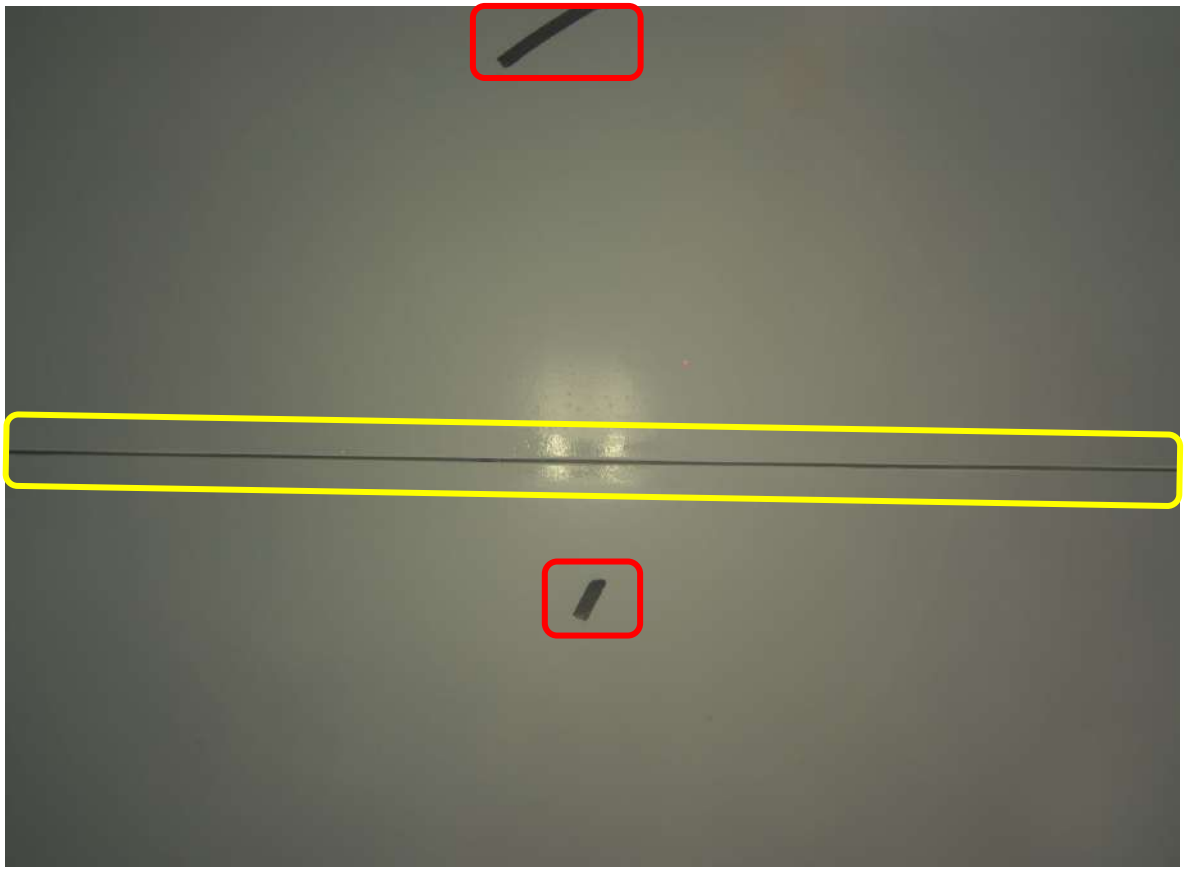


Not defects DETECTED by the algorithm, because the bridge was new!

Monitoring and Maintenance Robotic System for San Giorgio Bridge

Results

SECOND DEFECT DETECTION (2022, July)

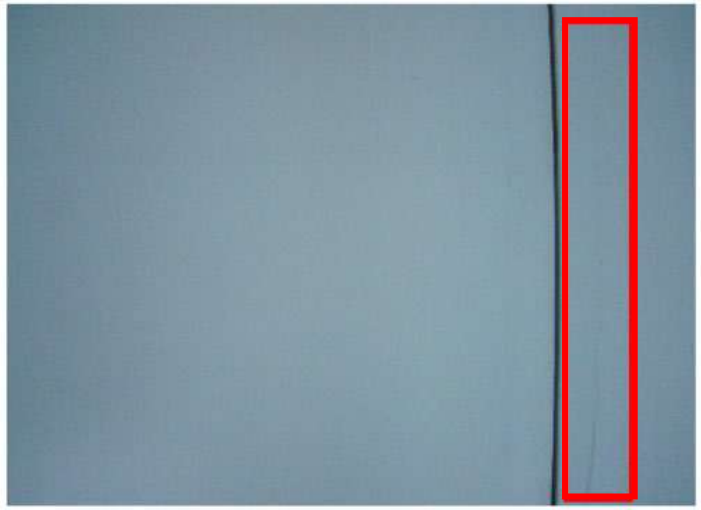


Considering the bridge was detected just 1.5 year before, none was expeting any defect, an overall check up was carried on on the robots and only the cameras were tested around the robot parking areas with the artificial markers in order to check their functionalities after 18 months without being used.

Monitoring and Maintenance Robotic System for San Giorgio Bridge

Results

THIRD DEFECT DETECTION (2023, December)



The third inspection involved almost half bridge with around 1000 pictures (statistically detemined) to asses where same difects were come out: considering that only some dirty areas was found, the captured pictured were drastically reduced compared to 30000 for scanning the whole bridge.

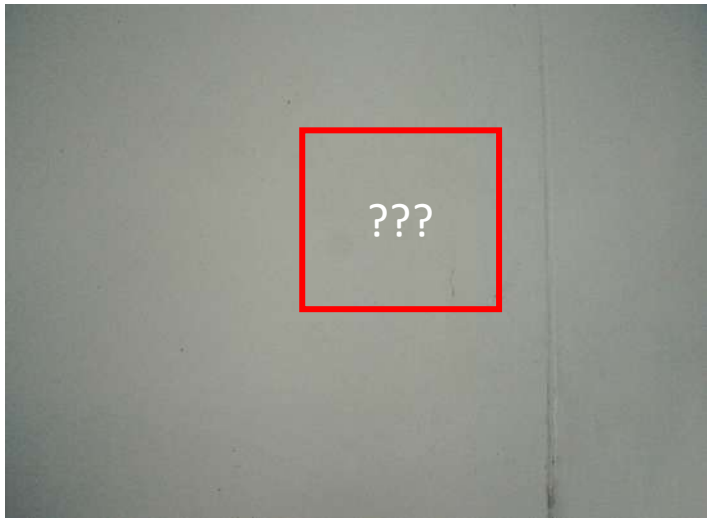
Evident dirt zone EASILY DETECTED by the algorithm

Not Evident dirt zone NOT EASILY DETECTED by the algorithm (the ML needs to be trained about the dust and similaf defects)

Monitoring and Maintenance Robotic System for San Giorgio Bridge

Results

FOURTH DEFECT DETECTION (202?, ???)



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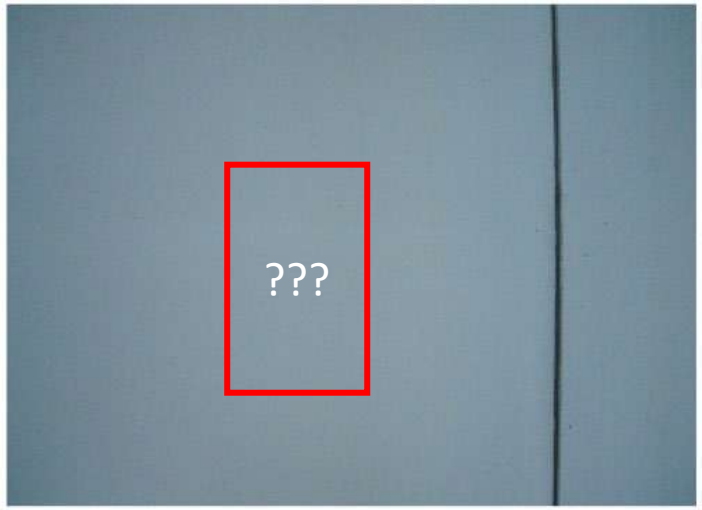

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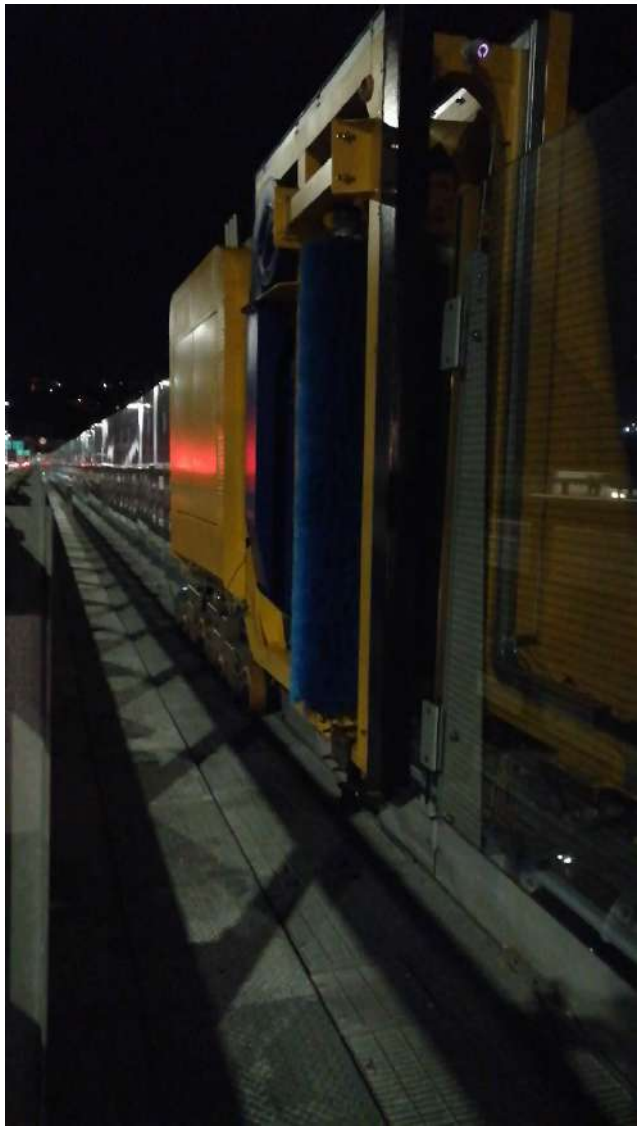
Inspection and Maintenance Robotic System for San Giorgio Bridge

Wash

The transversal movement compensates the structure misalignments (rails, glasses, floor, etc.)



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Thank you for the attention!

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