University of Messina

DIPARTIMENTO DI INGEGNERIA

A tool for cranes to manage risk due to release of hazardous materials

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Dep. of Mechanical and Industrial Engineering, NTNU, Norway 2th June 2017

About me

Education:

- PhD in Industrial Engineering - Program in "Nuclear Engineering and Industrial Safety“
- MS in Management of Territorial Risks
- BS in Analysis and Management of Natural and Man-made Risks

Main research topics:

- Na-Tech (Natural - Technological) Risk Assessment
- Vulnerability models for Industrial equipment
- **Safety in crane-operations**

About me - Department of Engineering & Supervisor -

The Department of Engineering was founded in 2015 by merging the:

- Department of Civil Engineering, Computer Science, Construction, Environmental and Applied Mathematics;
- Department of Electronic Engineering, Industrial Chemistry and Industrial Engineering.

Supervisor: Maria Francesca Milazzo

Assistant Professor of Chemical Engineering (Chemical Plants) at the Department of Engineering of the University of Messina

Education:

- MS degree in Industrial Chemistry
- Ph.D. in Nuclear and Industrial Safety

Main research activities:

- Risk Analysis in the Chemical Industry and the Transport of Hazardous Materials;
- NaTech Risk Assessment
- Environmental Risk Assessment,
- Environmental Impacts of Biofuels.
- …

Project leader of the European Project:

- "Smart PRrocess INdustry CranEs" (SPRINCE)

Main research topics:

- Na-Tech (Natural - Technological) Risk
- Vulnerability models for Industrial equipment
- …

Na-Tech events

Na-Techs are technological events triggered by natural phenomena

In Europe there are many vulnerable installations located in areas subject to natural hazards

Climate change increases Na-Tech risks:

- Extreme weather events are becoming more severe and common
- Existing technological infrastructures are not designed for this new emerging criticalities

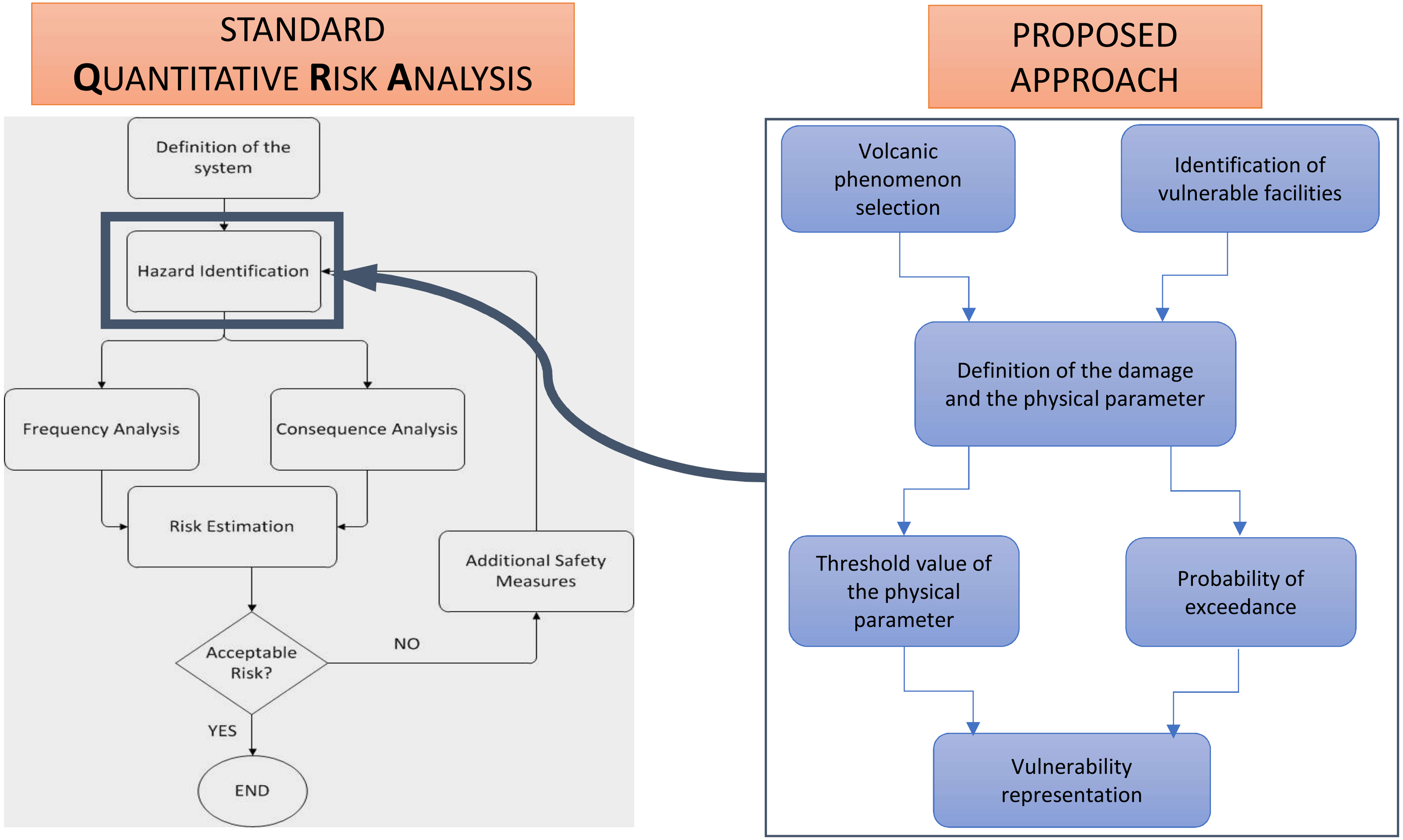
In general, the magnitude of a Na-Tech is much broader than that of a natural event.

Its management is much more complex

Fukushima nuclear accident represents a tragic example of this event's typology.

Example of a developed vulnerability model

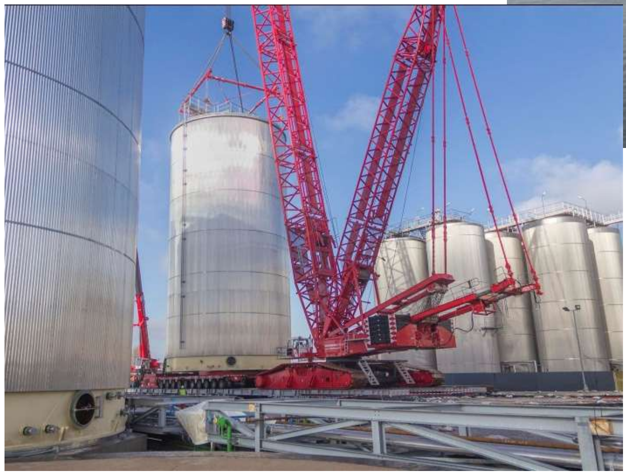
Vulnerability models allow estimating the probability of equipment damage under the impact of a **natural phenomenon**



Safety in Crane Operations

Overview on crane operations

- Construction
- Transportation
- Manufacturing
- …



When installed and properly used, cranes make operations easier and safer.
Nevertheless, **even if the technology and risk awareness have substantially increased, safety still needs to be improved.**

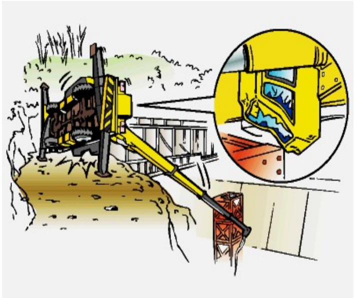
This is evidenced by many accidents and near misses that occur each year.

Background

M.F.Milazzo, G.Ancione, V.Spasojevic Brkic, D.Valis (2017). ***Investigation of crane operation safety by analysing main accident causes****. Proc. European Safety and Reliability Conference ESREL 2016 "Risk, Reliability and Safety: Innovating Theory and Practise", 74-80, Glasgow. Taylor & Francis Group.*

Major causes of cranes-related accidents are due to:

- crane capsizing
- dropped load
- structure collapse



These events can give:

- Upset the equipment, …
- Injure workers, …
- Fatalities

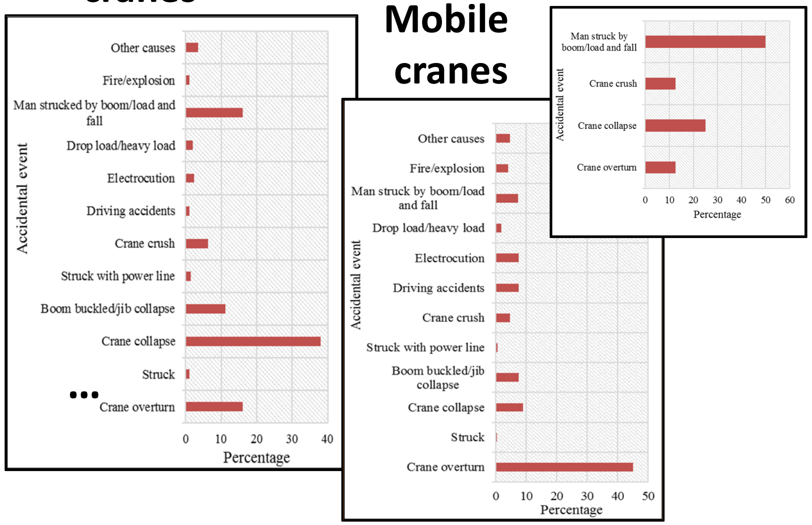
Crane accidents could be more severe if they occur in the:

- chemical and process industry and
- intermodal transport

where hazardous materials are handled.

Accidents occur for each crane typology:

Tower cranes | **Mobile cranes** | **Overhead cranes**



Aims

A relevant event that causes crane accidents is the (partial or total) obstructed view of the crane operator.

Crane accidents, caused by obstructed view, can be predicted.

Aims of this study are:

- The development of a Visual Guidance System (VGS) (*i.e. a real-time object detection solution to industrial cranes*) improving the safety in the working-place by supporting crane-operators to avoid potential collision during the handling of loads. This has been the goal of a recent European funded project entitled SPRINCE (*Smart PRocess Industry CranEs).*

- The analysis of some case-studies related to different kind of industry (i.e chemical industry, intermodal transport, etc.), where the real-time detection of loads, during the handling of loads, allows obtaining a dynamic estimate of the consequence by means the developed system (VGS).

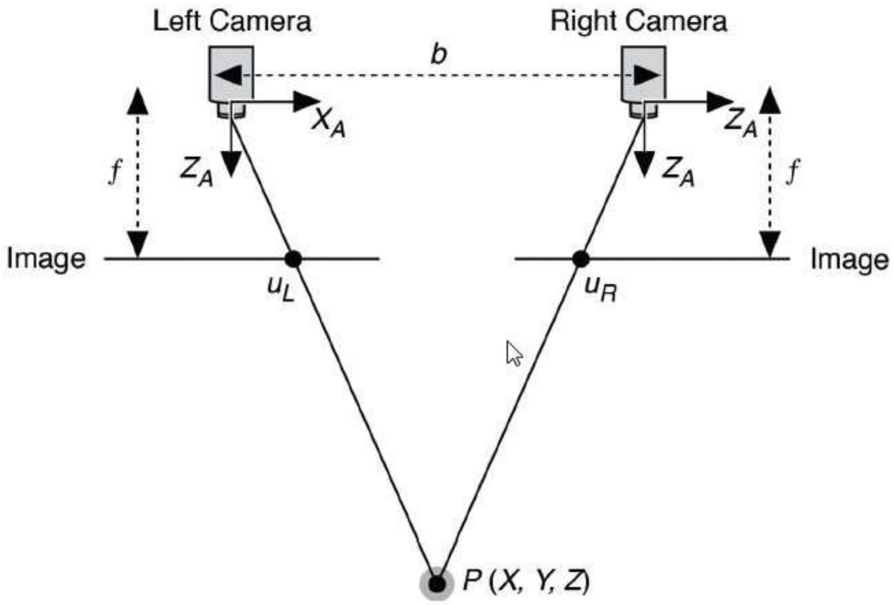
Development of a real-time object detection solution for industrial cranes

- Algoritms
- Interface
- Hardware configuration
- Results

Stereoscopic Vision methods

is able to estimate the distance between objects and the camera.

This technique permits assessing the depth of the objects.



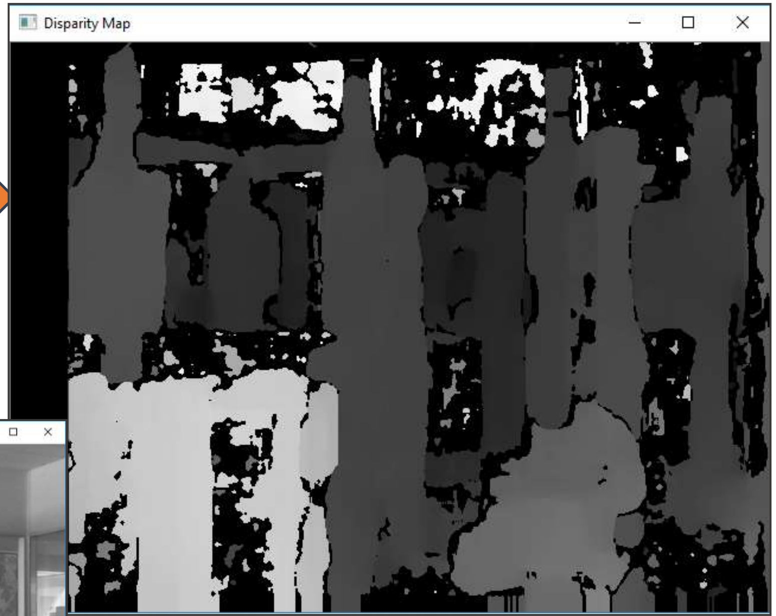
This can be obtained when two cameras (with identical characteristics) acquire an image of the same scene from slightly different positions.

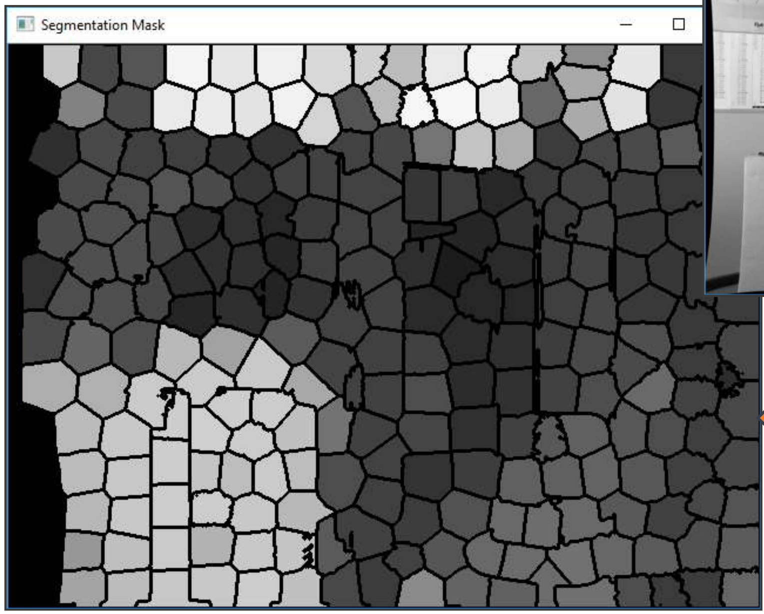
VGS - Basic algoritms -

Depth map

Semiglobal Matching and Mutual Information algorithm
(Hirschmuller, 2008)

To assign a depth value to each pixel of the image



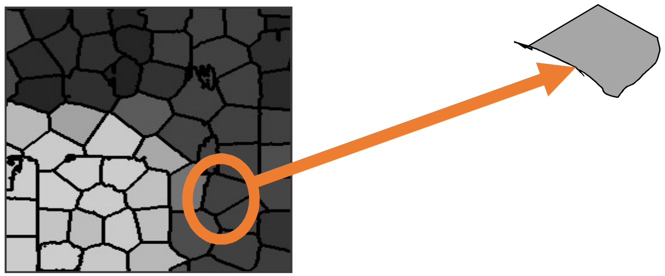


Superpixel

Simple Linear Iterative Clustering
(Achanta et al., 2012)

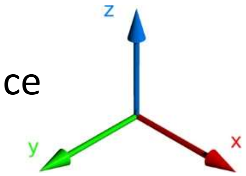
To divide the image in smaller and semantically similar areas

VGS - Basic algoritms -



For each *superpixel*, an average depth of the pixels (contained within the *superpixel*) is calculated.

Each *superpixel* can be precisely defined in the 3D space



This algorithm represents a good solution for the detection, but in **open and unrestricted environments** the process can be altered by a large number of parameters.

false results →

- illumination/weather changes,
- periodic objects motion in the working area,
- undesired camera movements,
- Etc.

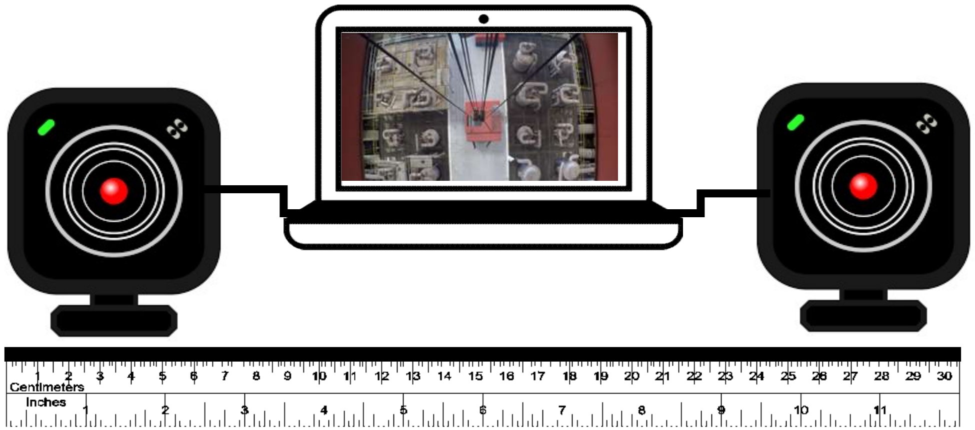
The implementation of the system must be as much accurate as possible to avoid false positive and negative indications

A **false negative result** occurs when a trespasser is moving inside the monitored area but the algorithm fails in reporting it.
A false positive result determines that the operator should interrupt his work to control the area and ensures that the operation can be safely continued.

VGS - Hardware configuration -

Prototype

The developed prototype adopts two cameras having the same focal length and optical properties.



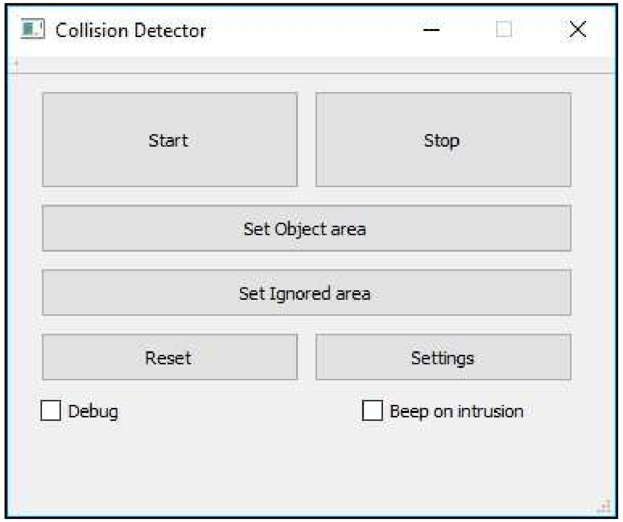
Crane operator uses the VGS interface by a **remote control device**

Graphic User Interface

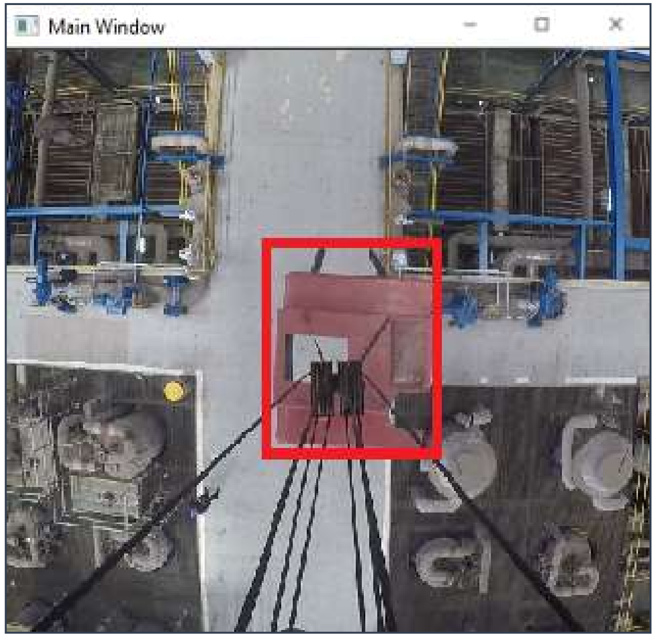
Collision Detector

Main Window

(Control Panel)



(Working Area)



VGS - Graphic User Interface -

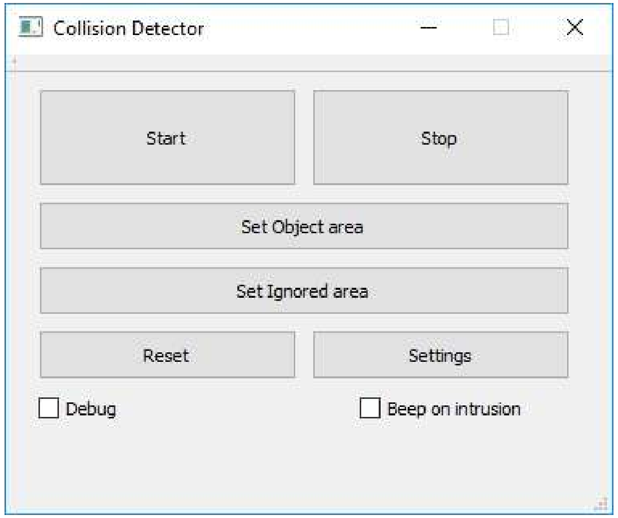
The *Start*, *Stop* and *Reset* buttons are respectively used to start, end and reset the monitoring process

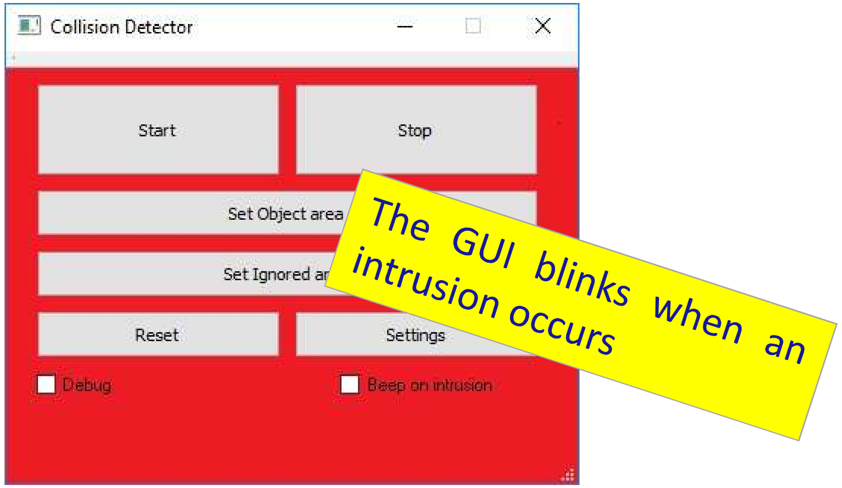
The *Set Object area* and *Set Ignored area* buttons permit to set respectively the load that can be monitored and any item to be excluded.

The *Settings* button opens the setting window of the application

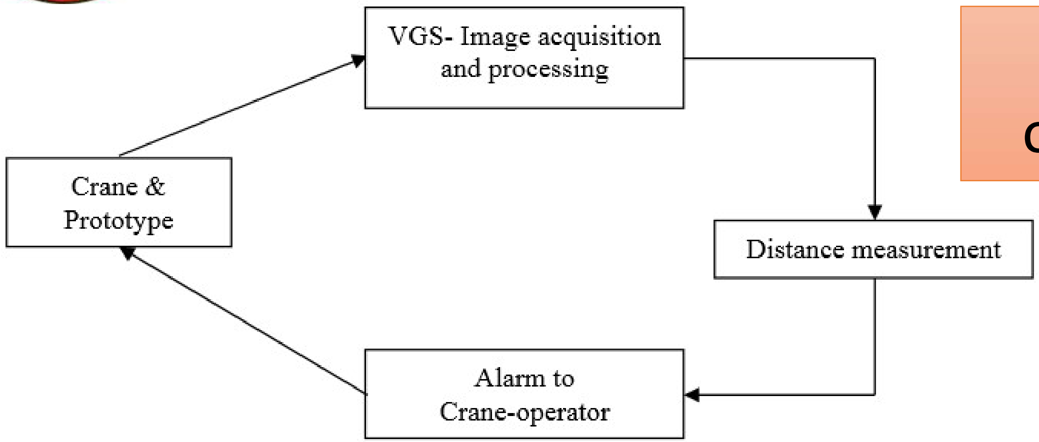
The *Debug* checkbox is inserted for debugging purposes.

The *Beep on intrusion* checkbox enables or disables the acoustic signal alerting that an object is detected.

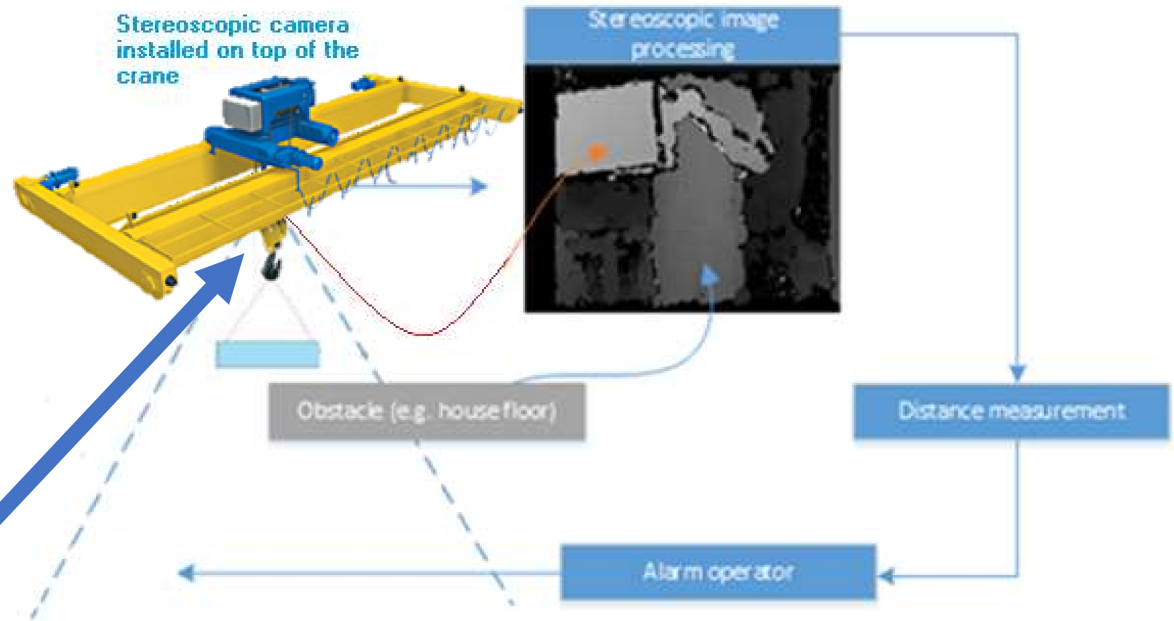




VGS – Architecture -



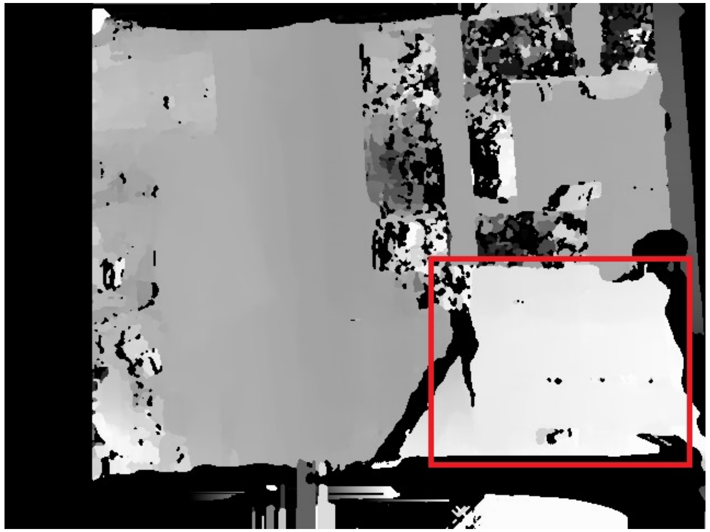
- Architecture of the developed system -

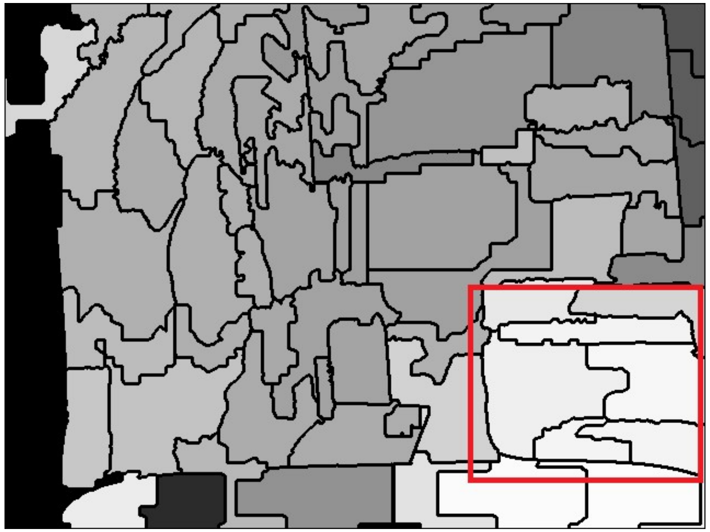


The hardware arrangement is strongly conditioned by the crane type.

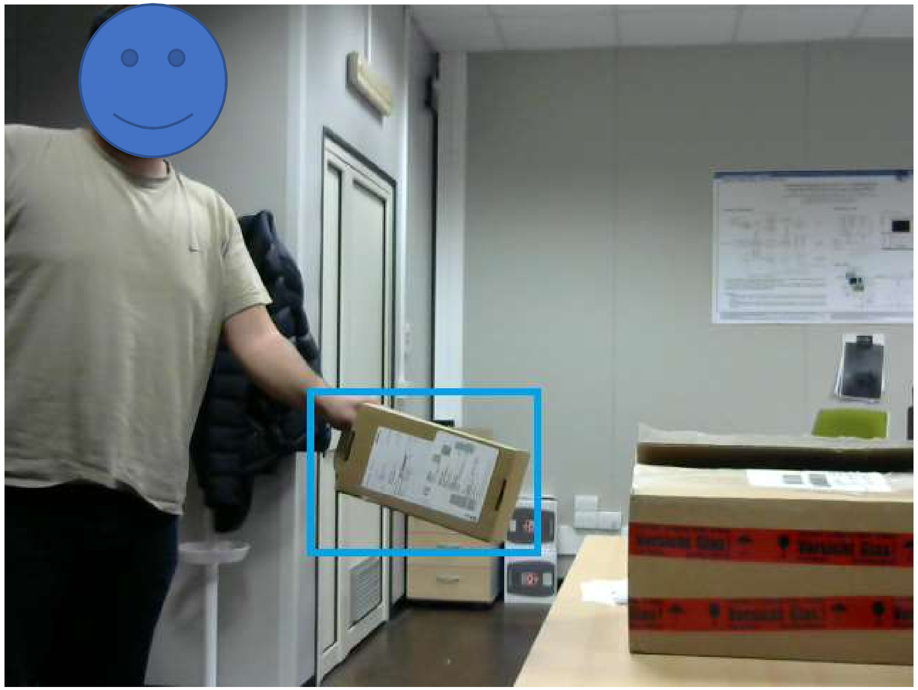
VGS - Laboratory test results -

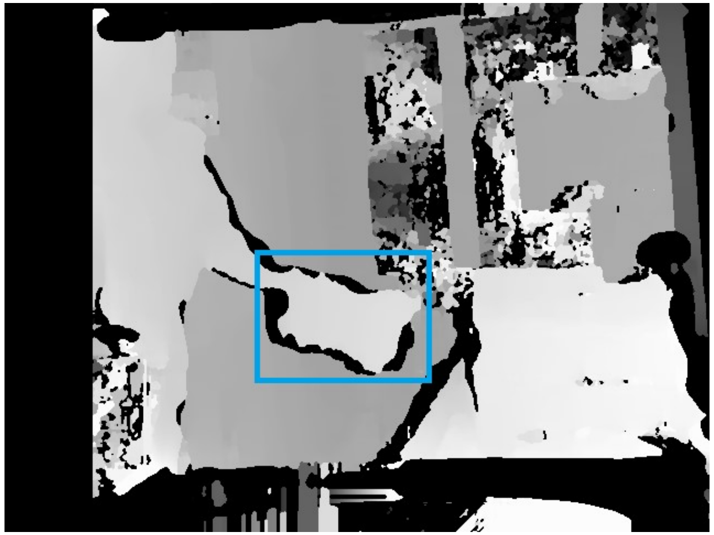
t_0

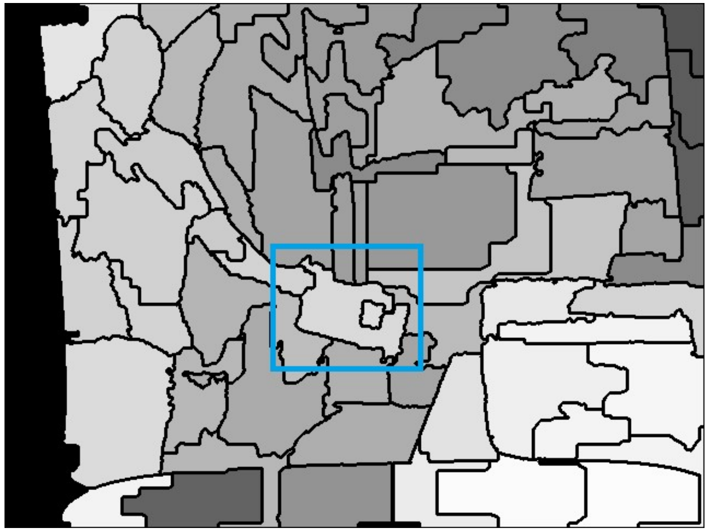




VGS - Laboratory test results -

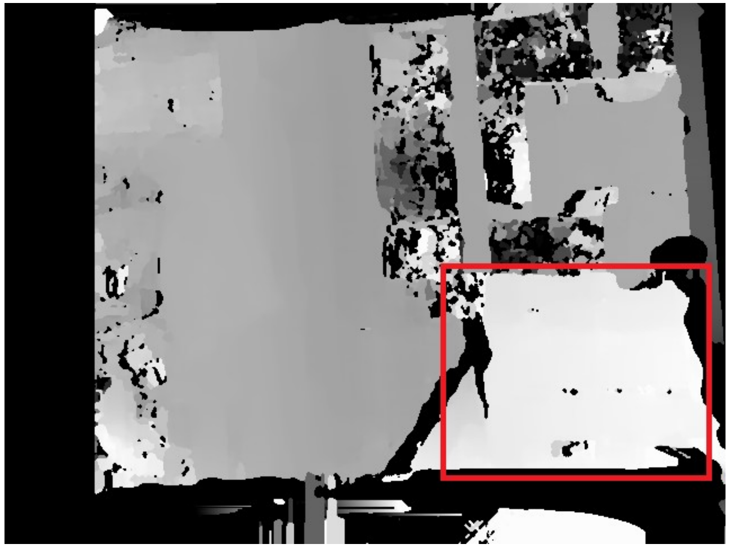


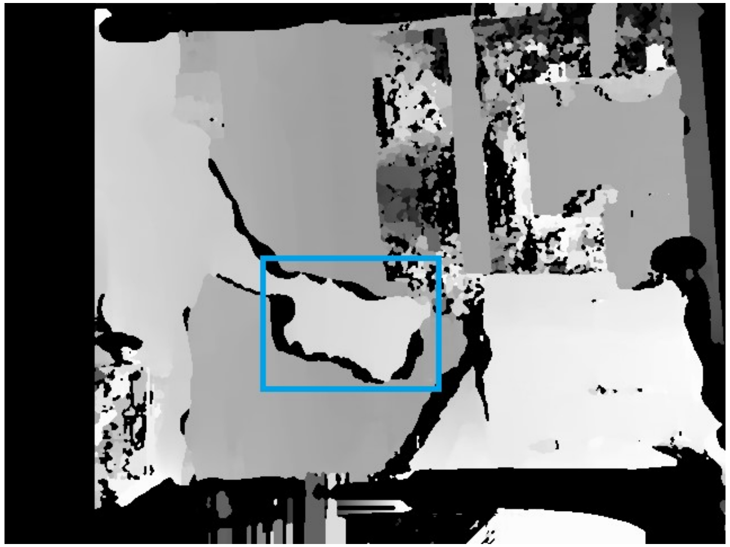




t_1

VGS - Laboratory test results -





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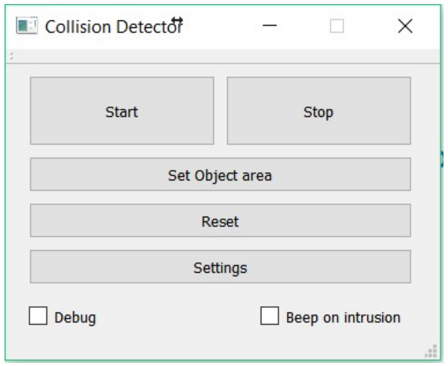

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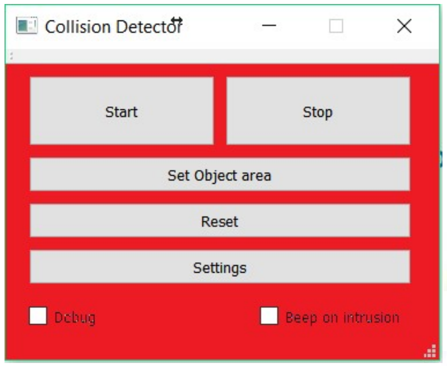
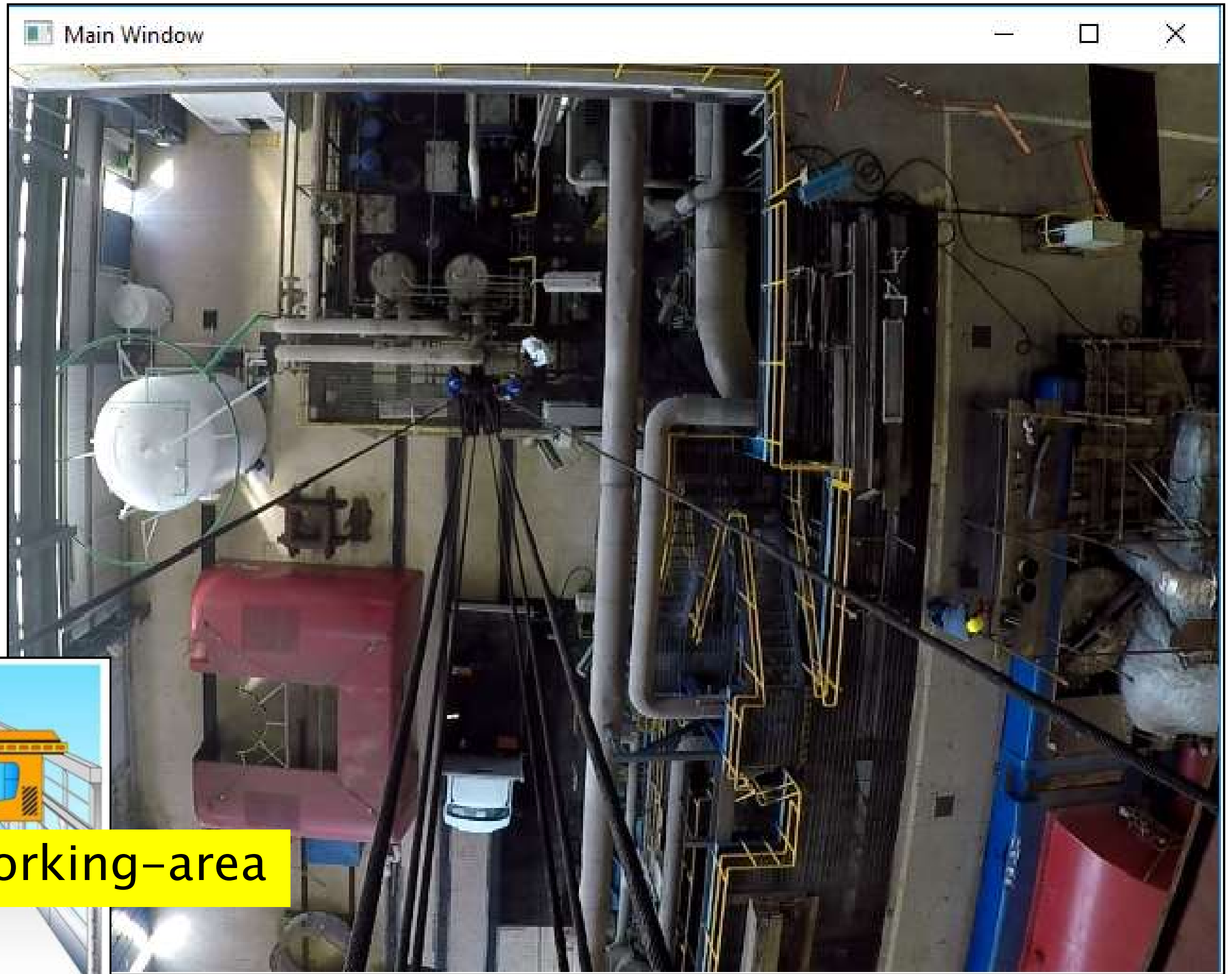
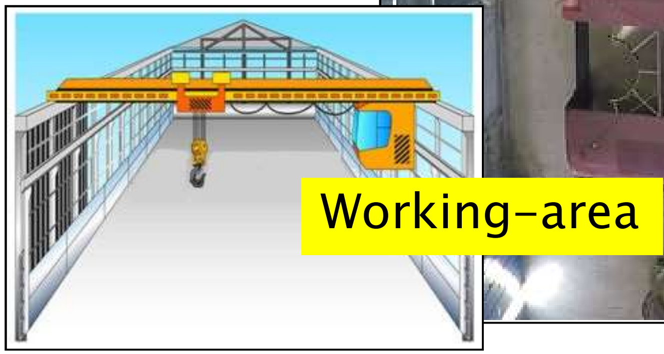


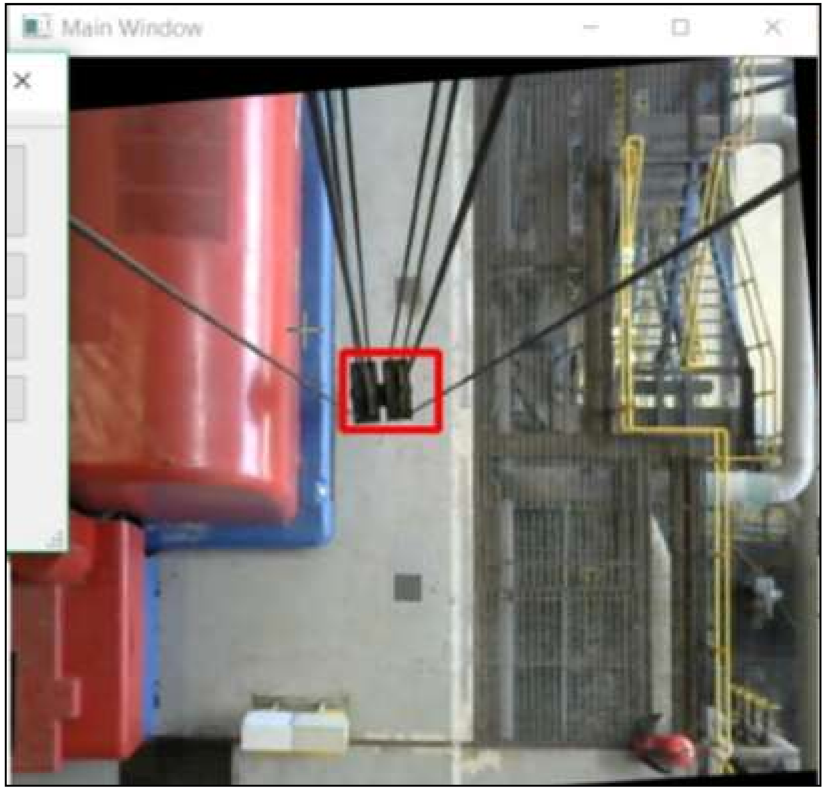
VGS - Case Study -



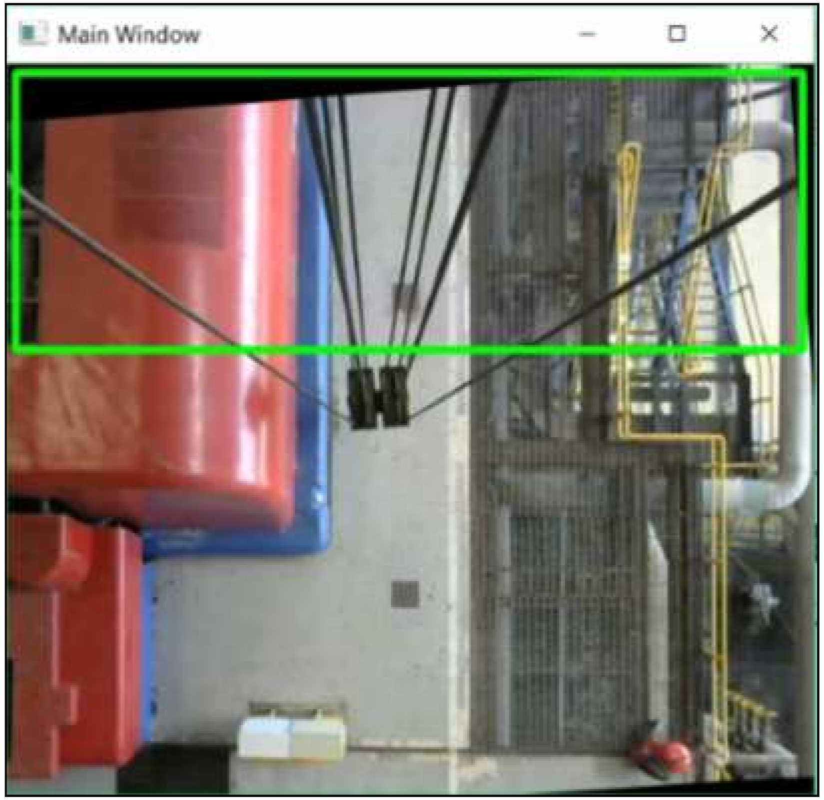


VGS - Case Study Results-

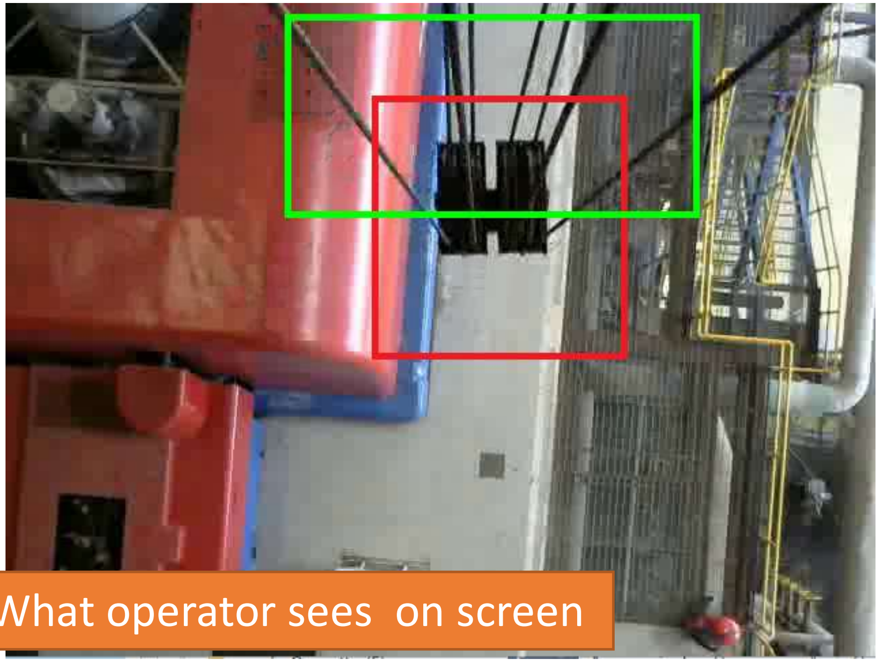
Setting the Object area



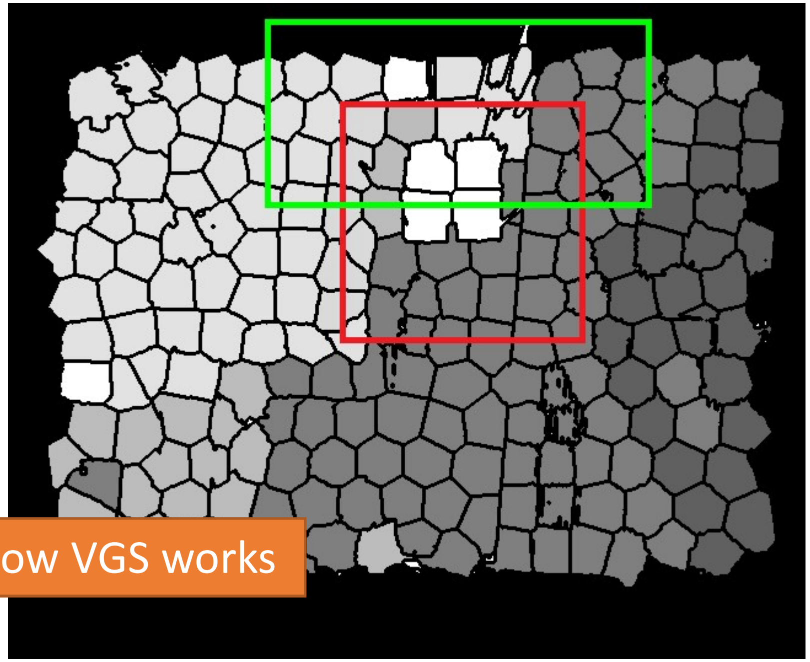
Setting the Ignored area



Visual Guidance System - Case study results -

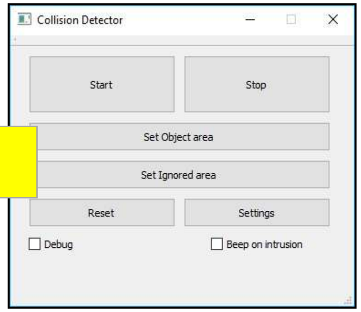


What operator sees on screen

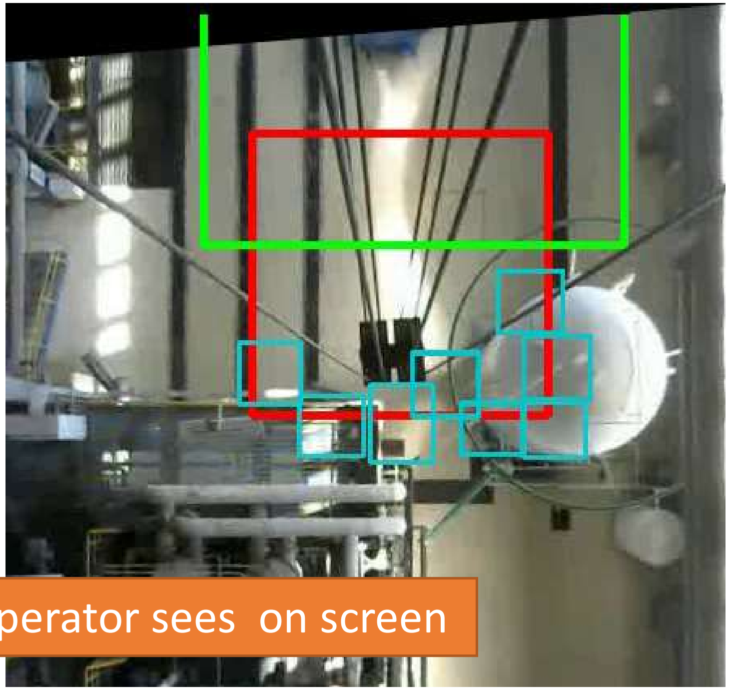


How VGS works

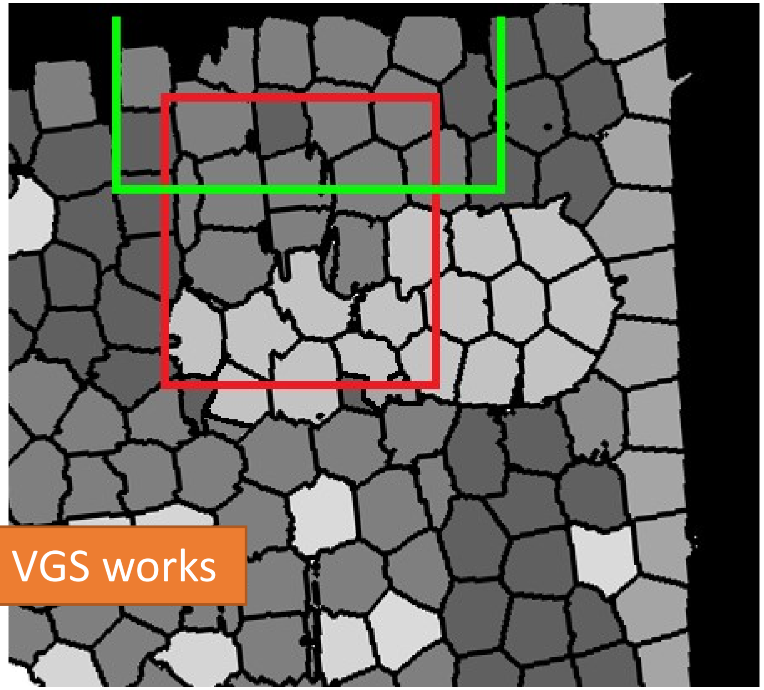
Control Panel → unchanaged



Visual Guidance System - Case study results -

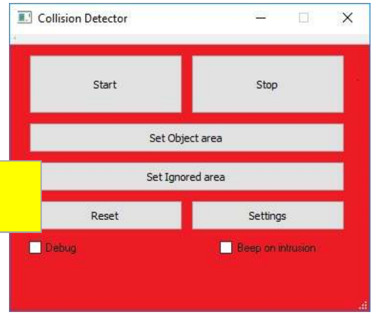


What operator sees on screen



How VGS works

Control Panel → blinking red



Conclusions

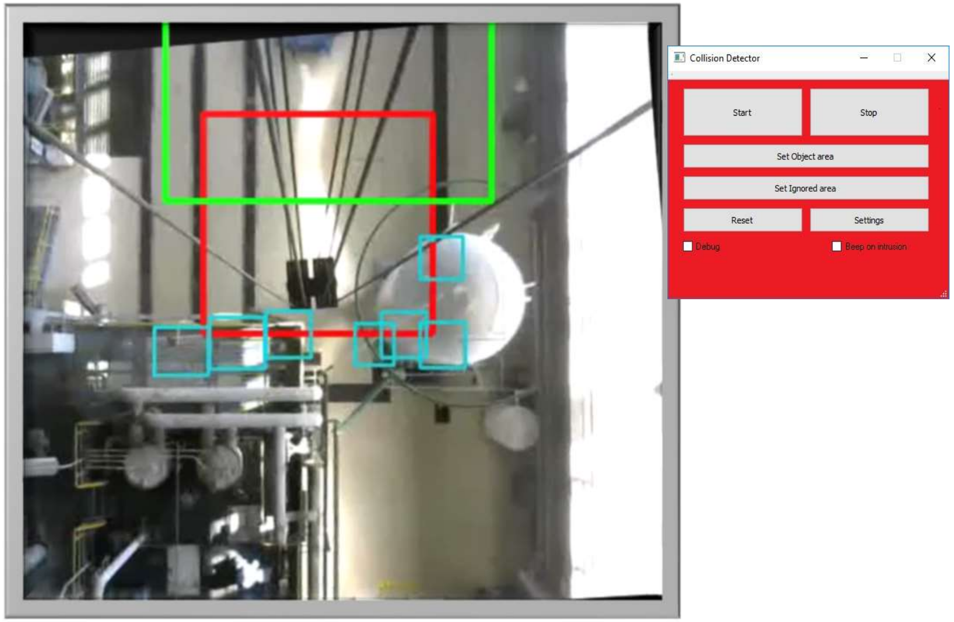
The developed VGS, installed on cranes, carries out an **improvement of the safety** in the working space as it supports crane-operator to avoid potential collision during the handling of loads.

At this moment, excessive false results represents the main **critical issue noted**

Future developments: optimize the segmentation, improve the algorithm, automation the system, improve performance, etc.

Conclusions

How to integrate the VGS tool for cranes within the **Dynamic Risk Analysis** in the Chemical and Petroleum Industry



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SPRINCE

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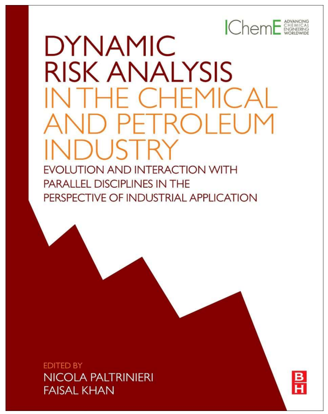

Thanks for your kind attention!

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