Human-Robot Cooperation in Surface Inspection Aerial Missions

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Outline

- Why a Human-Robot Cooperation System?
- The recognition model
- The collaborative model
- Results
- Conclusions and Future research
- References

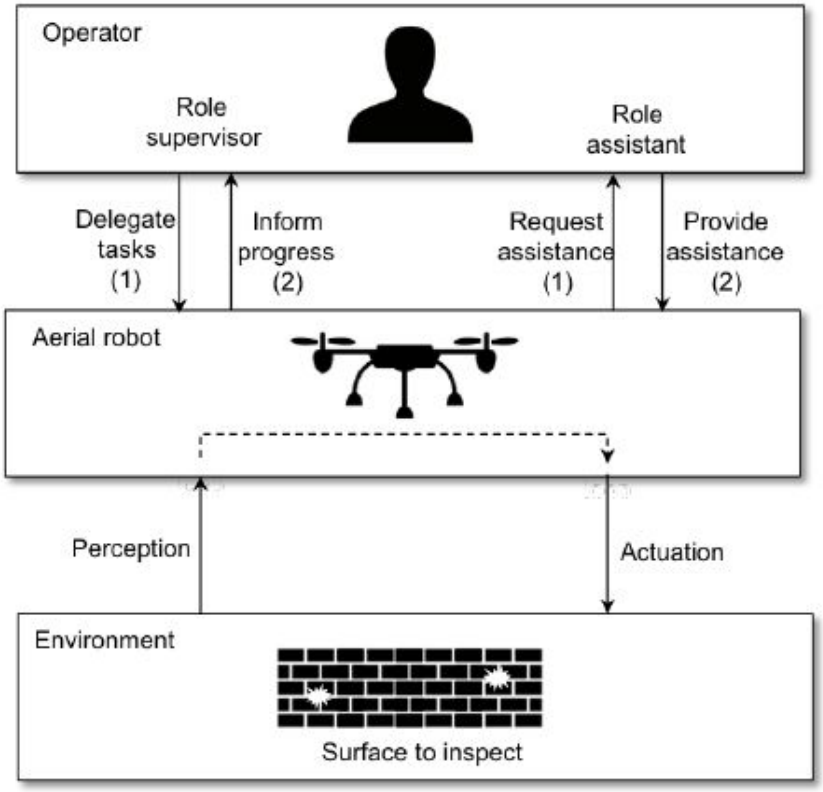
Why a Human-Robot Cooperation System?

Goal

→ Develop a system to be used as a defect recognizer on walls

→ Two main concerns:

- Behaviors of the drone
- Flaw Recognition



Semi-Autonomy and recognition tasks

→ **AI means autonomy!**

→ Start with a semi-autonomous system → reduce the cognitive load

→ Tasks modelled as recognition missions:

- Starting point
- Surface Inspection
- Ending point and results

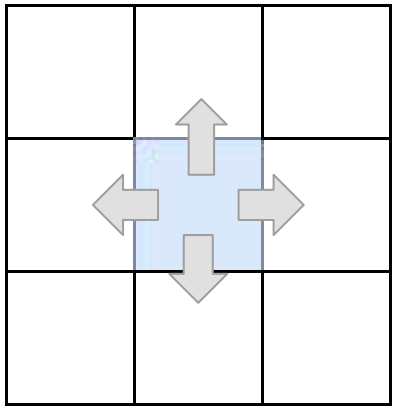
The Recognition Model

Frequency Histogram of Connected Elements

→ Concept of neighborhood

→ Pixel grayscale value comparison

→ Sum of the same valued pixels and generation of the histogram

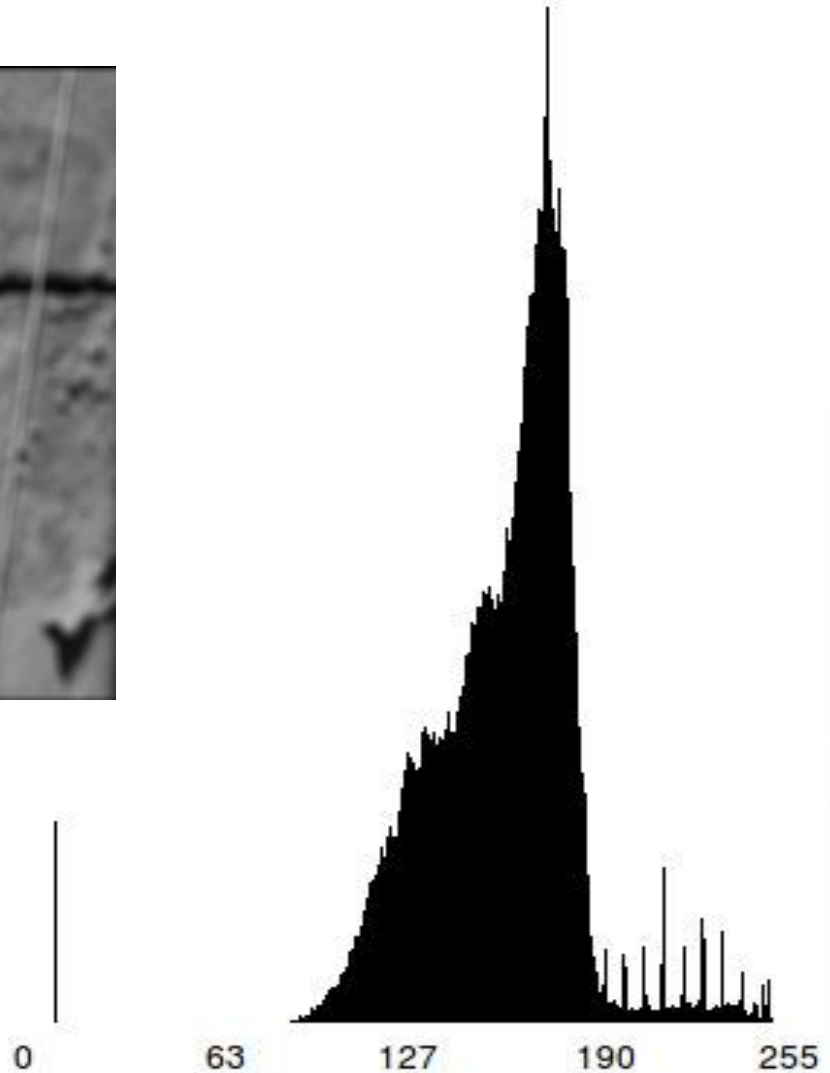


$$C_{(i,j)}(T) = \varphi^{r,s}_{(i,j)} : I(k,l) \subset [T-\varepsilon,\ T+\varepsilon],\ \forall (k,l) \in \varphi^{r,s}_{(i,j)}$$

$$H(T) = C_{(i,j)}(T) \quad 0 \le T \le I_{max} - 1$$

[3] D. Maravall and M. A. Patricio.
[4] M. A. Patricio and D. Maravall

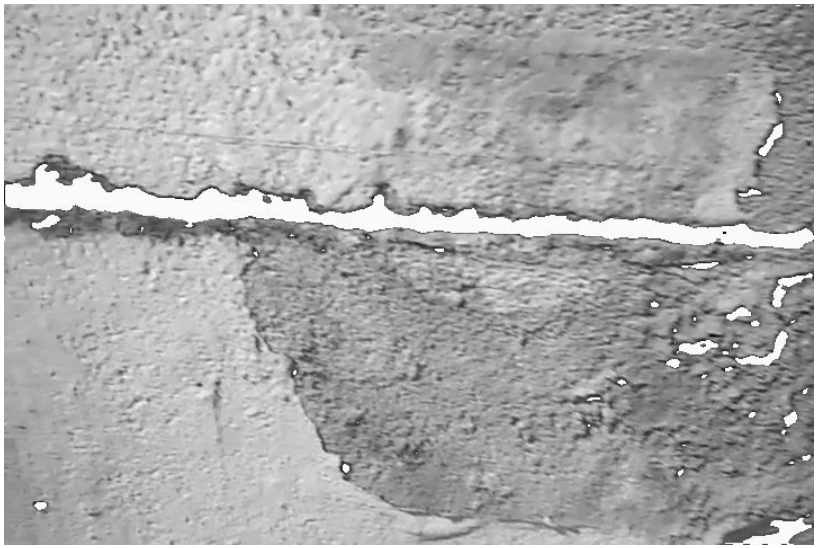
A Fissure and its histogram



Extracting the defects

→ Identify the range of values corresponding to a flaw

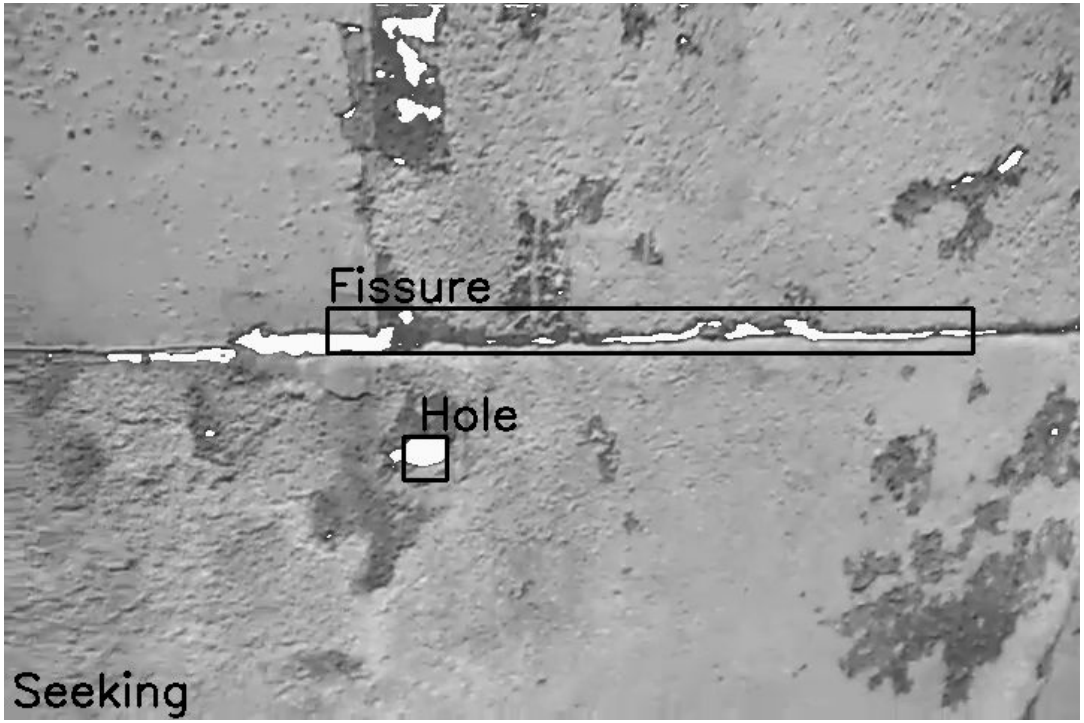
→ Assign white values to those pixels to separate the flaw



Distinction

→ Fissures: Linear flaw

→ Holes: Square (or circular flaw)



Evaluation dataset






200 labelled images

- **70** fissures
- **70** holes
- **60** normal surface

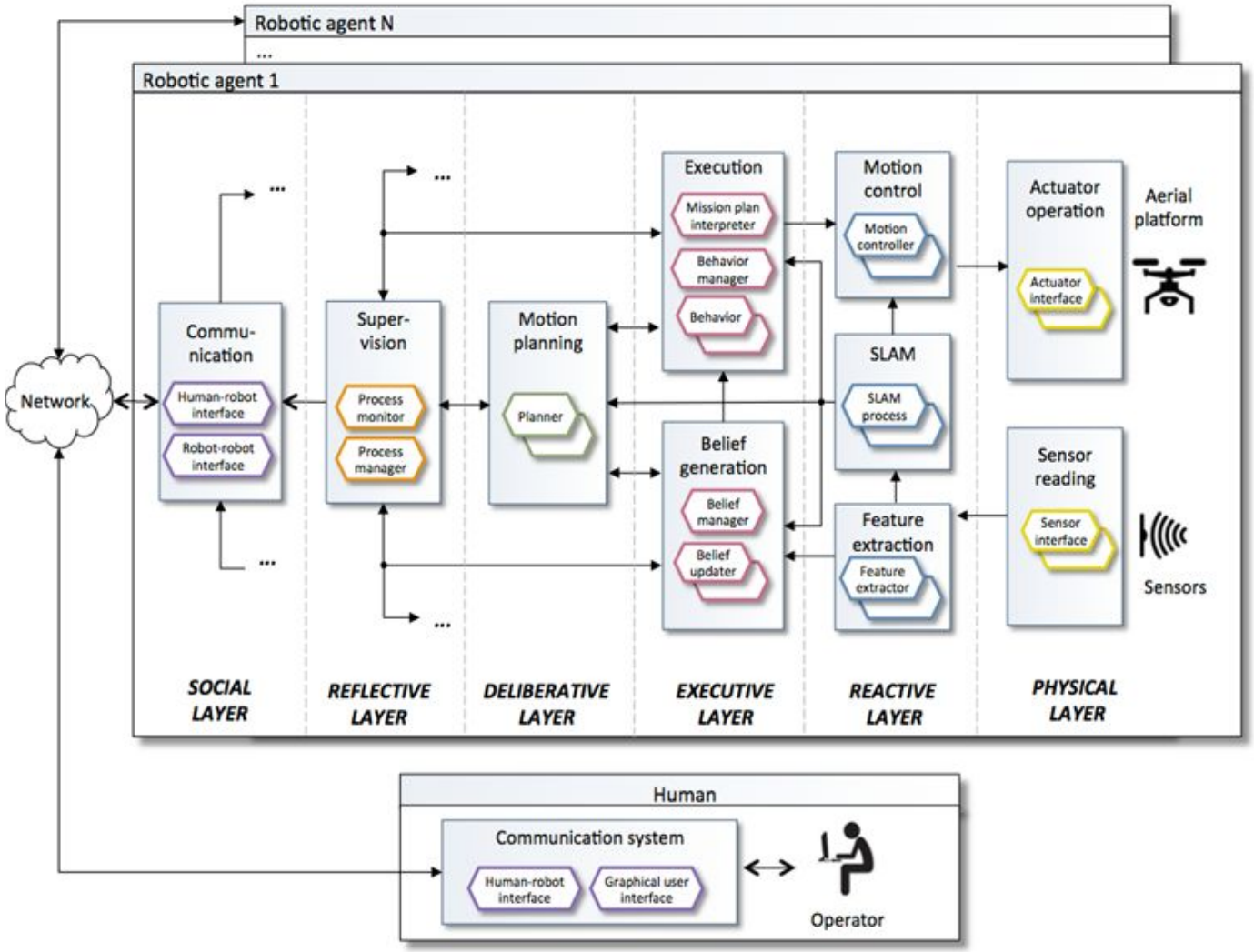
Recognition results

		Prediction			
		Hole	Fissure	No Hole	No Fissure
Reality	Hole	49.5%	0%	40%	N/A
	Fissure	10.5%	88.5%	N/A	11.5%
	No Hole	0	0	0	0
	No Fissure	0	0	0	0

The Collaborative Model

www.aerostack.org

[1] J. L. Sanchez-Lopez, R. A. Suárez Fernández, H. Bavle, C. Sampedro, M. Molina, J. Pestana, and P. Campoy
[2] J. L. Sanchez-Lopez, M. Molina, H. Bavle, C. Sampedro, R. A. Suárez Fernández, and P. Campoy.

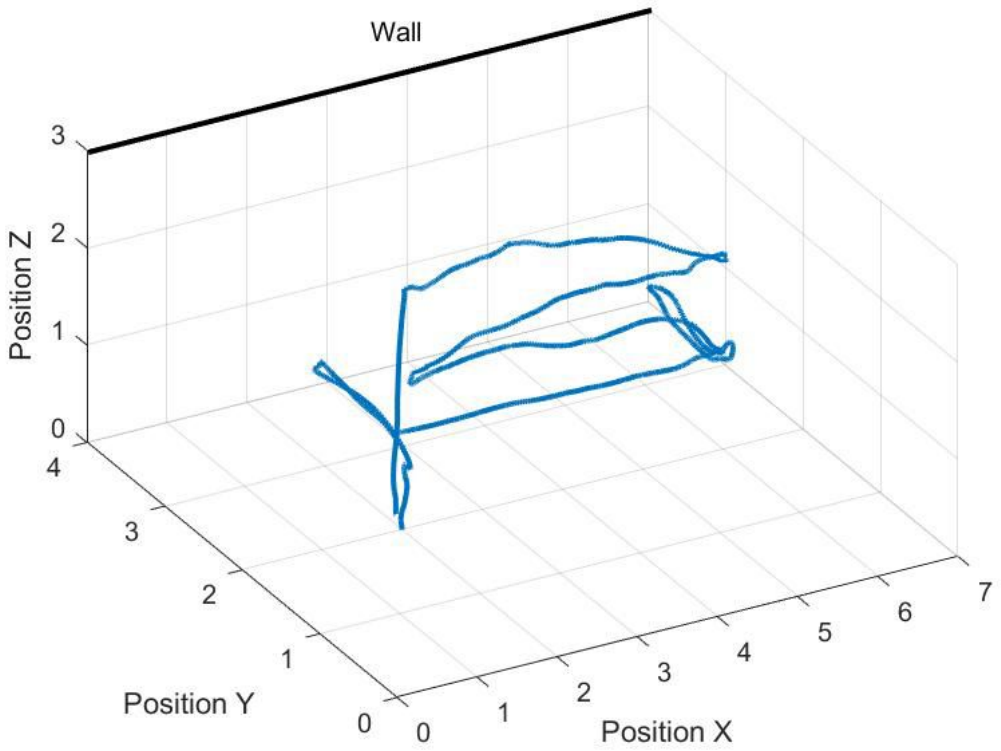


Main Behaviors

→ Movement: Zig zag, Up & Down

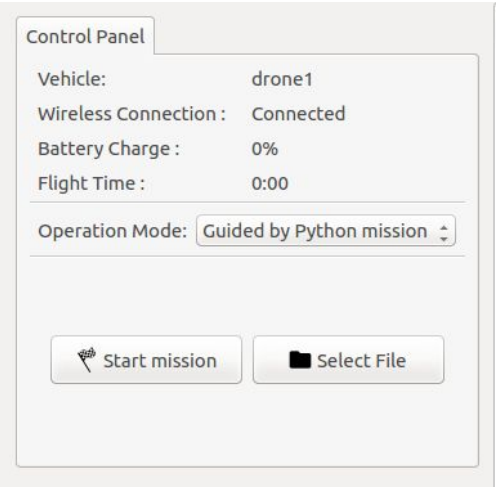
→ Information retrieval: Position

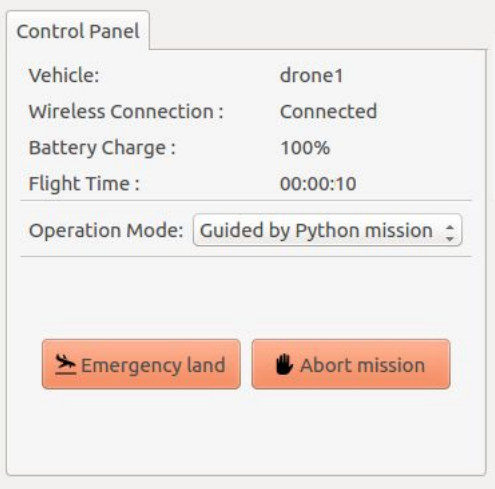
→ Emergency notifications: Low battery, low visibility

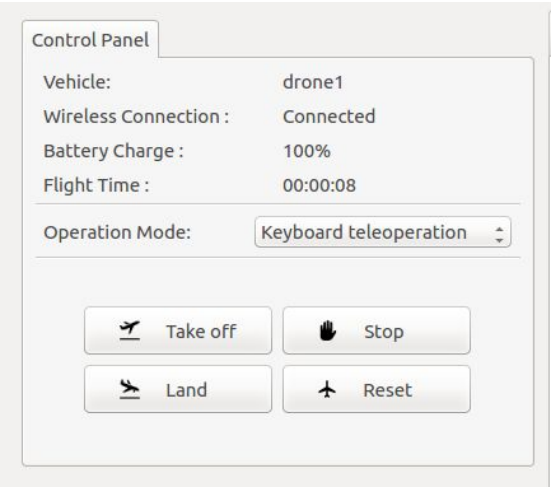


Communication channels

1. **Control panel:** The operator starts/stops the mission and supervises the main flight parameters.
2. **Behavior commands:** The operator commands specific behaviors → ease of supervision. Robot → accept or reject such commands (e.g., for safety reasons). + Use of keyboard
3. **Assistance request:** The robot asks the operator for assistance in the presence of certain events.





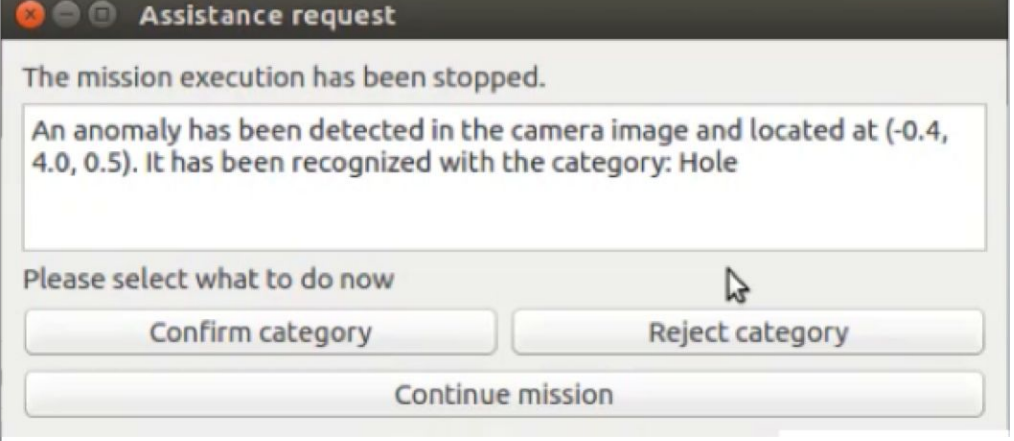


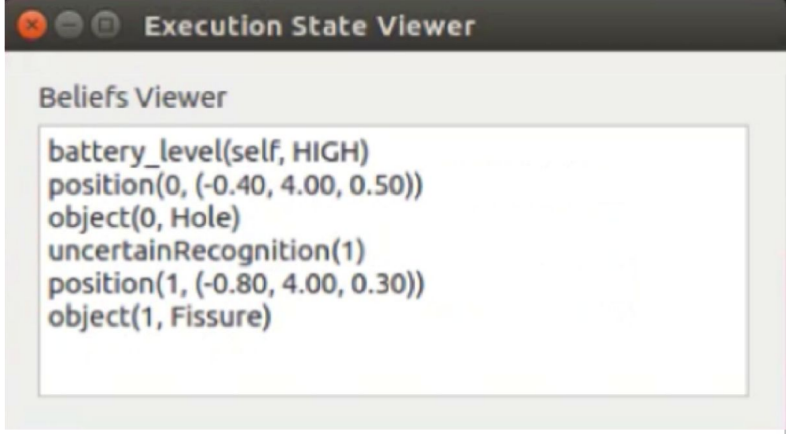
Communication during assistance request

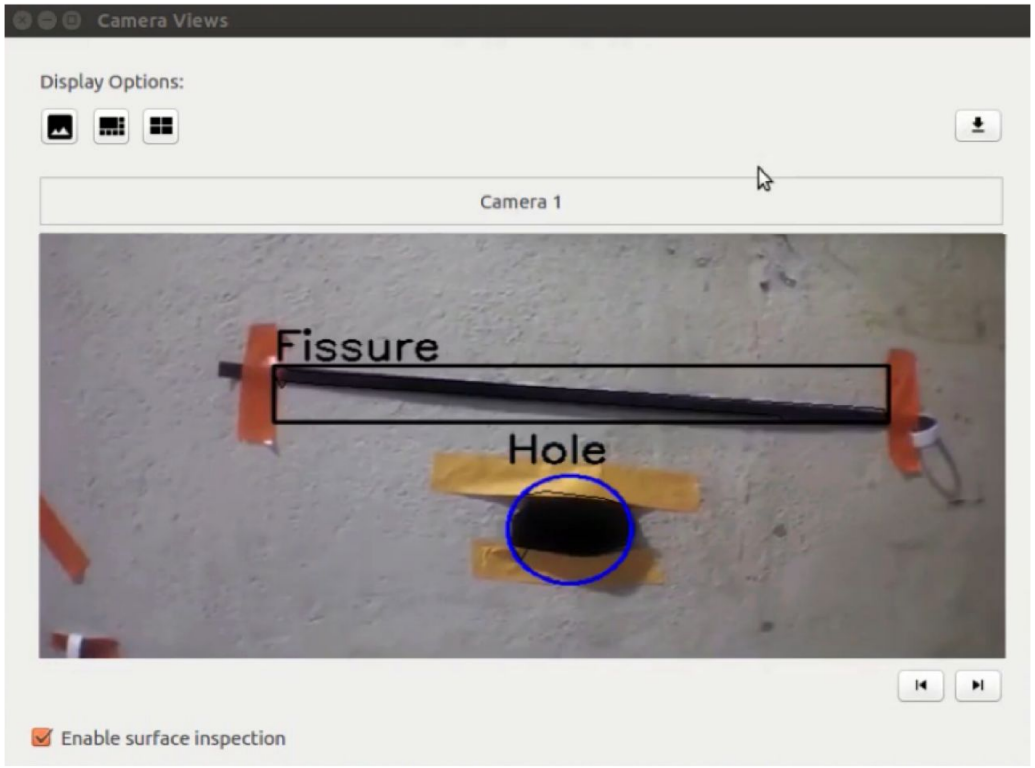
Window for assistance request

Dynamic memory of beliefs

Multiple object detection with a priority scheme



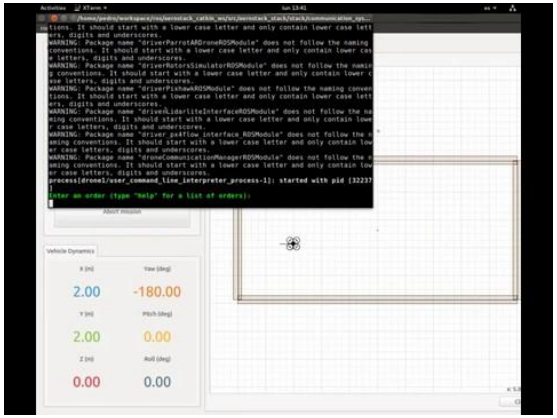




Communication system

→ Two directional communication via a command line interpreter

→ Commands: Take off, Land, Zoom In/Out, Start Mission, Finish Mission, Change Movement Strategy, ...



```
/home/pedro/workspace/ros/aerostack_catkin_ws/src/aerostack_stack/stack/communication_sys...
[INFO] - Orders list:
- Take Off: to
- Land: l
- Go Home: gh
- Call Painter: cp
- Zoom In: zi
- Zoom Out: zo
- Continue Mission: cm
- Start Mission. sm
- Finish Mission: fm
- Move Up/Down/Left/Right: mu, md, ml, mr
- Stop: s
- Send Current Position: sp
- Turn Light On: ton
- Turn Light Off: toff
- Change Movement Strategy: cms
--------------------------------------------------

Enter an order (type "help" for a list of orders):
zo
Enter an order (type "help" for a list of orders):
ml
Enter an order (type "help" for a list of orders):
```

Conclusions and Future Research

Conclusions

→ Recognition method with acceptable performance:

Partial recognition (88% for fissures, 49% for holes)

Efficient to operate in aerial robotics

→ General interaction model with mixed initiative:

Channel (1) Operator asks robot to perform missions

Channel (2) Operator asks robot to perform specific behaviors

Channel (3) Robot asks operators for assistance

→ Experimentation with real flights

Implemented using Aerostack framework

Future Work

→ Improve Recognition accuracy

→ Dynamic feature extraction from histograms

→ Add new categories to recognize

→ Reduce computational load

→ Implement other communication systems (voice commands)

→ Other applications?

References

[1] **J. L. Sanchez-Lopez, R. A. Suárez Fernández, H. Bavle, C. Sampedro, M. Molina, J. Pestana, and P. Campoy**. Aerostack: An architecture and open-source software framework for aerial robotics. In 2016 International Conference on Unmanned Aircraft Systems (ICUAS), pages 332–341, June 2016.

[2] **J. L. Sanchez-Lopez, M. Molina, H. Bavle, C. Sampedro, R. A. Suárez Fernández, and P. Campoy**. A multi-layered component-based approach for the development of aerial robotic systems: The Aerostack framework. Journal of Intelligent & Robotic Systems, May 2017.

[3] **D. Maravall and M. A. Patricio**. Image segmentation and pattern recognition: a novel concept, the histogram of connected elements. In Pattern recognition and string matching, pages 411–463. Springer, 2003.

[4] **M. A. Patricio and D. Maravall**. A novel generalization of the gray-scale histogram and its application to the automated visual measurement and inspection of wooden pallets. Image and vision computing, 25(6):805–816, 2007.