SLAM TO RECONSTRUCT AIRCRAFT ENGINES IN 3D

A PERFORMANCE ANALYSIS USING BORESCOPE VIDEOS

Author: Thomas Markhorst
Supervisors: Prof. Dr. Jan van Gemert and Burak Yildiz
TU Delft Department of Intelligent Systems
Contact: t.c.markhorst@student.tudelft.nl

01 BACKGROUND

- Model blades for damage assessment & counting blades
- SLAM reconstructs surroundings
- Indirect SLAM: feature matching
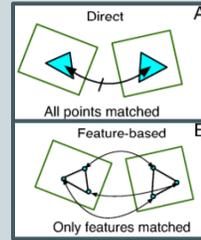- Direct SLAM: pixel matching

Figure 1*

02 PROBLEM

How well does SLAM perform on borescope inspection videos of aircraft turbines?

03 METHOD

Systems under test:

- Indirect SLAM:
  - Traditional matcher: ORB
  - CNN matcher: SuperGlue (SG)
  - CNN matcher: LoFTR
- Direct SLAM:
  - LSD: matches using pixels from gradients
  - DSO: matches using gradient pixels distributed over frame

Figure 2: Example frame from the test videos, showcasing the differences. Left – Video A; Right – Video B.

04 EXPERIMENTS & RESULTS

Normal representative videos: *(Fig. 3)*

- ORB: no reconstruction
- SuperGlue: sparse & long tracking
- LoFTR: semi-dense & semi-robust initialization
- LSD: dense, robust & noise free
- DSO: dense, robust & long tracking

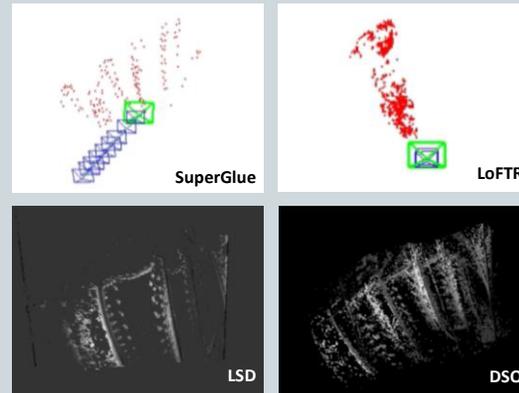| Vid.	Matcher	# Inits	Max. duration (s)	Avg. duration (s)	Use for
A	SG	0	-	-	-
	LoFTR	15	1.4	1	Count/loc
	LSD	9	2	1.5	Count/loc
	DSO	5	3.6	2.7	Count/loc
B	SG	2	1.3	1.3	Count/loc
	LoFTR	5	0.4	0.2	-
	LSD	7	1.9	1.8	Damage
	DSO	4	5.1	3	Damage

Figure 3: Reconstruction of Video A. Using SuperGlue, LoFTR, LSD & DSO. Red/gray dots – model; blue squares – previous camera positions; green square – current camera position.
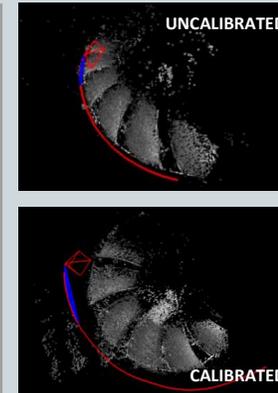
Looped representative videos:

- Indirect: track longer
- Direct: track all frames
- No quality improvement of the model

Influence of calibration for direct: *(Fig. 4)*

- Tested with computer fan
- Calibrated better at linking blades

Direct SLAM follow-up:

- Near real-time does not improve performance compared to real-time
- Removing static pixels by cropping or masking does not improve performance

Figure 4: camera calibration effect

05 CONCLUSIONS

- Indirect:
  - Traditional ORB fails, CNN depends on orientation and texture (and therefore the video)
  - SuperGlue suffers when texture lacks, LoFTR more invariant
  - SuperGlue tracks longer than LoFTR when initialized
- Direct systems outperform indirect in: model density, robustness of initialization and duration of tracking
  - Calibration has major influence on reconstruction quality

*Younes et al. Keyframe-based monocular slam: design, survey, and future directions. Robotics and Autonomous Systems, 98:67â88, Dec 2017.