

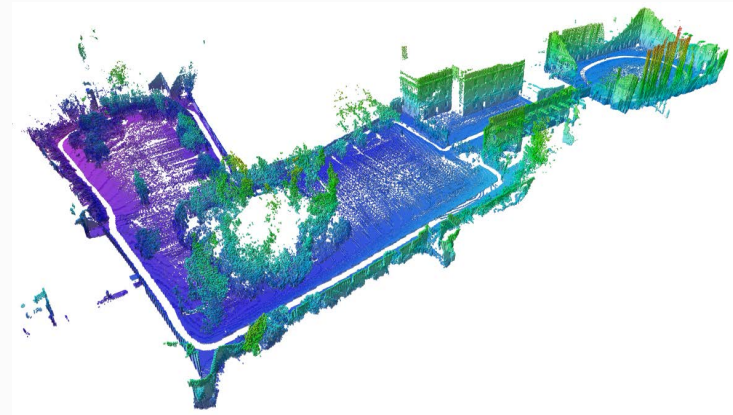
FPGA-based Binocular Image Feature Extraction and Matching System

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Introduction



Visual Odometer



SLAM

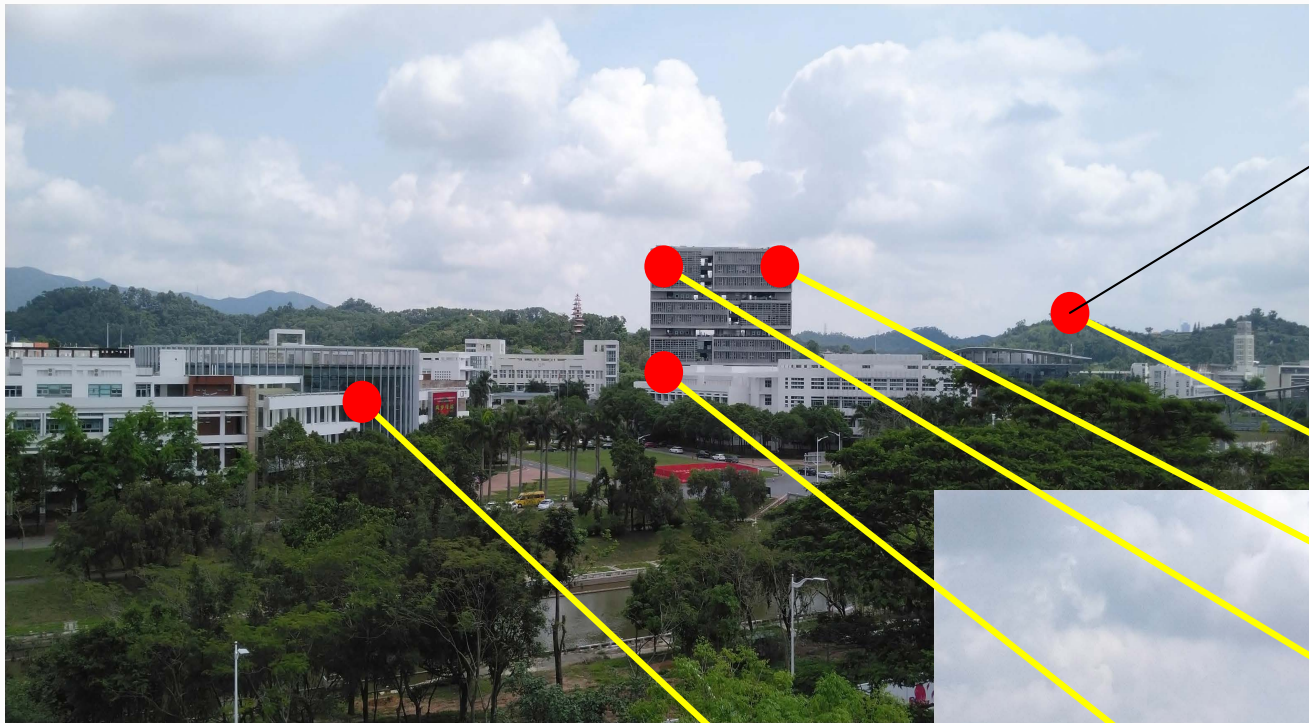


AR

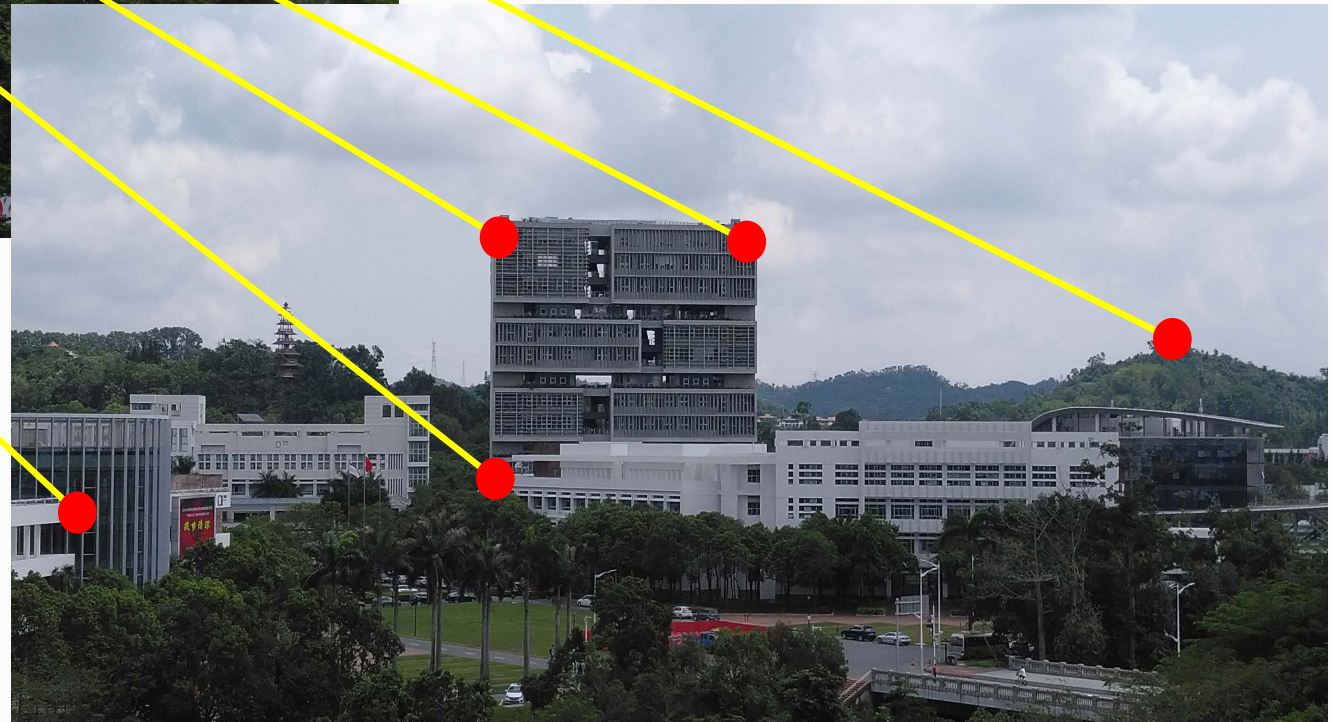


Image Stitching

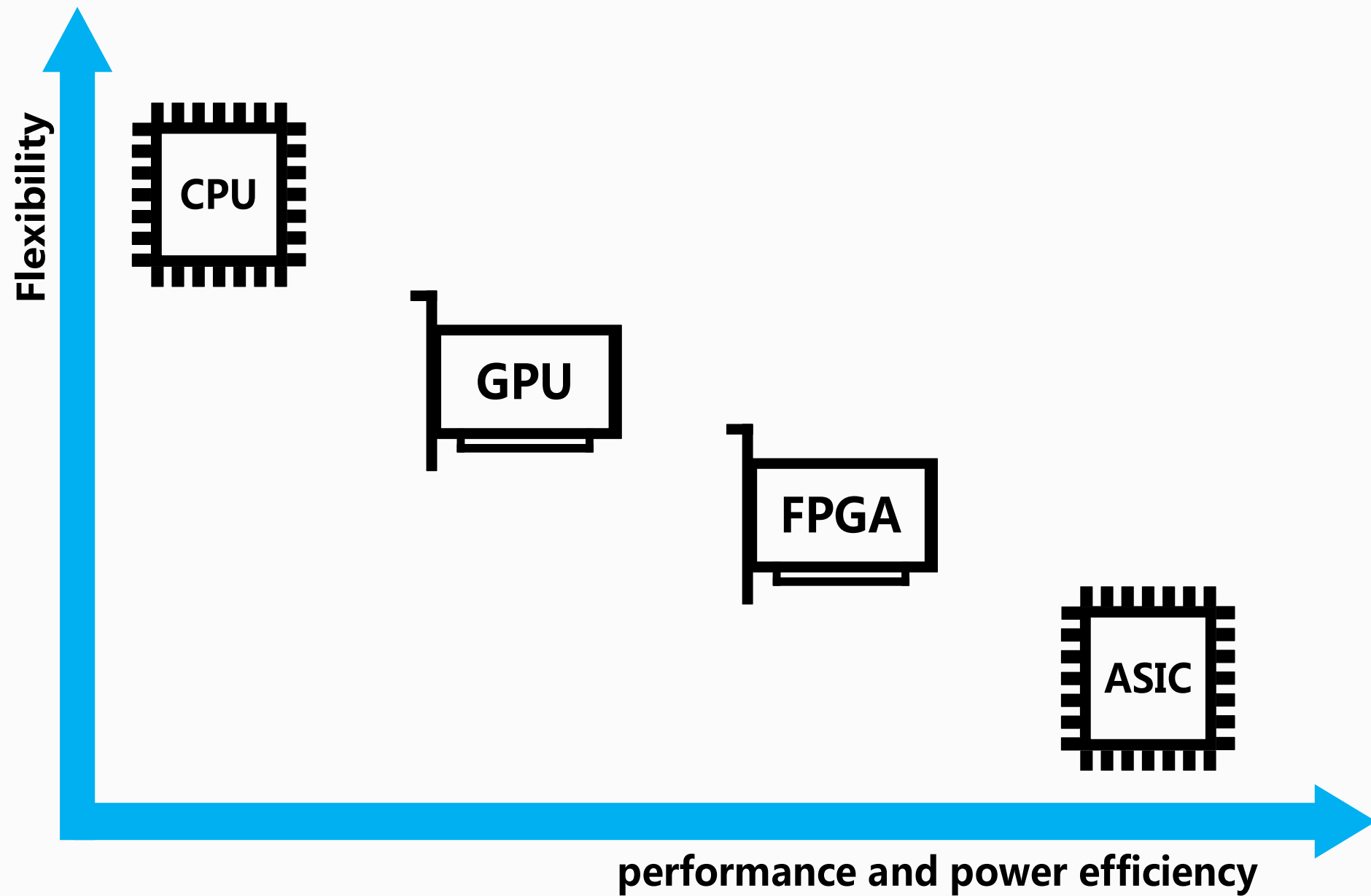
Introduction



Feature Point



Introduction

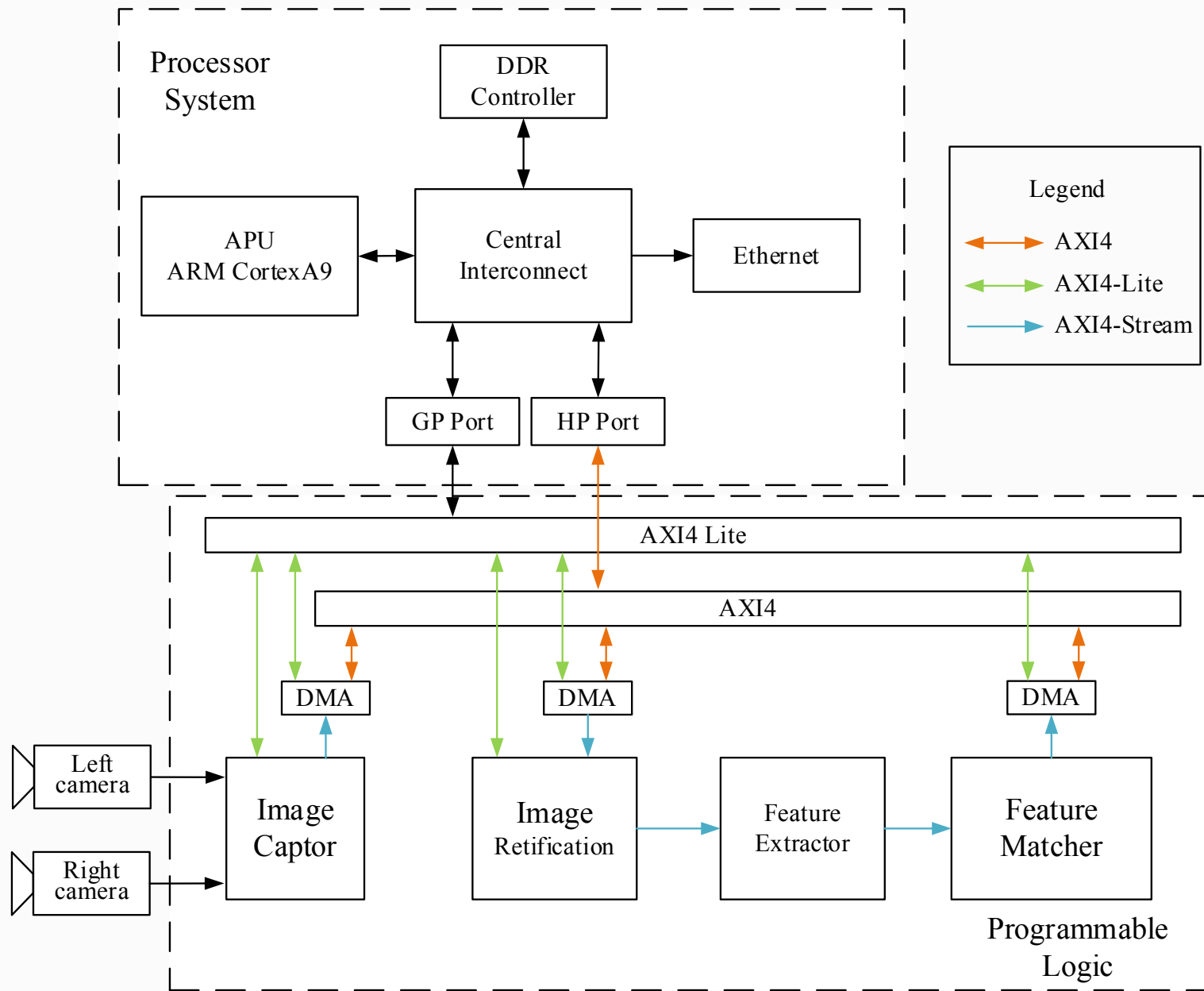


Contribution

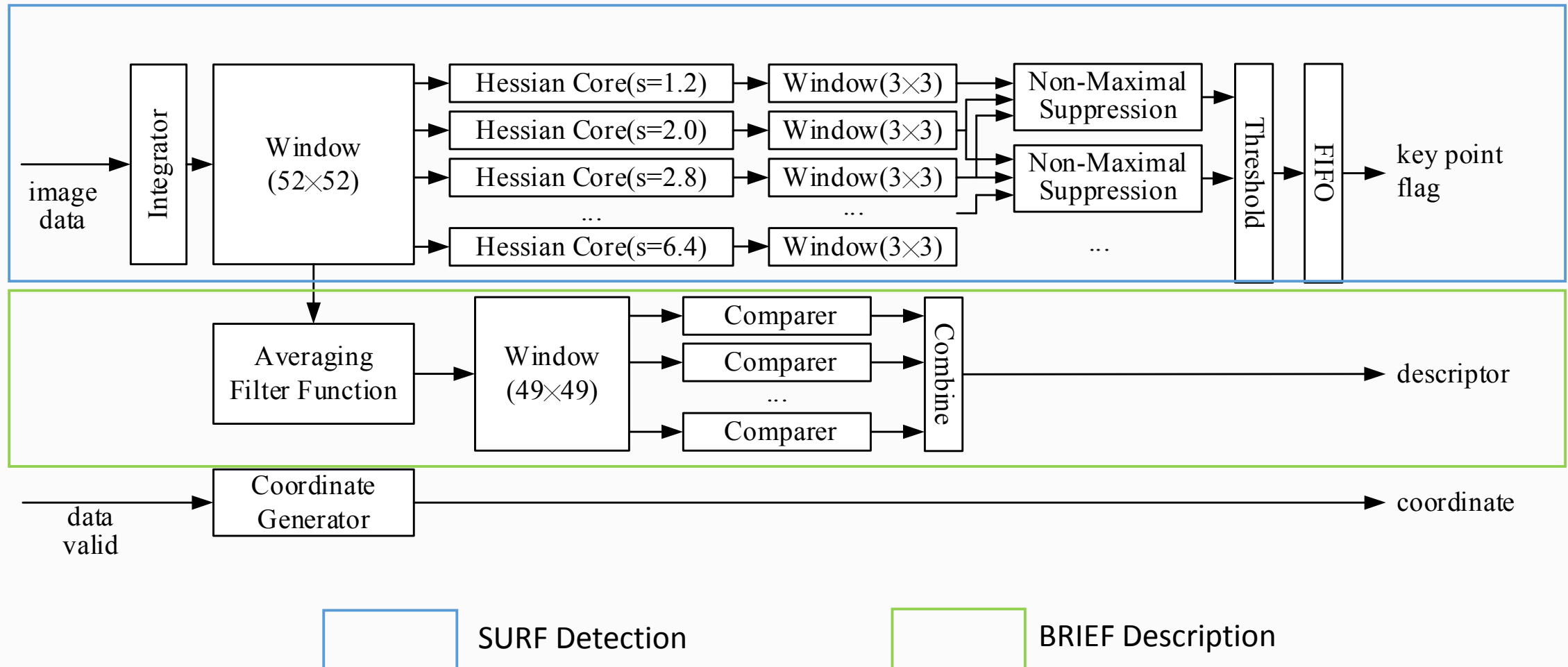
- 1) A binocular system on FPGA is built, which covers SURF detection, BRIEF description and matching, and runs at a frame rate of 162fps @640 x 480.

- 2) Standard AXI protocol is used, and different IPs can be flexibly exchanged or configured. Consequently, the design can be extended to more complex applications.

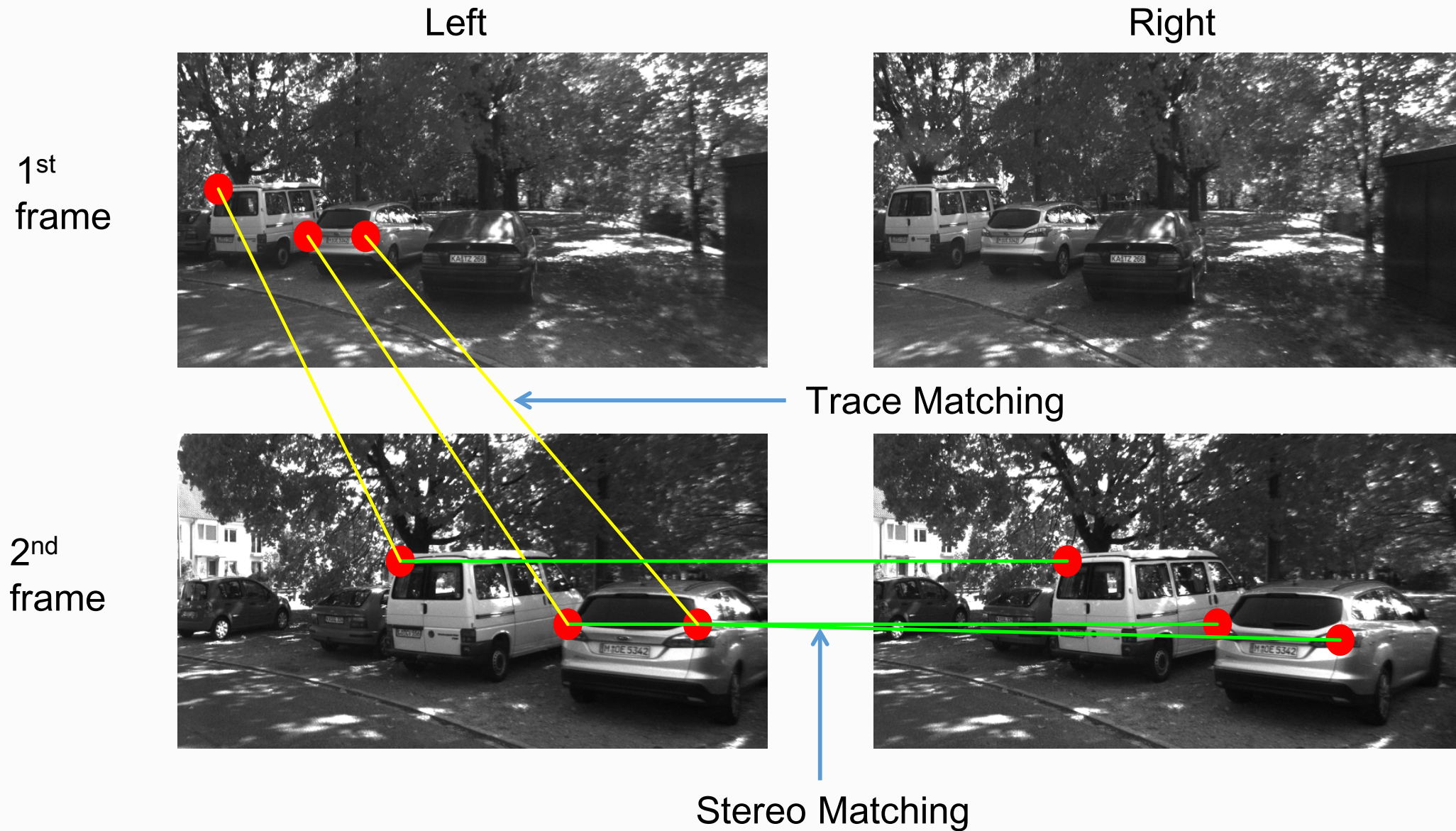
System Design



Feature Extractor



Feature Matcher - Trace and Stereo Matching



Feature Matcher - Pipeline

Extraction:



Matching:



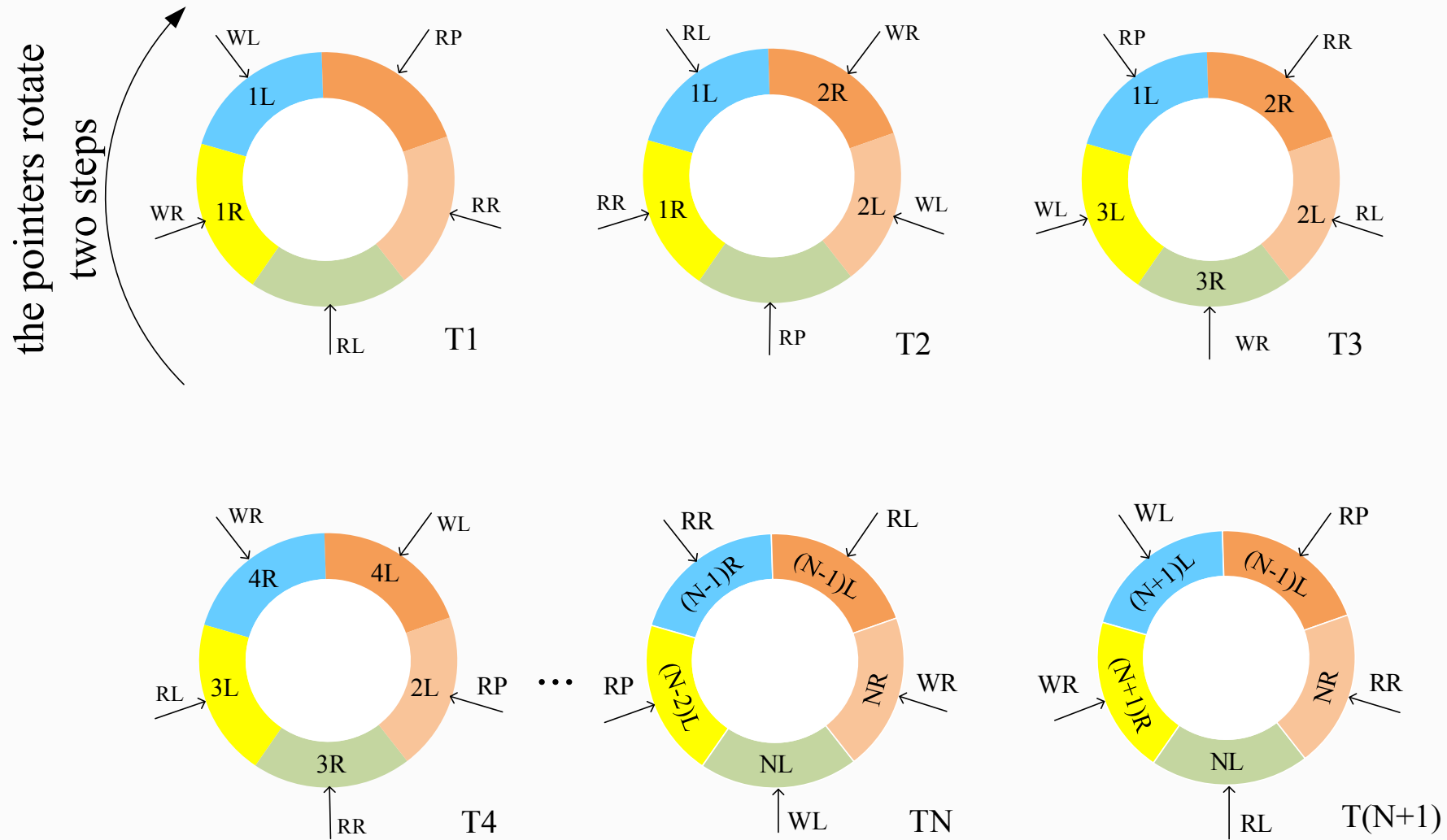
Legend

NL(R): feature extraction of left(right) image in Nth frame.

NT(S): trace (stereo) matching of Nth frame.

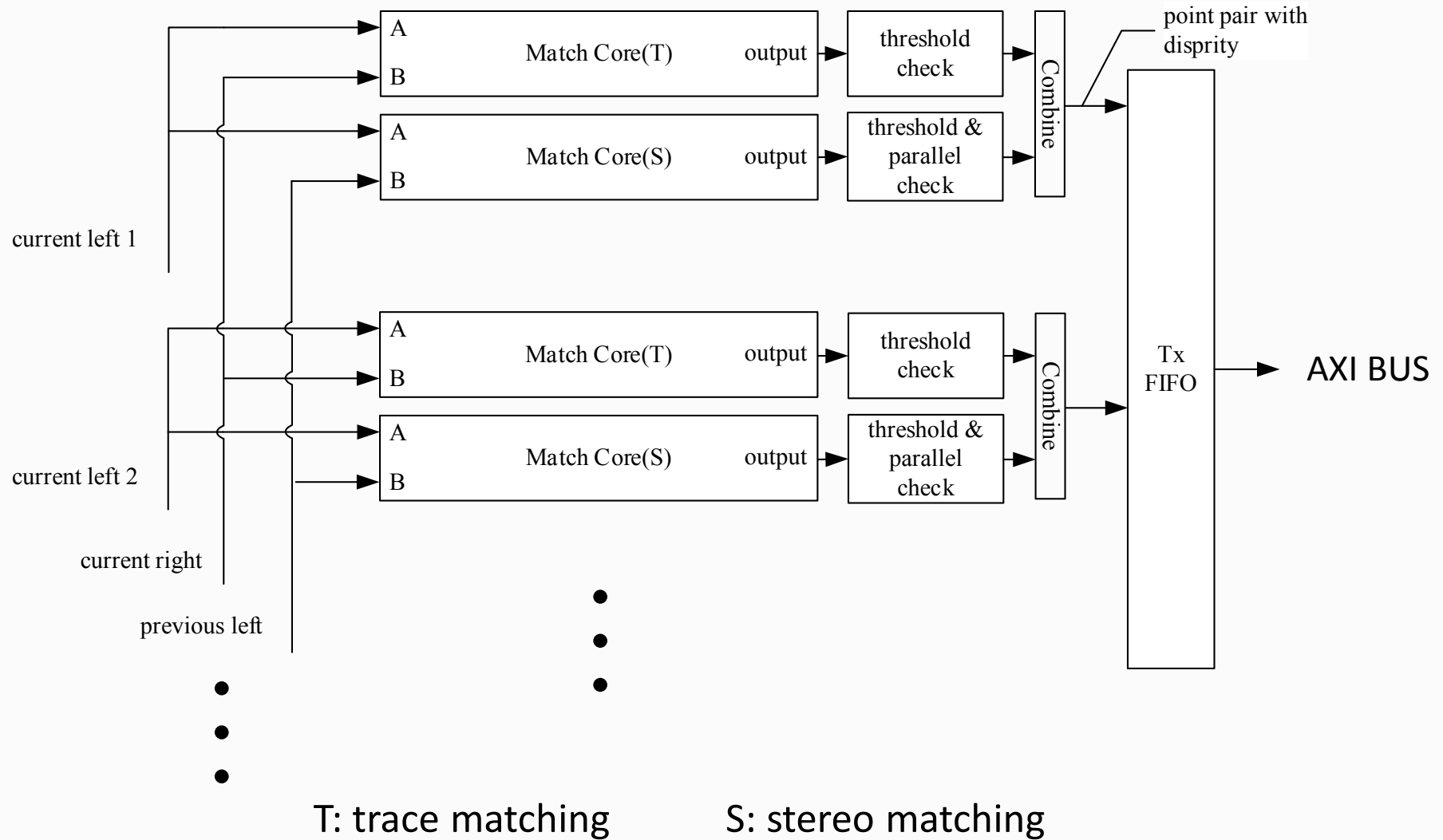
—————▶ Data dependency

Feature Matcher - Buffer



WP: write pointer for previous left extraction WR: write pointer for current right extraction RP: read pointer for previous left extraction
 RR: read pointer for current right extraction RL: read pointer for current left extraction NL/R: the left/right extraction result that is read or wrote

Feature Matcher – Match Executor



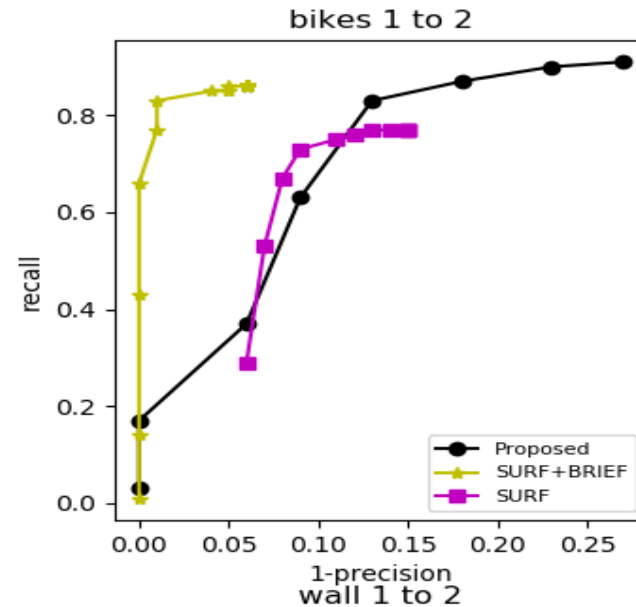
Experiments – Trace Matching



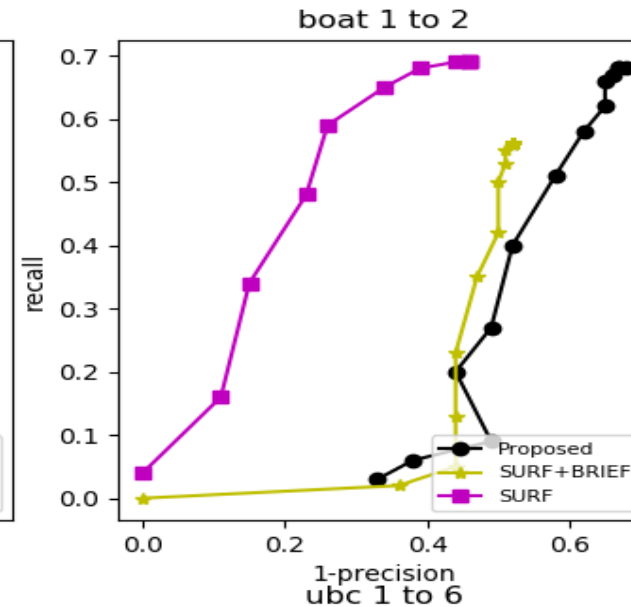


Experiments – Error Analysis

blurring



zoom + rotation



translation

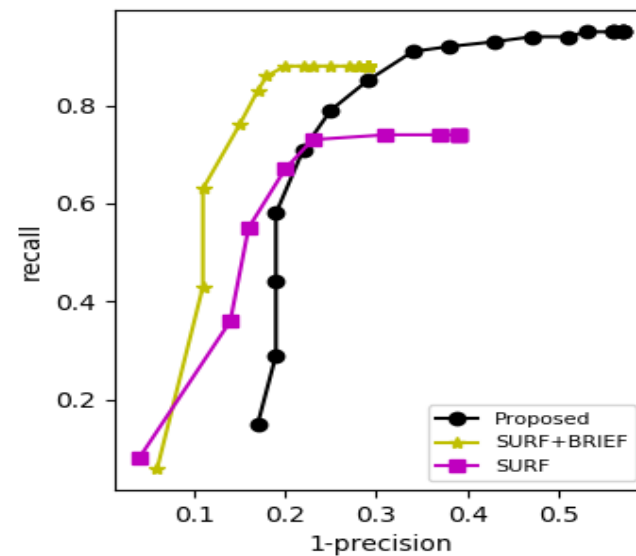
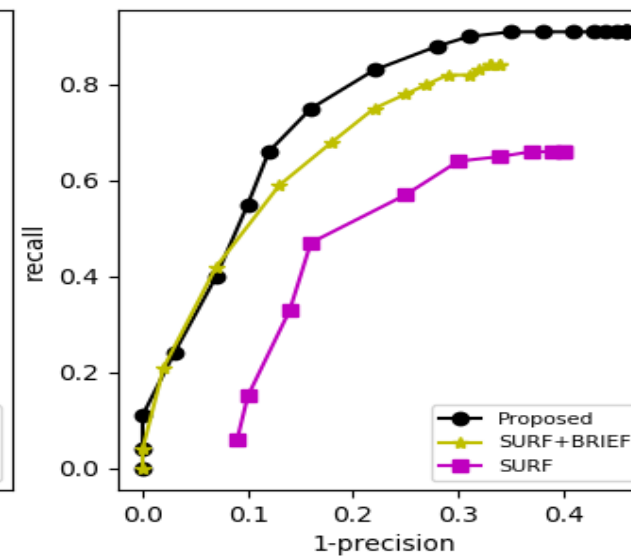


image compression



Data set: <http://www.robots.ox.ac.uk/~vgg/research/affine/>

Experiments – FPGA Utilization

Module	LUT (as logic)	LUT (as memory)	FF	BRAM	DSP
detector	10878	5702	18435	26	160
descriptor	3097	2281	9272	68	0
matcher	3479	26	2134	22.5	0
Total	17454 (%18)	8009 (%11)	29841 (%7)	116.5 (%21)	160 (18%)
Available	148200	70400	437200	545	900

Chip: Xilinx SOC Zynq XC7Z045

Experiments – Performance Comparison

Ver.	Detection	Description	Architecture	Clock (MHz)	Image Size	Frame Rate (fps)
(Bonato et al., 2008)	SIFT	SIFT	Stratix+NIOS	100	320×240	30
(Fowers et al., 2013)	SURF	BASIS	Virtex+CPU	400	640×480	30
(Heo et al., 2013)	FAST	BRIEF	ZYNQ	100	640×480	55
(Wang et al., 2014)	SIFT	BRIEF	Virtex	200	1280×720	60
(Fularz et al., 2015)	FAST	BRIEF	ZYNQ	100	640×480	308
Our (Monocular)	SURF	BRIEF	ZYNQ	100	640×480	325
Our (Binocular)	SURF	BRIEF	ZYNQ	100	640×480	162

Thank you!