Search-Free Linear Projection and Temporal Local Matching for High Frame Rate and Ultra-Low Delay SLAM System

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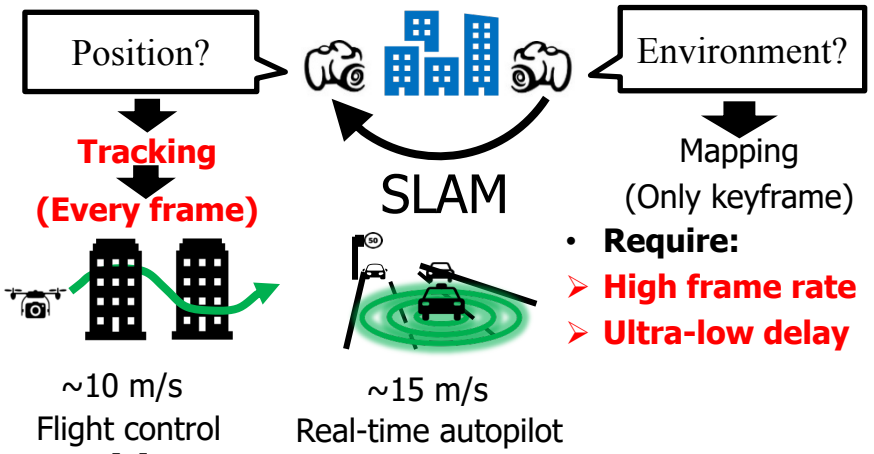


- **Require:**
  - **High frame rate**
  - **Ultra-low delay**

■Problems:

Projection
- Large computation
- Division has large latency

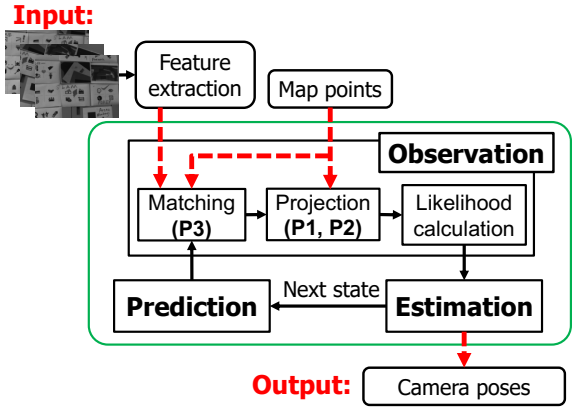
Matching
- Data dependency
- Global comparison

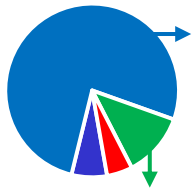
■Acceleration method:

Algorithm
- Iteration based algorithm (ORB-SLAM)
- ✓Parallelism based algorithm (Particle filter)

Device
- GPU
- ✓FPGA

■Framework:

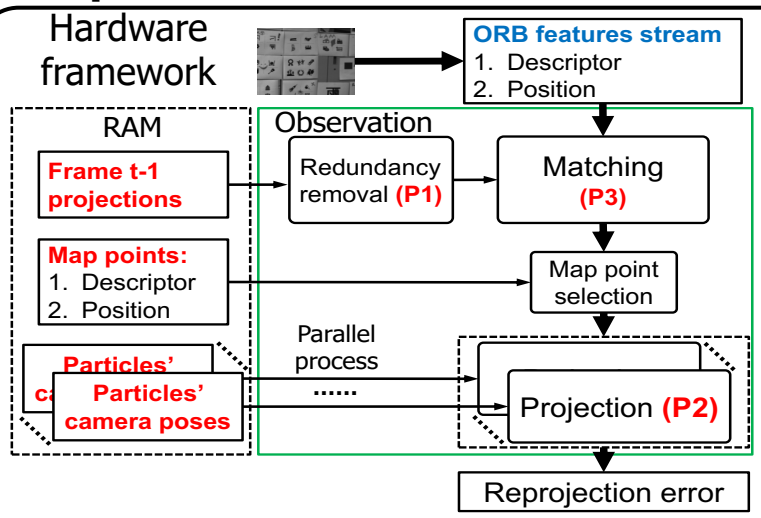




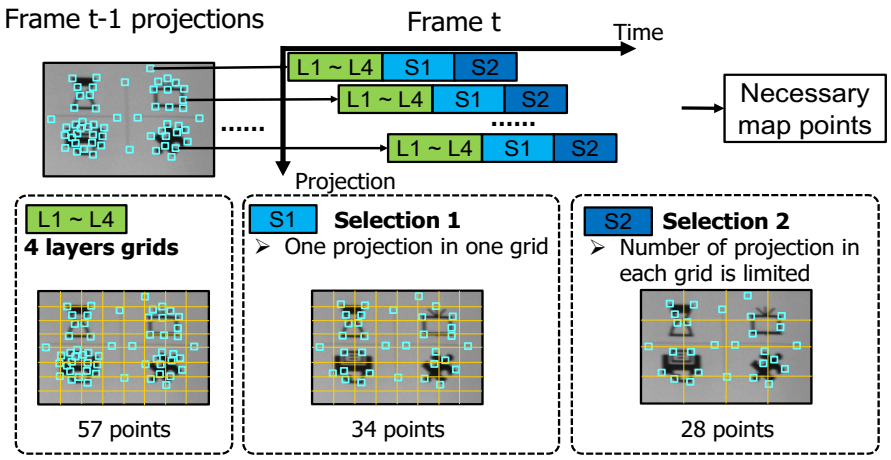
- Input from image

Target:
Projection and matching acceleration on FPGA

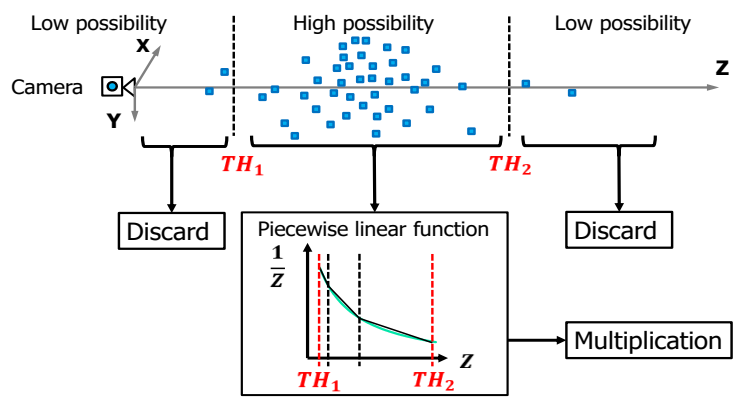
■Proposals:



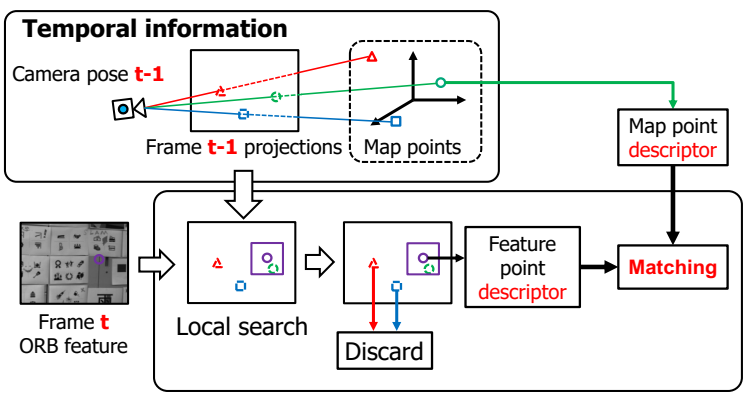
Proposal 1: Search-free gridding based redundant projection removal



Proposal 2: Non-iterative linear function based division



Proposal 3: Temporal 2D local matching



■Experiment result:

Software simulation accuracy (RMSE)	Rotation error (°)				Translation error (cm)			
	Conventional	P1	P1+P2	P1+P2+P3	Conventional	P1	P1+P2	P1+P2+P3
Average	1.24	1.23	1.17	1.20	1.85	1.84	1.91	1.90

Performance	Latency (ms)			
	Redundancy removal	Matching	Projection	Sum
Software	-	4-29	21-81	25-110
Conventional	0.0528	1.89	1.09	3.03
P1	0.00952	1.89	1.09	2.99
P1+P2	0.00952	1.89	0.271	2.17
P1+P2+P3	0.00952	0.177	0.271	0.457

Utilization	Utilization (used/total)		
Parallelism	16	32	64
# of LUT	21274 (3%)	42534 (7%)	99498 (16%)
# of Flip Flop	31076 (5%)	55743 (9%)	111508 (18%)
# of BRAM	74 (3%)	90 (5%)	106 (6%)
# of DSP	256 (13%)	480 (25%)	928 (48%)
Maximum frequency	135.969 MHz		

■Conclusion:

1. High processing speed: 0.457 ms per frame processing time.
2. High accuracy: 1.20° error in rotation and 1.90 cm error in translation

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