

Robust and Efficient Depth-based Obstacle Avoidance for Autonomous Miniaturized UAVs

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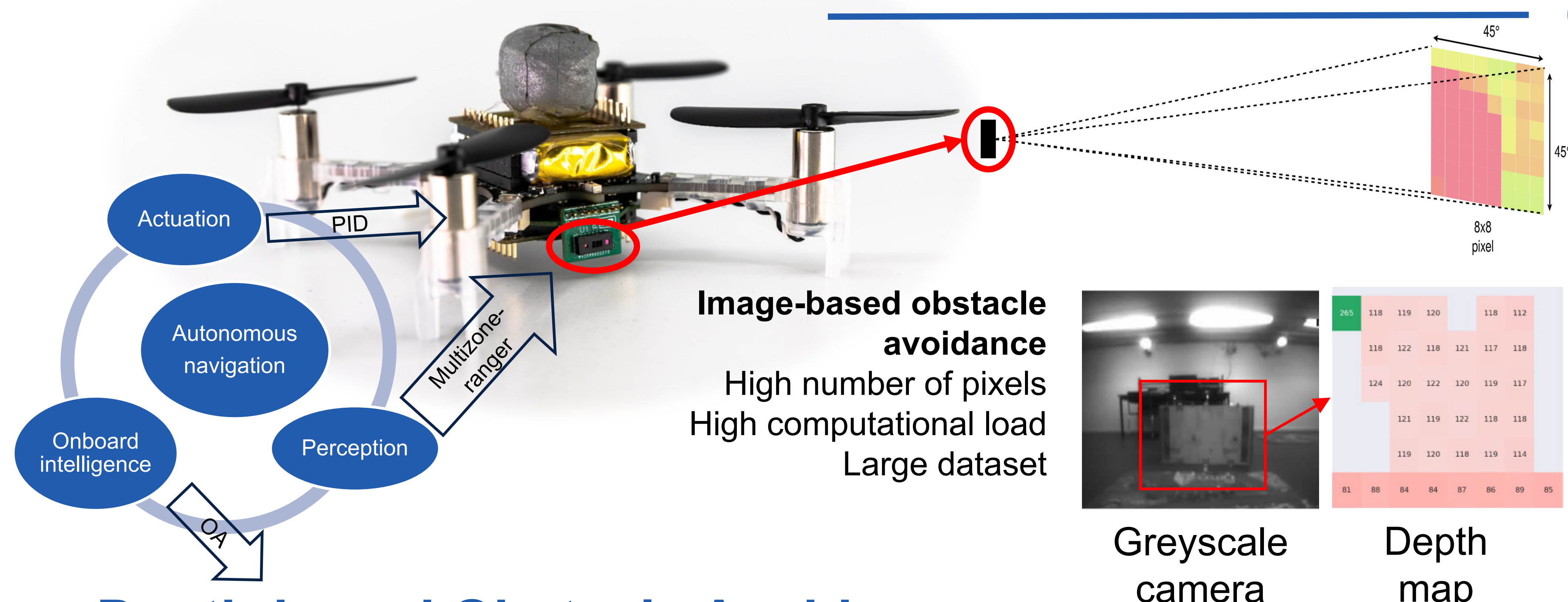
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Challenges in Nano-UAVs

- Power constraint
 - ~1 W for sensing/processing
- Weight constraint
 - Crazyflie: 27 g + < 15 g payload
- Limited computational power
 - ARM Cortex-M4 168 MHz
 - 192 kB SRAM

Depth-based obstacle avoidance

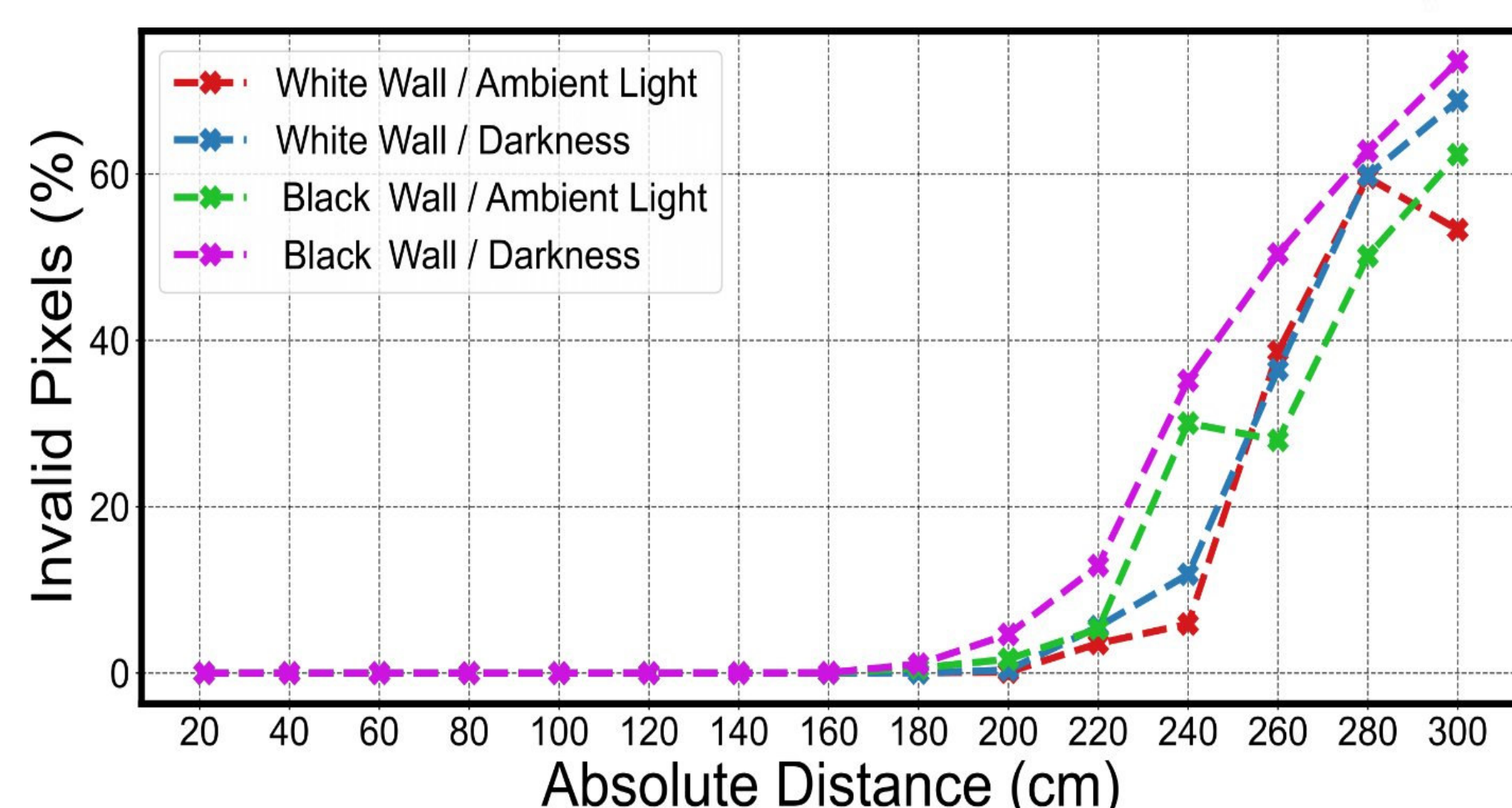
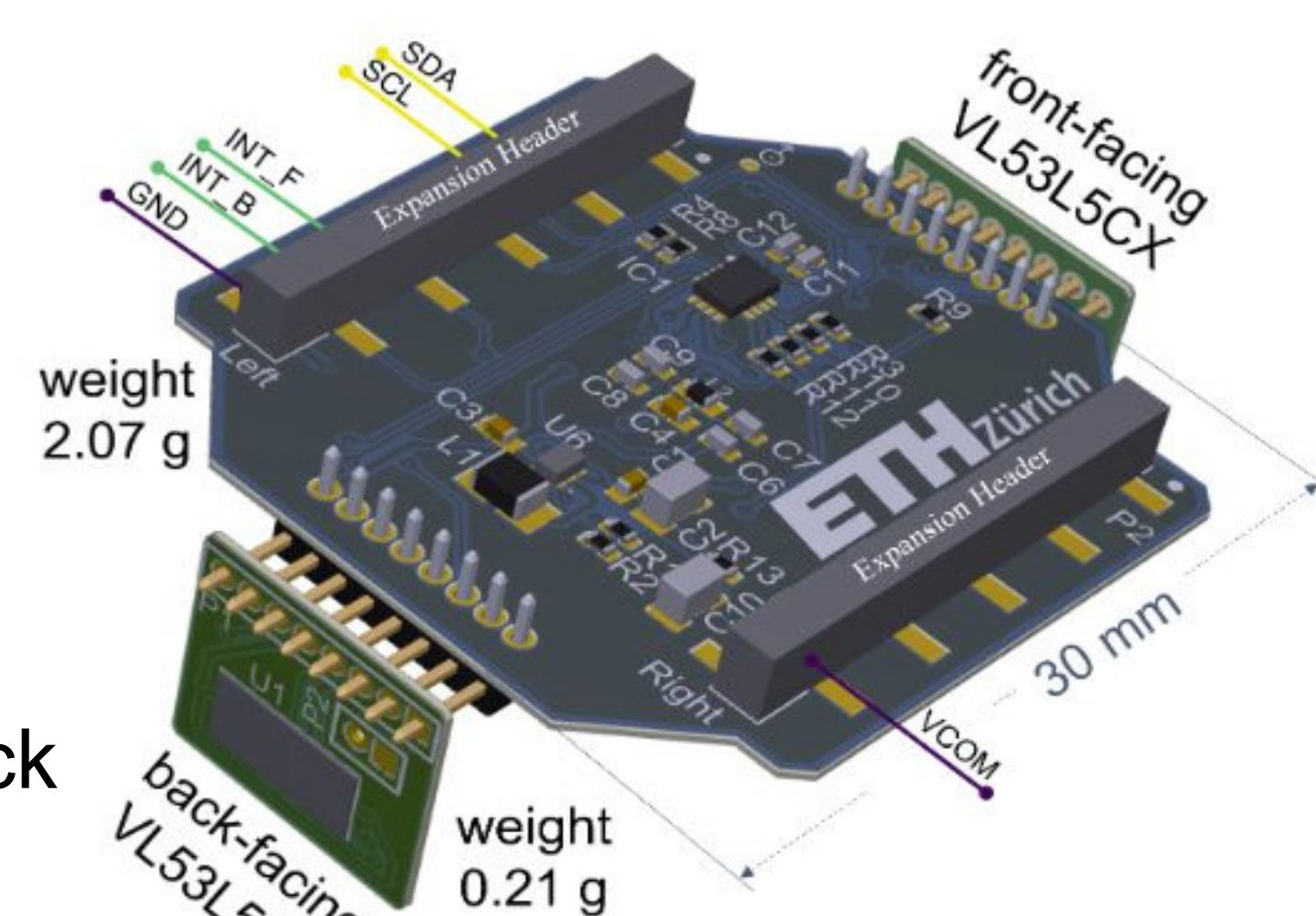
Direct depth map
Low resolution
No dataset required



Depth-based Obstacle Avoidance

STM VL53L5CX

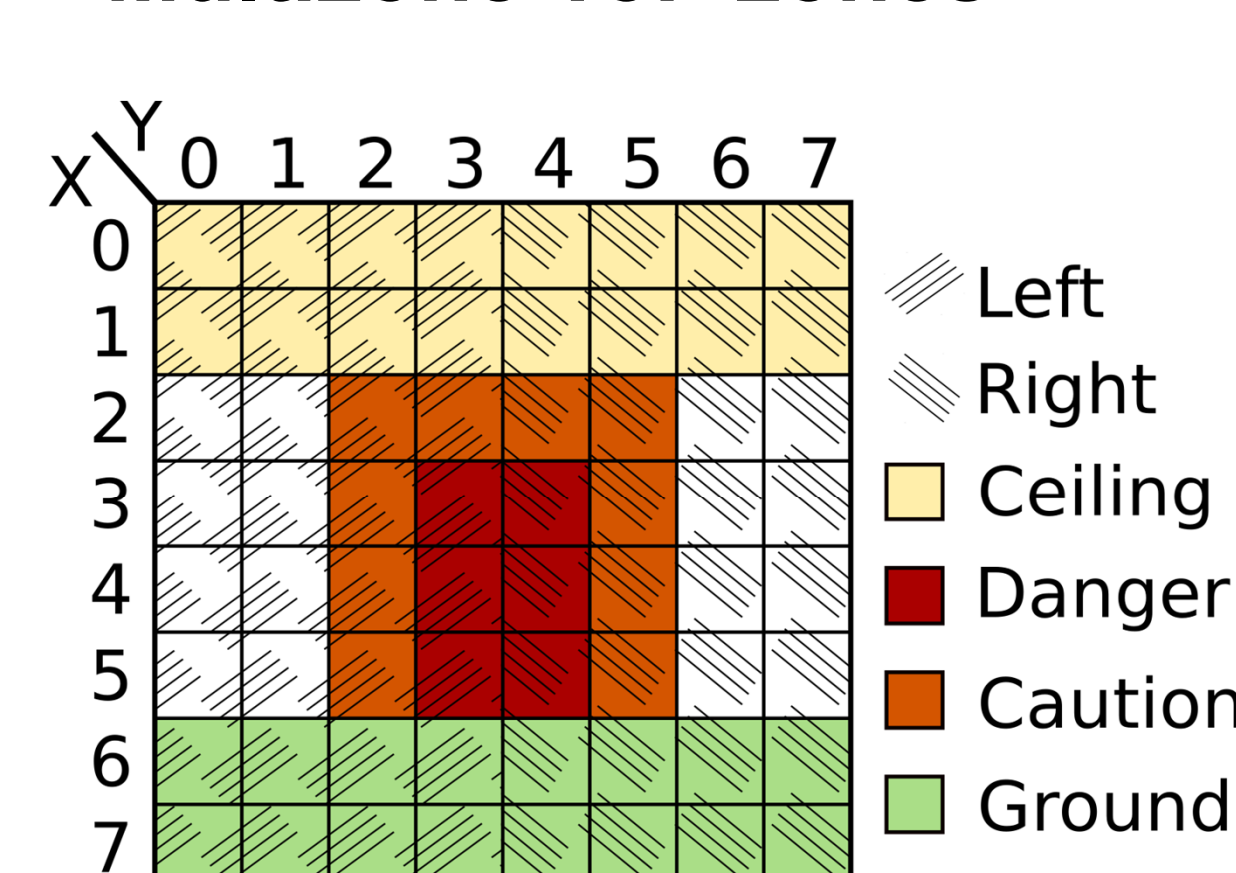
- 900nm laser-based
- Time-of-flight multizone
- 15 Hz @ 8x8 pixel
- 65° diagonal FoV
- Up to 4 m range
- Modular integration on 2.2 g deck



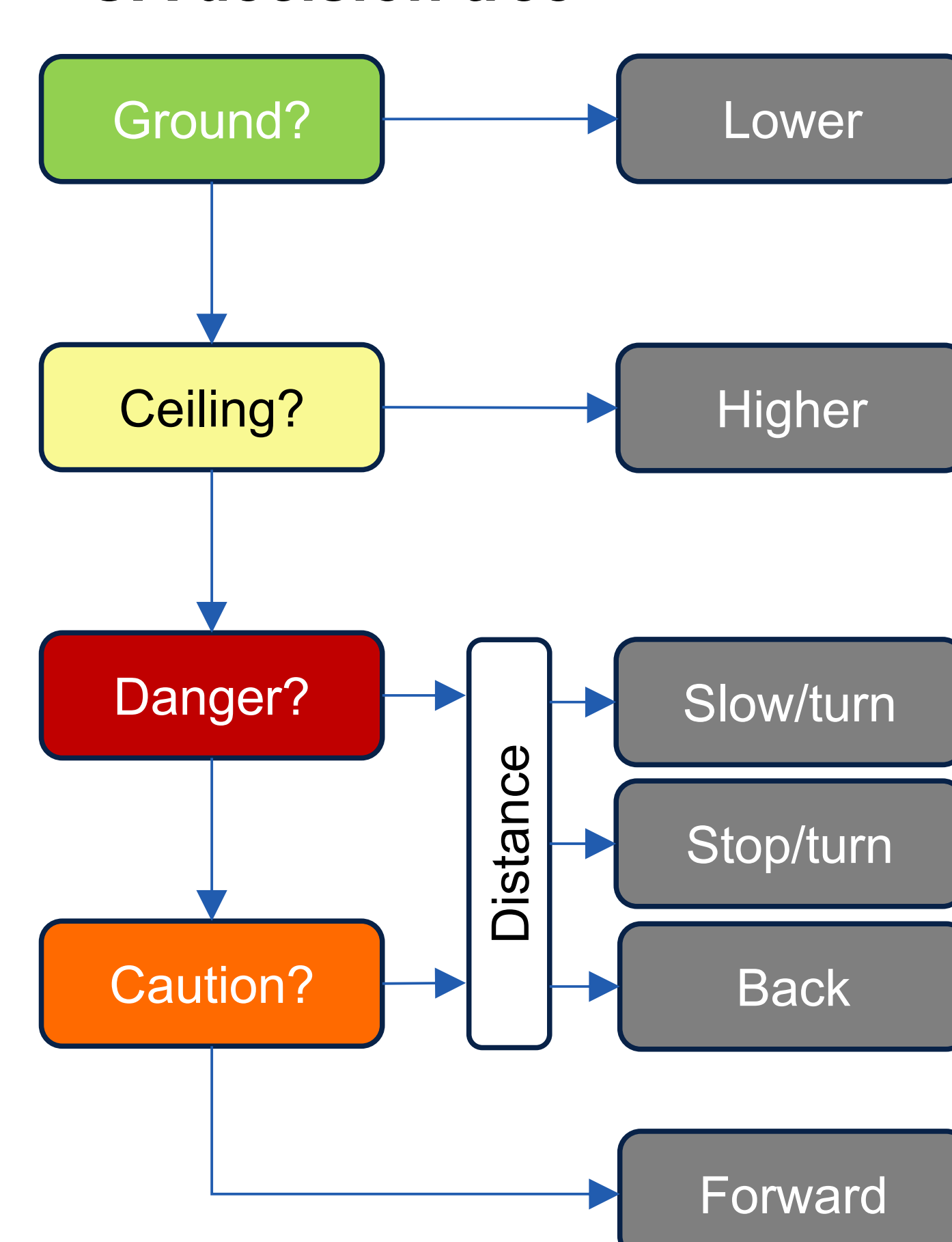
Decision tree for obstacle avoidance

- Low latency (210 us)
- Low computational requirements
- Not relying on training data

Multizone ToF zones

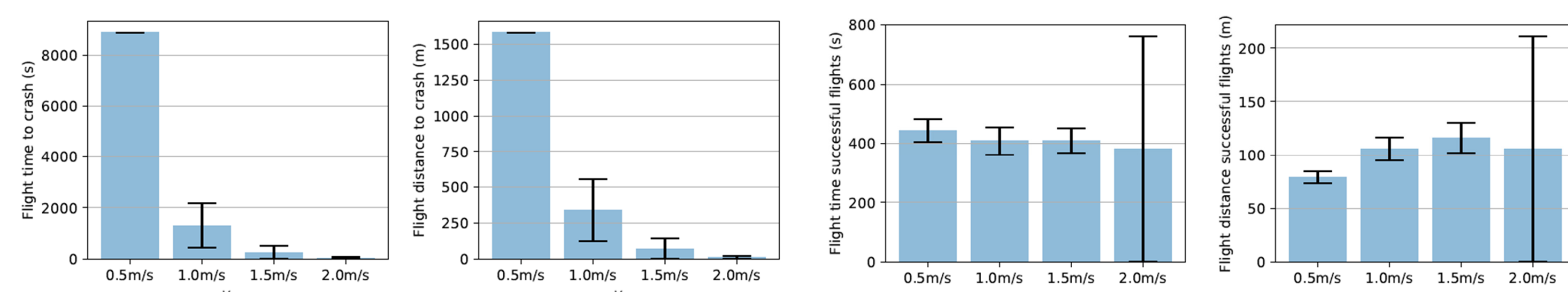
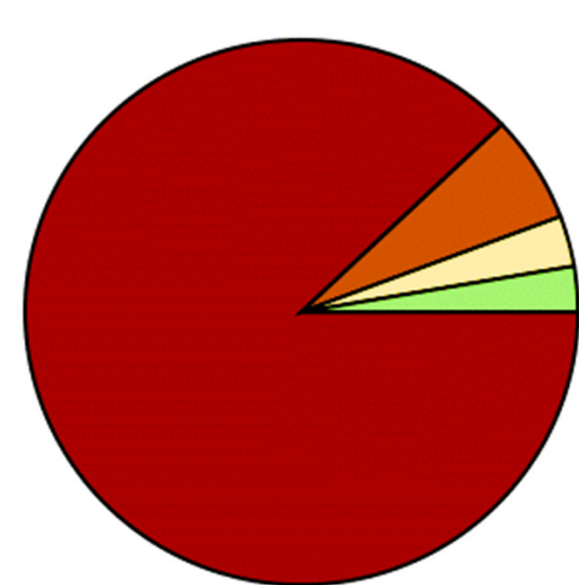


OA decision tree



Results

- Power consumption
 - 600 mW for sensing - computation
 - < 10% added in total
- Field tests
 - 100% success in controlled environments
 - 100% success @0.5 m/s in general office environment



	Environment	Max. vel.	Flight time	Flight distance	#flights with crash
Maze		1m/s	6'31"	199m	0/3
			6'34"	209m	
			6'45"	212m	
Office		average over 20 flights	7'23"	79m	0/20
			1m/s	98m	
			1.5m/s	73m	
			2m/s	47m	
Outdoor		1m/s	50"	61m	2/3
			5'54"	116m	
			6'38"	147m	
			1.5m/s	43m	
		1.5m/s	2'29"	131m	3/3
			2'37"	109m	
			3'24"	109m	
			2m/s	102m	
		2m/s	59"	143m	3/3
			1'44"	146m	
			1'50"	146m	

Robust, Efficient and Open-Source!!!

- Robust obstacle avoidance
 - 100% success with 0.5 m/s in a general office environment
- Efficient onboard implementation
 - 0.31% of available computational power (ARM Cortex-M4)
- Lightweight and low-power
 - <10% power consumption added (lift weight and drive electronics)

- Open-source
 - Hardware
 - Firmware
 - Dataset
 - internal state, motion capture
 - ToF, camera

