Multi-space multi-objective design-space exploration for 3D scene understanding using active learning

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Software Performance Optimisation group

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In collaboration with:

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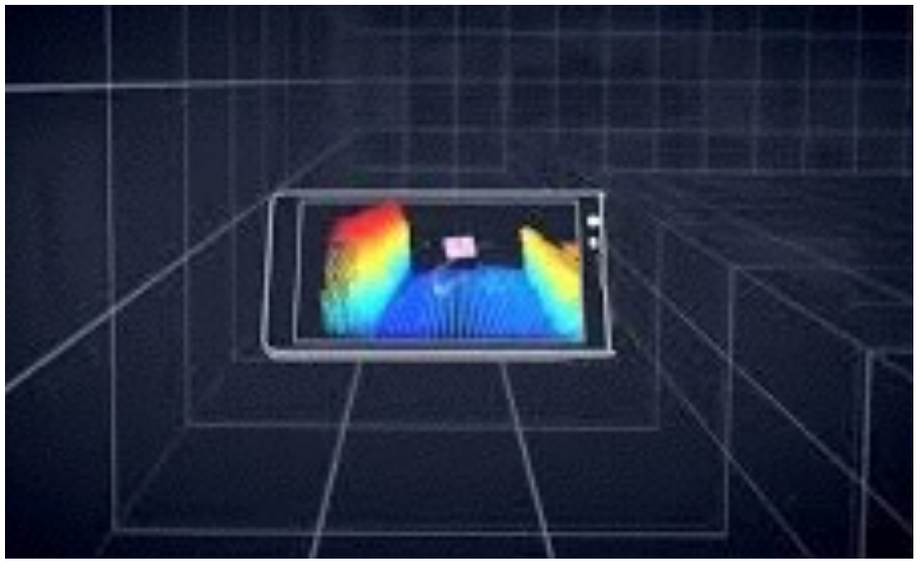
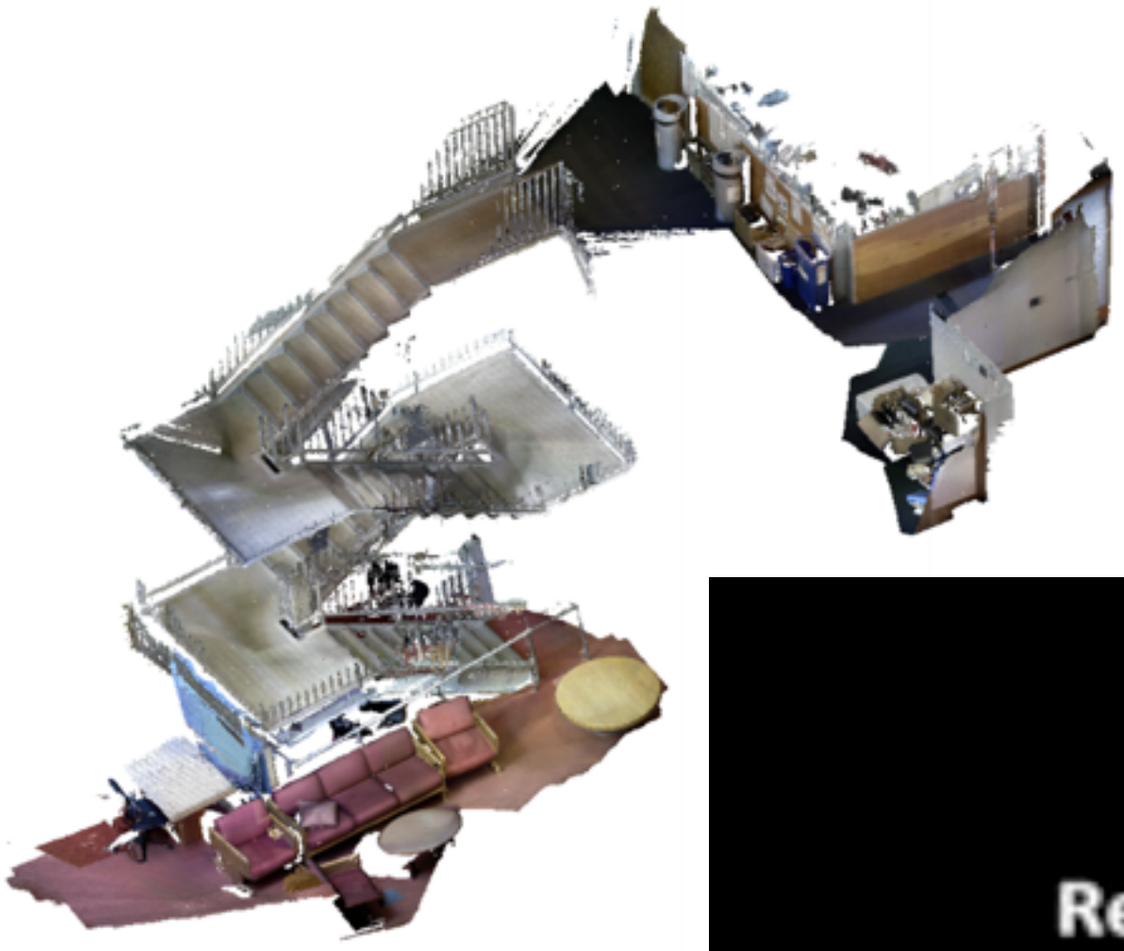
Simultaneous localisation and mapping (SLAM)

Build a coherent world representation and localise the camera in real-time



Video:
Dyson 360 Eye

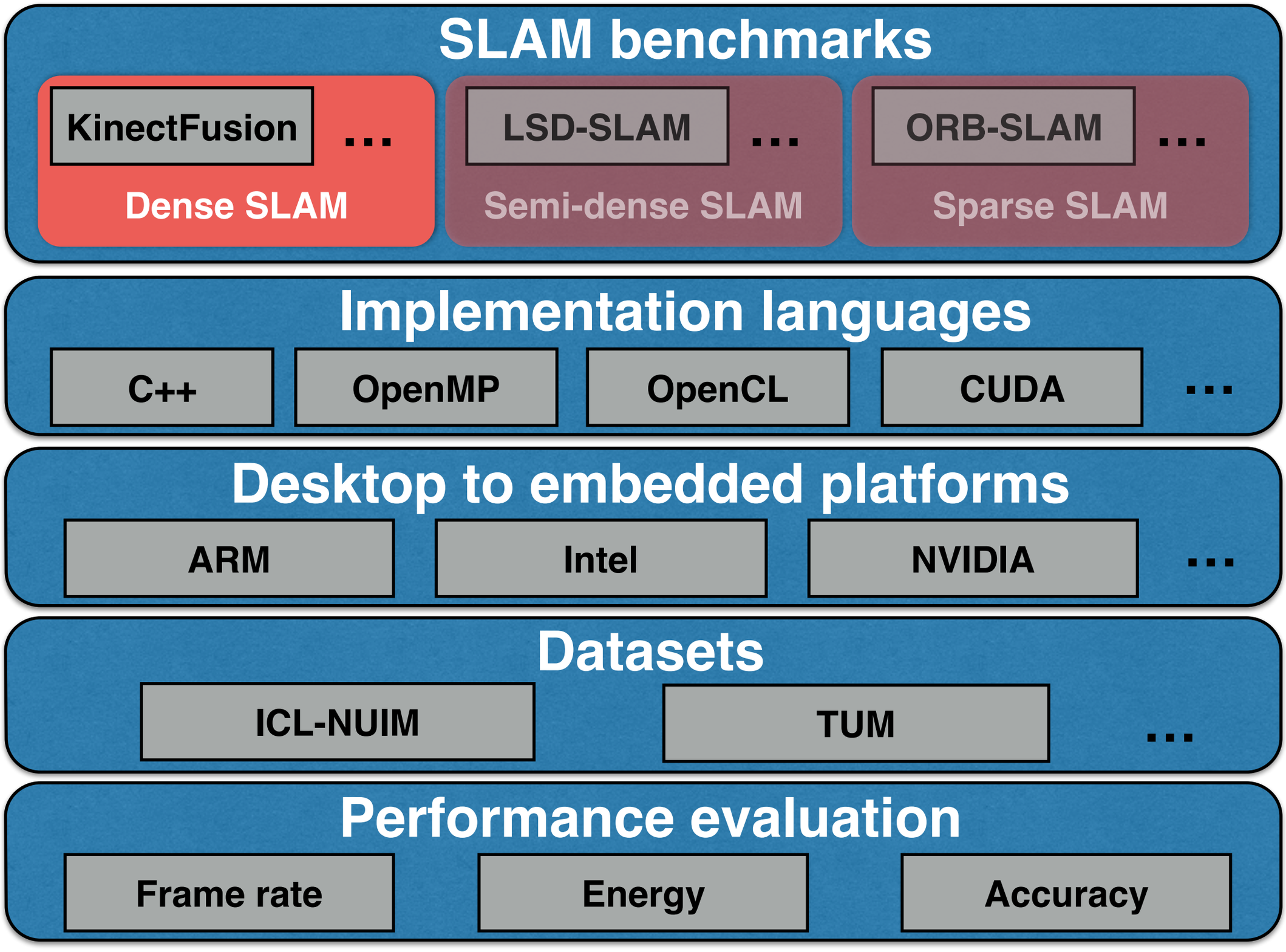
Simultaneous localisation and mapping (SLAM)



[Whelan et al. 2012]

Video:
[Newcombe et al. ISMAR 2011]

SLAMBench framework



[Nardi et al., 2015]

“Performance” on SLAMBench

- Runtime/energy/accuracy measurements
- Accuracy provided via absolute trajectory error (ATE)

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Machine	CPU	CPU name	CPU GFLOPS	CPU cores	GPU	GPU name	GPU GFLOPS	TDP Watts
Hardkernel ODROID-XU3	ARM A15 + A7	Exynos 5422	80	4 + 4	ARM	Mali-T628	60 + 30	10

“Performance” on SLAMBench

- Runtime/energy/accuracy measurements
- Accuracy provided via absolute trajectory error (ATE)

ATE in cm	
C++	2.06
OpenMP	2.06
OpenCL	2.01

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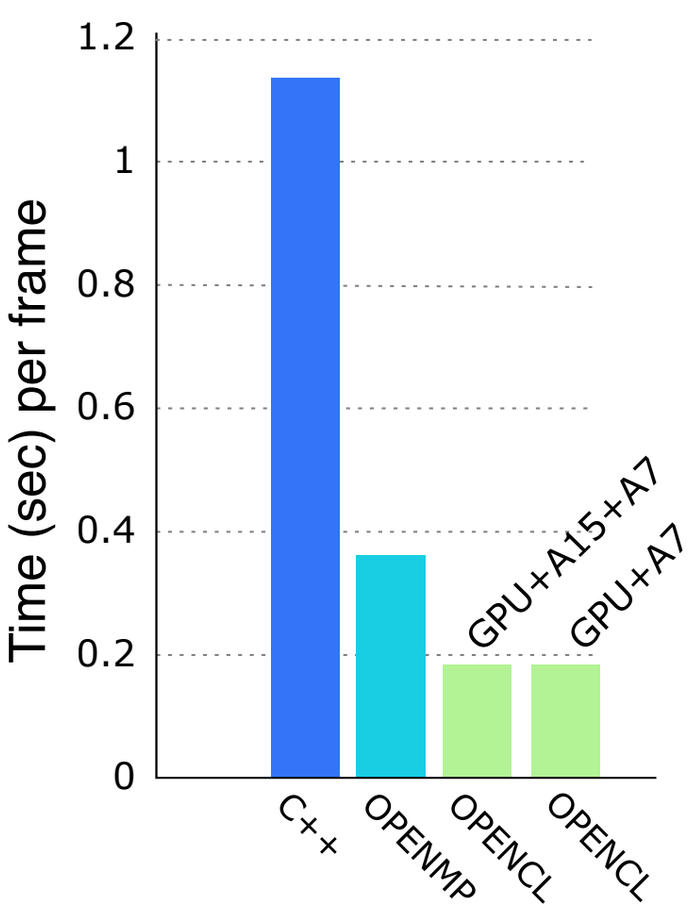

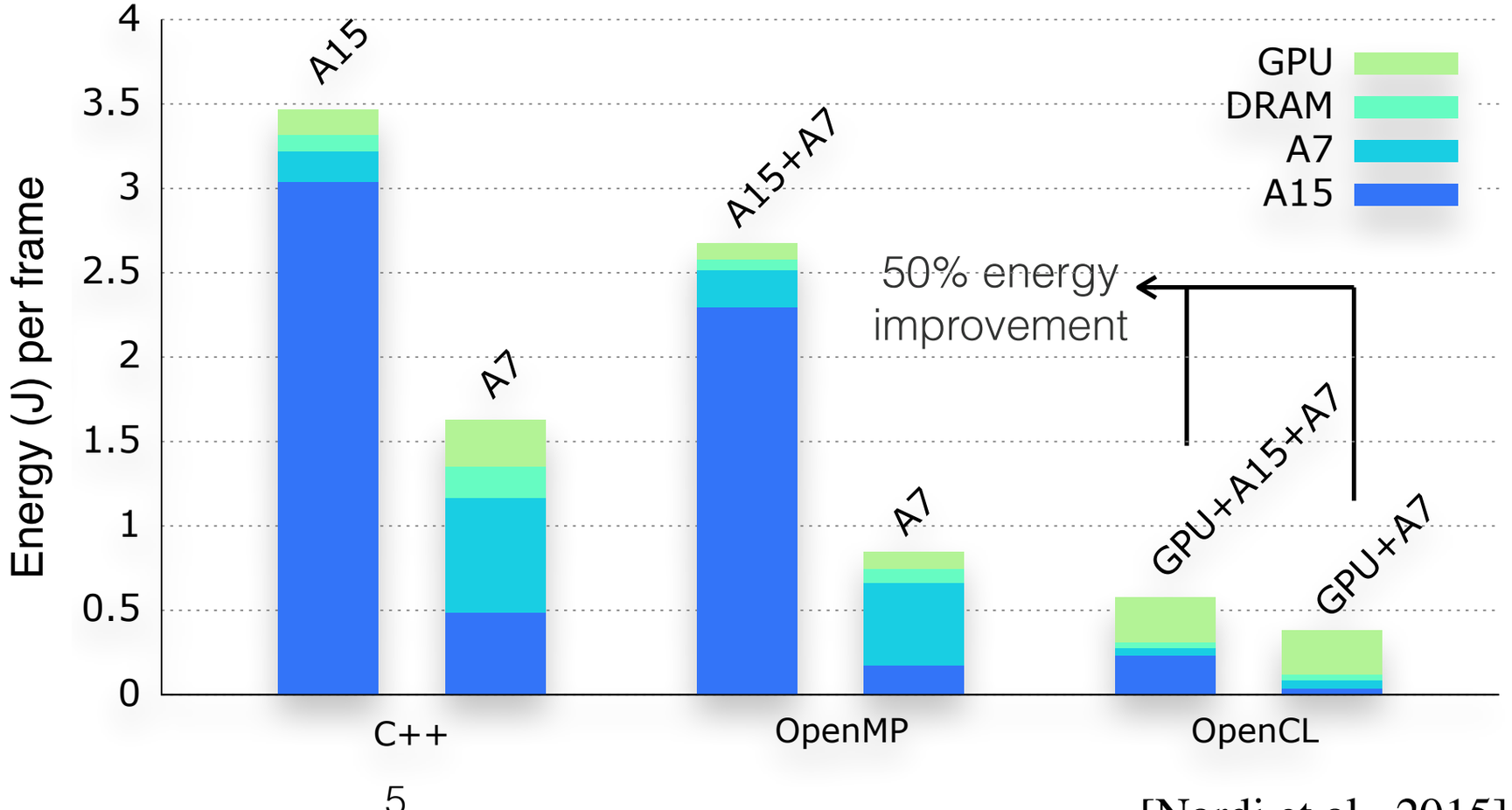

[Nardi et al., 2015]

What is the optimisation space?

Configuration parameters:

Space 1

1. Algorithmic:
   - Application-specific parameters
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   - CPU frequency
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Joint space

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3. Hardware:
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   - # of active big cores
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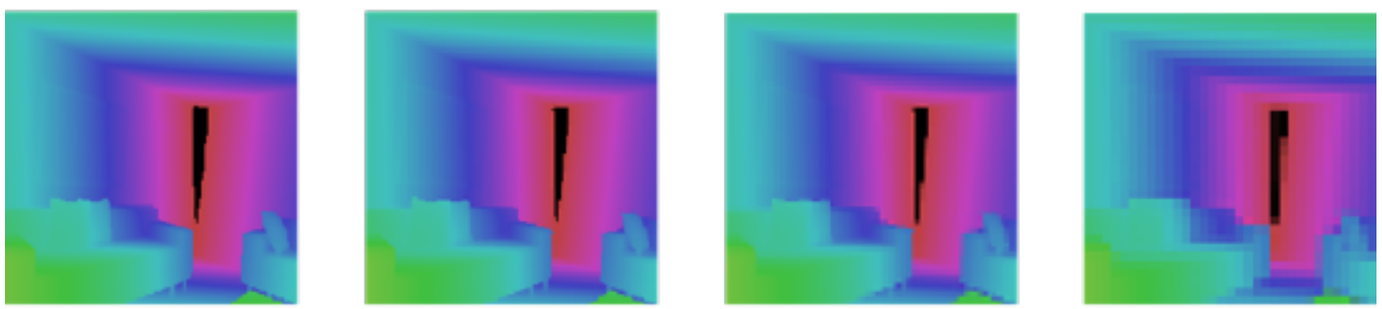
Warning: huge spaces, impossible to run exhaustively

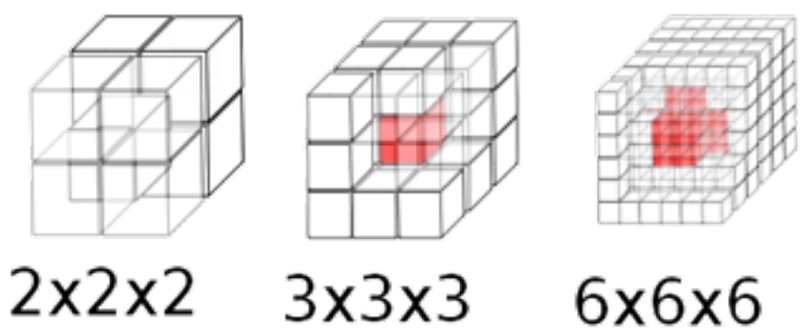
KinectFusion algorithmic features

Features	Ranges
Volume resolution	64x64x64, 128x128x128, 256x256x256, 512x512x512
***μ* distance**	0 .. 0.5
Pyramid level iterations (3 levels)	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Image resolution (image ratio)	1, 2, 4, 8
Tracking rate	1, 2, 3, 4, 5
ICP threshold	10^{-6} .. 10^{2}
Integration rate	1 .. 30

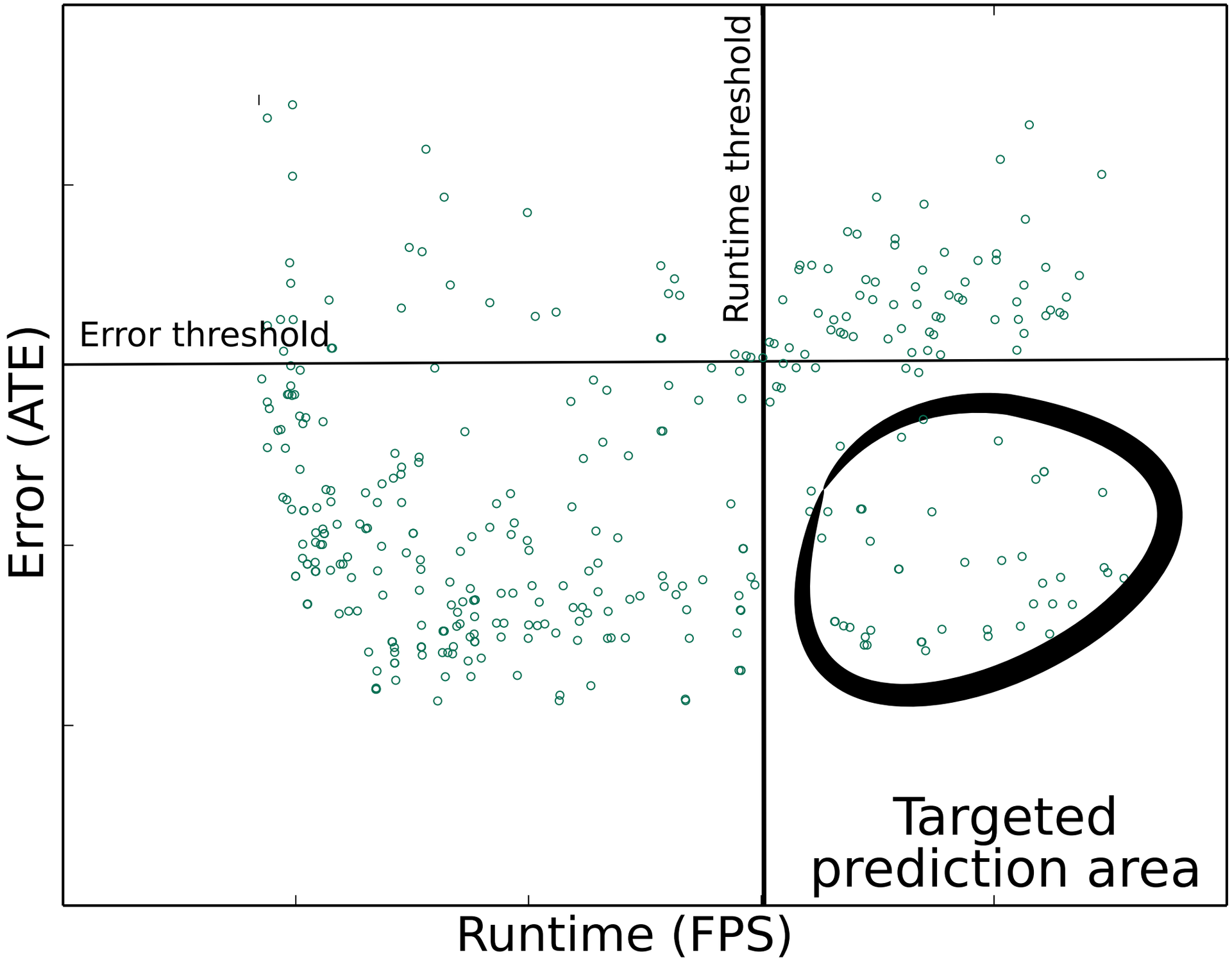
Image resolution (image ratio)



Volume resolution

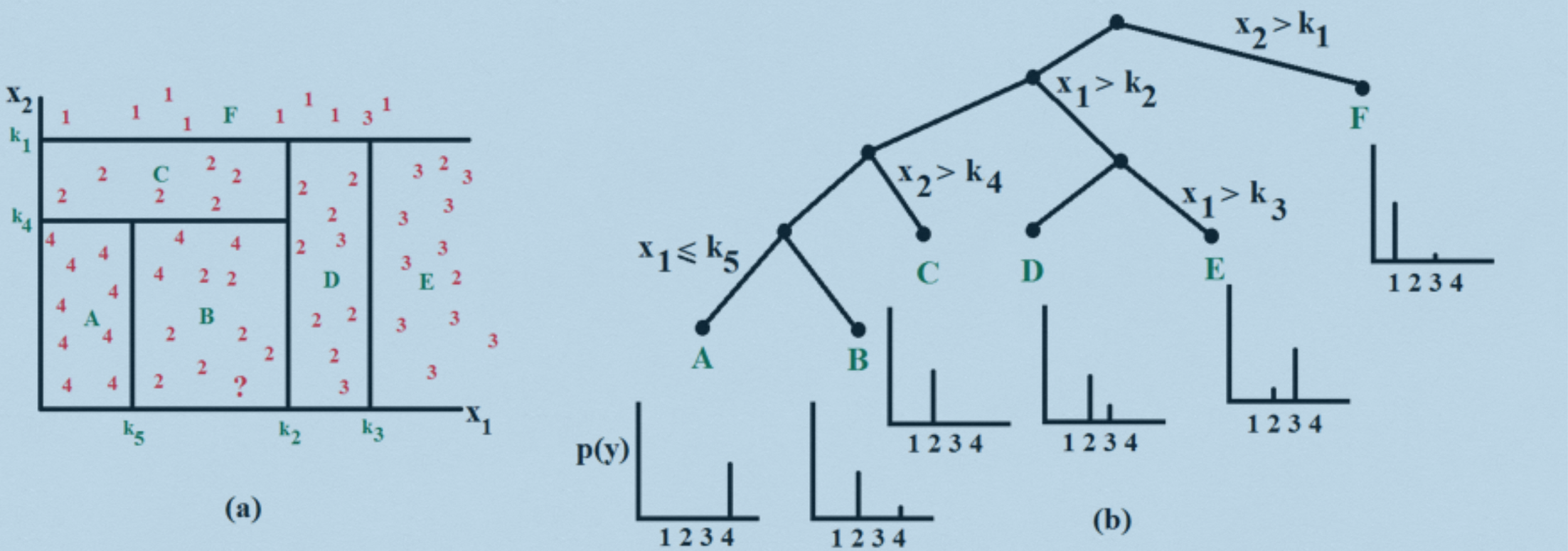


Goal of the exploration

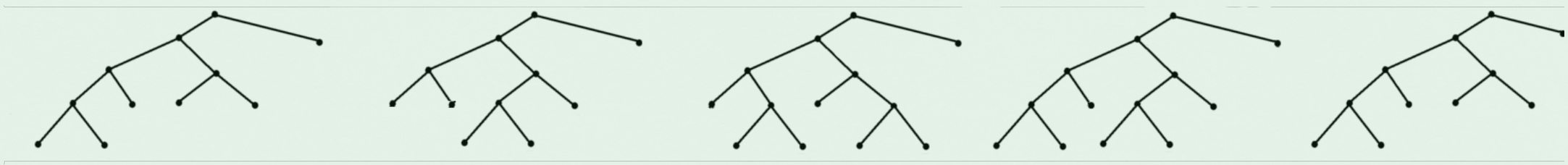


Machine learning methods used

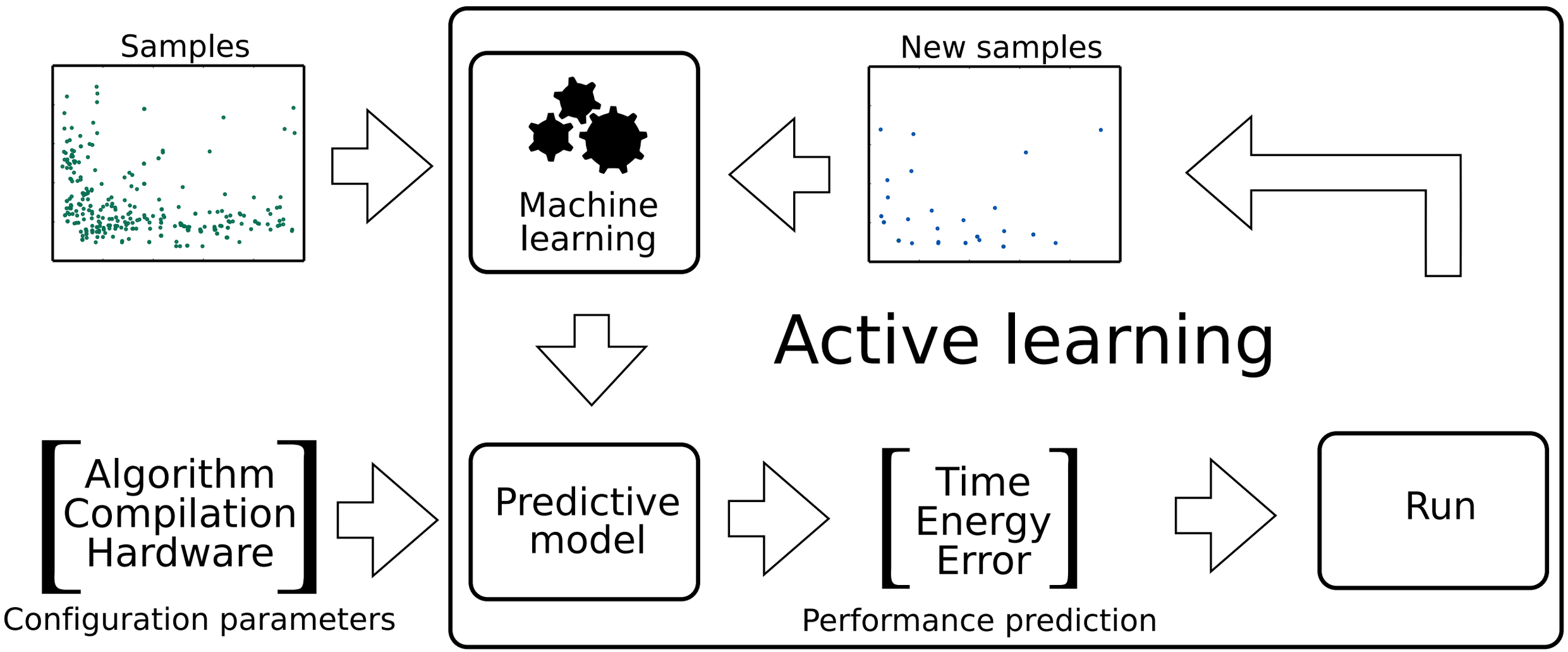
Decision tree



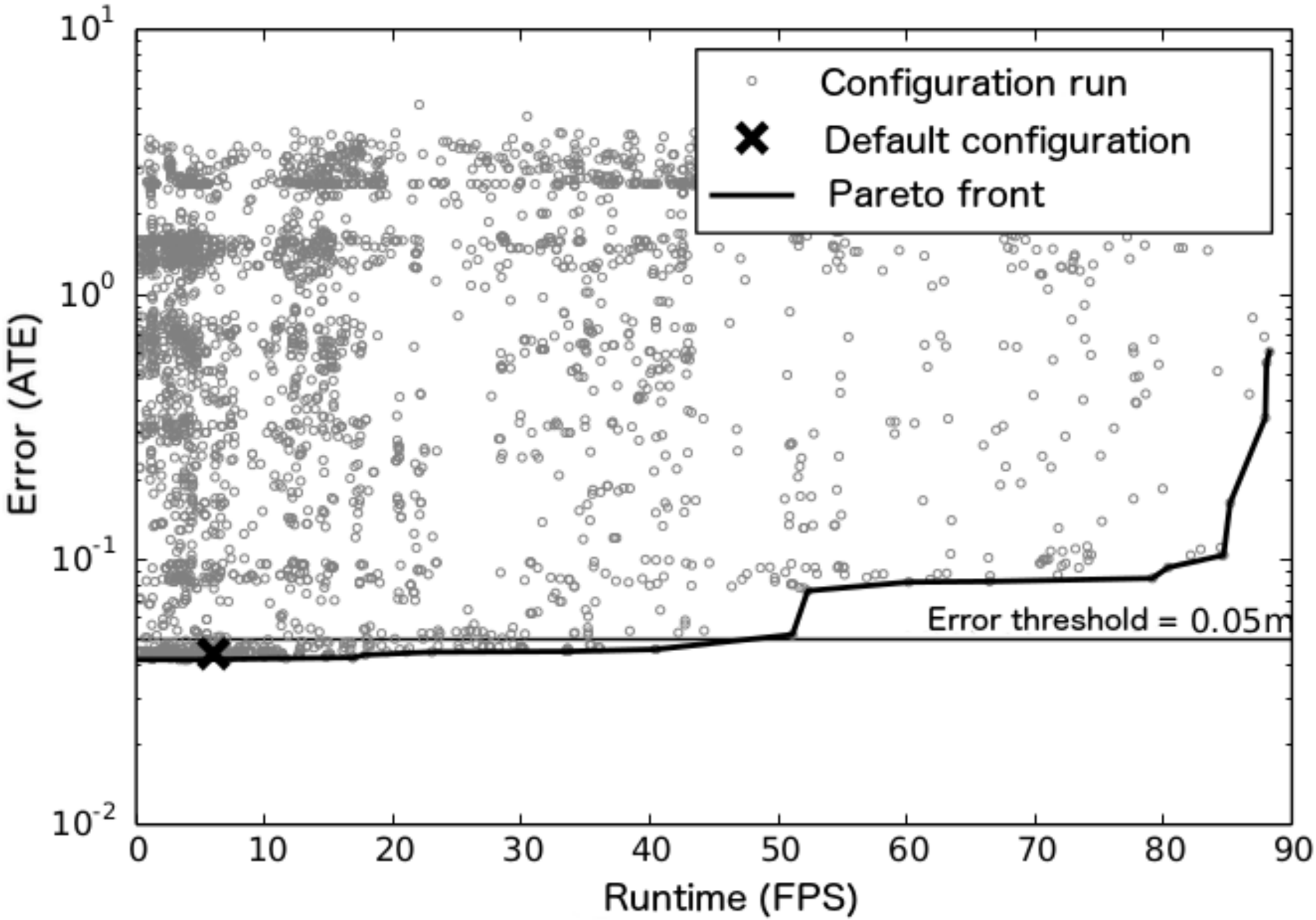
Random forest



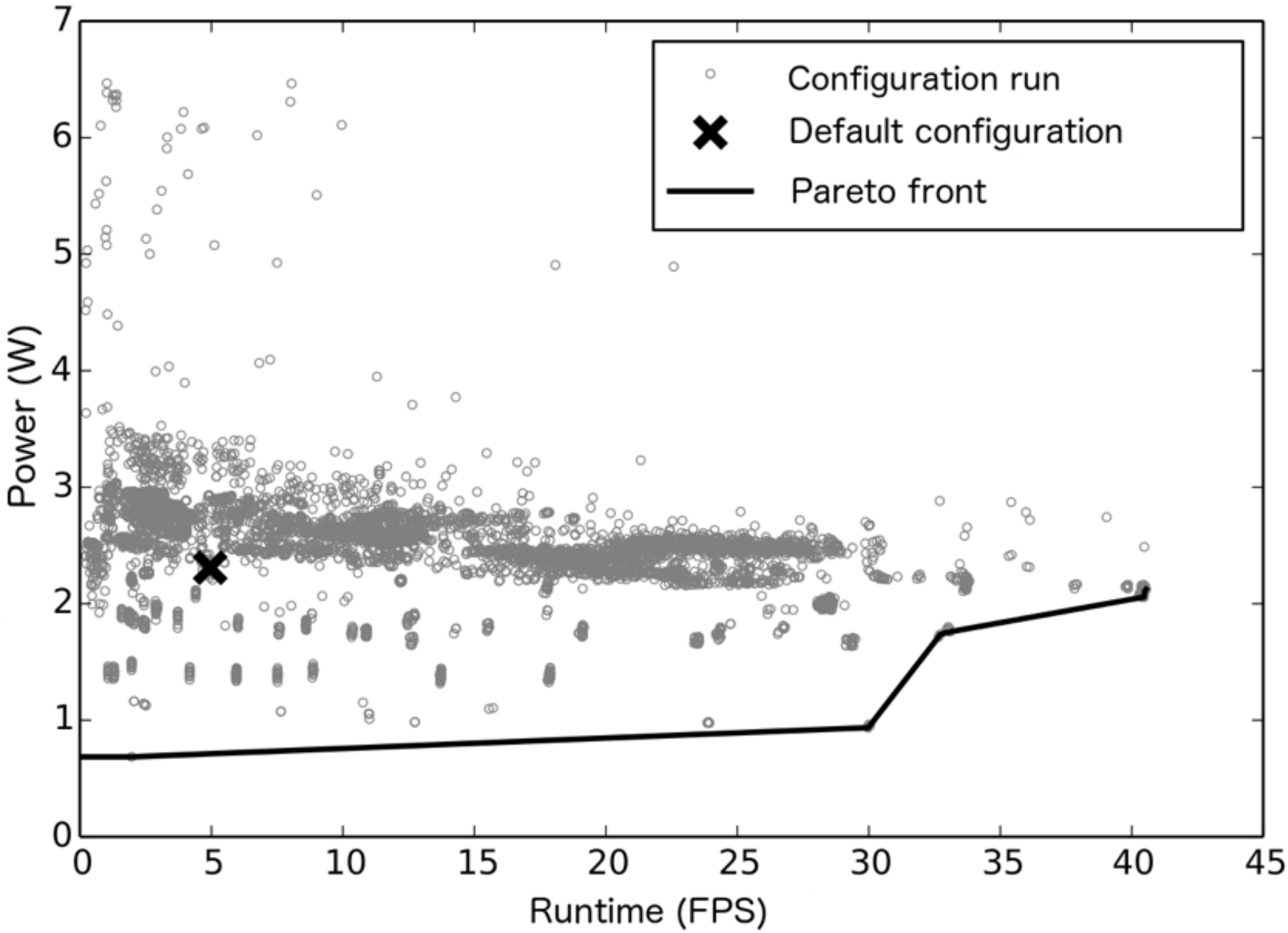
Joint design-space exploration (DSE)



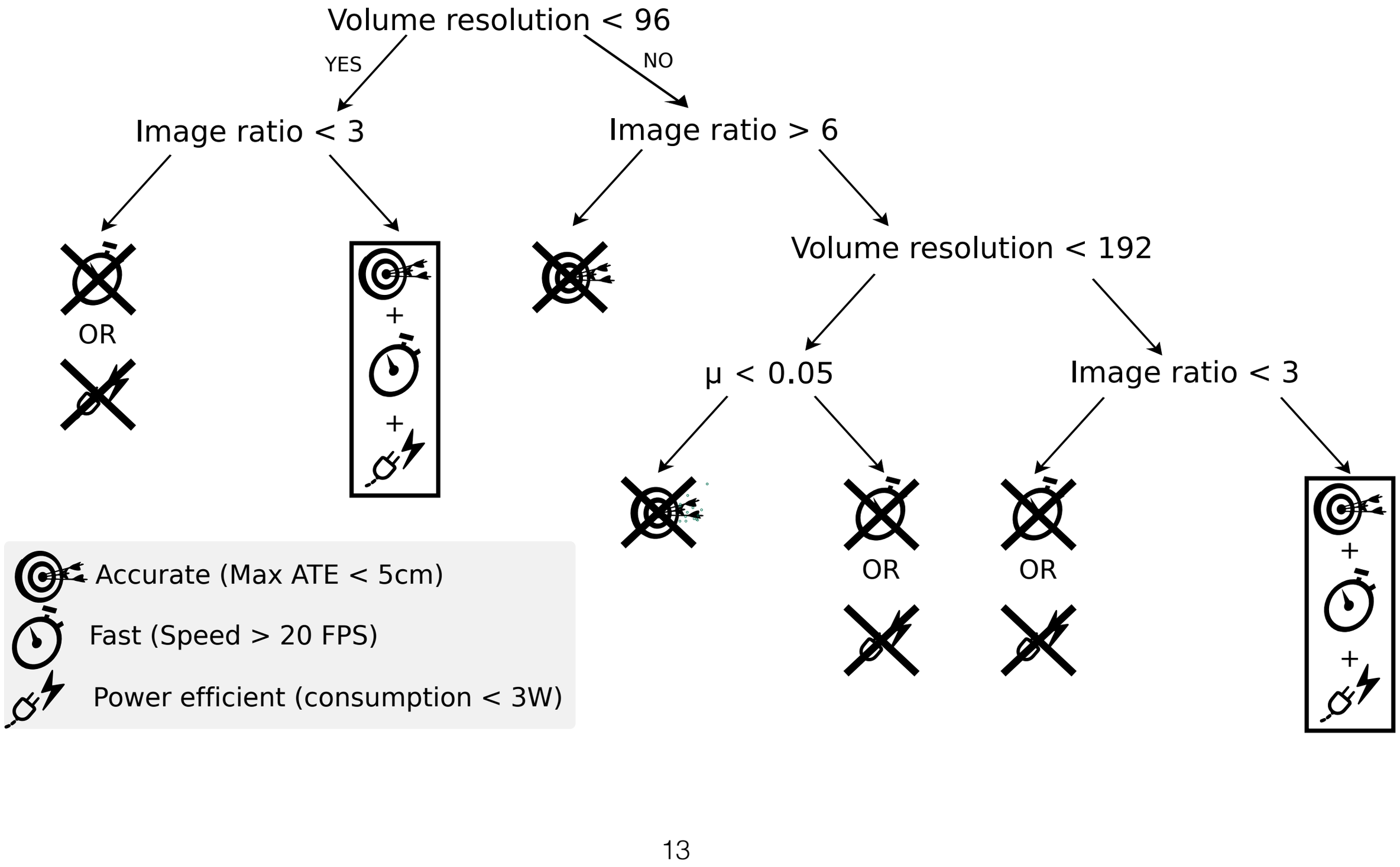
DSE on algorithmic parameters Error/Runtime



DSE on algorithmic parameters Power/Runtime



Predominant algorithmic features



Multi-objective DSE conclusions

- Multi-objective “performance” optimisation: runtime/energy/accuracy
- Auto-tuning tool to pick interesting points
- KinectFusion real-time on a popular embedded device
- Enabling auto-tuning at the domain-specific language (DSL) level

Future work

- Joint design-space exploration
- Reconstruction accuracy metric

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