Imperial College London

MANCHESTER 1824 The University of Manchester

The University of Edinburgh

SLAMBench: A performance and accuracy benchmarking methodology for SLAM

Speaker: Zeeshan Zia, Imperial College London

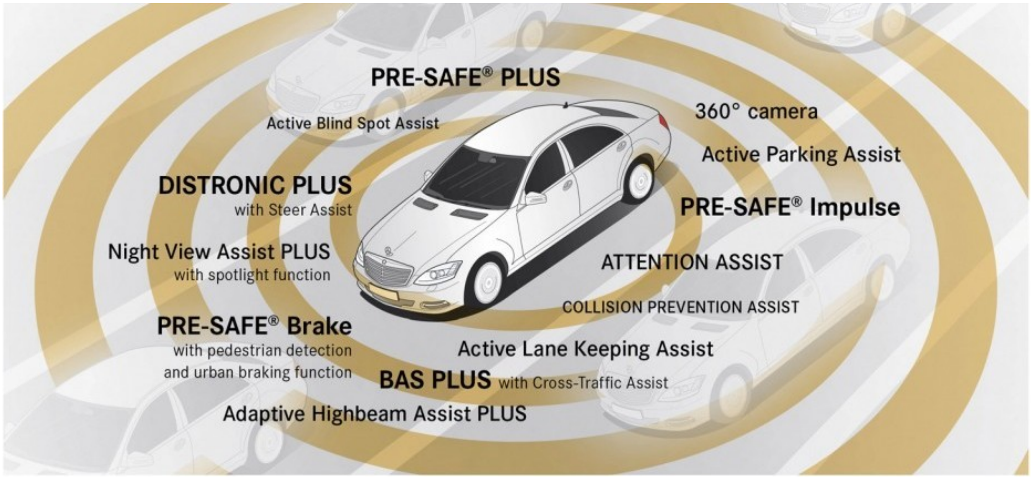
Team: Luigi Nardi, Bruno Bodin, Zeeshan Zia, John Mawer, Andy Nisbet, Paul Kelly, Andrew Davison, Mikel Lujan, Michael O'Boyle, Graham Riley, Nigel Topham, Steve Furber

BMVA Meeting: Vision for Robotics, 3rd December 2014

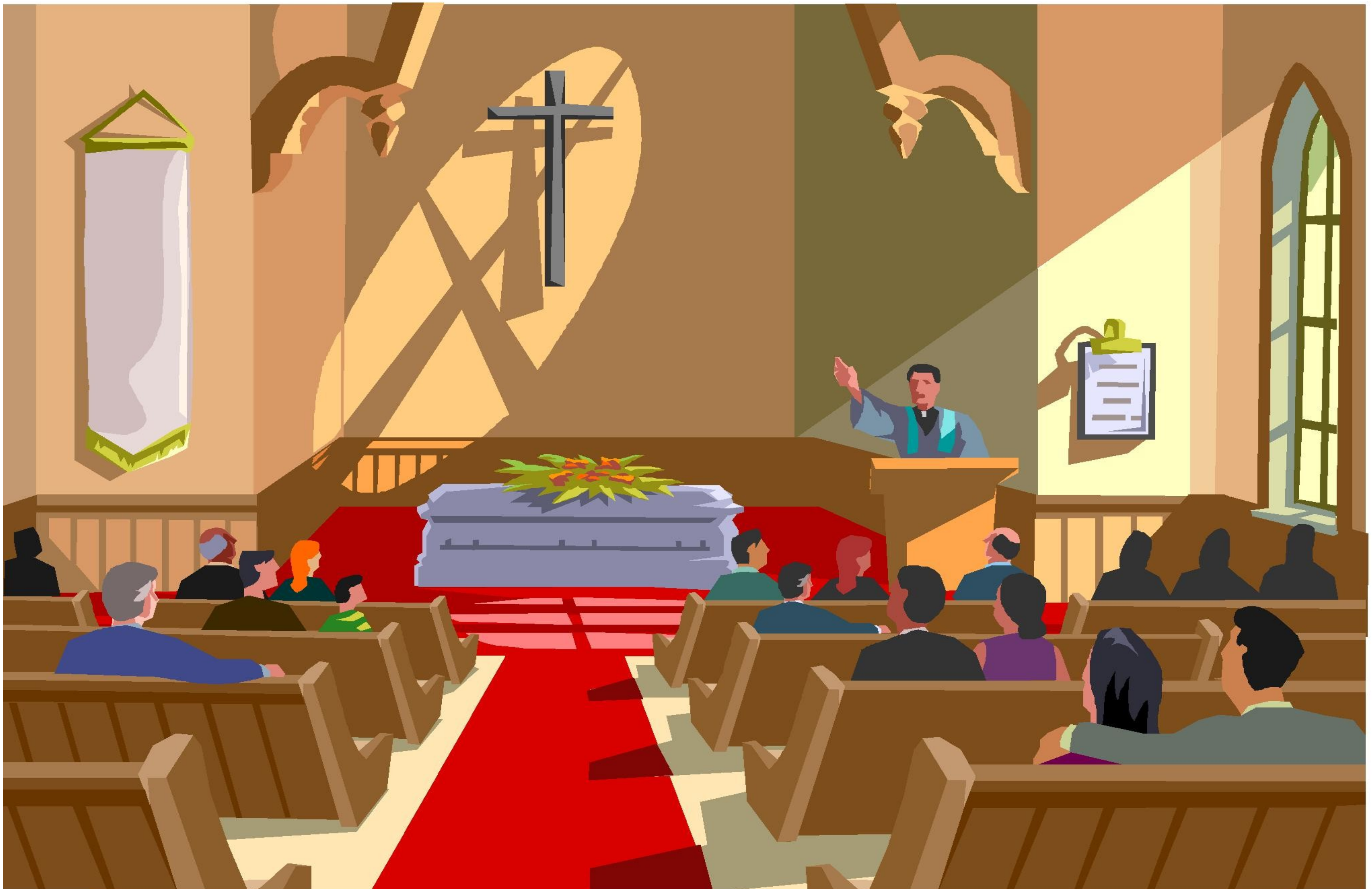
PAMELA

Imperial College London

Robot vision entering mass market



Death of Moore's law

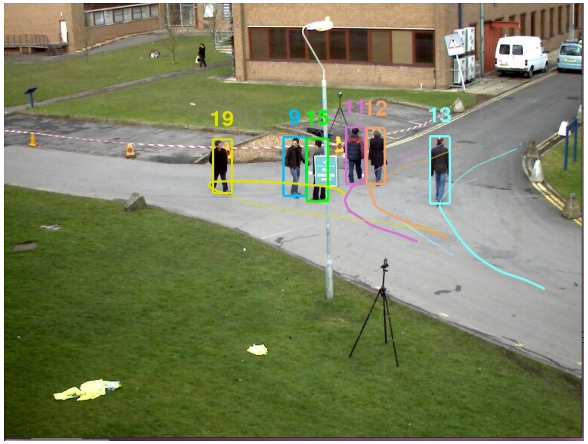


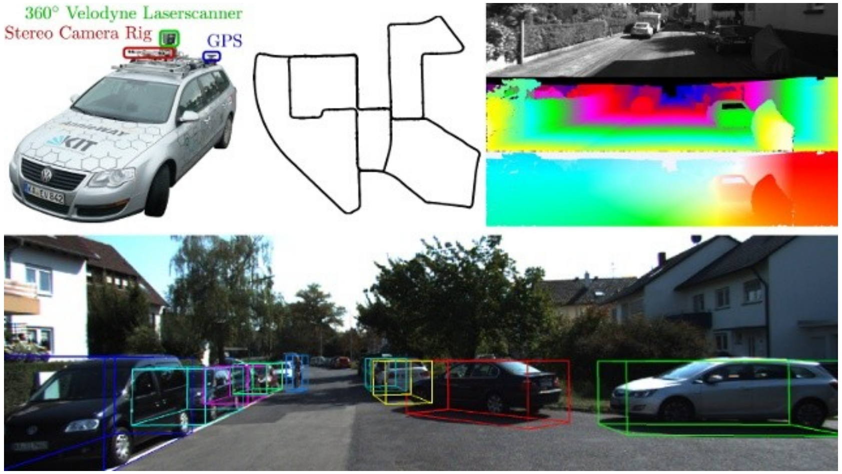
PAMELA – A Panoramic View of the Many-core Landscape

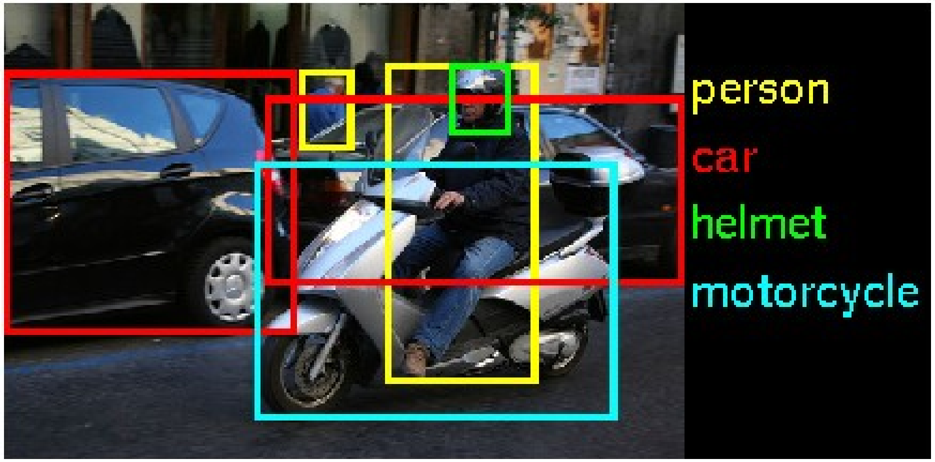
- 5-year EPSRC Programme Grant
- Three partners: Edinburgh, Imperial, Manchester
- Groups specializing in:
  - Computer architecture
  - Domain specific optimization and languages
  - Compiler and runtime design
  - Robotic vision
- Holistic look at the entire software/hardware stack
- **3D scene understanding** as the unifying challenge application

Need for a performance benchmark

Computer vision benchmarks only consider accuracy!



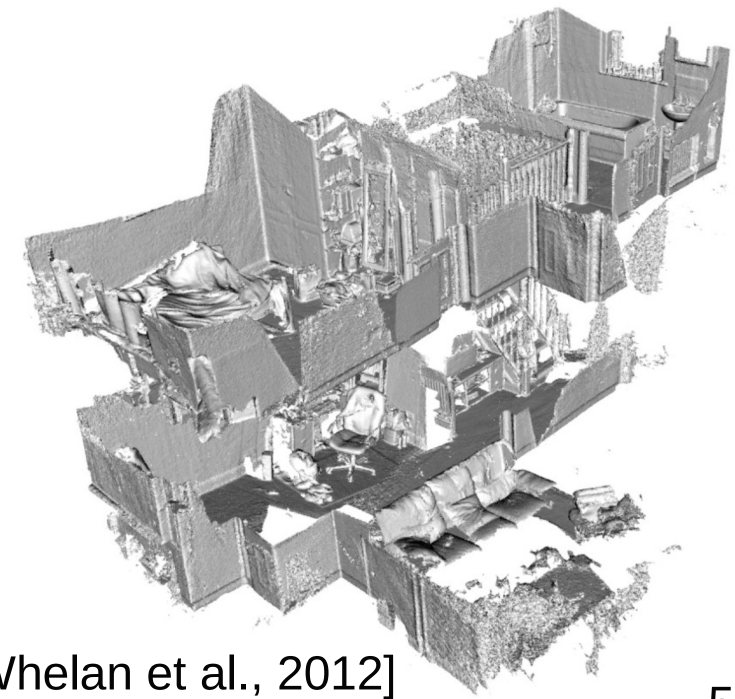




Where do we start?

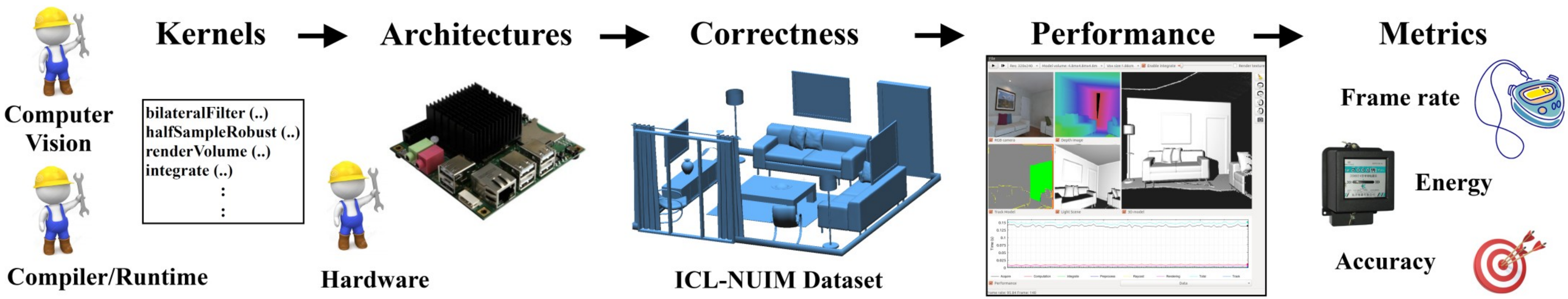
- Simultaneous Localisation and Mapping (SLAM)
- Dense SLAM with a depth camera – KinectFusion
- Building block of large scale dense systems

[Chen et al., 2013]



[Whelan et al., 2012]

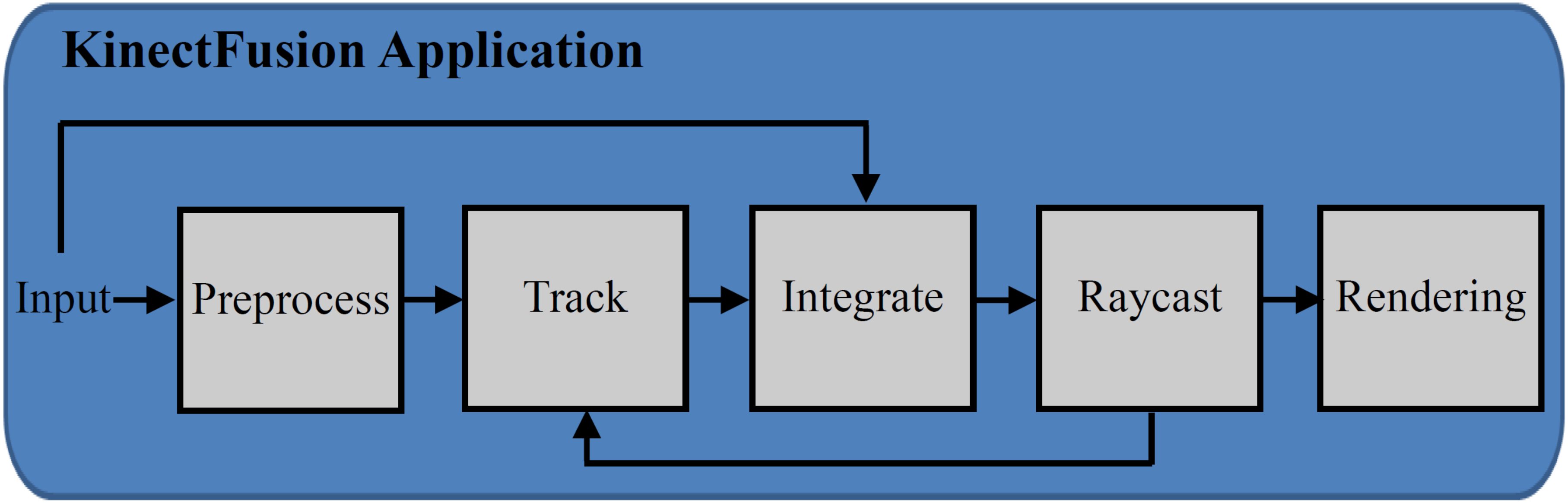
SLAMBench



- Multi-platform KinectFusion implementations
- Measure correctness on synthetic dataset [Handa et al., 2014]
- Kernel-level speed, and energy characterisation
- Enable multi-disciplinary cooperation

Imperial College London

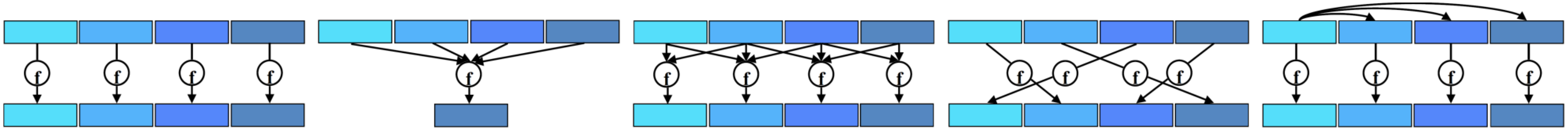
SLAMBench: Application pipeline



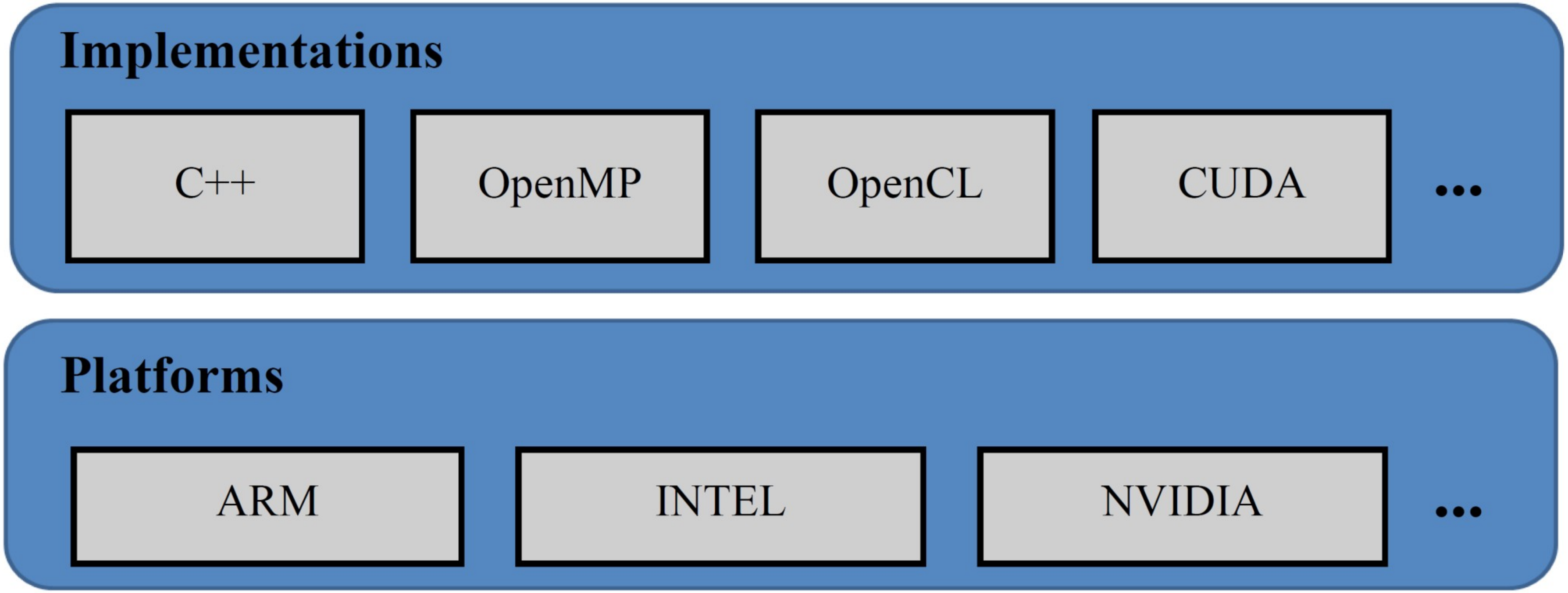
- Truncated Signed Distance Function (TSDF) representation for map (dense 3D reconstruction)
- Predict new depth map from reconstruction
- Align using Iterative Closest Point (ICP) algorithm

SLAMBench: Application pipeline

Kernels	Building Block	Pattern
mm2meters	Preprocess	Gather
bilateralFilter	Preprocess	Stencil
halfSample	Track	Stencil
depth2vertex	Track	Map
vertex2normal	Track	Stencil
track	Track	Map/Gather
reduce	Track	Reduction
solve	Track	Sequential
integrate	Integrate	Map/Gather
raycast	Raycast	Search/Stencil
renderDepth	Rendering	Map
renderTrack	Rendering	Map
renderVolume	Rendering	Search/Stencil



SLAMBench: Multiple platforms

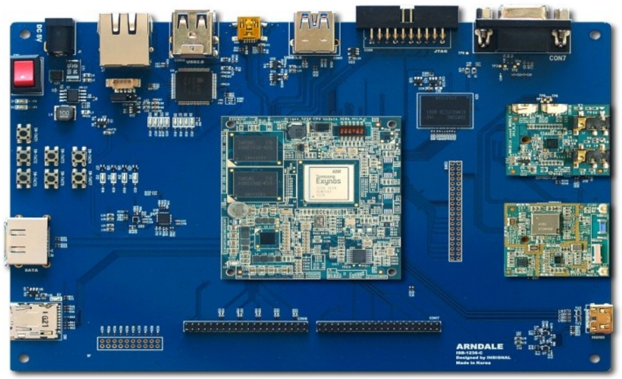


SLAMBench: Multiple platforms

Machine	Type	CPU cores	GPU FPU32s	GPU GFLOPS (SP)
TITAN	Desktop	4 (i7 Haswell)	2688	2250
GTX870M	Laptop	4 (i7 Haswell)	1344	1260
TK1	Embedded	4 (Cortex-A15) + 1	192	330
ODROID (XU3)	Embedded	4 (Cortex-A15) + 4 (Cortex-A7)	60	60+30
Arndale	Embedded	2 (Cortex-A15)	40	60

TK1

ODRIOD (XU3)



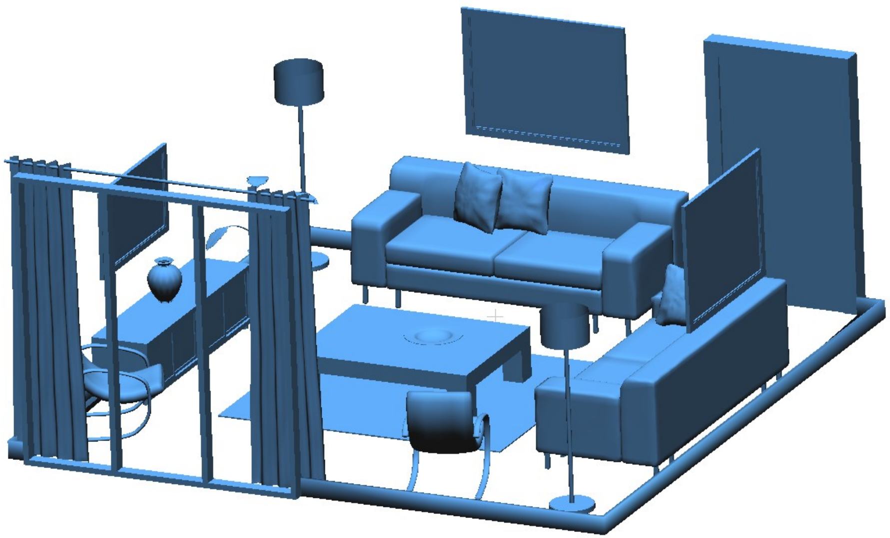
Arndale

SLAMBench: Accuracy

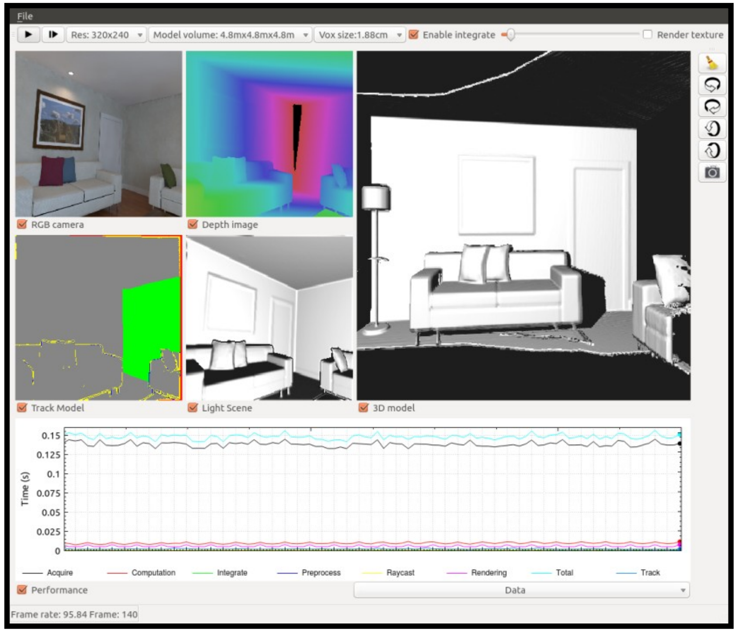
Correctness Verification

ICL-NUIM Dataset

Visualisation Tool

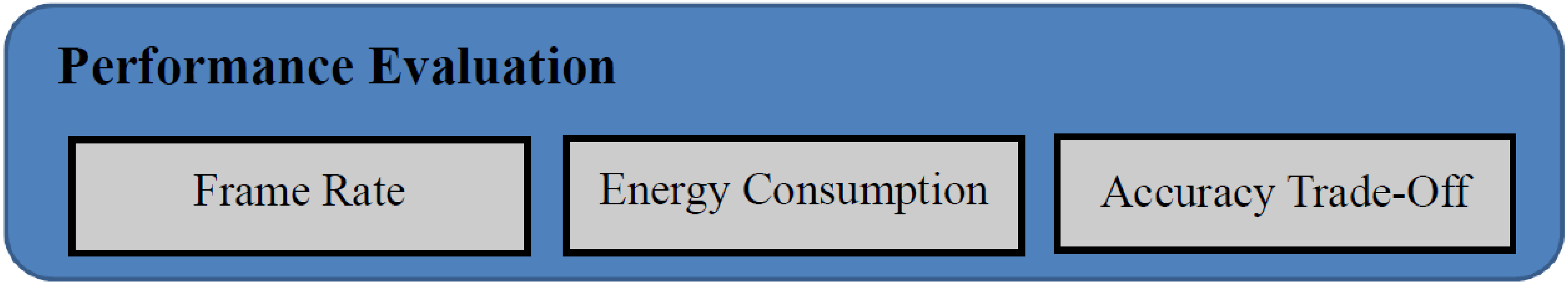


[Handa et al., 2014]



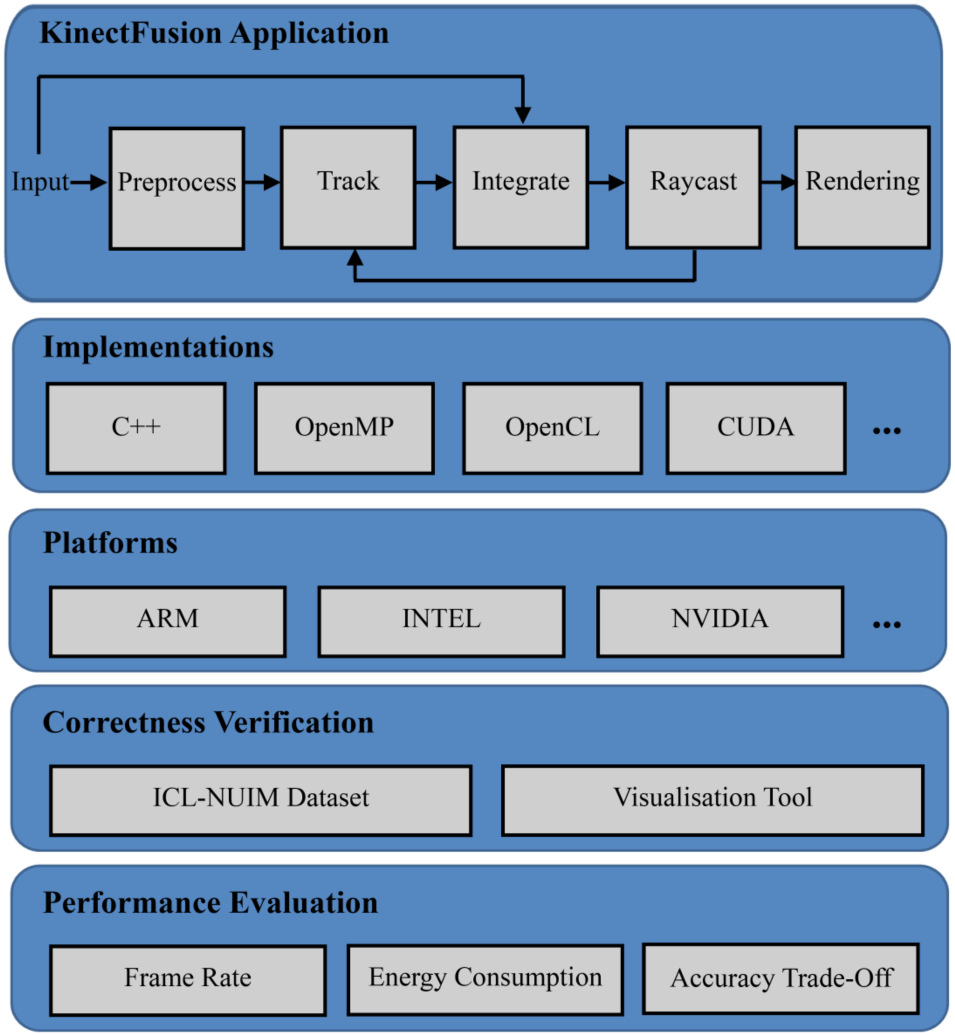
Imperial College London

SLAMBench: Metrics



- Kernel-wise evaluation of compute time
- ODROID voltage/current sensors exploiting split power rails
- Knobs to vary different algorithmic parameters affecting accuracy, energy, and frame rate

SLAMBench Suite



- Publicly available
- Easy to understand and extend
- Early adopters include: ARM, IBM TJ Watson Labs, Intel
- ICRA submission [Nardi et al., 2015], available on arXiv.

Experiments

- ICL-NUIM dataset [Handa et al., 2014]
- Synthetic living room model (4.5 m x 4.5 m x 4.5 m)
- Kinect sensor noise added
- Trajectory manually recorded with a real sensor

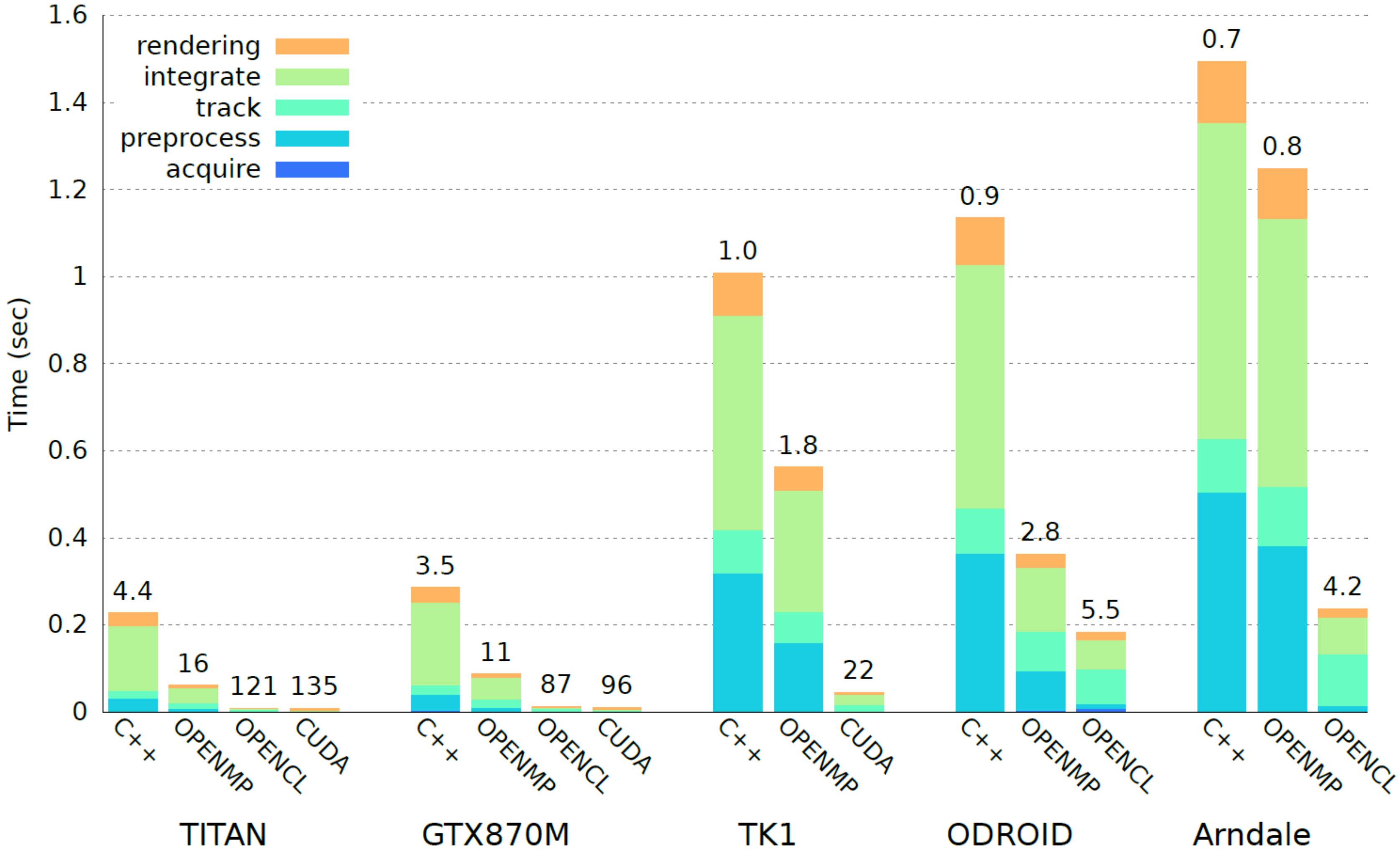
Imperial College London

Accuracy

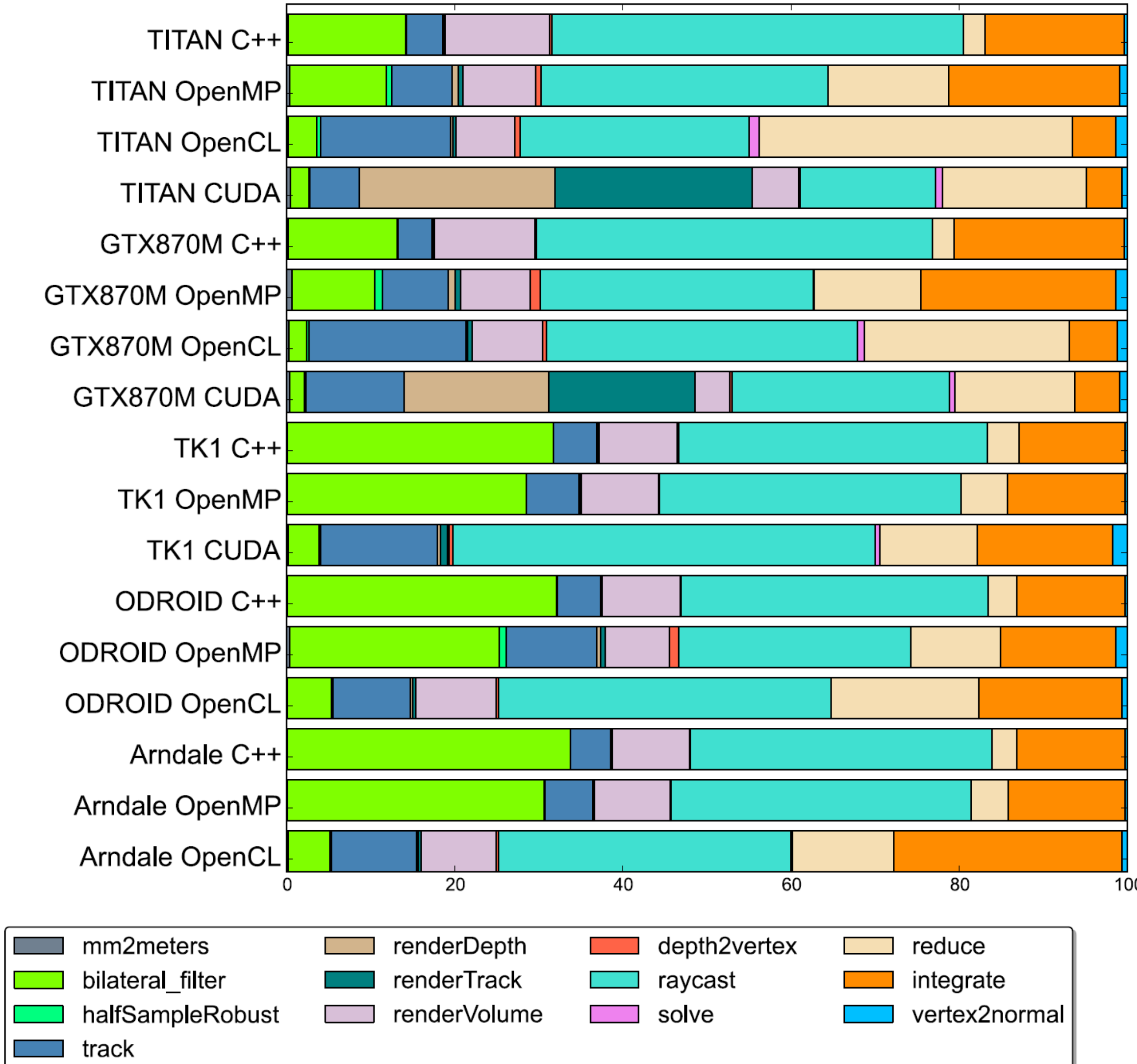
- Total 17 platform, language combinations evaluated
- Platforms: TITAN, GTX870M, TK1, ODROID, Arndale
- Languages: C++, OpenMP, OpenCL, CUDA
- Absolute trajectory error in the range of **2.01-2.07 cm**
- Not the same: due to multi-threaded execution and different hardware architectures!

Imperial College London

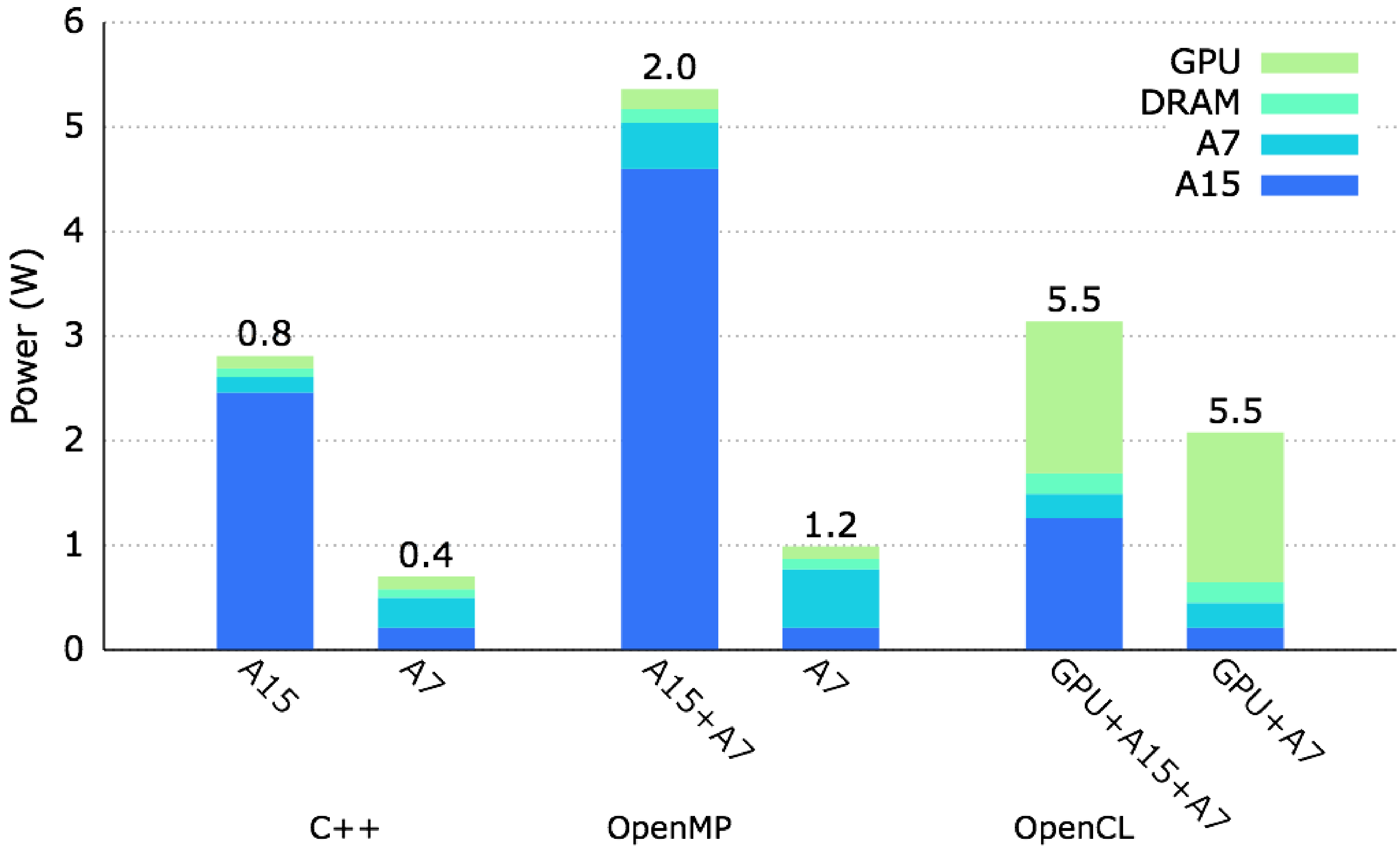
Elapsed times and frame rates: Blocks



Percentage of time spent in each kernel



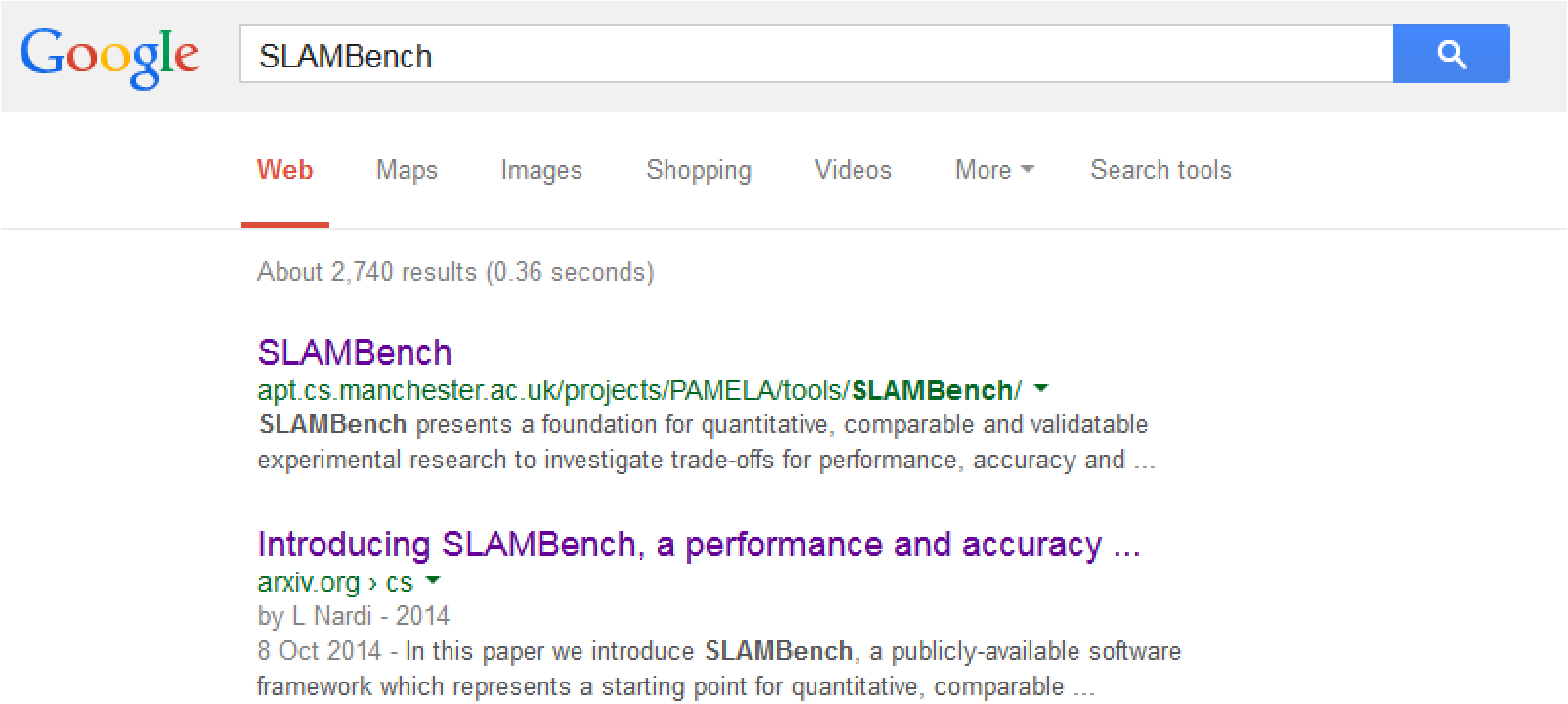
Power consumption on ODROID



Conclusion and future work

- Accuracy + Computational performance + Energy
- Benchmark to compare hardware accelerators, software tools, and novel algorithms
- Future: Extension, Design-space exploration, domain specific languages and optimizations

Questions?


Google
SLAMBench
Web
Maps
Images
Shopping
Videos
More
Search tools
About 2,740 results (0.36 seconds)
SLAMBench
apt.cs.manchester.ac.uk/projects/PAMELA/tools/SLAMBench/
SLAMBench presents a foundation for quantitative, comparable and validatable experimental research to investigate trade-offs for performance, accuracy and ...
Introducing SLAMBench, a performance and accuracy ...
arxiv.org › cs
by L Nardi - 2014
8 Oct 2014 - In this paper we introduce SLAMBench, a publicly-available software framework which represents a starting point for quantitative, comparable ...