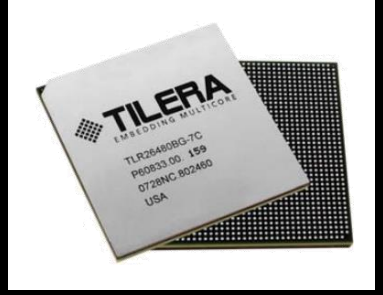
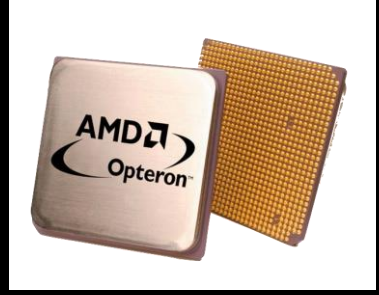



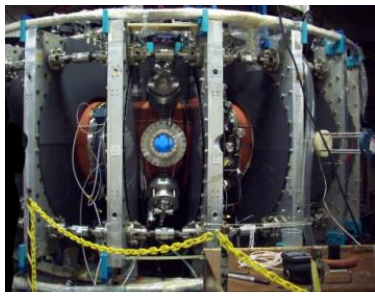


自動運転システムにおける マルチ・メニーコア技術

名古屋大学　大学院情報科学研究科
准教授　加藤真平










Shinpei Kato

Associate Professor, School of Information Science
Nagoya University

Keio U. — Ph.D. → U. Tokyo / Carnegie Mellon University → UC Santa Cruz

2004 2005 2006 2007 2008 2009 2010 2011 2012

Core Research

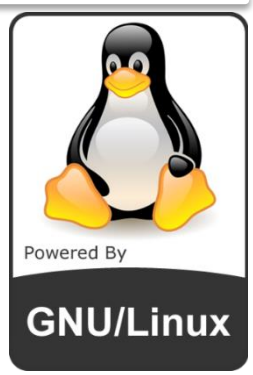
Safety App1 | Safety App2 | Safety App3 | Safety App4 | Safety App5 | Safety App6

Hardware Platform

Safety-Critical Systems

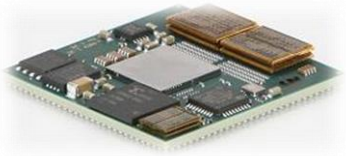
Autonomous Driving

Supercomputing



Operating Systems

応用



Real-Time Processing LSI

GPGPU

Multi-Core

Cloud Computing

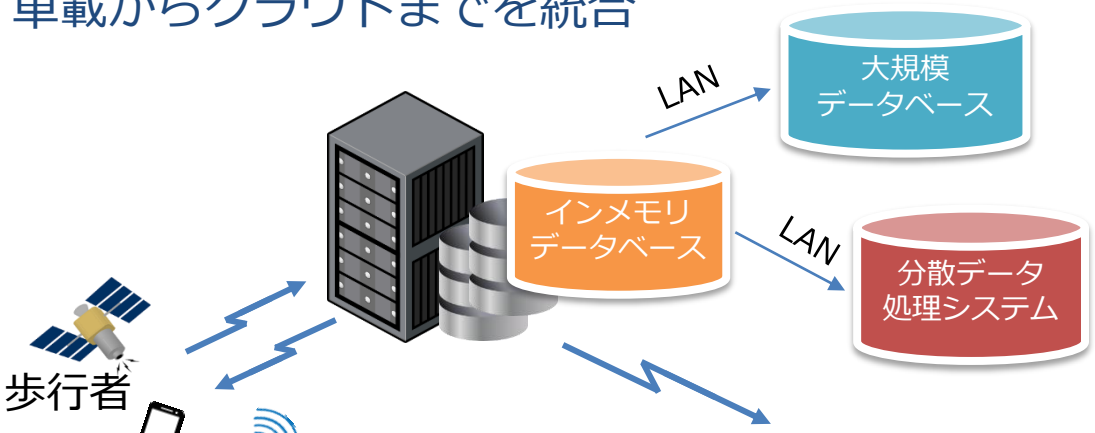
1.自動運転の概要

2.名古屋大学の研究紹介

3.マルチ・メニーコア技術

自動運転の研究プラットフォーム

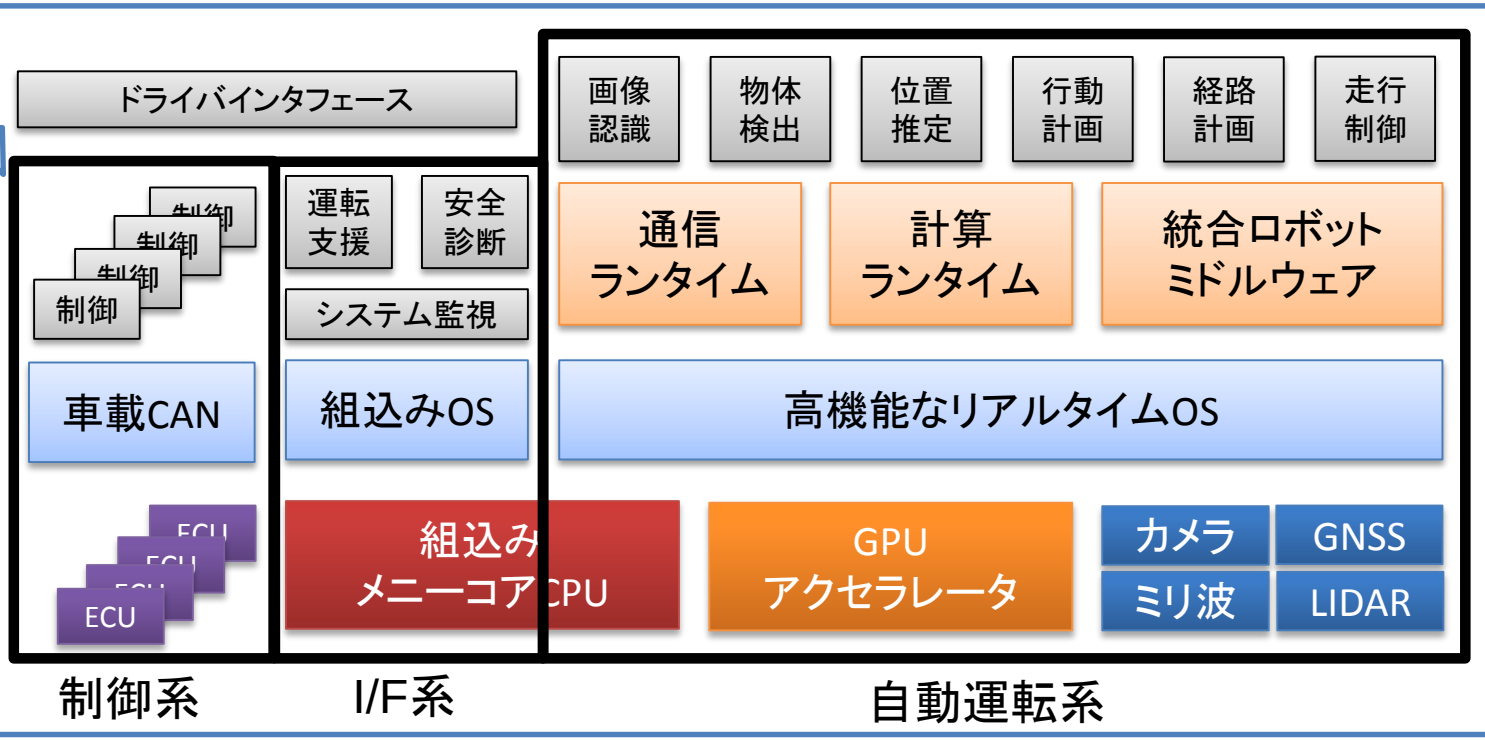
車載からクラウドまでを統合



- ✓ ハッキングされない
- ✓ 情報漏えいしない
- ✓ 安い
- ✓ 速い
- ✓ 小さい
- ✓ 長持ち
- ✓ 省電力

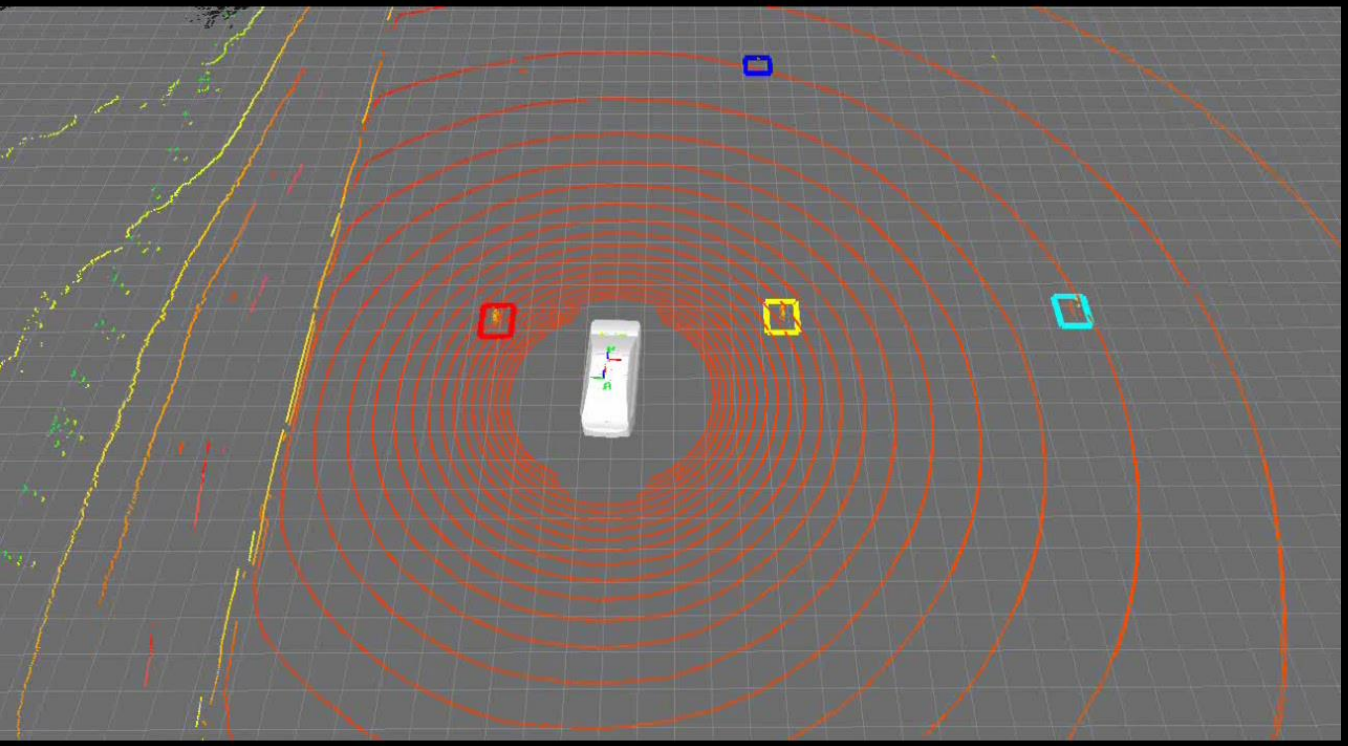
運転者

車




名古屋大学の研究紹介

自動運転システムにおけるマルチ・メニーコア技術



名古屋大学 NAGOYA UNIVERSITY

長崎大学 NAGASAKI UNIVERSITY

National Institute of Advanced Industrial Science and Technology AIST 産総研 独立行政法人産業技術総合研究所

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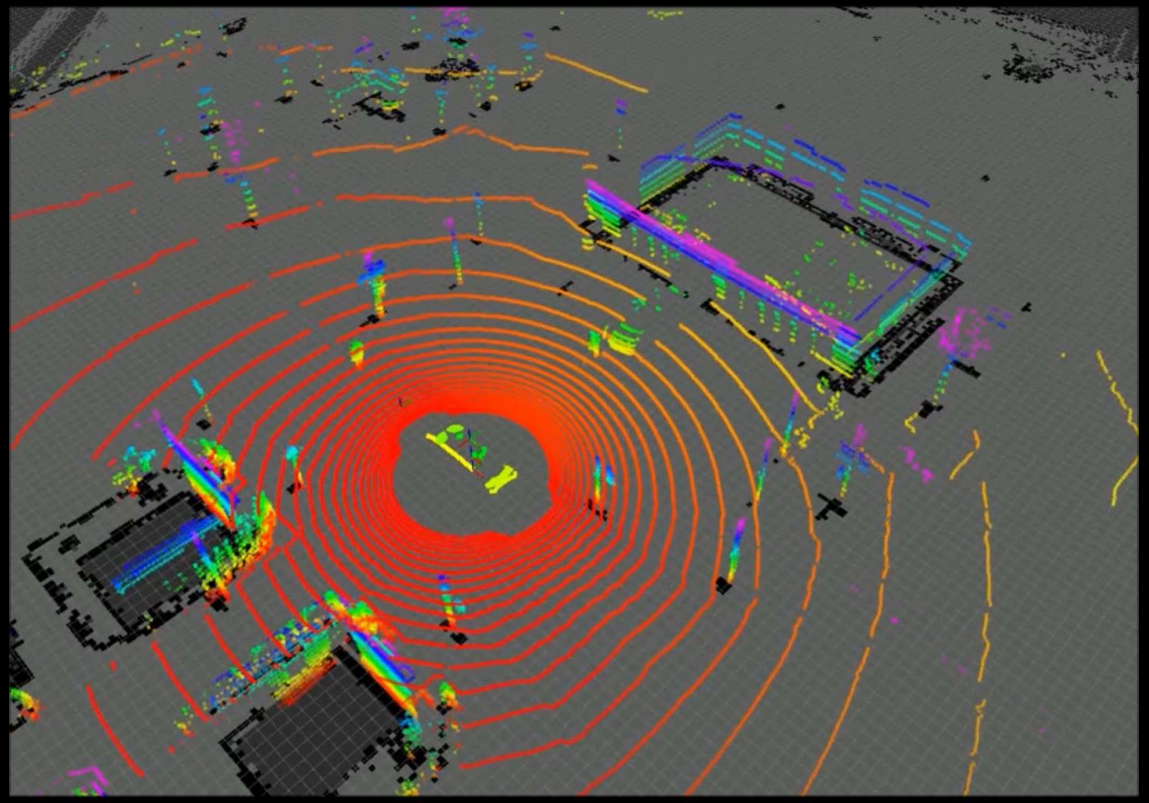


GNSS

GNSS: Global Navigation Satellite System

GPS: Global Positioning System – one of GNSS

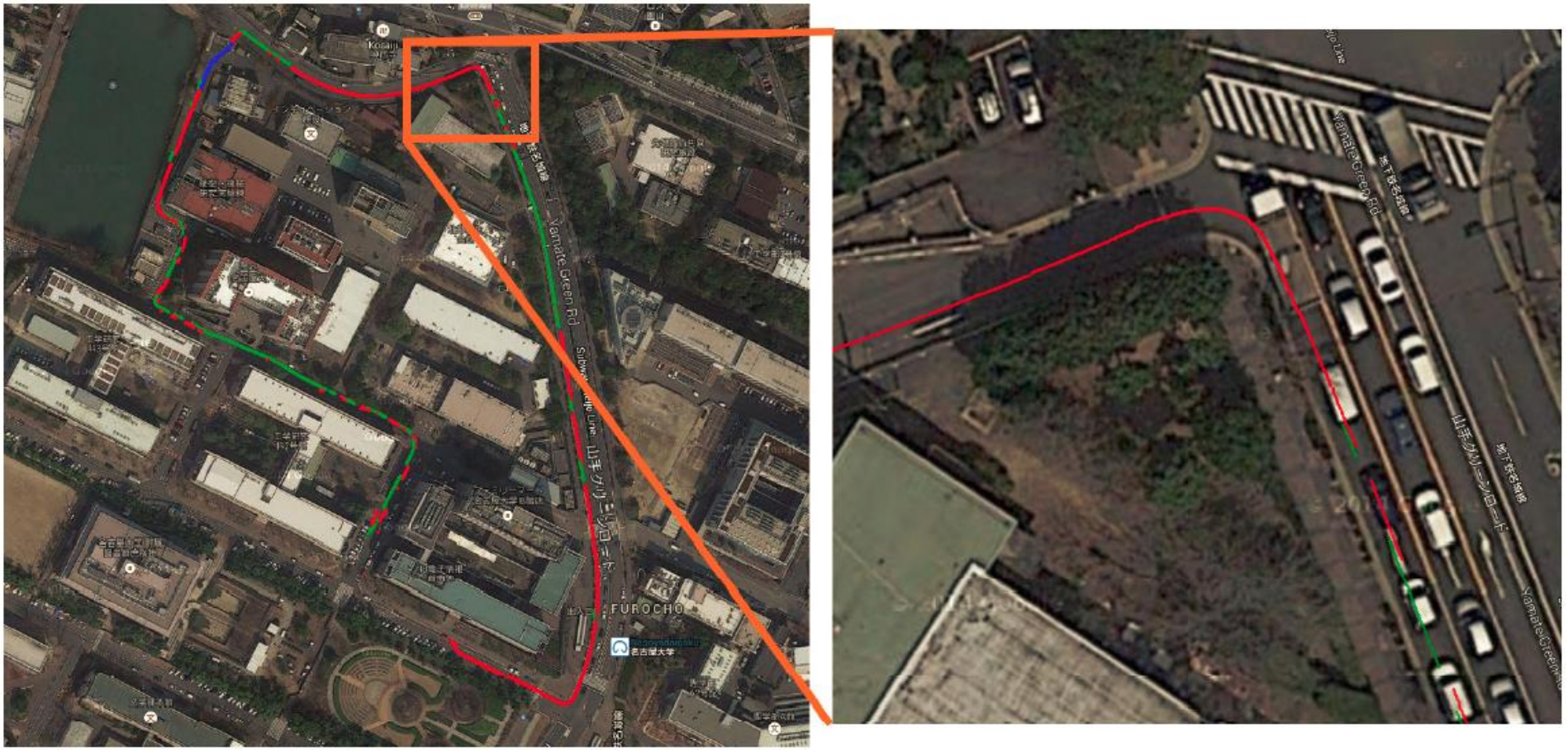
JAVAD

- JAVAD GyrAnt（Antenna）

- JAVAD DELTA（Receiver）

- CPTrans (Carrier)

GNSS



Logging on the left lane

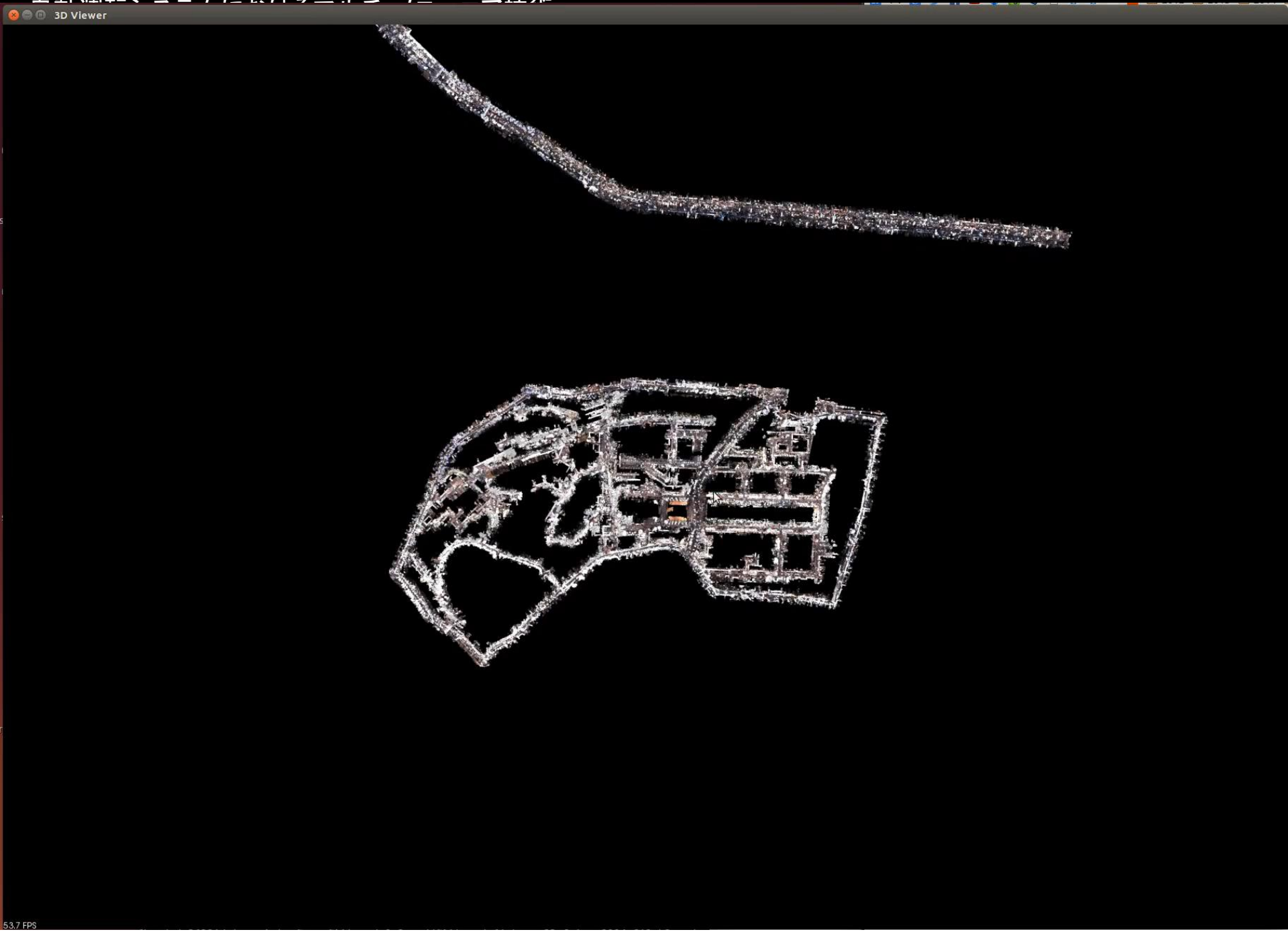
High-Precision 3D Mapping

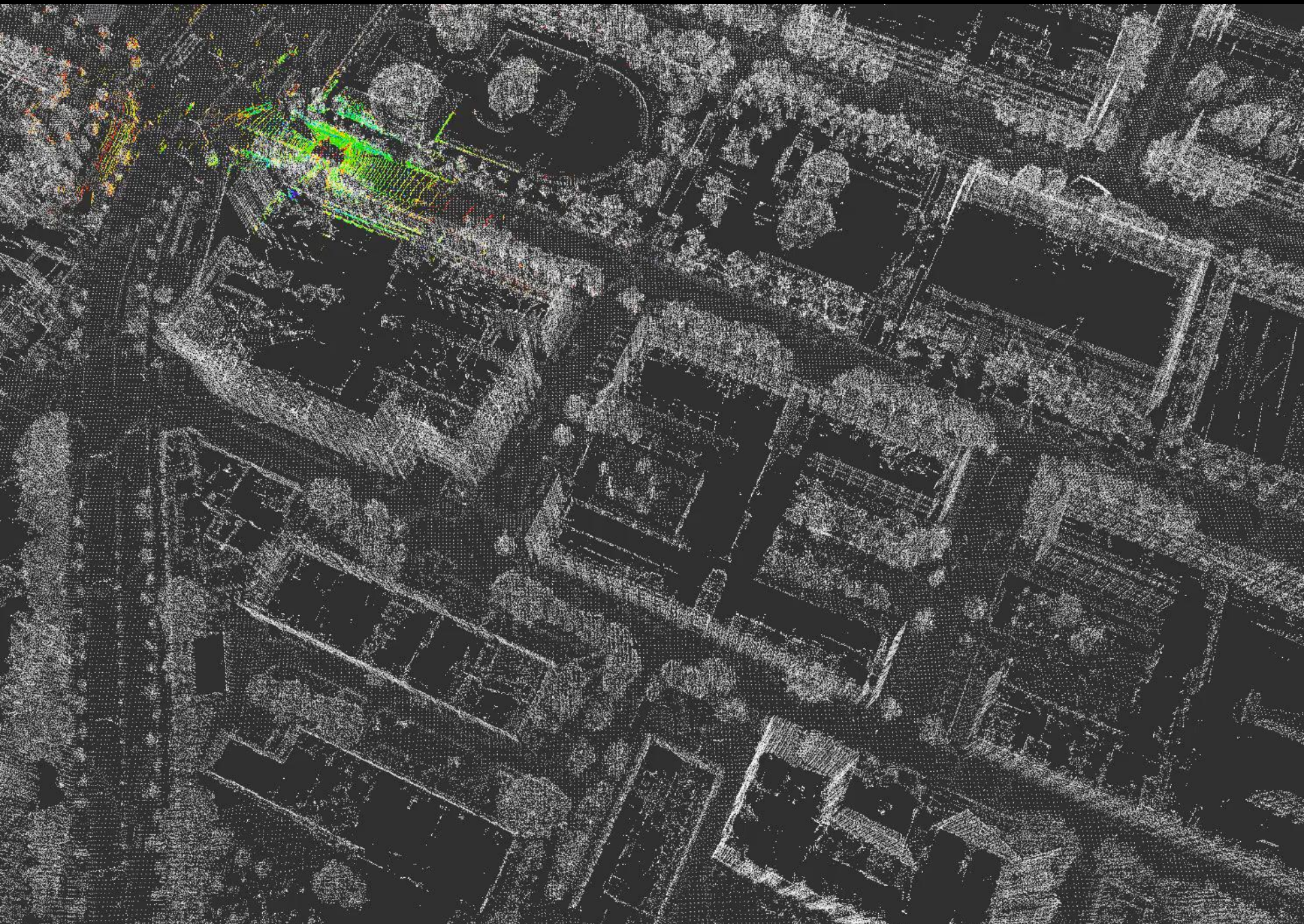
MMS(Mobile Mapping System)

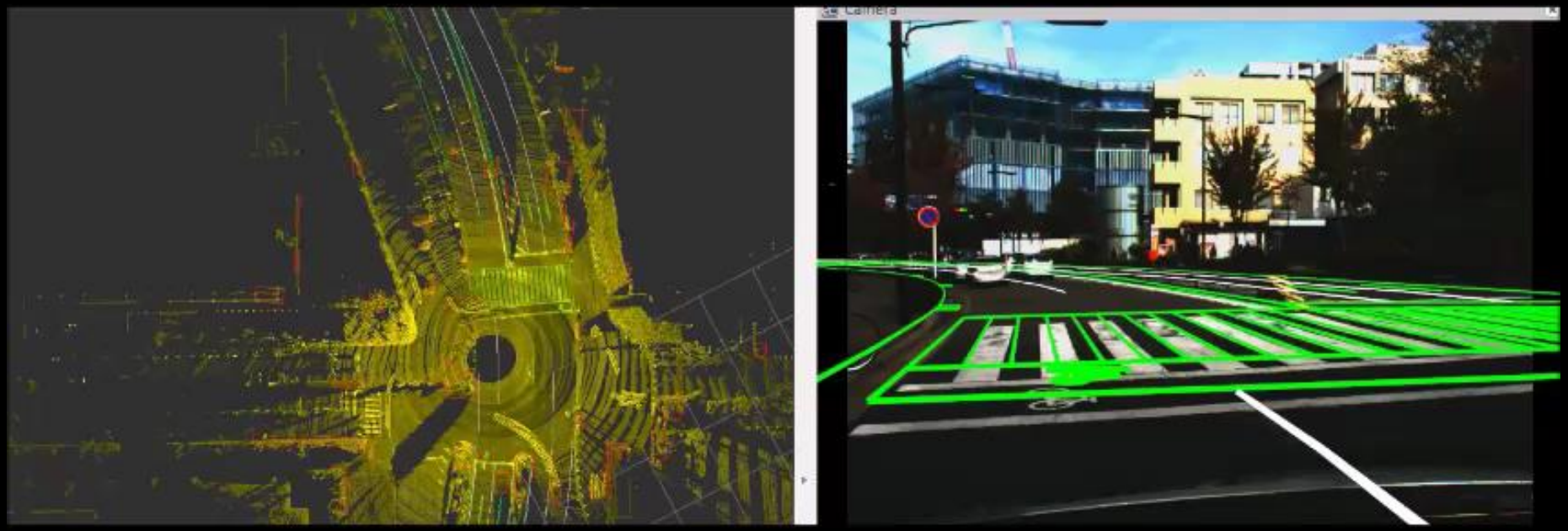
To obtain 3D maps (real world) from LIDARs and cameras through post processing

Aisan Technology Inc.

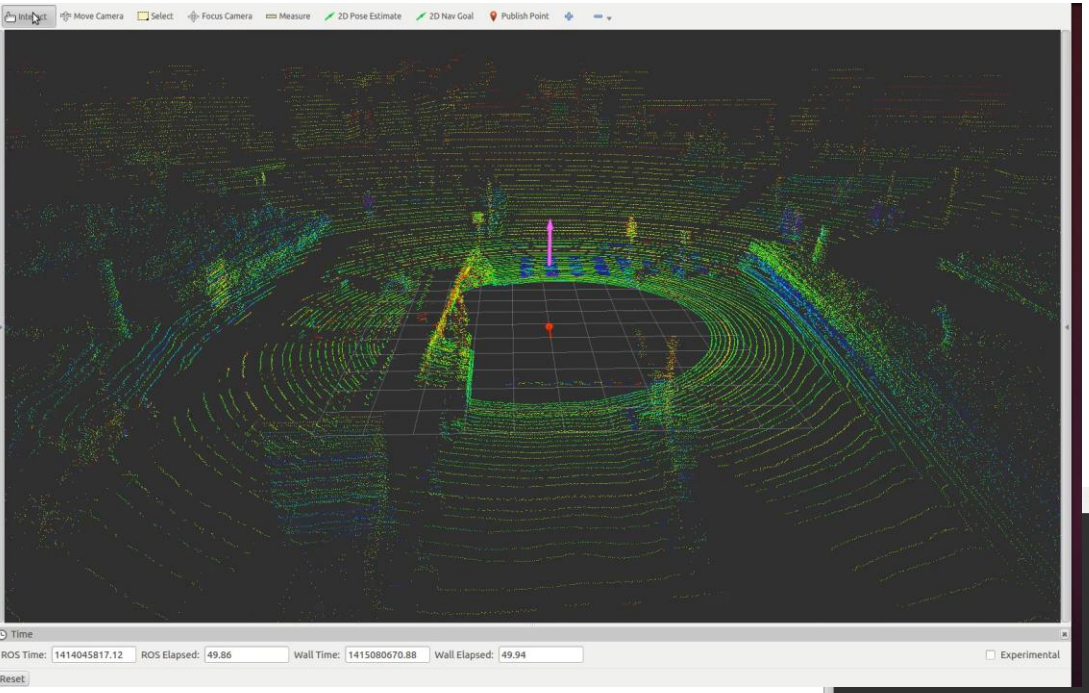
Image-integrated point cloud

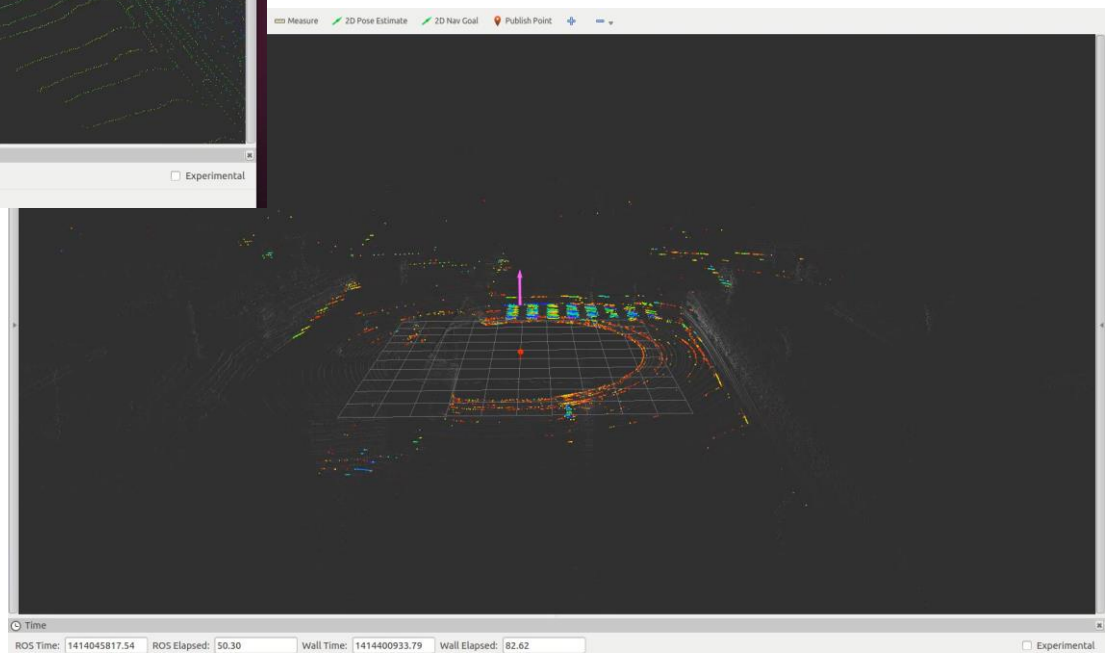

3D Viewer
53.7 FPS

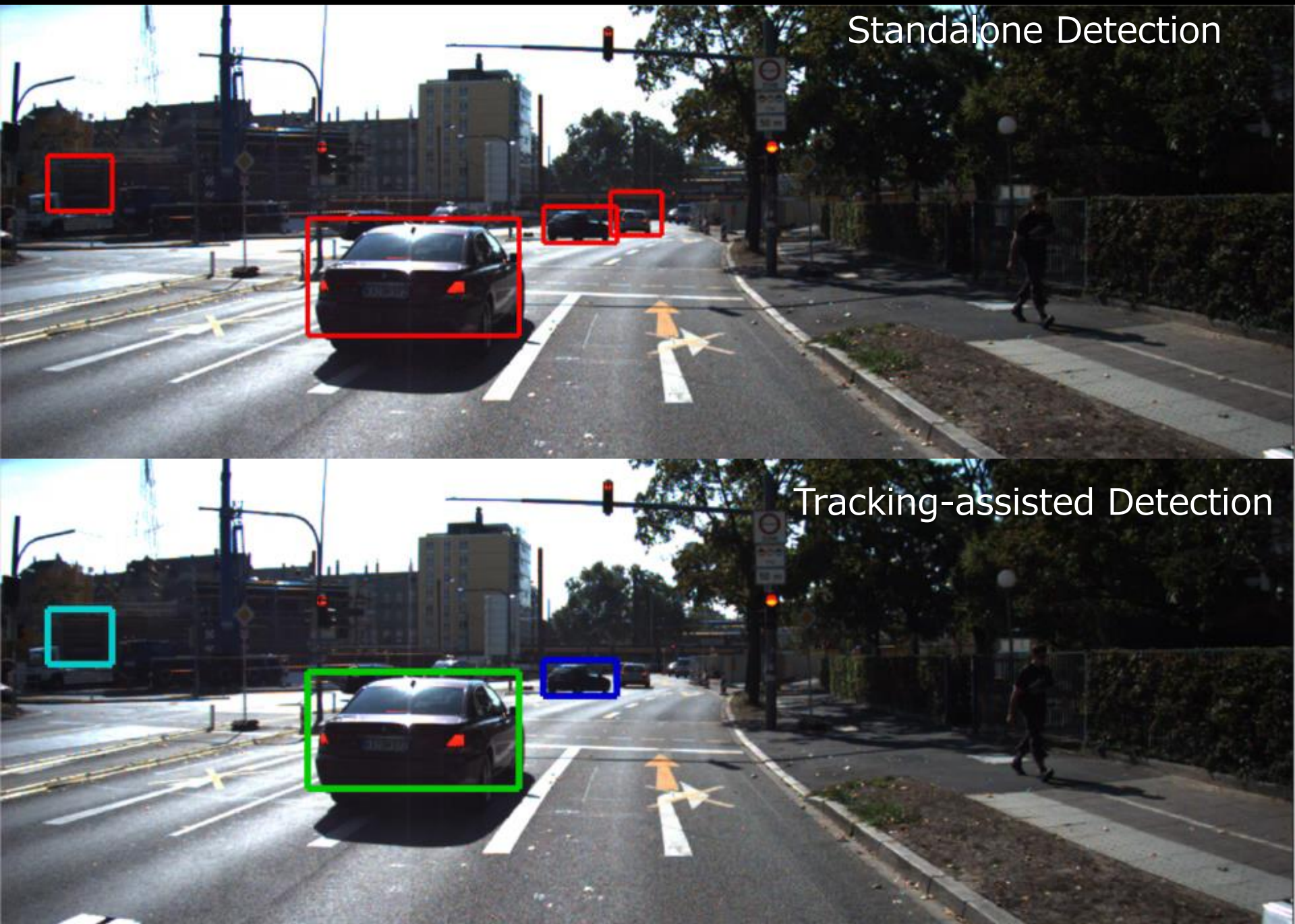



Camera

Extracted Road Signs





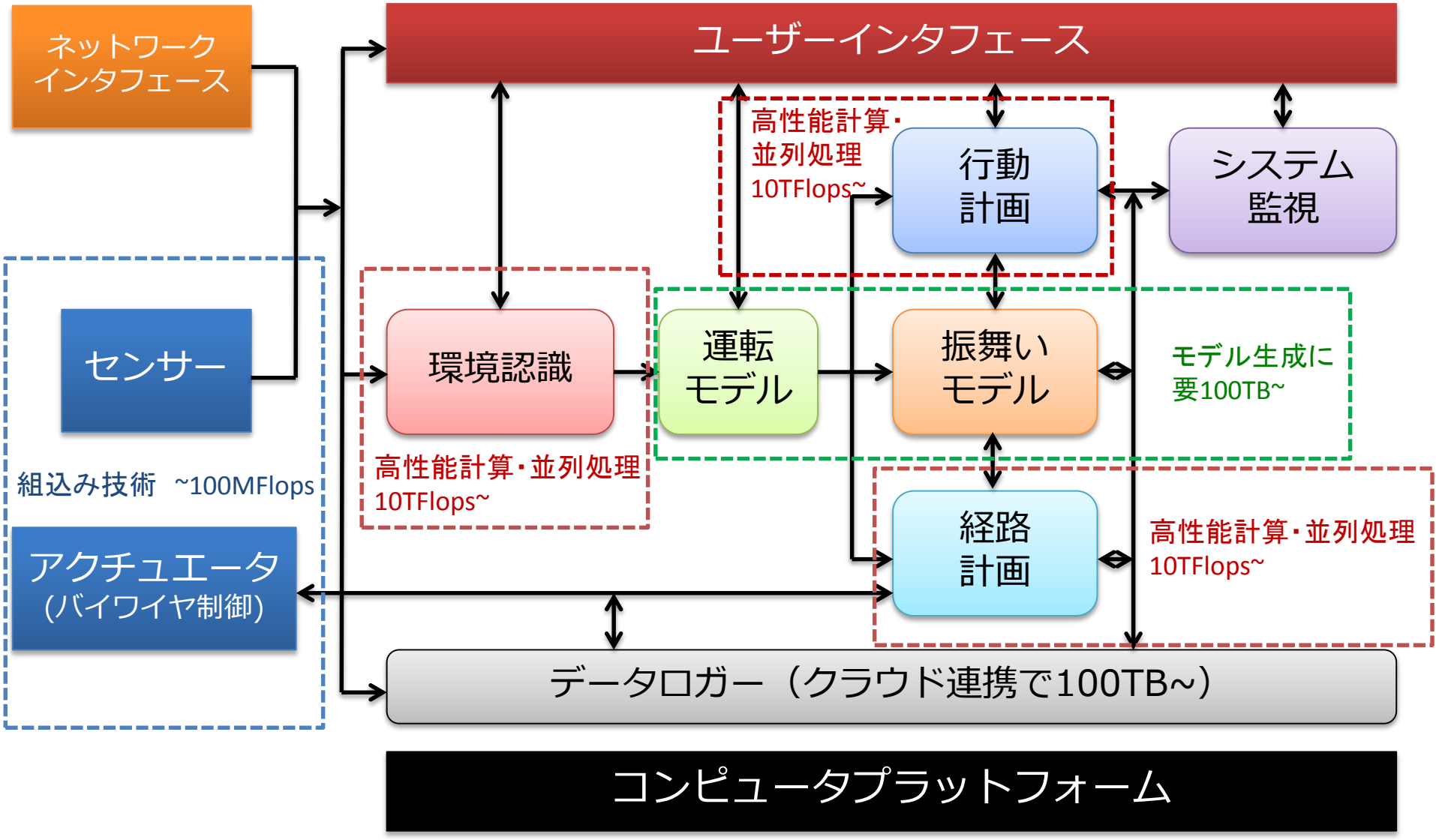

Standalone Detection
Tracking-assisted Detection

Sensor Fusion

DPM-based Vehicle Detection
+
Ground-Object Segmentation

マルチ・メニーコア技術

自動運転の研究プラットフォーム



画像認識の例

Computing

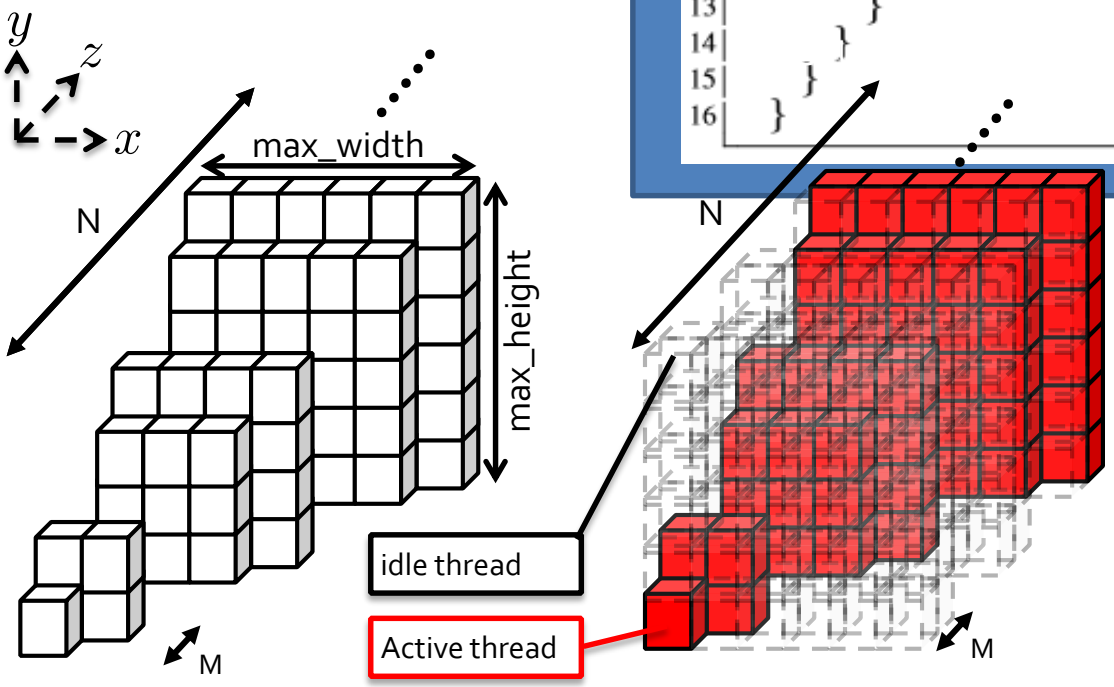
ROSノード

data

Listing 1. The program structure of similarity scoring

```
1  for(int level=0; level<RESIZED_INPUT_NUM; level++) {
2    for(int i=0; i<ROOTFILTER_NUM; i++) {
3      for(int j=0; j<C_height; j++) {
4        for(int k=0; k<C_width; k++) {
5          .....
6        }
7      }
8    }
9    for(int i=0; i<PARTFILTER_NUM; i++) {
10     for(int j=0; j<C_height; j++) {
11       for(int k=0; k<C_width; k++) {
12         .....
13       }
14     }
15   }
16 }
```

画像認識の部分例



画像認識や経路計画はデータ並列処理
（制御はしばしば並行プロセス？）

GPUやハイエンドメニーコアに対応する必要がある。

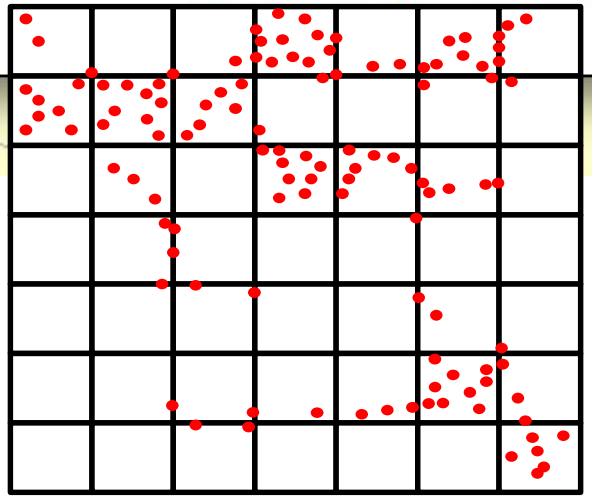
経路生成の例

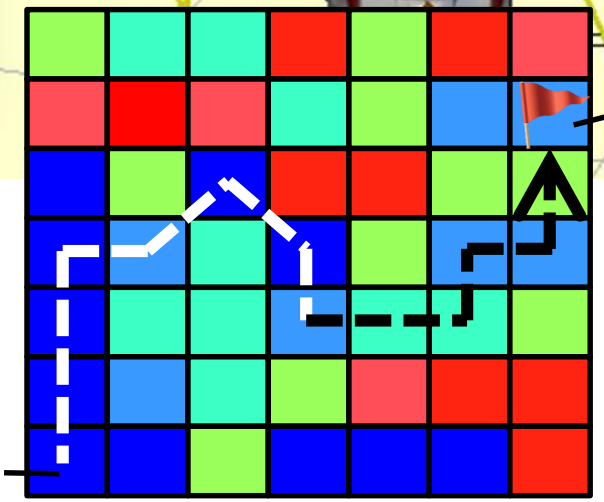
Parallel threads

Master thread

Parallelization with OpenMP

```
    // calculate paths
    omp_set_num_threads(N);
#pragma omp parallel for
    for (int i=0; i<LAYERNUM+1; i++) {
        for (int j=0; j<TRAJNUM; j++) {
            for (int k=i+1; k<LAYERNUM+1; k++) {
                for (int l=0; l<TRAJNUM; l++) {
```

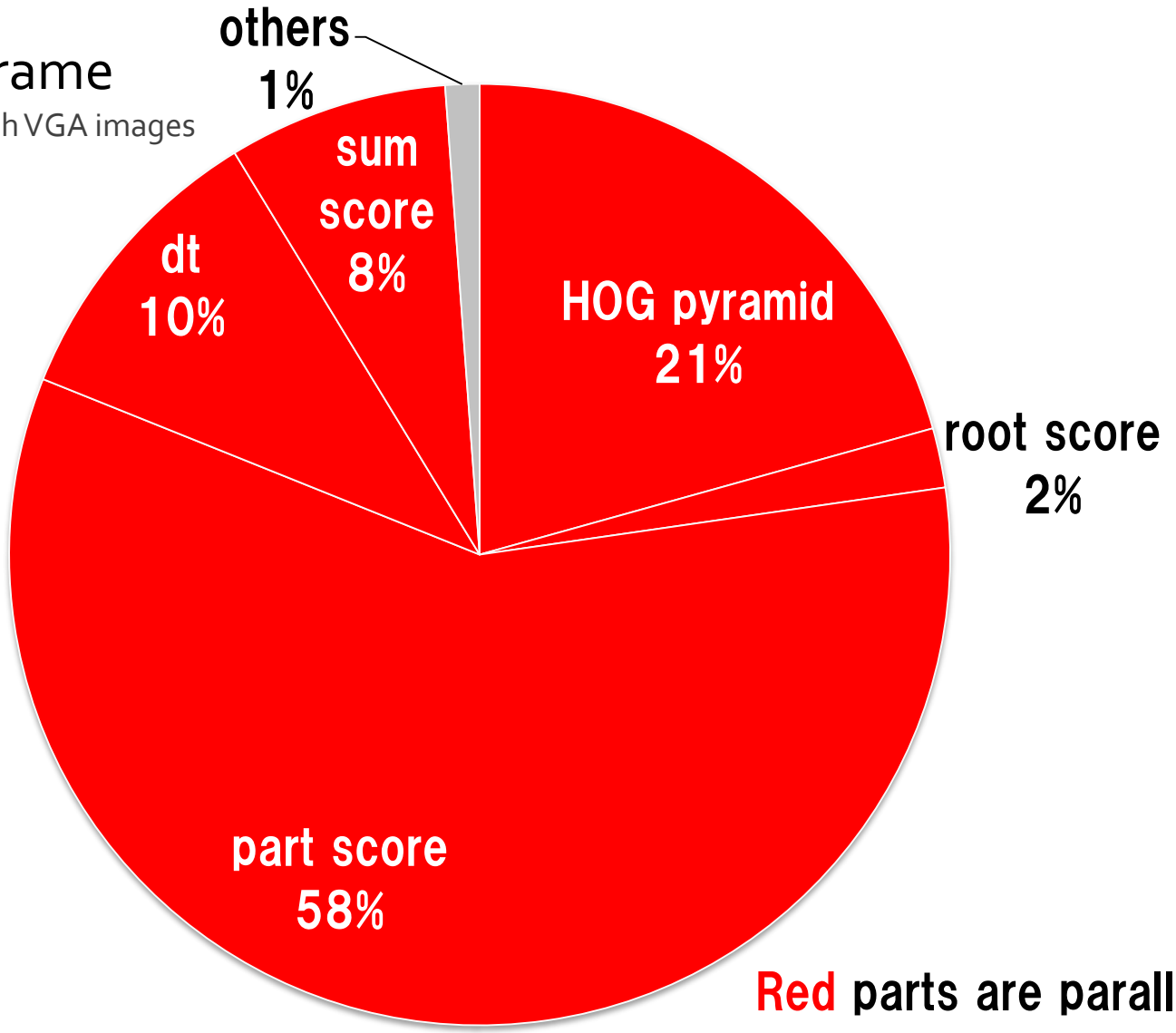




E.g., Execution Time of DPM

2 seconds per frame

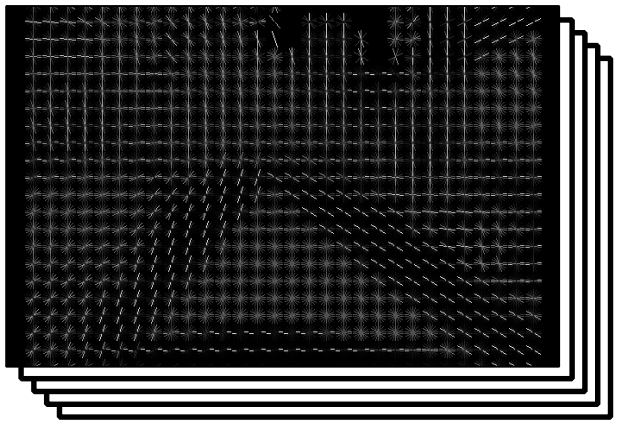
Detection in 20 meters with VGA images



Red parts are parallelizable

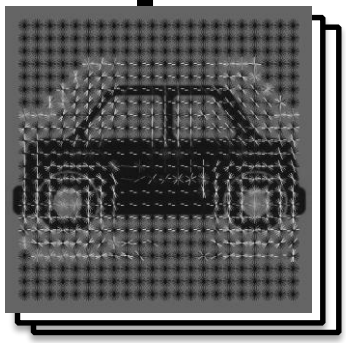
Graphics Processing Unit (GPU)

HOG feature(= input)
N



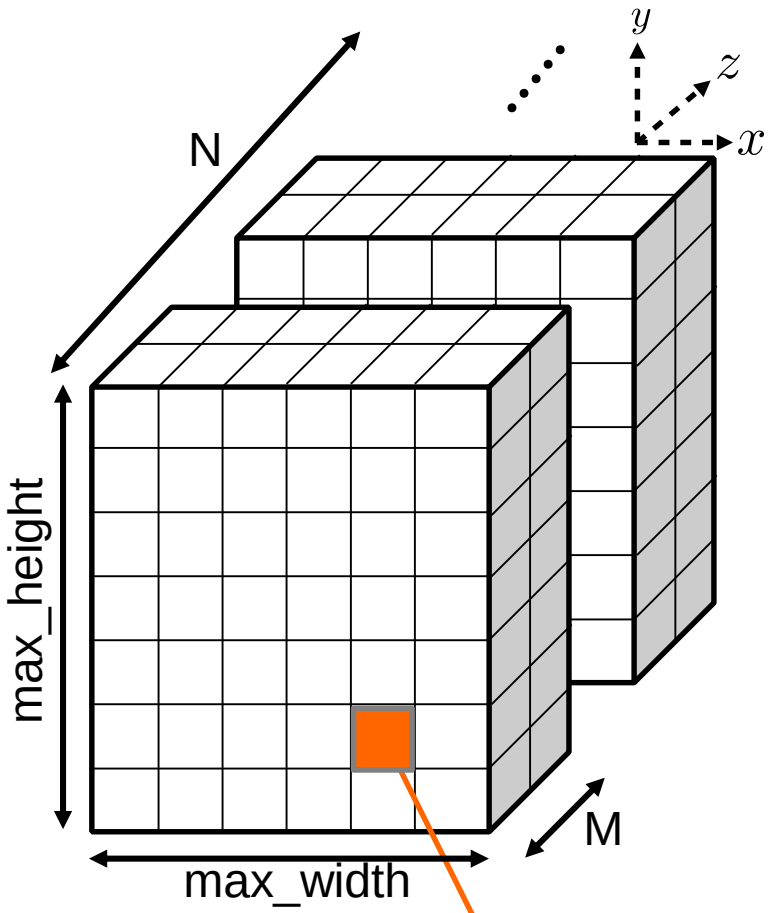
generates

score array



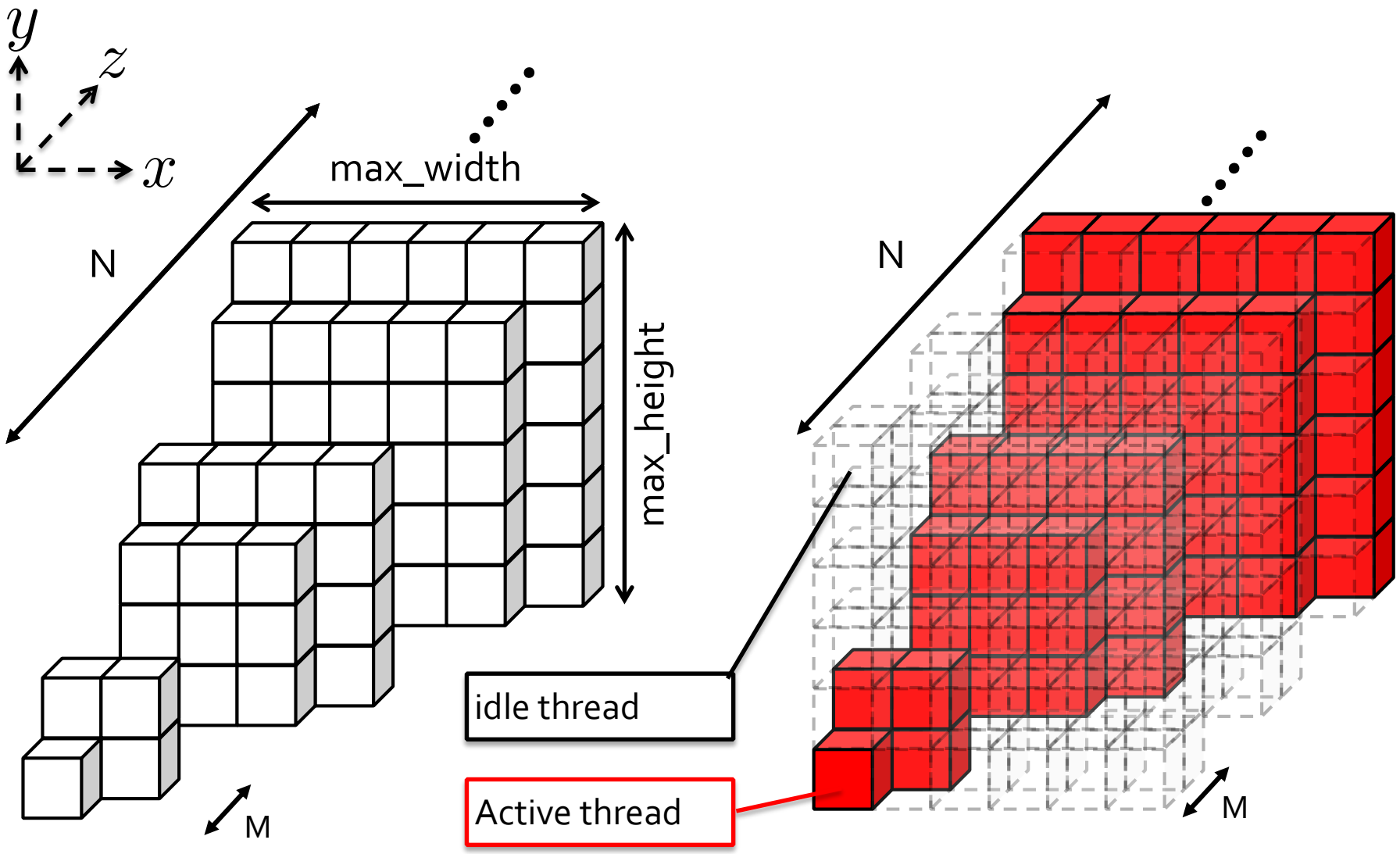
filter(= model)
# M

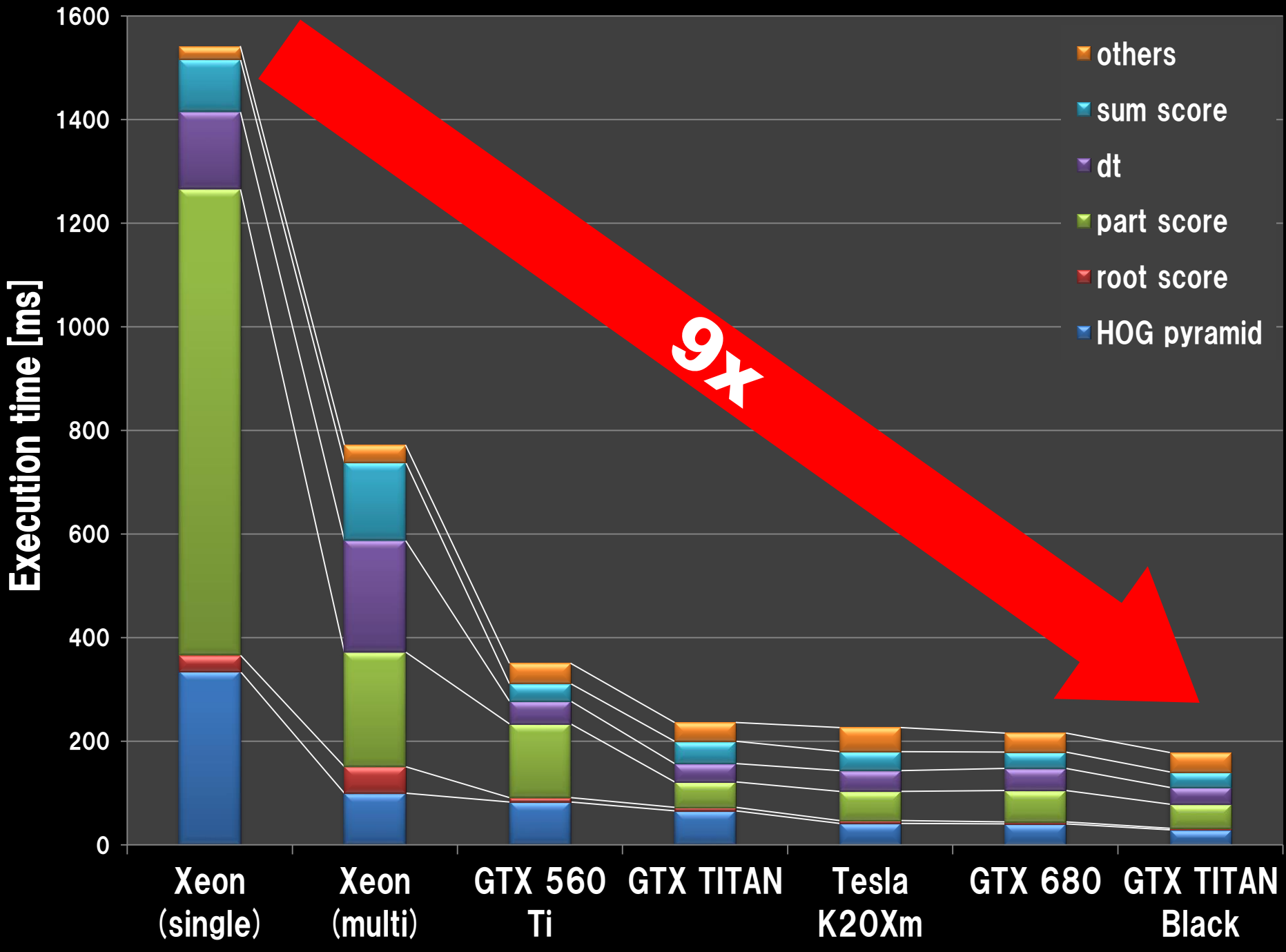
Each score indicates the degree of similarity
Between the feature and filter



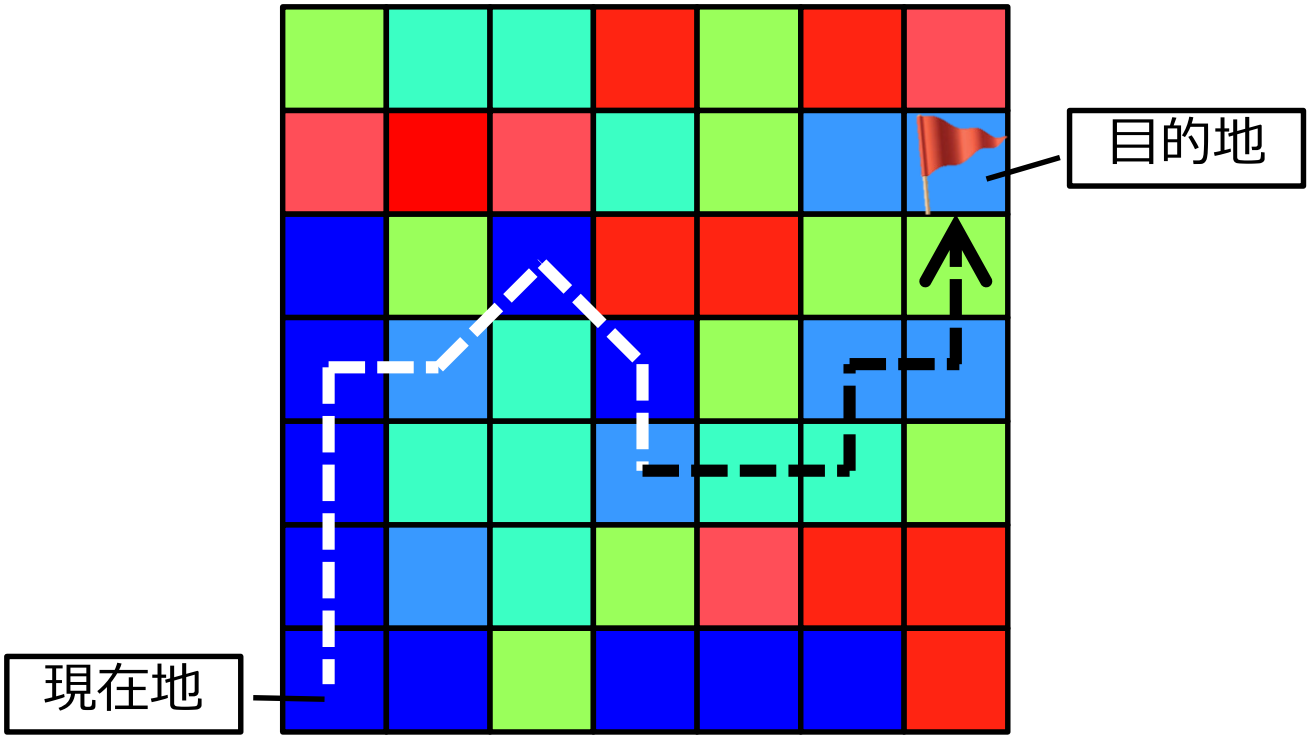
Computed by one thread on the GPU

Parallel Algorithms




Execution time [ms]
1600
1400
1200
1000
800
600
400
200
0
others
sum score
dt
part score
root score
HOG pyramid
9x
Xeon (single)
Xeon (multi)
GTX 560 Ti
GTX TITAN
Tesla K20Xm
GTX 680
GTX TITAN Black

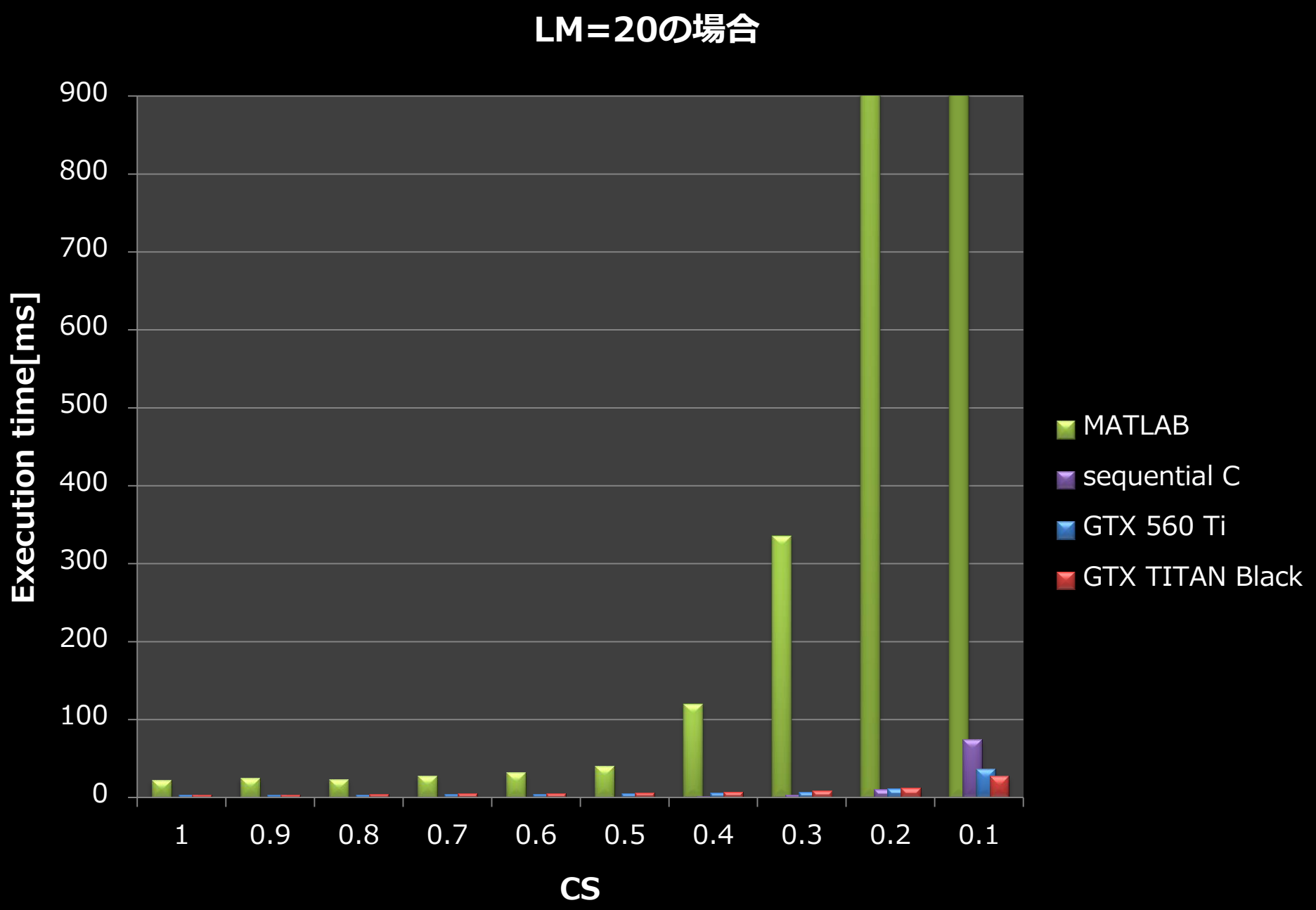
経路生成



コストマップをもとに

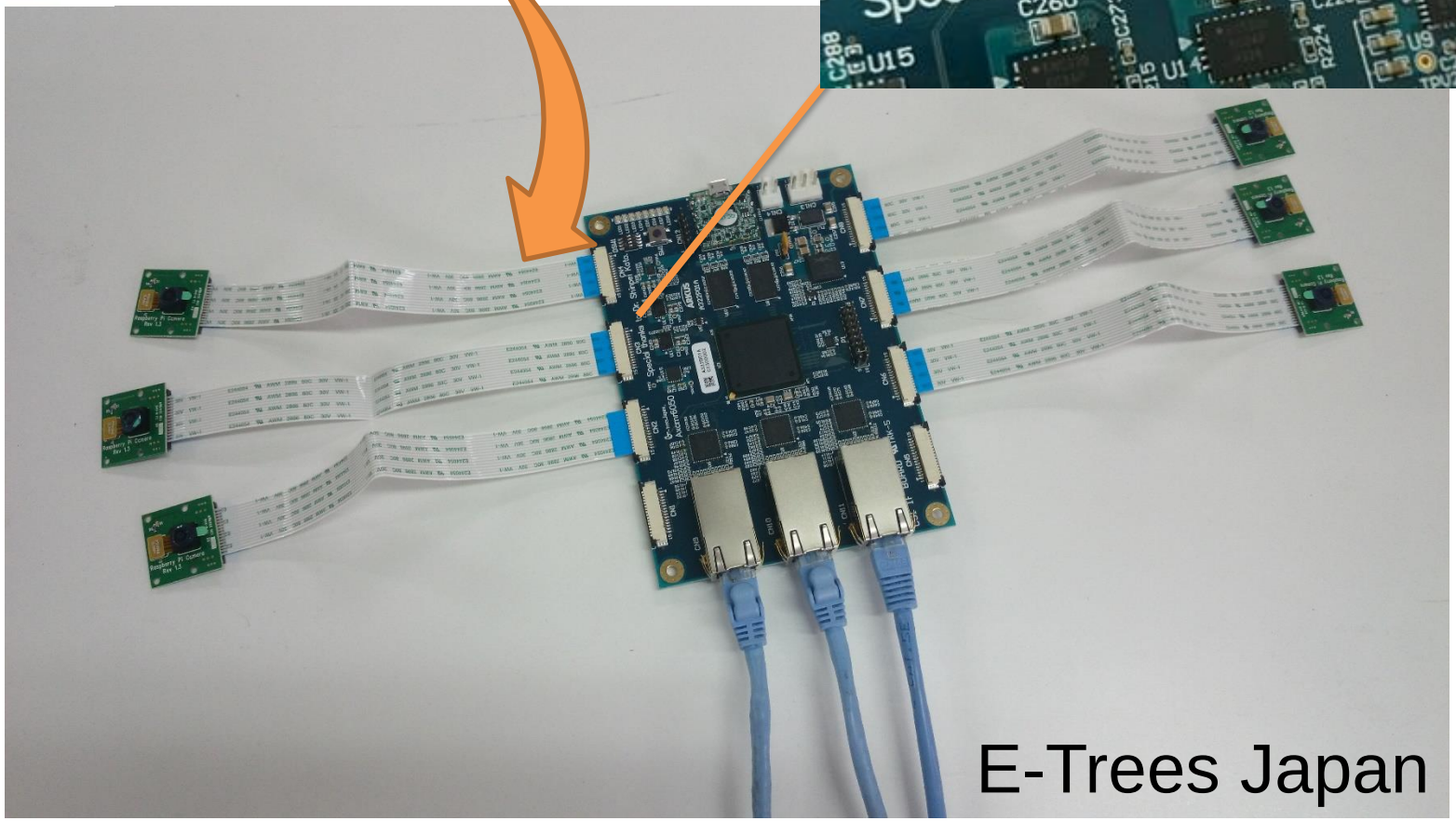
1. なるべく経路の総コスト和が小さく
2. なるべく移動距離の少ない

ような経路を探索


LM＝20の場合
Execution time[ms]
900
800
700
600
500
400
300
200
100
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
CS
MATLAB
sequential C
GTX 560 Ti
GTX TITAN Black

20K USD

500 USD



Nagasaki DEGIMA

Titech TSUBAME

Embedded Supercomputing

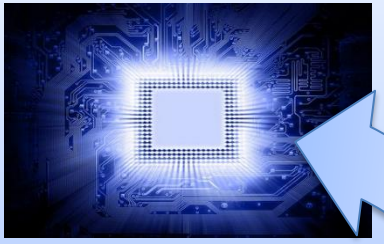
2002 → 2014 → 2020+

One Room
1300m²
6000KW

1000x
3000x

One Box
1m²
2KW

100x
300x



One Chip
1cm²
6W

Fastest Supercomputers
- 40TFLOPS
- 600M USD

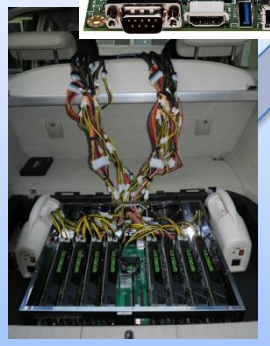
Today's GPUs
- 40TFLOPS by 8 GPUs
- 10K USD

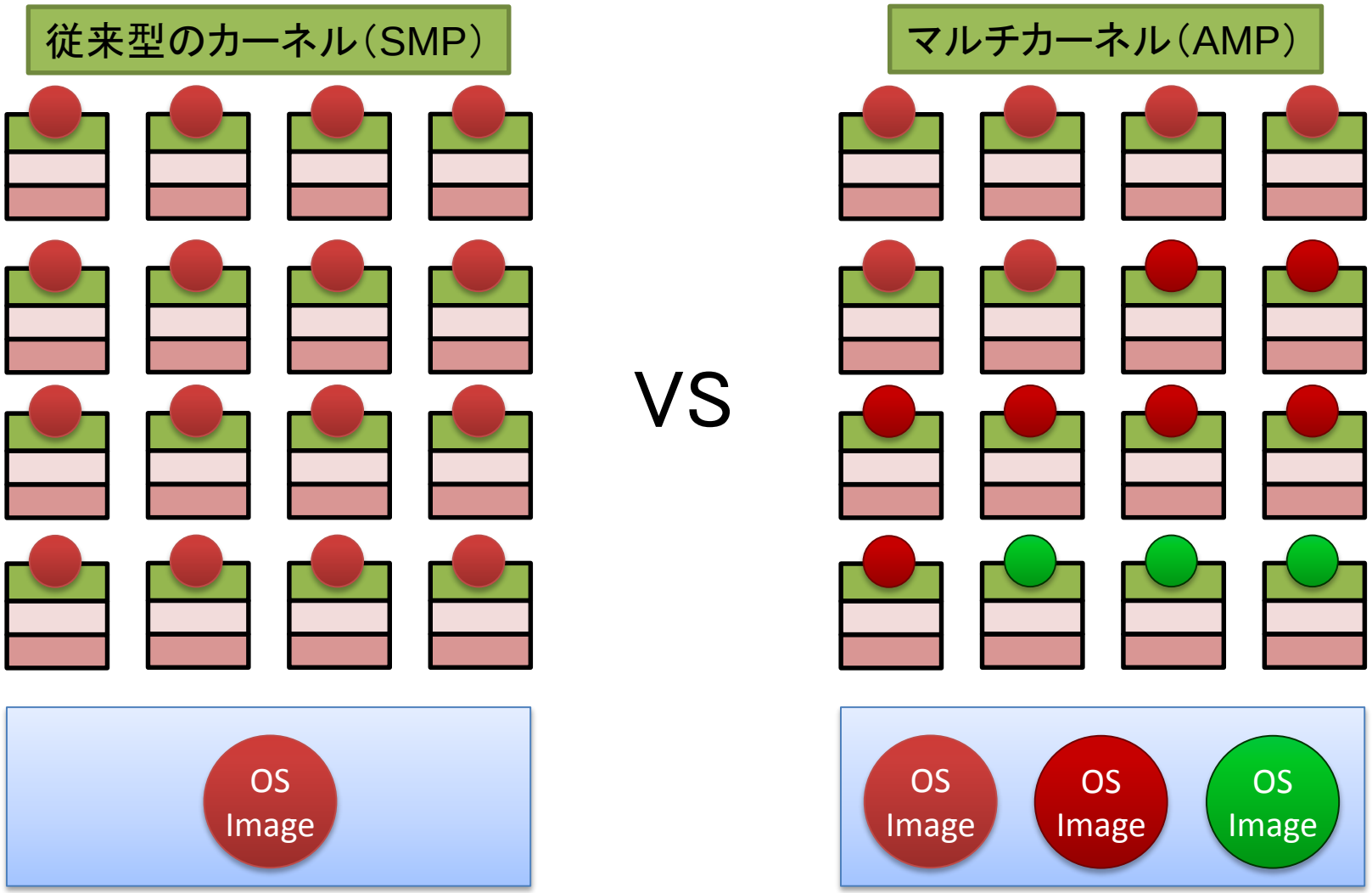
Future Embedded Systems
- 40TFLOPS in smartphone size
- 100 USD

Today

Car makers and Google

Look forward 10 years ahead




従来型のカーネル（SMP）
マルチカーネル（AMP）
VS
OS Image
OS Image
OS Image
OS Image

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Nagoya University
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