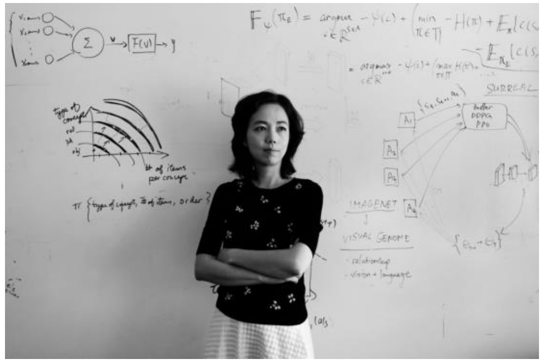
適合邊緣佈署之類神經網路研發與應用*

林永隆

創鑫智慧股份有限公司

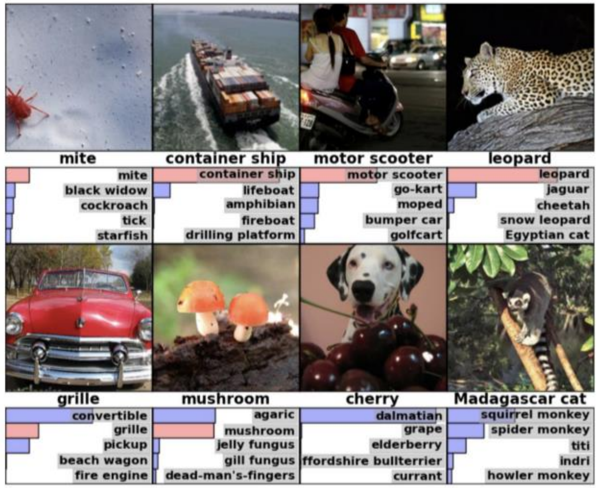
*Work done with students in National Tsing Hua University
Partially supported by a grant from the Ministry of Science and Technology

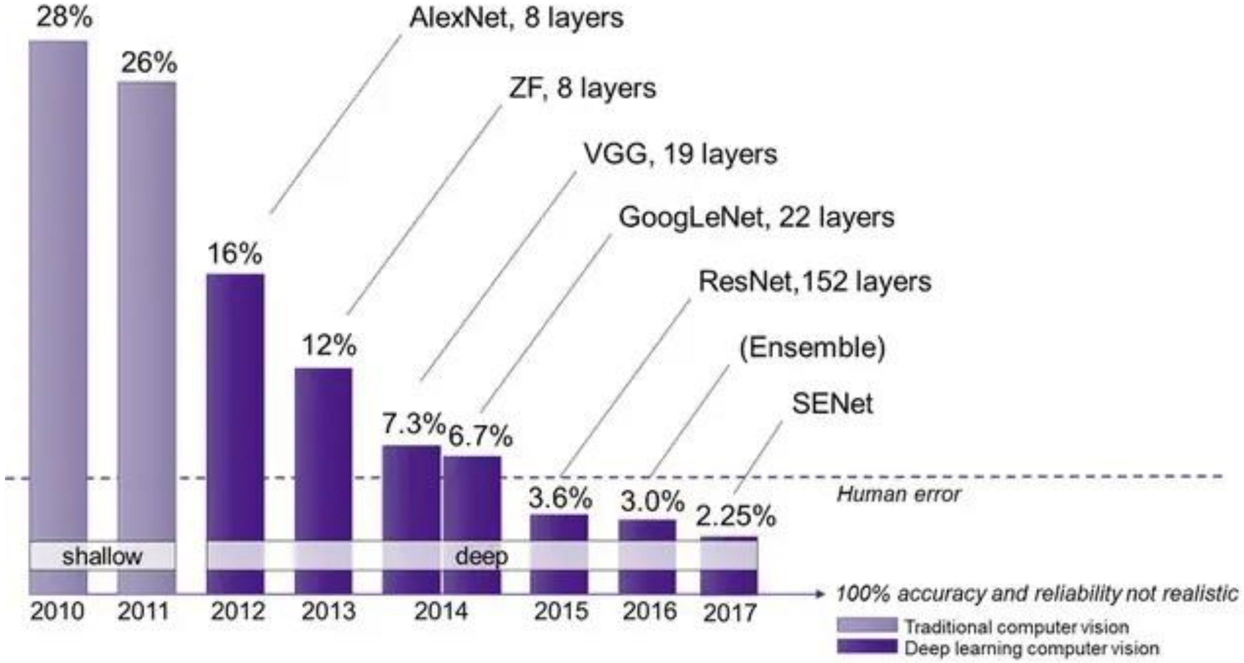
A Grand Challenge -- ImageNet Image Classification



IMAGENET

- 1,000 object classes (categories).
- Images:
  - 1.2 M train
  - 100k test.



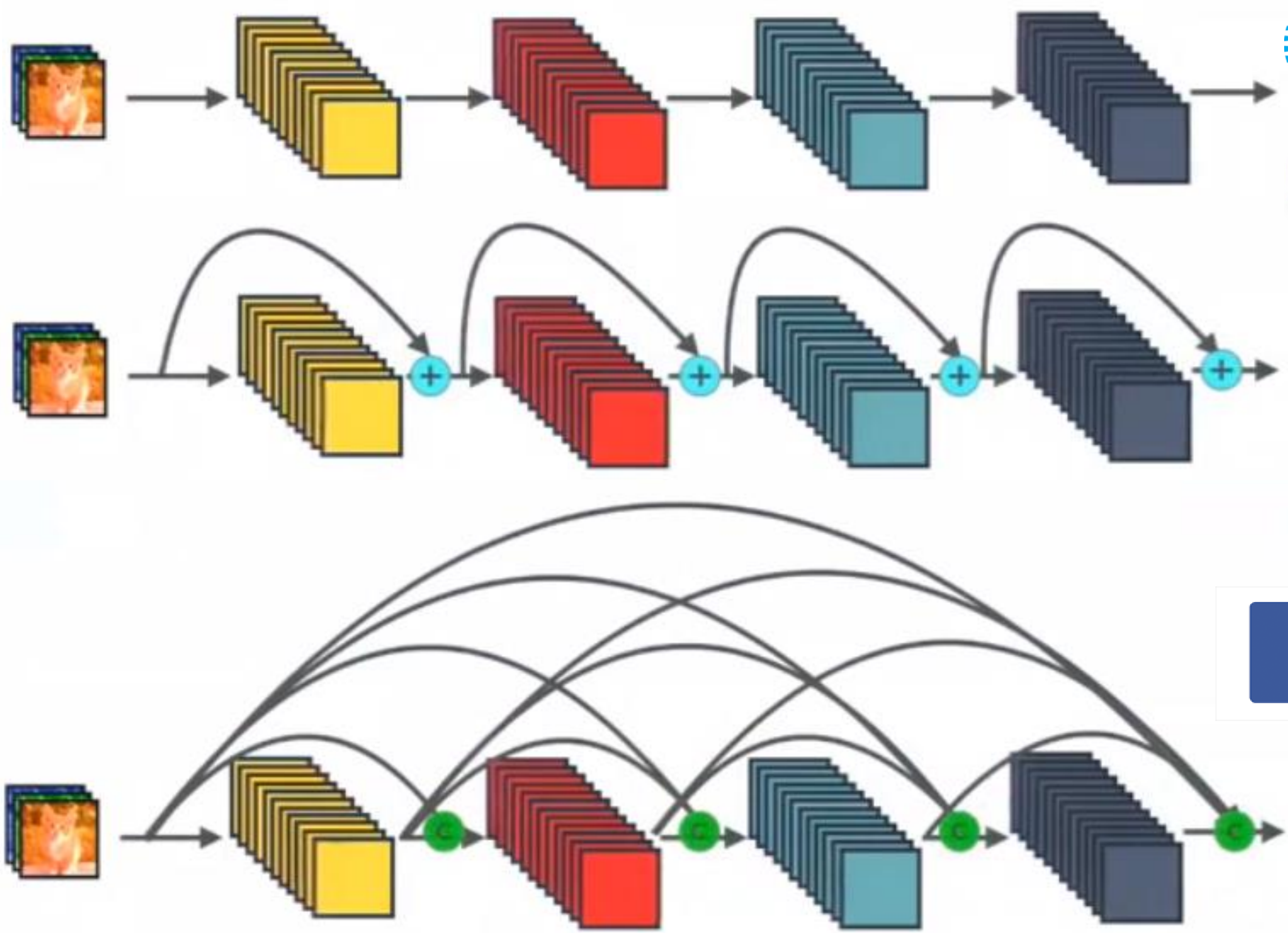


CNN Evolution – The more shortcuts, the better?

1998 LeNet
2012 AlexNet
2014 VGG
2014 GoogLeNet

2015 ResNet

2018 DenseNet



AT&T Bell Laboratories
Google
Microsoft
facebook

Review: DenseNet — Dense Convolutional Network (Image Classification) Sik-Ho Tsang Nov 25, 2018

NEUCHIPS

CNN Architecture Design Considerations

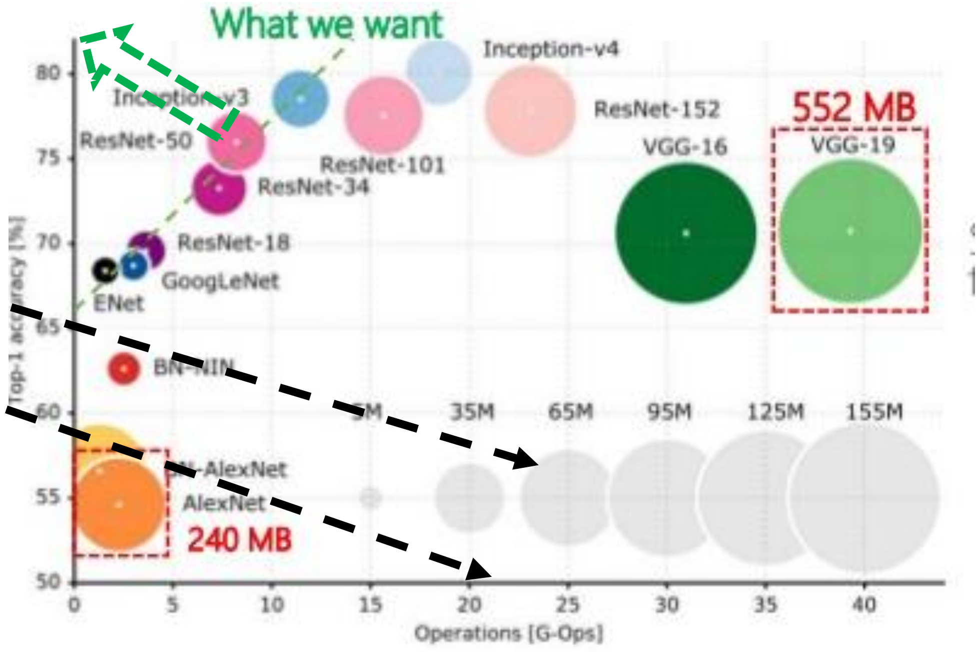
ImageNet Classification Challenge

Conventional Metrics

- Accuracy
- Model size (# Parameters)
- Operations per inference

What we really care

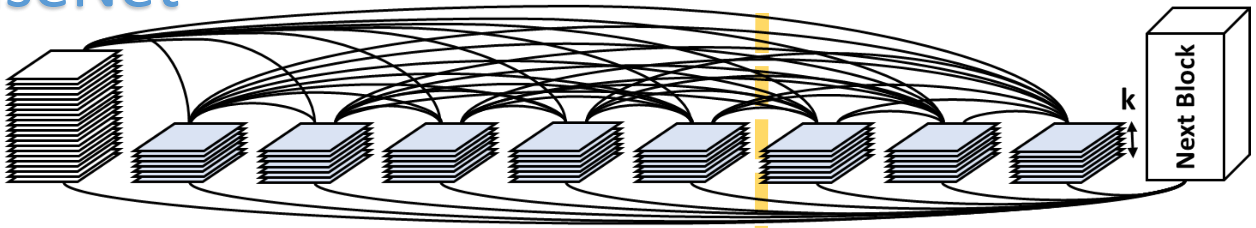
- Accuracy, of course!
- Inference time (~ #Ops?)
- Energy consumption (~ #Ops?)
- Model Size
- General applicability
- Trainability, Robustness, etc



Canziani, Alfredo, Adam Paszke, and Eugenio Culurciello. "An analysis of deep neural network models for practical applications." arXiv preprint arXiv:1605.07678 (2016).

HarDNet – Harmonic Densely Connected CNN

2018 DenseNet

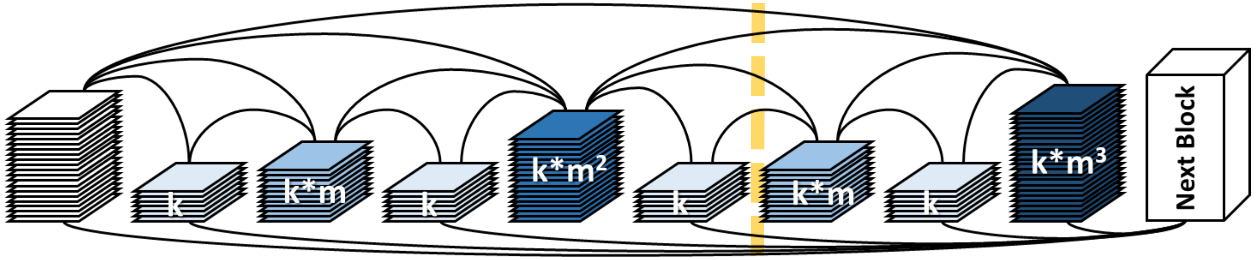


DenseNet

facebook

1. Harmonic Wave

2019 HarDNet



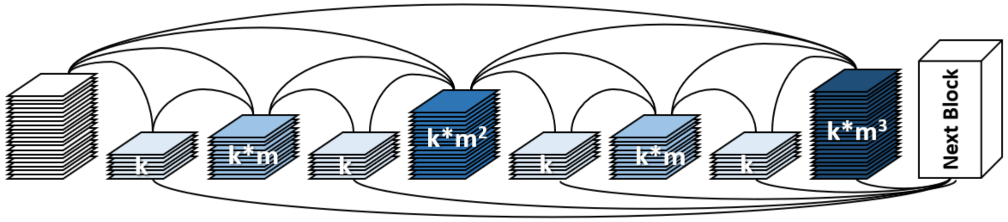
HarDNet

國立清華大學
NATIONAL TSING HUA UNIVERSITY

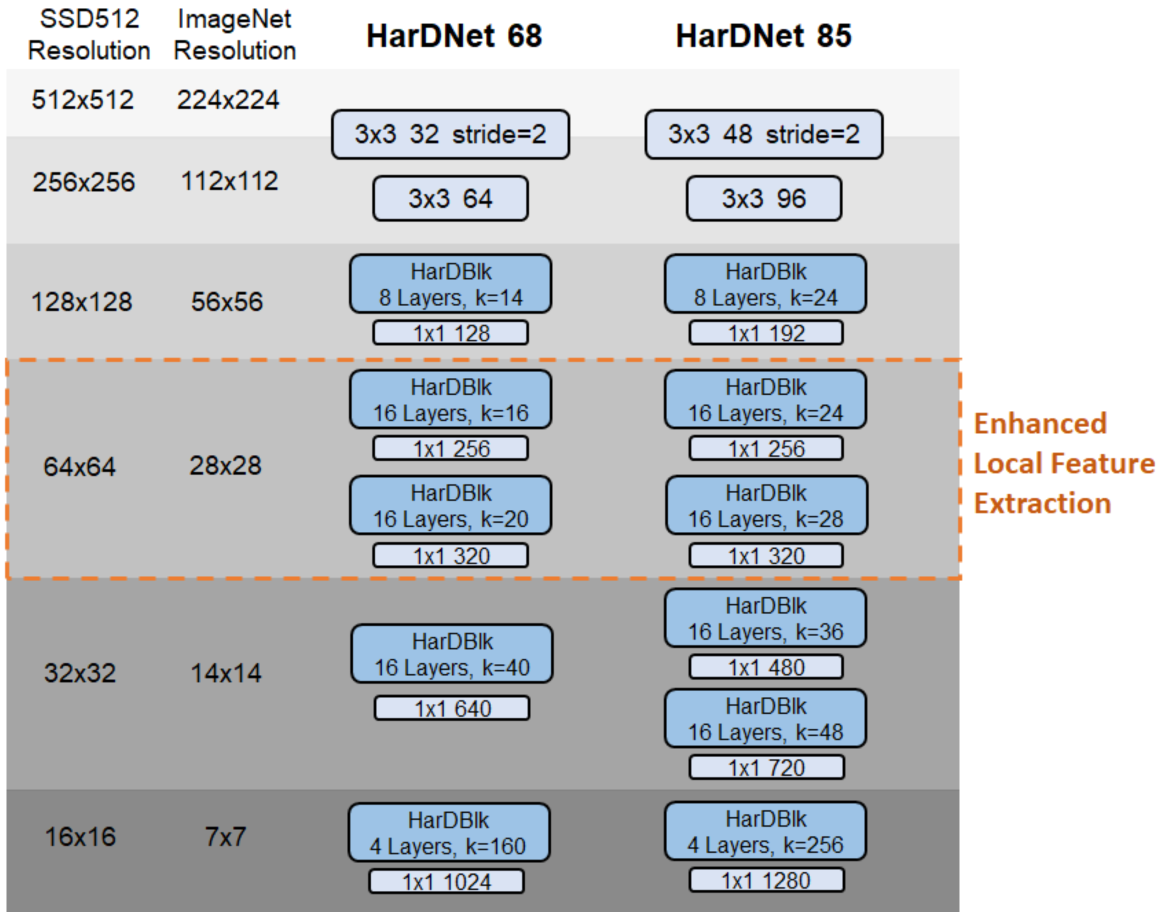
3. Variable Channels

2. Less Intermediate Result

HarDNet: A Low Memory Traffic Network



An 8-Layer HarDBlk
Similarly, 4-Layer, 16-Layer



Feedback on HarDNet

ICCV 2019 Seoul, Korea

Conventional Metrics

- Accuracy
- Operations per inference
- Model size (# Parameters)

What we really care

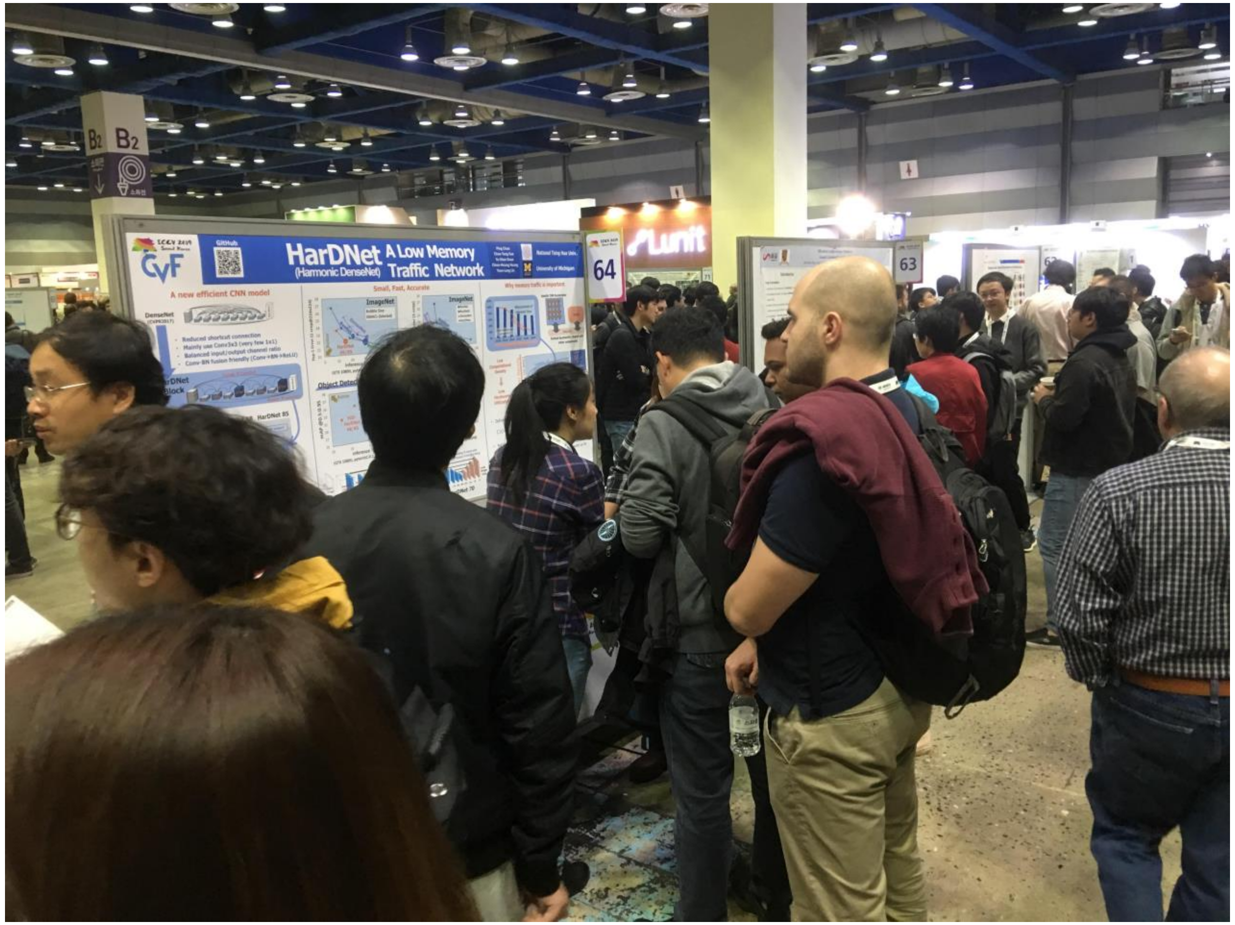
- Accuracy, of course!
- Inference time (~ #Ops?)
- Energy consumption (~ #Ops?)
- Model Size
- General applicability
- Trainability, Robustness, etc

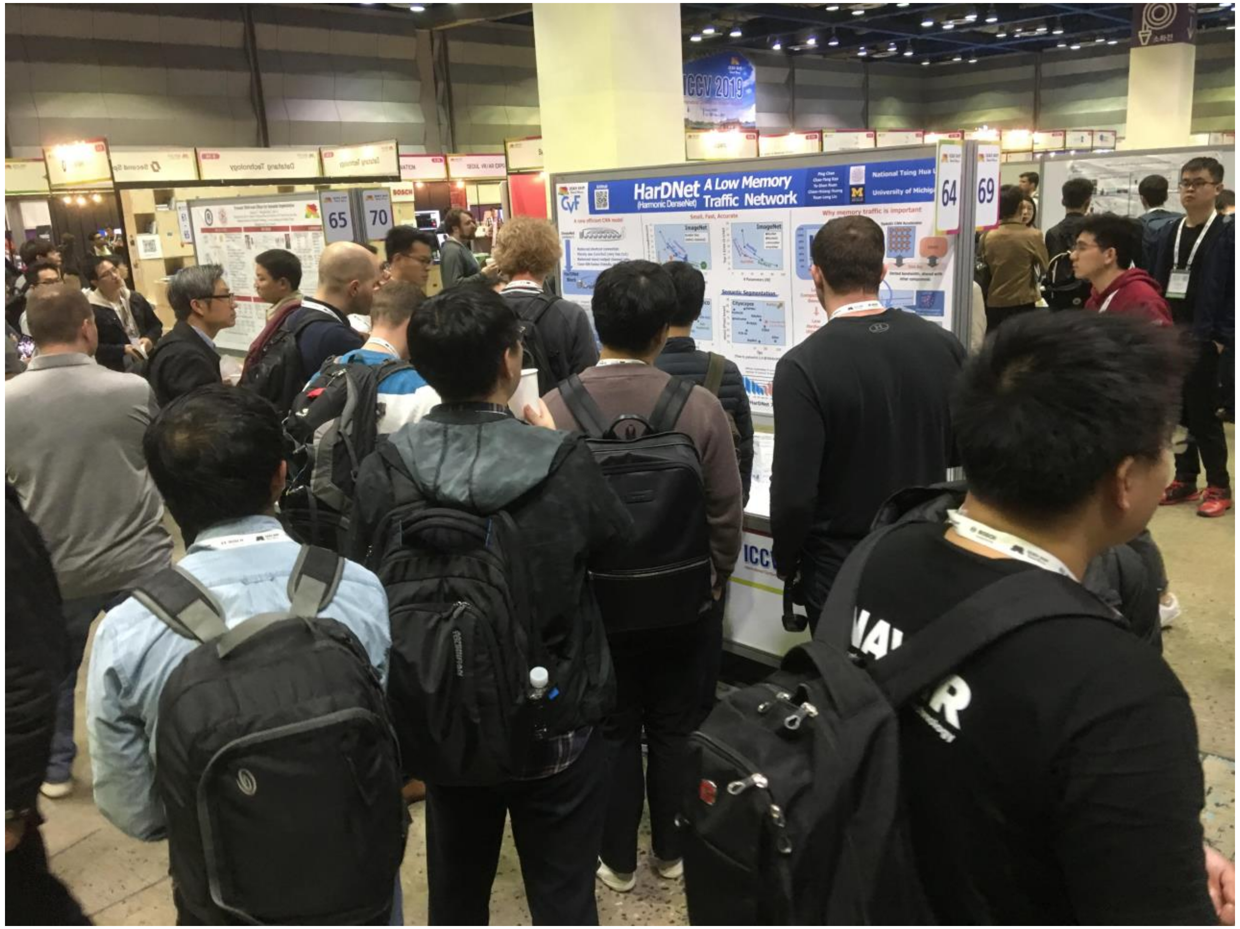
Area Chair Comment:

... This paper makes a meaningful contribution to the literature by introducing a new proxy metric for real-world performance, and additionally showing how neural network architectures might be designed to optimize that metric. This is a fresh idea in a space where nearly every paper focuses exclusively on FLOPs and parameter counts.

HarDNet @ ICCV-2019, Seoul

ICCV 2019
Seoul, Korea





HarDNet Open Source

Pytorch-HarDNet Public

35% faster than ResNet: Harmonic DenseNet, A low memory traffic network

Python ☆ 355 61

FCHarDNet Public

Fully Convolutional HarDNet for Segmentation in Pytorch

Python ☆ 171 48

CenterNet-HarDNet Public

Forked from xingyizhou/CenterNet

Object detection achieving 44.3 mAP / 45 fps on COCO dataset

Python ☆ 164 25

800+ Stars

✓ GitHub Open Source

- ✓ https://github.com/PingoLH/Pytorch-HarDNet
- ✓ [ICCV 2019] HarDNet: A Low Memory Traffic Network

✓ In "PapersWithCode"

- ✓ https://paperswithcode.com/paper/hardnet-a-low-memory-traffic-network
- ✓ State-Of-The-Art for Real-Time Semantic Segmentation on Cityscapes since 2019/09
- ✓ #5 for Real-Time Object Detection on COCO
- ✓ State-Of-The-Art for Polyp Segmentation on Kvasir

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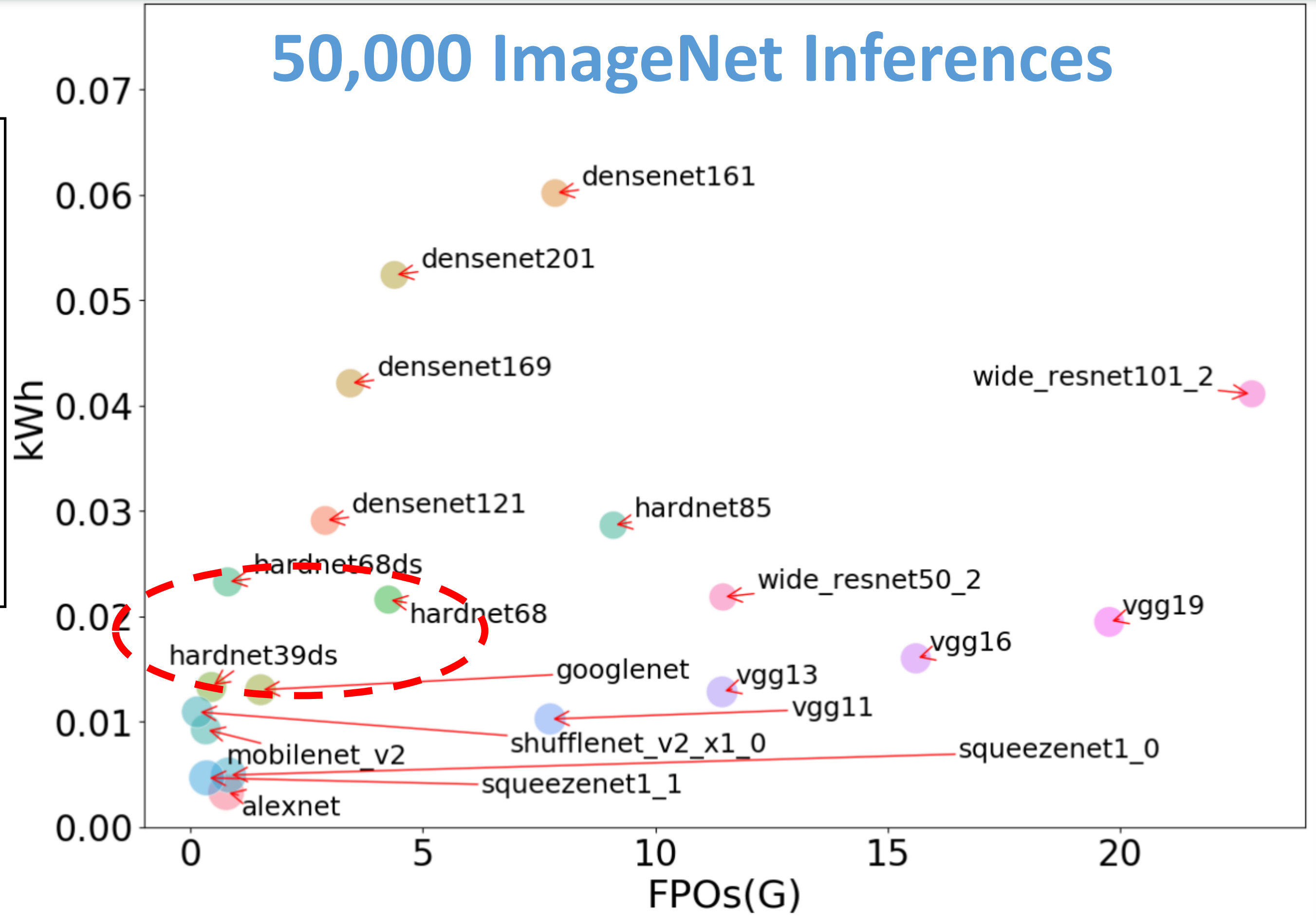
HarDNet is Energy Efficient

Towards the Systematic Reporting of the Energy and Carbon Footprints of Machine Learning

A Working Paper

Peter Henderson[†], Jieru Hu[‡], Joshua Romoff[◇]
Emma Brunskill[†], Dan Jurafsky[†], Joelle Pineau[‡,◇]
[†]Stanford University, [‡]Facebook, [◇]Mila, McGill University

February 14, 2020



Mila

Object Detection

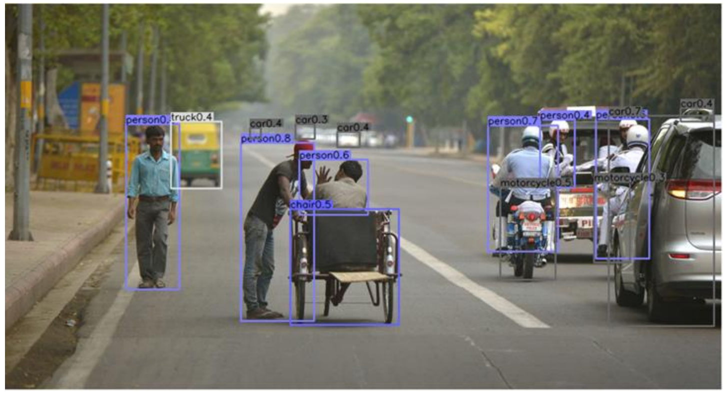
NEUCHIPS

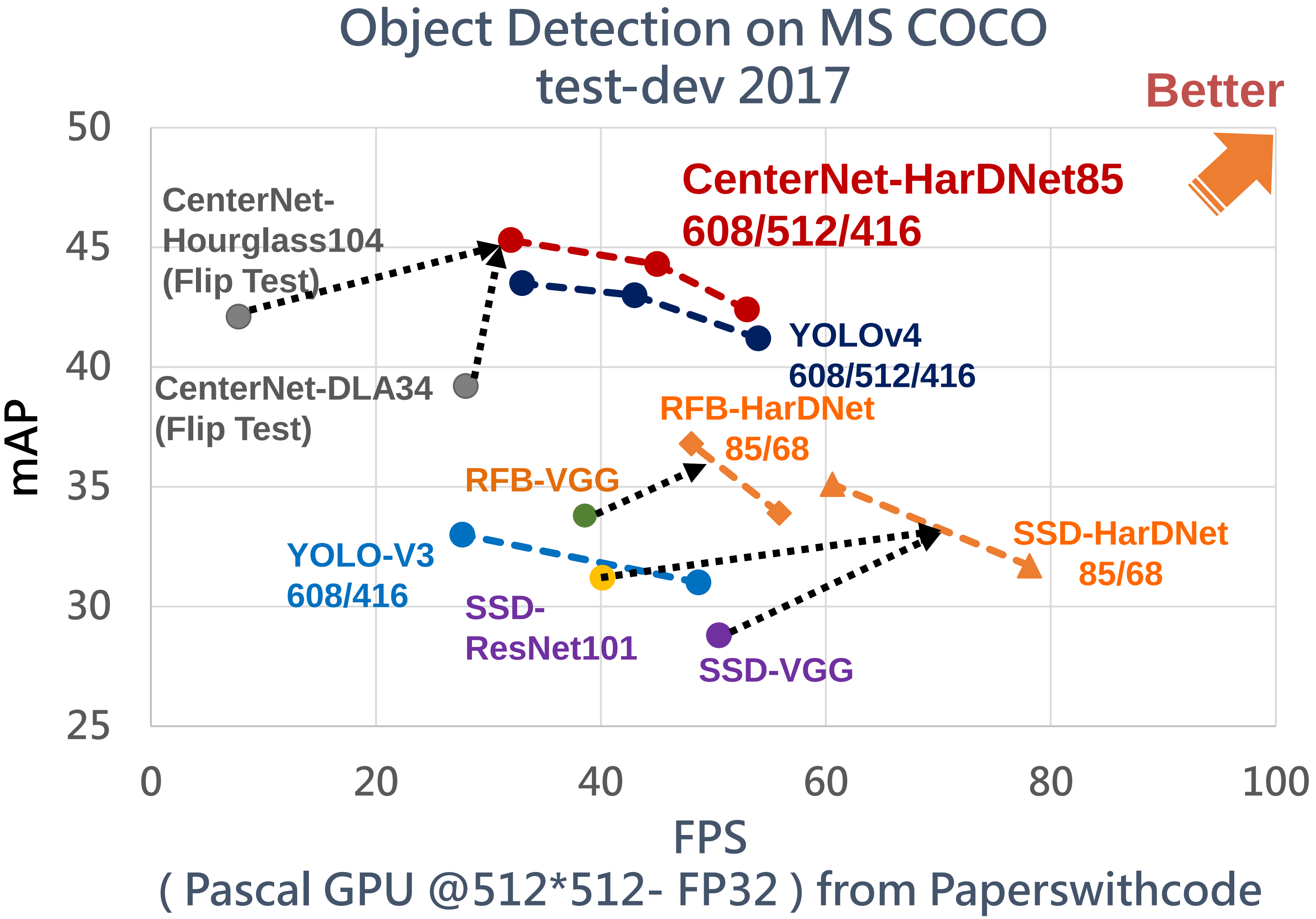
HarDNet Empowers Famous Detectors

SSD-VGG,
SSD-ResNet101 →
SSD-HarDNet

RFB-VGG →
RFB-HarDNet

CenterNet-DLA,
CenterNet-Hourglass →
CenterNet-HarDNet





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SSD-HarDNet for Warehouse AGVs

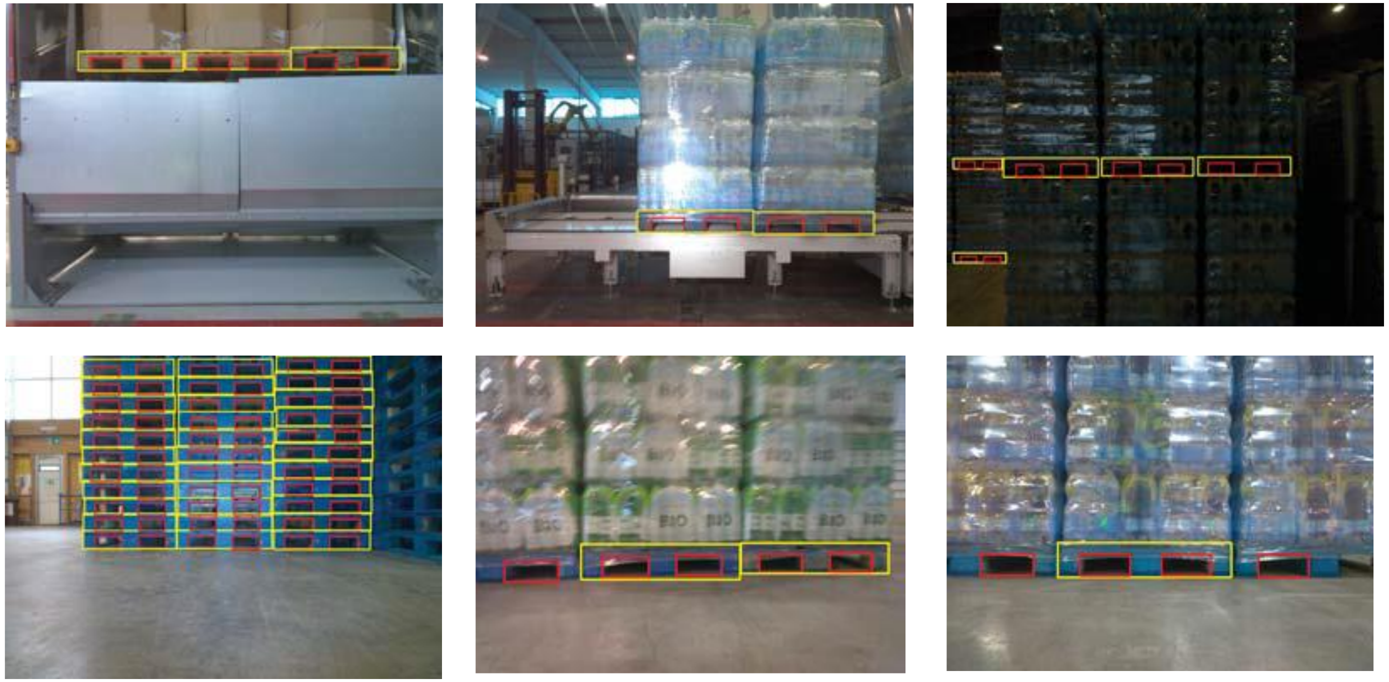
A Comparison of Deep Learning Models for Pallet Detection in Industrial Warehouses

ELETTRIC80

UNIVERSITÀ DI PARMA

TABLE III
COCO METRICS FOR CNNS DETECTION
OF THE FRONT SIDES OF PALLETS AND PALLET POCKETS.

	Faster R-CNN	SSD	YOLOv4
AP	75.4	75.8	69.1
AP_{50}	93.8	92.0	86.3
AP_{75}	89.7	88.0	82.1
AP_S	0.0	6.5	14.3
AP_M	37.7	40.5	18.3
AP_L	78.8	78.3	73.6
AR_{max1}	12.6	12.6	11.7
AR_{max10}	53.3	53.6	49.4
AR_{max100}	82.1	80.4	78.0
AR_S	0.0	6.3	18.4
AR_M	53.4	50.9	31.1
AR_L	84.8	82.7	82.1
Pallet front side AP	80.1	81.5	69.5
Pocket AP	70.8	70.1	68.7

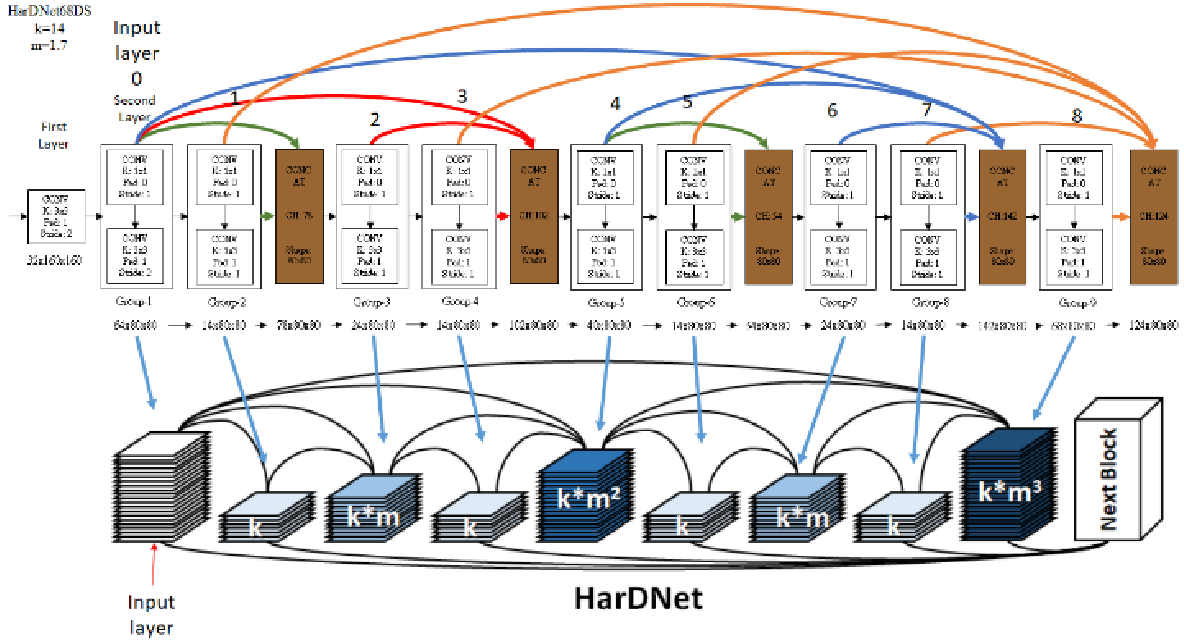


SSD-HarDNet for Road Maintenance Inspection

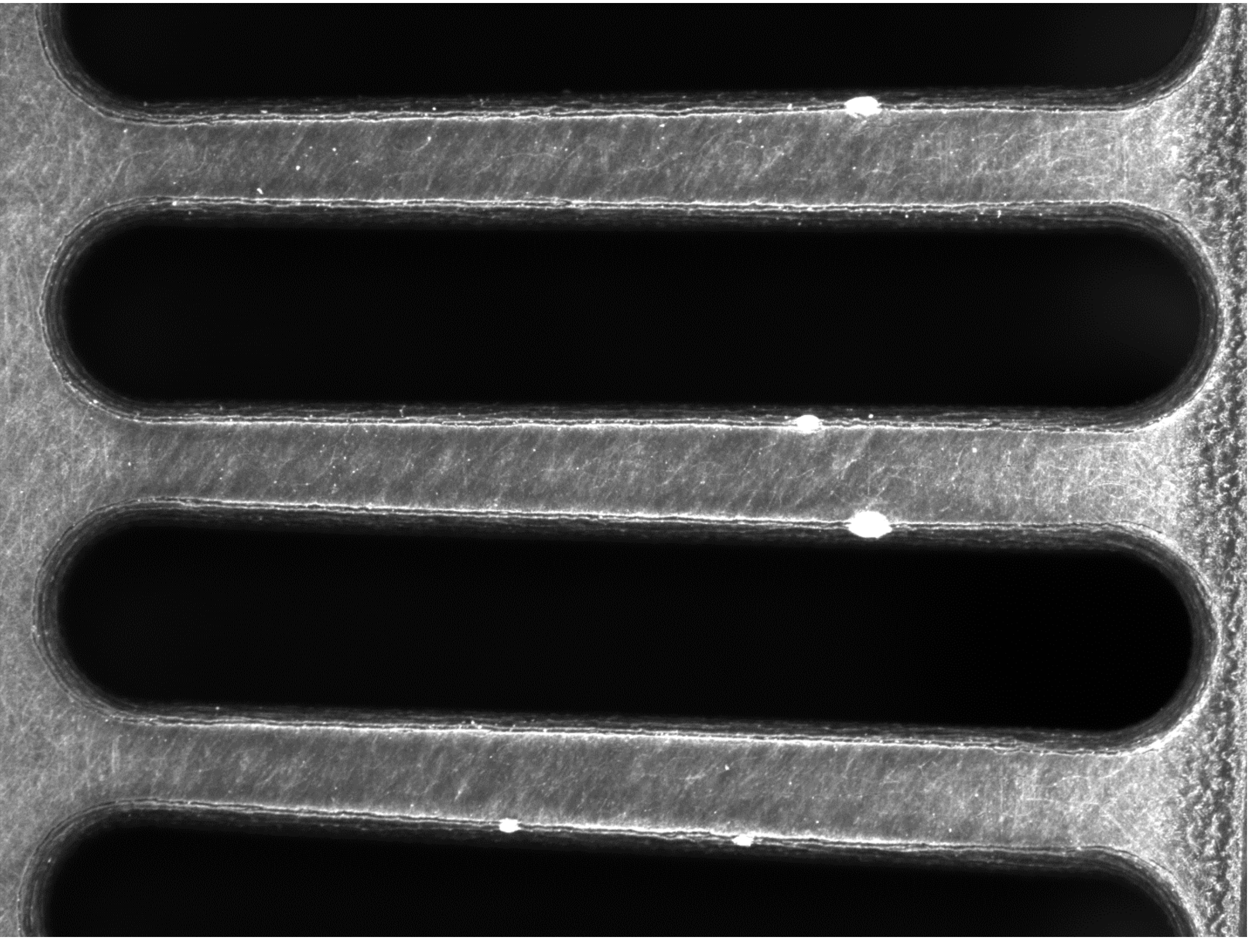
AI Driven Road Maintenance Inspection

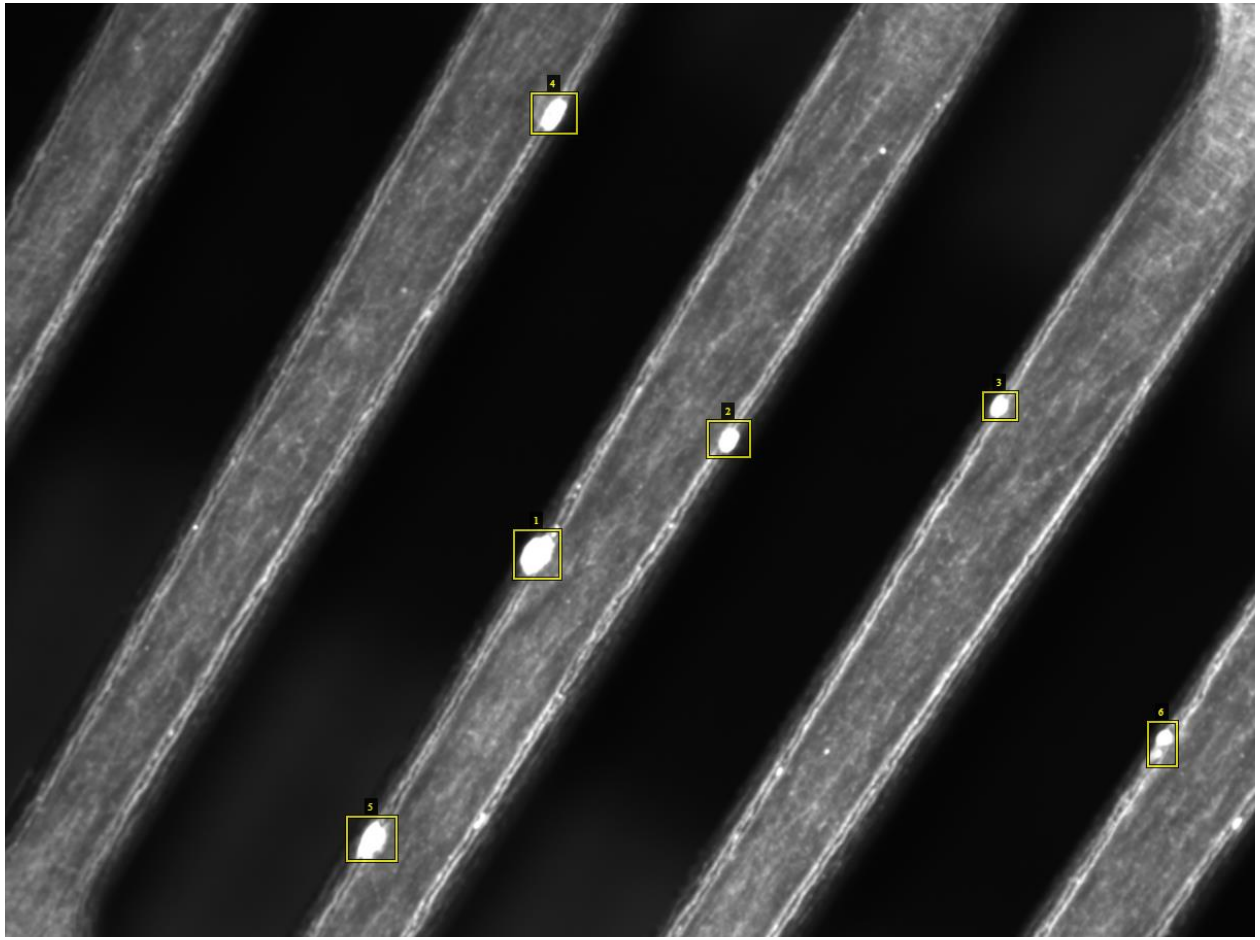
NAVINFO Europe

+ In-House RGPNet

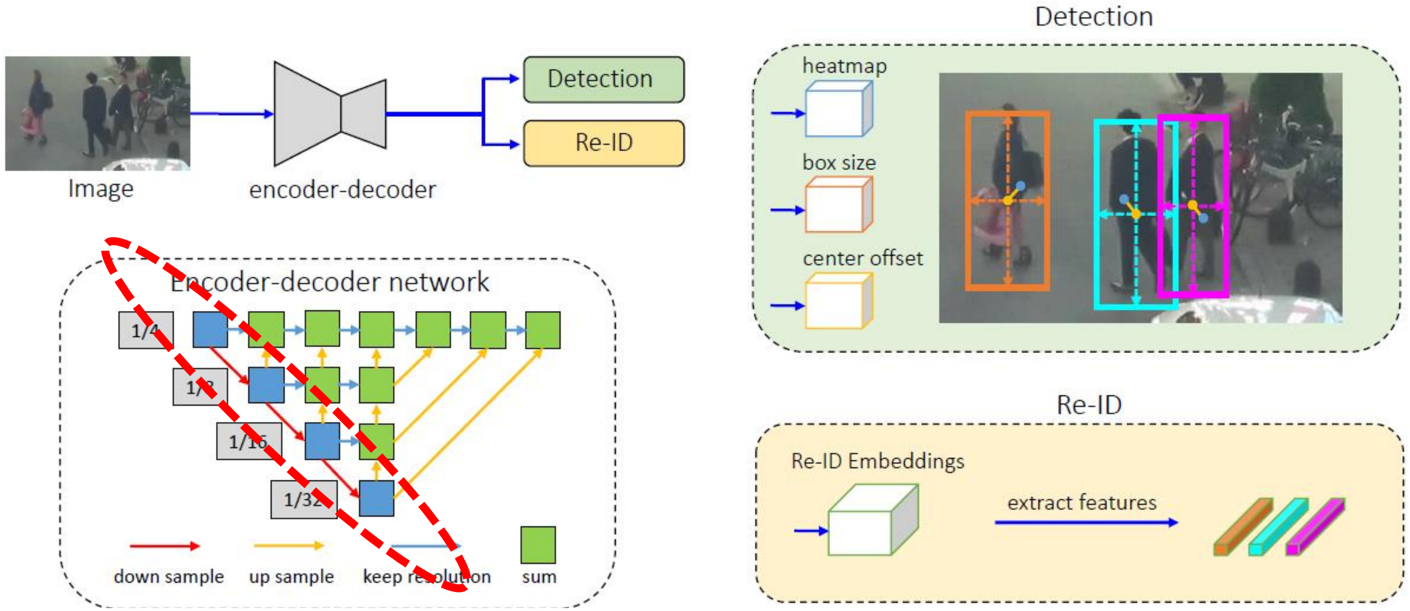


CenterNet-HarDNet for Foundry Parts Inspection





HarDNet85 – Best B'bone for SOTA FairMOT



Backbone	w/ MLFF	MOTA↑	IDF1↑	IDs↓	AP↑	TPR↑	Acc↑
ResNet-34		63.6	67.2	435	75.1	90.9	75.2
ResNet-50		63.7	67.7	501	75.5	91.9	77.8
RegNetY-4.0GF		63.9	68.0	407	75.8	91.9	**79.4**
ResNet-34-FPN	✓	64.4	69.6	369	77.7	94.2	75.2
RegNetY-4.0GF-FPN	✓	65.8	69.3	257	78.0	94.3	**79.4**
HRNet-W18	✓	67.4	74.3	315	80.5	94.6	76.8
DLA-34	✓	69.1	72.8	299	81.2	94.4	76.9
HarDNet-85	✓	**71.2**	**74.5**	**198**	**82.6**	**95.8**	77.0

FairMOT: On the Fairness of Detection and Re-Identification in Multiple Object Tracking

NEUCHIPS & NTHU

FairMOT + HarDNet for Multiple Vehicle Tracking

多类别车辆跟踪 -- 模型训练、评估、预测、优化到部署的全流程方案

模型	IDF1	推理速度-V100	推理速度-T4	准确率	召回率
MCFairMOT +DLA-34	46.3	14.1	11.5	74	50.9
MCFairMOT +HRNetV2-W18	50.5	15.8	13.6	80.2	51.2
MCFairMOT +HardNet	48.8	13.4	10.8	**80.5**	**47.8**

Top Choice for Object Detection on Low-Memory Edge Devices

Rugved Hattekar
Mar 24, 2021 · 5 min read · Listen

Which Deep Learning Framework to choose for Object Detection on low memory Edge Devices?

	Head Network	Backbone Network	mAP	Inference Time (ms)	FPS
1	SSD	ResNet 101	31.2	125	9
2	YOLOv3	ResNet 101	31	41	37
3	CenterNet	ResNet-101	34.6	22	45

	Head Network	Backbone Network	mAP	Inference Time (ms)	FPS
1	YOLO v3	DarkNet-53	33	22	20
2	CenterNet	DLA	41.6	28	35

	Head Network	Backbone Network	mAP	Inference Time (ms)	FPS
1	CenterNet	HarDnet-85	43.6	22	45

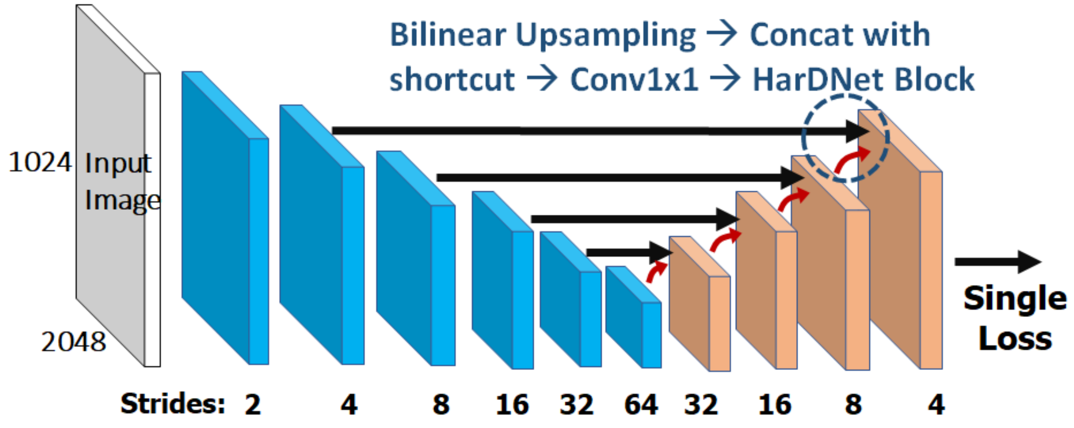
…HarDNet as a backbone, the **CenterNet performs even better** by reducing the inference time and increasing the FPS even more. This type of performance is **well suited for an edge-device implementation** where we can acquire high FPS with low inference speed.

Finally, HarDNet is used **as a backbone to SSD object detector** to verify the robustness of the HarDnet feature extractor …HarDNet considerably reduces the inference time (~80%) of SSD ... This shows that **HarDNet should be a top choice for the deployment on low-memory devices.**

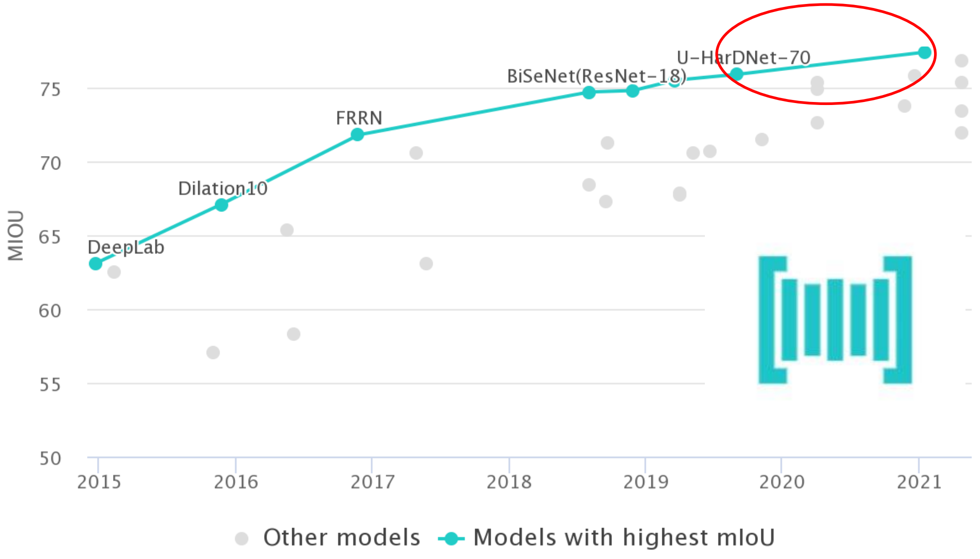
	Head Network	Backbone Network	mAP	Inference Time (ms)	FPS
1	SSD	HarDnet-85	35.1	25	39
2	SSD	ResNet-101	31.2	125	9

Real-Time Semantic Segmentation of High-Definition Video

FCHarDNet (Fully Convolutional, U-HarDNet) for Real-Time Semantic Segmentation



FC-HarDNet 70



Cityscape Benchmark

FCHarDNet for Autonomous Driving

Annotating Automotive Radar efficiently: Semantic Radar Labeling Framework (SeRaLF)

Simon T. Isele[1,3,4]*, Marcel P. Schilling[1,2]*, Fabian E. Klein[1], J. Marius Zoellner[3,4]

[1]Dr. Ing. h.c. F. Porsche AG, Weissach, Germany
{simon.isele1,fabian.klein1}@porsche.de
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[4] FZI Research Center for Information Technology, Karlsruhe, Germany
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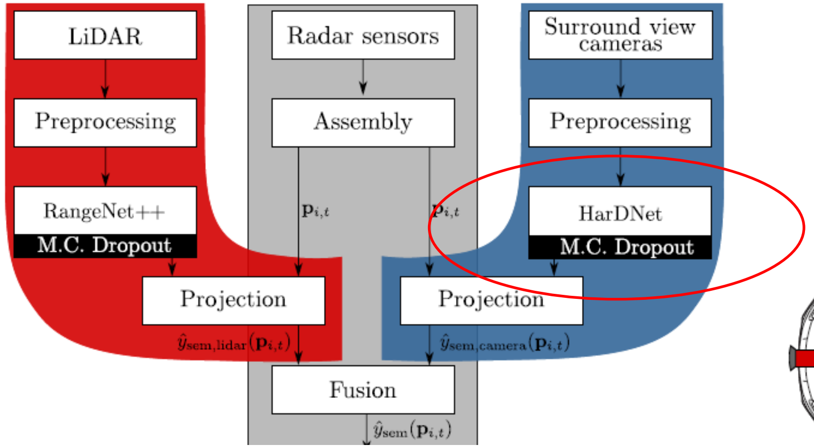
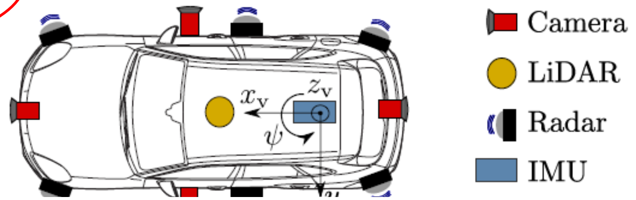
PORSCHE

FZI

KIT Karlsruher Institut für Technologie





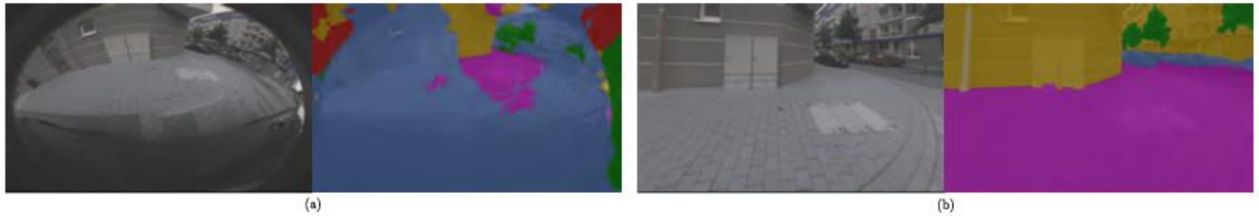
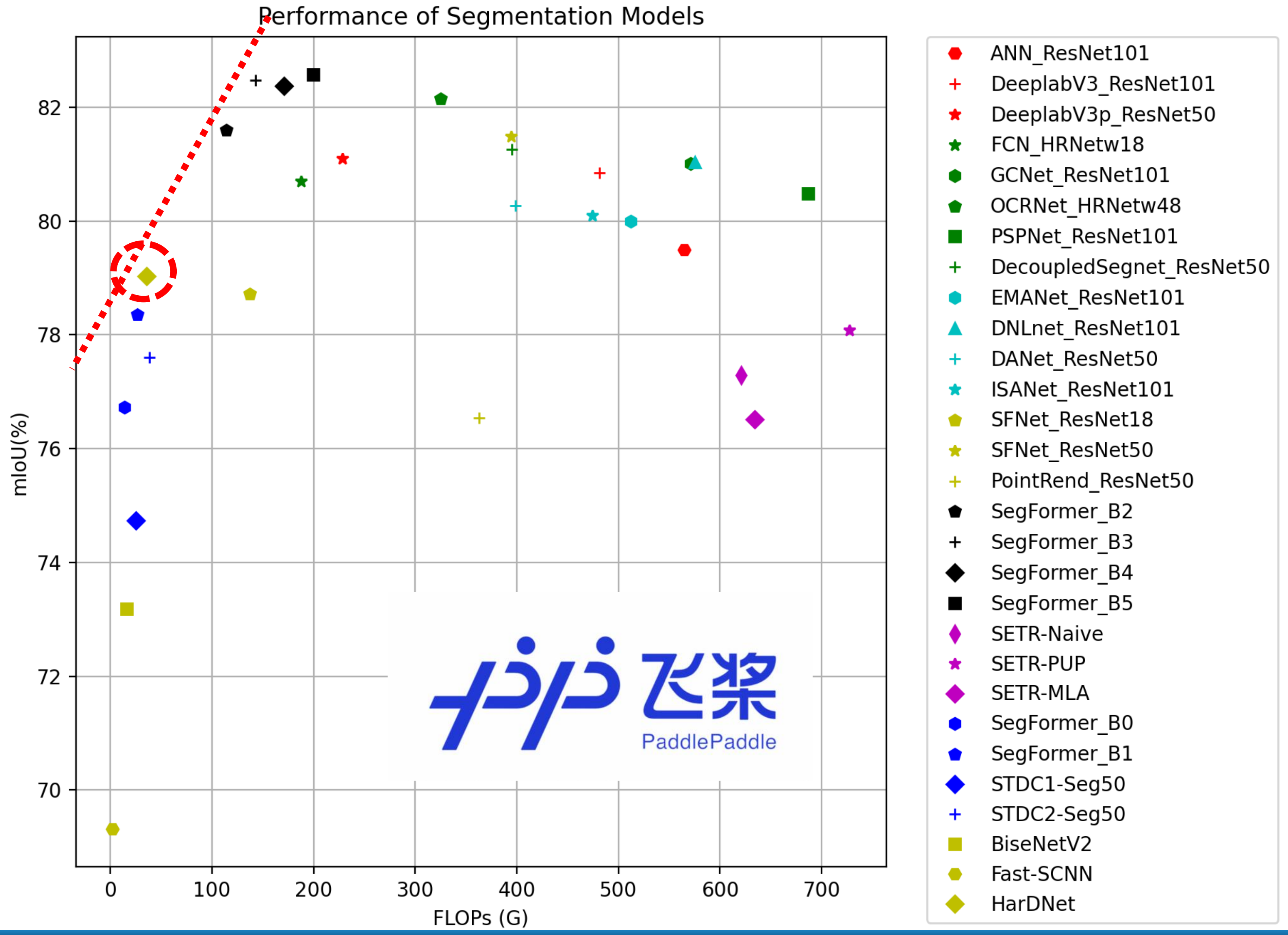


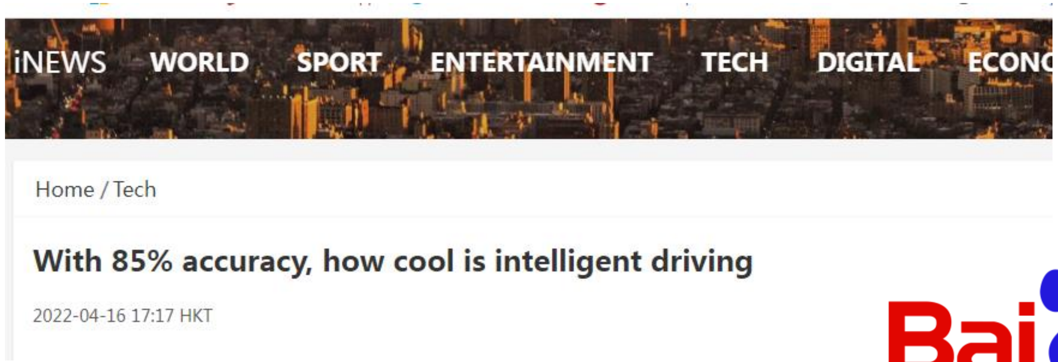
Figure 3: Results of semantic segmentation on fisheye camera (a) and after preprocessing (b).

Figure 4: Results of semantic segmentation on LiDAR image (a) and scene overview (b).

FCHarDNet in Baidu PaddleSeg Model Zoo



FCHarDNet + PPYOLOv2 for Intelligent Driving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Home / Tech

With 85% accuracy, how cool is intelligent driving

2022-04-16 17:17 HKT

Baidu 百度

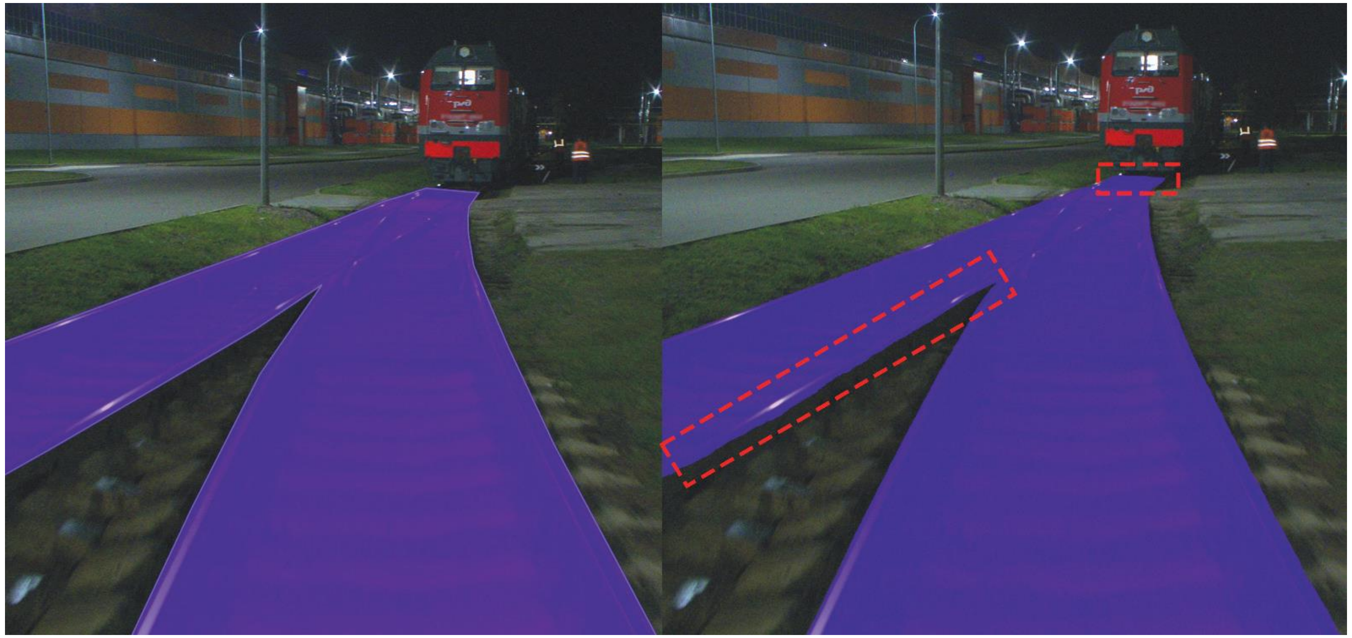
FCHarDNet for Unmanned Railroad Trains

Оптимизация модели нейронной сети U-HarDNet-70 для сегментации железнодорожного пути

LocoTech SIGNAL

П. Е. Мащенко,
канд. техн. наук,
зам. генерального директора
ООО «ЛокоТех-Сигнал»

П. П. Ширяев,
специалист по компьютерному зрению
ООО «ЛокоТех-Сигнал»



CSPHarDNet = CSP-Net + HarDNet for Autonomous Parking

Deep-Learning-Based Parking Area and Collision Risk Area Detection Using AVM in Autonomous Parking Situation

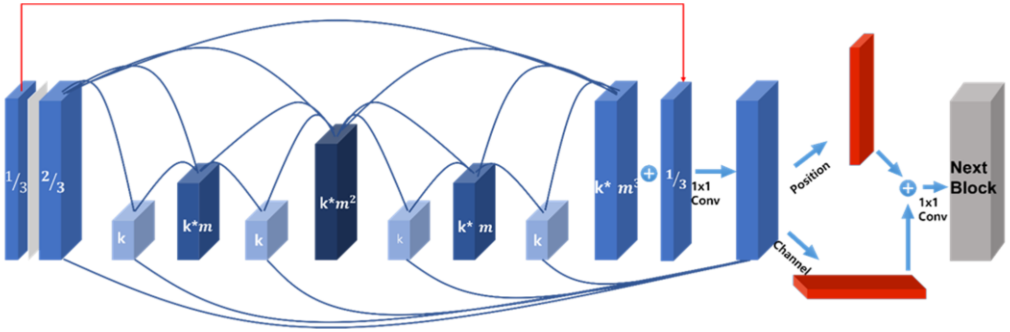
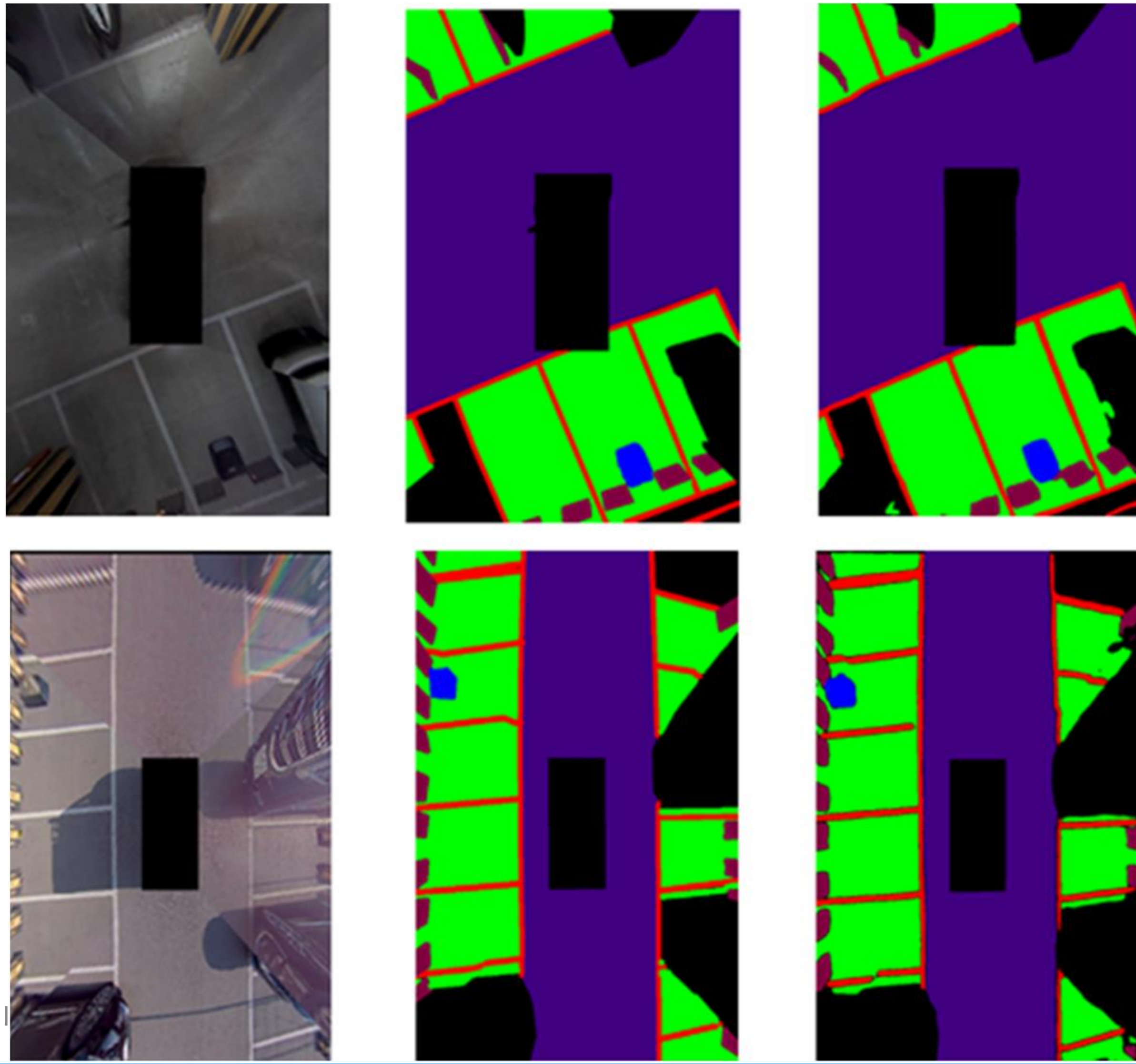


Table 4. NIA dataset results.

Model	mIoU(%)	BFLOPS	FPS(PC)	FPS(Xavier)
HarDNet	83.31	110.39	15.44	15.92
CSPDenseNet	79.84	60.356	19.98	20.11
CSPHarDNet	81.89	72.847	18.15	18.36
Attention CSPHarDNet	83.76	81.443	17.33	17.45



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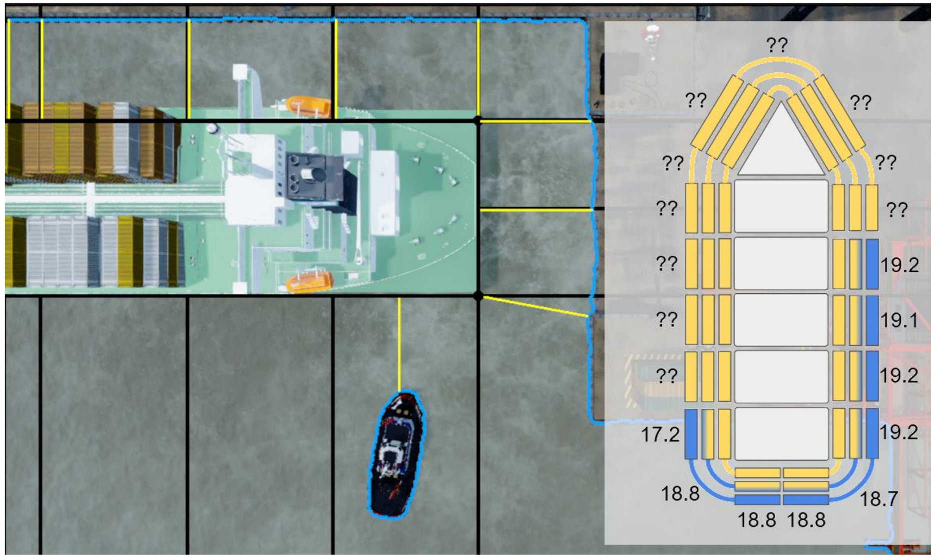
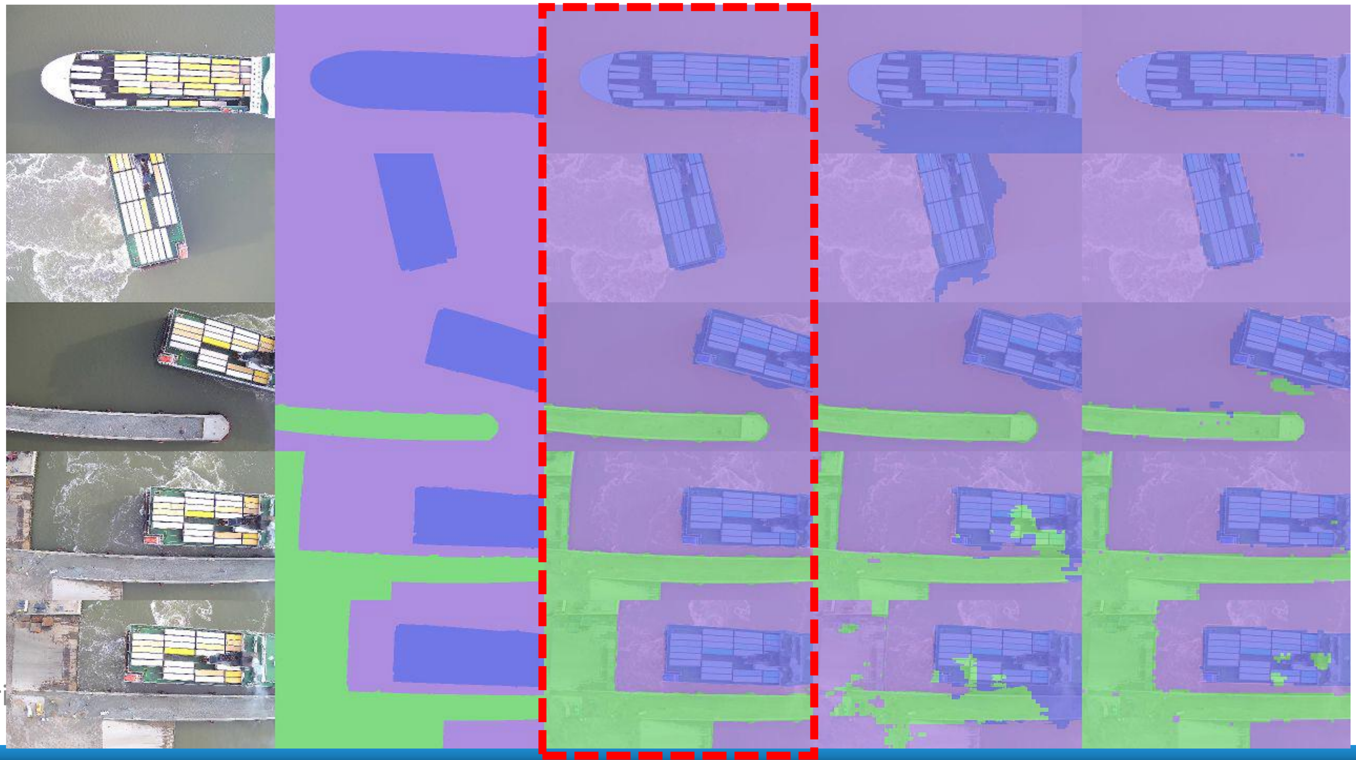
FCHarDNet for Safe Vessel Navigation

Safe Vessel Navigation Visually Aided by Autonomous Unmanned Aerial Vehicles in Congested Harbors and Waterways

AARHUS UNIVERSITY

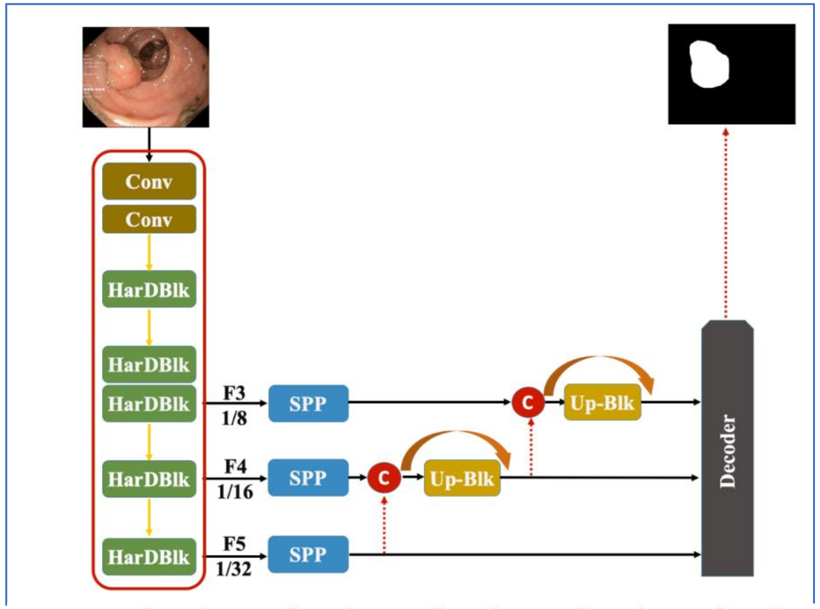


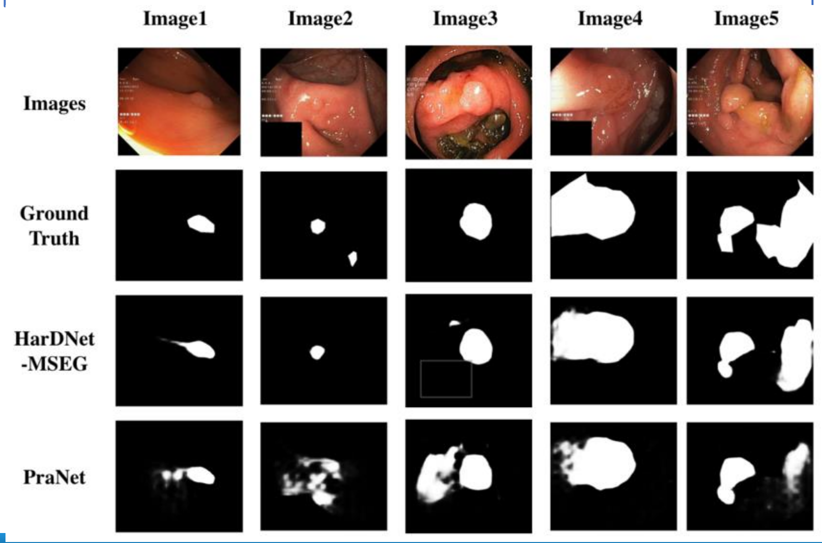
Model	Dataset	Mean accuracy	IoU Unknown	IoU Water	IoU Ship	IoU Mean	Speed (FPS)	Resolution (w,h)	Params
BiSeNet v2	Val	96.4	91.	97.7	93.3	94.0	**133.43**	512x288	3.5M
	Test	75.4	47.5	70.2	54.5	57.4			
HarDNet	Val	**98.6**	**96.3**	**98.7**	**96.6**	**97.2**	91.75	640x360	4M
	Test	**97.3**	**90.9**	**96.6**	**92.6**	**93.4**			
DDRNet-23	Val	97.4	92.5	97.6	92.9	94.3	100.12	640x360	7.6M
	Test	86.4	73.4	80.4	62.	72.			

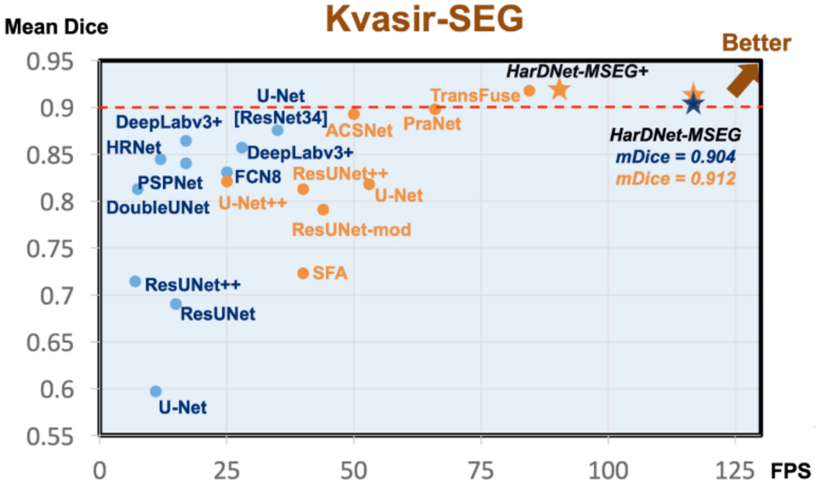


Medical Imaging – Polyps Segmentation

HarDNet-MSEG for Endoscopy Polyp Segmentation







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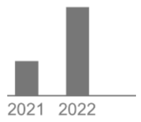
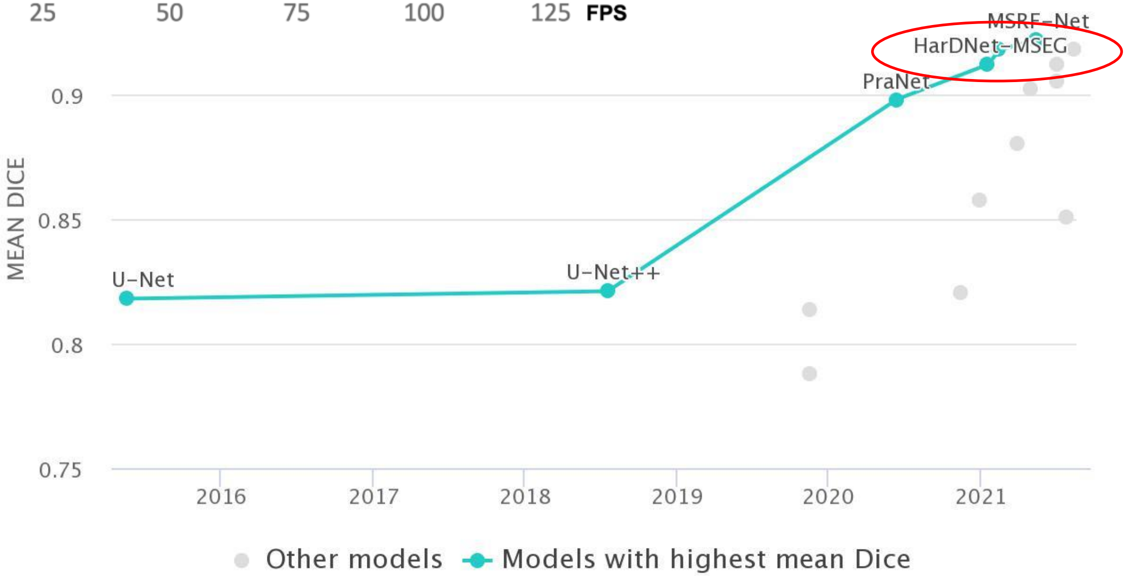


arXiv



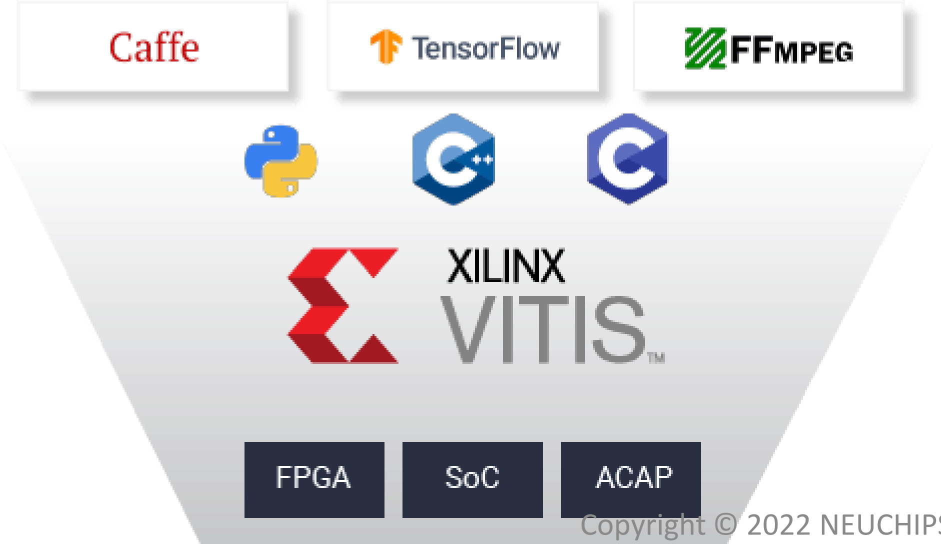
HarDNet-MSEG in XILINX VITIS AI Library

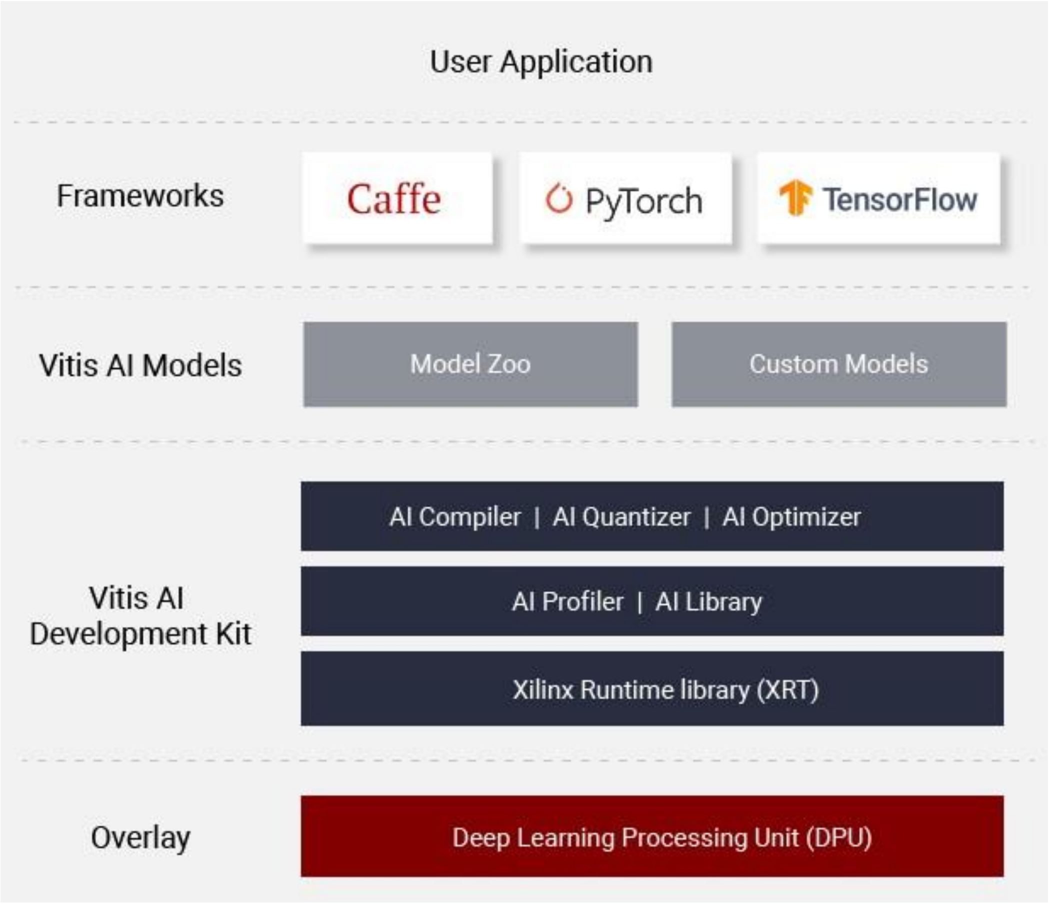
The following table lists the Polyp Segmentation models supported by the Vitis AI library.

Table: Polyp Segmentation Models

No	Model Name	Framework
1	HardNet_MSeg_pt	PyTorch

https://docs.xilinx.com/r/en-US/ug1354-xilinx-ai-sdk/Polyp-Segmentation





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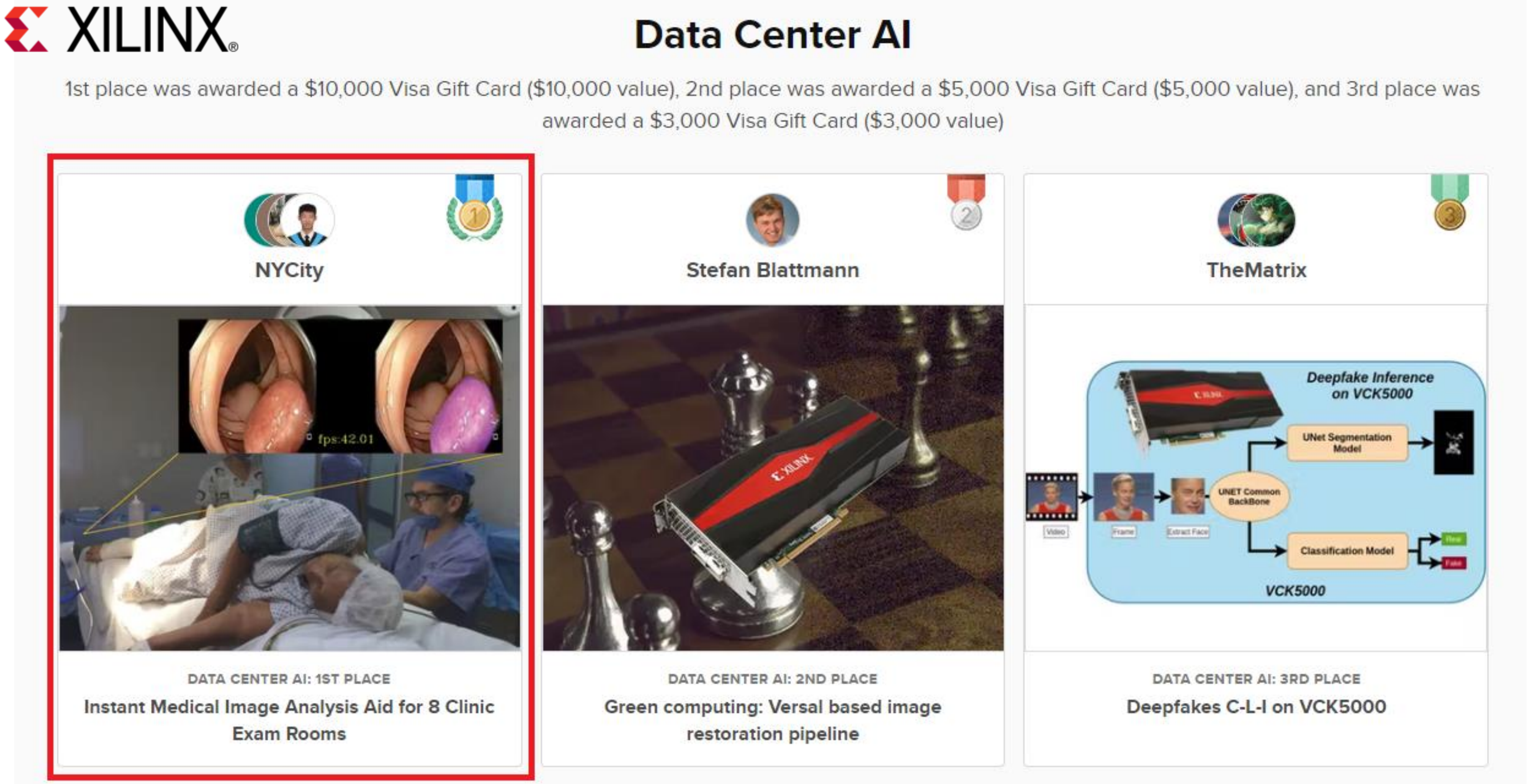
HarDNet-MSEG X8 – US$10,000 Prize

2021 Xilinx Adaptive Computing Challenge (XACC)

- 1649 participants
- 168 submissions
- Data Center AI using Xilinx VCK5000 Card
- Judges are CTO & VPs

https://www.hackster.io/contests/xilinxadaptivecomputing2021



1st Place Award Winner: Prof. Juinn-Dar Huang's Lab
National Yang Ming Chiao Tung University, Taiwan

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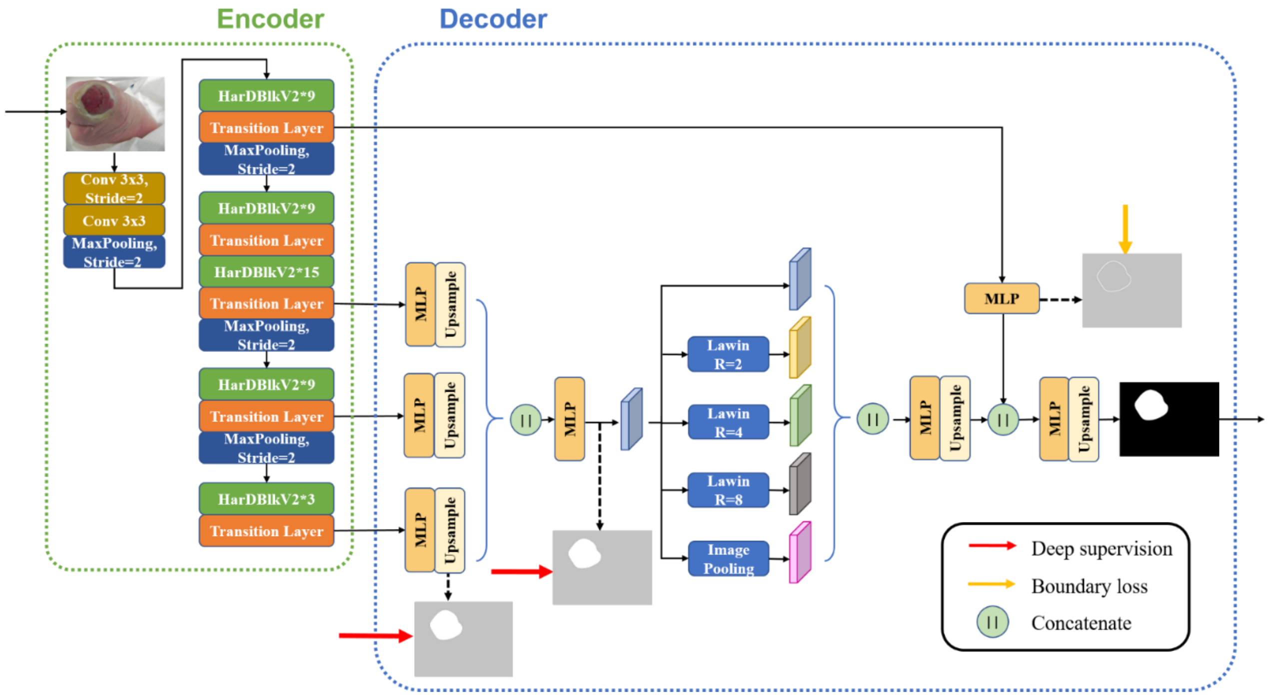
HarDNet-DFUS for Diabetic Foot Ulcer Segmentation



MICCAI2022 Singapore

25th International Conference on Medical Image Computing and Computer Assisted Intervention

September 18-22, 2022

Resorts World Convention Centre Singapore

DFUC DIABETIC FOOT ULCER CHALLENGE

HarDNet-DFUS: An Enhanced Harmonically-Connected Network for Diabetic Foot Ulcer Image Segmentation and Colonoscopy Polyp Segmentation

國內醫生怎麼說?

After validating with 100+ captured videos (15 min+)

… the gastroenterologist has reviewed the results and found them to be very good. The model generally skipped proliferative polyps (less pathogenic) and detect all adenomatous polyps (prone to become cancer). This is helpful for clinicians.…

感謝射月計畫團隊

國立陽明交通大學
NATIONAL YANG MING CHIAO TUNG UNIVERSITY

國立清華大學

中原大學
Chung Yuan Christian University

感謝國網中心

行政院
Executive Yuan

十、推動科研卓越發展，落實跨域規劃合作

(一)深耕基礎科研，落實在地性及國際性，提升科研價值貢獻：

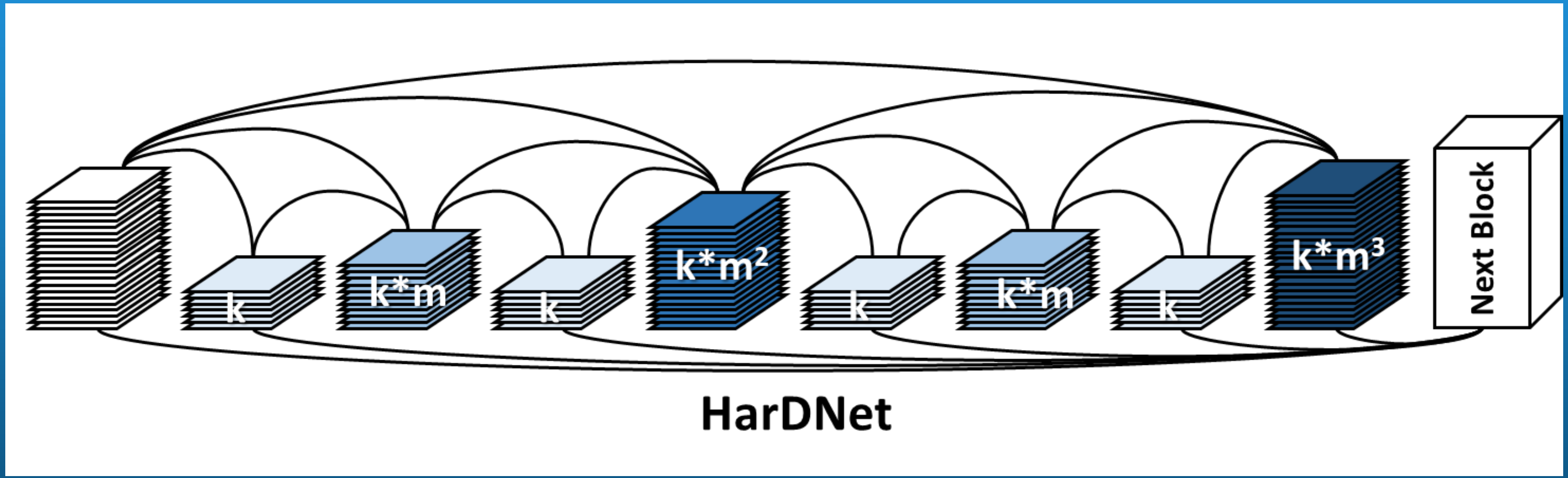
1、研發最適合硬體實現之類神經網路架構 HarDNet，在影像辨識、物件識別、物件追蹤、視訊語意分割等應用都有優異表現，對於惡意攻擊具更強免疫力。相關技術已成立新創公司，所開發之神經網路加速器矽智財，獲得知名大廠採用，已完成 MPW 驗證，即將進入量產。

2、開發全球最靈敏之重金屬感測晶片，可輕易且迅速地偵測低於政府飲用水法規閥值以下 1 萬倍之重金屬濃度；另將光譜儀微縮成一顆晶片(光譜晶片)，用於建置新冠病毒抗體定量篩檢機臺，可於 15 分鐘至 20 分鐘內篩檢出陽性病患，與國內醫療系統密切合作，並獲得國際高度重視。

3、發現罕見疾病早衰症致病關鍵因素「細胞表面之初級纖毛異常」，有助瞭解早衰症及其他核纖層蛋白病症之致病機制，以供開發早衰症治療策略。

4、透過精準運動科學跨領域整合研究，已成功開發棒球之電子好球帶及 3D 動

Thank You!!



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