

# PLAY AND LEARN: USING VIDEO GAMES TO TRAIN COMPUTER VISION MODELS

Alireza Shafaei, James J. Little, and Mark Schmidt

DECEMBER 2016 – CIFAR LEARNING IN MACHINES AND BRAINS





# Single-Label vs. Dense-Labels

- CNNs are now the dominant models in computer vision.
  - Key ingredient: large labeled datasets (ImageNet: >13 million images).
- What about **dense labels** as in image segmentation?
  - Much harder to get large labeled datasets (Cityscapes: 5k images).



# Simulations vs. Reality

- Classic solution: simulate more labeled examples.
- This work: can **video games** augment real data?



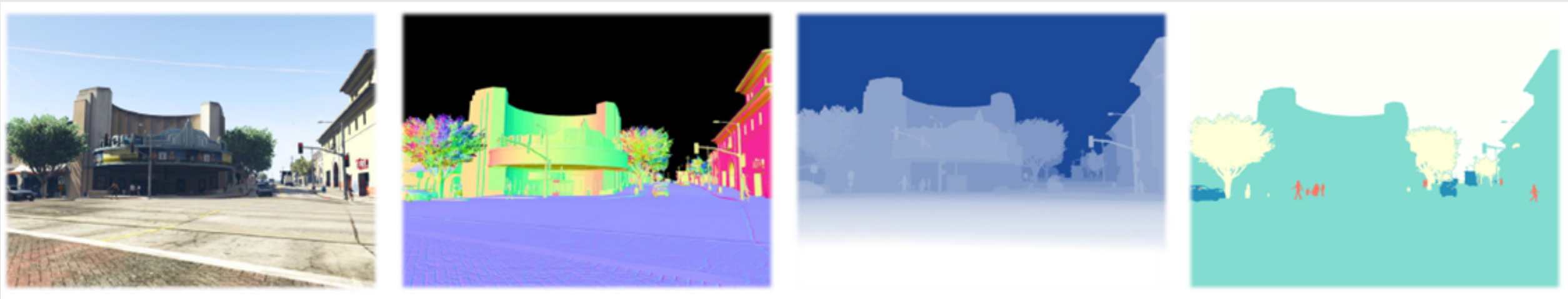
Video game



Google street view

# Why Video Games?

- **Free and scaleable groundtruth** annotation for many tasks:
  - Segmentation, depth, surface normal, shadows, optical flow, and so on.
- **Active control of environment:**
  - Viewpoints, time of day, weather, dangerous situations, and so on.



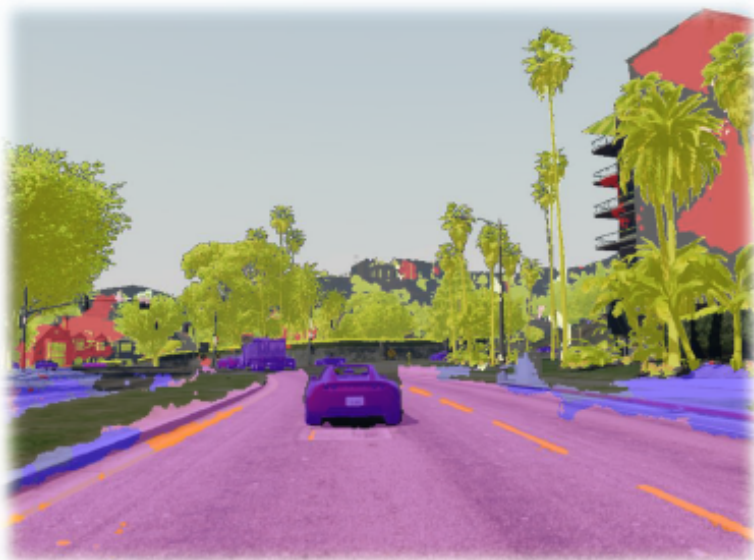


## Method

**Dense Image Classification.** Measure the performance of FCN8s [3] in two approaches: (i) fine-tuning on a real-world dataset with various pre-training strategies, and (ii) cross-dataset evaluation.

**Depth Estimation.** Measure the improvement in image patch ordering task under the method of Zoran *et al.* [4].

# Datasets



Synthetic



CamVid [1]



Cityscapes [2]

- **Synthetic.** A camera is mounted on a car, and an autonomous driver wanders around the city while a separate process captures data. We collect over 60,000 samples with annotation.
- **CamVid and Cityscapes.** A 5-class annotation of the data.
- **CamVid+ and Cityscapes+.** A 12-class annotation of the data.



# Fine-tuning performance (Segmentation)

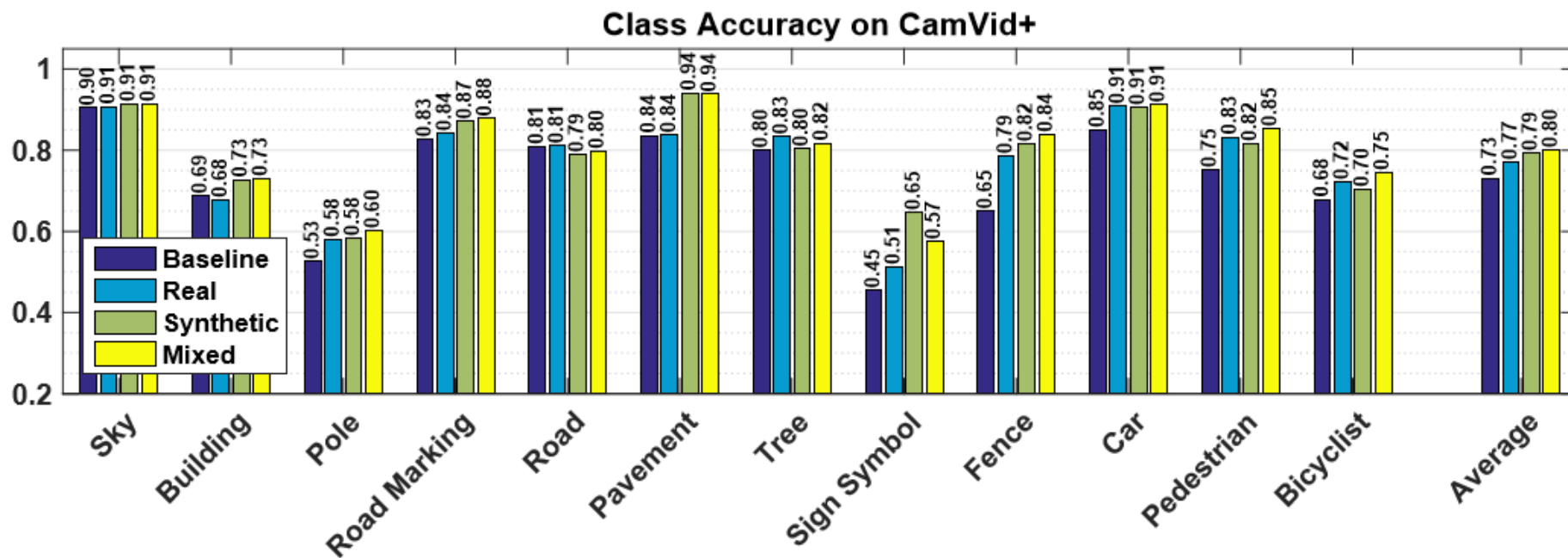
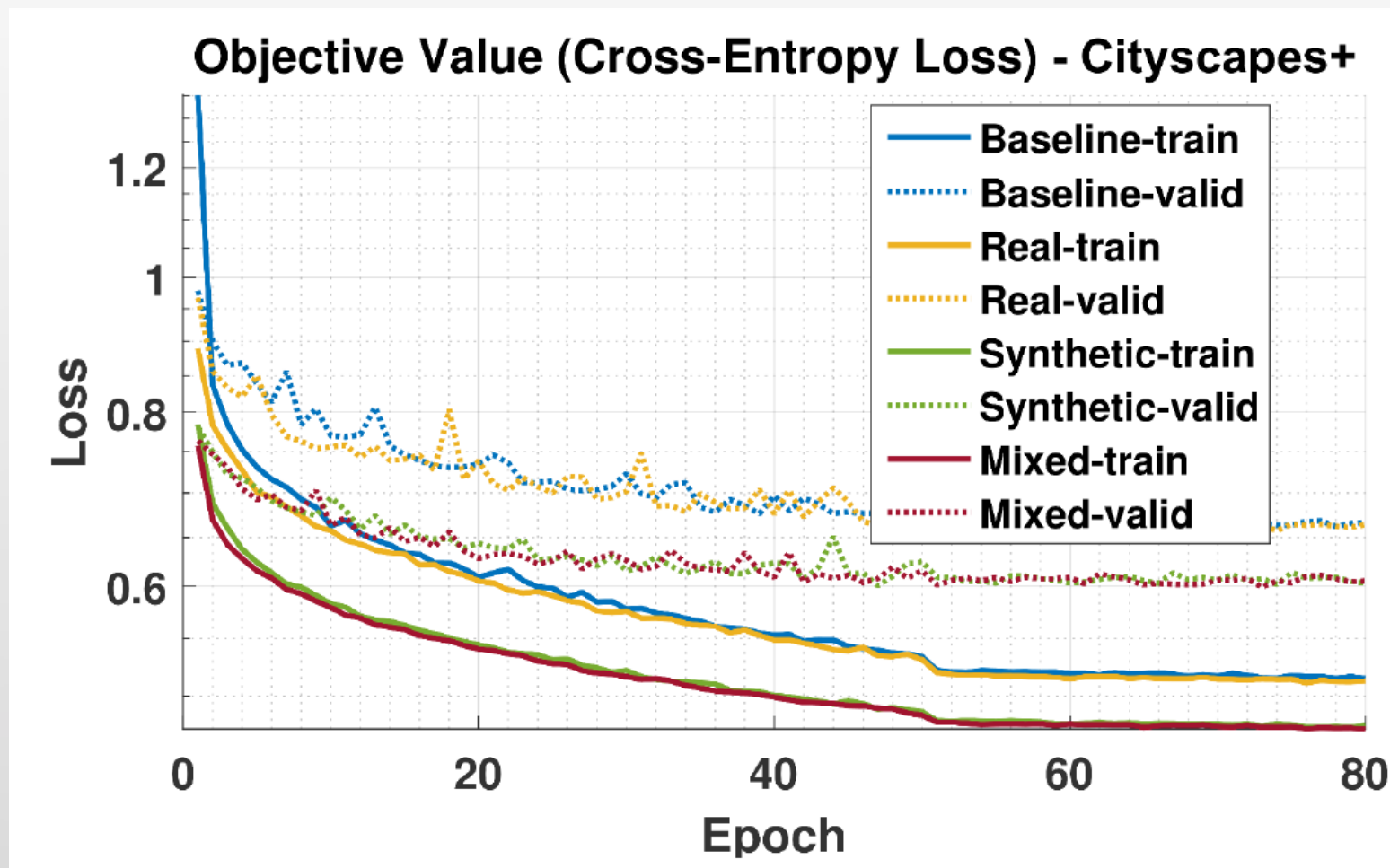


Figure 4: The per-class accuracy on the test set of CamVid+ dataset. The baseline is trained on the target dataset, the `real` is pre-trained on the real alternative dataset, and the `synthetic` is pre-trained on VG+. The `Mixed` approach is pre-trained on both synthetic and the real alternative dataset. Pre-training the baseline with the synthetic VG+ improves the average accuracy by 6%, while pre-training with the real-world Cityscapes+ improves the average by 4%.

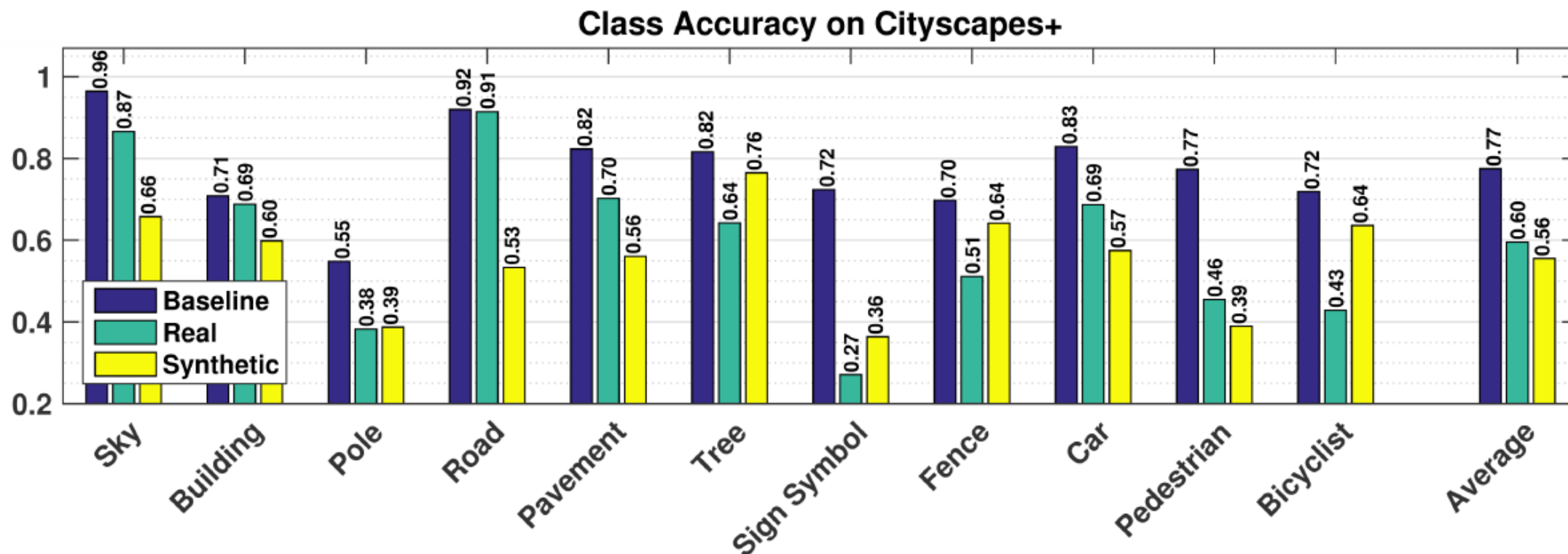
# Fine-tuning performance (Segmentation)





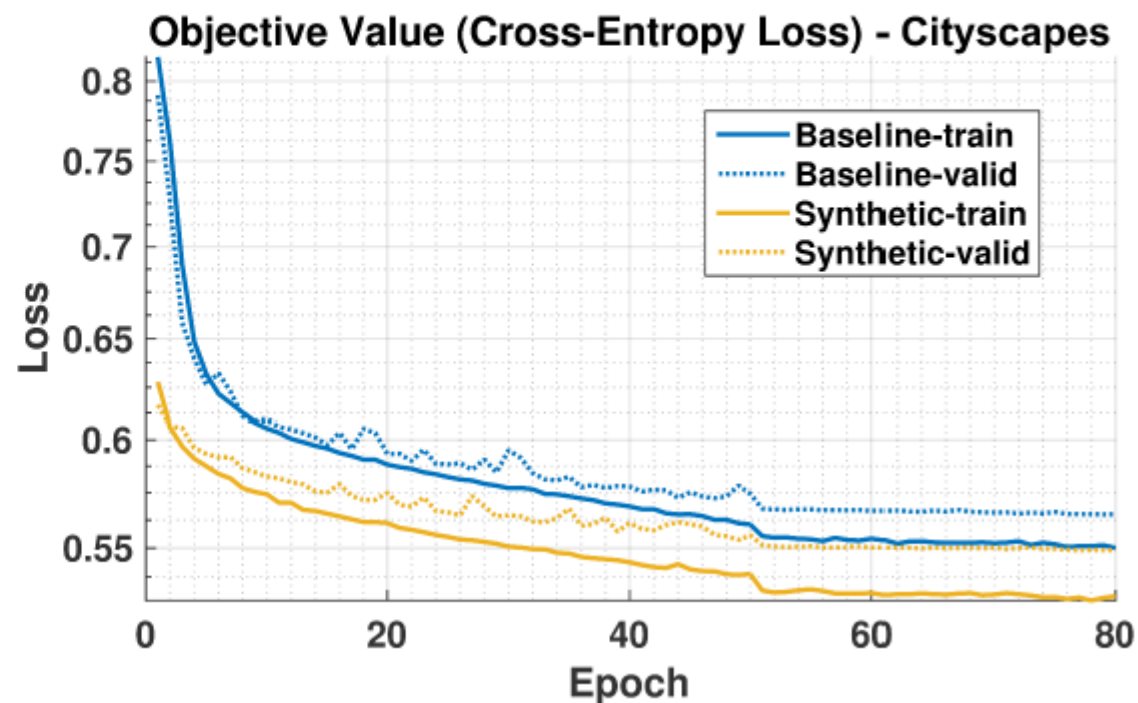
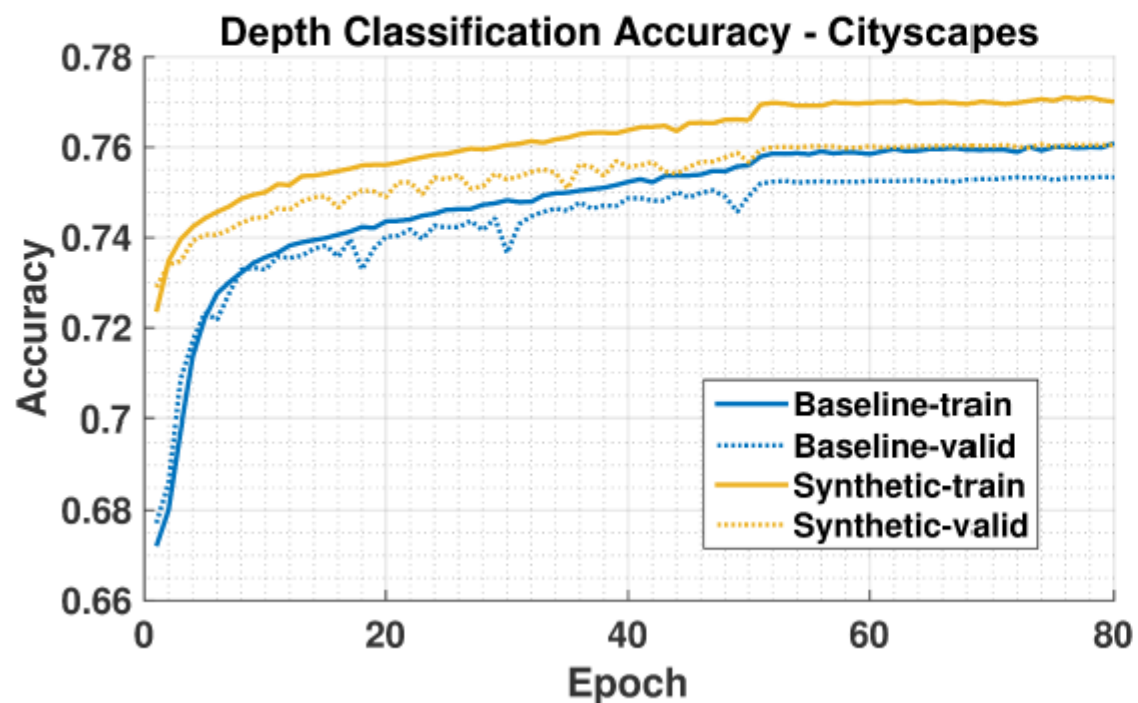
# Performance without fine-tuning.

## Cross-dataset Dense Image Classification



# Fine-Tuning Performance (Depth)

## Depth Estimation from RGB





# Take-Home Message

- Training on video game synthetic data achieved:
  - Similar test accuracy to training on another real dataset.
  - Better test accuracy when using real data to fine-tune.
- Video games may offer a way to compile large labeled datasets.

MIT Technology Review

Robotics

## Self-Driving Cars Can Learn a Lot by Playing Grand Theft Auto

Hyper-realistic computer games may offer an efficient way to teach AI algorithms about the real world.

by Will Knight September 12, 2016

Spending thousands of hours playing Grand Theft Auto might have questionable benefits for humans, but it could help make computers significantly more intelligent.

MailOnline

## Self-driving cars are playing Grand Theft Auto to become better drivers: Realistic scenes train cars to recognize objects on the road

COMMUNICATIONS THE UNIVERSITY OF CALIFORNIA

ACM TECHNICAL

## Self-Driving Cars Can Learn a Lot by Playing Grand Theft Auto

By Technology Review September 12, 2016

Several research groups are using the "Grand Theft Auto" videogame to adjust algorithms with potential application to...

MOTHERBOARD

## Video Games Are So Realistic That They Can Teach AI What the World Looks Like

METRO

## GTA V used to train self-driving cars (no, really)

GameCentral for Metro.co.uk Thursday 15 Sep 2016 10:47 am

the HUSTLE

## 'GTA' Is So Awesome, It's Being Used to Train Self Driving Cars

Nerdist

## SELF-DRIVING CARS ARE LEARNING TO DRIVE USING GRAND THEFT AUTO V

NOWLOADING

## 'GTA V' Becomes An Unlikely Mentor For Artificial Intelligence; Will Teach Self-Driving Cars To Prevent Obstacles

September 14, 2016 at 22:30PM

JALOPNIK

## Self-Driving Cars Will Use GTA V To Learn How To Drive, Run For The Hills

Andrew P Collins 8/12/16 4:33pm Filed to: GTA V



UBC CS is (also) hiring in all ranks/areas.

