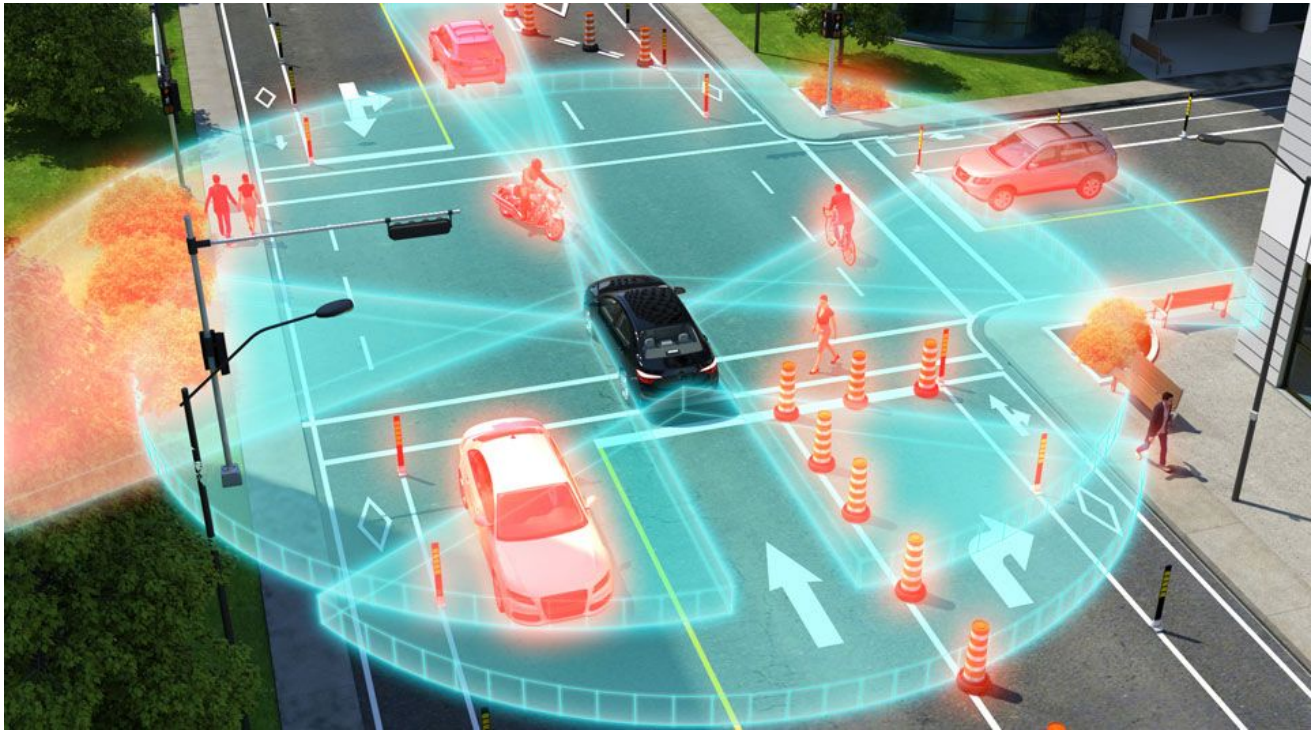
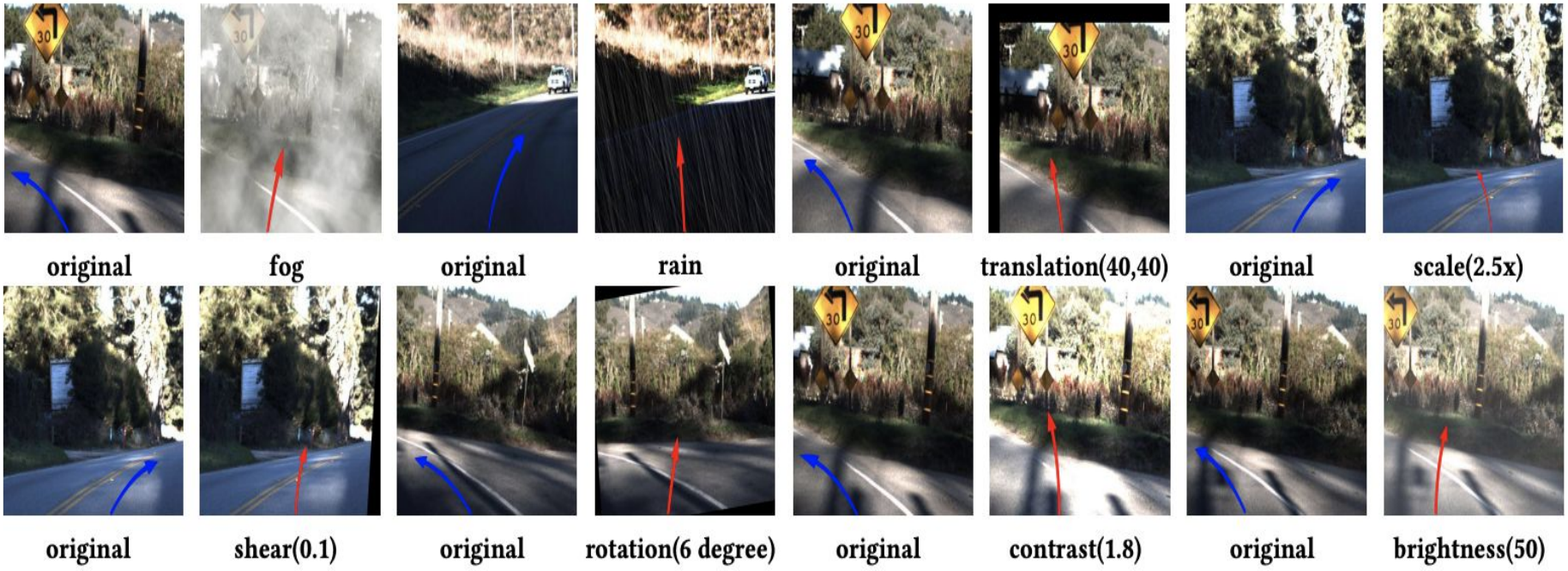
Apply Image-to-Image Translation on Autonomous Driving Systems Testing

Presented by Yilin Han, Ziyi Chen

Deep Neural Networks and Autonomous Driving Systems



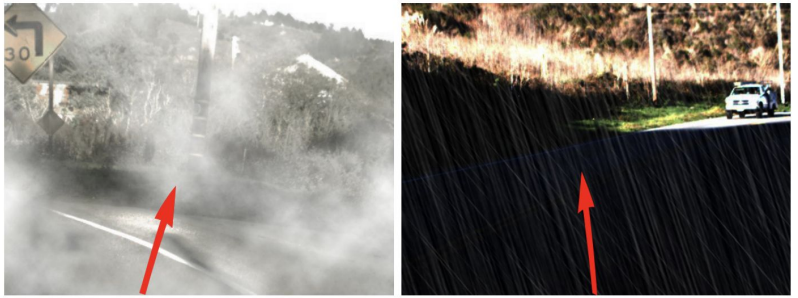
DeepTest


original
fog
original
rain
original
translation(40,40)
original
scale(2.5x)
original
shear(0.1)
original
rotation(6 degree)
original
contrast(1.8)
original
brightness(50)

DeepRoad

- GAN Based Image-to-Image

  Translator in Unsupervised Manner



(a) (b)

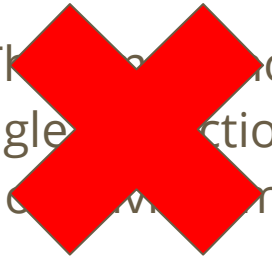
Figure 1: Foggy and rainy scenes via DeepTest

(a) (b)

Figure 2: Snowy and rainy scenes via DeepRoad

Problem

- Both frameworks uses metamorphic testing. Th[illegible]orphic relation is an autonomous driving system's steering angle [illegible]ction does not change after modifying the weather condition o[illegible]mages.



- Testing metrics are uninformative

- DeepRoad claims "the test cases (image frames) generated with DeepTest are unrealistic simply because they look artificial." However, This is subjective claim.

Objectives

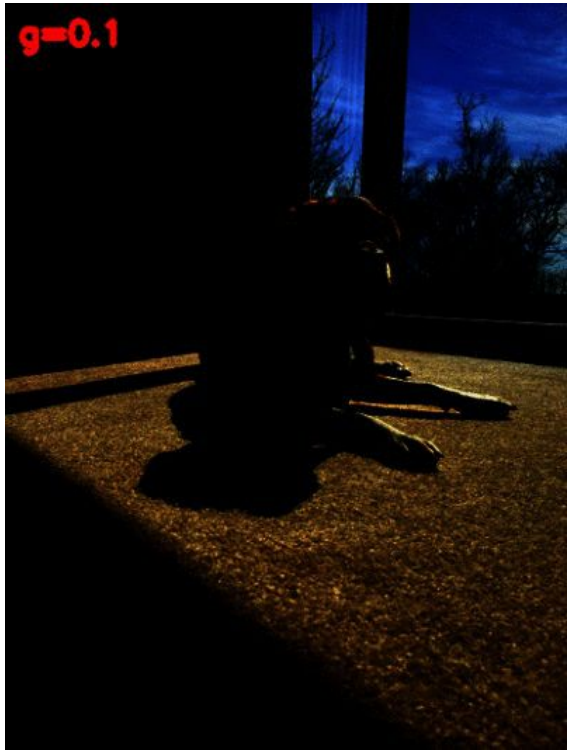
- A more realistic metamorphic relation we proposed:

  Comparing predictions from real night time images to predictions from synthetic night time images

- Using more effective measurements to understand the difference between the real-life images and synthetic images.
- Implementing naive image generator and machine learning based generator to evaluate how much difference between these two generators.

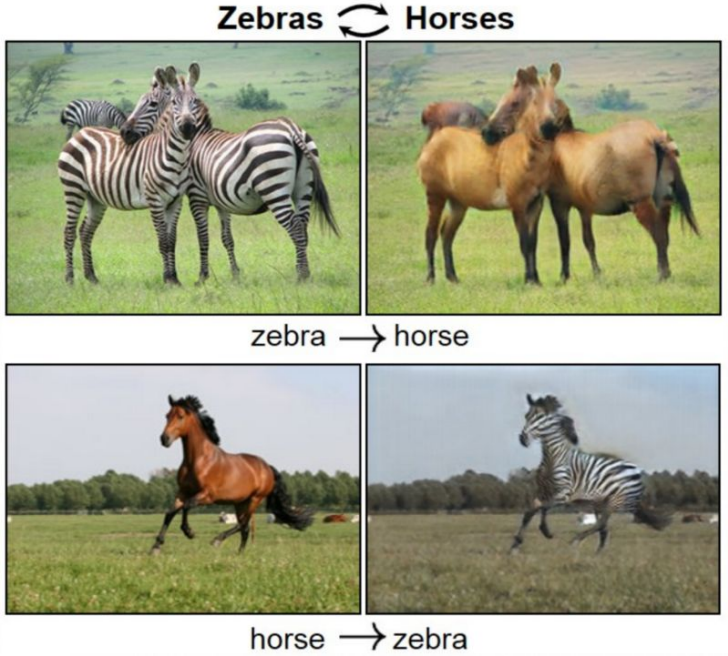
Methodology: Naive Image Generator

- Gamma Correction
- Brightness
- Warming Filter



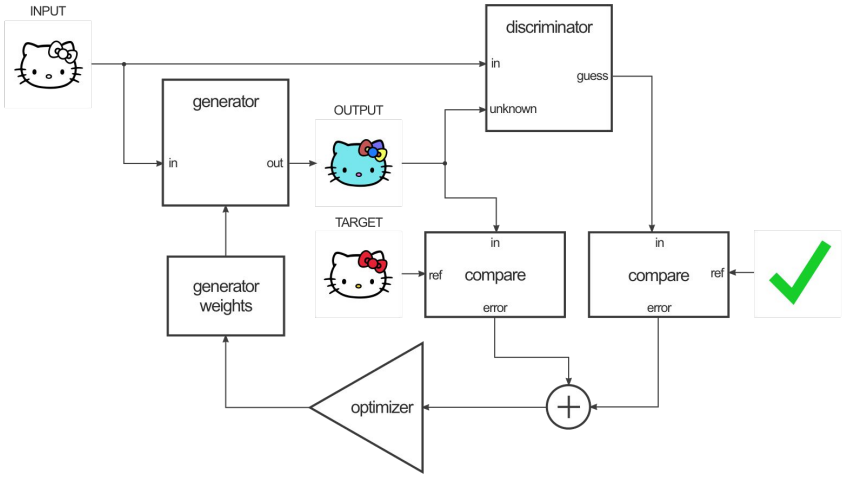
Methodology: Generative Adversarial Network

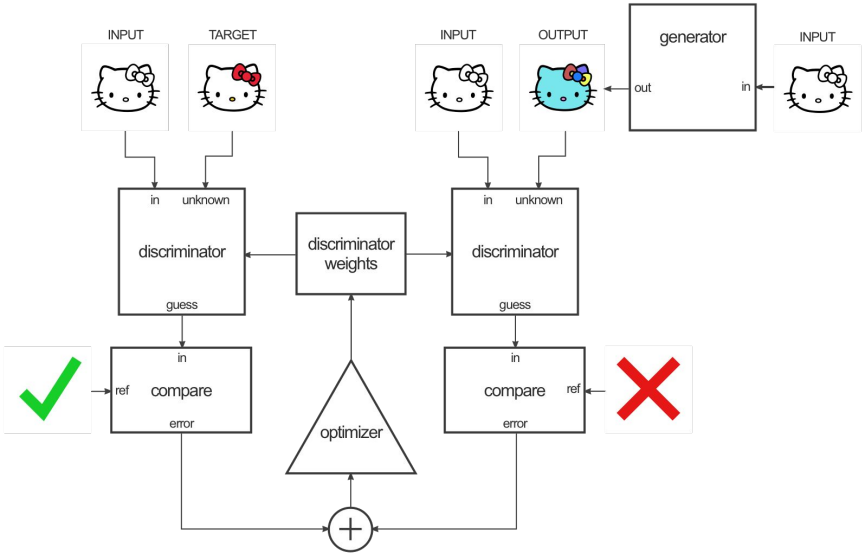
- Pix2Pix



Methodology: Generative Adversarial Network

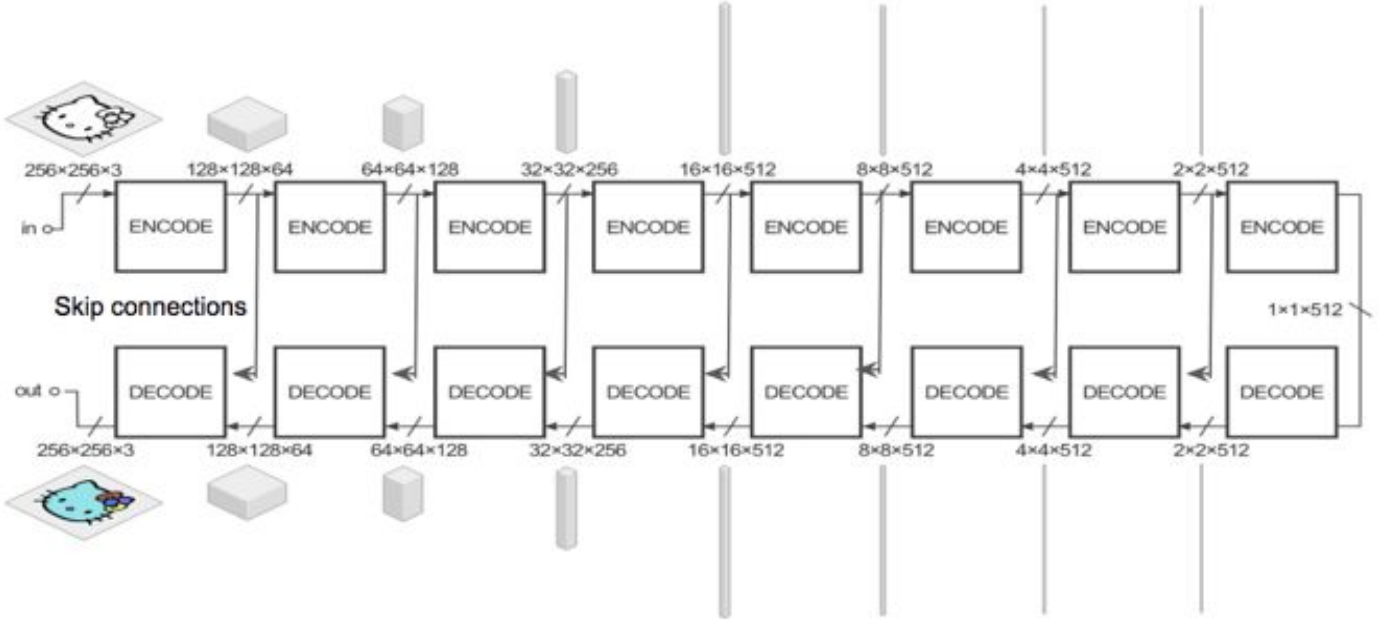
- Pix2Pix





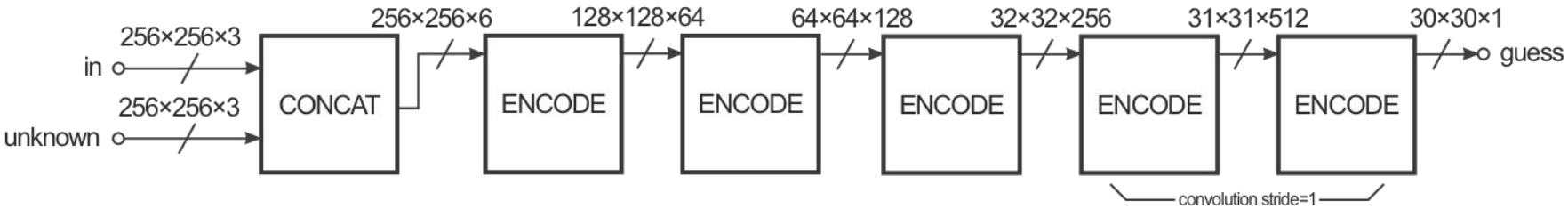
Methodology: Generative Adversarial Network

- Generator:UNet256



Methodology: Generative Adversarial Network

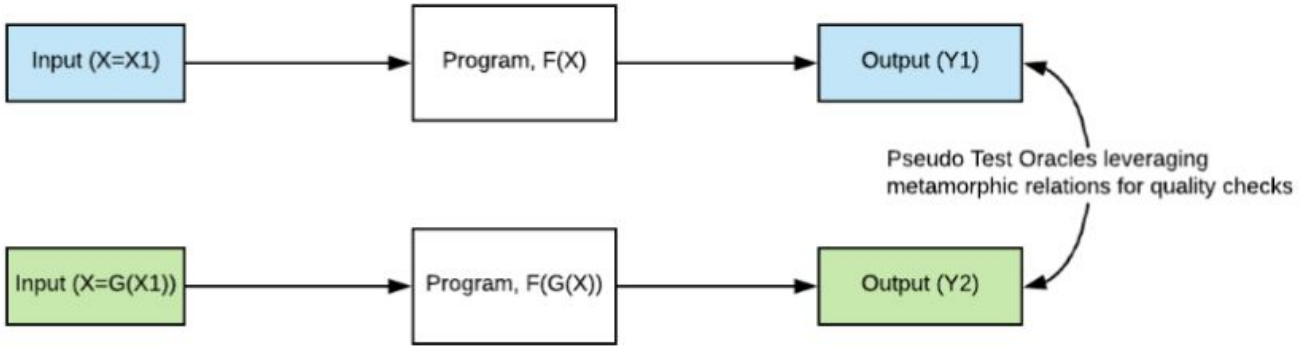
- Discriminator:PatchGAN



Metamorphic Testing

- Oracle problem: determining correct output from given input
- MT: using known relations between inputs and outputs (MR)

$$p[\![i]\!] = o \qquad \forall i.\, p[\![f_I(i)]\!] = f_O(p[\![i]\!])$$



Metamorphic Testing (cont.)

- DeepRoad: $f(x) = f(g(x))$

- Unrealistic to assume same predicted steering angles under different road conditions

- Proposed MR: $f(z) = f(g(x))$ *iff* $c(z) = c(g(x))$

Data Collection

Udacity Autonomous Driving Models

- Chauffeur:
  - CNN + RNN
  - Second place in Udacity challenge
- Rambo:
  - 3 CNNs
  - Third place in Udacity challenge
- Rwightman:
  - Not open-sourced
  - Sixth place in Udacity challenge

Results

Results (cont.)

- Metrics: difference between the predicted angle from synthetic image frames and the predicted angle from original image frames of same road condition

	Mean	Standard Deviation
Chauffeur GAN	1.40	1.08
Chauffeur Naïve	1.44	1.08
Rambo GAN	19.93	14.89
Rambo Naïve	27.18	18.06
Rwightman GAN	1.07	0.88
Rwightman Naïve	1.21	0.94

Results (cont.)

- Recall Proposed MR: $f(z) = f(g(x))$ $\quad iff \quad c(z) = c(g(x))$
- Implemented classifier in autoencoder
- Comparing latent vectors to determine road conditions
- Results were not consistent → Future work

Conclusion & Future Work

- Proposed a new metamorphic testing relation
- Experiment results show prediction differences between image generators and ADS models

- Future Work:
  - Road condition classifier
  - More road conditions
  - Better image generators

Thank you!

Questions?