Novel Framework for Generative Destruction Adversarial Networks (G-DANs) for Humanitarian Assistance and Disaster Relief (HADR)

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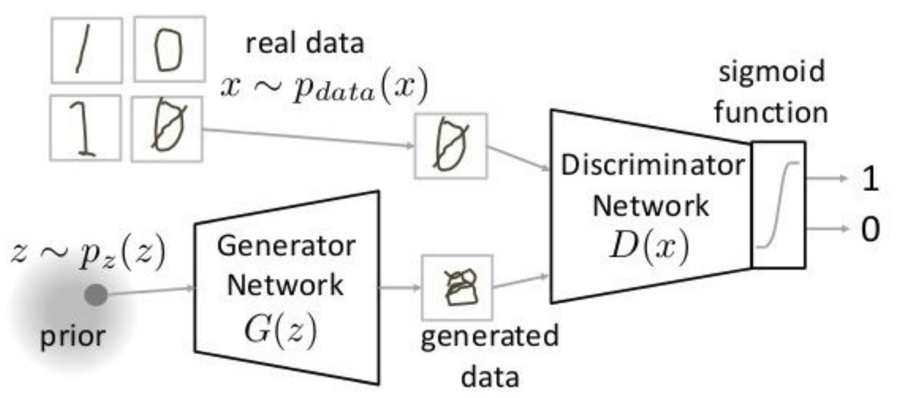
Open source-code available at:
https://github.com/Jasperabez/G-DANs

Introduction

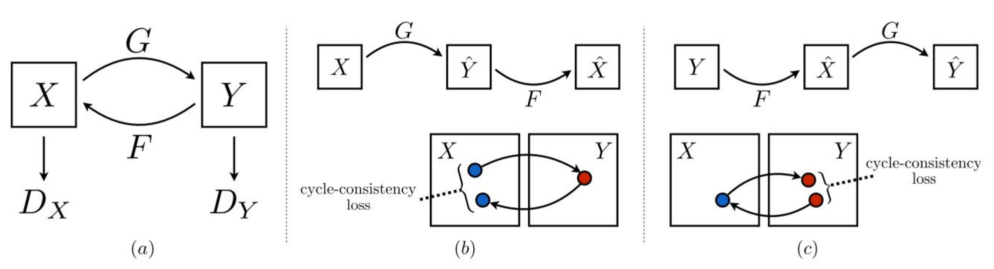
During monsoon season, typhoons also known cyclones are generated when the water at sea surface heats up, evaporates and form clouds that can be translated to strong wind and rain depending on the water and wind conditions. The destructive force becomes more extensive when they enter populated land. As HADR demands a degree of flexibility and adaptation to changing typhoon conditions, our solution called **G-DANs** is a method to identify destruction hotspots through CycleGAN that is an extension of GAN. The predicted destruction hotspots then coupled with the occupational experience from rescue personnel would serve as combined input to the planning of logistics to support the post-disaster relief effort beyond those typical and localized scenarios.

Generative Adversarial Network (GAN)



Generative Adversarial Networks or GANs (Papers.nips.cc, 2020) is a deep learning process of generating samples in imagery or audio form. In our G-DANs application, we focused our model on generating the destruction caused by a typhoon. Under our modified GAN architecture, there are two models that act as a generator and discriminator. Throughout the process, the generator learns and produces images that look more real and concurrently the discriminator becomes better at detecting fake images.

CycleGAN



CycleGAN (Arxiv.org, 2020) is an extension of the GAN technique that involves the automatic training of image-to-image translation models without paired examples. The models are trained in an unsupervised manner using a collection of images from the source and target domain. This adversarial network learns to discriminate between ground-truth segmentations and those predicted by the segmentation network. The advantage of CycleGAN is that it avoids the limitations of paired training datasets that require preprocessing and destruction images that might not be available.

Dataset

For our generative model, the dataset is based on satellite images of the destruction caused by typhoons. To train G-DANs, we preprocessed before and after satellite images from the worst-hit city of Tacloban in the Philippines during Typhoon Haiyan (see Figure 1). Based on the images of unpaired pre and post typhoon, the model extracted unique characteristics for image translation. To increase the robustness of our model, we input other satellite images of destruction with a 1:2 ratio where we had 100+ post-typhoon images and nearly 300 pre-typhoon images. We trained the model till the loss curve had converged and that the images generated becomes realistic of a typhoon destruction path after almost a hundred epoches. To test our model, we applied images from Singapore, Choa Chu Kang (see Figure 3).

(a) Ground truth - Before (b) Ground truth - After

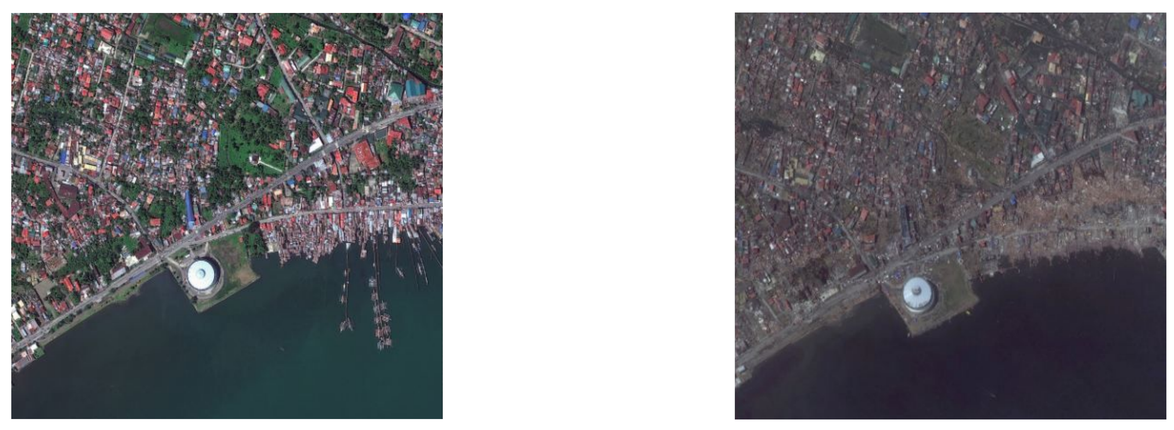


Figure 1. Image dataset from Philippines, Tacloban in 2013 and 2014 as an example of before (a) and after (b) Typhoon Haiyan

Results from G-DANs

(a) Ground truth (b) Generated

Figure 2. Image of Philippines, Tacloban in 2014 as an example of before a) and after (b) typhoon

Predicting destruction hotspots with no prior dataset using G-DANs

(a) Ground truth (b) Generated

Figure 3. Image of Singapore, Choa Chu Kang in 2020 as an example of before a) and after (b) typhoon

Destruction hotspots in typhoon

Our proposed novel framework that is G-DANs will enable rapid analysis and prediction even before the typhoon makes landfall to identify potential hotspots for destruction. This information will allow

non-governmental organizations also known as NGOs and the military around the world to estimate medical supplies, manpower for search and rescue. More importantly, identify pieces of equipment required for debris removal to search for survivors after the typhoon makes landfall.

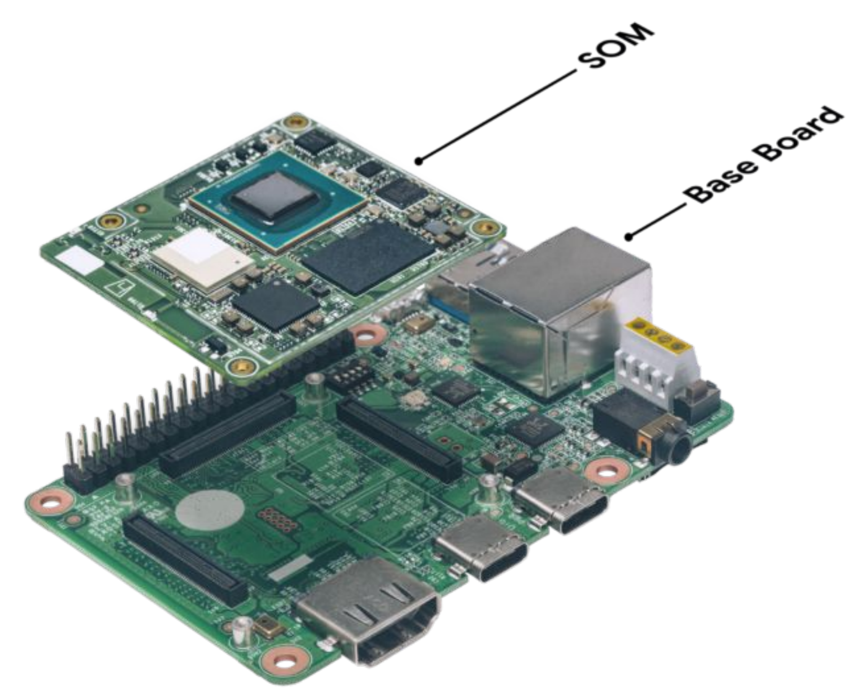
Cost Estimation caused by typhoon

The cost of the typhoon is measured by the extent of damage to entities such as homes, schools, public buildings, and transport infrastructures. Due to the scale and intensity of a typhoon, the actual calculation takes a long period of time and initial estimates are inaccurate due to them being based on past typhoons of similar intensity. Using G-DANs, the cost estimation can be made to be

more accurate by generating plausible destruction scenarios. For the government, knowing the degree of destruction allow for the allocation of resources towards reinstating important infrastructures. While insurance companies can make financial contingencies based on the aspected insurance payout to speed up the rebuilding of lives.

Roadmap and Improvements

The team is determined to make G-DANs open-sourced and become a key enabler in rescue efforts. With the new cutting edge artificial intelligence (AI) technology that is GANs, G-DANs will empower the community and academia with the ability to add more useful features and customization to cater specifically toward their needs. Furthermore, with the advancement in computation in hardware, this can be run on the



edge and make inference on local hardware available on low orbit satellites and on an unmanned aerial vehicle (UAV) such as the Airbus Zephyr as opposed to cloud computation. Therefore, as less data needs to be streamed over a network connection, and real-time decisions can be made. In the future, more parameters can be taken to account such as the typhoon direction and wind speed.

DISASTER MANAGEMENT USING G-DANs

PRE-DISASTER PREPARATION → **ASSESSMENT**: Use G-DANs to visually identify vulnerable spots and estimate loss → **MITIGATION**: Deploy protective counter measure while allocating medical, food and water → **PLANNING**: Use G-DANs to focus efforts to evacuate worst hit areas to strategize and practice drills → **POST-DISASTER RECOVERY** → **RELIEF**: Use G-DANs to clustered response teams to effectively dispatch search and rescue → **ASSISTANCE**: Use G-DANs to restore communities and buildings according to before destruction → **POST ANALYSIS**: Use G-DANS to train relief personnel and improve design of townships → **PRE-DISASTER PREPARATION**

Discussion

As G-DANs will enable rapid analysis and prediction even before the typhoon makes landfall to identify potential hotspots for destruction. This information will allow disaster relief organizations and the military around the world to estimate medical supplies, manpower for search and rescue. More importantly, identify pieces of equipment required for debris removal to search for survivors after the typhoon makes landfall. Using G-DANs, the cost estimation can be made to be more accurate by generating plausible destruction scenarios according the degree of the intensity of typhoon to allow for the allocation of resources towards reinstating important infrastructures and speed up the rebuilding of lives.

Reference

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