Introduction to Image Super Resolution and Generative Adversarial Networks

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Outline

Introduction

Introduction

- Artificial Intelligence (AI) has boomed tremendously during the last few years
- Various AI models have been developed (e.g. GANs, Deep Networks, etc.)
- Generative Adversarial Model - among various models used in AI and Machine Learning (ML)
- AI today is being used for a large number of applications
- Image Super-resolution is one such application

Image Super-Resolution

Basics & Terminology

- **Image Super-resolution:** Conversion of (one or more) low resolution images into a high resolution image
- Benefits of increasing image resolution:
  - The resultant image is larger
  - It provides more details
  - Can be used to improve image quality as well as video quality

Increasing Image Resolution

- **Reducing Pixel size:**
  - Increases the number of pixels per unit area
  - Advantage: Increases spatial resolution
  - Disadvantage: Introduction of Noise
- **Increase Chip Size:**
  - Hardware based solution
  - Advantage: Enhances spatial resolution
  - Disadvantage: Expensive
- **Image Super-resolution:**
  - Combines multiple low resolution images to form high resolution image
  - Advantage: Less expensive
  - Disadvantage: May not be always accurate

Image Super-resolution - Technique

- **Single-frame Super-resolution**
  - Traditional resolution enhancement - includes smoothing, interpolation and sharpening
  - Estimates detail that is not present
  - Training-set used to learn details of images at low resolution
  - These learned relationships used to predict details of other images
- **Multi-frame Super-resolution**
  - Works if multiple low resolution images are available of the same scene
  - Each image is naturally shifted with sub-pixel precision
  - Works when each of the images have different sub-pixel shifts

Applications of Image Super-resolution

- Enhancing surveillance footage
- Enhancing medical diagnostic images
- Enhancing astronomical and remotes sensing images
- Enhancing low resolution videos (from the past)
- Enhancing photographs and self-portraits of people

Generative Adversarial Networks

Basics & Terminology

- Generative Adversarial Networks (GANs) are AI models that contains a combination of two models - generator model and discriminator model
- **Generator model:**
  - It is responsible for generating images (usually from noise)
- **Discriminator model:**
  - It is responsible to determine whether the image was originally available or generated by the generator
- Both the models work in tandem:
  - Generator tries to recreate the image as faithfully as possible so that the discriminator cannot differentiate between original image and generated image
  - Discriminator tries to identify the generated images from the original images

Sample Training Phrase of a GAN

- The generator tries to recreate original image from noise
- This image is then input to discriminator which tries to identify whether it was generated
- The generator then again improves on the generated images
- The discriminator again determines whether the images was generated or not
- This process is repeated until the discriminator can no longer determine whether the image was generated or not
  $P(\textit{generated}) = P(\textit{original}) = 0.50$
- Both the generator and discriminator may be pre-trained to improve performance

Types of GANs

- **DCGAN**
  - Deep Convolutional GANs
  - Consists of convolution layers without max pooling or fully connected layers
  - Use transposed convolution for upsampling
- **WGAN**
  - Wasserstein GAN
  - Attempts to solve vanishing gradient problem of regular GANs
  - WGAN learns no matter the generator is performing or not
- **Softmax GAN**
  - Replaces the classification loss (regular GAN) with a softmax cross-entropy loss
  - Stabilizes GAN training

Image Super-resolution using GAN

Image Super-resolution using GAN

- Single-frame Super-resolution will be attempted using the following procedure:
  - High resolution images will be converted to low resolution images for training
  - Generator model will be trained on training set individually
  - Discriminator model will be trained on training set individually
  - Both the models will be combined in a GAN and trained
  - Test data-set consisting of low resolution images will be used to gauge performance of the model
- After the model has been trained and saved, a simple web-application will be developed to convert low resolution images input by users to high resolution images

References

References

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