Image Inpainting with Deep Learning

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Overview of Image Inpainting

- Definition: Filling in missing or damaged areas of digital images.
- Purpose:
  - Enhance photo quality
  - restore historical images
  - edit content

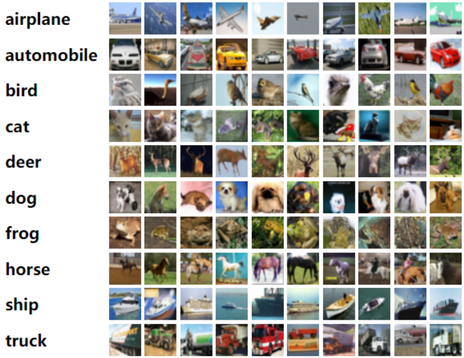
How Does Image Inpainting Work (Traditionally)?

- Patch-based methods: patches from the surrounding areas are used to fill in gaps

- Limitations:
  - Surrounding regions might not have suitable information
  - Missing regions require the inpainting system to infer properties of the would-be-present objects
- With a Deep Learning approach, we can better capture spatial contexts in images

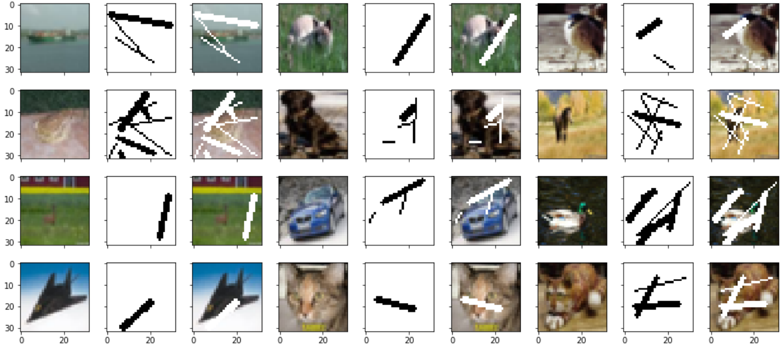
CIFAR10 Dataset

- A widely used dataset in ML, containing 60,000 32x32 color images across 10 classes
- Provides a benchmark for comparing different methods and tracking progress in the field



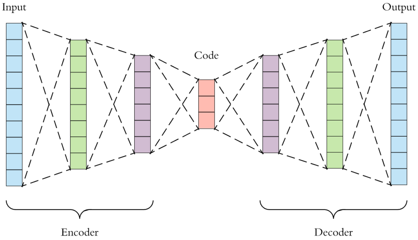
Data Preparation

- Inpainting is a process of reconstructing lost or deteriorated parts of images
- Add artificial deterioration to our images through masking
    - Drew lines of random length and thickness using OpenCV



Convolutional Autoencoders

- Autoencoders: a type of neural network that can be used to learn a compressed representation of a dataset
- Encoder: maps the input data to a lower-dimensional representation
- Decoder: maps the lower-dimensional representation back to the original dimensionality



- Convolutions: learn hierarchical representations of data including shapes, edges, etc.

Partial Convolutions

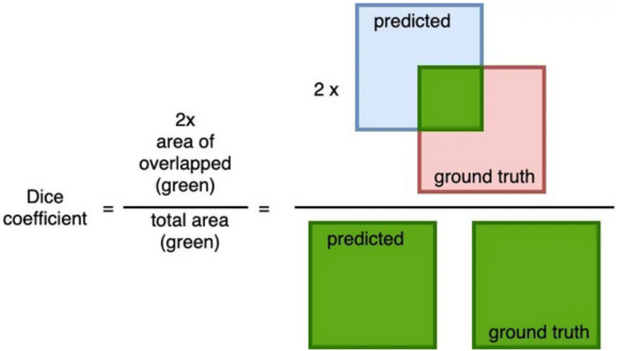
- In traditional convolutional layers, missing pixels are also used for convolution, resulting in poor image quality.
- We wish to only use valid pixels to learn representations

$$x' = \begin{cases} \mathbf{W}^T(\mathbf{X} \odot \mathbf{M}) \frac{\mathrm{sum}(\mathbf{1})}{\mathrm{sum}(\mathbf{M})} + b, & \text{if } \mathrm{sum}(\mathbf{M}) > 0 \\ 0, & \text{otherwise} \end{cases}$$

- After each partial convolution operation, we then update the mask

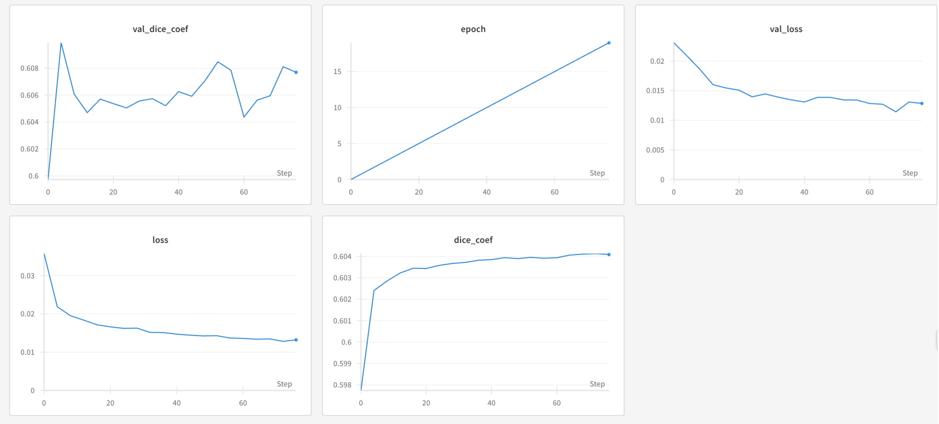
$$m' = \begin{cases} 1, & \text{if } \mathrm{sum}(\mathbf{M}) > 0 \\ 0, & \text{otherwise} \end{cases}$$

Dice Coefficient

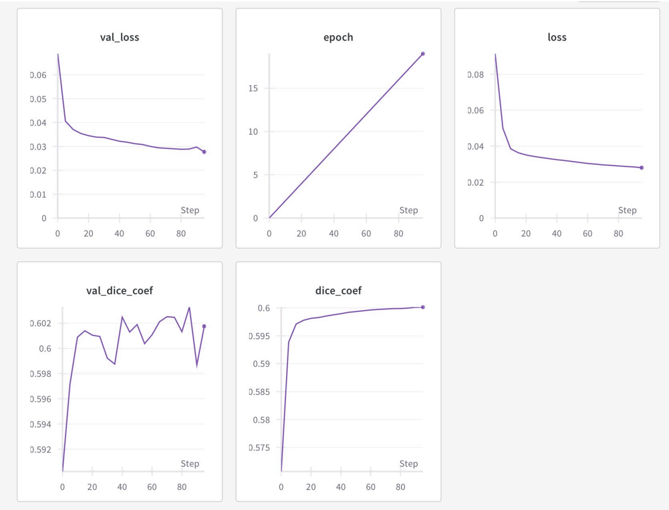


- Measures the accuracies of our predictions!

Convolutional Autoencoder Results



Partial Conv Autoencoder Results



Next Steps

- Test both methods on higher resolution datasets
- Image inpainting with stable diffusion
- Tractibility of Diffusion Models