Deep Learning Methods to Solve the Inverse Problem of Artificial Image Colourisation

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Black and White Image Colourisation

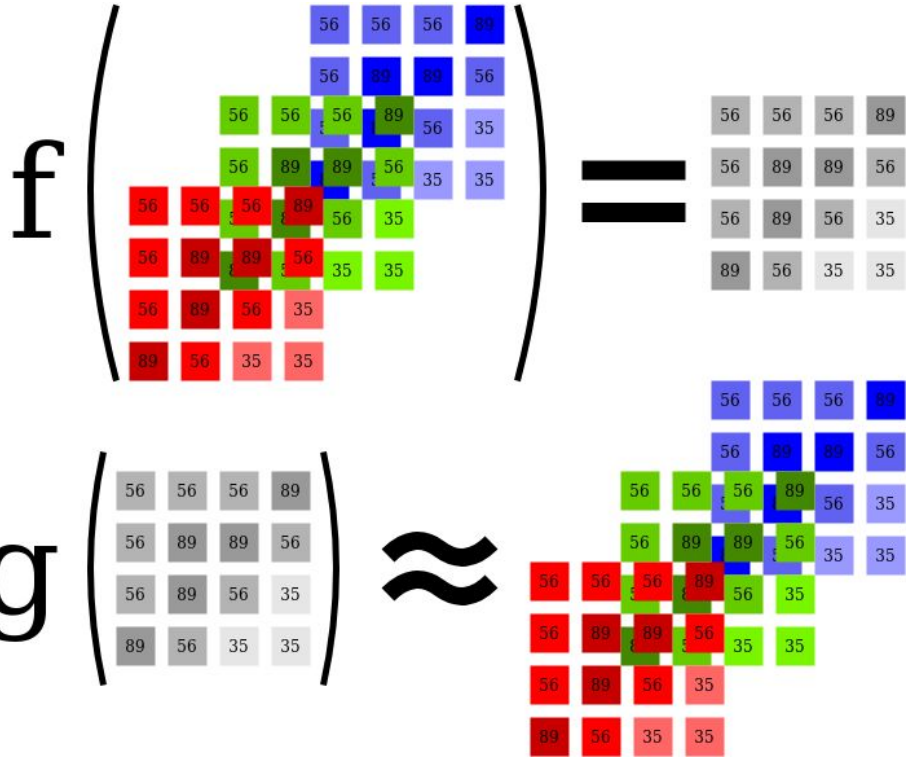
Current Manual Process

- Artist infers the colours based on details
- Usually assisted by semi-automatic tools
- Requires time and skill

Automatic Colourisation

- Allows colourisation in a fraction of the time
- Would allow efficient video coloursiation
- New applications for monochromatic image systems (infrared)

An Ill-Posed Inverse Problem



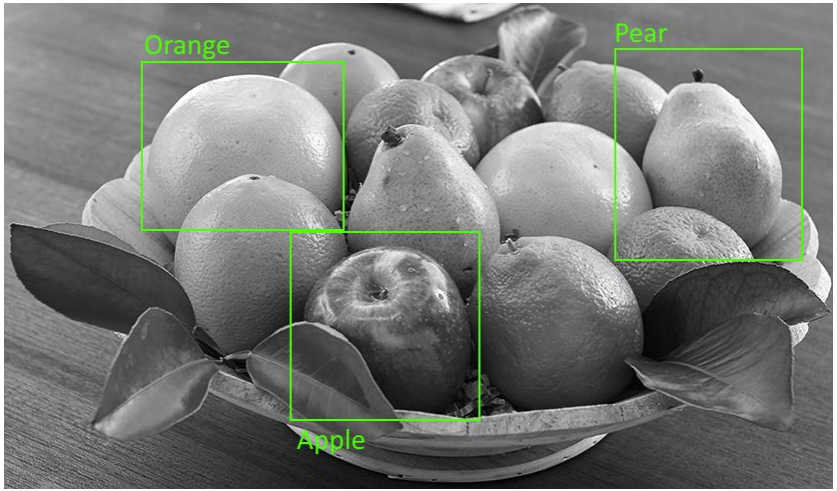
Inverse Problem

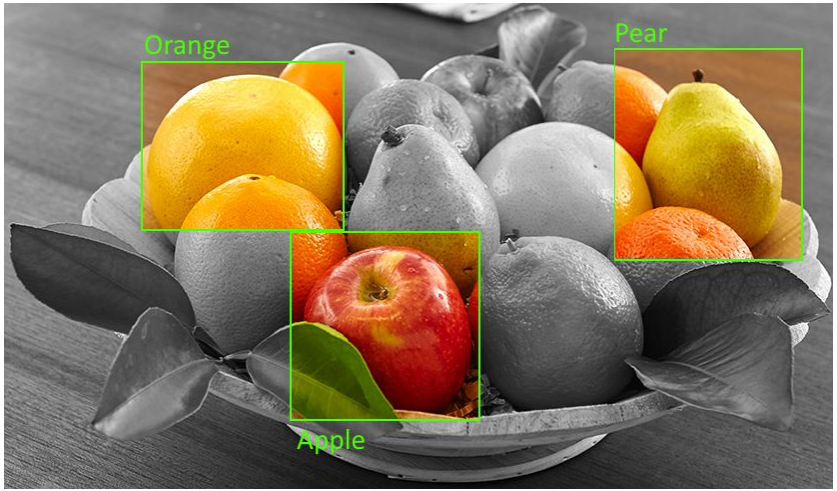
- Greyscale to colour conversion can be seen as the inversion of colour to greyscale conversion
- Ill-posed: no unique method for this conversion

Approximate solution

- No unique solution can be created to reverse the process
- Gather as much additional information (priors) as possible to help develop the best approximate solution

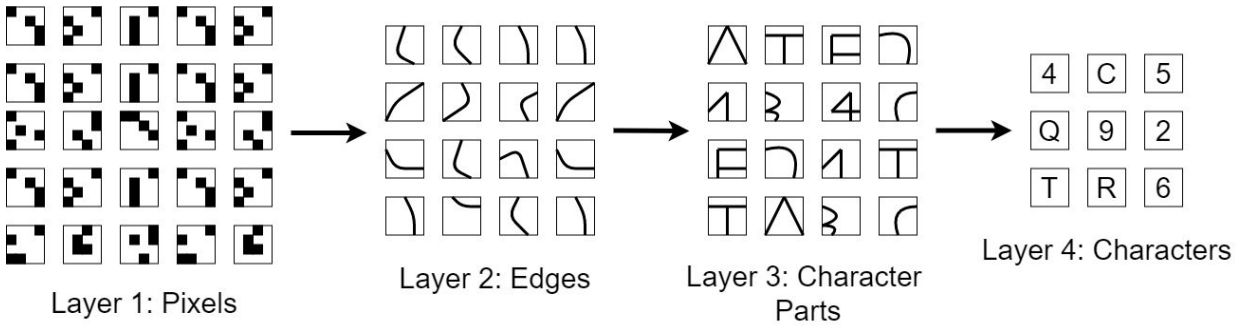
Colourising with Priors





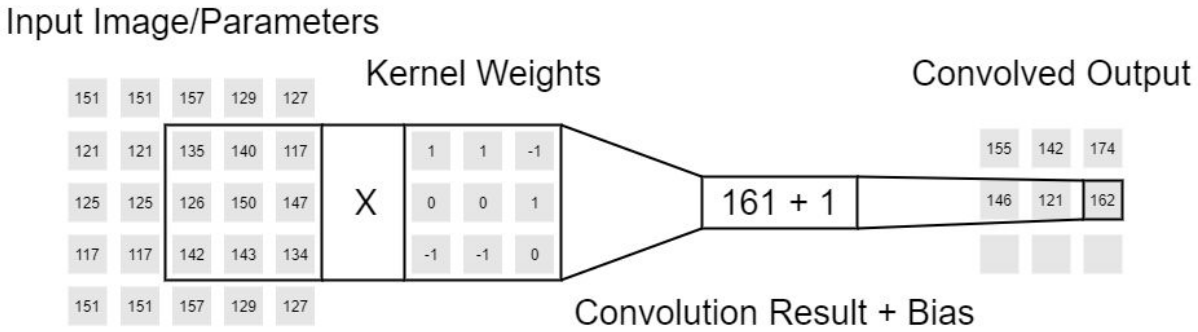
Deep Learning as a Solution

- Neural Networks can develop solutions based on the analysis of large amounts of data
- Can recognise patterns in data, and combine those patterns to find the priors that can help them develop a solution
- Deep Learning’s strengths have made it a common solution for colourisation
- No consensus on which Deep Learning model is best for colourisation



Convolutional Neural Network (CNN)

- Extracts the features in an image through “Convolution” operations
- Uses these features to learn how to best colourise the image
- Convolution is the most commonly used method for tackling Computer Vision problems with Deep Learning
- The CNN was developed first, as it could be used as a baseline for other models
- Designed with repeated testing and tuning

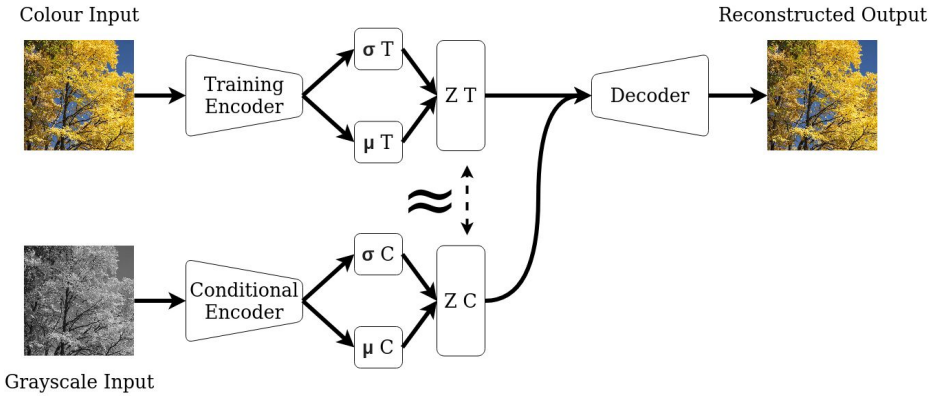


Convolutional Generative Adversarial Network (CGAN)

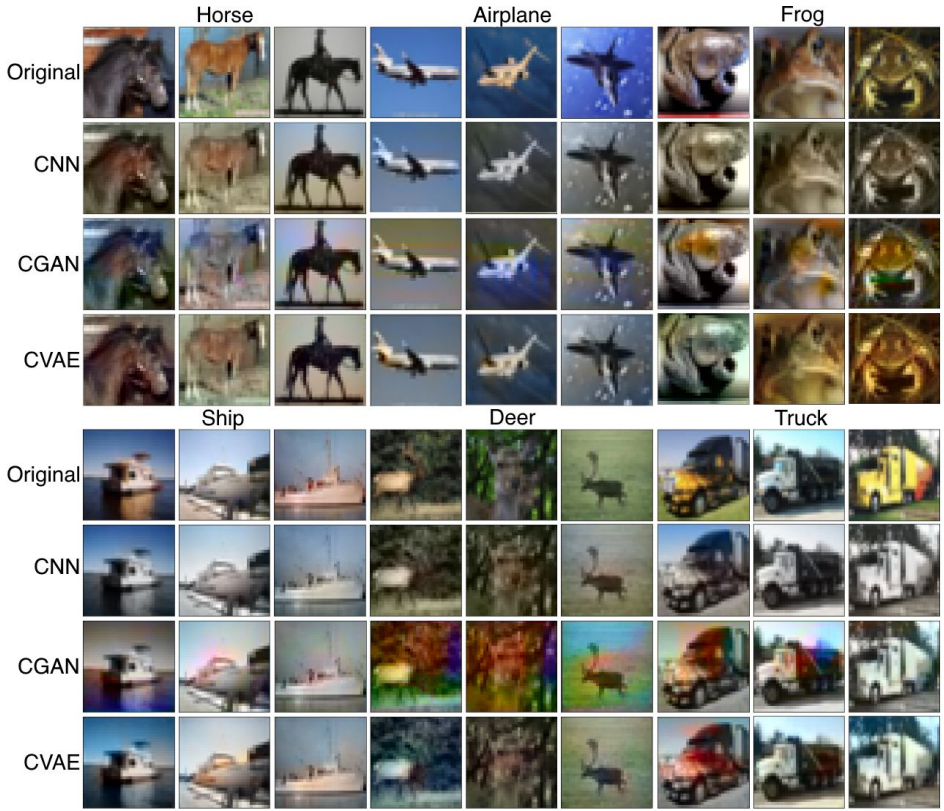
- Trains through two networks that compete together, generator learns to generate images, while the discriminator learns to determine if an image is real or generated
- Can generalise better than normal NNs
- Adopted in a number of projects for image colourisation
- Difficult and time-consuming to train
- Due to lengthy training, it was designed primarily based on examples and suggestions

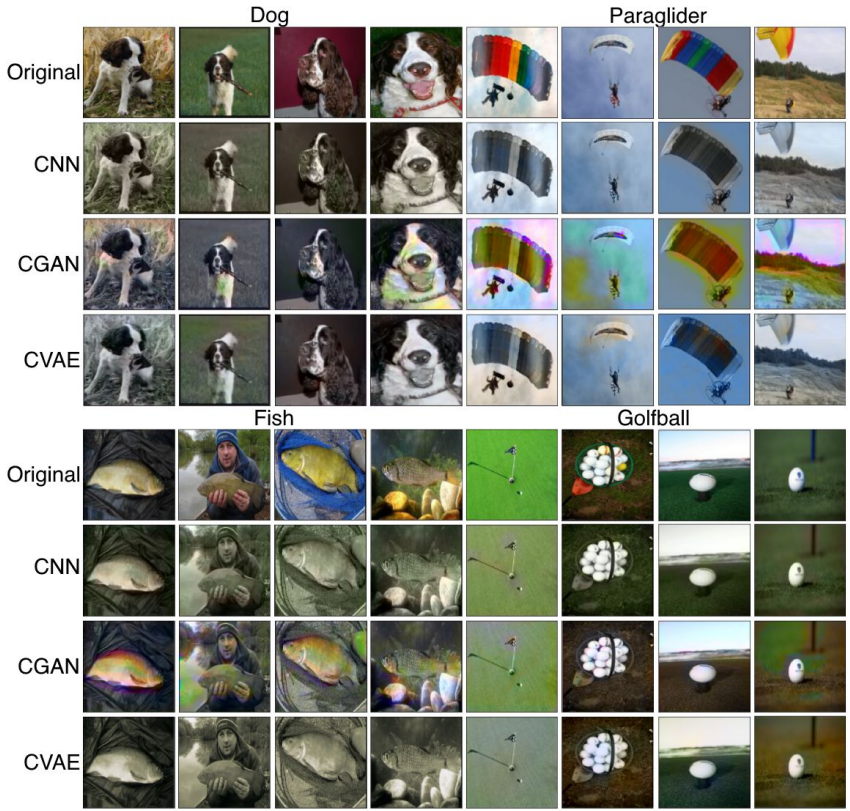
Convolutional Variational Autoencoder (CVAE)

- Implemented after the CGAN, as it is less commonly adopted for colourisation, and needed more research
- Encoder networks compress input images into latent feature representations, while the decoder network decompresses these representations into output images
- Capable of providing diverse colourisations for a given image
- Trains very quickly, so could be better designed with repeated testing

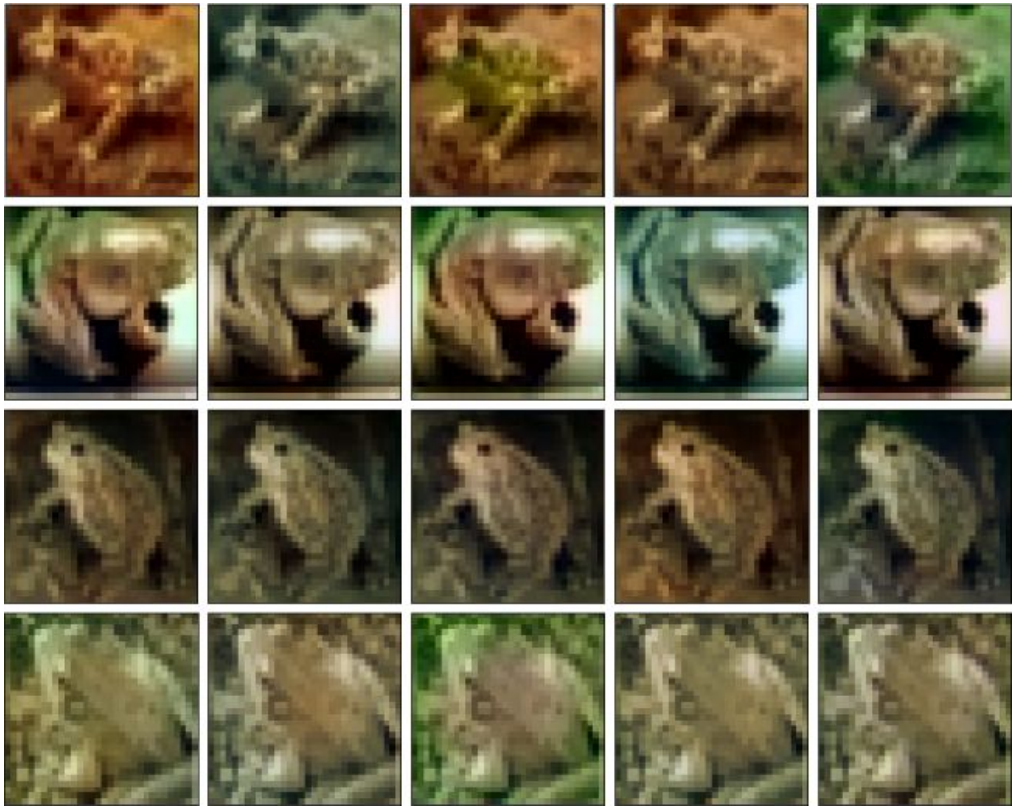


Results


Horse
Airplane
Frog
Original
CNN
CGAN
CVAE
Ship
Deer
Truck
Original
CNN
CGAN
CVAE


Dog
Paraglider
Original
CNN
CGAN
CVAE
Fish
Golfball
Original
CNN
CGAN
CVAE

Diverse CVAE Colourisation



Conclusion

CNN

- Well adapted but rudimentary
- Needs a lot of priors in order to colourise in detail

CGAN

- Implementation difficulties
- Poor results
- Could be viable if the design were improved

CVAE

- Most detailed outputs and fits the data very well
- Ability to produce diverse colourisations
- Most interesting solution