A Practical Cloud Based Single Image Super Resolution Method

REAL D

Author:
Brian Hawkins

An age old problem

Making images bigger

Image Scaling is a problem as old as photography.

Projection was used to increase image size in darkroom photography.

- Limited only by the grain size of the photographic emulsion.
- This chemical process allowed massive scaling factors compared with digital images.
    - 35 mm negative to 40 feet theatre screen.

An age old problem, made worse through technology

Making images bigger

Digital Imaging makes the problem worse.

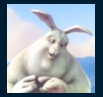
Finite pixels distributed in a grid limit the scalability of an image.

All scaling is an interpolation problem.

- “True” image data is spread out and new data must be created to fill in the gaps.
- Reconstructing ground truth data is impossible.

But we can do our best…

General interpolation models exist to address the issues of image scaling.



Input Image

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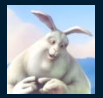
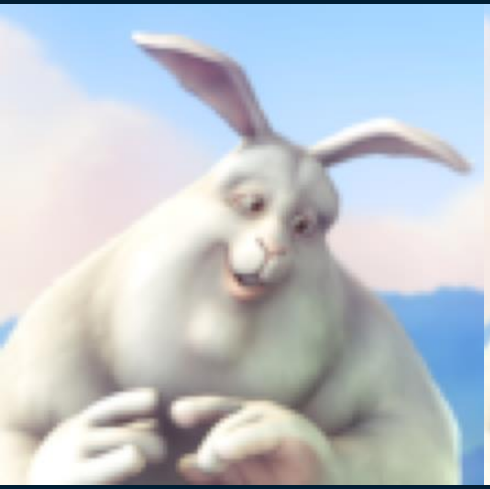
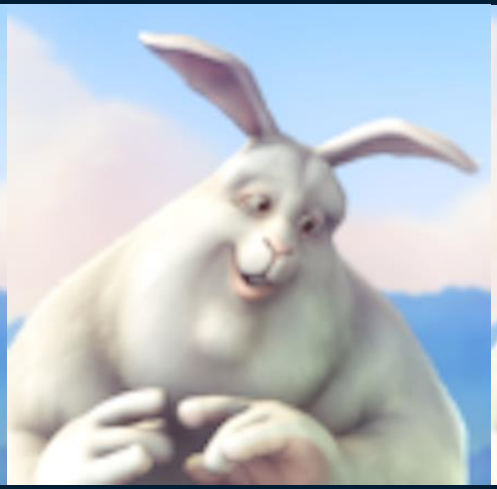


Input Image

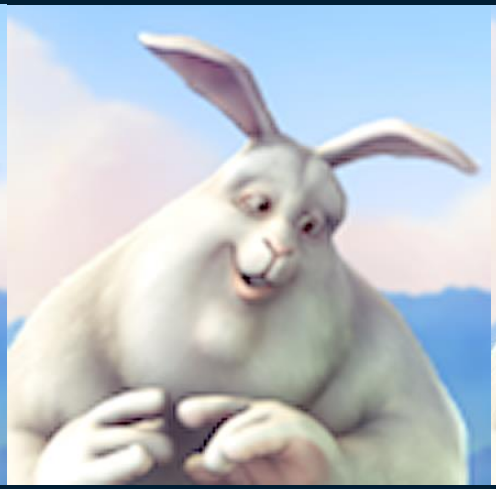
4x Scale



Bicubic



Lanczos



Sinc

Ground Truth

But we can do our best…

General interpolation models exist to address the issues of image scaling.

And many more…

- Bilinear
- Nearest Neighbor
- Fourier
- Quadratic
- Catmull-Rom
- Edge directed
- Hqx
- Vectorization
- And so on, and so on, and so on…

Why do we need more?

Generalized solutions all introduce artefacts

Ringing
(Lanczos/Sinc)

Pixelation
(Nearest Neighbor / Bilinear)

Softening
(Bicubic / Parzen)

Why do we need more?

Generalized solutions all introduce artefacts

Why?

- Different image structures require different interpolation methods.
  - An edge should be treated differently than a low detail image patch.
  - Offline vs Realtime trade off

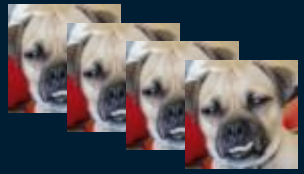
Super resolution

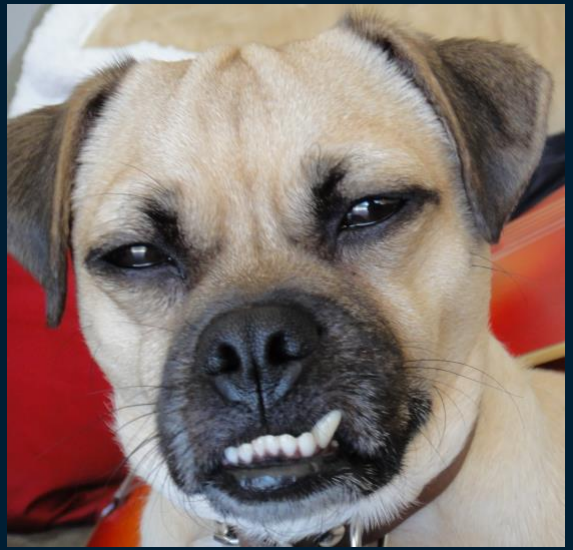
Making images bigger

Super resolution algorithms enable higher quality image scaling through resolving multiple image samples.

Super resolution

Making images bigger





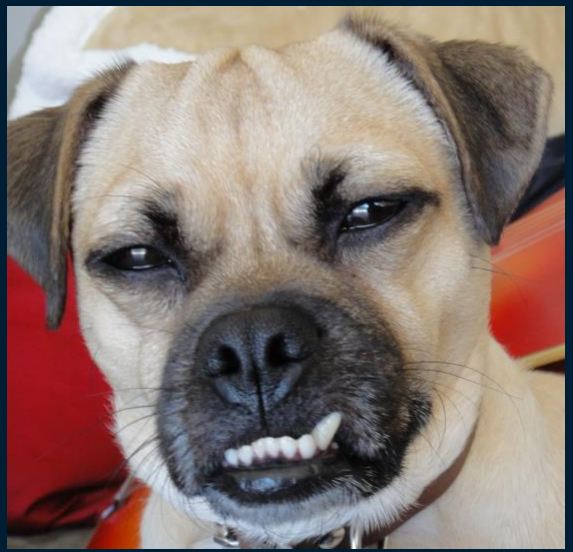
Super resolution algorithms enable higher quality image scaling through resolving multiple image samples.

Multi-Frame Approach

- Requires target to remain invariant.
  - OR correct for variation using motion estimation.
  - Can introduce temporal artifacts.
- Good for astronomy, not great for film.

Super resolution

Making images bigger



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Single Frame Approach

- Relies on naturally occurring structural similarities within a single image.
    - Extremely computationally expensive.
        - Each input pixel requires search and comparison of entire input image.

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Can we create a better system?

Our method:
A deep convolutional neural network approach

We train a DCNN using an input image that is up-sampled to match the resolution of the desired output image.

The convolutional network is composed of three operational steps:

1. Patch Extraction and vectorization
2. Non-linear mapping
3. Reconstruction

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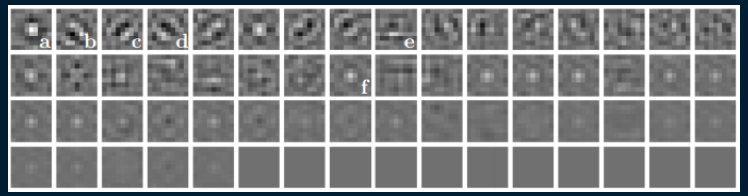

Our method:
A deep convolutional neural network approach

Patch Extraction and vectorization

- Multiple overlapping patches are collected from a single input image and stored as high dimensional vectors.
  - Overlapping patches = larger input context window when compared to standard scaling models.
- These vectors are then filtered using a set of trained filters.

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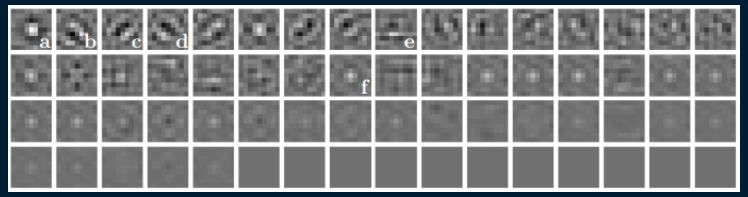

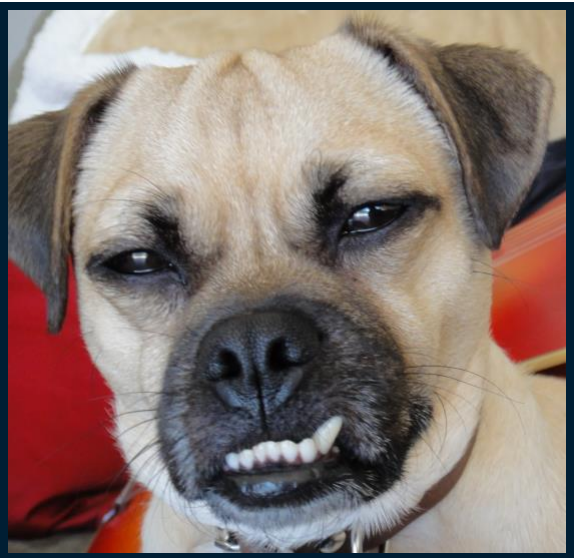

Our method:
A deep convolutional neural network approach

Non Linear Remapping

- Each vector is then remapped from the low resolution source to the high resolution target using a trained bias per channel.
- Creates a dynamic system where the network learns to apply different combinations of filters depending on the input patches.
    - Solves problem of treating edges differently than low detail or textured regions.

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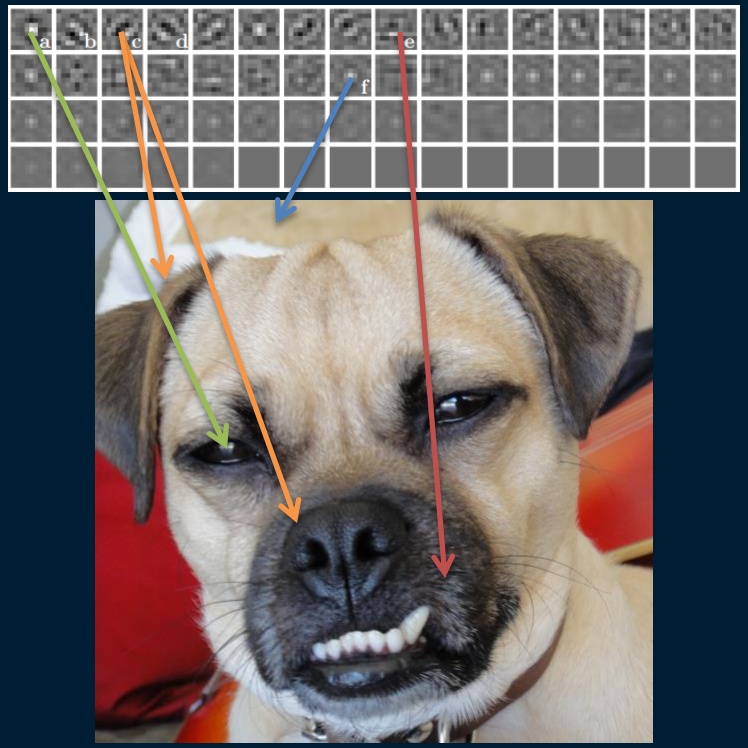

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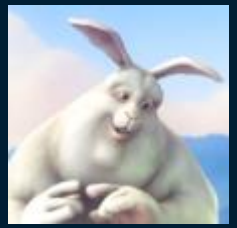
Reconstruction

- The overlapping high resolution feature vectors are then combined using biased averaging to produce the high resolution output.

Our results?

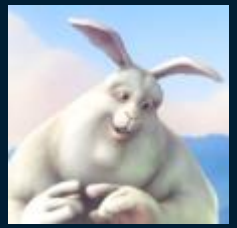


Input

Ground Truth

Bicubic

Our results?



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Ground Truth

Lanczos

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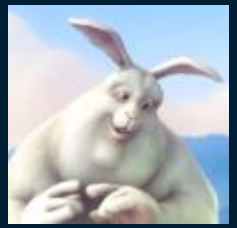

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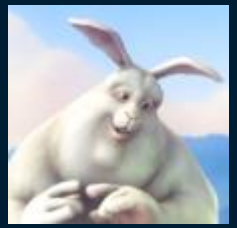
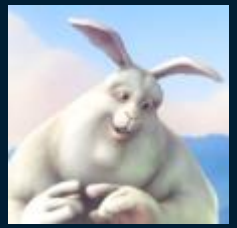


Input

Ground Truth

Nearest Neighbor

Our results?



Input

Ground Truth

Our Method

Performance versus SISR?

Testing system:
Dell Precision T7600 Desktop
16 x Intel Xeon Dual Core 3.10 GHz
64 GB RAM

FHD → UHD
Our Machine Learning super resolution method:
31.8313 seconds / frame

Single Image Search super resolution method:
103.06 seconds / frame

323% speed increase… but still slow.

Performance versus SISR?

Need Speed?

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Need Speed?

- Our DCNN solution can be deployed to FPGA for realtime scaling.
- Our Super resolution software is CPU based and scales linearly per number of CPU cores.
    - N x Cores = N x Speed

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OR

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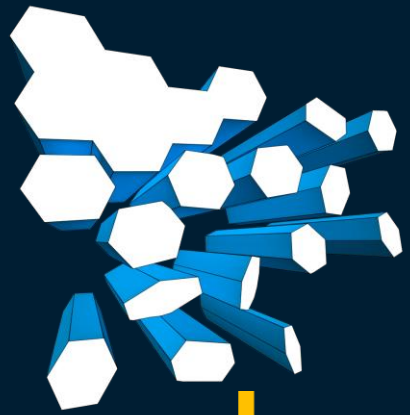

sundog

Media Toolkit

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OR

Deploy to the cloud…
Our software is currently deployed on Sundog's Media Toolkit platform in order to ensure a scalable solution for any project's needs.