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Algorithm

Database: $2 \times 10^6$ images (400Gb) from Flickr

1. **Find subset** of images depicting semantically similar scenes

2. **Find patches** in subset that match the context surrounding the missing region

3. **Blend** in the most similar patches

Write down a suitable cost-function at each stage...
1. Finding the most similar subset

- **Purpose:**
  - Ensures filled in regions have sensible content.
  - Reduces the amount of data (to 200 images) for subsequent stages

- **Measure similarity using:**
  - colour histogram
  - a low dimensional representation of the images (GIST scene descriptors)
2. Finding matching patches

- Define some region **around the missing area**
- Find patches in subset that are a “closest” match to this region
- Distance = pixel-wise error + texture dissimilarity
- Search across translations and scales (small translations cost less)
3. **Blending: Poisson Interpolation**

Fill in the missing area $\Omega$ such that

- boundary conditions matched $f|_{\partial\Omega} = f^*|_{\partial\Omega}$
- close to the guide ($g$) as possible: $\min f \int_{\Omega} |\nabla f - \nabla g|^2$
- Solved by the Poisson Eqn: $\nabla^2 f = \nabla^2 g$
Additional Trick - Seam Finding

Find the optimal boundary ("seam finding") for blending

- minimise gradient differences round the boundary
- encourage the seam to be tight to the missing area
- optimise energy using graph-cut algorithm.

Hardware: Cluster of 15 machines, full algorithm takes $\approx 10$ mins.
Blending failure: textures not matched
Blending failure: textures not matched
Scene matching failure
Scene matching failure
High level semantics violated
High level semantics violated
Psychophysical Benchmark

![Graph showing the percentage of images marked fake against maximum response time (seconds). The graph compares Criminisi et al., Our algorithm, and Real Photographs.]
Summary

• If you've got millions of images, there are a number that share similarly shaped areas with similar semantic content.

• Moving toward the realm where you have
  – enough data to stop being Bayesian
  – too much data to be Bayesian