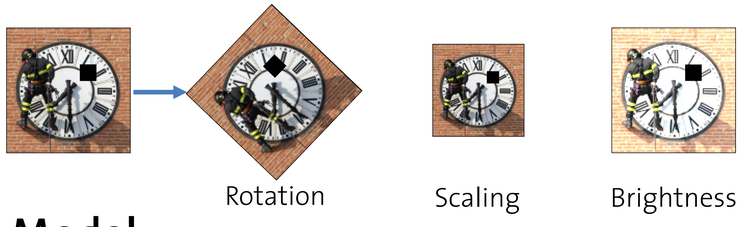
ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

# Transforming Image Completion

**Alex Mansfield[1], Mukta Prasad[1], Carsten Rother[2], Toby Sharp[2], Pushmeet Kohli[2], Luc Van Gool[1]**
[1]Computer Vision Lab, ETH Zürich, Switzerland [2]Microsoft Research, Cambridge, UK
Microsoft Research

## Problem Statement

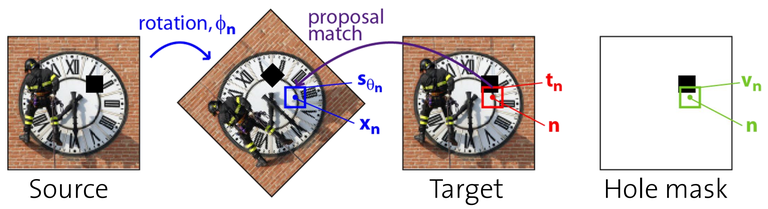

Image completion is an important photo-editing task in which holes should be filled such that the image still **appears natural**. State of the art work uses patches from the rest of the image to fill the holes. We go beyond previous work to extend our search space to include patches in **natural transformations** of the source image:




## Model

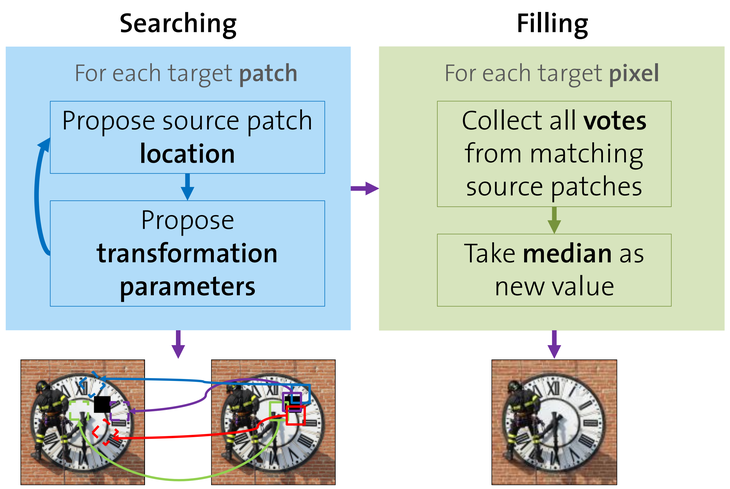
We extend the model of the state of the art algorithm of Wexler et al. [2]:

$$T^* = \underset{T}{\operatorname{argmin}} \left( \sum_{\mathbf{n}} \min_{\theta_{\mathbf{n}}} \left\| [\mathbf{t_n} - \mathbf{s}_{\theta_{\mathbf{n}}}] \cdot \mathbf{v_n} \right\|^2 \right)$$




## Optimisation

We optimise with an algorithm also based on Wexler et al. [2]:




## Searching

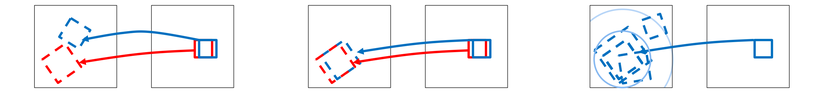
Propose source patch **location** using one of:

| | |
|---|---|
| `Ex` | Exhaustive search |
| `PM*` | Patch Match [1] |

Propose **transformation parameters** using one of:

| | |
|---|---|
| `d*` | Discrete search |
| `c` | Continuous (Levenberg-Marquardt) |
| `GPM*` | Generalized Patch Match [1] |
| | Closed form optimisation (for brightness shift) |

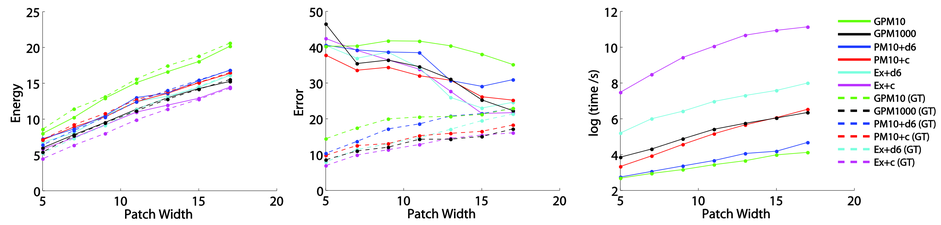
Patch Match methods use the following processes:




## Results

Qualitative results show clearly our improvement (see right). Quantitative results also show our improved and allow evaluation of the different search methods:

- **Energy** normalised to [0,255]
- RMS **error** with respect to ground truth normalised to [0,255]
- **Time taken** to produce results




Quantitative results for a set of 8 images under rotation

## Conclusions

- Using transformations can **give much better results**
- Important to **limit transformations** used, to ease search
- Important to determine an **appropriate patch size**
- **Efficient optimisation is possible** over so many continuous variables using Patch Match based search algorithms

Paper and our Matlab/C++ code are available online:
**www.vision.ee.ethz.ch/~mansfiea/transformic/**

[1] C. Barnes, E. Shechtman, D. B. Goldman and A. Finkelstein, The generalized patch match correspondence algorithm, ECCV 2010
[2] Y. Wexler, E. Shechtman and M. Irani, Space-time completion of video, IEEE PAMI 2007