"Image De-fencing using Microsoft Kinect"

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Abstract: De-fencing of Images

- Use of RGB-D data to detect fence
- Capture multiple views of the same scene to borrow information
- Inpaint fence regions using Loopy Belief Propagation

Contents

1. Introduction

1. Introduction

Objective:

To remove fences/occlusions from images

Novelty:

Use of depth maps (from Microsoft Kinect) to detect fences

Scope of Work:

- Capture image data to de-fence
- Experiment with different parameters such as type of fence, types of subjects, lighting conditions, etc.
- Design methodology to align depth map with colour image
- Experiment with algorithms required to calculate pixel shifts between images
- Code required operations in MATLAB

1. Introduction

Work completed:

- Prepared workflow for capturing images using Microsoft Kinect
- Experimented with external parameters such as lighting, number of multiple views, types of fences, types of subjects, lighting conditions, etc.
- Designed methodology to align depth map with colour image
- Captured multiple images and removed fences
- Experimented with algorithms to calculate shifts between multiple images
- Experimented with preprocessing steps required to detect fences in images
- Wrote original code, except for Loopy Belief, in MATLAB
- Optimized Loopy Belief code; brought down time taken to de-fence one colour image from around 30 minutes to less than 3 minutes

2. Proposed Algorithm

2. Proposed Algorithm

1. Detection of Fence

   - Using depth map (Microsoft Kinect)

2. Computation of Pixel Shifts between Images

   - 3 methods explored

3. Inpainting of Fence Region

   - Using Loopy Belief Propagation

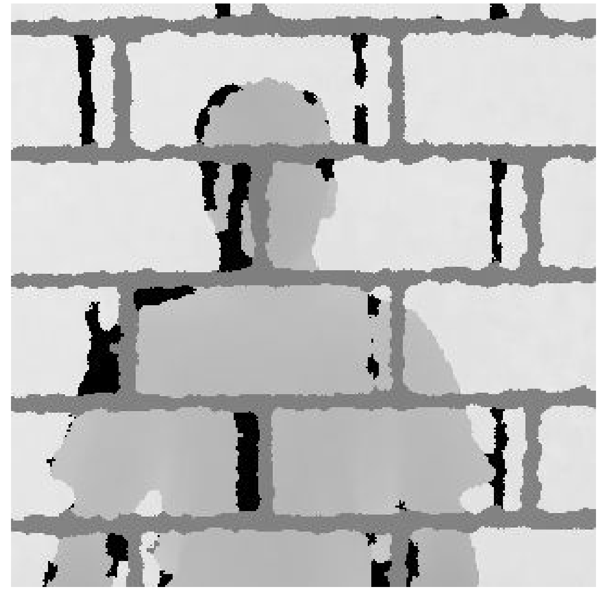
Proposed Algorithm:

1. Detection of Fence
2. Computation of Pixel Shifts
3. Inpainting of Fence Region

3. Detection of Fence

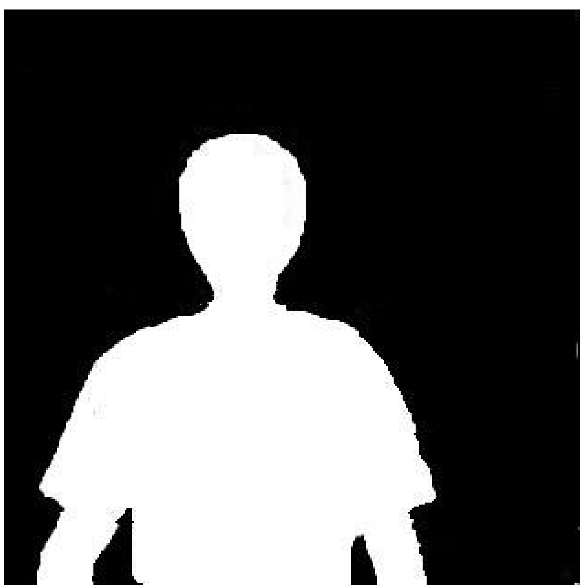
3. Detection of Fence

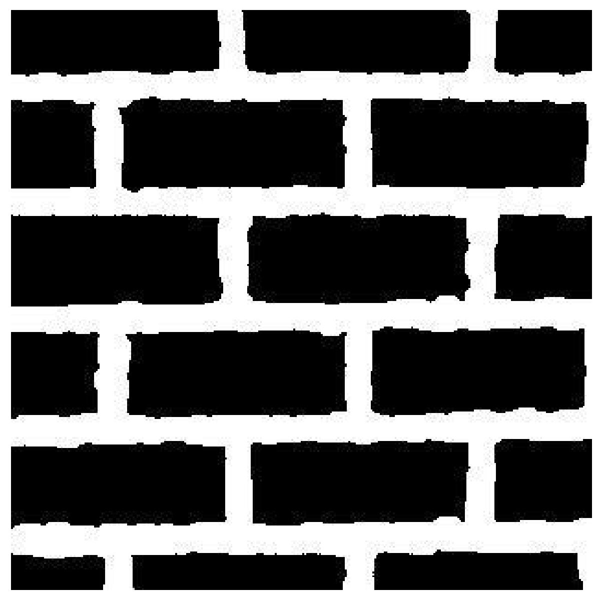
RGB Data



D Data

Foreground segmented out of depth map





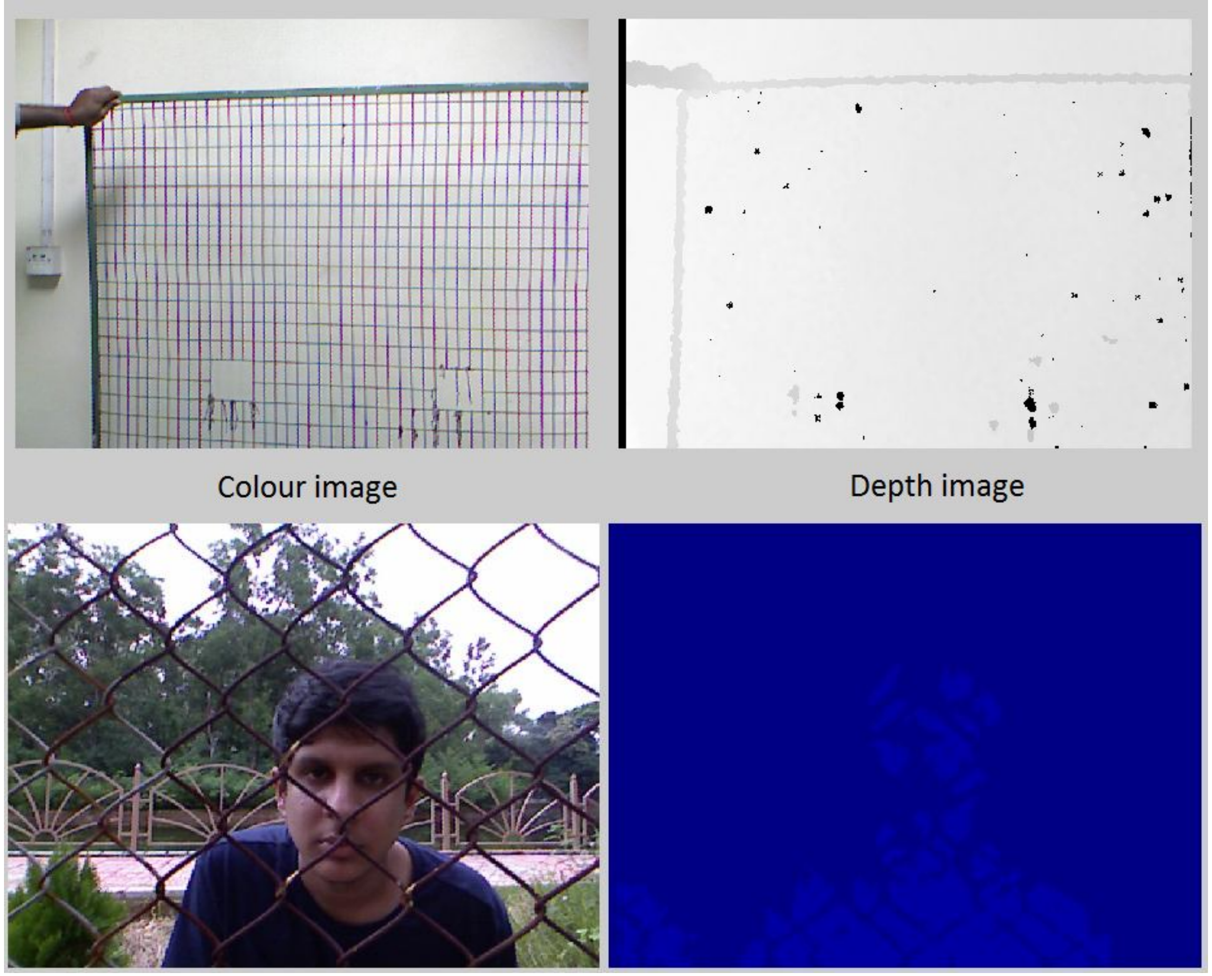
Fence (aligned) segmented out of depth map

3. Detection of Fence

Failure Cases

1) Minimal reflection from fence

2) Over-exposure to infrared light



4. Alignment of Depth & Colour Images

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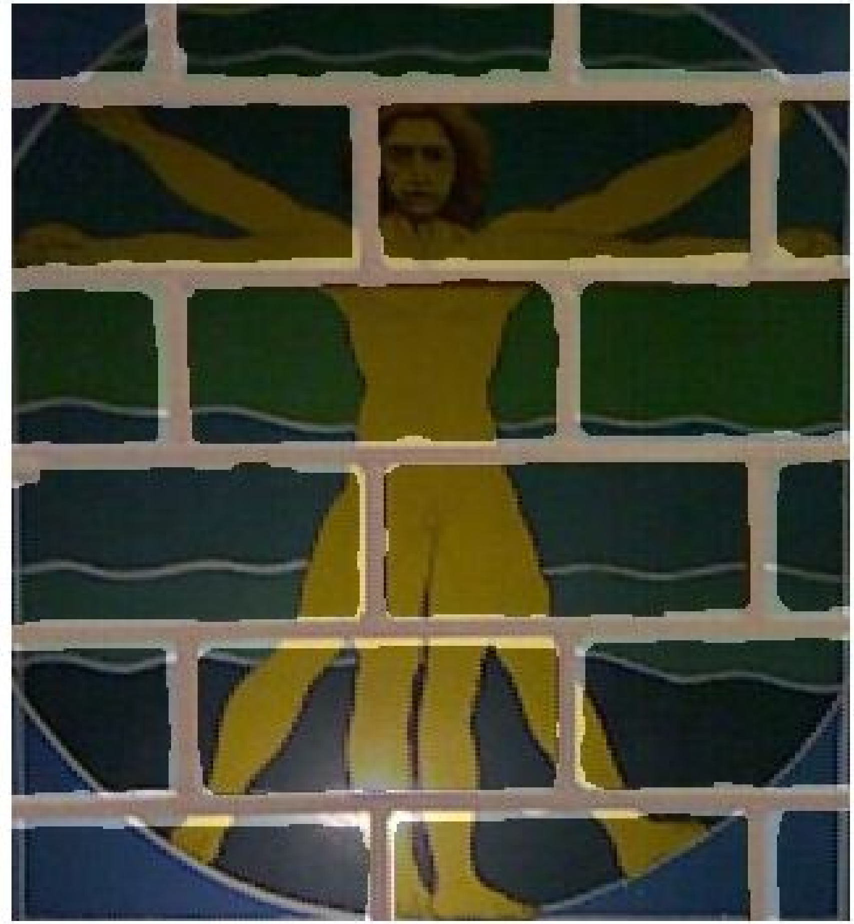
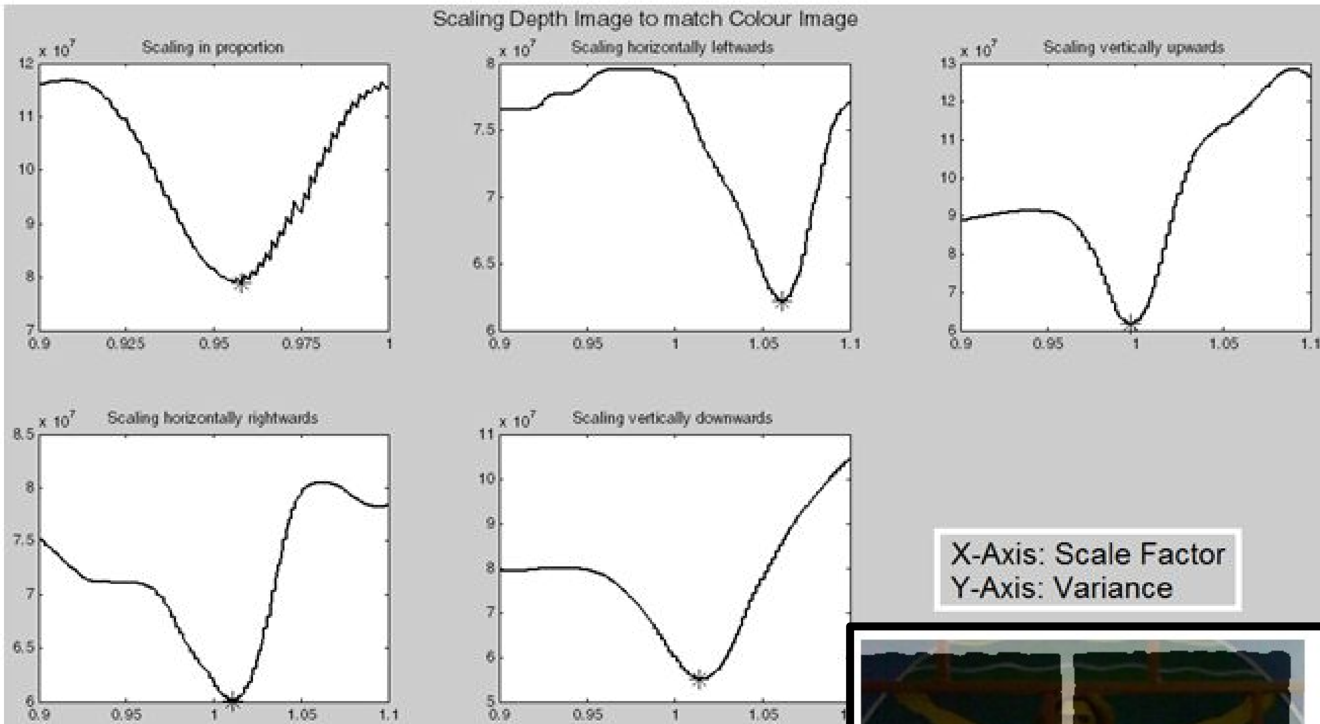


Not aligned → Aligned

Scaling

4. Alignment of Depth & Colour Images



Proposed Algorithm:

1 Detection of Fence

2 Computation of Pixel Shifts

3 Inpainting of Fence Region

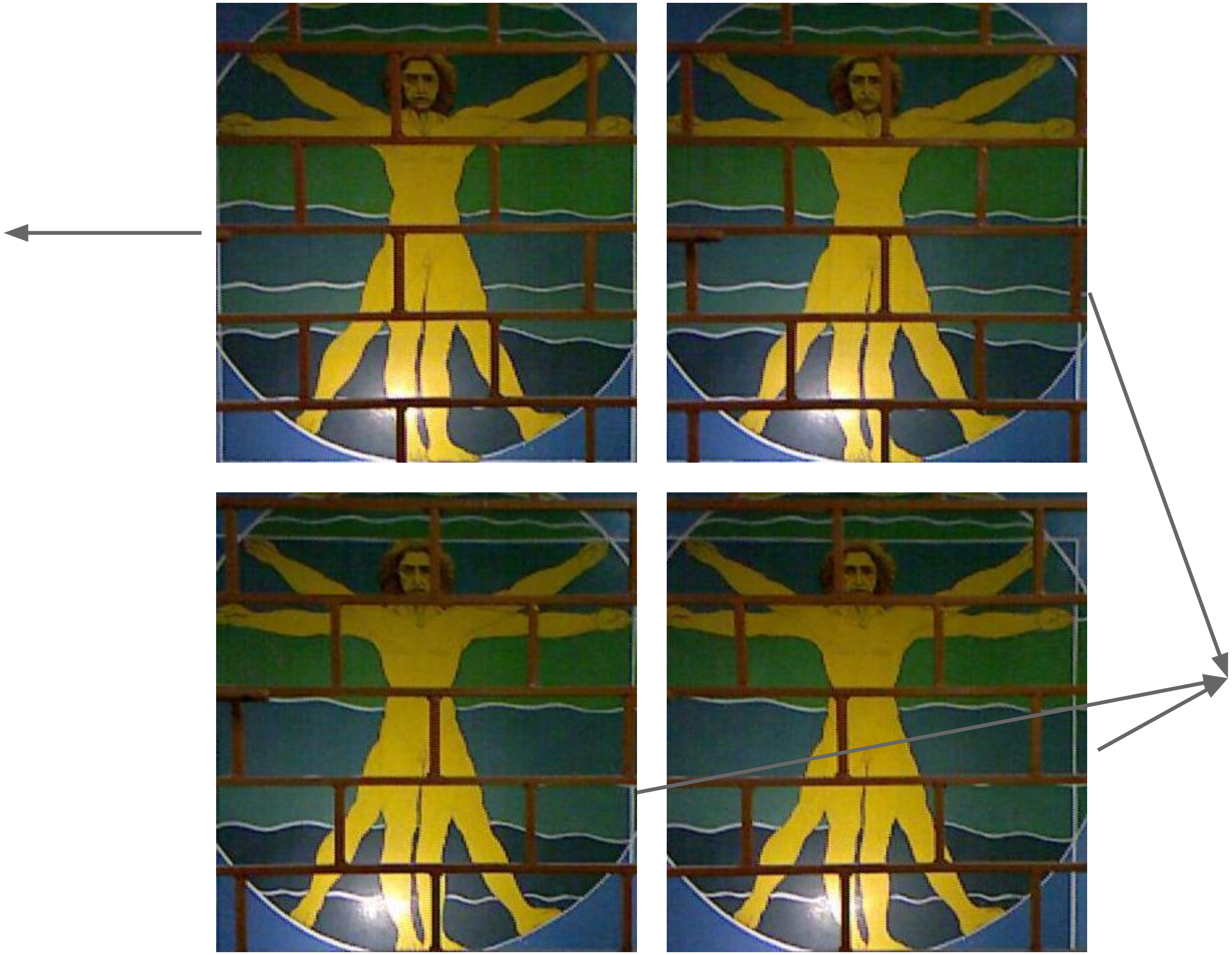
5. Computation of Pixel Shifts

1) Naive algorithm

2) Optical Flow

3) ASIFT

5. Computation of Pixel Shifts

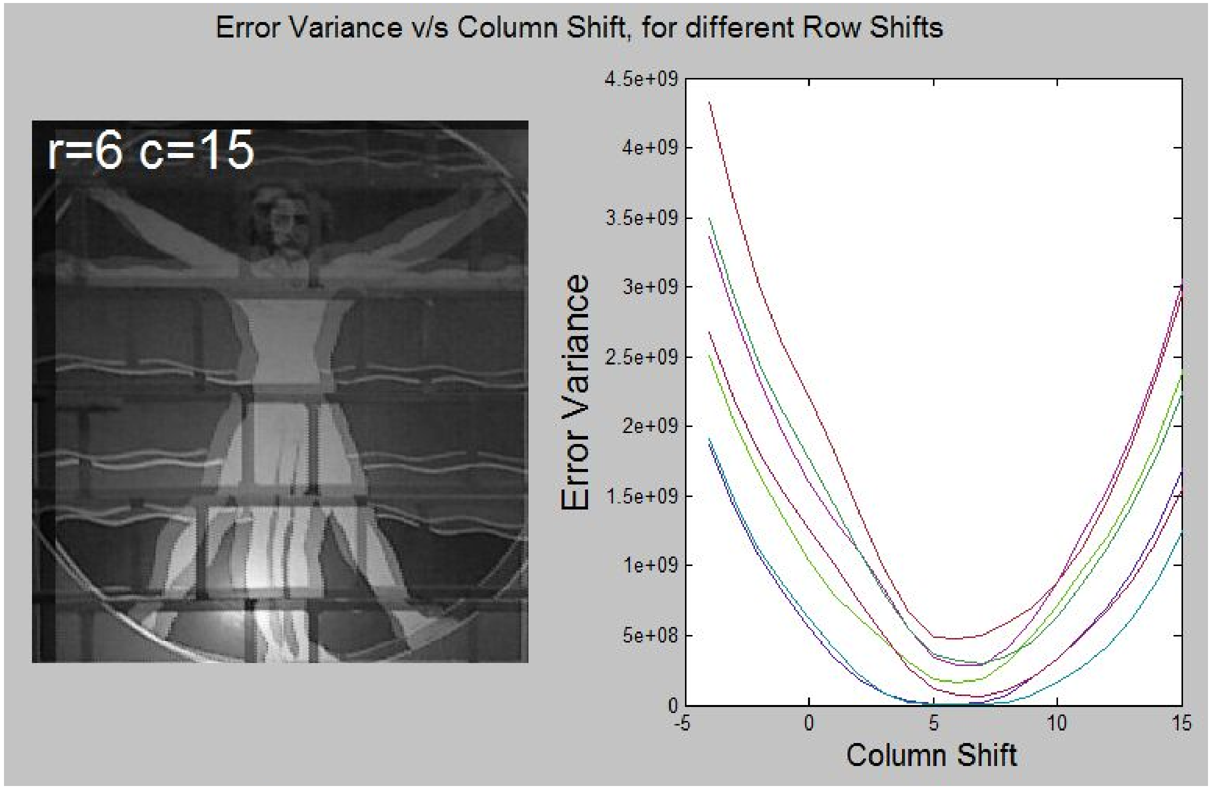


<u>Assumption</u>: Global motion

5. Computation of Pixel Shifts

1) Naive algorithm

Error Variance = variance[non-fence(Reference_Image - shift(Test_Image))]/(number of non-fence pixels)^(a convenient power)

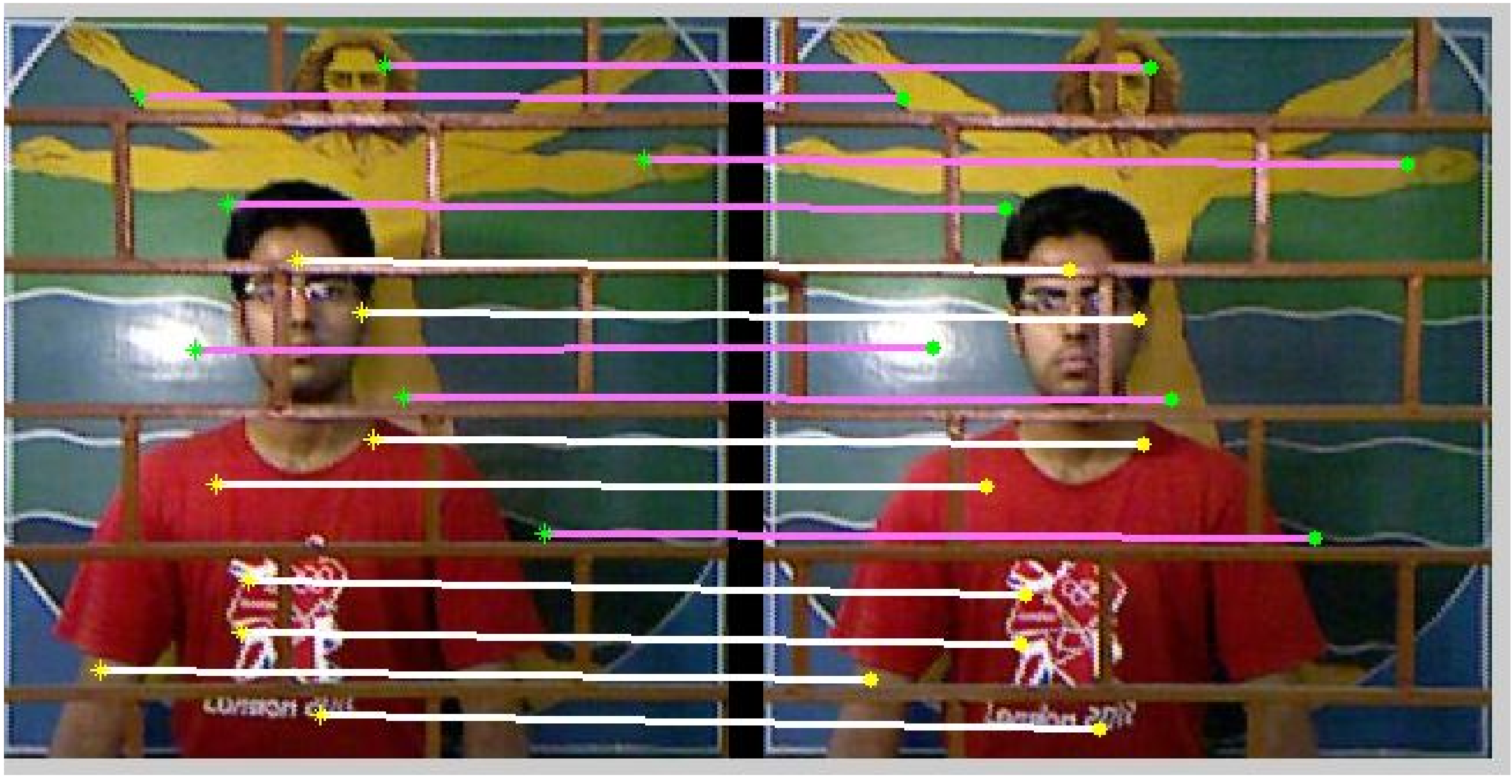


5. Computation of Pixel Shifts

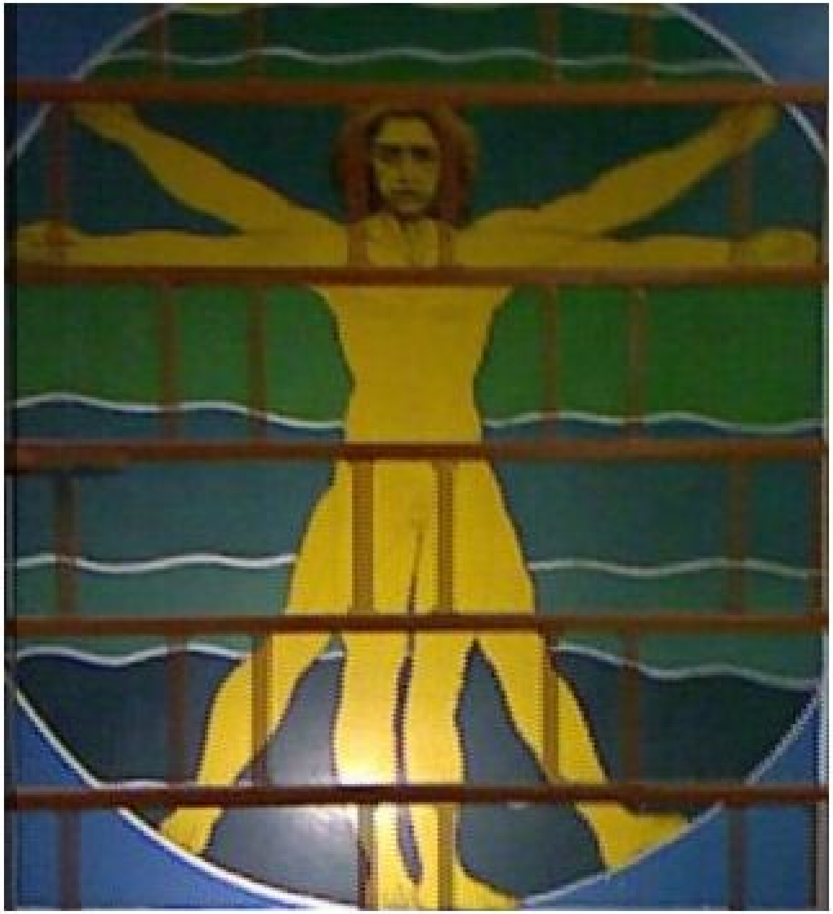
2) Optical Flow

- Cannot handle occlusions

3) Affine Scale-Invariant Feature Transform (ASIFT)



5. Computation of Pixel Shifts



Superimposition of Reference Image
and Shifted Test Image

Proposed Algorithm:

1 Detection of Fence

2 Computation of Pixel Shifts

3 Inpainting of Fence Region

6. Inpainting of Fence Region

6. Inpainting of Fence Region

- De-fenced image is modelled as a Markov Random Field

- Degradation Model:

$$\mathbf{y_m = O_m . W_m . x + n_m}$$

$\mathbf{x}$ is De-fenced image,

$\mathbf{W_m}$ is Warp matrix: describes the Pixel Shift from Reference Image,

$\mathbf{O_m}$ is an operator that crops out non-fence regions from $\mathbf{x}$,

$\mathbf{y_m}$ is observed image,

$\mathbf{n_m}$ is noise, assumed to be Gaussian.

6. Inpainting of Fence Region

$$\underbrace{\mathbf{J}(\mathbf{x})}_{\text{Cost function}} = \underbrace{\|\mathbf{y}_m - \mathbf{O}_m.\mathbf{W}_m.\mathbf{x}\|^2}_{\text{Data term}} + \underbrace{\beta}_{\text{Regularization parameter}} \underbrace{\sum_{c \in C} \mathbf{V}_c(\mathbf{x})}_{\text{Smoothness term}}$$

Clique Potential function $\mathbf{V}_c(\mathbf{x})$

$= |\mathbf{x}_{i,j} - \mathbf{x}_{i,j+1}| + |\mathbf{x}_{i,j} - \mathbf{x}_{i,j-1}| + |\mathbf{x}_{i,j} - \mathbf{x}_{i-1,j}| + |\mathbf{x}_{i,j} - \mathbf{x}_{i+1,j}|$

$$\hat{x} = \arg\min_{\mathbf{x}} (\mathbf{J}(\mathbf{x})) \longrightarrow \text{using Loopy Belief Propagation}$$

7. Experimental Results

7. Experimental Results

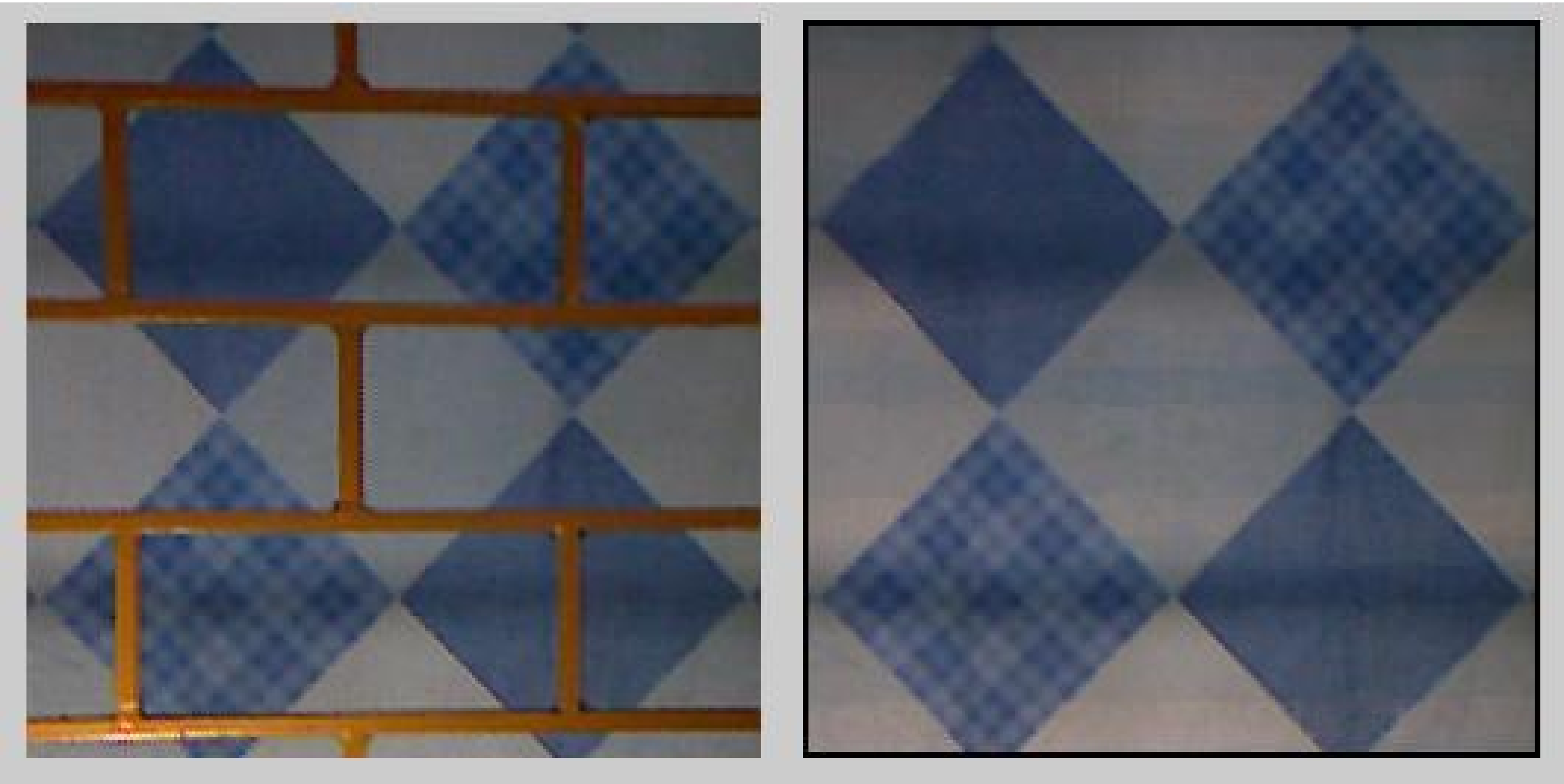
Rectangular fence with single object: Board

7. Experimental Results

Rectangular fence with single object: Poster

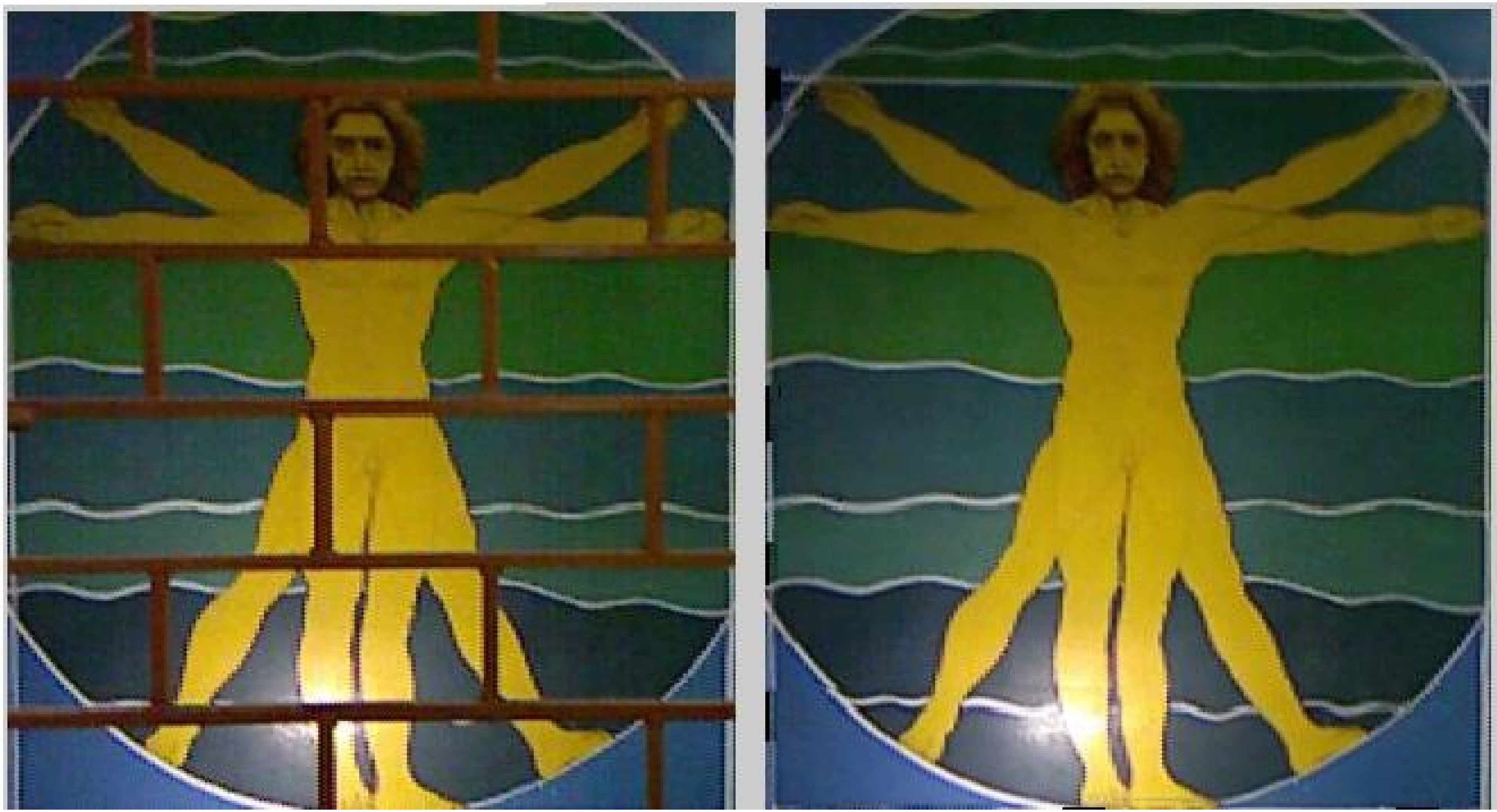
7. Experimental Results

Rectangular fence with single object: Bedsheet



7. Experimental Results

Rectangular fence with single object: Painting



7. Experimental Results

Rectangular fence with two objects

7. Experimental Results

Diagonal fence with two objects

8. Comparison with Other Methods

1) Total Variation Inpainting using Split Bregman

2) De-fencing using Learning-Based Matting

8. Comparison

1) Total Variation Inpainting using Split Bregman

Using Proposed Algorithm

Using Total Variation Inpainting using Split Bregman

8. Comparison

2) De-fencing using Learning-Based Matting

Using Proposed Algorithm

Using De-fencing using Learning-Based Matting

9. Precautions

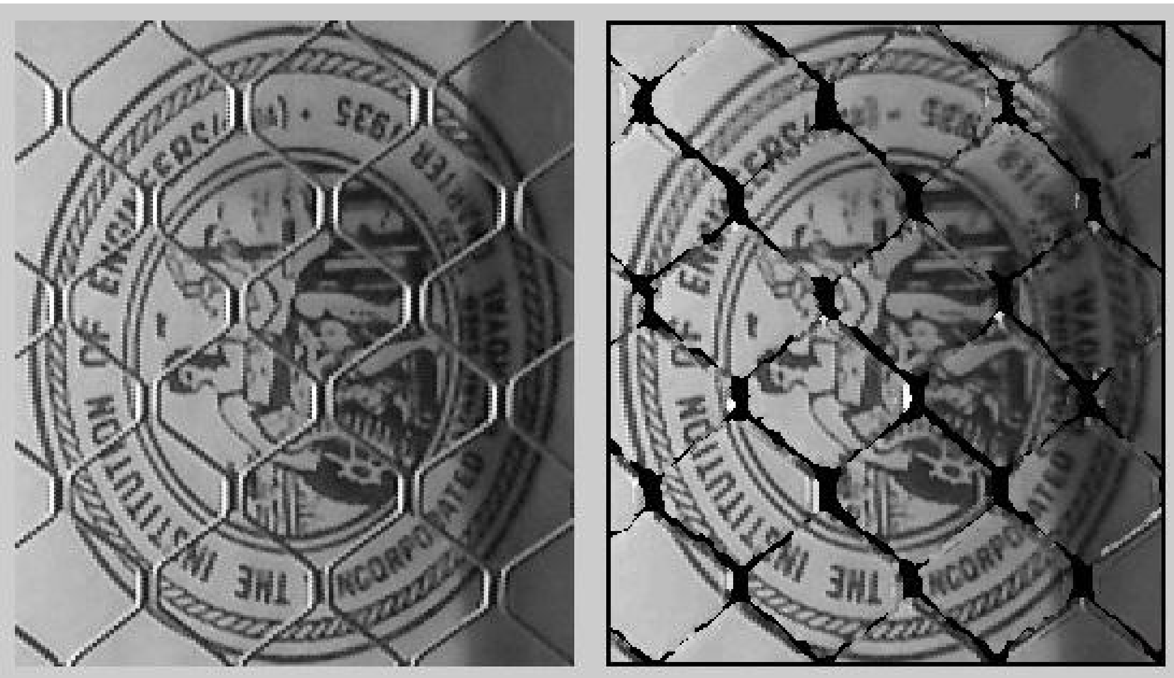
1) Sufficient Fence Dilation
2) Sufficient Camera Translation
3) Limited Pixel Shift

9. Precautions

1) Sufficient Fence Dilation

9. Precautions

2) Sufficient Camera Translation

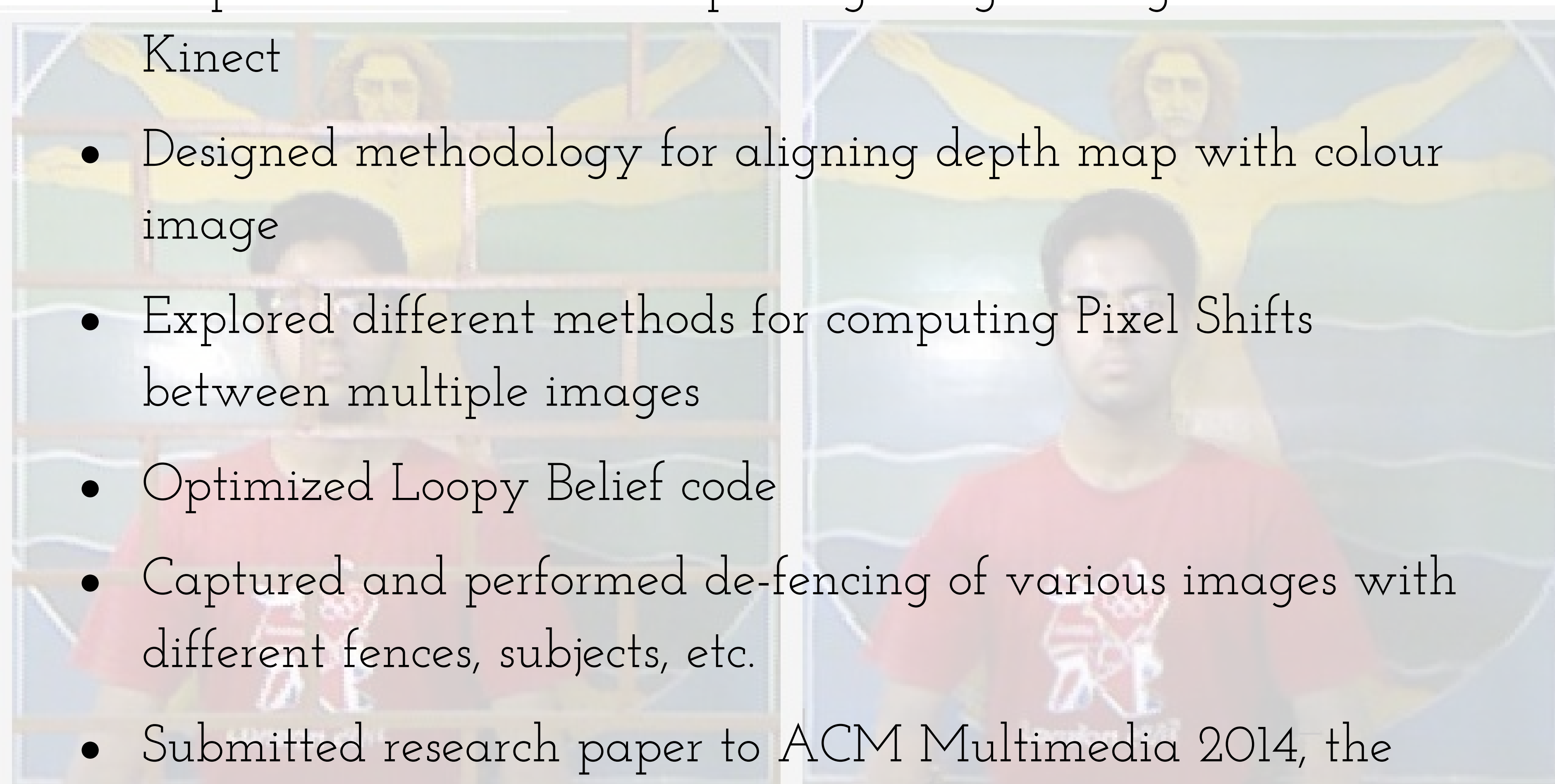


9. Precautions

3) Limited Pixel Shift

10. Conclusion

10. Conclusion



- Prepared workflow for capturing images using Microsoft Kinect
- Designed methodology for aligning depth map with colour image
- Explored different methods for computing Pixel Shifts between multiple images
- Optimized Loopy Belief code
- Captured and performed de-fencing of various images with different fences, subjects, etc.
- Submitted research paper to ACM Multimedia 2014, the 22nd International Conference on Multimedia

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Thank you.