FAKULTÄT FÜR !NFORMATIK
Faculty of Informatics

Diplomarbeitspräsentation

Temporal Upsampling for Image Sequences Using a Non-Local Means Algorithm

Masterstudium:
Visual Computing

Clemens Rögner

Technische Universität Wien
Institut für Computergraphik und Algorithmen
Arbeitsbereich: Computergraphik
BetreuerIn: Associate Prof. Dipl.-Ing. Dipl.-Ing. Dr.techn. Michael Wimmer
Betreuender Assistent: Dr. Johannes Hanika, Karlsruher Institut für Technologie (KIT)

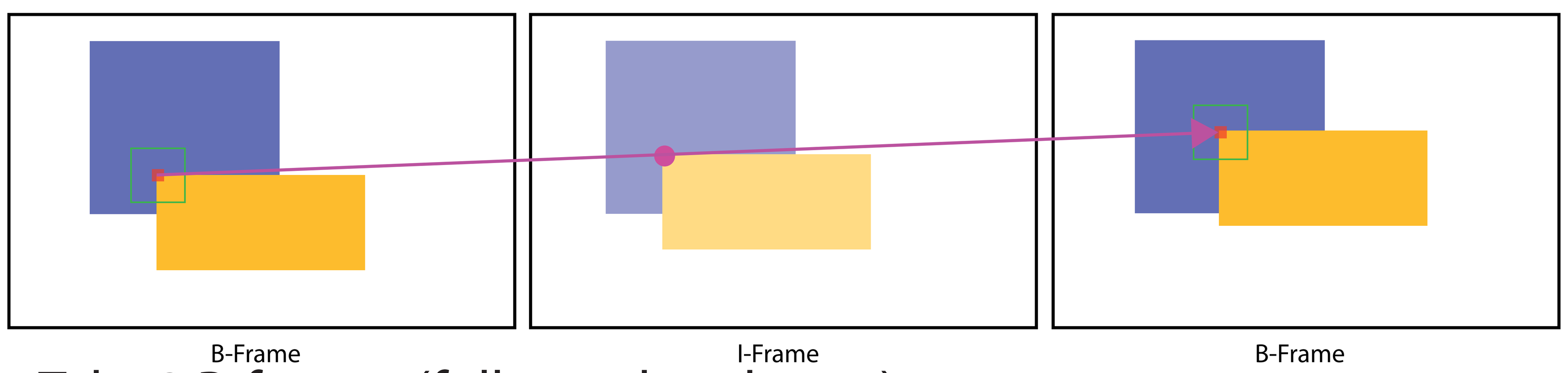
Problem and Motivation

- CGI Industry lately favors global-illumination (GI) and higher frame-rates, both of them increase visual quality but take longer for the image sequences to render.
- Temporal coherence (upsampling) methods for GI algorithms increase performance compared to regular rendering.
- Image-based upsampling techniques generate frames based on ground-truth ones and are in general significantly faster than the previous mentioned ones.
- However, upsampling techniques can not handle reflections and refractions correctly, because they result in motion of image features which is incoherent to the objects motion in the scene.

Contribution

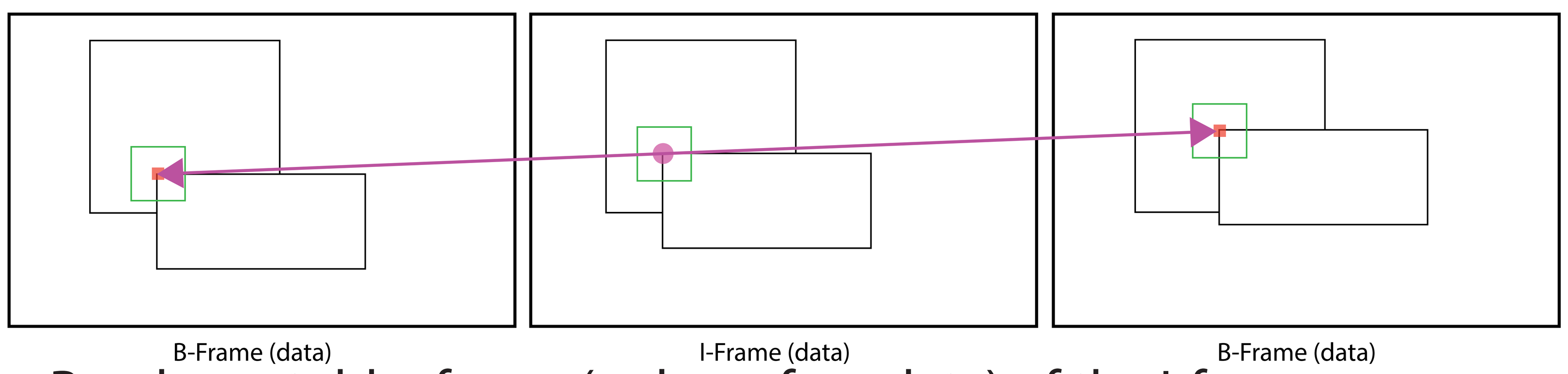
- Two image-based upsampling techniques, that use temporal coherence to create additional frames.
- Independency from rendering algorithm allows for portability.
- Preserves image features such as specular or transparent surfaces better than previous work.
- First to utilize the non-local means denoising algorithm for upsampling frames, because it does not rely on object movment, in contrast to previous work, and it can be optimized for parallel execution.
- More accurate than some image-based previous work.

Motion-Vector Technique



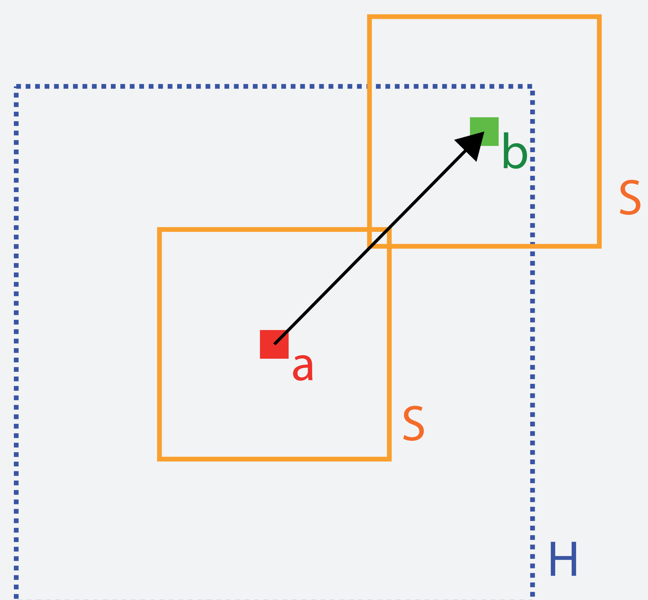
- Take 2 B-frames (fully rendered ones).
- Find similar pixels from one frame to the other based on the color, using the non-local means algorithm (with the difference in color as ξ). Those similarities can be interpreted as motion vectors.
- For each pixel in the I-frame (the interpolated one) find the source pixel in the B-frames based on the motion vectors.
- Mix the source pixel together or use the scene-assisted method of Yang et al. [1] as fallback.

Pixel-Similarity Technique



- Render a stubby frame (only surface data) of the I-frame.
- Search in adjacent B-frames for points with similar surface data, using the non-local means algorithm.
- The similarity measure ξ is made up of:
  - the diffuse surface similarity: point-location.
  - the specular surface similarity: location after reflection.
  - the transparent surface similarity: location after refraction.
- Color the I-frame based on the similarities.

Adapted Non-Local Means Algorithm

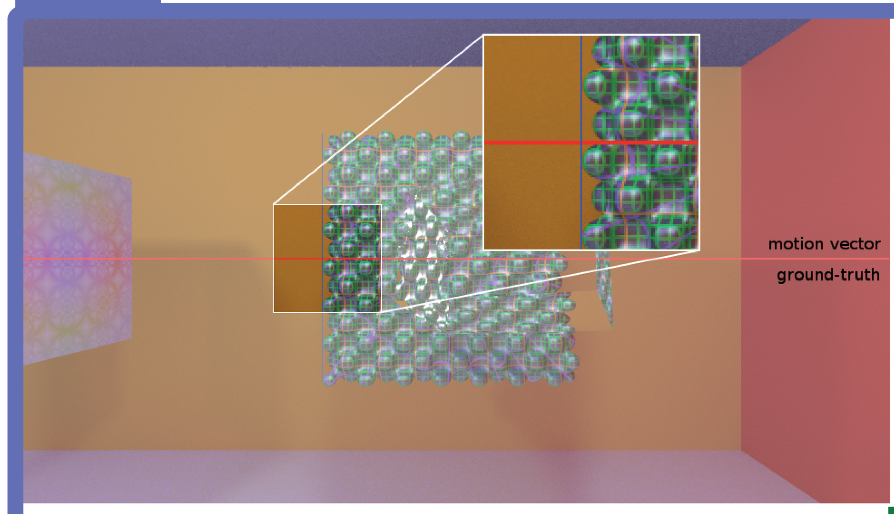


- Searches for similar pixels b in a pre-defined neighbourhood H around a.
- Two pixels a and b are similar if the pixels in their surrounding S match.
- A match in the sourrounding is calculated by the similarity measure ξ.
- How similar two pixels are, is defined by the sum of the smiliarity measures results.
- Can be optimized for parallel execution.
- Adaption stores the n most similar pixels.

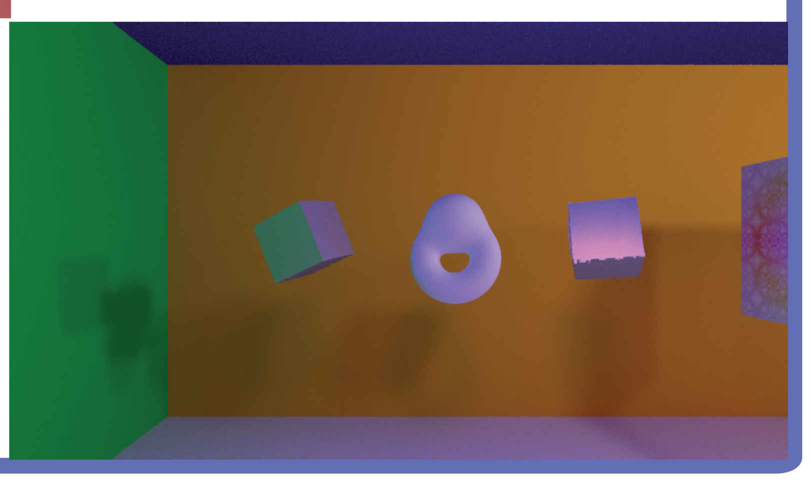
Unoptimized adapted non-local means:

```
for each pixel a in image do
  for each h in neighbourhood H do
    Σ = 0;
    for each s sourrounding S
      calculate  Σ += ξ(a+s,a+h+s)
    end
    keep if Σ maximal
  end
end
```

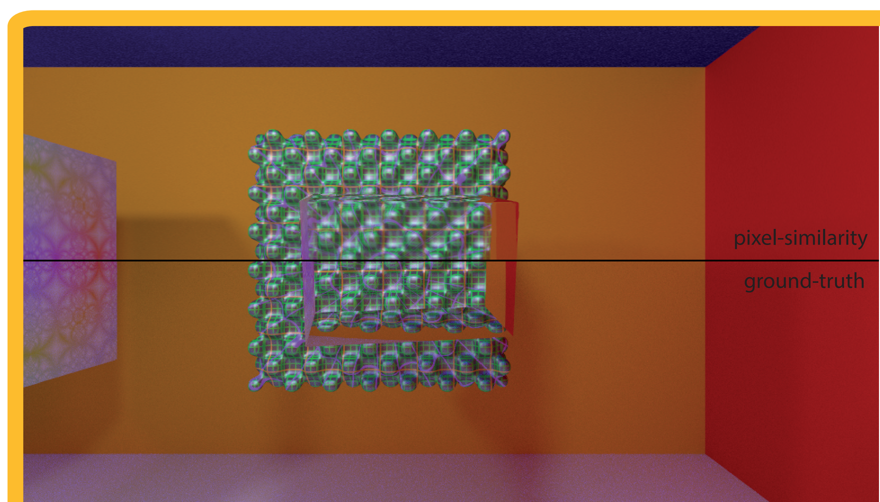
Results



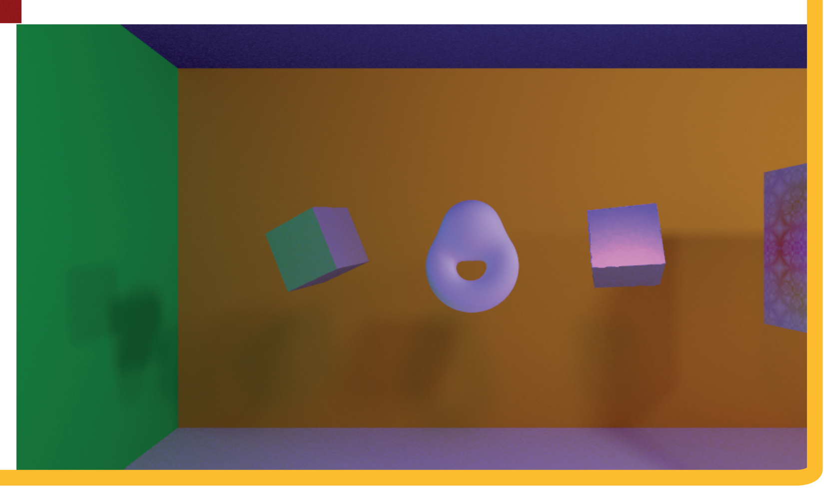
- Handles transparent objects better than other methods.
- Not data-dependent, unlike pixel-similarity technique.
- Color bleeding when new geometry shows, for example due to rotation.
- Edge location is off due to non-linear movement.



Results



- Handles reflections better than other methods.
- Edge-location always similar to ground-truth.
- Depends on availability of surface data. When the appropiate data is not available, it produces artifacts, e.g. at transparent surfaces.



[1] Lei Yang, Yu-Chiu Tse, Pedro V. Sander, Jason Lawrence, Diego Nehab, Hugues Hoppe, and Clara L. Wilkins. Image-based bidirectional scene reprojection. ACM Trans. Graph., 30(6):150:1–150:10, dec 2011.

Kontakt: clemens.roegner@gmx.at, wimmer@cg.tuwien.ac.at