Part Manipulation for Editing with Image-Based Rendering

Masters 2 Internship (6 months)

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Context and goal

Image-Based Rendering (IBR) [Buehler 01, Chaurasia 13], allows free-viewpoint 3D navigation of a real scene, captured with a set of photographs ("multi-view dataset"). The pose of the cameras is estimated with Structure from Motion, and a coarse 3D model computed with Multi-view stereo (MVS); IBR reprojects the input photos into novel views, allowing free-viewpoint navigation. While it provides high-quality free-viewpoint navigation, a major restriction is that current solutions only allow the user to interact with the scene *as it is at the moment of capture.*

In recent work, we have developed novel algorithms that greatly improve the quality of IBR [Hedman 16, Hedman 18]. We have also developed initial solutions that allow limited editing of these scenes by allowing the removal of elements (e.g., cars in a street) [Philip 18, Thonat 16]. There is currently no available solution that allows the modification (i.e., scaling, translation, cutting etc) of different pieces of a reconstructed scene, subsequently allowing IBR to be used with the modified scenes.

Figure 1: Our previous solution [Philip 18] allows simple removal of objects thanks to our multi-view inpainting algorithms, but does not allow editing (scaling, cutting etc) of the different objects in the scene.

Our goal in this internship is to develop new data structures and algorithms to allow these editing operations.

Approach

To solve this problem, the first task in this internship will be to build a simple interface for part segmentation and manipulation of the captured model. This involves selecting parts of the reconstructed 3D model based on geometry and image content, then identifying corresponding image pixels in the different input views (or even novel rendered views). To do this efficiently we need to design a data structure (e.g., based on superpixels [Achanta 12]) to accelerate interactive segmentation, driven by image content.

Once the parts are identified, the second task will be to generate a new set of images for the modified geometry, and then design and implement a multi-pass rendering approach to allow IBR for part-based models. The third task will involve the actual manipulation of the different parts of the model.

Generating New Images for Modified Geometry. We will start with the case of cutting pieces (i.e., reducing the size of an object). This is the easiest case, and will only require minor modification of the input images to handle potential artifacts at object borders, which can typically be treated with Poisson blending and some inpainting for boundaries and preserving structure.

We will then move on the harder case of extending surfaces. To generate the corresponding input image content, we will extend the multi-view inpainting solutions developed in the group [Thonat 16, Philip 18], and investigate potential additional view generation if required. There are two research challenges: first handling non-planar geometry, overcoming the limitation of [Philip18] and treating slightly non-diffuse materials. In particular, we will design a novel representation for non-diffuse materials to encode directional dependence, based on the original input images, possibly using interpolation to increase directional sample density.

Complete Rendering Algorithm. The complete solution will allow pieces of captured environments to be re-assembled and reused by rendering them in different contexts. The novel rendering algorithm will involve new spatial data structures to allow efficient rendering of the separate edited objects, possibly originating from different captures. Some level of color harmonization will also be included to provide coherent rendering (e.g., for the more diffuse parts of the objects).

A target application will be the integration of reconstructed houses with the current-day remains of the prehistoric site of Catalhoyuk, which we have captured for image-based rendering techniques in the context of the EU project EMOTIVE.

The intern will develop this research in the existing C++/OpenGL software framework of the group that includes existing implementations of [Buehler 01, Ortiz-Cayon 15, Hedman 16 and 18].

Work environment and requirements

The internship will take place at Inria Sophia Antipolis, in the beautiful French Riviera. Inria will provide a monthly stipend between 450 and 1100€ depending on the situation of the candidate. The intern will work closely with the Ph.D. students in the group.

Candidates should have strong programming and mathematical skills as well as knowledge in computer graphics (a 4th year or higher graphics course is desirable), computer vision, geometry processing and machine learning. Successful Masters internships may lead to a Ph.D. in the context of the ERC FUNGRAPH project (http://fungraph.inria.fr)

References

[Achanta 12] ACHANTA, Radhakrishna, SHAJI, Appu, SMITH, Kevin, *et al.* SLIC superpixels compared to state-of-the-art superpixel methods. *IEEE transactions on pattern analysis and machine intelligence*, 2012, vol. 34, no 11, p. 2274-2282.

[Buehler 01] C. BUEHLER, M. BOSSE, L. MCMILLAN, S. GORTLER, and M. COHEN. "Unstructured lumigraph rendering." In *Proceedings SIGGRAPH 2001*, pp. 425-432. ACM, 2001.
https://www.ics.uci.edu/~gopi/ICS280Win02/UnstructuredLumigraph.pdf

[Chaurasia 13] G. CHAURASIA, S. DUCHENE, O. SORKINE-HORNUNG, & G. DRETTAKIS. (2013). Depth synthesis and local warps for plausible image-based navigation. *ACM Transactions on Graphics (TOG)*, *32*(3), 30.

http://www-sop.inria.fr/reves/Basilic/2013/CDSD13/

[Hedman 16] P. HEDMAN, T. RITSCHEL, G. DRETTAKIS, G. BROSTOW, Scalable Inside-Out Image-Based Rendering, ACM Transactions on Graphics 35 (SIGGRAPH Asia), 6, December 2016
http://www-sop.inria.fr/reves/Basilic/2016/HRDB16/

[Hedman 18] P. HEDMAN, J. PHILIP, T. PRICE, J.-M. FRAHM, G. DRETTAKIS, G. BROSTOW, Deep Blending for Image-Based Rendering, ACM Transactions on Graphics 37 (SIGGRAPH Asia), 6, Dec. 2018
http://www-sop.inria.fr/reves/Basilic/2018/HPPFDB18/

[Ortiz-Cayon 15] ORTIZ-CAYON, Rodrigo, DJELOUAH, Abdelaziz, et DRETTAKIS, George. A bayesian approach for selective image-based rendering using superpixels. In : *International Conference on 3D Vision-3DV*. 2015.

http://www-sop.inria.fr/reves/Basilic/2015/ODD15/

[Philip 18] PHILIP, Julien et DRETTAKIS, George. Plane-based multi-view inpainting for image-based rendering in large scenes. In : *Proceedings of the ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games*. ACM, 2018. p. 6.

http://www-sop.inria.fr/reves/Basilic/2018/PD18/

[Thonat 16] THONAT, Theo, SHECHTMAN, Eli, PARIS, Sylvain, *et al.* Multi-view inpainting for image-based scene editing and rendering. In : *2016 International Conference on 3D Vision (3DV)*. 2016.
http://www-sop.inria.fr/reves/Basilic/2016/TSPD16/