We ran 3DFlow on a variety of datasets. Full source code, executable binaries for OSX and Linux, and datasets are provided. This supplemental document showcases the datasets at different levels of detail and rendered with different visualization options. The mesh figures are rendered at high resolution; zoom in for more details.

Some of the mesh figures were rendered using a modified environment mapping shader, a technique called matcaps. Matcaps simulate complex material and lighting setups and are often used by sculpting artists to help either emphasize or demphasize the high-frequency details, depending on artist’s preference or the current workflow phase. For example, highly specular or glossy looking matcaps accentuate wrinkles, sharp edges, and surface normals, while highly diffuse matcaps smooth out the appearance for blocking-out phase, focusing on contours and shape. The surface change magnitude can be used to mix appearance of two matcaps.

A few dependency graphs, or degraphs, are included in Figures 10 and 11. A node exists for every delta in the original input, labeled with the index of the delta. Directed edges indicate spatial dependencies (orange) and temporal dependencies (blue). The nodes across the very top correspond to the creation of completely disconnected components, where surfaces were added in a delta but none were deleted. Full resolution versions are available as separate documents.

The sculpting workflows were created by professional artists. The subdivision sculpting workflows used subdivision tessellation to control the mesh resolution, while the dynamic sculpting workflows used a dynamic remeshing technique that automatically controls the tessellation of the surface.

The polygonal modeling workflows were created using polygonal modeling techniques, such as box modeling, extrusion, and modeling by parts. The helmet, hydrant, robot, shark, biped workflows are the inputs to MeshFlow [Denning et al. 2011].

The durano [Vazquez 2009] and creature [Goralczyk 2008] workflows are from two Blender open movie workshop DVDs. The durano workflow is one of the inputs to MeshGit [Denning and Pellacini 2013].

The sintel [Blender Foundation 2011] workflow is extracted from the production repository [Roosendaal 2011] of the open movie Sintel [Blender Foundation 2011]. It contains 210 of the 353 commits to the file pro/chars/sintel.blend, only the commits that actually modified the mesh. In at least one version during the production, the blend file had included: a ground plane, several artifacts (staff, backpack, sunglasses, etc.), multiple versions early in the development phase, a low-resolution version for animation, reposing of character during rigging phase, and a significant rescaling of the character. All of these mesh changes and additions are included as input to 3DFlow.

The digital sculpting workflows and the helmet, hydrant, robot, shark, and biped workflows were created using an instrumented version of Blender that saved a snapshot of the mesh after every change. The durano, creature, and sintel workflows were created by periodically committing saved files, which is typical of a normal digital artist workflow.

References


Figure 1: The input to 3DFlow is a sequence of meshes with optional edit and software information. All 797 meshes of the monster workflow are rendered. Edit information can include which tool or command was used to modify the mesh. Software information can include visualization settings or viewing orientation.
Figure 2: From the original input sequence, we compute a sequence of mesh deltas to capture changes between meshes. The mesh deltas of monster workflow are rendered with transparency. Green indicates added polygons, and red indicates deleted polygons.
Figure 3: Monster workflow summarized in 2, 4, 8, 16, 32 steps without highlighting.
Figure 4: Monster workflow rendered using golden highlights over a pedestal with a drop shadow and mirror effects. Brighter highlights indicate stronger changes to surface. The mirror allows both sides of mesh to be seen simultaneously.

Figure 5: Monster workflow rendered with fixed camera location and orientation (left) and dynamic camera that centers on and zooms into areas of change (right).
Figure 6: Monster workflow rendered using two colors. Blue indicates surfaces that are "pulled out", and orange indicates surfaces that are "pushed in".

Figure 7: Monster workflow rendered blending two matcaps. Unchanged surfaces are rendered with a dull, dark gray matcap, and strongly changed surfaces with a glossy red matcap.
Figure 8: Monster mesh exported from 3DFlow, imported into Blender, and rendered using Cycles.

Figure 9: Monster workflow rendered using dark gray matcap and with tool usage overlaid. The annotations are filtered at 92%, 84%, 80%, 80% for the entire level (respectively) to reduce clutter and prevent occluding view of mesh. The color of the strokes indicate the type of sculpting tool used.
Figure 10: Visualization of depgraphs. Full resolution versions available in supplemental. There is a node (black) for every delta in the original input, labeled with the index of the corresponding delta. Directed edges indicate temporal dependencies (blue) and spatial dependencies (orange) of respective deltas. The nodes across the very top correspond to the creation of completely disconnected components.
Figure 11: Visualization of depgraphs (continued). Note: the merman workflow used subdivision techniques to control resolution. Changing the level of subdivision not only increases the number of faces and vertices in the mesh, it also smooths the surface, which is considered an edit in 3DFlow. Because subdivision is a global operation, it depends spatially on all previous edits, and all following edits spatially depend on it.
Figure 12: Gargoyle workflow of 819 original deltas summarized in 4,8,16,32 steps.

Figure 13: Sintel workflow of 210 original deltas summarized in 2,4,8,16 steps. Unchanged faces are drawn at 50% transparency in order to show changes that would otherwise be hidden.
Figure 14: Alien workflow of 2118 original deltas summarized in 2,3,4,8,16,32 steps. The initial mesh, a cube, was not held out while being summarized.
Figure 15: Biped workflow of 1267 original deltas summarized in 4,8,16,32 steps. The initial mesh, a cube, was not held out while being summarized.

Figure 16: Creature workflow of 123 original deltas summarized in 4,8,16,32 steps. Note: the creature mesh was significantly rescaled when the ground plane was added. We used different viewing orientations for before and after this rescaling to best show the changes.
Figure 17: Durano workflow of 11 original deltas summarized in 4,8,11 steps.

Figure 18: Elder workflow of 2958 original deltas summarized in 4,8,16,32 steps. Note: the artist used subdivision surface rules to control mesh resolution for this workflow. Whenever the artist increased the level of subdivision, the vertices are moved to smooth the surface. This is considered an edit and therefore seen in the renders as speckling of highlights. Although the geometry count nearly quadruples every time subdivision increases, 3DFlow considers only the surface area and delta coverage for the cost function, and therefore is able to produce intuitive summaries.
Figure 19: Elf workflow of 4125 original deltas summarized in 4, 8, 16, 32 steps using a fixed viewing position. In this workflow, the artist rescaled and changed the proportions of the mesh multiple times. The initial mesh, a cube, was not held out during summarization.
Figure 20: Engineer workflow of 863 original deltas summarized in 4, 8, 16, 32 steps.
Figure 21: Explorer workflow of 1699 original deltas summarized in 4, 8, 16, 32 steps.
Figure 22: Gorilla workflow of 2482 original deltas summarized in 4, 8, 16, 32 steps. The meshes are rendered with a pedestal and drop shadow and mirror effects.

Figure 23: Merman workflow of 2218 original deltas summarized in 4, 8, 16, 32 steps. The meshes are rendered with a pedestal and drop shadow and mirror effects.
Figure 24: Helmet workflow of 1321 original deltas summarized in 4, 8, 16, 32 steps.

Figure 25: Man workflow of 1459 original deltas summarized in 4, 8, 16, 32 steps.
Figure 26: Hydrant workflow of 691 original deltas summarized in 4, 8, 16, 32 steps.
Figure 27: Ogre workflow of 1459 original deltas summarized in 4,8,16,32 steps.

Figure 28: Robot workflow of 1810 original deltas summarized in 4,8,16,32 steps.
**Figure 29:** Fighter workflow of 1532 original deltas summarized in 4,8,16,32 steps. The meshes are rendered with a pedestal and drop shadow and mirror effects.

**Figure 30:** Gargoyle workflow of 819 original deltas summarized in 4,8,16,32 steps.
Figure 31: Shark workflow of 1457 original deltas summarized in 4,8,16,32 steps.

Figure 32: Sage workflow of 1686 original deltas summarized in 4,8,16,32 steps.