Micropolygon Modeling: A New Paradigm for Authoring High-Poly Meshes

Benjamin Mastripolito
University of Utah
Salt Lake City, UT, USA
ben_jpm@pm.me

Rushikesh Vidye
University of Utah
Salt Lake City, UT, USA
vidye.rushikesh@utah.edu

Amarnath Murugan
Marmoset Toolbag
Salt Lake City, UT, USA
amarnath@marmoset.co

Dhruv Ram
University of Utah
Salt Lake City, UT, USA
dhruv.ram@utah.edu

Cem Yuksel
University of Utah
Salt Lake City, UT, USA
cem@cemyuksel.com

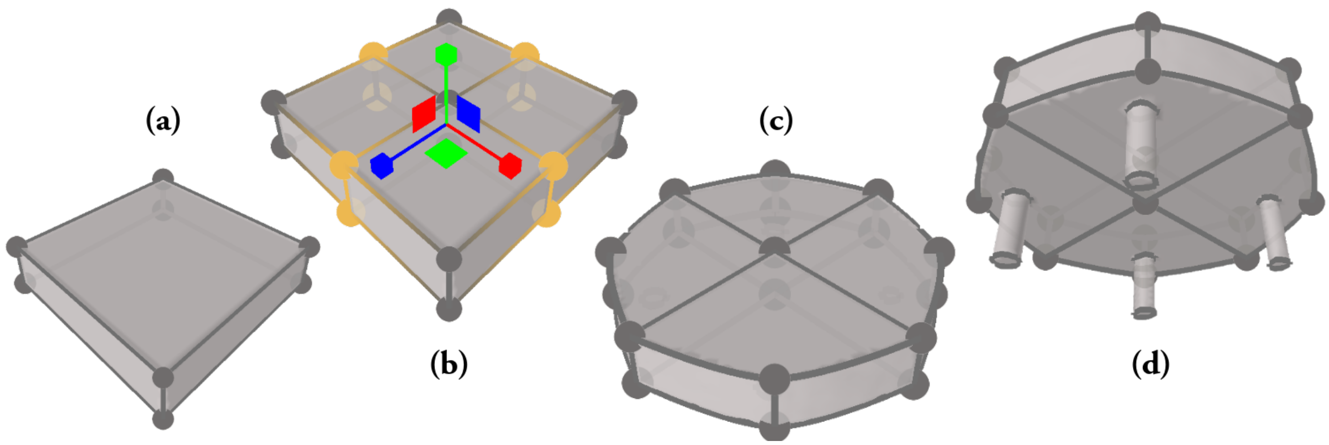

Figure 1: *Micropolygon Modeling workflow. Starting from a simple mesh, the user defines editable regions using slice and transform operations, then applies modeling tools such as carve and extrude, while the underlying high-resolution triangle mesh is automatically maintained, and its topology is kept hidden from the user. Only the topology of the high-level elements (identified by the user) remains visible.*

Abstract

Polygon meshes are popular for modeling 3D objects, but mastering polygonal modeling is a challenging task. This is mainly because polygonal modeling involves working at a low level of abstraction, manipulating vertices, edges, and faces of a potentially high-resolution mesh, while relying on additional tools such as subdivision, retopology, and rigging to bridge the gap between intended shape and editable representation. We explore an alternative in which polygon meshes are treated as a geometric substrate rather than the primary authoring interface.

We present Micropolygon modeling, a user-authored interactive segmentation of a 3D surface into meta-primitives that serve as an intuitive high-level interface for organic and hard-surface modeling. The underlying micropolygon mesh is maintained and re-meshed automatically, so that edits are expressed over the meta-structure rather than over individual polygons. A set of familiar polygonal modeling operations applied to this structure, along with brushing tools that can alter the high-resolution geometry without exposing the high-resolution topology.

SIGGRAPH Posters '26, Los Angeles, CA, USA

ACM ISBN 979-8-4007-2548-7/2026/07
https://doi.org/10.1145/3799825.3818772

CCS Concepts

• **Computing methodologies** → **Shape modeling**; **Mesh models**; • **Human-centered computing** → *Interaction design theory, concepts and paradigms.*

ACM Reference Format:
Benjamin Mastripolito, Rushikesh Vidye, Amarnath Murugan, Dhruv Ram, and Cem Yuksel. 2026. Micropolygon Modeling: A New Paradigm for Authoring High-Poly Meshes. In *Special Interest Group on Computer Graphics and Interactive Techniques Conference Posters (SIGGRAPH Posters '26), July 19–23, 2026, Los Angeles, CA, USA.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3799825.3818772

1 Introduction

Polygonal modeling represents 3D objects as collections of connected faces, edges, and vertices. While this representation is expressive and widely adopted, it is inherently low-level: the unit of interaction is the polygon, not the region or feature the artist intends to manipulate. Constructing or modifying shapes often requires sequences of localized edits while maintaining clean topology so that future operations remain viable, and modern workflows rely heavily on auxiliary tools such as subdivision surfaces, retopology pipelines, and skeleton-based deformation with weight maps.

These tools address a mismatch between how artists conceptualize form and how modeling systems expose it. Artists often author through regions, boundaries, and features, while polygonal meshes expose low-level elements, so a substantial portion of modeling effort is devoted to topology management alongside shape design.

We propose a shift in modeling abstraction. Rather than treating the mesh as the primary interface, we treat it as a maintained substrate and introduce a higher-level representation built on top of it. In our *Micropolygon Modeling* system, users edit a persistent, user-authored structure of regions, boundaries, and points (meta-faces, meta-edges, and meta-vertices), while the system maintains the underlying high-resolution triangle mesh automatically. The meta-structure is the primary editable object: edits are expressed over it rather than over individual polygons, newly created structure persists and remains available to later operations, and the system keeps the triangle mesh consistent throughout. This separates *authoring intent* from *geometric detail* and reduces the need for explicit topology management.

We introduce an authoring-first representation for high-poly mesh modeling, in which a persistent user-authored structure of meta-faces, meta-edges, and meta-vertices, rather than the polygon mesh, is the primary editing interface. Our system provides a unified interaction model in which a small set of operations, transforms, extrusion, slicing, and carving, performs region-level editing, additive modeling, and re-segmentation, with newly created structure remaining reusable in later edits. We have built an interactive prototype demonstrating these behaviors. The contribution is the abstraction and interaction model rather than new low-level remeshing or deformation algorithms.

2 Related Work

Micropolygon Modeling relates to several high-level modeling paradigms but differs from each in a consistent way: the artist-authored structure is the persistent primary representation, while the triangle mesh is maintained by the system.

CAD and high-level solid modeling. Computer-aided design also exposes modeling above individual elements, typically through feature-based parametric modeling and boundary-representation direct modeling, where constraints and design intent are central [Bodein et al. 2014]. We instead target freeform, densely triangulated surface authoring rather than exact, manufacturable solids, and the maintained artifact is an adaptively remeshed triangle mesh.

Segmentation and structure-aware editing. Mesh segmentation partitions a surface into meaningful parts for downstream processing and analysis [Mitra et al. 2013; Shamir 2008]. In our setting the partition is not preparatory: it is the persistent primary object of authoring, and the mesh is updated to match it.

Deformation handles and cages. A large class of editing methods drives deformation through sparse handles or an enclosing cage, keeping mesh connectivity fixed and changing only vertex positions [Jacobson et al. 2011]; we refer to Ströter et al. [2024] for a recent survey. Our control structure is itself authored, evolves through carving and slicing, and re-segments and remeshes the surface as it changes.

Sculpting and retopology tools. Production tools provide region groupings such as Blender face sets and sculpt masks [Blender Online Community 2025] and ZBrush polygroups [Maxon Computer 2025a], and group boundaries can guide a one-shot retopology pass [Jakob et al. 2015; Maxon Computer 2025b]. These remain auxiliary groupings on a mesh the artist still edits at the polygon or brush level. Our closest distinction is persistence: the authored regions and boundaries remain the primary target of later edits and drive continuous maintenance of the underlying mesh.

3 Micropolygon Modeling

Our approach has three components: the meta-geometry representation, an automatic geometry update, and a set of interactive operations on meta-level elements. The user edits the meta-geometry; the system maintains the underlying high-resolution triangle mesh.

The representation consists of meta-faces, meta-edges, and meta-vertices. A meta-face represents a continuous region of the surface, potentially spanning many triangles. Meta-edges define boundaries between adjacent meta-faces, and meta-vertices act as anchor locations at meta-edge intersections or within meta-faces. Together they form a user-defined segmentation that encodes authoring intent independently of mesh resolution. Meta-elements are explicitly connected, so operations propagate coherently across the structure and newly created meta-elements persist and remain editable like the original segmentation.

Edits to the meta-structure are propagated to the underlying mesh automatically. When a user modifies a meta-face, meta-edge, or meta-vertex, the affected region is updated and locally remeshed so that it remains well-formed for further editing, following adaptive schemes similar to prior work on real-time mesh deformation [Dunyach et al. 2013], while preserving the boundaries defined by the meta-structure. Interaction therefore stays focused on high-level structure rather than low-level topology.

User interaction is defined through a small set of operations. Translation, rotation, and scaling propagate across connected meta-elements, producing region-level deformation without a separate rigging or weight-painting workflow [Jacobson et al. 2011]. Extrusion displaces a selected meta-face along its normal, producing an additive form bounded by the meta-face's own boundary. Slicing and carving introduce new meta-edges, re-segmenting the surface without explicit topology restructuring. In each case the structure produced by one operation is immediately available to the next.

4 Demonstration

We demonstrate Micropolygon Modeling through representative operations performed on meta-faces, meta-edges, and meta-vertices. Figure 1 follows a single object through the full workflow, and Figure 2 isolates an operation on a high-poly surface with a non-linear boundary.

Starting from a simple mesh (Figure 1a), slicing re-segments the surface by introducing new meta-edges, creating smaller editable meta-faces without changing the overall shape (Figure 1b). Slicing

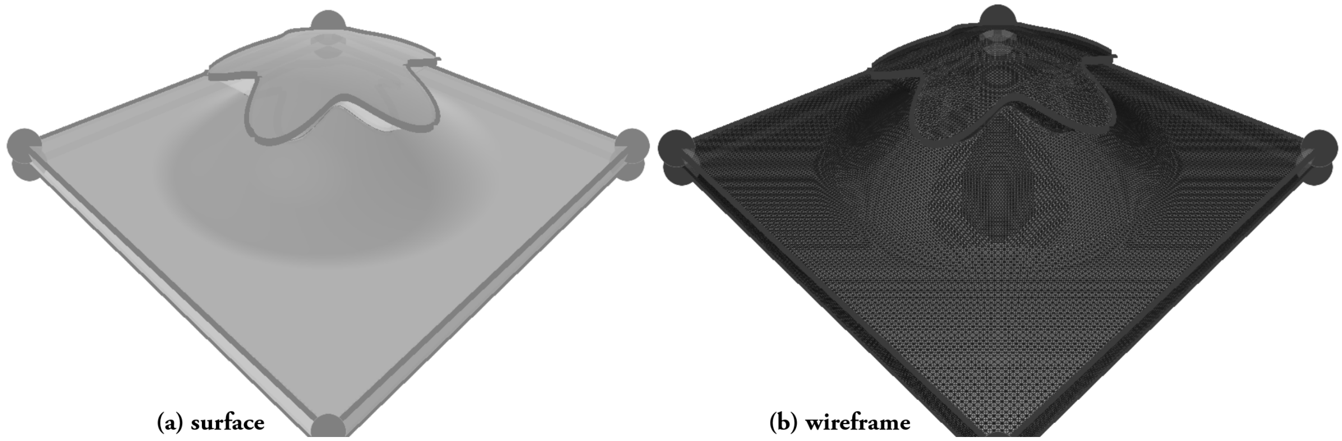

Figure 2: *An operation on a high-poly surface. (a) A flower-shaped meta-face whose curved outline is a non-linear meta-edge. (b) The maintained mesh beneath it, a dense field of sub-pixel micropolygons rather than a coarse control cage.*

is a structural edit, and the resulting meta-faces remain available for later operations. Region-level transforms then act on the connected meta-faces together, reshaping the sliced block into a rounded disk (Figure 1c); the transform propagates across the structure without a separate rigging or weight-painting step. Carving works the same way, adding persistent closed boundaries inside existing meta-faces, and those regions are reused as the input to extrusion, which displaces them along their normals into the legs of the table (Figure 1d). This is the central workflow: structure created by one operation persists and becomes the input to the next, while the user keeps working above the triangle mesh. Each meta-face looks like a single low-resolution facet but is composed of many sub-pixel triangles that can be shaped freely without exposing their topological connections.

Figure 2 shows a single high-poly surface that makes the scale of the maintained mesh explicit. The authored region is bounded by a smooth, flower-shaped meta-edge (Figure 2a): a meta-edge need not be a straight segment, but can follow a freeform, non-linear curve and still be selected, transformed, and reused like any other boundary. The maintained mesh beneath it (Figure 2b) is a dense field of triangles finer than a pixel, so the region shaped at the meta level is backed by true sub-pixel micropolygons rather than a coarse control cage. The user edits only the meta-face and its curved boundary, while the system maintains the micropolygon mesh.

5 Conclusion and Future Work

We have presented Micropolygon Modeling, a structure-aware representation for 3D modeling that shifts the focus from polygon-level editing to higher-level authoring. By treating the mesh as a maintained substrate and exposing a persistent user-authored segmentation as the primary interface, a small set of familiar operations expresses region-level deformation, additive modeling, and re-segmentation within a single interaction model. Our contribution is this authoring abstraction and interaction model rather than new low-level re-meshing or deformation algorithms.

Our system is an early prototype, and our evaluation is qualitative. We do not yet have an artist study or production-scale comparison, robustness on meshes with high topological complexity remains open, and the approach is not intended as exact, constraint-driven solid modeling. Promising directions include symmetric editing across a user-specified plane, fitting parametric curves to borders for smoother boundaries, and integrating automatic retopology [Jakob et al. 2015] to connect meta-level authoring to downstream animation and simulation.

References

Blender Online Community. 2025. Visibility, Masking & Face Sets — Blender Manual. https://docs.blender.org/manual/en/latest/sculpt_paint/sculpting/introduction/visibility_masking_face_sets.html. Accessed: 2026-06-01.

Yannick Bodein, Bertrand Rose, and Emmanuel Caillaud. 2014. Explicit reference modeling methodology in parametric CAD system. *Computers in Industry* 65, 1 (2014), 136–147. doi:10.1016/j.compind.2013.08.004

Marion Dunyach, David Vanderhaeghe, Loïc Barthe, and Mario Botsch. 2013. Adaptive Remeshing for Real-Time Mesh Deformation. In *Eurographics 2013 — Short Papers*. Eurographics Association, 29–32. doi:10.2312/conf/EG2013/short/029-032

Alec Jacobson, Ilya Baran, Jovan Popović, and Olga Sorkine. 2011. Bounded biharmonic weights for real-time deformation. *ACM Transactions on Graphics* 30, 4, Article 78 (July 2011), 8 pages. doi:10.1145/2010324.1964973

Wenzel Jakob, Marco Tarini, Daniele Panozzo, and Olga Sorkine-Hornung. 2015. Instant field-aligned meshes. *ACM Transactions on Graphics* 34, 6, Article 189 (Nov. 2015), 15 pages. doi:10.1145/2816795.2818078

Maxon Computer. 2025a. ZBrush Documentation: PolyGroups. https://help.maxon.net/zbr/en-us/. Accessed: 2026-06-01.

Maxon Computer. 2025b. ZBrush Documentation: ZRemesher. https://help.maxon.net/zbr/en-us/Content/html/reference-guide/tool/polymesh/geometry/zremesher/zremesher.html. Accessed: 2026-06-01.

Niloy J. Mitra, Michael Wand, Hao Zhang, Daniel Cohen-Or, Vladimir Kim, and Qi-Xing Huang. 2013. Structure-aware shape processing. In *SIGGRAPH Asia 2013 Courses*. doi:10.1145/2542266.2542267

Ariel Shamir. 2008. A survey on mesh segmentation techniques. *Computer Graphics Forum* 27, 6 (2008), 1539–1556. doi:10.1111/j.1467-8659.2007.01103.x

Daniel Ströter, Jean-Marc Thiery, Kai Hormann, Jiong Chen, Qingjun Chang, Sebastian Besler, Johannes Sebastian Mueller-Roemer, Tamy Boubekeur, André Stork, and Dieter W. Fellner. 2024. A Survey on Cage-based Deformation of 3D Models. *Computer Graphics Forum* 43, 2 (2024), e15060. doi:10.1111/cgf.15060