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Reverse Engineering in Simulation - Bridging Meshes and CAD for Seamless Integration

Abstract:
Reverse engineering (RE) has traditionally served as a bridge between physical artifacts and their digital representations, enabling applications from product benchmarking to piracy mitigation. While optical scanners and point clouds dominate the RE landscape, the increasing prevalence of simulation meshes introduces a unique opportunity to extend RE methodologies into the virtual domain. A simulation mesh, despite its origins in computational analysis, shares many structural characteristics with a scanned mesh, suggesting it can be processed using similar RE techniques. This paper explores the integration of reverse engineering methodologies into simulation workflows, focusing on converting simulation meshes into CAD models to enhance compatibility and usability. Such conversions, while promising, often encounter limitations: the output is typically non-parametric, reduced to static freeform patches that lack the flexibility of true CAD geometry. Addressing these challenges, we provide a comprehensive overview of current techniques for mesh-to-CAD transformation, including automated surfacing, parametric reconstruction, and hybrid approaches. Key advancements discussed include adaptive patching for improved accuracy, incorporating geometric primitives into mesh reconstruction, and leveraging software tools for parametric solid modeling. Each approach's benefits and drawbacks are critically examined, with emphasis on balancing usability, computational efficiency, and geometric fidelity. Case studies illustrate how these techniques enable applications such as enhanced simulation validation, manufacturing integration, and digital twin creation. While no single method achieves universal applicability, the alignment of RE techniques with simulation outputs presents a scalable framework adaptable to various use cases. By treating simulation meshes as virtual "scanned" data, the paper argues for a paradigm shift that promotes tighter integration of simulation and design workflows. The findings are supported by insights from existing RE solutions, offering a roadmap for adopting these methodologies across industries. This study underscores that bridging simulation and CAD is not merely a technical challenge but a strategic opportunity to unlock the full potential of simulation data. By fostering interoperability and efficiency, reverse engineering becomes a linchpin in the next generation of digital engineering ecosystems.

Speaker:

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