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VERAM: View-Enhanced Recurrent Attention Model for 3D Shape Classification

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Abstract
Multi-view deep neural network is perhaps the most successful approach in 3D shape classification. However, the fusion of multi-view features based on max or average pooling lacks a view selection mechanism, limiting its application in, e.g., multi-view active object recognition by a robot. This paper presents VERAM, a recurrent attention model capable of actively selecting a sequence of views for highly accurate 3D shape classification. VERAM addresses an important issue commonly found in existing attention-based models, i.e., the unbalanced training of the subnetworks corresponding to next view estimation and shape classification. The classification subnetwork is easily overfitted while the view estimation one is usually poorly trained, leading to a suboptimal classification performance. This is surmounted by three essential view-enhancement strategies: 1) enhancing the information flow of gradient backpropagation for the view estimation subnetwork, 2) devising a highly informative reward function for the reinforcement training of view estimation and 3) formulating a novel loss function that explicitly circumvents view duplication. Taking grayscale image as input and AlexNet as CNN architecture, VERAM with 9 views achieves instance-level and class-level accuracy of 95.5% and 95.3% on ModelNet10, 93.7% and 92.1% on ModelNet40, both are the state-of-the-art performance under the same number of views.

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Mechanics-Aware Modeling of Cloth Appearance

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Abstract
Micro-appearance models have brought unprecedented fidelity and details to cloth rendering. Yet, these models neglect fabric mechanics: when a piece of cloth interacts with the environment, its yarn and fiber arrangement usually changes in response to external contact and tension forces. Since subtle changes of a fabric's microstructures can greatly affect its macroscopic appearance, mechanics-driven appearance variation of fabrics has been a phenomenon that remains to be captured. We introduce a mechanics-aware model that adapts the microstructures of cloth yarns in a physics-based manner. Our technique works on two distinct physical scales: using physics-based simulations of individual yarns, we capture the rearrangement of yarn-level structures in response to external forces. These yarn structures are further enriched to obtain appearance-driving fiber-level details. The cross-scale enrichment is made practical through a new parameter fitting algorithm for simulation, an augmented procedural yarn model coupled with a custom-design regression neural network. We train the network using a dataset generated by joint simulations at both the yarn and the fiber levels. Through several examples, we demonstrate that our model is capable of synthesizing photorealistic cloth appearance in a dynamic and mechanically plausible way.

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Spectral Analysis of Quadrature Rules and Fourier Truncation-based Methods Applied to Shading Integrals

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Abstract
We propose a theoretical framework, based on the theory of Sobolev spaces, that allows for a comprehensive analysis of quadrature rules for integration over the sphere. We apply this framework to the case of shading integrals in order to predict and analyze the performances of quadrature methods. We show that the spectral distribution of the quadrature error depends not only on the samples set size, distribution and weights, but also on the BRDF and the integrand smoothness. The proposed spectral analysis of quadrature error allows for a better understanding of how the above different factors interact. We also extend our analysis to the case of Fourier truncation-based techniques applied to the shading integral, so as to find the smallest spherical/hemispherical harmonics degree L (truncation) that entails a targeted integration error. This application is very beneficial to global illumination methods such as Precomputed Radiance Transfer and Radiance Caching. Our proposed framework is the first to allow a direct theoretical comparison between quadrature- and truncation-based methods applied to the shading integral. This enables, for example, to determine the spherical harmonics degree L which corresponds to a quadrature-based integration with N samples. Our theoretical findings are validated through a set of rendering experiments.

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Localization and Completion for 3D Object Interactions

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Abstract
Finding where and what objects to put into an existing scene is a common task for scene synthesis and robot/character motion planning. Existing frameworks require development of hand-crafted features suitable for the task, or full volumetric analysis that could be memory intensive and imprecise. In this paper, we propose a data-driven framework to discover a suitable location and then place the appropriate objects in a scene. Our approach is inspired by computer vision techniques for localizing objects in images: using an all directional depth image (ADD-image) that encodes the 360-degree field of view from samples in the scene, our system regresses the images to the position where the new

object can be located. Given several candidate areas around the host object in the scene, our system predicts the partner object whose geometry fit well to the host object. Our approach is highly parallel and memory efficient, and is especially suitable for handling interactions between large and small objects. We show examples where the system can hang bags on hooks, fit chairs in front of desks, put objects into shelves, insert flowers into vases, and put hangers onto laundry rack.