School of Computing Collaboration with NVIDIA Leads to a Breakthrough in Real-Time Graphics, *to be presented at SIGGRAPH 2022*

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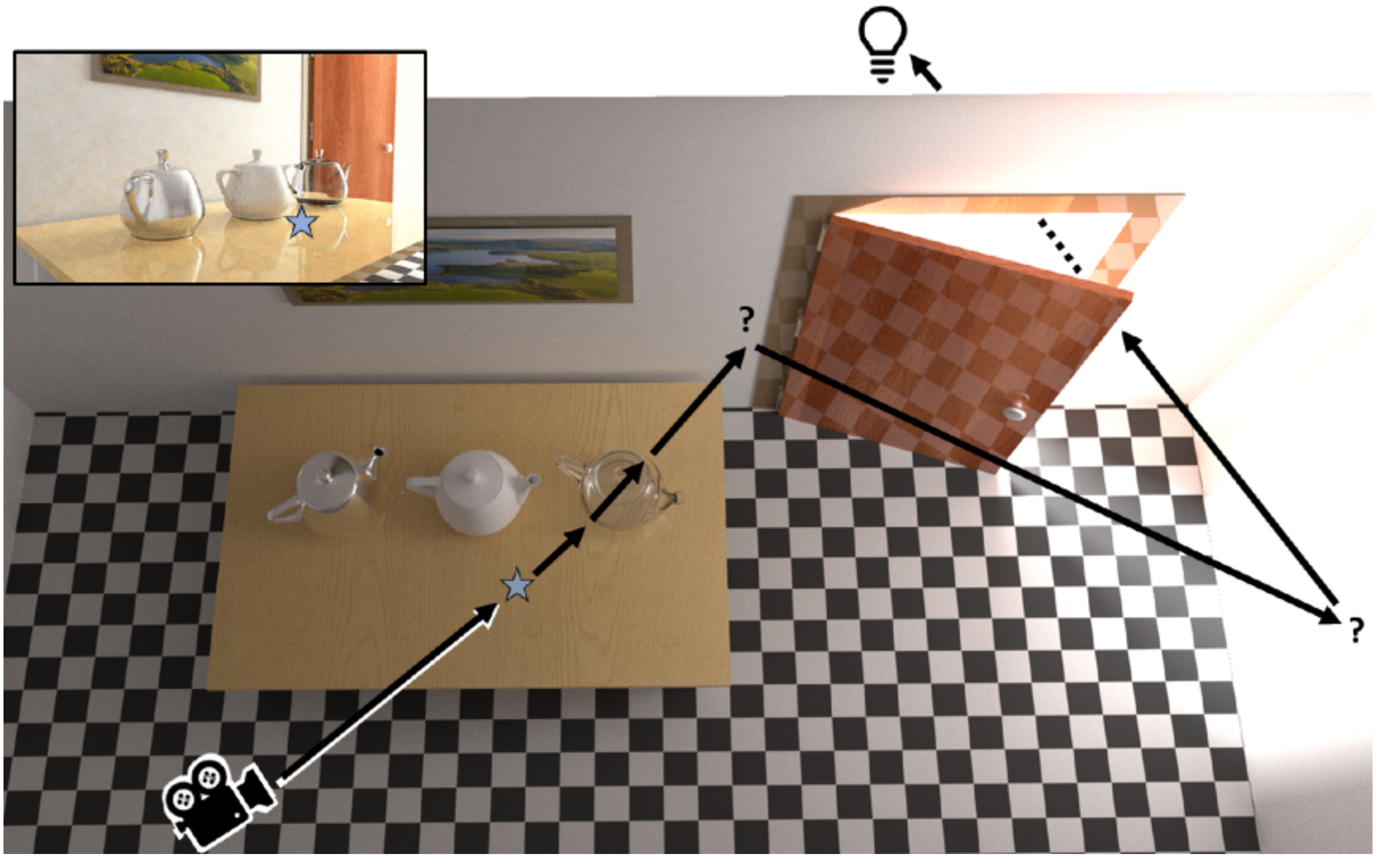
At ACM SIGGRAPH 2022, researchers from the University of Utah's School of Computing and NVIDIA will present a technical paper on "Generalized Resampled Importance Sampling: Foundations of ReSTIR". This paper generalizes recently developed statistical resampling techniques that have enabled virtual environments with a lighting complexity never before seen in real-time, including scenes with millions of dynamic lights, real-time global illumination, and even dynamic participating media.

From a practical perspective, this new research enables real-time rendering of glass, metal, and shiny or glossy surfaces, even in scenes where such objects are lit by hidden light sources (like those from another room). These surfaces introduce long "light paths", where light bounces many times between the light and eye. The expensive computations to follow such paths, known as path tracing, have traditionally been limited to offline and film rendering.

Our generalization of resampled importance sampling and ReSTIR allows us to **reuse the computations** for these complex paths thousands of times. Reuse greatly improves image quality at a given cost, and this benefit requires no complex data structure, training phase, or any other significant precompuations that would limit our ability to dynamically modify the environment.

Why are these paths so hard to capture in real time? As seen below, paths contributing to each pixel may be multiple ray segments long. This requires sufficient ray tracing capacity to afford 5 to 10 rays per pixel. But tracing one path is insufficient. To achieve complex lighting, we must integrate over all possible paths contributing to each pixel. Our new ReSTIR PT resampling algorithm allows us to efficiently approximate this integration with only a few paths per pixel.



(OLD) Path Tracing + basic ReSTIR (in 40 ms).

The New ReSTIR PT (in 40 ms)

Underlying all spatiotemporal resampling algorithms, including our new generalized form, is the idea that important paths in neighbor pixels likely contain information highly relevant for our current pixel. This helps inform how we sample, and essentially acts as a form of filtering. But rather than postponing filtering until image generation is complete (as in most widely-used filtering algorithms), ReSTIR-based techniques filter **during** rendering.

To achieve these improvements, our paper goes beyond engineering insights and also makes fundamental theoretical advancements that allow us to stably and controllably achieve such groundbreaking quality. This overcomes fundamental assumptions from earlier work that cannot be made in arbitrary virtual environments.

https://graphics.cs.utah.edu/research/projects/gris/