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Real-Time Global Illumination Using Temporal Coherence

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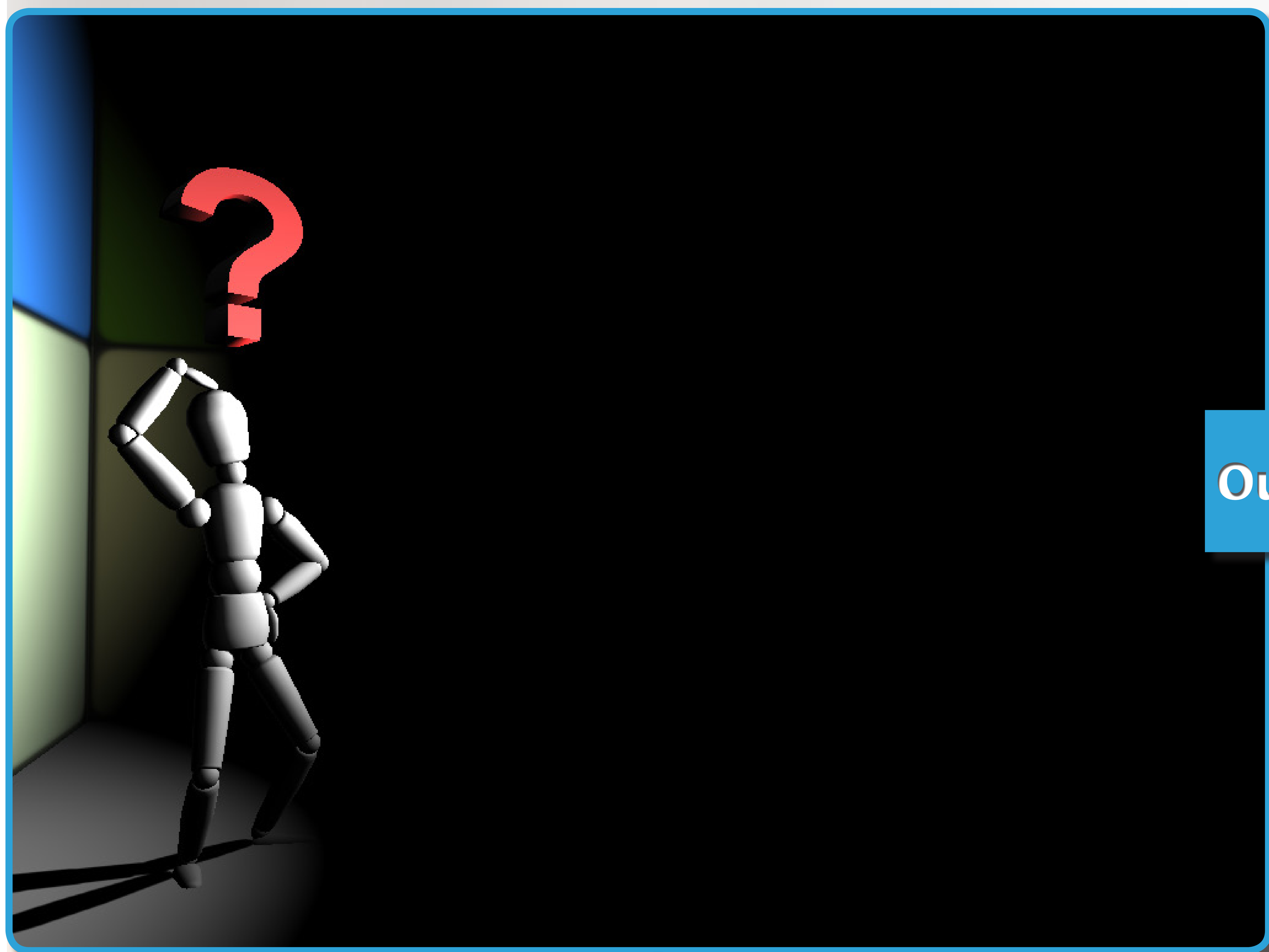


Our Method

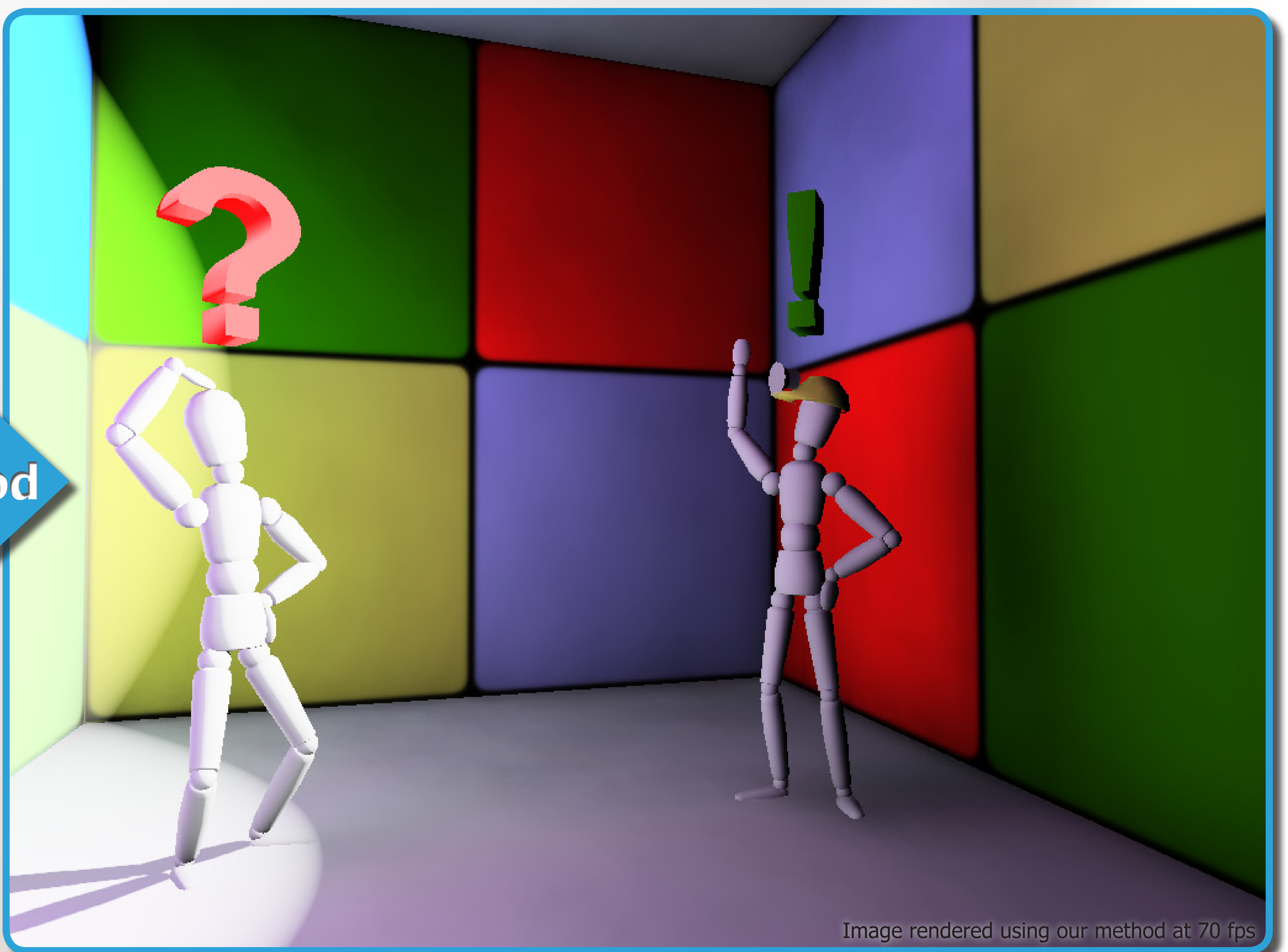


Image rendered using our method at 70 fps

In this thesis, the generation of plausible **global illumination in real time** is discussed:

- Static global illumination algorithms are widely used in today's games & applications
- Fast global illumination computation for **arbitrary dynamic scenes** is a complex task and an area of active research!

We present a **new algorithm**, that is capable of rendering **global illumination in real time** for completely dynamic scenes by exploiting **temporal coherence** between neighboring frames.

Global illumination (GI) describes, how light propagates in a scene.

Light starts from a **light source** and **bounces off** at the surface several times before it actually hits the retina of **the eye**. This process introduces an **infinite amount** of **paths** that **light** can take from the light source to the eye!

Our new method is based on the **Instant Radiosity** and **Imperfect Shadow Maps** approaches. While Instant Radiosity is a method to calculate GI on the fly, Imperfect Shadow Maps are a method that allows taking into account hundreds of indirect light bounces per frame.

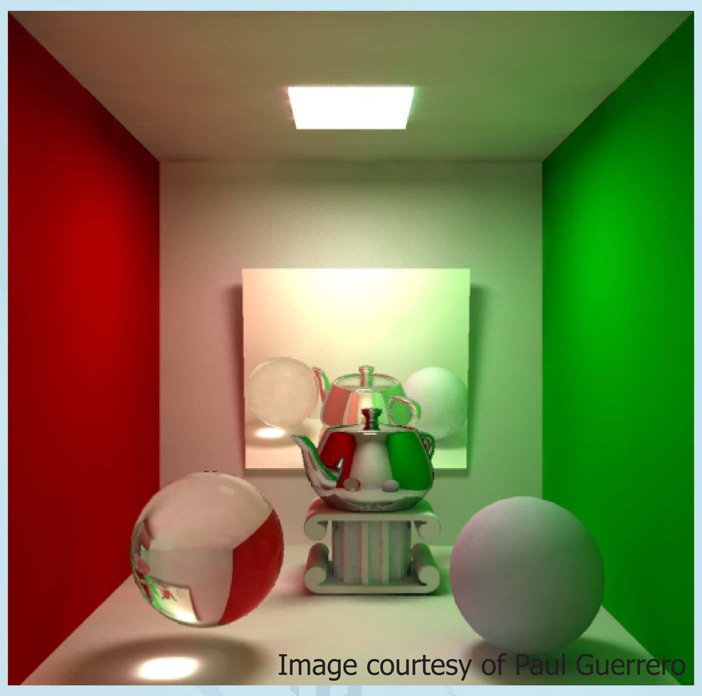
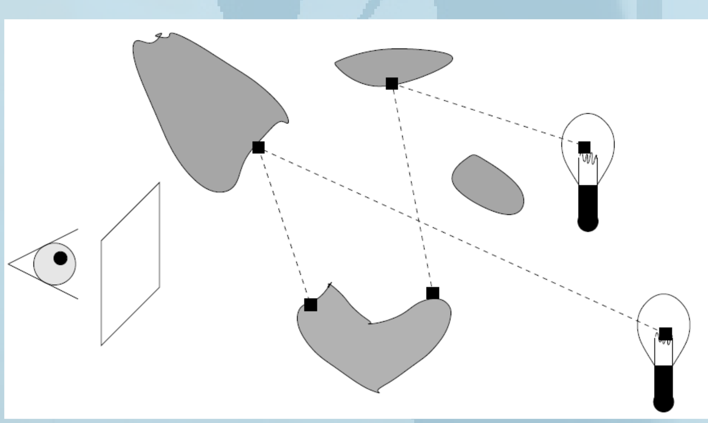
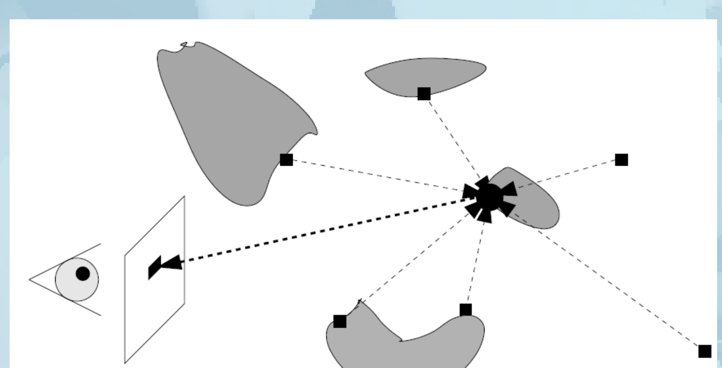


Image courtesy of Paul Guerrero

Instant Radiosity is a clever method to calculate GI without any precomputation. The **idea** is to place so-called **virtual point lights (VPL)** in the scene to **simulate indirect light** that bounces off from the surface.



a) In the first step, **rays** are **shot** into the scene and at the **hitpoints VPLs** are **created**. This step is repeated recursively to get multiple light bounces.



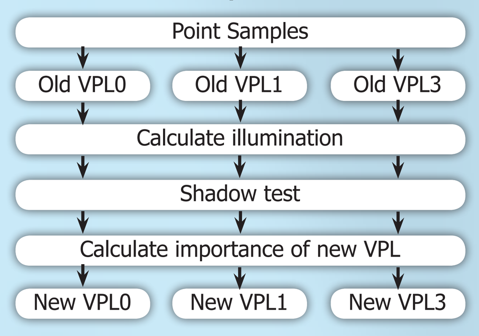
Images courtesy of Benjamin Segovia

b) In the second step, **all light sources** including the VPLs are used to **shade** the **surface**. Imperfect shadow maps allow us to query visibility between VPL and surface.

We furthermore have developed a **new method** to calculate **multiple light bounces**. Instead of creating a so-called imperfect reflective shadow map, we **create** a complete new virtual point light set in **one render pass**.

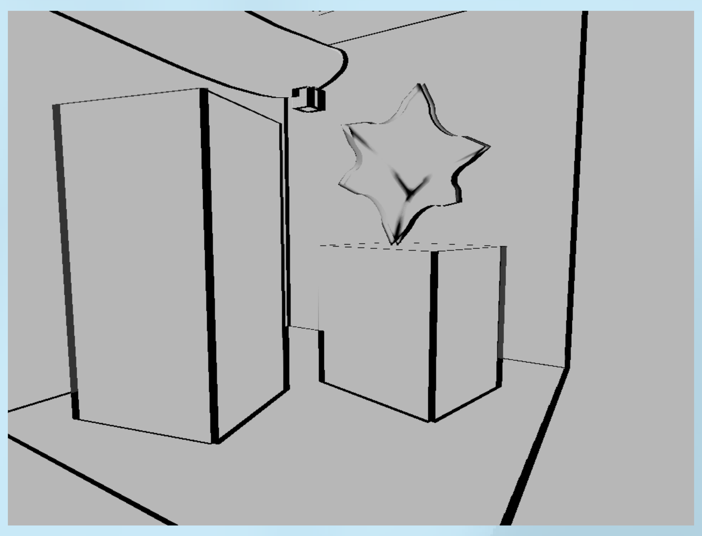
The new method drastically **reduces fill-rate** and creates a virtual point light set that contains only those virtual point lights that have the **highest contribution** to the scene.

Our new method is over **11x faster** than the previous methods.



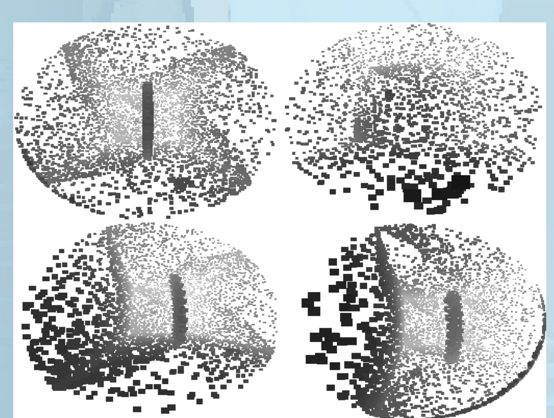
Temporal coherence between consecutive frames can be exploited to **reuse** as much **information** from the **previous frame** as possible.

Through moving camera and objects, pixels may get occluded or disoccluded. A so-called confidence value decides on a per pixel basis **how confident** the **information** from the **previous frame** really is. We use the **three** indicators, **position**-, surface **normal**- and **illumination difference,** to calculate how confident the information from the previous frame is.

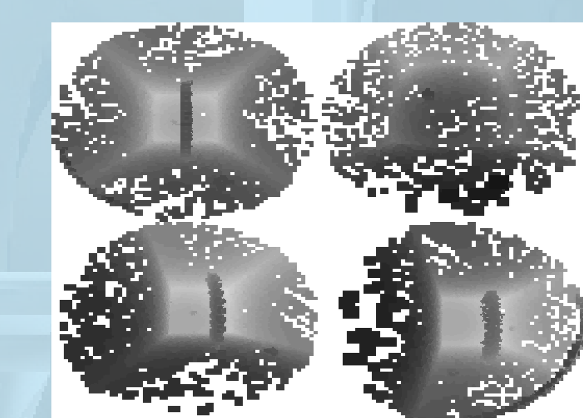


Our new method has a small overhead due to temporal coherence calculation. However, the extra costs are worth the improvement of image quality.

While shading **imperfect shadow maps** are used to test if a surface point receives light from a VPL or not. The **Imperfect Shadow Maps** approach allows creating hundreds of imperfect shadow maps every frame. The **idea** is to use a **point cloud representation** of the scene that is then used to **create** several shadow maps in **one render pass**.



a) In the first step, the **point cloud** gets **splatted** into a **large** texture **map** that contains all **imperfect shadow maps**.



b) In the second step, the **quality** is **improved** by filling the holes between the sample points.

The image in the background shows the Sibenik Cathedral consisting of over 74k triangles. It was rendered using our new method at 65 frames per second using only 256 virtual point lights.

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