Real-time Illumination Estimation Using Collaborative Photorealistic Rendering for Mobile Augmented Reality

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ABSTRACT
High quality rendering on mobile devices is constrained by lack of resources in terms of processing power and memory leading to low visual fidelity of the rendered scenes. Previous works [1][2][3], try to overcome this computational challenge by offloading tasks to a powerful server. In this poster, we introduce the idea of *collaborative rendering*, which entails distributing the tasks over multiple mobile devices for sensing environment as well as rendering high quality scenes. We propose a case study in the form of dynamic illumination estimation to update the appearance of rendered objects in real-time, based on the environment lighting.

COLLABORATIVE RENDERING FOR BETTER AUGMENTATION
In a typical augmented reality application, we sense the world through a camera and render object(s), introducing interactions between the user and the world via these objects. The objects need to appear a part of the world in order to have a true sense of augmentation. One of the major factors that determines the appearance of a rendered object is its quality of rendering.

High quality rendering is required in order to make the rendered object fit more naturally in the scene. Objects rendered as such seems more realistic, making it easier for the users to perceive them as a part of the scene. Unfortunately, high quality rendering requires substantial resources, specifically if the rendering needs to be performed in real-time.

High demand for resource is difficult to meet in mobile devices such as tablets and HMDs. Rendering high quality scene depends on factors such as complex models, realistic scene lighting and physically consistent interactions between the world and the objects rendered. Introducing such features increases amount of data (number of primitives) to be processed, leading to an increase in computations per unit time. The computations required to estimate and modify the primitive properties (vertex and fragment colors), in sync with the environment lighting, compounds the problem even further.

With the introduction of mobile GPUs, processing challenges has been somewhat addressed. Still, the use of mobile GPUs is restricted owing to the limitations arising from high power consumption. Hence, we propose collaborative rendering, which combines the processing power of multiple mobile devices to perform light-weight computations on each device, resulting in a single heavy rendering process with optimal power consumption on each device. Since the major bottleneck towards such a system are the rendering overhead compared to the networking overhead [4], we propose to network the mobile devices locally.

ILLUMINATION ESTIMATION USING COLLABORATIVE RENDERING
To investigate our idea, we aim to design a system to study the use-case of real-time illumination estimation. Illumination estimation is one of the main components for rendering objects photo-realistically and is still an unsolved problem for mobile devices. For estimating the lighting, we typically use a light probe image, which captures the global lighting of a scene. The problem with light probe image is its limited field-of-view which restricts a global estimation of the environment lighting. Using the light probe image, we create an environment map which maps the light intensity to the direction its coming from. With our approach, we exploit collaborative sensing to estimate the lighting via multiple light probe images, sensed through multiple devices leading to a global illumination estmation.

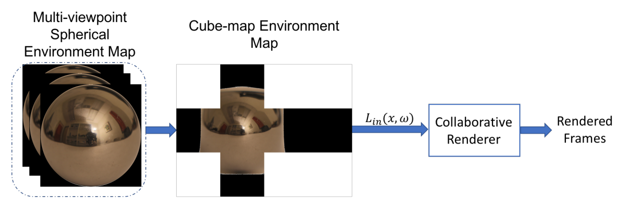

Figure 1. System diagram of our proposed exploration for dynamic real-time illumination estimation on mobile devices

Figure 1 shows our system design for the exploration. We sense multiple spherical environment maps in the form of light probe images from different viewpoints. We combine these to form a cube map representation of environment lighting from all directions. Using this estimated map, we render the objects lit according to the environment lighting. We further improve the rendering by updating the environment map dynamically, with the frequency of updates depending on the number of devices in the system. Thus, our system gets better with increased participation!

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