Analyzing Controllable Energy Consuming Factors of AR Head-Mounted Display

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***Abstract*—Nowadays augmented reality (AR) applications are expanding their area. To extend application area, the device lifetime is a critical factor, which affects the user experience. In this poster we propose an energy management layer to lengthen AR mobile device's lifetime. To improve energy efficiency we categorized energy consumption factors as low-level and high-level features and provided plugin-based design of energy management layer to expand applicability to additional features.**

I. Introduction

As mobile AR application grows, for example Pokemon Go[3], AR mobile devices also are published like Microsoft HoloLens[2]. As same as other mobile devices, AR head mounted display also suffers energy consumption problem. In general AR applications use rich hardware resources for example CPU, GPU and wireless network in their application. As much life time significantly influences user experience, improving energy efficiency is crucial problem to broaden AR application area.

II. Energy management layer

To improve energy efficiency, we propose energy management layer between user application and subsystem to control energy consumption in light-weight way.

When designing the AR application energy management layer, we focused on providing application transparency. Specifically, we make sure that the developer does not need to change their source code to apply our layer to their application. For this, we should receive only minimal information from the application and have the capability to control the application outputs without modifying the source code.

To design this layer, we analyzed system-level factors that affect the application energy efficiency. Though there are many features that affect energy usage, we classify the features as either low-level or high-level features based on their proximity and relevance with the hardware resource. For example, factors related to resources such as CPU and LCD, which cannot be abstracted directly, are considered low-level features. This means that we cannot control low level features freely, as we cannot set a target CPU usage as $x\%$ directly. Rather we can only take implicit approaches to control the CPU load. On the other hand, high-level features are relatively farther from the hardware, and have an abstracted form, which allows direct control. High level features such as display frame rate and network data rate can be managed and controlled directly.

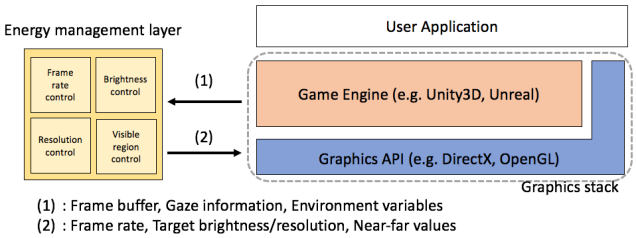

Fig. 1. Software structure of AR development and operation stack with our proposed energy management layer.

For mobile phones, graphics control, network management, LCD, and CPU utilization are the top four energy-usage affecting factors in idle mode [1]. Given that LCD and CPU are low level features we can only control them only indirectly, for example by controlling the brightness or by reducing computation intensive operations. Specifically, in our layer, we control the low level features in two ways; First, we abstract high level features as widely used indirect metrics. Second, we prune low-level features if it is difficult to control using abstractions (e.g., CPU usage) and will not control about difficult features to control.

III. Summary

We propose an energy management layer to improve energy efficiency on AR HMDs in an application transparent way. To design this layer, we first identify controllable features and group them as either high level features or low level features.

As a future work, we plan to analyze these energy-affecting features and measure their correlation to the device lifetime.

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References

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[3] Pokemon Go Website. Available at https://www.pokemongo.com/.