Frame Rate Scaling Technique to Reduce Power Consumption in Mobile Virtual Reality Game

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***Abstract*—Recently, it is possible to enjoy virtual reality game on the smartphones as various virtual reality devices are provided. However, game user may suffer discomfort in a battery because virtual reality game consumes more power than existing games. To overcome this, we introduce a Frame Rate Scaling technique for reducing power consumption of a mobile virtual reality game. After measuring the power by controlling the Frame Rate in the mobile virtual reality game, we analyze the relationship between power consumption and Frame Rate. By using the proposed technique, we can achieve low power consumption.**

Keywords—vritual reality;frame rate;low power

I. INTRODUCTION

As Oculus Rift is developed, the environment easy to buy virtual reality devices is equipped. So, Interest and demand of public about virtual reality are sharply increased.

In addition, due to spread of smartphones, the cases taking structure combines smartphones with virtual reality devices are frequent. For example, there are Gear VR, G3 VR and Cardboard. As virtual reality devices are spread, a various virtual reality contents are being developed and the high-resolution graphics contents are appeared to provide a more realistic effect. The recent mobile devices display to perform display role in virtual reality environment such as Samsung's Galaxy S6 and LG's G4 is being provided as QHD(2560 x 1440). As the display size of the mobile devices is increased and high-resolution graphics contents are appeared, mobile GPU technology has become more important[1].

Currently, mobile GPU is in the relationship of trade-off with the usage and battery life. For instance, If GPU utilization increases, graphics quality is improved but the power consumption also increases and the duration of battery is shortened. In contrast, If GPU utilization decreases, the duration of the battery is longer but the graphics quality and the frame rate is reduced and it will drop the user's satisfaction. Therefore, there are researches on the hardware and software aspect to find the optimal balance point.

In hardware aspect, the manufacturers of the mobile GPU propose a various techniques such as multi-level clock gating, power gating and DVFS(Dynamic Voltage and Frequency Scaling) and have gained a lot of effects. The study is conducted to reduce power consumption applying a DVFS the CPU and GPU in [2]. But, in software aspect, it depends on application developer's ability yet. In [3], it measured the power consumption according to the scene complexity controlling FPS such as 60, 30, 20 15. However, this method was hard to apply a various mobile environment because the maximum scene complexity is that the number of triangle is 8250. In particular, [3]'s experiment has been revealed the limitations because virtual reality environment has feature that even if the same scene is rendered, the scene complexity is further increased.

This research suggests the effective FPS control method to reduce mobile GPU power consumption in mobile virtual reality environment. To do this, we determined the location of three points(maximum triangle number 159.3k) according to the scene complexity and measured power consumption for each location. Analyzing the relation between the scene complexity and measured power consumption and considering human resolution, we determine proper FPS. If FPS is controlled to determined FPS, the power consumption can be decreased by 25.96% on average.

In the following chapter, we describe the virtual reality implementation using the Unity 3D game engine. The chapter 3 discusses our proposed method and chapter 4 describes experimental results and analyzes. The chapter 5 discusses the conclusion and the future work.

II. VIRTUAL REALITY IMPLMENTATION

We exploit Google's Cardboard SDK[4] and Demo package to convert bootcamp that is provided by Unity 3D game engine into virtual reality environment. And gamepad is linked to mobile devices using Unity 3D game engine to control user's motion in mobile virtual reality environment. [Figure 1] shows the scene of running bootcamp applying the virtual reality environment.

Figure 1 The scene of running bootcamp applying the virtual reality environment

III. FPS CONTROL

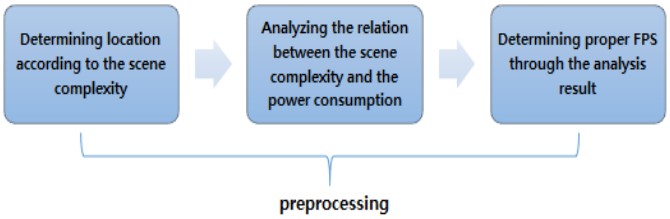

Figure 2 Process of proposed method

[Figure 2] shows proposed method process that considers human resolution and can effectively reduce power consumption to determine the FPS. In order to measure the power consumption according to the complexity of the scene in a bootcamp virtual reality environment, we determine the location that distinguish the scene complexity in bootcamp. Scene complexities are low position, intermediate position and a high position that the number of triangle is respectively 29k, 96.1k, 159.3k. In order to measure the power consumption according to the scene complexity, we use the Trepn profiler application.

In [3], they argued that it is not effective method running over 30 FPS in terms of power consumption because most console games are running 30 FPS and films are running 24 FPS. In [5], they argued that if FPS is between 15 FPS and 30 FPS, it is marginally playable and if FPS is over 30 FPS, it is playable. We limit the experimental conditions by the maximum 35 FPS and minimum 20 FPS based on [3] and [5] and measure the power consumption.

FPS control is performed by entering the FPS value you want in Application.targetFrameRate function. [Figure 3] shows power consumption measurements after controlling FPS. When the FPS is 20, it was confirmed that the power consumption is lowest in every scene complexity.

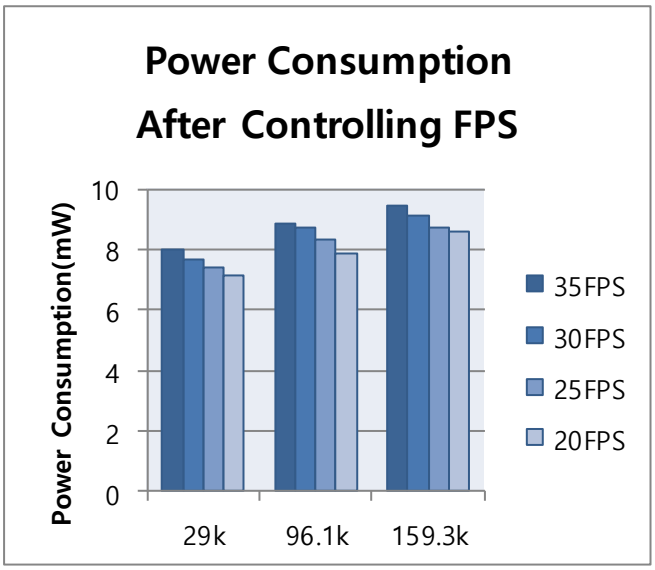

Figure 3 Power consumption according to the scene complexity after controlling FPS

IV. EXPERIMENTAL RESULTS

Table 1 The power consumption measurements before and after FPS control

	Scene Complexity		
	29k	**96.1k**	**159.3k**
GPU power consumption before FPS control(mW)	9.44	10.598	11.906
GPU power consumption after FPS control(mW)	7.116	7.896	8.6
GPU power consumption reduction(%)	24.62	25.50	27.77

[Table 1] shows power consumption measurements before and after FPS control. When the FPS is controlled to 20 FPS, the power consumption value is less than the power consumption when the FPS is not controlled for the same scene complexity. In addition, as the scene complexity decreases GPU power consumption, GPU power consumption reduction is reduced and power consumption reduction before and after the FPS control can be reduced by 25.96% on average.

V. CONCLUSION AND FUTURE WORKS

This research suggests the effective FPS control method to reduce mobile GPU power consumption in mobile virtual reality environment. We used the Unity 3D game engine in order to implement mobile virtual reality environment and implemented application to experiment. As a result, the method that is applied our proposed method consumes the power less 25.96% on average.

Currently, FPS control technique should be applied to each new application because our proposed method is applied in application level. In future, It will be necessary to reduce GPU power consumption regardless of kind of application through API hooking[6].

REFERENCES

[1] “Qualcomm Presentation - How to minimize the power consumption of your app,” http://www.slideshare.net/QualcommDeveloperNetwork/69-minimize-powerconsumptioninappsschwartz918gg67

[2] A. Pathania, Q. Jiao, A. Prakash, and T. Mitra, ″Integrated CPU-GPU Power Management for 3D mobile Games," In *Proceedings of the 51st Annual Design Automation Conference*, pp. 1-6, Jun. 2014.

[3] K. Nixon, X. Chen, H. Zhou, Y. Liu, and Y. Chen, ″Mobile GPU power consumption reduction via dynamic resolution and frame rate scaling," In *Proceedings of the 6th USENIX conference on Power-Aware Computing and Systems. USENIX Association*, pp. 5-5, Oct. 2014.

[4] "Cardboard SDK,” https://developers.google.com/cardboard/unity/

[5] R. Bakalash, Y. Shoshan, and O. Remez, ″Application-transparent resolution control by way of command stream interception,″ U.S. Patent, Application No. 13/789,518, July. 11, 2013

[6] C. W. Cho, C. P. Hong, J. C. Piao, Y. K. Lim, and S. D. Kim, ″Performance optimization of 3D applications by OpenGL ES library hooking in mobile devices," In *Proceedings of IEEE/ACIS 13th International Conference on Computer and Information Science*, pp. 471-476, Jun. 2014.