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GPU-Based Fast Signal Processing for Large Amounts of Snore Sound Data

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***Abstract*—Snore sound (SnS) data has been demonstrated to carry very important information for diagnosis and evaluation of sleep related breathing disorders with high prevalence, such as Primary Snoring and Obstructive Sleep Apnea (OSA) – a serious chronic sleep disorder with a big community. With the increasing number of collected SnS data from subjects, how to handle such large amount of data is a big challenge, and a huge opportunity for further study on optimally combining signal processing techniques with machine learning algorithms. In this study, we utilize the Graphics Processing Unit (GPU) to process a large amount of SnS data collected from hospitals in Germany (37 subjects, 38.34 hours, 15.10 GB). Experimental results prove that, our GPU-based platform significantly speeds up the audio processing for features extraction of SnS data, compared with the traditional Central Processing Unit (CPU) system.**

I. Introduction

Obstructive Sleep Apnea (OSA), [1] is a chronic long-term sleep disorder, which affects 13 % of men and 6 % of women in the USA [2]. In the past decades, it was proven that, the snore sound (SnS) data carry very important information for diagnosis and evaluation of OSA [3]. With the present increasing number of SnS data collected by numerous subjects, how to handle such large amount of data will be a 'Big Data' problem [4] in the near future. Qian et al. proposed a private computing system for processing snore related signals in 2014 [5], which showed the feasibility to implement suited audio signal processing techniques into a private cloud computing system to speed up the time-consuming task. Ingo Schmdecke *et al.* studied an example for GPU-based processing of electronic media content is the automated classification of music collections [6], which is verified by a quantitative comparison to the results of a single core processor implementation in terms of computation times. In paper [7], Tomasz Maka *et al.* proposed an OpenMP standard optimized software library for audio features extraction, which shorten the computational time up to above 60 percent in comparison with its sequential counterpart. In this study, we further the works in [5], and explore the performance on a large amount of SnS data processing by the Graphics Processing Unit (GPU) with CUDA support from NVIDIA. First, we give a brief description of our GPU-based system for processing SnS data in Section II; then, we introduce acoustic features we extracted in this work, and set up the experiments, and discuss the results in Section III before drawing a conclusion of the findings in Section IV.

II. Proposed GPU SnS Data Processing System

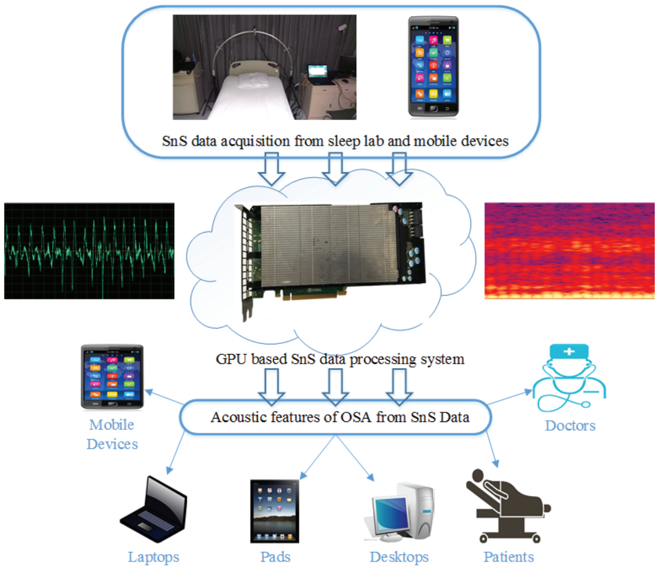

Fig. 1. The proposed GPU-based system for processing SnS data collected in the hospital or via personal smart devices.

Figure 1 shows our GPU-based system for processing of large SnS data. The data can be collected in hospital sleep laboratories, or via personal smart devices, e. g., a smart phone, and be processed by our GPU system for extracting acoustic features, which can be useful for further doctors' analyses. In terms of software, we need a free scientific computing tool which should be highly efficient and supports GPU programming, and also having capabilities to fully

TABLE I
SNORE SOUNDS DATA INFORMATION.

	# Subjects	Total Time (hours)	Data Size (GB)
Munich	37	38.34	15.10
Beijing	20	149.41	16.00
Total	57	187.75	31.10

utilize the CPU. In addition, taking programming effort into account, we decided to use the Anaconda Python distribution with Numba/NumbaPro which support for NVIDIA's CUDA-enabled GPU programming [8]. In terms of hardware, the GPU is a SIMD parallel processor which has very high performance at linear algebra operations comparing with the CPU. Thus, the linear algebra-based acoustic likelihood computing tasks can be more efficient in use of GPU hardware.

III. EXPERIMENTS AND RESULTS

The original SnS data in our study are provided by two public hospitals, namely "Klinikum rechts der Isar", Technische Universität München, Germany, and the Beijing Hospital, China. Table I shows the details of original SnS data. The acoustic signal processing algorithms we employ refer to the work [5], we extract 11 frequently-used acoustic features as in our previous SnS studies [9], [10], which can represent the frequency and spectrum distribution of SnS. The configuration of our experimental environment can be found in Table II.

TABLE II
THE CONFIGURATION OF EXPERIMENTAL ENVIRONMENT.

	Configuration
CPU	Intel Core i7-3930K @ 3.20 GHz
GPU	Tesla-k20 with 5.0 GB GDDR5
Memory	48 GB DDR3 1600
OS	CentOS 7.2 with CUDA 7.0
Python	Anaconda Python 2.7 with numpy 1.10.4 scipy 0.17, Numba/Numbapro 0.23.1

In this experiment, firstly, we set 1 CPU (with Python2.7, numpy 1.10.4 and scipy 0.17 packages) to process 1 subject's data as our baseline. We use our GPU-based platform to process all the SnS data. Figure 2 demonstrates that, the GPU is almost 4.6× faster than the CPU implementation. However, the experiment results show that the speed-up decreases when we increase the data size. We think that this result should be caused by the fact that, the transmission of data is not hidden by other computations, as will be a real-world application.

IV. CONCLUSION

In this study, we have shown that the usage of a GPU can speed up a Python programmed acoustic processing for a large amount of SnS data by almost five times, meanwhile, keeping high running efficiency and programming effort. In our future work, we will need to collect considerably more data and implement more sophisticated data processing algorithms [11] ready for efficient distribution in our openSMILE toolkit [12], and investigate the machine learning performance in HPC for big amounts of SnS data.

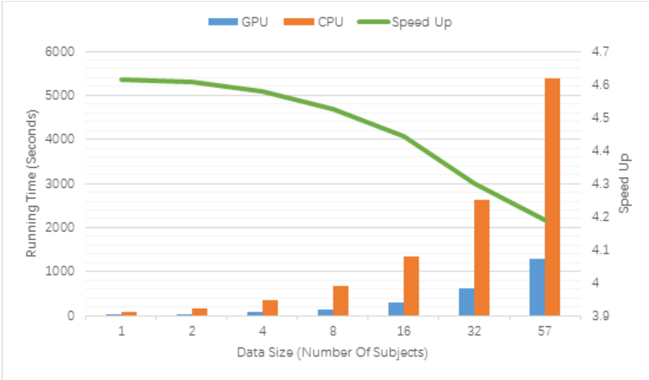

Fig. 2. Results of GPU, and CPU based system for processing SnS data.

ACKNOWLEDGMENT

This work is supported by China Scholarship Council (CSC), National Natural Science Foundation of China under grant No. 61271410, and the European Union's Seventh Framework and Horizon 2020 Programmes under grant agreements No. 338164 (ERC Starting Grant iHEARu) and No. 645378 (ARIA-VALUSPA).

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