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PERFORMANCE AND POWER CONSUMPTION EVALUATION IN SMARTPHONE BASED IMAGE PROCESSING FOR MEDICAL APPLICATIONS

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Abstract :

More and more image processing applications are intended to run on mobile devices. This trend is visible also in medical industry, which have very strict reliability and safety requirements. Increased power consumption and inefficientimage processing can affect both of these factors significantly. More over, it affects the user experience as well. In this paper authors investigates the performance and power consumption of several different numeric algorithms implemented on iPhone device. The comparison is made between CPU and GPU based solutions. Authors evaluated the test scenarios involving common used operations: matrix multiplication, thresholding and Canny's edge detection. The results showed that GPU based solution can be up to 4 times faster as CPU based one, with similar power footprint in particular cases. All measurements have beengathered without hardware interference nor jailbreaking of the device. Finally authors discuss possible application considerations and scenarios in medical related image processing smartphone apps.

Keywords : Batteries, Power demand, Graphics processing units, Image edge detection, Power measurement, Biomedical imaging

1. INTRODUCTION

The fast evolution of mobile devices have bring the new opportunities to programmers, engineers and researchers for rapid development of new applications. This trend is present also in medical industry, where it shortened the distance between the content creator and the medical staff. This results in increasing number of medical related smartphone apps [1]–[4]. Researchers can now prototype the new ideas and validate it with users within the days. However for medical industry issues regarding safety and reliability are crucial. More over, convincing medical staff to use a particular app is not an easy task. Especially in this case for successful market adoption as well as safety a good user experience (UX) of the app is needed. According to work of Dirin [5], UX can be defined as the emotions that the user encounters while using an application. Designing good UX is not a trivial task, as there need to be considered technical limitations of the

platform, perception of the user as well as cultural background. This is especially important in case of medical applications, which cannot bring more distraction than additive values [?], [6]. More and more of them are being used for supporting the doctors, some of them are even intended to use in harsh environment of operating room [7]–[9]. In such environment it is extremely important to assure good and reliable user experience. Good UX involves limited energy consumption of the app and fluent operation of the User Interface and backend algorithms. Both instant amperage from the battery and algorithms efficiency affects the temperature of the mobile device itself. According to the Apple's "Energy Efficiency and the User Experience" guide, battery life and device temperature is one of the most important UX factors. More over, in case of smartphone Lithium based batteries increased temperature combined with extended instant power consumption can lead to significant shortage of battery life, or in worst case to battery

damage [10]. This applies especially to image-processing based, augmented reality and machine learning apps which have usually high energetic footprint. In the case of iOS pps

development, power consumption measurement is possible using the Xcode IDE during debug session of the app as it is shown in Fig. 2. However, the indicators embedded into Xcode provides only a rough estimation with relative values varying from 1 to 20, where 1 is indicating very low power footprint, and 20 very high. In some particular cases this measurement is not sufficient, as it provides only rough estimation about the power consumption without detailed values. The scenario, where two different algorithms have the same power impact, according to Xcode IDE is not uncommon. As this study shows, this indicator value can be even misleading. What is more important, it makes the comparison of any algorithms or technologies regarding energy footprint impossible. Thus in this paper authors propose a workaround of this issue using the common available tools and reverse engineering. Thus, in this article authors focus on the evaluation of energy consumption and efficiency of popular image processing frameworks. These two factors forms the basic technical background of the good UX which is a crucial issue in mission-critical medical applications. In the next paragraphs authors show a way of accurate power measurement procedure for iPhone based image processing applications. Next the GPU and CPU based image processing algorithms implementations are compared

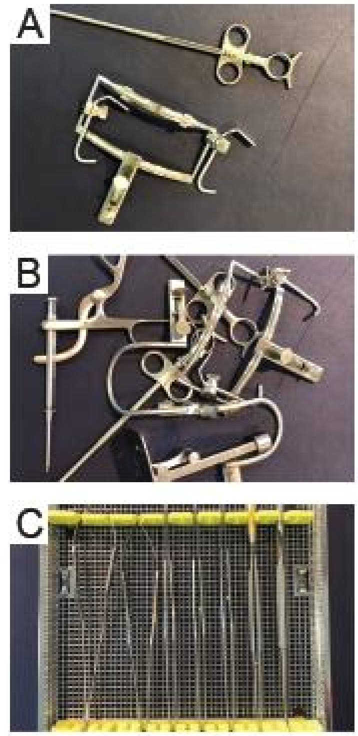


Fig. 1. Test images with different detail levels from least complicated (A) to the most complicated (C)

2. RELATED WORKS

[I]. Chatzipapas, N. Kathopoulis, A. Protopapas, and D. Loutradis, Using a Mobile Smartphone to Perform Laparoscopy, J. Minim. Invasive Gynecol., vol. 25, no. 5, pp. 912915, Jul. 2018.

Laparoscopy has gradually expanded its use in gynecologic surgery over the last 3 decades. In this report, a new laparoscopic setup is presented using a mobile smartphone that allows for a low-cost, portable laparoscopic viewing system. The setup was created with the coupling of a rigid 0-degree, 10-mm-diameter laparoscope via a commercially available adapter with a smartphone. The light source used was also a portable and rechargeable light-emitting diode cold light source. We completed 17 diagnostic laparoscopies for different pathologies such as ectopic pregnancy, ovarian torsion, a luteal hemorrhagic cyst, and disseminated ovarian cancer. Five operations were converted from diagnostic to operative laparoscopy. The diagnosis was right tubal pregnancy, salpingectomy was performed, and the new setup was used for the entire operation, allowing the surgeon to complete the surgery successfully. This is the first report of the application of mobile technology used to facilitate a laparoscopic operation. It is our intention that this experience coupled with future hardware improvements will lead to future studies to expand the use of mobile technology in the laparoscopic setting.

[2] M. J. Dietz, D. Sprando, A. E. Hanselman, M. D. Regier, and B. M. Frye, Smartphone assessment of knee flexion compared to radiographic standards, Knee, vol. 24, no. 2, pp. 224230, Mar. 2017.

Measuring knee range of motion (ROM) is an important assessment for the outcomes of total knee arthroplasty. Recent technological advances have led to the development and use of accelerometer-based smartphone applications to measure knee ROM. The purpose of this study was to develop, standardize, and validate methods of utilizing smartphone accelerometer technology compared to radiographic standards, visual estimation, and goniometric evaluation.

[3] R. K. Patel, A. E. Sayers, N. L. Patrick, K. Hughes, J. Armitage, and I. A. Hunter, A UK perspective on smartphone use amongst doctors within the surgical profession, Ann. Med. Surg., vol. 4, no. 2, pp. 107112, Jun. 2015.

Hospitals are increasingly looking for mobile solutions to meet their information technology needs. Medical professionals are using personal mobile devices to support their work, because of limitations in both time and space. Our aims were to assess smartphone use amongst UK surgical doctors, the prevalence of medical app use and online activity.

[4] A. Jahanshir, E. Karimialavijeh, H. Sheikh, M. Vahedi, and M. Momeni, Smartphones and Medical Applications in the Emergency Department Daily Practice , Emergency, vol. 5, no. 1, p. e14, Jan. 2017

Medical applications help physicians to make more rapid and evidence based decisions that may provide better patient care. This study aimed to determine the extent to which smart phones and medical applications are integrated in the emergency department daily practice.

[5] A. Dirin and T. Laine, User Experience in Mobile Augmented Reality: Emotions, Challenges, Opportunities and Best Practices, Computers, vol. 7, no. 2, p. 33, 2018.

Mobile Augmented Reality (MAR) is gaining a strong momentum to become a major interactive technology that can be applied across domains and purposes. The rapid proliferation of MAR applications in global mobile application markets has been fueled by a range of freely-available MAR software development kits and content development tools, some of which enable the creation of MAR applications even without programming skills. Despite the recent advances of MAR technology and tools, there are still many challenges associated with MAR from the User Experience (UX) design perspective. In this study, we first define UX as the emotions that the user encounters while using a service, a product or an application and then explore the recent research on the topic. We present two case studies, a commercial MAR experience and our own Virtual Campus Tour MAR application, and evaluate them from the UX perspective, with a focus on emotions. Next, we synthesize the findings from previous research and the results of the case study evaluations to form sets of challenges, opportunities and best practices related to UX design of MAR applications. Based on the identified best practices, we finally present an updated version of the Virtual Campus Tour. The results can be used for improving UX design of future MAR applications, thus making them emotionally engaging. **View Full-Text**

[6] B. Esenther and R. Ko, Smartphones in the Operating Room: Distraction or Diagnostic Aid? A Case of Newly Diagnosed Wolff-Parkinson White in a Pediatric Patient Having Bronchoscopy

Under General Anesthesia, AA case reports, vol. 5, no. 3, pp. 4042, 2015.

A 4-year-old boy presented for elective bronchoscopy after years of pharmacologically unresponsive reactive airway disease that limited physical activity. After mask induction with nitrous oxide and sevoflurane, the patient was noted to be intermittently in a hemodynamically stable tachyarrhythmia. The anesthesia machine, though equipped with electrocardiogram (ECG) recording capabilities, malfunctioned during the case and was not able to print a rhythm strip. As a substitute, a smartphone picture and video were recorded. In the recovery room, initial 12-lead ECG showed sinus tachycardia. Shortly after, a presumptive diagnosis of Wolff-Parkinson White was given upon review of the smartphone recordings by the pediatric cardiologist on service. Twelve lead ECG was repeated which showed intermittent Wolff-Parkinson White. This case highlights 2 points. First, any prolonged or sustained pediatric dysrhythmia revealed during anesthesia warrants further investigation and should not be assumed secondary to an anesthetic drug. Second, ubiquitous smartphones are an excellent tool for capturing data that the monitor is unable to capture.

Int. Conf. Data Softw. Eng. ICODSE 2014, 2014.

3. EXISTING SYSTEM

Designing good UX is not a trivial task, as there need to be considered technical limitations of the platform, perception of the user as well as cultural background. This is especially important in case of medical applications, which cannot bring more distraction than additive values [?], [6]. More and more of them are being used for supporting the doctors, some of them are even intended to use in harshenvironment of operating room [7]–[9]. In such environment it is extremely important to assure good and reliable user experience. Good UX involves limited energy consumption of the app and fluent operation of the User Interface and backend algorithms. Both instant amperage from the battery and algorithms efficiency affects the temperature of the mobile device itself. According to the Apple's "Energy Efficiency and the User Experience" guide, battery life and device temperature is one of the most important UX factors. More over, in case of smartphone Lithium based batteries increased temperature combined with extended instant power consumption can lead to significant shortage of battery life, or in worst case to battery damage [10]. This applies especially to image-processing based, augmented reality and machine learning apps which have usually high energetic footprint. In the case of iOS apps development, power consumption measurement is possible using the Xcode IDE during debug session of the app as it is shown in Fig. 2. However, the indicators embedded into Xcode provides only a rough estimation with relative values varying from 1 to 20, where 1 is indicating very low power footprint, and 20 very high. In some particular cases this measurement is not sufficient, as it provides only rough estimation about the power consumption without detailed values. The scenario, where two different algorithms have the same power impact, according to Xcode IDE is not uncommon. As this study shows, this indicator value can be even misleading. What is more important, it makes the comparison of any algorithms or technologies regarding energy footprint impossible.

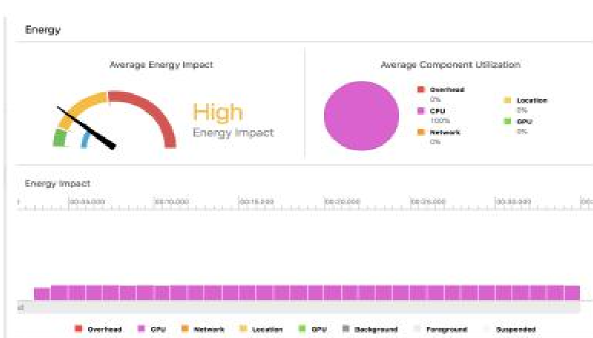
4. PROPOSED SYSTEM

Thus in this paper authors propose a workaround of this issue using the common available tools and reverse engineering. Thus, in this article authors focus on the evaluation of energy consumption and efficiency of popular image processing frameworks. These two factors forms the basic technical background of the good UX which is a crucial issue in mission-critical medical applications. In the next paragraphs authors show a way of accurate power measurement procedure for iPhone based image processing applications. Next the GPU and CPU based image processing algorithms implementations are compare

5. IMPLEMENTATION:

5.1 Power measurements

Apple provides a way for logging system parameters as well as diagnostic informations through the tool called sysdiagnose. These informations are intended to use by technical staff to solve the bugs and issues of iOS operating system. For gathering such data, a special profile have been installed on test device. Then, to start the logging, user needs to push volume and the power buttons. After the measurement, sysdiagnose generates one zip archive with all of the data. Then it needs to be transferred to the macOS or PC. Power consumption log is stored in SQLite based file called powerlog. This file includes multiple tables containing the power related data. For the measurement of the detailed battery parameters the PLBatteryAgentEventBackwardBattery table have been investigated. The table contains several data according to the battery status, however for this research we have been interested in battery voltage, instant amperage and a temperature. For the assurance of repeatable results, the appropriate profile blocking the remote connection and other power consuming events needs to be installed on the device. The logs are taken every 20 seconds. The long term applications tests were made to gather at least 20 values. Figure 3 presents the example battery voltage and instant current log taken over 2 days of regular smartphone usage. The semitransparent red rectangles are indicating battery charging.



5.2 Efficiency measurements

Many different efficiency evaluation methods are proposed in the literature regarding the smartphone devices [11]. However we have focused on the measurements which can be easily replicated in any single smartphone app. Each test scenario was fired in the loop for 10.000 times. Then, two timestamps before and after selected function have been taken to estimate the time needed for the execution. Each procedures have been set in a pipeline way, so each time the new instance of algorithm is processed after the current one, however the single instance can use multiple cores and parallelization. During the tests two different approach have been used. GPU based approach based on native iOS frameworks like metal (GPUImage2) have been compared with CPU based algorithms based on general pre-compiled C++ frameworks (OpenCV).

5.3.GPUImage2

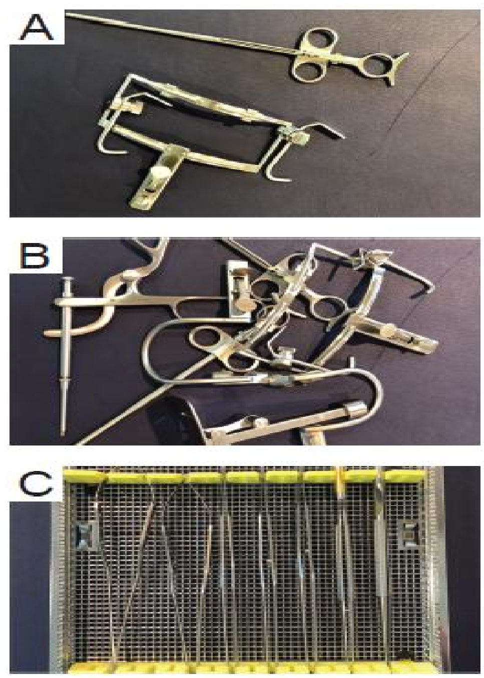
GPUImage 2 is the second generation of the GPUImage framework, an open source project for performing GPU-accelerated image and video processing on Mac, iOS, and now Linux. The objective of the framework is to make it as easy as possible to set up and perform realtime video and image processing. The framework is built according to the concept of a processing pipeline. In such a pipeline image sources are referenced as input images, then several different filters and procedures can be applied down the pipeline and finally the processing result can be targeted to the output image. The biggest advantage of such approach is that arbitrarily complex processing operations can be built from a combination of a series of smaller operations in very easy and intuitive way.

5.4 OpenCV

OpenCV was designed for computational efficiency and with a strong focus on real-time applications. Written in optimized C/C++, the library can take advantage of multi-core processing using CPU. Enabled with OpenCL, it can take advantage of the hardware acceleration of the underlying heterogeneous compute platform. OpenCV is combined from several different modules including image processing, video analysis, multiple-view geometry, features detection and GPU accelerated algorithms. In this paper, CPU based image processing module have been used

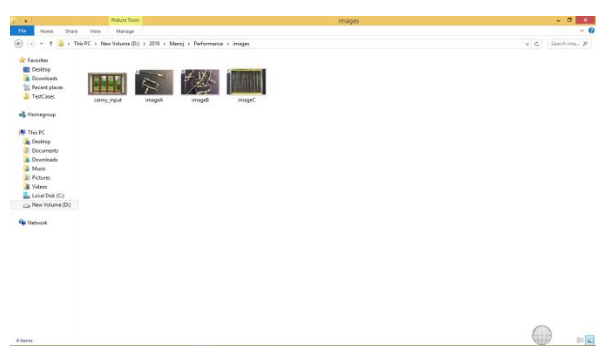
6. System Architecture

The datasets are collected from the database. In phase two the data will be pre-processed whichwill include data cleaning, integration and transformation. By using Random Forest algorithmwe can find better accuracy when compared to other algorithms.Fig.1

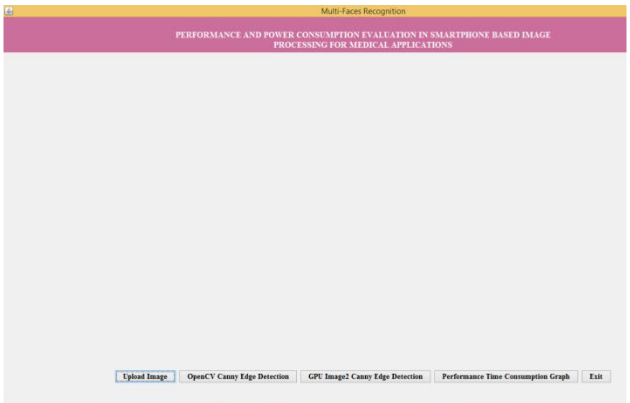


7. OUTPUT RESULTS

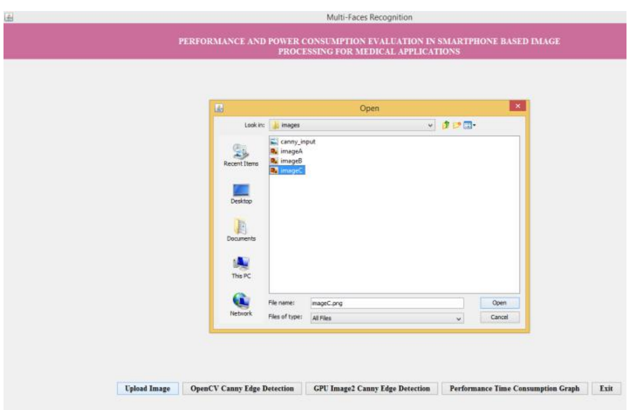
For performance comparison I am using below images from paper



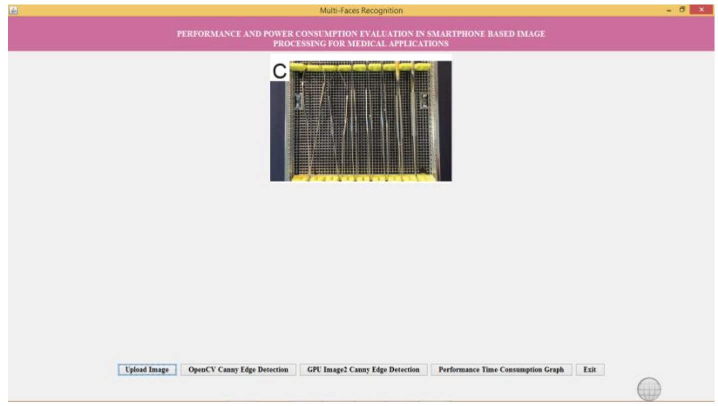
Double click on 'run.bat' file to start project execution and after running 'run.bat' file will get below screen



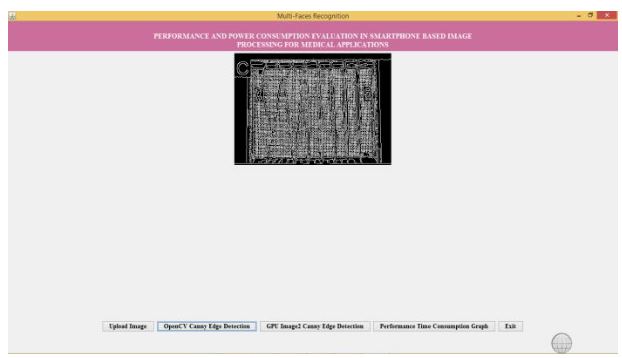
In above screen double click on 'Upload Image' button to upload image



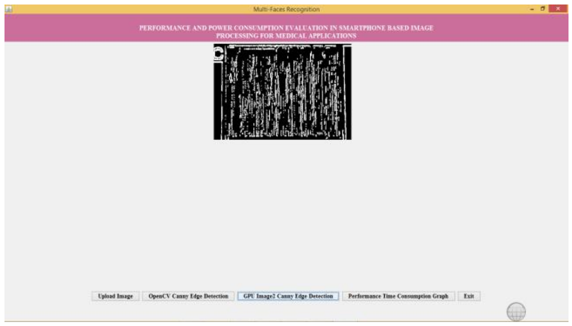
In above screen i am uploading ImageC and after uploading will get below screen



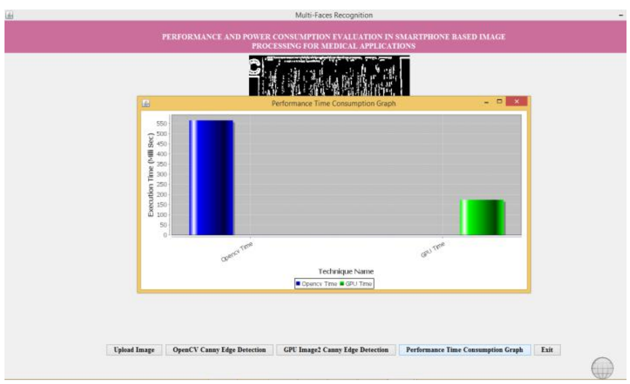
Now click on 'OpenCV Canny Edge Detection' button to detect edge from uploaded image. After running canny will get below screen



In above screen we can see edges detected from uploaded image using OPENCV. Now click on 'GPU Image2 Canny Edge Detection' button to perform edge detection using GPU processor



Above screen showing edge from GPU canny edge detection. Now click on ‘Performance Time Consumption Graph’ button to get below graph



In above graph x-axis represents technique name such as OPENCV and GPU Time and y-axis represents time in milliseconds taken by each technique. From above graph we can see GPU based performance is better than CPU based OPENCV.Similarly you can upload any image and perform edge detection

8. CONCLUSION

In this paper authors presented a robust and reliable method for power measurement of specific algorithms and code snippets among iOS app. The comparison between GPU based and CPU based image processing algorithms shown an advantage in efficiency of GPU based ones. In some cases the CPU based implementation can be much more power efficient, however in case of more complicated input images the differences are not significant. The paper discuss also different practical use scenarios in the development of the medical image processing applications, with its specific requirements. It is shown, that the balance between GPU and CPU based algorithms implementations may result in optimal efficiency and increase the UX of the smartphone app significantly

9. REFERENCES

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