Evaluation of Image Processing Algorithms on ARM Powered Mobile Devices

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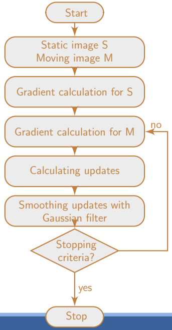
Introduction

- Image enhancement plays an important role in different research fields such as medical image analysis.
- The most popular methods for image processing and analysis are very resource hungry.
- We investigate the possibilities and limitations of well known Demons algorithm implemented for mobile Android device.
- To our knowledge there is no implementation of Demons registration method for Android platform.
- The contributions of this work are:
  - Implementation of the Thirions Demons registration algorithm on ARM CPUs running Android.
  - Speeding-up the implementation using hardware optimizations
  - Performance evaluation for Gaussian parameters.

Demons registration

- Image registration tries to find a mapping from one coordinate system of one image to the coordinate system of the other image.
- The one of the most widely used deformable registration algorithm is Demons registration algorithm.
- Advantages: widely known, simple to use, linear computational complexity, easily parallelizable.



Start

Static image S
Moving image M

Gradient calculation for S

Gradient calculation for M

Calculating updates

Smoothing updates with Gaussian filter

Stopping criteria?

no

yes

Stop

Figure : Flowchart of Demons algorithm

Implementation for an Android device

- Android platform is now a world dominant in mobile platform market.
- Applications are developed in the Java language using Android Software Development Kit (SDK).
- Resouce consuming parts can be with C/C++ language using Native Development Kit (NDK)
- With NDK we can exploit Single Instruction, Multiple Data (SIMD) optimizations
- For Tegra 3 and Samsung Exynos platforms optimizations for ARM V7 instructions with NEON instructions can be used.

Hardware and Software

- Used devices were: desktop (small laptop, home PC, server machine), cell phones and tablet.
- GCC 4.6.3 compiler with optimizations using GNU/Linux.

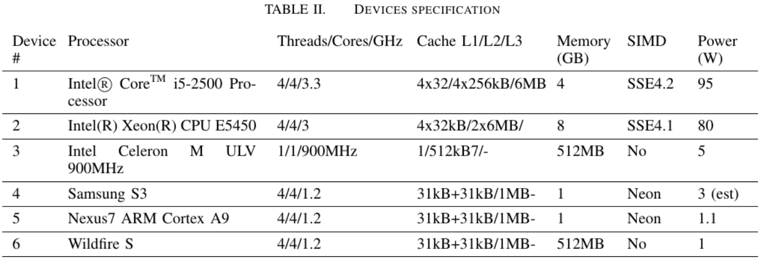


TABLE II. DEVICES SPECIFICATION

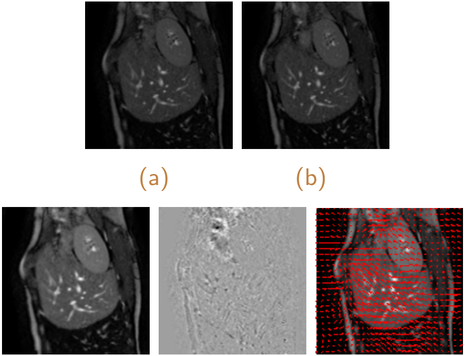
Device #	Processor	Threads/Cores/GHz	Cache L1/L2/L3	Memory (GB)	SIMD	Power (W)
1	Intel® Core™ i5-2500 Processor	4/4/3.3	4x32/4x256kB/6MB	4	SSE4.2	95
2	Intel(R) Xeon(R) CPU E5450	4/4/3	4x32kB/2x6MB/	8	SSE4.1	80
3	Intel Celeron M ULV 900MHz	1/1/900MHz	1/512kB7/-	512MB	No	5
4	Samsung S3	4/4/1.2	31kB+31kB/1MB-	1	Neon	3 (est)
5	Nexus7 ARM Cortex A9	4/4/1.2	31kB+31kB/1MB-	1	Neon	1.1
6	Wildfire S	4/4/1.2	31kB+31kB/1MB-	512MB	No	1

Table : Optimization parameters for GCC compilers

Platform	Optimization string
Desktop	-O2
ARMv7	-march=armv7-a -mtune=cortex-a9 -mfloat-abi=softfp -mfpu=neon
ARMv6	-march=armv6 -marm -mfloat-abi=softfp -mfpu=vfp

Results

- Two MRI liver images 256 × 256 were used in all experiments.
- We varied Gaussian parameters in Demons: kernel width, and σ.



(a) (b)

(c) (d) (e)

Figure : Images used for registration a) fixed b) moving c) registered d) difference after registration e) overlayed deformation field

Results (2)

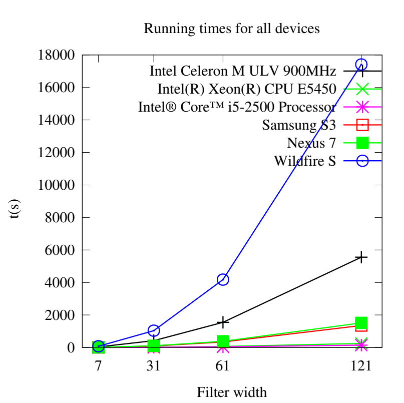


Figure : Registration results for all devices

	Parameters		Device #					
Image size	width	σ	1	2	3	4	5	6
256 × 256	7	1.0	1.5	1.2	34.3	8.6	9.7	30.1
	31	5.0	12.8	18.2	422.7	91.2	103.3	1033.8
	61	10.0	42.2	63.2	1549.9	338.8	379.6	4175.5
	121	20.0	144.7	245.9	5558.1	1351.2	1514.3	17414.5

Discussion and Future Work

- Results shows, in general, that mobile devices cannot compete with desktop CPUs in higly demanding tasks like image registrations.
- Can be used as an alternative with smaller Gaussian kernel widths, (i.e. smaller deformations).
- The best results were about 9 times slower than desktop.
- Further research in this direction can evaluate tradeoff between registration precision and execution times regarding floating point optimizations.
- Another possibility is multicore implementation of Demons algorithm on the ARM CPUs, i.e. implementation using Threading Building Blocks (TBB).

Acknowledgement

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Thank you for your attention