

A Competitive Massive Slide Scanner Test: *scanning performance*

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Outline

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Rationale

- main aim: feasibility study for **routine application** of **digital slides** in the **surgical pathology** laboratory as **outsourced service**
- Research questions:
 - Do scanners support continuous acquisitions on 24/7, in terms of software and hardware behaviour ?
 - Are manual operations related to scanners repeatable and hassle-free?
 - How many slides per day can be truly acquired, taking into account all the operations needed?
 - How many slides need to be acquired again due to quality issues?
 - Is there any connection between clinical pathology laboratories procedures and glass quality, that influence acquisition quality or speed?

Study design

- collection of a number of **glass slides** coming from different pathology labs;
- their **acquisition** by means of some digital slide scanners on a 24/7 basis;
- **measurement** of a number of variables, including acquisition speed, ease of loading/usage, accidental events, digital slide size, digital slide based diagnosis, etc
- **evaluation** of output basing on scanner and on originating laboratory

Material: scanners

- Three scanners (A, B, C) have been provided by three manufacturers
 - by means of their national distributors,
 - which also provided training and technical support during the experimentation
- the scanners were chosen among those aimed at high throughput,
 - i.e., with slide loaders able to host hundreds of slides.

Material: glass slides

- Glass slides have been provided by six Pathology laboratories from Italian hospitals
- Glass slides were aimed at representing the average production of those labs,
 - so they have been chosen consecutively from lab archives.
- 1200 slides per lab have been requested, for a total of 7244* glass slides
 - *an hospital gave more

Methods/1: qualitative analysis

- Marks (1-5) given to the below aspects, and weighted to provide a global rating of the scanners:
 - setup phase: hardware and software expertise and features (*weight: 7*)
 - loading phase: speed, ease of execution, batch loading and single slides (*weight: 12*)
 - trays: usable for storage, robustness (*weight: 14*)
 - software: completeness, usability, log, database accessibility, documentation (*weight: 12*)
 - image quality (*weight: 10*)
 - Industrial aspects: commercial approach (8), manufacturer (3), partnerships (5)
 - customer care and technical assistance (*weight: 15*),
 - failure management (*weight: 14*)

Methods/2: quantitative analysis

- per scanner / per hospital:
 - acquisition speed (min/slide, total time)
 - acquisition success (%)
 - barcode acquisition (successful, failed)
 - scanner downtime during experimentation
 - average digital slide size
 - accidental events (slide jams, etc)
- average, minimum, maximum, totals when useful

Results/1: material

Each Pathology Lab provided glass slides from biopsies and surgical samples, full cases up to 1200 slides in total.

Lab	slides	cases	%biopsies	slides/case
1	1200	449	77,95%	2,67
2	1200	238	78,57%	5,04
3	1200	250	60,79%	4,80
4	1200	n.a.	n.a.	n.a.
5	1200	433	88,22%	2,77
6	1244	402	69,15%	2,99
avg		354	74,94%	3,65

Results/2: scanner throughput

Scanner	slides	% success	total time	time/ slide	barcode failure %	downtime (h)
A	7332	99,19%	72:47	3:46	1,86%	1,54
B	7200	95,65%	100:38	5:14	1,19%	2,04
C	7210	98,31%	92:43	4:25	0,00%	1,00
<i>average</i>	21742	97,72%	89:27	4:28	1,02%	1,53

(most barcode errors were at the beginning, then quickly solved by software developers)

Results/3: throughput by lab

Lab	total slides	% success	total time	time/slide	barcode failure %	downtime (h)
1	3600	97,86%	109:37	5:23	0,55%	0,67
2	3600	98,25%	101:45	4:52	1,06%	0,75
3	3610	97,34%	70:14	3:27	0,69%	0,83
4	3600	98,44%	73:29	3:37	0,85%	1,33
5	3600	97,03%	91:21	4:52	3,47%	4,00
6	3732	97,39%	92:00	4:37	7,14%	1,58
	21742	97,72%	89:27	4:28	1,02%	1,53

Results/4: Throughput variability

GB/minute acquired

	1	2	3	4	5	6	avg
A	111,22%	102,26%	102,95%	98,79%	81,50%	103,28%	0,109
B	115,74%	124,77%	111,96%	103,34%	63,83%	80,37%	0,074
C	96,38%	148,58%	101,89%	88,16%	73,32%	91,67%	0,134

Throughput depends on the lab?

Results/5: the digital archive

- A total of about 10TB of slides has been acquired in about 1600 hours of scanning work
 - ~22000 slides, equivalent to 1 year of lab work

Avg. Slide Size		(GB)			<i>avg</i>	% <i>biopsies</i>
A	B	C				
1	0,56	0,52	0,70	0,59	77,95%	
2	0,50	0,53	0,89	0,64	78,57%	
3	0,33	0,30	0,52	0,38	60,79%	
4	0,32	0,30	0,48	0,36		
5	0,36	0,29	0,43	0,36	88,22%	
6	0,41	0,35	0,53	0,43	69,15%	
avg	0,41	0,38	0,59	0,46		

Results/6: qualitative analysis (summary)

	scanners			
	<i>weight</i>	A	B	C
Setup (HW, SW, complexity)	7	4	4,7	2,7
Loading phase	12	4,3	4	1,4
Trays features	14	4,5	4	2
Software	12	3,8	2,5	2,3
Image quality	10	3	4	2
Commercial support	8	5	4	2
Manufacturer/reseller	3	4	5	2
Partnerships	5	4	5	1
Customer care & Tech assistance	15	5	4	3
Failure management	14	3	4	1
weighted average		4,07	3,95	1,96

Discussion

- the present study provides novel insights on current slide scanners
- from the point of view of their massive application in a slide scanning service
- as far as we know, no other study attempted yet the same kind of intensive evaluation
 - though relevant evaluations have been done in the Scanner Contests 2010-2012
- **here we present some preliminary discussion**

Discussion/1: scanning time

- real world scanning time seems higher than declared
- however, it seems also dependent on slide preparation quality
 - preparing for scanning is more crucial than preparing for microscope + human eye!
- massive scanning ->
need for preparation guidelines/standards

Discussion/2: supervision

- reliability is high, scanning success too, but both are not 100%, so:
- even if scanning is automatic, it is not possible to do it in a non supervised way
- need for personnel taking care of all the steps: loading, scanning, trouble management, informatics and networks issues, etc
- **expertise needed: both laboratory and IT**
 - laboratory technician + IT training?
 - IT expert + laboratory basic training?

Discussion/3: the role of trays

- the least trays are manipulated, the least errors, glass breakings, misidentifications, and time lost
 - plus, their mechanics should be reliable and misplacement free
- so, trays should serve not only as a loading medium for the scanner, but also:
 - as a transport medium
 - as a definitive glass slide storage medium
- **current trays are only aimed at loading**
 - is it possible to extend their usage?

Discussion/4: slide size

- slide size varies even greatly from lab to lab
- in these preliminary analysis, no clear reason has been identified,
 - except some likely correlation with glass slide quality
 - ...although not correlated with acquisition time
- The total amount of memory needed is massive, and grows rapidly
 - how to manage the growth?
 - buy disks or buy storage on-demand (i.e., **cloud**)?
 - how long to maintain digital slides?

Conclusions/1

- this experimentation of massive scanning in a real world scenario revealed some information useful for everyone interested in applying Digital Pathology to surgical pathology routine
- scanners seem to provide a good image quality and reliable behavior, however:
- trays design, for some manufacturer also technical support and other small details suggest that:
 - scanners until now have been maybe aimed at the enthusiast pathologist
 - scanning limited numbers of slides, not in a hurry,
 - and not inside the regular routine workflow

Conclusions/2

- the step beyond is to (re-)design some features having in mind industrial usage of scanners
- tenths of thousands slides per year!
- in a regular workflow
- standards-based process
 - including imaging standards
- industrial-level tech assistance and customer care
 - downtime as reduced as possible
 - clear relationships among those providing hardware, software and services

Conclusions/3

- the infrastructure needed for Digital Pathology is not just a scanner on a spare table in corner of the lab
- memory sizing, resizing, and management,
- backup, power supply, network sizing and management, software management and upgrade, ...
- slide loading, verification, unloading, archival, ...
- **who may take care of all of this in the current surgical pathology lab?**

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