Medical Imaging Special Topics
Teleconference
6 August 2014 • 15:00 (UK) / 10:00 (EDT)

The meeting was called to order at 10:00 am (EDT) by Craig Revie, MIWG chair, with the following attendees:

Aldo Badano
Wei-Chung Cheng
Chris Bai
Craig Revie
Elizabeth Krupinski
Hong Wei
James Chang
Kaida Xiao
Bryan Kennedy
Tom Kimpe
Martin Maltz
Masahiro Nishibori
Masahiro Yamaguchi
Michael Flynn
John Penczek
Jeremie Pescatore
Phil Green
Pinky Bautista
Po-Chieh Hung
Takashi Matsui
Yu Kosugi
Max Derhak
Debbie Orf
Tyler Keay

Mr Revie gave a summary of future MIWG meetings [attached].

The agenda for this meeting was as follows:

1. Continuation of Displays teleconference (interrupted by fire at Barco)
2. Details of mRGB / dRGB
    - Po-Chieh Hung's presentation from FDA meeting

- color gamut requirements
- white point chromaticity and luminance

3. Follow up on topic of skin color database - Kaida Xiao
4. New topic: virtual reading of Petri plates - Jérémie Pescatore, FMLA System Design Architect, bioMérieux

1. Continuation of Displays teleconference

Mr Kimpe began with an apology for the interruption to the 17 July meeting, caused by a fire at Barco. He presented an outline of the tests to perform to validate the architecture discussed at the previous meeting [see attached]. The tests should include bench tests, with actual displays, and simulation tests. He asked for participation from those present. The first task was to contribute test images – some on the call had already agreed to do this. He also asked that people supplying test images specify their performance requirements. From the previous discussion, these requirements might include color difference (in CIEDE2000, JNDMetrix or VDP) and whether the system made a clinical difference or not.

For the bench test it was proposed to have a limited number of displays. Barco will test using both medical and consumer displays, and participants were asked to identify other displays that could be used for testing. Test details will be made public on the MIWG site.

For the displays used, it was important to characterise the luminance and gamut characteristics. It was acknowledged that measurement instruments would influence the results, but it was agreed that participants should use the best available instrument and document this in their report.

There had been some discussion about the viewer pipeline, and it had been felt that lcms was the most suitable tool for profile creation as it was open source C++ code, well documented and supported, and fully ICC v4 compliant. Matlab and Octave had been considered, but Matlab is costly and Octave would require more work to build viewer modules from scratch. Both have worse performance than compiled C++ code.

Suggested viewers for bench tests included one from FFEI, Adobe Photoshop, or other application with a reliable color management implementation (participants should document which is used).

Mr Kimpe proposed that the Virtual Clinical Trials (VCT) code be used for the simulation framework. VCT is an open source library that is being developed in a joint NIH R01 project between Barco and University of Pennsylvania. It includes an imaging pipeline and Mr Kimpe undertook to add lcms. It is planned to be public in September/October 2014. VCT had good performance and is structured so that recompiling is only needed when functionality is added. For run-time just an xml batch file is needed. He offered to provide a training session on VCT in a future telecon, after the source code has been put online.

It was also agreed that participants could use their own viewer for the simulation tests.

Dr Flynn recommended that configuration guidelines should be provided to maximise consistency between tests. Mr Kimpe also agreed to provide a standard list of questions to document the hardware used.

Mr Kimpe invited participation in the tests, and it was agreed to set up a web page to provide test details.

2. Details of mRGB / dRGB

2.1 Dr Po-Chieh Hung presented slides he had shown at the FDA meeting in June [see attached]. He had some concerns about color encoding using the mRGB standard. He described two types of color difference, micro and macro. The first is based on JND experiments, while the second is based on scaling experiments (e.g. magnitude estimation). He compared GSDF with the CIELAB L* scale, and showed the relative JND change with L* and the color difference per unit JND, where there was clearly a discontinuity in the scale.

He also showed how applying different GSDF luminance levels causes a change in uv chromaticity (the uv chromaticity diagram having better perceptual uniformity than CIELAB). He felt this shift in chromaticity was undesirable, and suggested that GSDF should be used for grayscale images but not color, where ICC profiles should be used.

Dr Flynn clarified that a given device has a fixed Lmax and different transforms would not be used for the same device. He felt that the possible chromaticity shift should be included in the benchmark testing being undertaken. He also noted that GSDF was derived from sinusoidal gratings, which produced different responses from the large patches used in deriving the CIE color difference metrics.

2.2 Dr Flynn presented slides on medical imaging workflow [see attached] as part of a discussion on mRGB gamut and white point luminance. He stated that the AAPM committee discussing mRGB has introduced the term dRGB, where d is for DICOM. This color space mainly encodes the neutral scale. The committee appreciates that there are many color issues in the different clinical modalities that need to be understood before finalising the color details.

AAPM were considering using the ICC v4 metadata tags to encode Lmax, Lmin and Lamb and also variants from the sRGB primaries. It was noted that ICC metadata tags were intended for profile selection rather than processing information, and there was a danger that different results would be obtained depending on whether the color management system correctly read and applied the metadata. An alternative approach was to have a profile for each luminance level, and state the luminance in the profile description tag. The latter is usually shown when lists of profiles are displayed, thus supporting both manual and automated profile selection.

Dr Flynn stated that the main use case for encoding an image as GSDF would be health centers using health information systems in which radiology images are distributed to different workstations. Some of these devices are not calibrated to GSDF grayscale, and web applications are often used. The goal was to improve on the current situation, although it was accepted that if the system did not use color management there could be errors as sRGB was likely to be assumed as the RGB interpretation.

Dr Flynn also discussed the need to test white point chromaticity issues in the bench testing. Optical microscope images are often yellowish, and a chromatic adaptation transform may be needed to make the image look correct on a D65 display. It was pointed out that users generally adapt well to the display white point, and that chromatic adaptation could readily be handled in the ICC architecture.

Dr Flynn also noted that in the encoded image there is no information about the Lmin or Lmax; this is only known from the actual workstation display, and he felt this requires a configurable parameter that can be set at the workstation.

It was agreed that color space, chromaticity shift and image encoding issues needed further discussion.

3. Skin color database

Dr Kaida Xiao presented a pilot study on skin color measurement [see attached]. In the study, instrument uncertainty had been investigated by measuring 5 times; the mean color difference from the mean (MCDM) was considerably higher for skin subjects than for a uniform skin color chart. Inter-instrument agreement (between the telespectroradiometer and spectrophotometer used in the study) were good on uniform patches but poor on actual subjects, and he considered that it was not feasible to combine data from different instruments.

He had also investigated the use of a digital SLR camera, using a Colorchecker target to make a profile from camera RAW images. In comparison with the measured colors, the mean error was 3.3 using the TSR and 4.4 using the spectrophotometer, across the 12 subjects in the study. The TSR was influenced by lighting non-uniformity, while the spectrophotometer potentially affected the skin color through contact. The DSLR had a number of advantages, including the option to do post-processing to correct for lighting non-uniformity, but it was necessary to select the appropriate measurement instrument for calibration purposes.

Dr John Penczek stated that NIST has a current project on producing a traceable standard for skin color, and agreed to provide a contact.

The meeting discussed the importance of accuracy of skin color measurement given the natural variation in a single subject, and Dr Xiao stated that an advantage of using a camera was the ability to record this variation.

Dr Xiao agreed to consider making the skin color measurement data available through the ICC web site in the future.

4. Virtual reading of Petri plates

Dr Jérémie Pescatore of bioMerieux presented an overview of Petri plate imaging [see attached]. Today Petri plate analysis is becoming highly automated, particularly in incubation, imaging and analysis. Imaging is performed periodically during incubation, and unlike other analytical tools the images are human readable. The goal of a virtual reader is provide similar information content to a manual system, which requires high quality images. To overcome the lack of depth information on the display, the bioMerieux system uses different light sources, background, exposure levels and backlight, and this allows some depth information to be captured.

Previous research shows that virtual reading performs better at detecting morphotypes, and the system can support both manual diagnosis and automated decision making (e.g. filtering images to present only those of clinical interest).

Dr Pescatore summarised the presentation in terms of the need for high image quality to support increased automation and provide useful information for clinical decision-making. Work is needed on colorimetry and standardisation, and he agreed to provide a list of areas where standardization might be useful in this field.

Mr Revie thanked the speakers and closed the meeting at 12.05. The next MIWG meeting is 21 August.

Action items

Actions agreed at the meeting were:

MIWG-14-39 Provide training session on VCT simulation framework (Kimpe)

MIWG-14-40 Provide configuration guidelines for tests, and checklist of hardware parameters for testers to document (Kimpe/Flynn)

MIWG-14-41 Set up web page for details of display architecture tests (Green/Kimpe)

MIWG-14-42 Provide NIST contact for skin color standard to Xiao (Penczek)

MIWG-14-43 Provide list of areas where standardization might be useful in virtual reading of Petri plates (Pescatore)

International Color Consortium

ICC Medical Imaging Working Group

Special Topics

6th August 2014

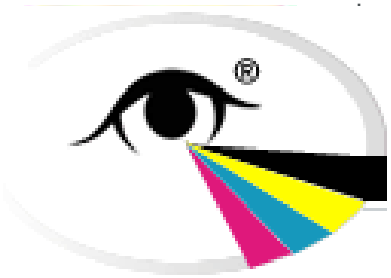
Future meetings

- **ICC MIWG, IS&T CIC and IADP Congress**
  - Boston (30th October – 7th November)
  - Saturday 1st November: ICC MIWG
  - Monday 3rd November: ICC DevCon
  - 3rd – 7th November: IS&T Color and Imaging Conference (CIC22) and the 2nd International Congress of the International Academy of Digital Pathology (IADP)
  - 3rd and 4th November: IADP / CIC Short Courses
- **Regular monthly teleconferences**
  - 21 Aug 2014 (TBD)
  - 25 Sep 2014 (Whole Slide Imaging)
  - 16 Oct 2014 (Medical Photography)
  - 11 Dec 2014 (Mobile)
- **Details on http://www.color.org/groups/medical/medical_imaging_wg.xalter**

Today's meeting agenda

- **Continuation of Displays teleconference (Tom Kimpe)**
- **Presentation from FDA meeting (Po-Chieh Hung)**
- **Details of mRGB / dRGB (Mike Flynn)**
  - colour gamut requirements
  - white point chromaticity and luminance
- **Follow up on topic of skin colour database (Kaida Xiao)**
- **New topic: virtual reading of Petri plates**
  - Jérémie Pescatore, FMLA System Design Architect, bioMérieux
- **Discussion**

International Color Consortium



MIWG - Displays

Teleconference August 6th 2014

Summary of the decisions taken at the face-to-face meeting on June 19-20th 2014

(see also: http://www.color.org/groups/medical/Minutes_Jun2014_mRGB.pdf)

1. The use cases have been fixed
2. Visualization architecture
   - We should aim for one architecture that can support all use cases (until proven that this does not work)
   - We should try the standard ICC framework first before making extensions
   - We need to practically validate/challenge the proposed framework against the use cases

Goal of this telephone conference

3. A series of validation tests need to be defined and agreed upon

Plain grey or color medical image

Use case 1
Use case 2

8 or 10-bit greyscale or color medical images

Display calibrated to be perceptually linear

- using DICOM GSDF for neutral (R=G=B) scale
- and optionally being also perceptually linear in its color behavior

- Calibration LUT of at least 12 bits depth

The tone scale changes when the white point or black point (including ambient illumination) changes

Grey or color medical image with ICC profile

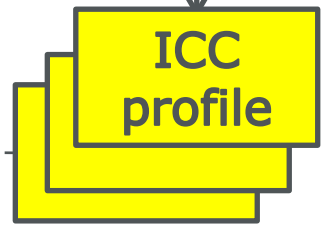
Use case 3

CMM

8 or 10-bit greyscale or color medical images

The standard operating system CMM may not be appropriate for this application

(eg. handling dynamic ICC profiles)



A set of example/default profiles could be developed for different white/black range and could be posted on the ICC web site

Your input and support is highly desired

- The next slides contain some suggestions to facilitate the discussion on which tests need to be performed
- Intention is to fully share all testing results within the MIWG Displays

- Feel free to:
  - Suggest changes
  - Propose alternative approaches for validation
  - Volunteer to do specific tasks

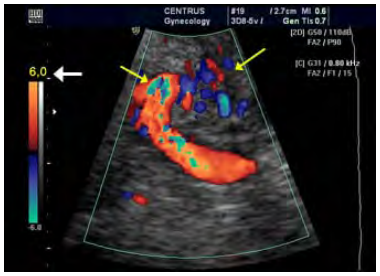
Proposed validation tests

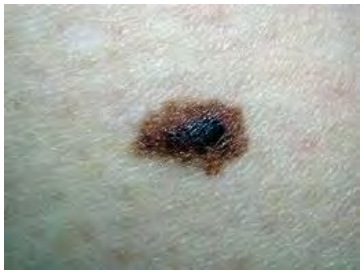
- Bench testing
  - Making a (reference) implementation
  - Showing that the architecture can work
  - Measuring/quantifying performance

- Simulation/theoretical
  - Making theoretical calculations about performance
  - Developing simulation software/pipeline to simulate behaviour in various configurations

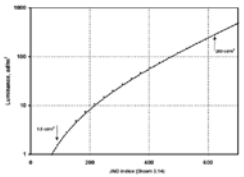
Tasks – General (1)

- Collect a set of representative test images for each use case
  - Greyscale radiology images
  - Fused multimodality images
  - Dermatology images
  - Digital pathology images





- Specify minimum performance requirements for each use case



  - Eg. DICOM GSDF compliance with max 10% error
  - Eg. Absolute colour accuracy with max error 5 deltaE2000 units
  - Eg. JNDMetrix / VDP differences
  - Eg. AUC

Tasks – General (2)

- Select a number of colour displays to be included in the testing
  - At least one medical colour display which uses internal luminance & color stabilization
  - At least one consumer sRGB display
  - Mobile display?

- Characterize these colour displays
  - Neutral grey luminance curve
  - Full colour gamut characteristics
  - ...

Tasks – Bench testing

- Define the specific setups to be evaluated
  (combinations of viewing application, use case, display)
  - ...
  - Include multi-monitor setup
  - Include variable ambient light conditions

- Create a reference implementation
  - ICC profile generation, using LittleCMS
  - Medical viewing application with CMM

Tasks – simulation (1)

- Develop a simulation framework such that the effect of (parameter) choices in the visualization chain can be tested. Eg.
  - What is the effect of positioning the calibration LUT inside the display or inside the CMM (/PC/GPU)?
  - What accuracy can be achieved (DICOM GSDF, PLCB, deltaE2000 absolute color rendering) when the display is natively sRGB vs DICOM GSDF vs PLCB?
  - What is the minimal bit depth needed in the calibration LUT in order to reach sufficient performance for the different use cases?
  - ...

Tasks – simulation (2)

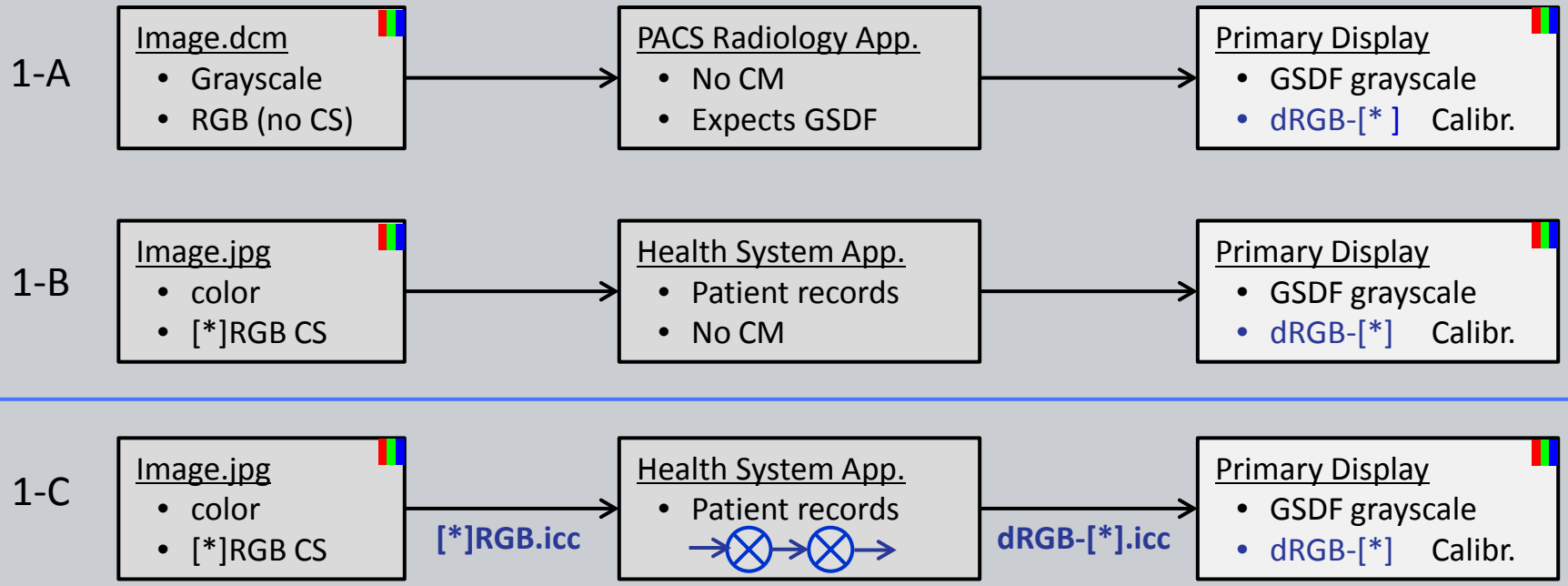
- As basis for the simulation framework the suggestion is to use VCT (http://link.springer.com/chapter/10.1007/978-3-319-07887-8_1)
  - This will be put online as open source in the Sep/Oct timeframe
  - This platform already contains a full imaging pipeline and various building blocks such as LUTs, display components, observer models, ...

It would be really nice if people participating in the MIWG Displays would volunteer to take care of some of the validation tasks to be performed

Thank you!

Case – Primary display, radiologist workstation

1. Medical image presentation on a workstation with DICOM calibrated primary monitors used for medical interpretations



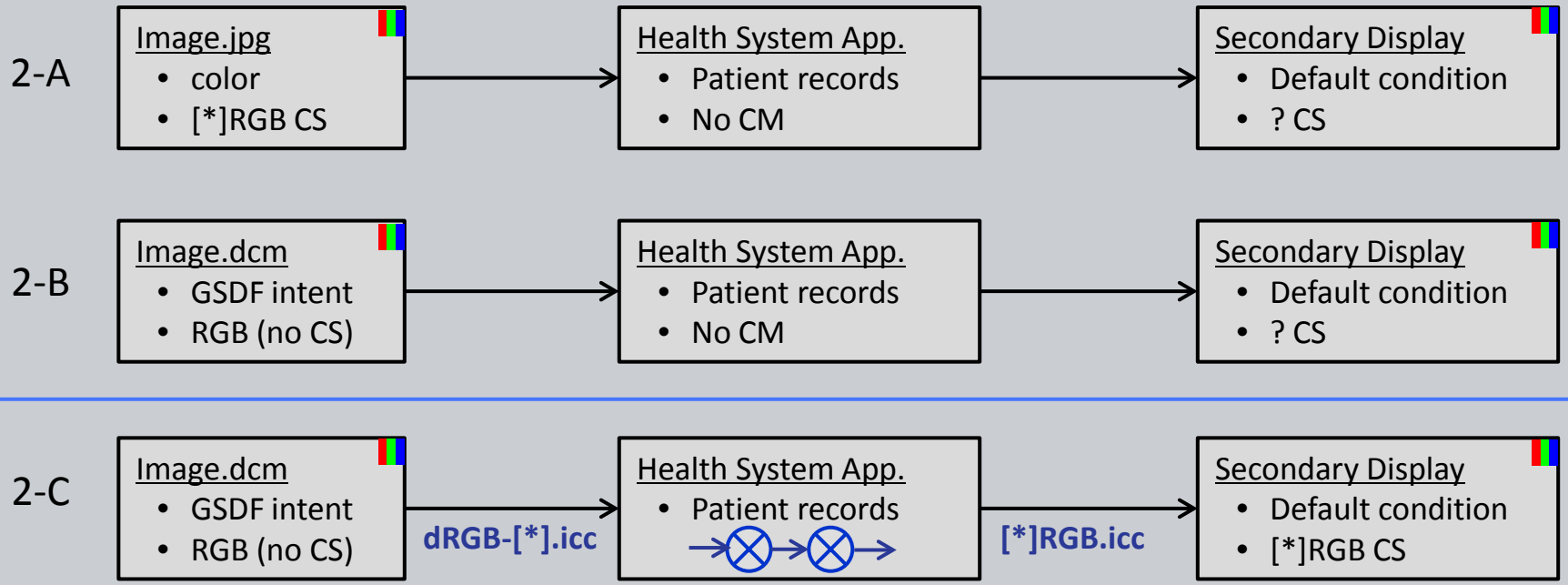
Case A:	Correct	Grayscale & pseudo-color DICOM images with GSDF neutral tones.
Case B:	Incorrect	Color photograph is presented with GSDF neutral tones.
Case C:	Correct	Color photograph is presented with the intended color space.

Denotes a color managed module
Using source and display profiles

CS – Color Space
CMS – ICC Color Management (full)

Case – Secondary display, physician workstation

2. Medical image presentation on a workstation with secondary monitors used for reviewing patient information.



Case A:	Uncertain	Color photograph is presented with the default configuration .
Case B:	Incorrect	Grayscale & pseudo-color DICOM images not presented with GSDF.
Case C:	Correct	Grayscale & pseudo-color DICOM images are mapped to GSDF

Denotes a color managed module
Using source and display profiles

CS – Color Space
CMS – ICC Color Management (full)

A Consideration of Image Display Method that Micro- and Macro- Color Differences Coexist

Po-Chieh Hung

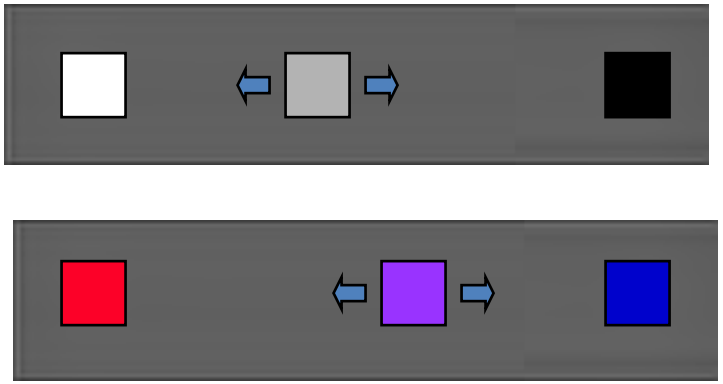
Konica Minolta Laboratory U.S.A., Inc.

Outline

- Types of color differences
  - Micro (JND)
  - Macro (scaling)
- Gray Scale Display Function
- Basic Idea
- Preliminary test
- Summary

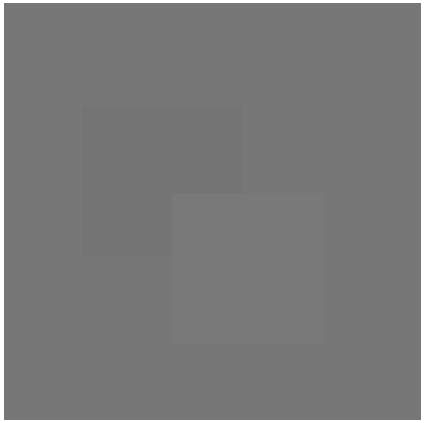
Two Types of Color Differences

Macro (By Scaling)



e.g.
Munsell Color System
CIE L*a*b* color space

Micro (By JND)

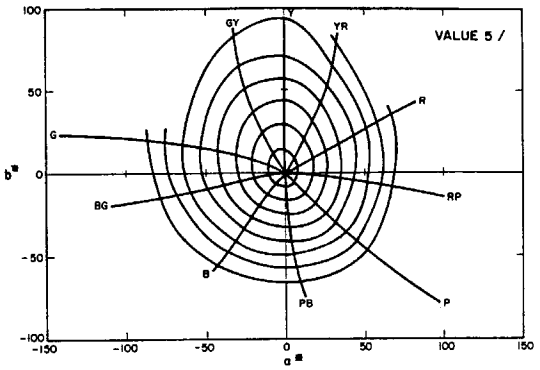


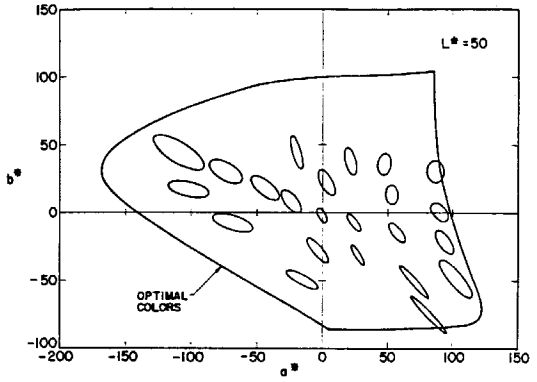
e.g.
GSDF
MacAdam's ellipses (Standard Deviation of Color Matching)

Two Types of Color Differences

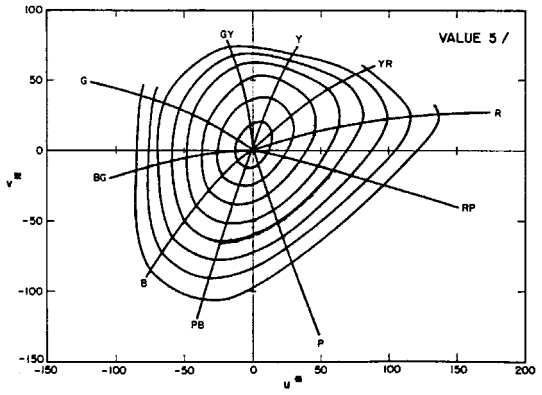
Comparison of CIE L*a*b* and L*u*v*

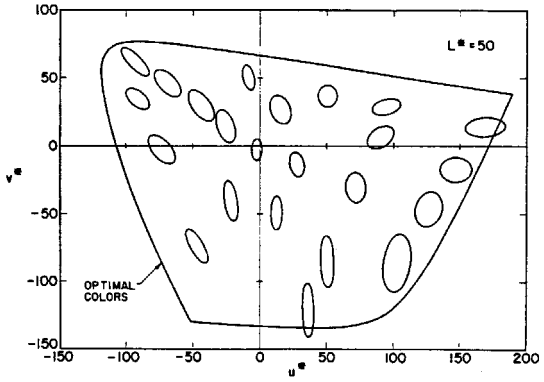
L*a*b*





L*u*v*





Munsell color space

MacAdam's ellipses

A. R. Robertson, The CIE 1976 color-difference formulae, Color Research and Application, 2, 1, pp. 7-11 (1977).

As a Result…

$$1_{jnd}+1_{jnd}+1_{jnd}+1_{jnd}+1_{jnd} \neq 5_{scale}$$

Micro color difference

Macro color difference

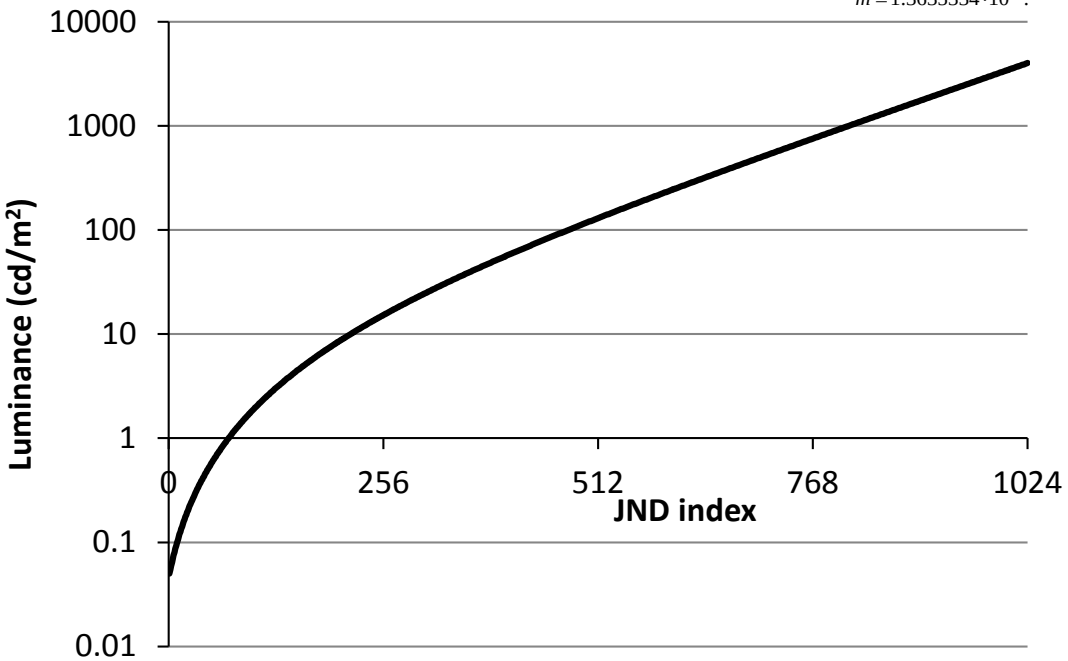
Color difference is not linear

Gray Scale Display Function

Grayscale Standard Display Function: The mathematically defined mapping of an input JND index to Luminance values defined in PS 3.14.

$$\log_{10} L(j) = \frac{a + c \cdot Ln(j) + e \cdot (Ln(j))^2 + g \cdot (Ln(j))^3 + m \cdot (Ln(j))^4}{1 + b \cdot Ln(j) + d \cdot (Ln(j))^2 + f \cdot (Ln(j))^3 + h \cdot (Ln(j))^4 + k \cdot (Ln(j))^5}$$

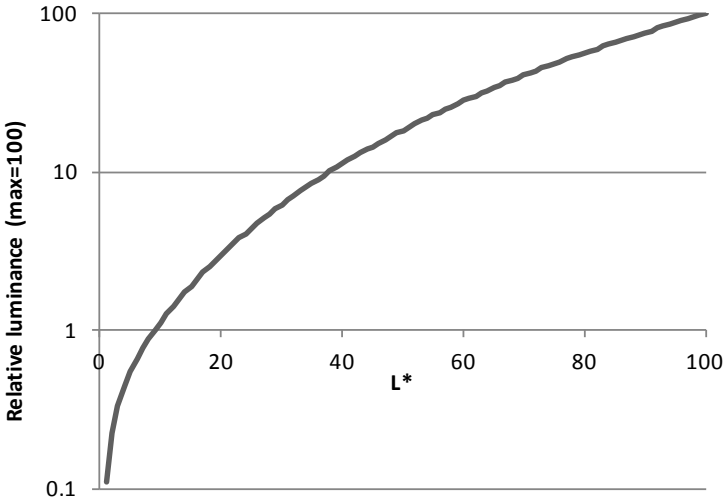
$a = -1.3011877,$
$b = -2.5840191 \cdot 10^{-2},$
$c = 8.0242636 \cdot 10^{-2},$
$d = -1.0320229 \cdot 10^{-1},$
$e = 1.3646699 \cdot 10^{-2},$
$f = 2.8745620 \cdot 10^{-2},$
$g = -2.5468404 \cdot 10^{-2},$
$h = -3.1978977 \cdot 10^{-3},$
$k = 1.2992634 \cdot 10^{-4},$
$m = 1.3635334 \cdot 10^{-3}.$



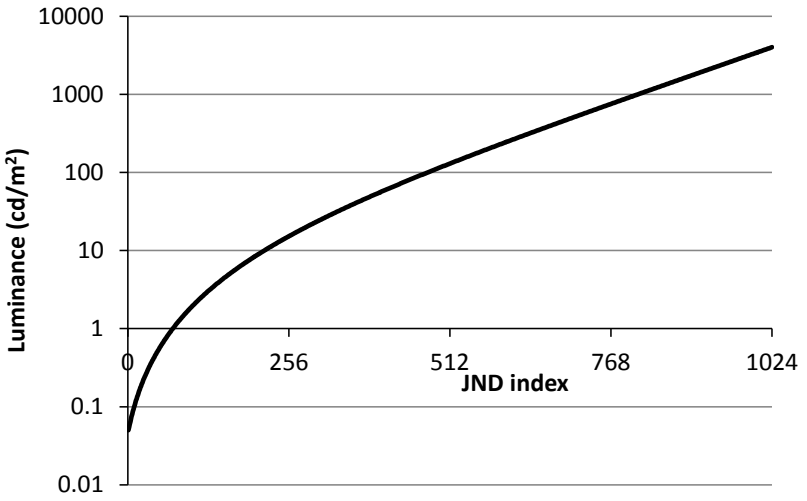
PS 3.14-2011, Digital Imaging and Communications in Medicine (DICOM), Part 14: Grayscale Standard Display Function, National Electrical Manufacturers Association.

Essential Difference between GSDF and L*

L*: Relative against white point
GSDF: Absolute to luminance



L*

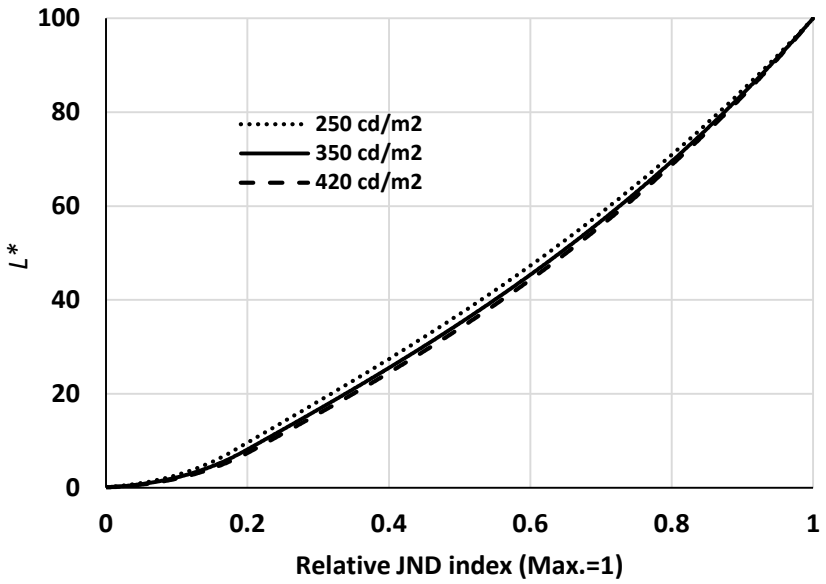


GSDF

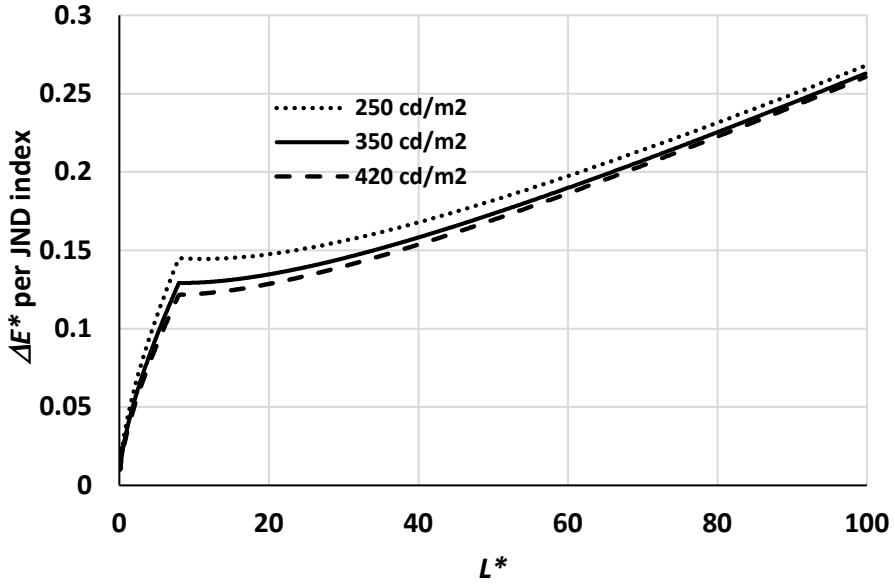
They look similar at a glance, but…

What would happen if GSDF is used for Color Space?

When it is plotted in L* axis under the conditions of different Luminance levels…



L* vs GSDF JND



L* vs ΔE* (ΔL*)

mRGB Color Space (not final)

KONICA MINOLTA

Color spaces compared

* IEC 62563 terminology

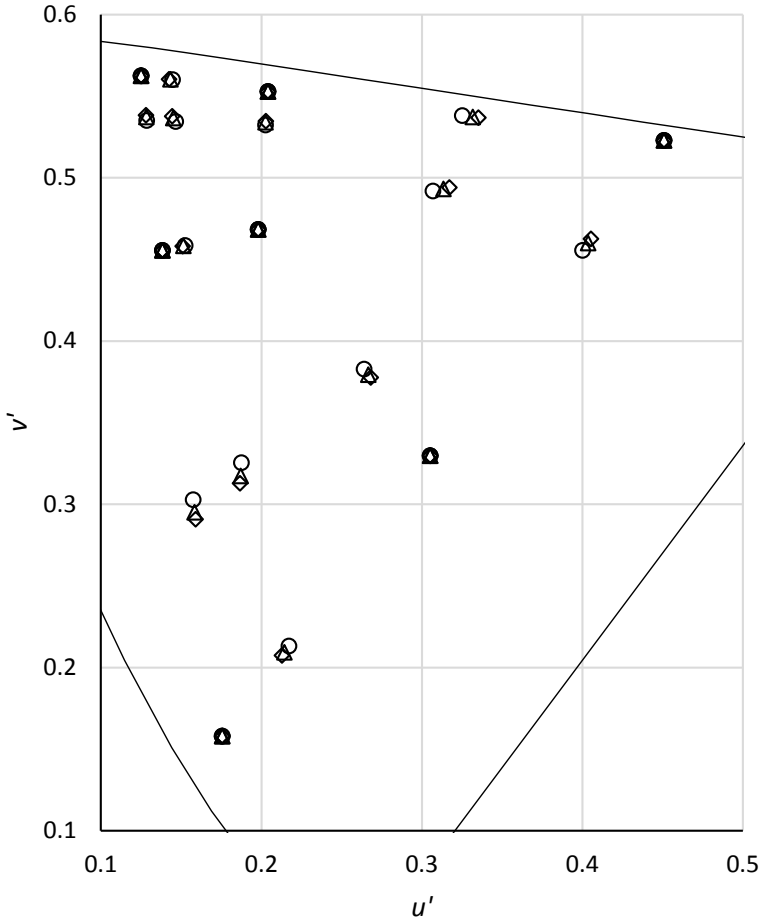
Specification*	sRGB	aRGB	ACR	mRGB
Luminance Response	~2.2 power function	2.199 power function	DICOM GSDF	DICOM GSDF
Color Gamut	HDTV based ITU-R BT.709-5	'Wide' (extended G)	-nd-	sRGB (aRGB option ?)
L_{max} , cd/m^2	80	160 (125-200)	350/420/250	350/420/250
L_{min} , cd/m^2	-nd-	0.56	L_{max} / LR	L_{max} / LR
Luminance Ratio (LR)	-nd-	287.9 (230-400)	350 (> 250)	350
White Point	D65	D65	D65	D65
Gray tracking	-nd-	-nd-	-nd-	IEC MT51
Surround	20% refl. Ix	Gray < 20% L_{max}	-nd-	20% L_{max}
Ambient Illumination, lx	64 (D50)	32	20-40	-nd-
Veiling Glare	1.0%	accounted	-nd-	-nd-
L_{amb} , cd/m^2	-nd-	-nd-	$L_{amb} < L_{min}/4$	$L_{amb} < L_{min}/4$

AAPM TG196

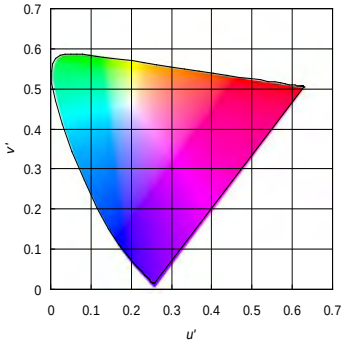
http://www.color.org/groups/medical/Flynn.pdf

What would happen if GSDF is used for Color Space?

Causes chromaticity shift!



○: 250 cd/m²
△: 350 cd/m²
◇: 420 cd/m²



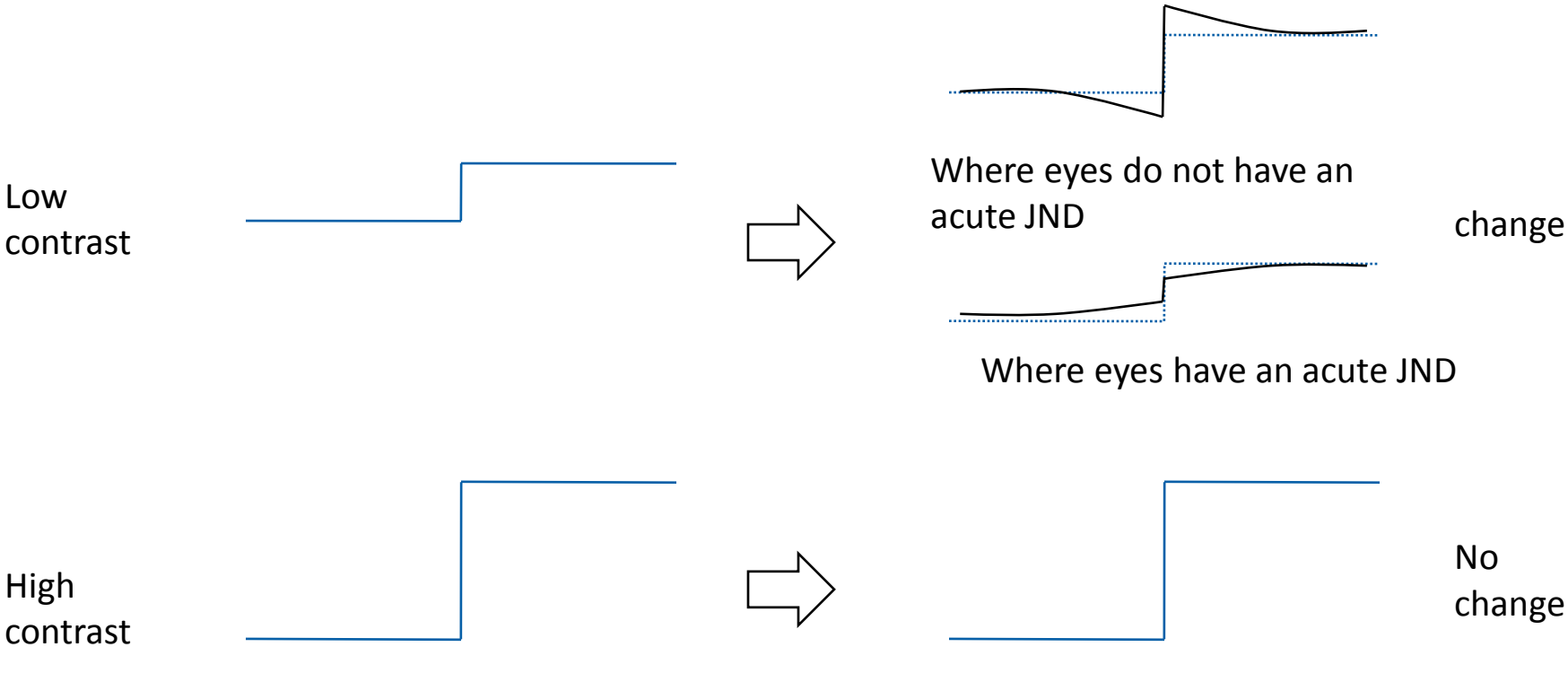
Can Both Color Differences Be Coexisted?

Proposal:
Employ "Color space adaptive to local image"
= Local spatial adjustment

[Criteria to achieve it]
a) Low spatial frequency image and high contrast image are displayed as same as usual color reproduction.
b) Targeted spatial frequency component for non-high contrast image is displayed as similar to micro-color difference (JND).

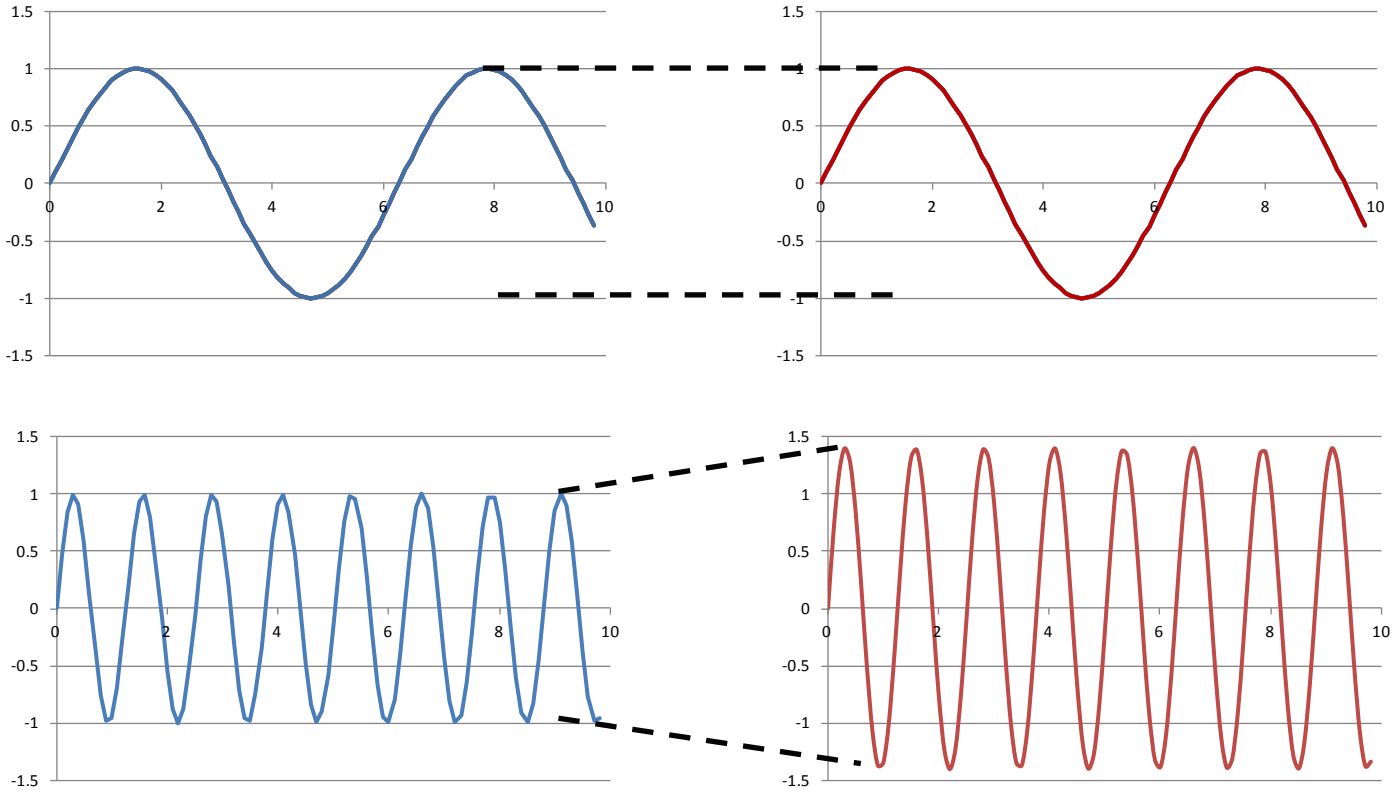
Can Both Color Differences Be Coexisted?

Desired effect (Conceptual): Step wedge



Can Both Color Differences Be Coexisted?

Desired effect (Conceptual)



Preliminary Test

Assumption:

- **Gray scale**
- **Edge enhancement using convolution**

Enhancement model:

$$P'(x,y) = P(x,y) + Coeff \cdot \varepsilon \qquad Coeff = f(Ave, \delta)$$

Edge element:

$$\varepsilon = \sum_{j=-N}^{N} \sum_{i=-N}^{N} P(x+i, y+j) \cdot W(i,j) \qquad \sum_{j=-N}^{N} \sum_{i=-N}^{N} W(i,j) = 0$$

Luminance level:

$$Ave = \frac{1}{(2N+1)^2} \sum_{j=-N}^{N} \sum_{i=-N}^{N} P(x+i, y+j)$$

Edge amount:

$$\delta = |\varepsilon|$$

Preliminary Test

Exact Equations Used

1D Simplified functions are used.

$$\varepsilon = 2.0 \cdot P(x) + 0.5 \cdot (P(x-1) + P(x+1)) - 0.5 \cdot (P(x-3) + P(x+3)) - 1.0 \cdot (P(x-4) + P(x+4)).$$

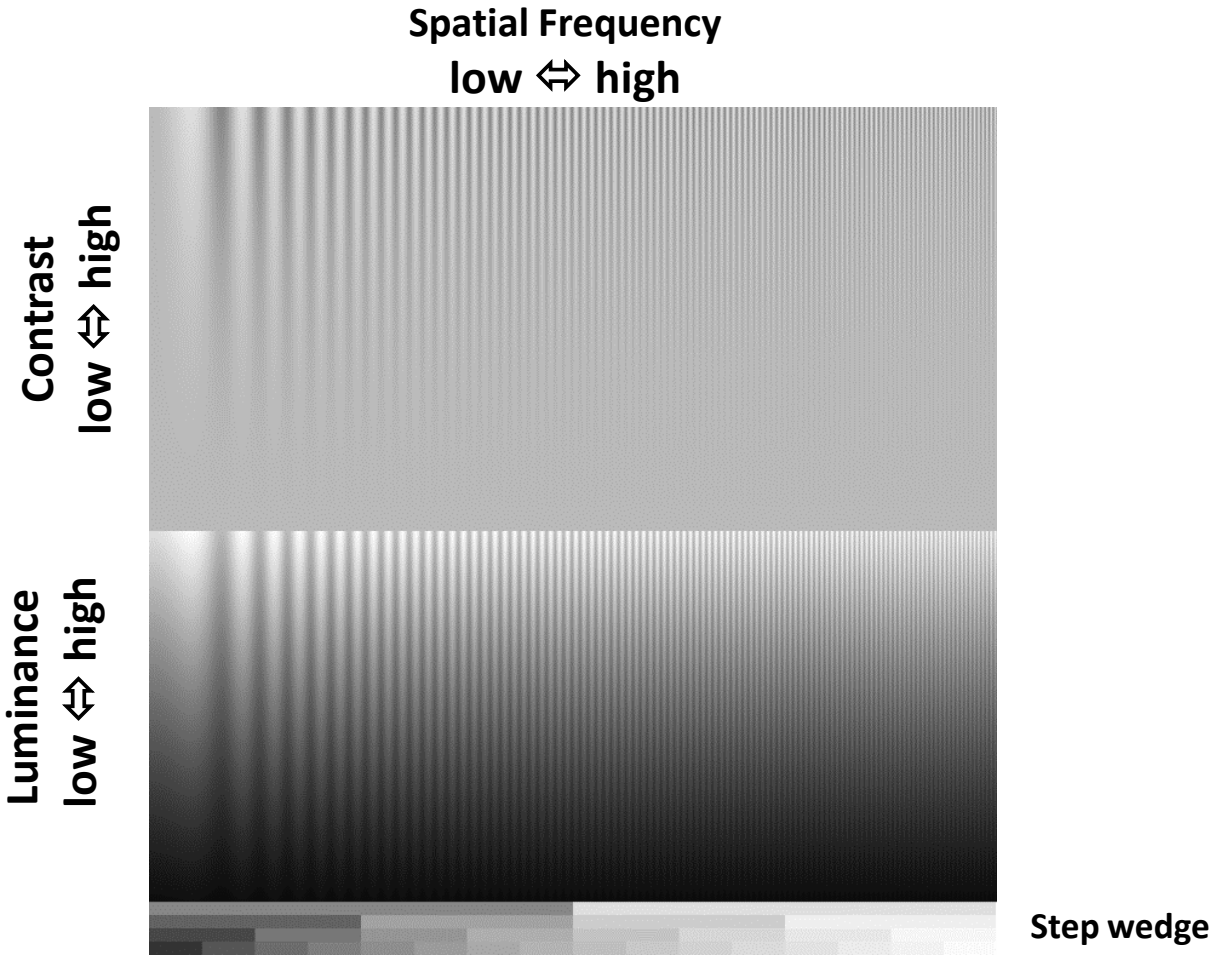
Parameters are adjusted trial and error basis

$$Coeff = (Ave + 0.5) \cdot (0.12 \cdot 4^{-abs(\varepsilon)})$$

Experiment

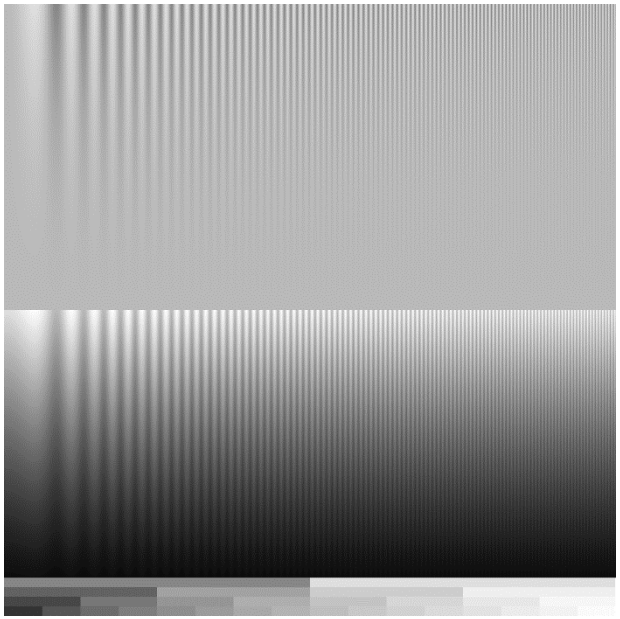
Test image:

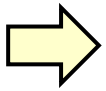
1D Chirp function image with step wedges

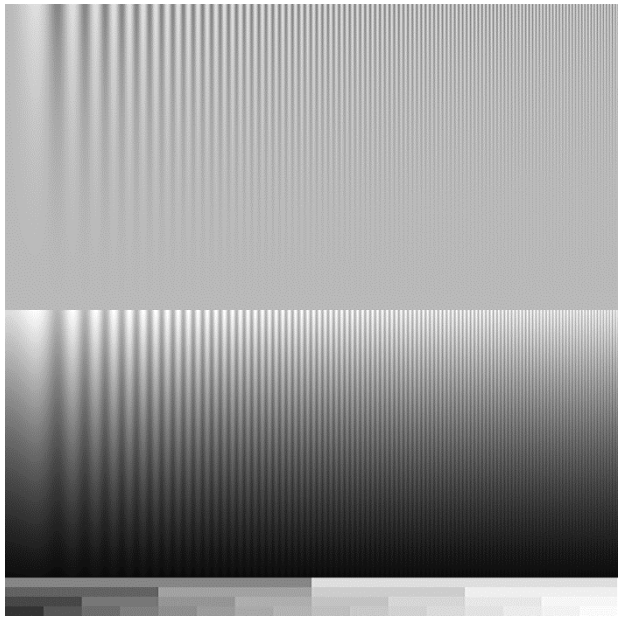


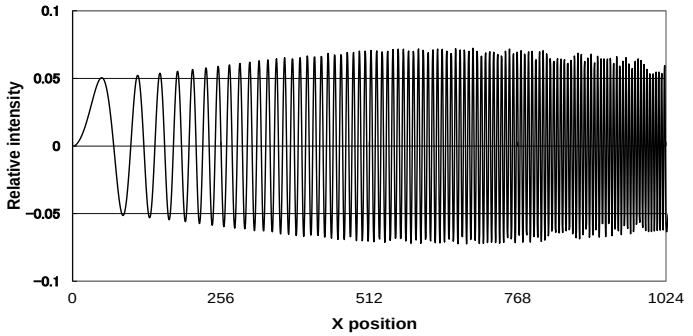
Experiment: Evaluation

Result of this algorithm









Discussion

KONICA MINOLTA

Limited usage of GSDF for tonal scale

- Specify luminance level(s)?

Expansion to chroma direction?

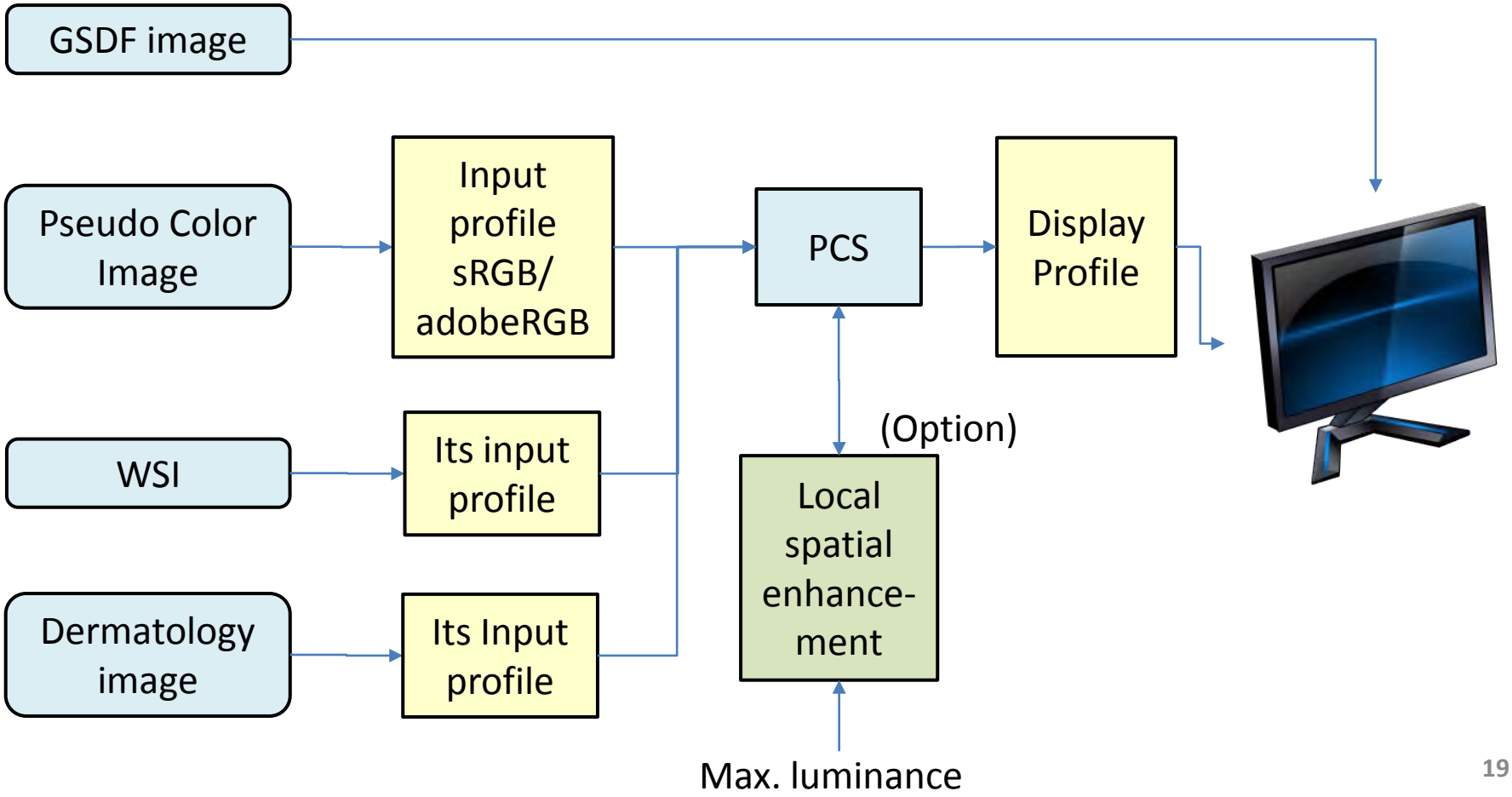
- E.g. Delta E 2000

How to optimize equations and parameters

- Computational load
- Spatial Frequency characteristics
- Actual test

One Idea

Without mRGB.



Summary

- Pointed out an issue between Micro- and Macro-Color difference
- Proposed a solution using adaptive color space and gave the criteria
- Tested the space for gray scale with simple parameters and verified a possibility to satisfy the criteria

Thank you for your kind attention!

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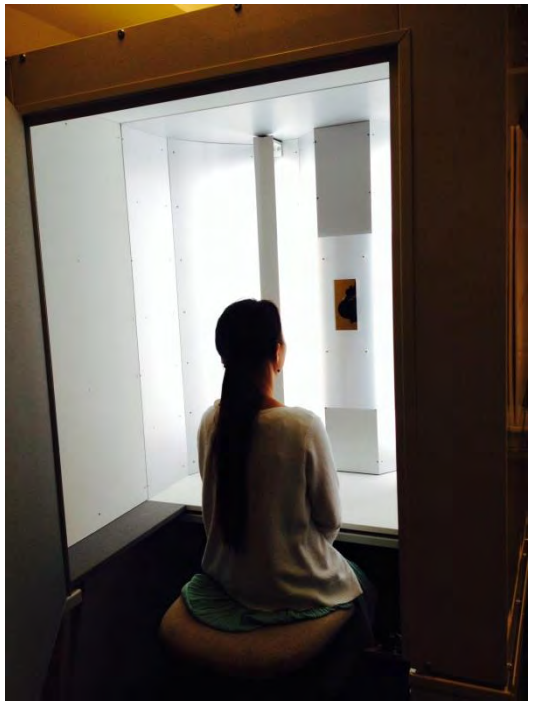
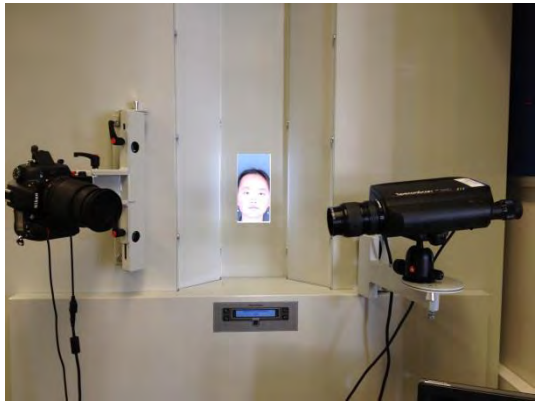
Pilot study for human skin measurement

Kaida Xiao

Skin colour measurement





Measurement Instruments

- Spectroradiometer
- Spectrophotometer
- Digital Camera

Measurement data

- Spectral reflectance
- CIEXYZ

Lighting

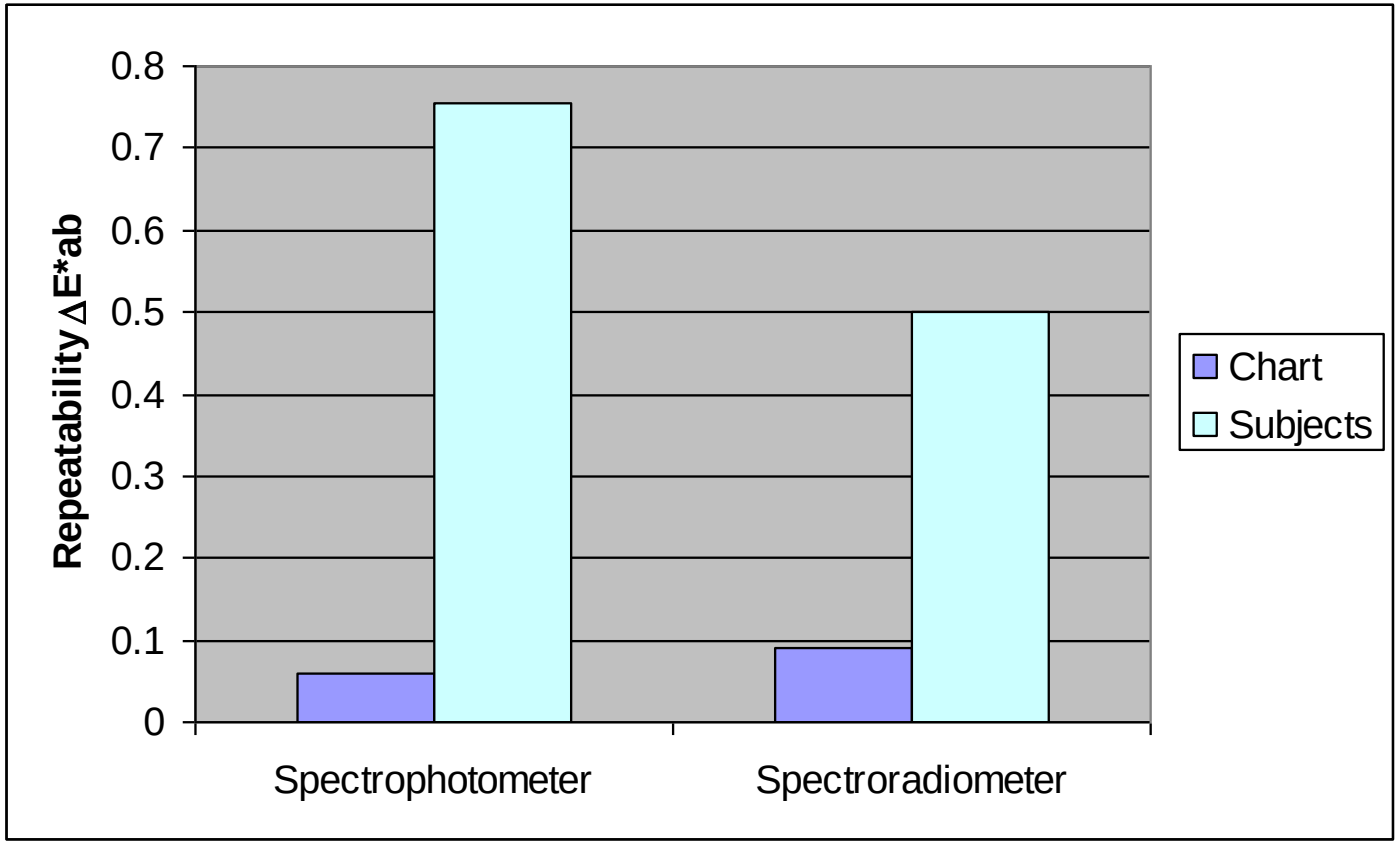
- CIE D65 simulator

Subjects

- 12 subjects measured
- 200 subjects in progress

Uncertainty of measurement

Repeatability of five measurements for both skin colour chart and subjects skin



Repeatability can be used as a basic threshold for acceptability measure for skin colour prediction.

Instrument agreements

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Spectroradiometer vs. Spectrophotometer

- Transform spectral reflectance data to CIEXYZ using CIE D65 illuminant
- CIELAB Colour difference

ΔE*ab	Mean	Max	STDEV
Skin chart	0.3	0.5	0.1
Subjects	3.6	5.4	0.9

Skin measurement from different type of instruments can not be combined.

Camera Measurement

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Camera

Nikon DSLR with Digieye imaging system

Camera setup

- Manual mode for exposure
- Pre-set white balance
- Raw data

Reference colour chart

MacBeth colour checker chart

Illumination

D65 simulator

Algorithm for colour profiling (rgb to CIE XYZ)

Polynomial regressions

Accuracy Evaluation

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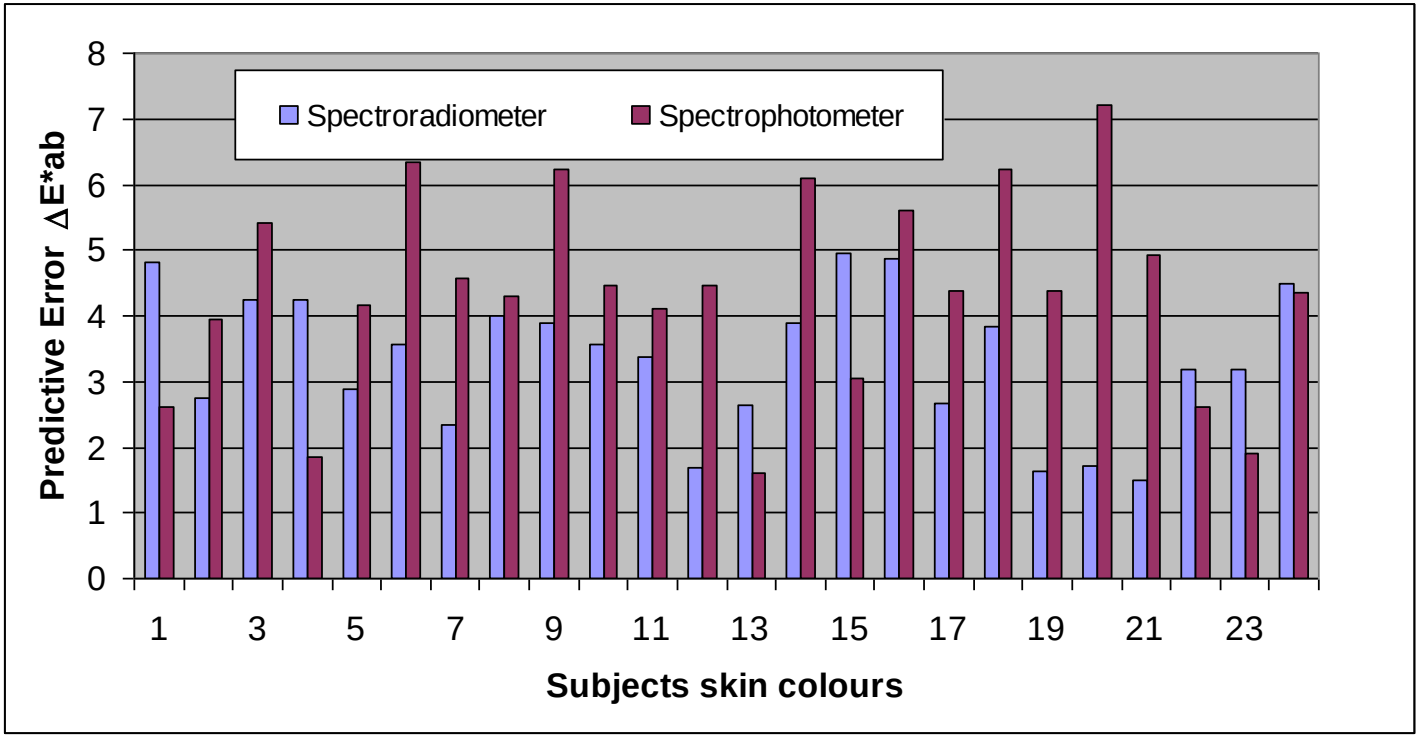
Testing colours: 24 skin colours (2 two facial positions in 12 subjects)

Performance: Colour difference between camera predicted results and each of measurement results by spectrophotometer or spectroradiometer.



ΔE*ab	Spectroradiometer	Spectrophotometer
Mean	3.3	4.4
STDEV	1.1	1.5

Summary

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- Human skin colours for 12 subjects were measured using different colour instruments.
- A large disagreement were achieved when same skin colour were measured using a spectrophotometer and a spectroradiometer respectively.
- Uncertainty of skin colour measurement and instrument agreements for human subjects were evaluated.
- Camera colour profile were developed and performance for human skin predicted were evaluated.

Imaging and Beyond : Changing Clinical Microbiology Practices

Geraldine Durand

BIOMÉRIEUX

Pasteur revisited: no future for Petri dish?

Are the good old days of the organism growth observation on agar plate over?

Is the Petri Art the only foreseeable future for the plates ?

Petri dish keeps a great future thanks to Microbiology Laboratory Automation

- Wave of lab automation
  - productivity, limited resources, lower reimbursement, less qualified staff, higher quality required...
- No breakthrough technology : culture-based microbiology will always be a fundamental part of diagnostics

Kiestra TLA, BD-Kiestra

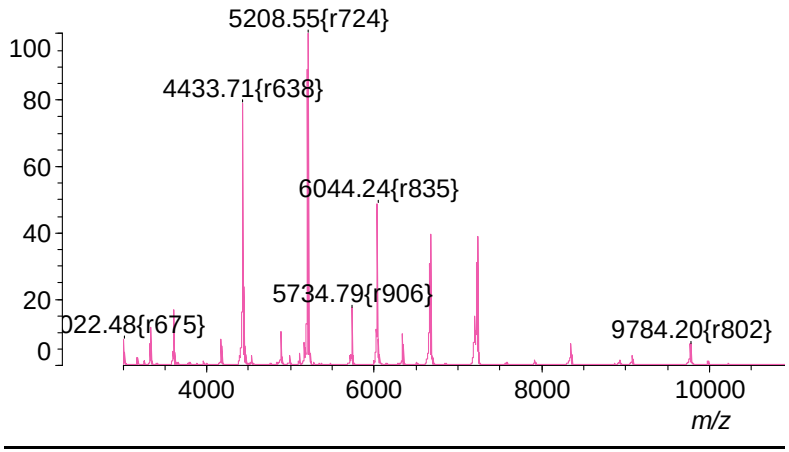
Path forward is plate imaging associated to automated incubation step

FMLA, bioMérieux

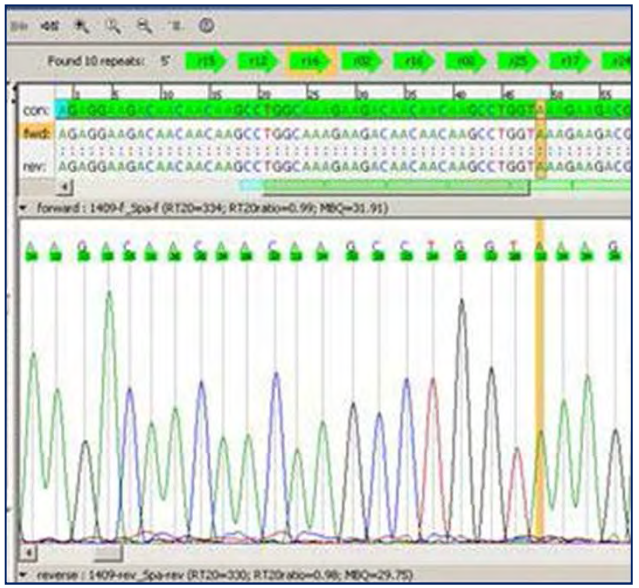
WASPLab, Copan

Plate imaging: not changing Clinical Microbiology Practices?

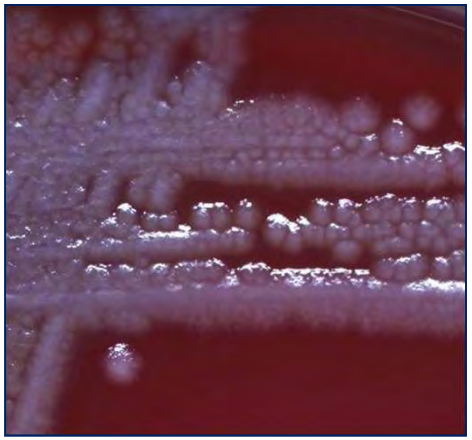
Ex: *Pseudomonas aeruginosa*



Mass spectrometry



Sequencing



Petri dish imaging

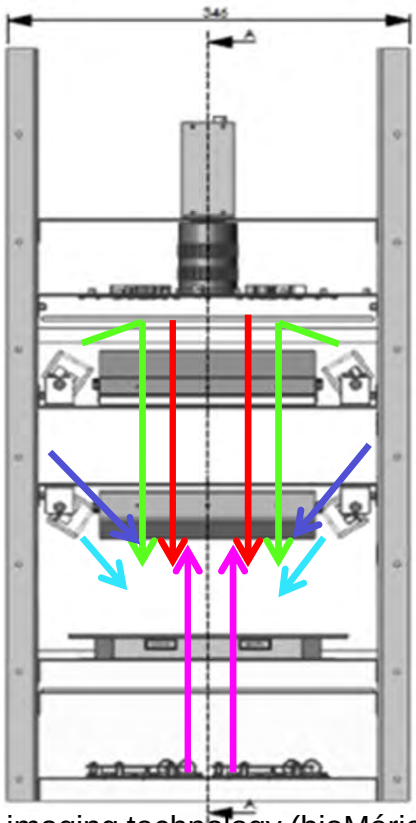
Unlike mass spectrometry or sequencing, the information provided by imaging remains human readable and understandable by the microbiologist

Plate imaging: changing Clinical Microbiology Practices?

- Switch from a visual reading to a virtual reading :
  - no smelling
  - no 3D vision
  - no possibility to move the plate in front of a light source
- The challenge is to convert the user by providing the same level of information

The imaging system has to deliver images of very high quality

How to provide high quality images?



SIS imaging technology (bioMérieux)

Illumination #1 (TopVertical)

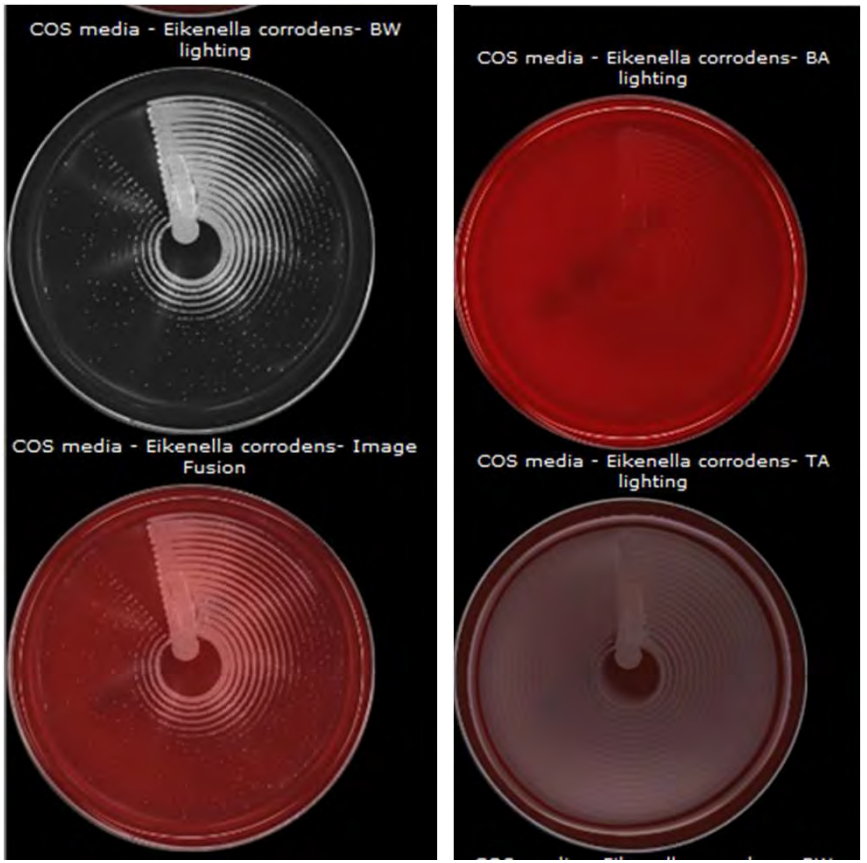
Illumination #2 (TopAnnular)

Illumination #3 (BottomAnnular)

Illumination #5 (UV)

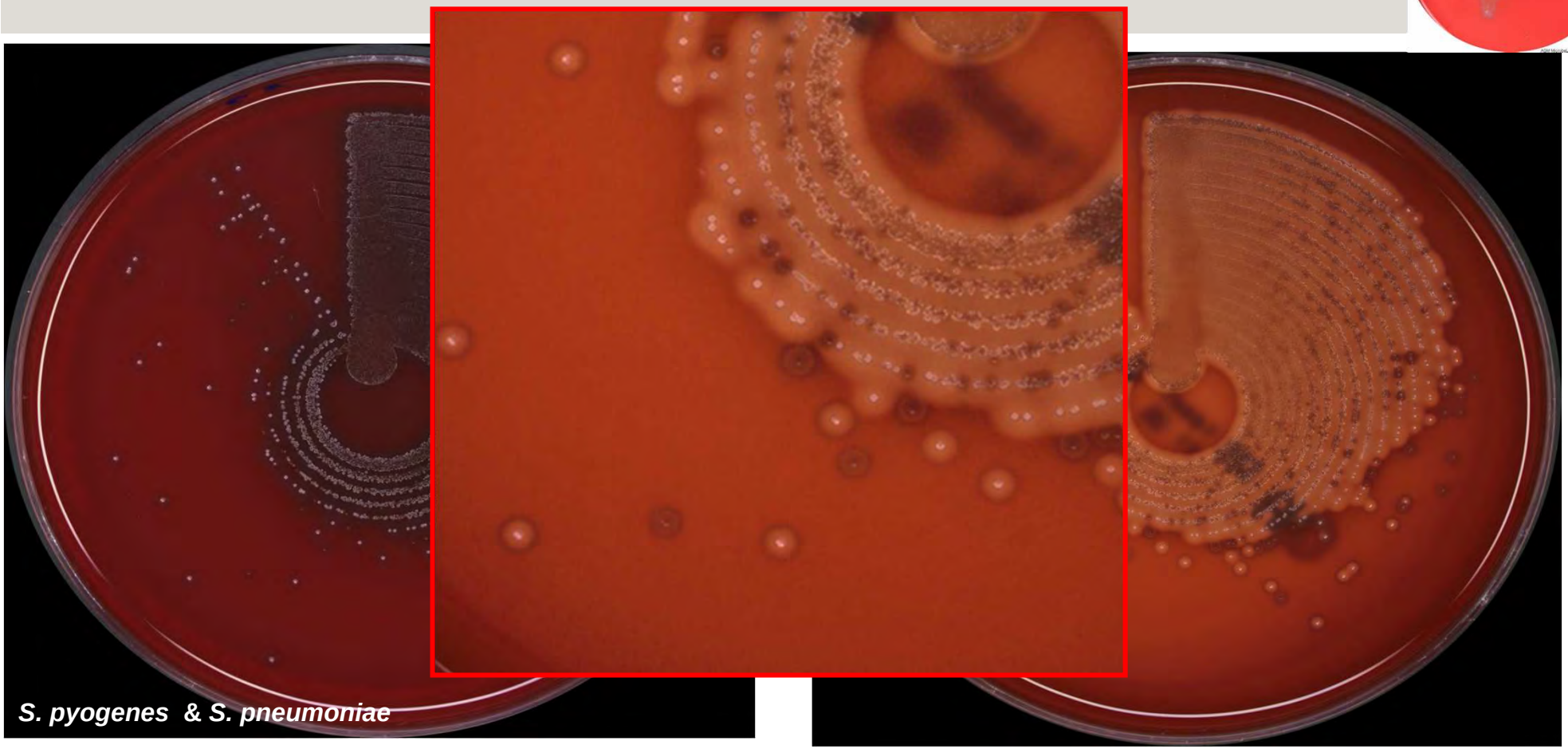
Backgrounds (w/o, white, black)

Illumination #4 (Backlight)



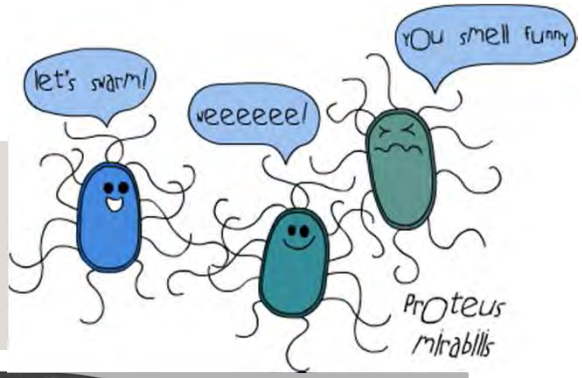
Providing different lighting conditions and exposure to maximize information

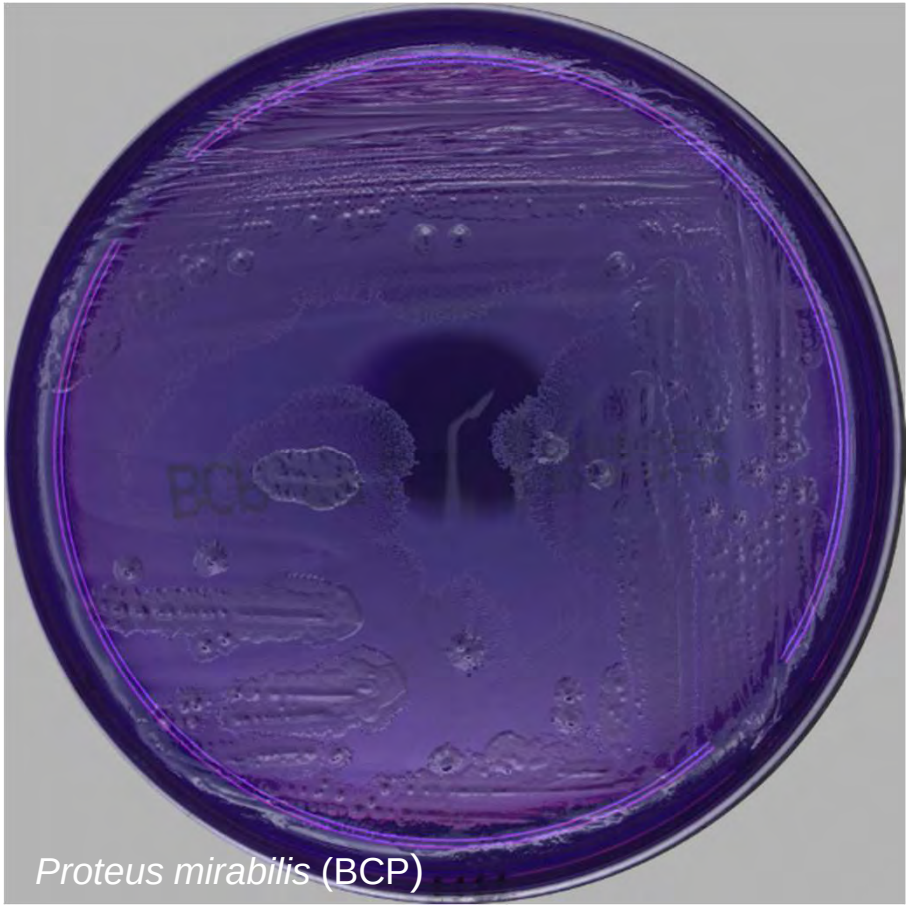
How to detect hemolysis?



Leveraging backlight illumination

How to detect *Proteus mirabilis* swarming?





Proteus mirabilis (BCP)

Using reflecting illumination

How to recognize colony morphology?

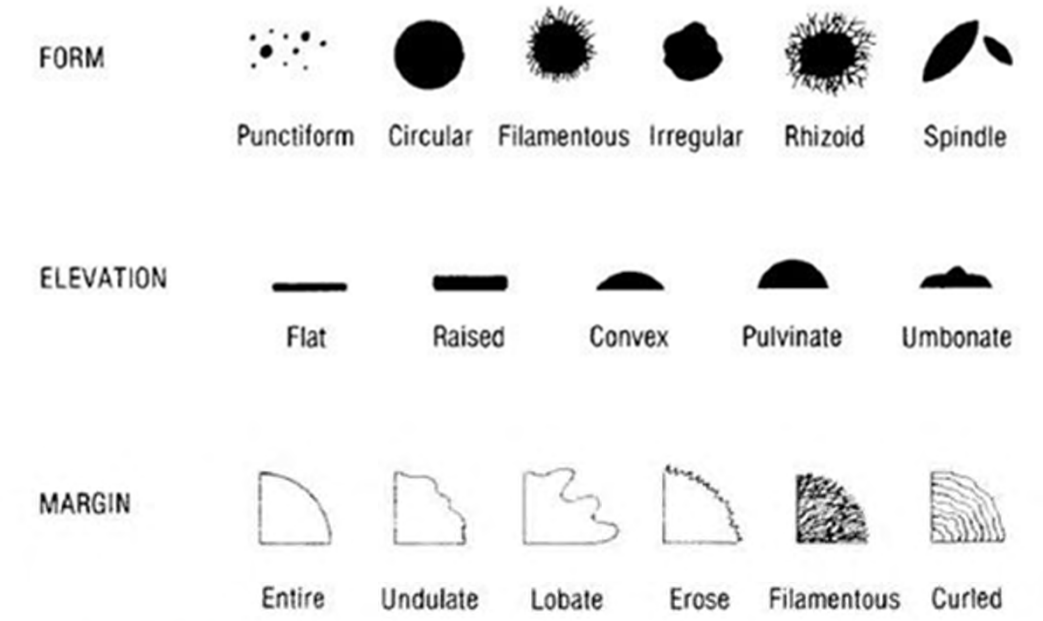


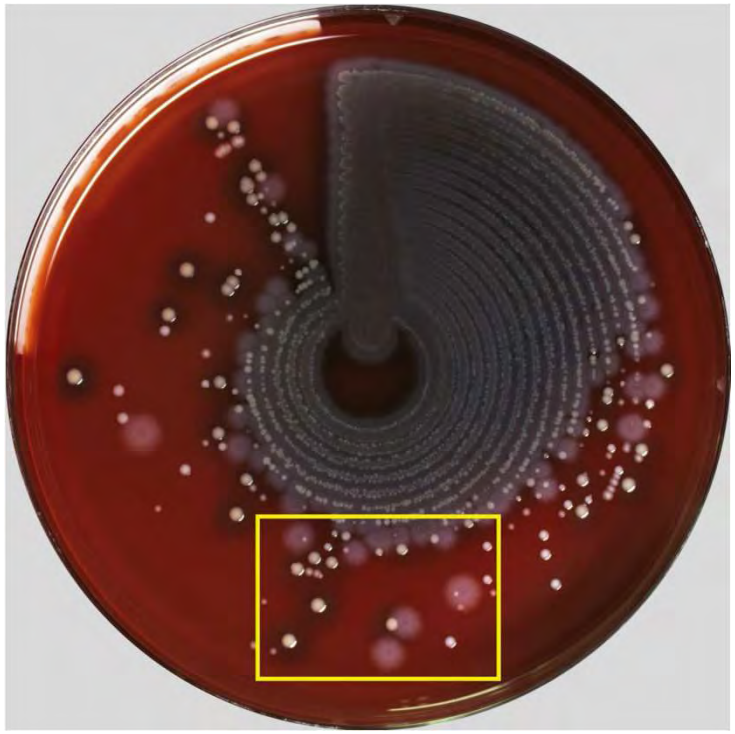
FIG. 1. Diagram illustrating the various forms, elevations, and margins of bacterial colonies (3).

Microbiology manual, 1957

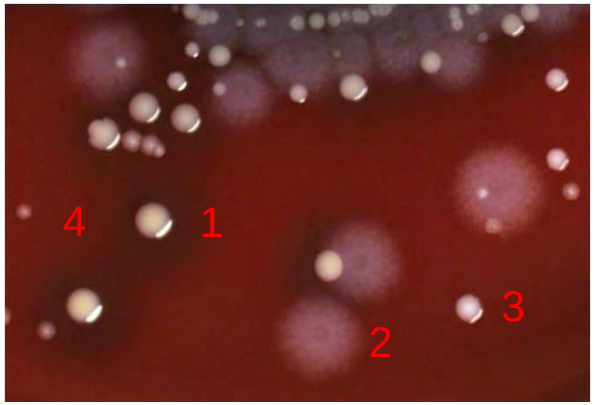
Sputum with normal flora (COS)

High definition image allowing zooming, combined with various lighting angles

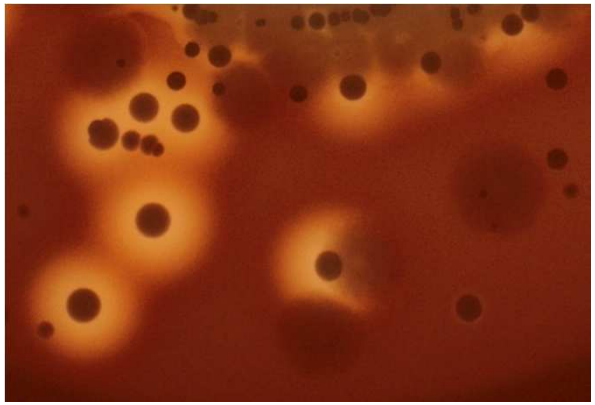
Morphotypes recognition : case of diabetic foot ulcer



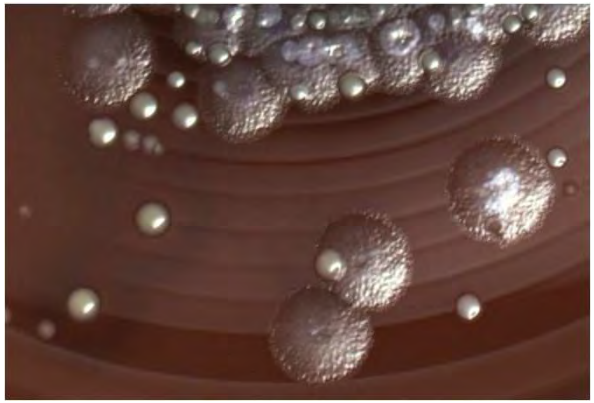
1. *S. aureus*
2. *P. aeruginosa*
3. *S. epidemidis*
4. *C. amycolatum*



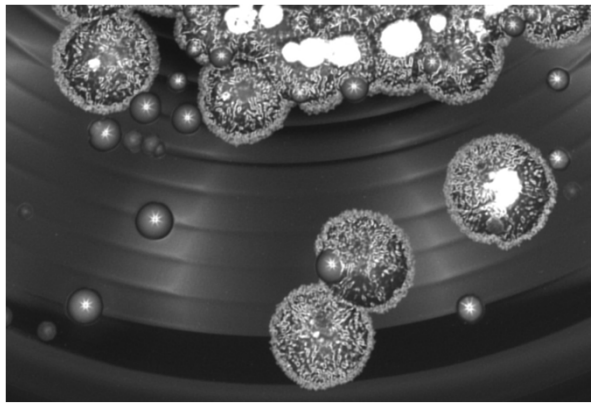
Bottom Annular



Backlight

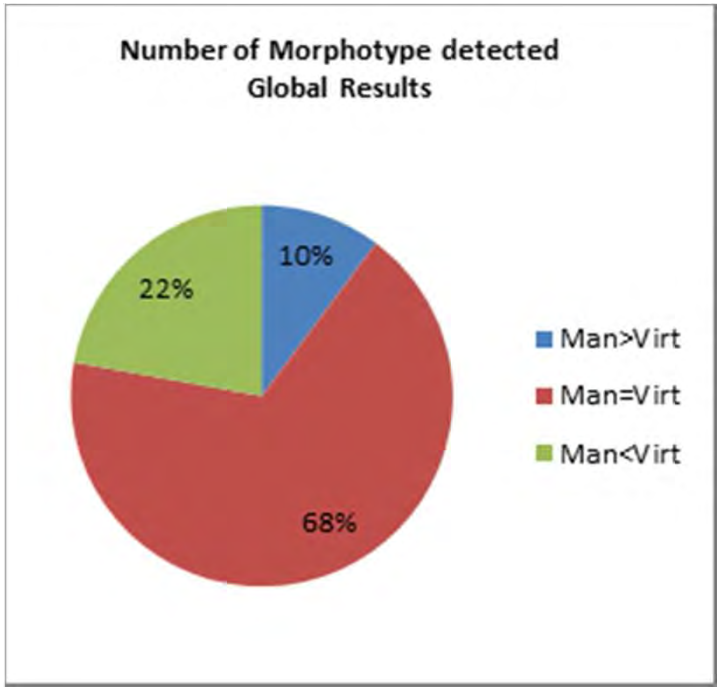


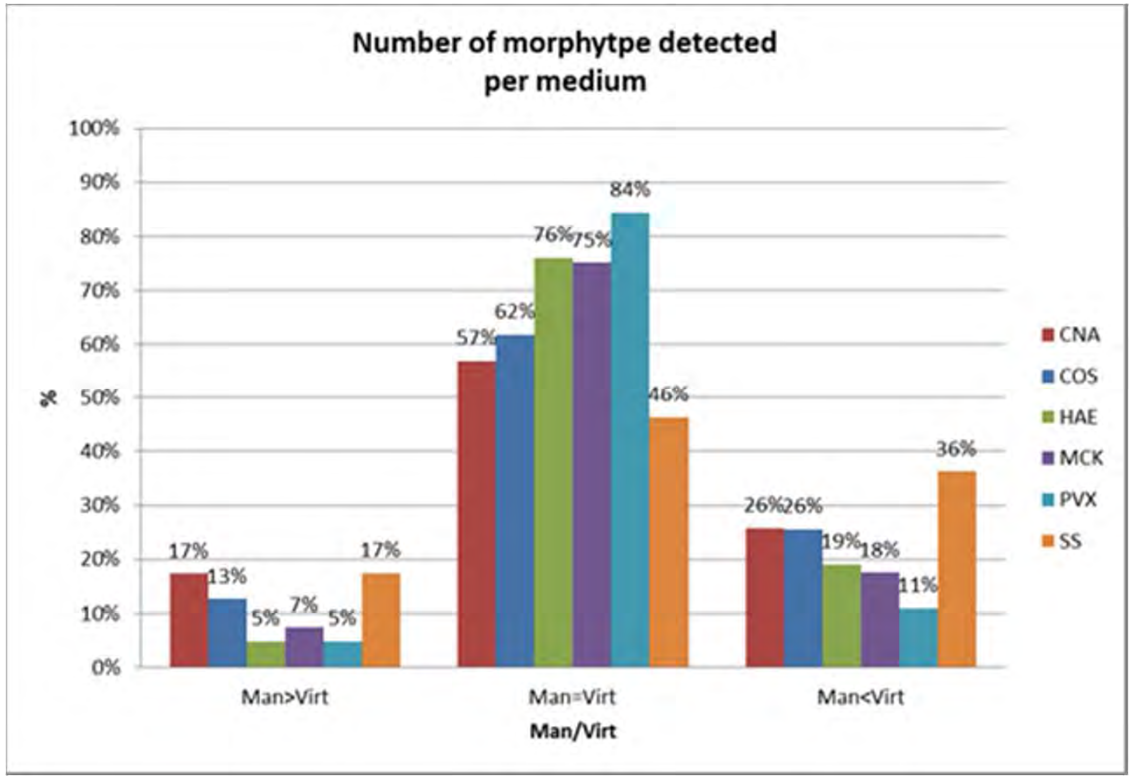
Top Annular



Top Vertical

Morphotypes detection comparative study : plate manual reading *versus* virtual reading (Labor Berlin, 2012)





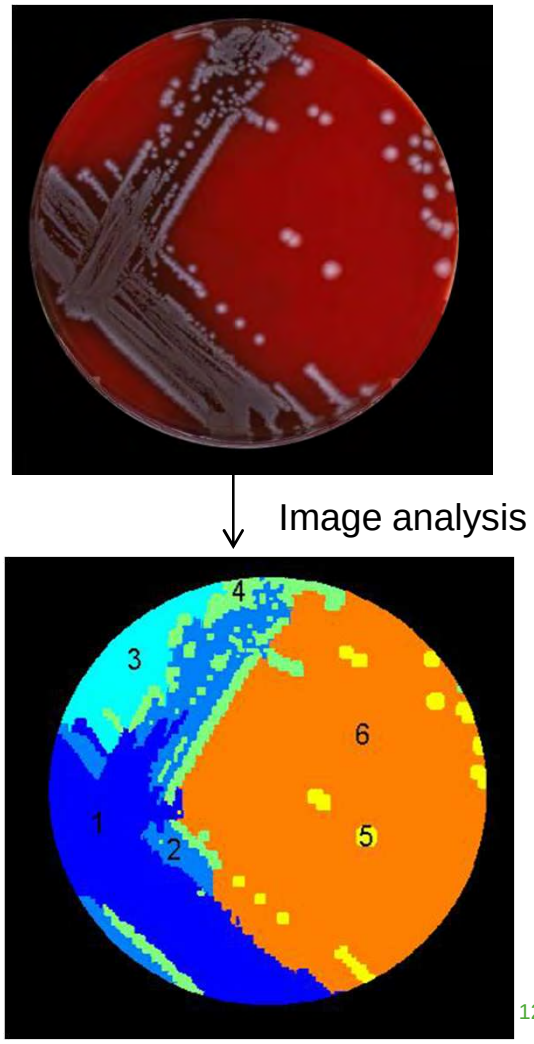
Virtual reading allows detection of significantly more morphotypes compared to manual reading

Is the quality of images self-sufficient for decision making?

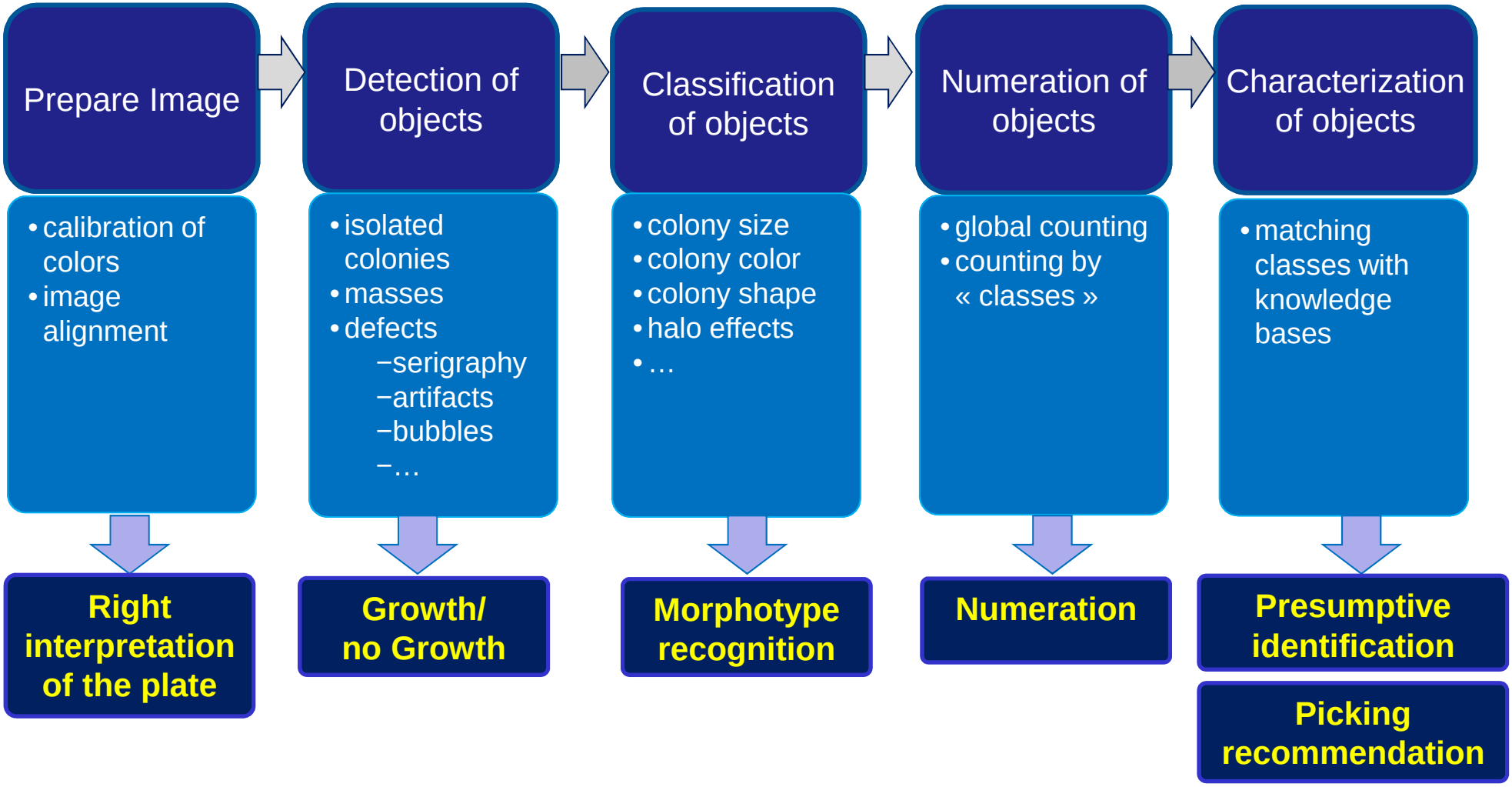
Added value resides in embedded intelligence through image analysis & decisional algorithm delivering more information from the picture:

- from growth/ no growth
- to presumptive identification and colony picking recommendation

Scalable algorithms for automated decision making

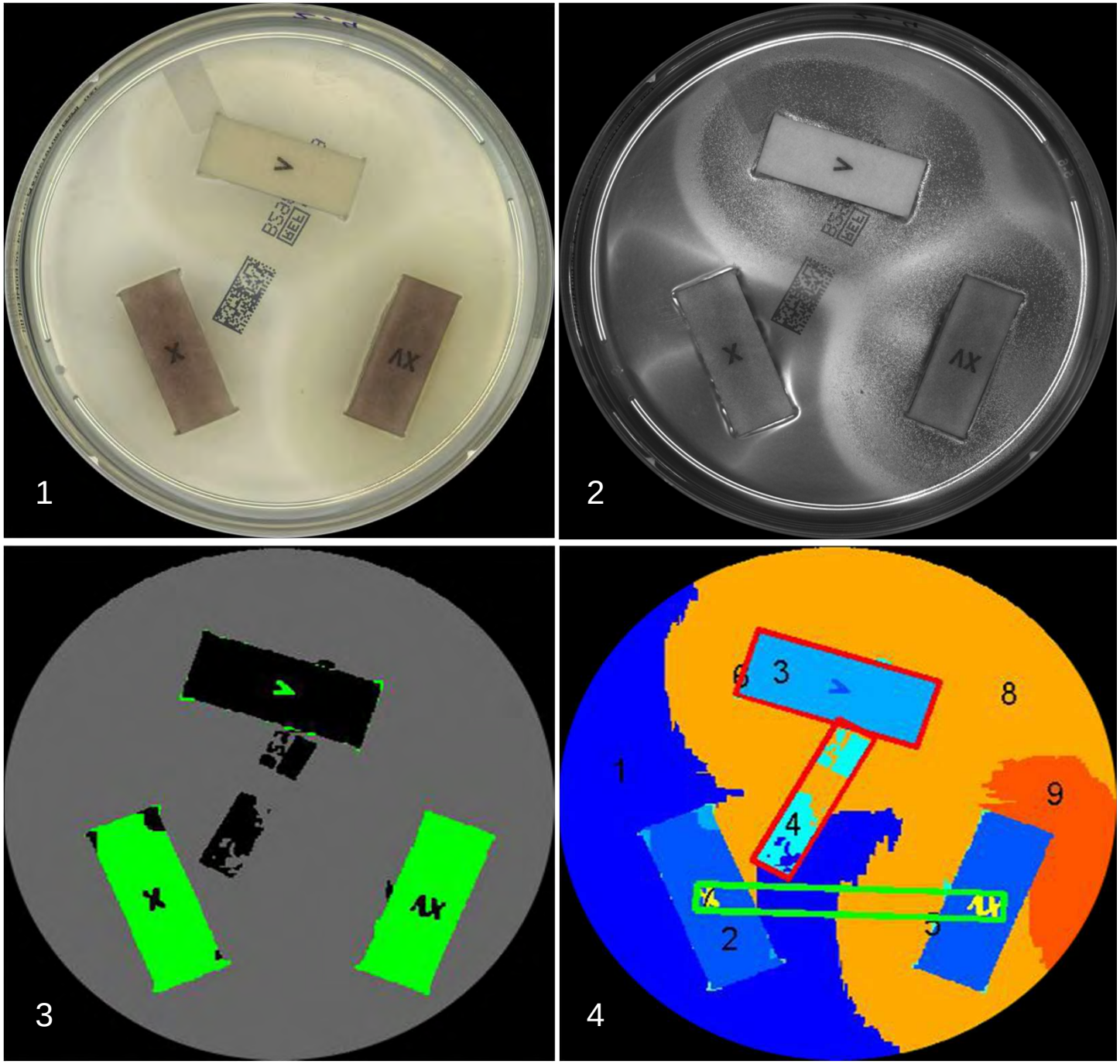


From image analysis to decisional algorithms



Objects detection

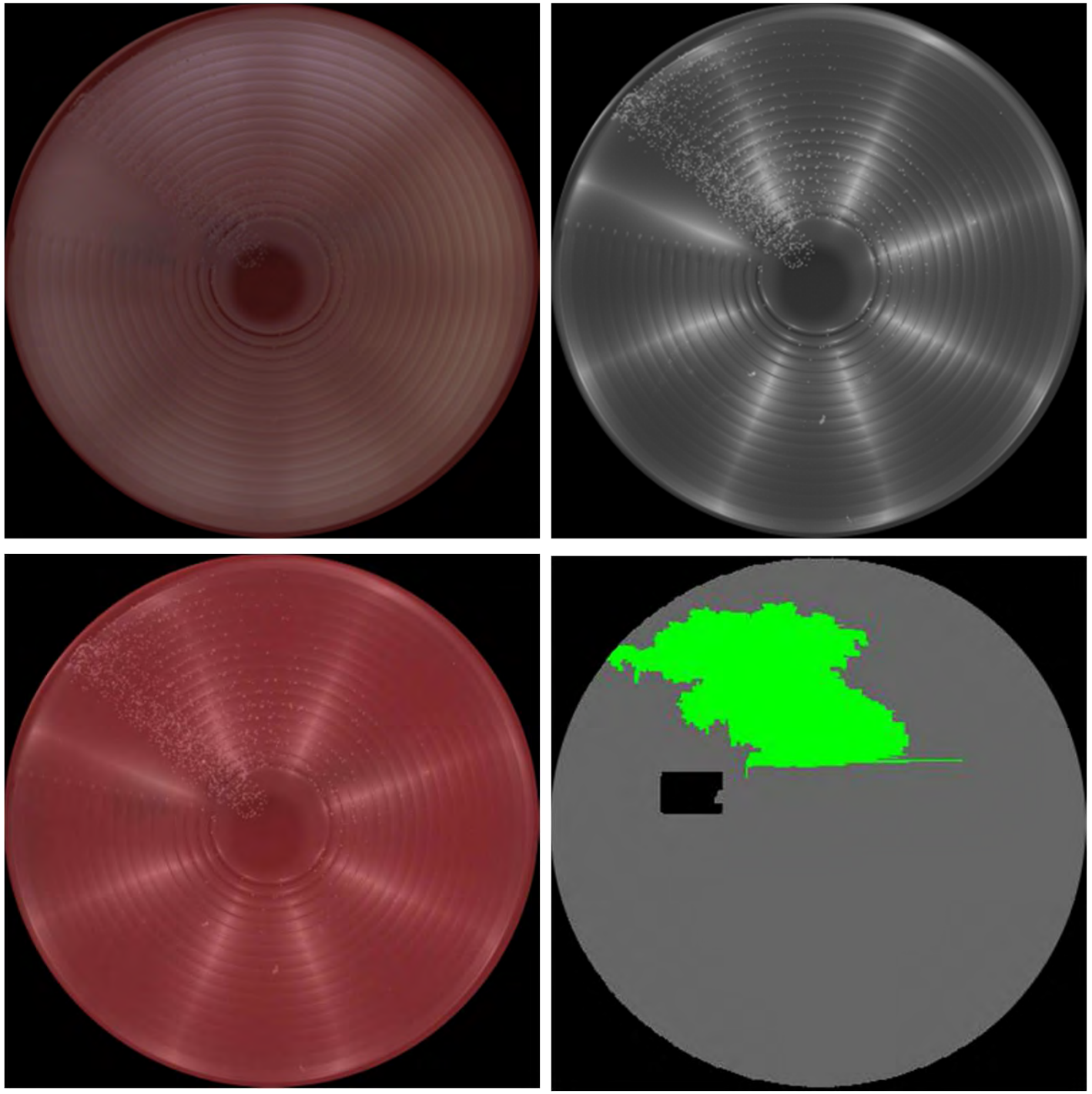
Haemophilus aphrophilus
(Aggregatibacter aphrophilus)
XV factors satellitism test



1. Top Annular
2. Top Vertical
3. Mass detection
4. Segmentation

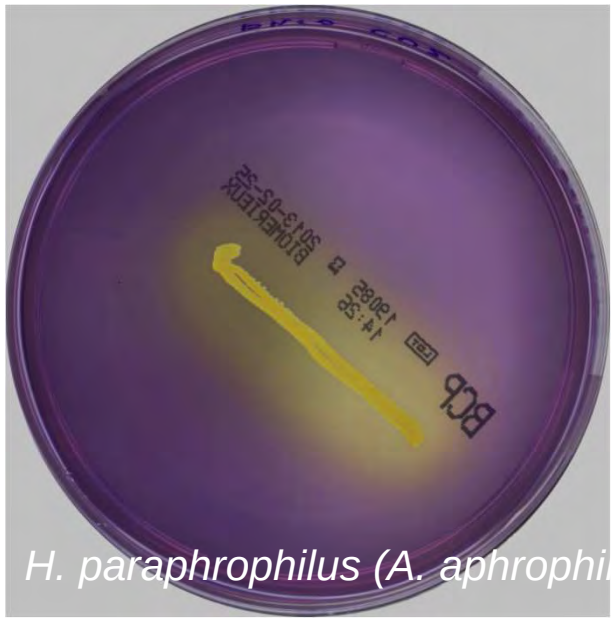
Growth detection

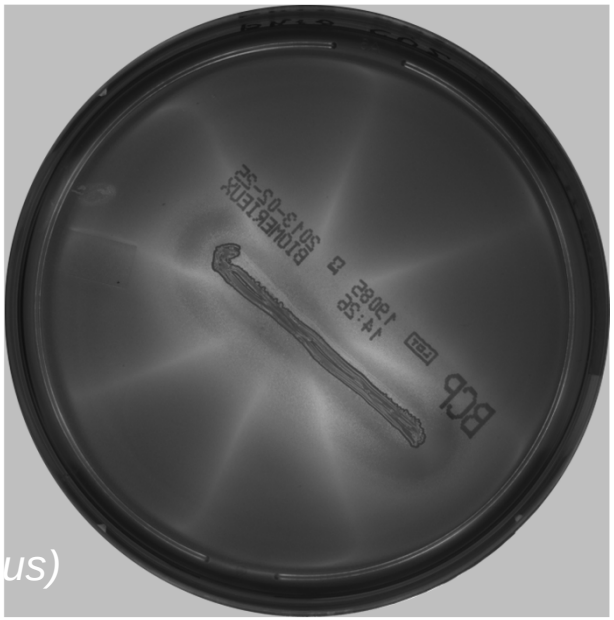
Nocardia beijingensis

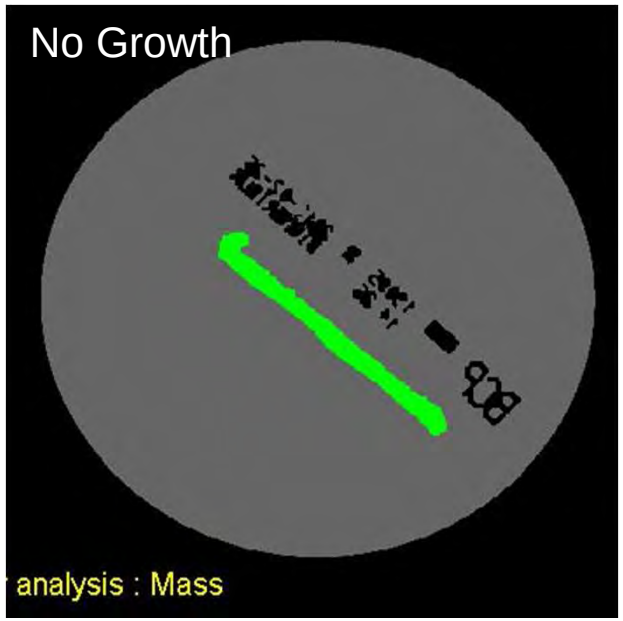


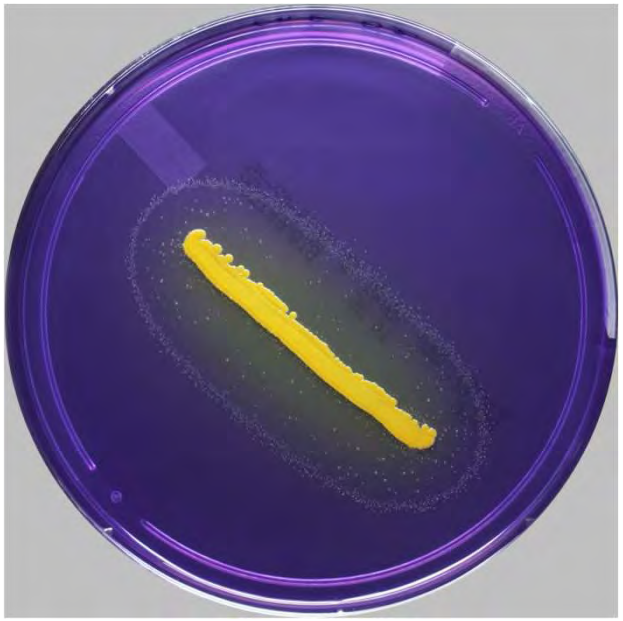
1. Bottom Annular
2. Top Vertical
3. BA & Top Vertical - fusion
4. Mass detection

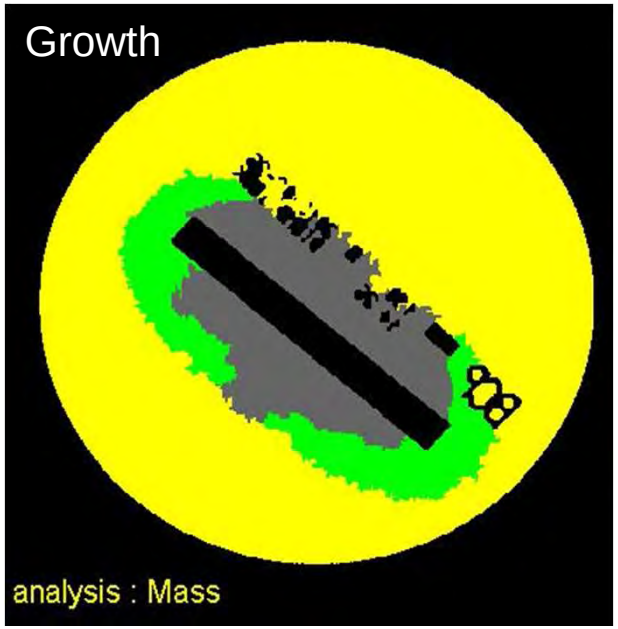
Haemophilus identification / Zinneman test (aerobiosis growth test around streak of *S. aureus)*





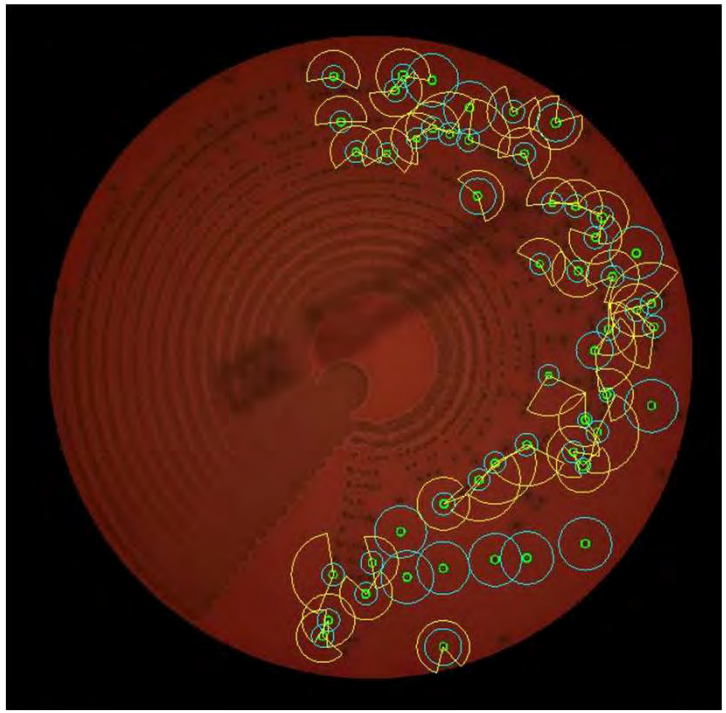






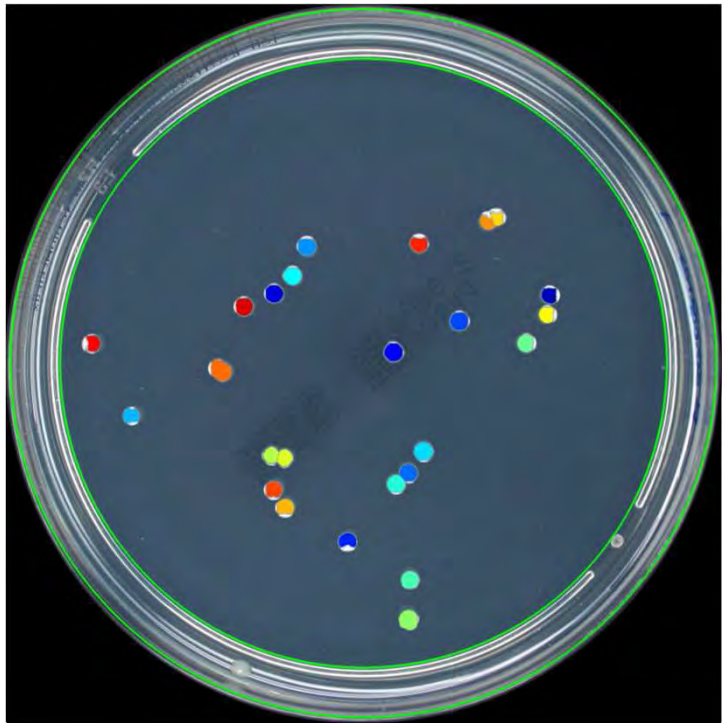
Isolated colonies localization

Ex : S. gordonii (COS)



Numeration

Ex : E. aerogenes (TSA)
NCTC 12924 bioBall

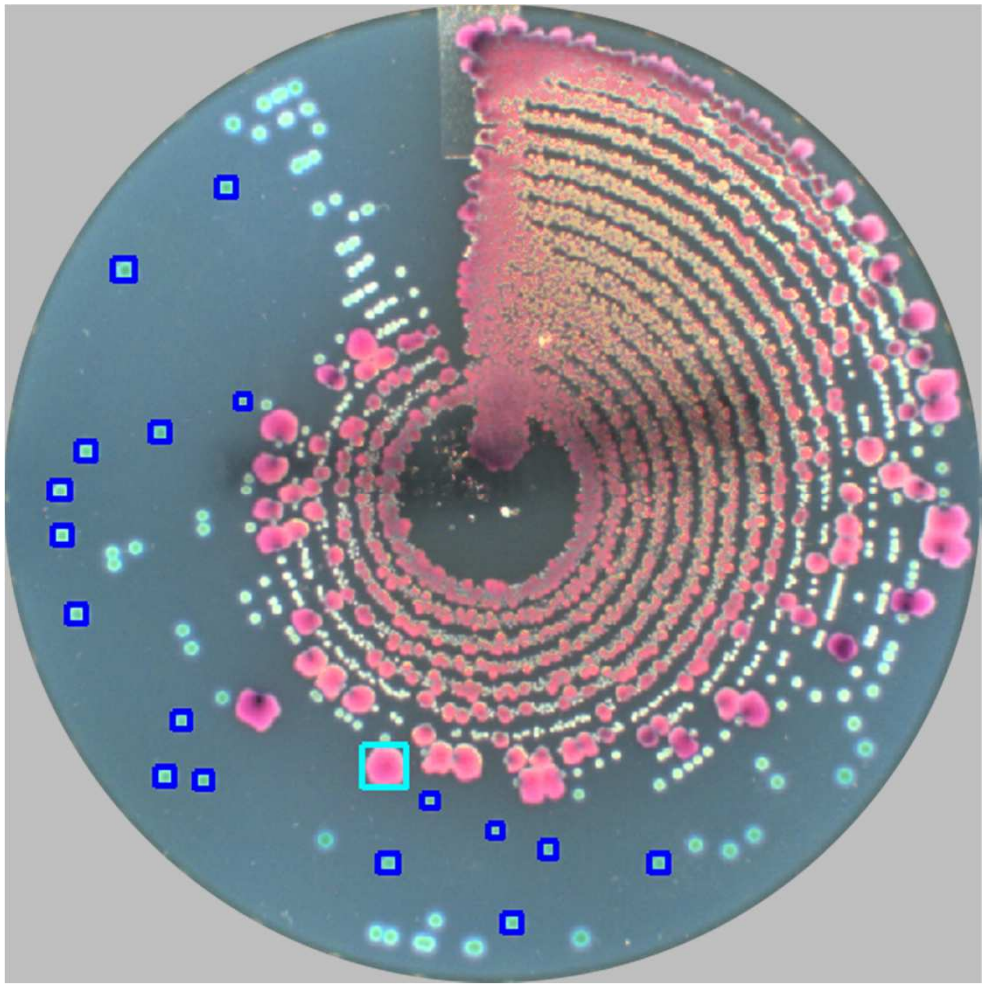


Presumptive identification

- Morphotype recognition as prerequisite (classification of objects)
- Matching classes (morphotypes) with knowledge bases

Picking recommendation

- Detection of colonies of interest as prerequisite (isolated colonies & presumptive identification)



E. coli & E. faecalis (CPS)

Image review and decision making software

- Ergonomics capabilities
  - smart display of images (order & orientation)
  - ability to zoom in
- Logistical efficiency by sorting images instead of plates
  - based on multiple criteria (specimen type, patient, medical unit, time of incubation, growth-no growth…)
- Medical efficiency allowing to make faster a safe decision
  - displaying all required contextual information related to the patient and the specimen including previous results

The software is a critical element for the whole plate reading automation

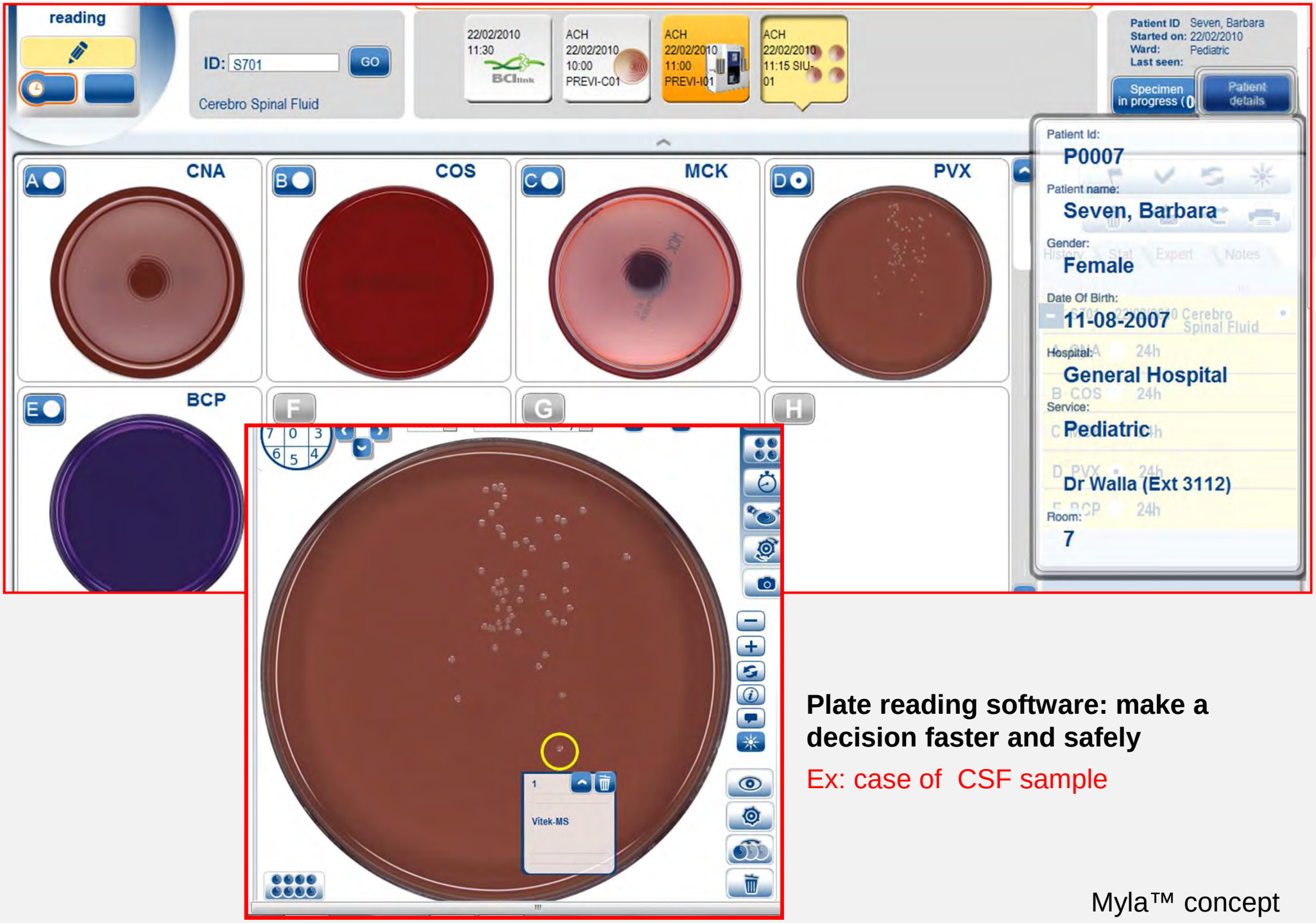


Plate reading software: make a decision faster and safely

Ex: case of CSF sample

Myla™ concept

Imaging and beyond : evolving microbiology practices

- Improve laboratory efficiency
  - dealing only with plates of interest
  - reduce turnaround time by plate reading at the appropriate incubation time rather than waiting the day shift
  - remote reading (clean room, at home, time zone…)
  - 24/7 service
- Quality and reproducibility of the results
  - standardization of procedures
  - traceability of decisions
- Powerful learning & coaching tool with images library
  - concept of simulation laboratory (Thomson *et al* JCM, 2011)

Conclusion : building a solution to make the decision easier

- Excellent quality of images for better colonies detection & identification
- Smart features : relevant images analysis & decisional algorithms
- Plate reading software has to provide functionalities not only for the reading itself but also all the information required to make the decision
- The microbiologist remains the one to make the final decision based on its own knowledge

The ultimate goal is to provide medical added value by delivering the relevant information to the clinician at the right time for a better patient management

And if you are not convinced….

…Petri dish creative activities still remain possible in black and white or in full color !

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