



Medical Imaging Working Group

FOGRA
Einsteinring 1a
85609 Ascheim
Munich, Germany
26 February 2018

Craig Revie, MIWG chair, opened the meeting at 08:45 and introduced the agenda as follows:

1. Introductions
2. Electro-Optical Requirements for Medical Display
3. Medical imaging projects at NTNU
4. Medical display calibration using remote clients
5. Identification of possible future projects for MIWG
6. Action items review

1. Introductions

Mr Revie performed a sound check and participants introduced themselves. He reminded the participants of the ICC MIWG web site http://www.color.org/groups/medical/medical_imaging_wg.xalter, which contains pages for all the activity areas as well as minutes, presentations and recordings of the meetings.

2. Electro-Optical Requirements for Medical Display

Wonseon Song of LG Display was unable to attend the meeting so this item was deferred to the next meeting.

3. Medical imaging projects at NTNU

Phil Green presented a summary of work undertaken by students taking his Colour in Medical Imaging course at NTNU [see attached]. This is a 7.5 ECTS course which is part of the Applied Colour Science semester at NTNU, in the Colour in Science and Industry programme offered jointly with other European universities. The projects were mostly novel imaging applications directed at non-contact monitoring of vital signs, with joint supervision by Professor Ruud Verdaasdonk of the Amsterdam Free University Hospital. A number of projects will be submitted to relevant conferences or journals for publication. Dr Green stated that collaborations from medical specialists and vendors for the next course session in the August-December 2018 semester were welcome.

4. Medical display calibration using remote clients

Tom Lianza of Portrait Displays introduced the CalMed software for medical display calibration [see attached]. This has a client-server architecture with a relatively low seat cost. The software manages direct digital control of the display hardware, and meets medical standards for calibration frequency. The main applications were DICOM and medical video. The software checks conformance and generates a report.

Mr Lianza undertook to provide links to industry recommendations on medical display calibration for the minutes.

5. Identification of possible future projects for MIWG

There was no further update on the projects discussed at the previous meeting [see attached]. Craig Revie undertook to contact MIWG members and ICC honorary members to invite suggestions.

6. Action item review

The meeting discussed open action items [see attached] as follows:

MIWG-15-30: Dr Kimpe had provided the calibration targets and they were available on the MIWG web site.

MIWG-16-01 and 16-20: Dr Pescatore had changed roles at BioMerieux and was unable to work on these actions, and hence it was decided to close them.

MIWG-16-12: The ICS for GSDF was on hold pending finalising the ICS template.

There being no other business, the meeting closed at 10:30.

Action items

The following action item was agreed at the meeting:

MIWG 2018-01 Provide links to industry recommendations on medical display calibration (Lianza).

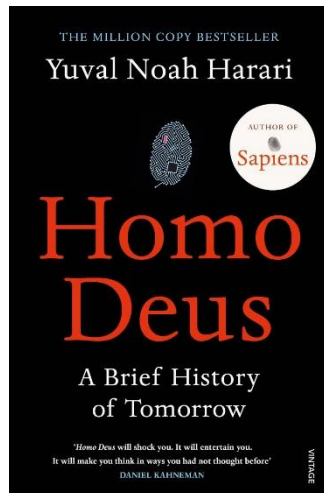
ICC Medical Imaging Working Group

Fogra

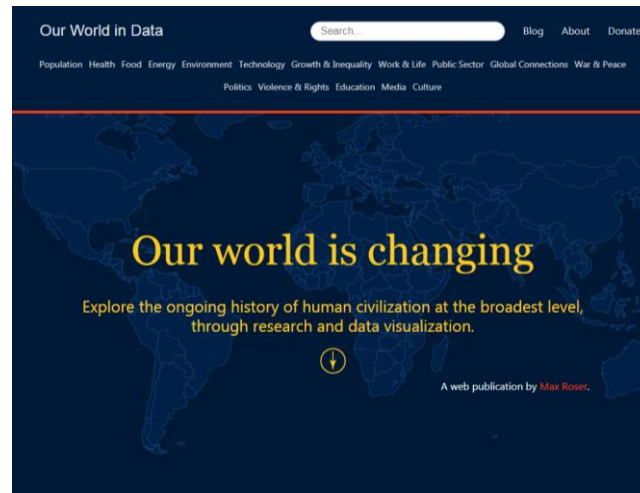
26th February 2018 (08:30-11:00)

This is the first century in history where Homo sapiens are more likely to die from...

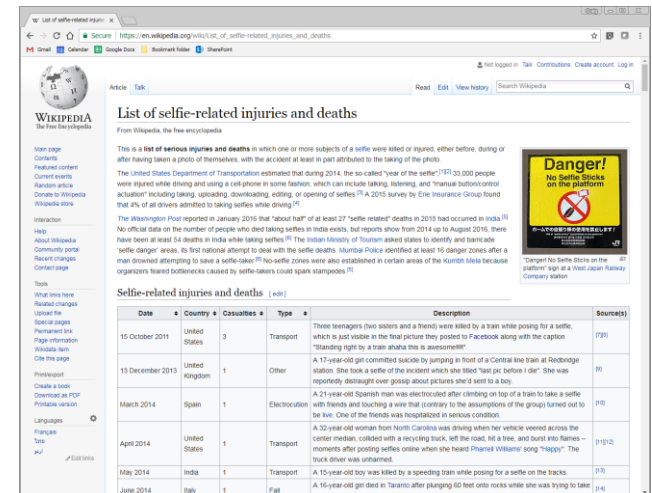
- eating too much than from eating too little
- old age than from a communicable disease
- suicide than from war
- taking selfies than being killed by sharks



www.ynharari.com/book/homo-deus/

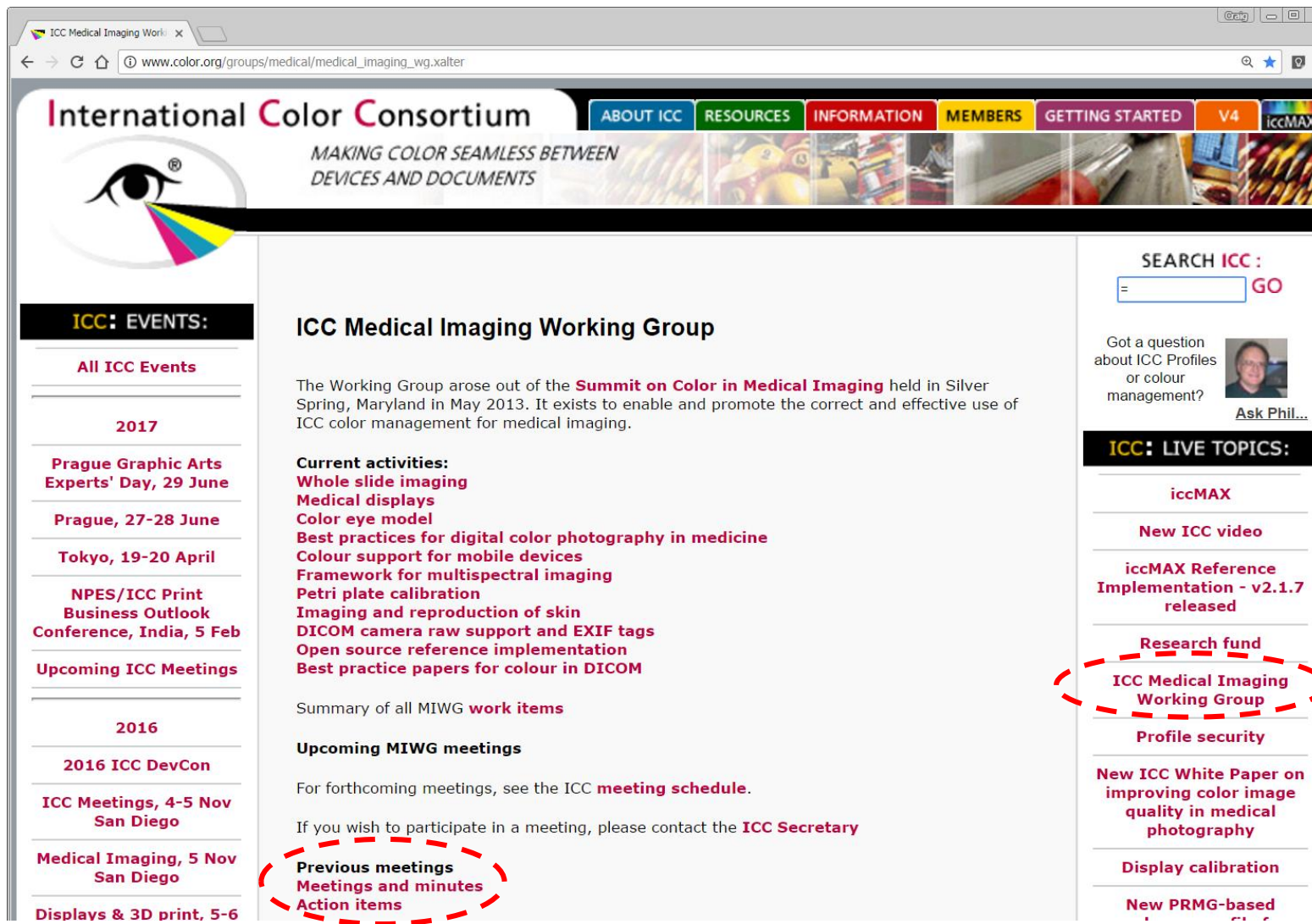


<https://ourworldindata.org/>



https://en.wikipedia.org/wiki/List_of_selfie-related_injuries_and_deaths

ICC MIWG web page at www.color.org



The screenshot shows the ICC Medical Imaging Working Group web page. The page features a navigation menu with links for ABOUT ICC, RESOURCES, INFORMATION, MEMBERS, GETTING STARTED, V4, and iccMAX. The main content area is titled "ICC Medical Imaging Working Group" and includes a description of the group, current activities, upcoming meetings, and previous meetings. A search bar is located in the top right corner, and a "SEARCH ICC:" section is also present. The page is divided into several sections, including "ICC: EVENTS:", "ICC: LIVE TOPICS:", and "Previous meetings Meetings and minutes Action items".

International Color Consortium
MAKING COLOR SEAMLESS BETWEEN DEVICES AND DOCUMENTS

ABOUT ICC RESOURCES INFORMATION MEMBERS GETTING STARTED V4 iccMAX

ICC: EVENTS:

All ICC Events

2017

Prague Graphic Arts Experts' Day, 29 June
Prague, 27-28 June
Tokyo, 19-20 April
NPES/ICC Print Business Outlook Conference, India, 5 Feb
Upcoming ICC Meetings

2016

2016 ICC DevCon
ICC Meetings, 4-5 Nov San Diego
Medical Imaging, 5 Nov San Diego
Displays & 3D print, 5-6

ICC Medical Imaging Working Group

The Working Group arose out of the **Summit on Color in Medical Imaging** held in Silver Spring, Maryland in May 2013. It exists to enable and promote the correct and effective use of ICC color management for medical imaging.

Current activities:

- Whole slide imaging
- Medical displays
- Color eye model
- Best practices for digital color photography in medicine
- Colour support for mobile devices
- Framework for multispectral imaging
- Petri plate calibration
- Imaging and reproduction of skin
- DICOM camera raw support and EXIF tags
- Open source reference implementation
- Best practice papers for colour in DICOM

Summary of all MIWG **work items**

Upcoming MIWG meetings


For forthcoming meetings, see the ICC **meeting schedule**.

If you wish to participate in a meeting, please contact the **ICC Secretary**

Previous meetings Meetings and minutes Action items

SEARCH ICC:

GO

Got a question about ICC Profiles or colour management?

[Ask Phil...](#)

ICC: LIVE TOPICS:

- iccMAX
- New ICC video
- iccMAX Reference Implementation - v2.1.7 released
- Research fund
- ICC Medical Imaging Working Group**
- Profile security
- New ICC White Paper on improving color image quality in medical photography
- Display calibration
- New PRMG-based

ICC MIWG Working group meeting

February 2018

- Introductions
- Electro-Optical Requirements for Medical Display Wonseon Song
- Medical imaging projects at NTNU Phil Green
- Medical display calibration using remote clients Tom Lianza, Portrait Displays
- Identification of possible future projects for MIWG Craig Revie
- Action items review Craig Revie

Possible future projects for MIWG

- Guidelines for digital pathology viewing environment (check telemedicine guidelines)
- Recommendation for colour vision testing and development of tools to aid practitioners with colour deficiency
 - Daltonisation to improve diagnostic ability
- Algorithms for analysis of medical images (we need to determine what the ICC could do to help this)
- LG medical display/application assessment
- Others? Call to MIWG + Honorary Members [CR]

Action items review

MIWG-15-30 Displays	Make assessment targets available to group	13-10-2015	Kimpe	Done
MIWG-16-01 Petri plate	Send Petri plate imaging guidelines for review by MIWG	16-02-2016	Pescatore	Close
MIWG-16-12 Displays	Discuss ICS for GSDF and report back to MIWG	04-05-2016	Bai, Derhak, Nagashima-san, Kimpe	Open
MIWG-16-20 Petri plate calibration	Distribute draft primer on Petri plate system calibration by December 2016	05-11-2016	Pescatore	Close
MIWG-17-03 General	Develop activity proposals on Viewing Environment in Pathology Imaging; Automation of Detecting Anomalous Features; and Electro-Optical Requirements for Medical Displays	20-05-2017	Revie; Lianza; Wonseon	Open



The Norwegian
Colour and Visual Computing
Laboratory



Colour in Medical Imaging

Coursework projects Fall 2017

The Norwegian Colour and Visual Computing Laboratory
Faculty of Computer Science and Media Technology
Norwegian University of Science and Technology
Gjøvik, Norway
<http://www.colourlab.no>





Colour Science and Industry

- 2-year Master degree
- EU Erasmus+ joint Master degree offered by 4 European universities + 15 industrial partners
- Consortium partners include Barbieri, FFEI, HP, Technicolor
- <https://master-colorscience.eu/cosi-master-degree/>
- Applied Colour Science semester in Norway



Colour in Medical Imaging

- 7.5 ECTS course
- Students undertake a coursework project on a medical imaging topic
- Co-supervision by Prof. Ruud Verdaasdonk, Amsterdam Free University Hospital
- Lab supervision at NTNU by Dr. Peter Nussbaum
- Support for oxyhemoglobin concentration project by Jacob Bauer



Colour in Medical Imaging

- Most projects involve an experimental set-up based on a novel imaging application and low-cost imaging devices
- Steps include building a suitable phantom, setting up imaging system and recoding and analyzing results
- Imaging devices were a mix of those at the Colorlab and lent for the project by Prof. Verdaasdonk
- Most projects used hyperspectral or multi-spectral imaging modes



The effectiveness of sunscreen protection for UV light using an UV imaging setup

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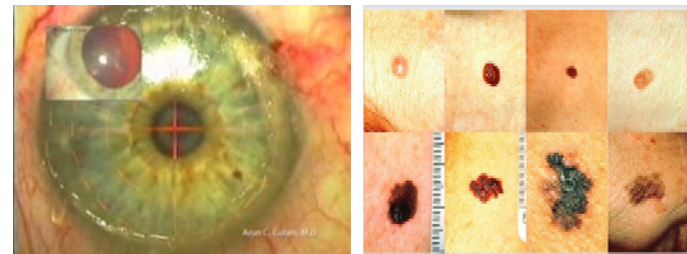
<http://www.colourlab.no>





Motivation

- UV radiation can result in acute and chronic harmful effects on the eye's dioptric system and retina.
- Overexposure to UVB radiation not only can cause sunburn but also some forms of skin cancer.
- 132000 melanoma skin cancers occur globally each year
- Most people only apply 25-50 percent of the recommended amount of sunscreen.





UV imaging system setup

- **Setup-I:** PIXELTEQ's SpectroCam Multispectral Camera with 8 rotating wheel filters from UV to IR range.



Figure-1. Setup-I utilizing PIXELTEQ's SpectroCam Multispectral Camera



UV imaging system setup

- **Setup-II:** full spectral converted camera – Sony NEXT 5T, with VIS cut-off filter and high UV transmitting filter.



Figure-2. Camera system for the Setup-II. (A) converter ring, (B) extension ring, (C) lens (D) filters and UV imaging Setup-II



Transmission measurement setup

- UV–Vis Ocean Optics USB2000+XR1 spectrometer with UV irradiating black-light

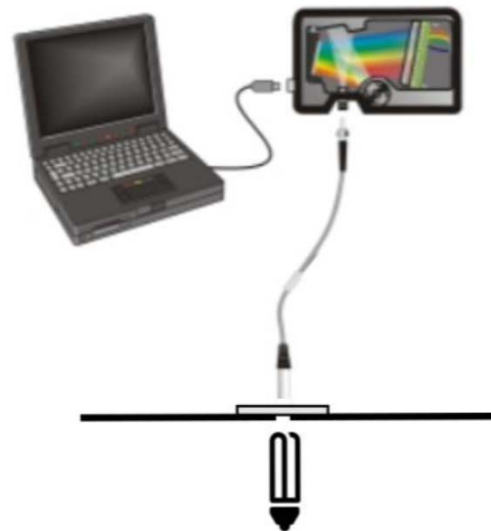


Figure-3. Setup employed to measure the UV transmission through sunscreen applied to a substrate sample holder. Positioned in the bottom UV light from a 365 nm black-light light source enters the setup through a fibre on the top.



Difference in SPF using UV imaging

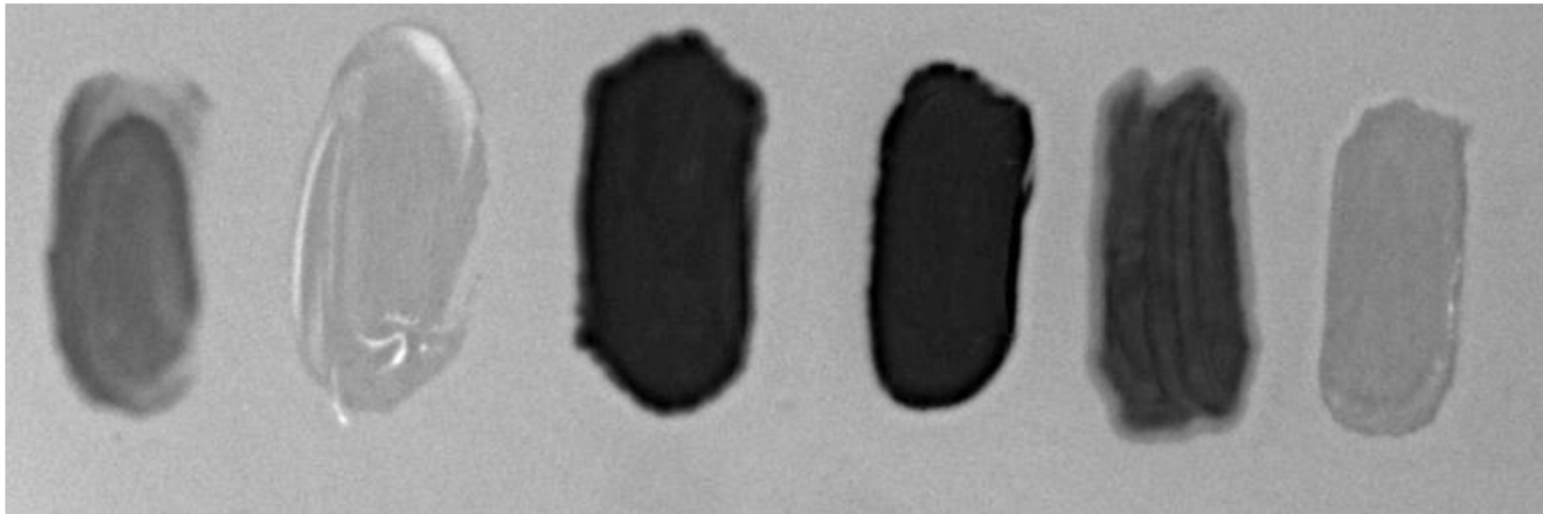


Figure-7. Image of Sunscreens applied on rough plastic film surface from Pixelteq camera.



Setup II images from Sony

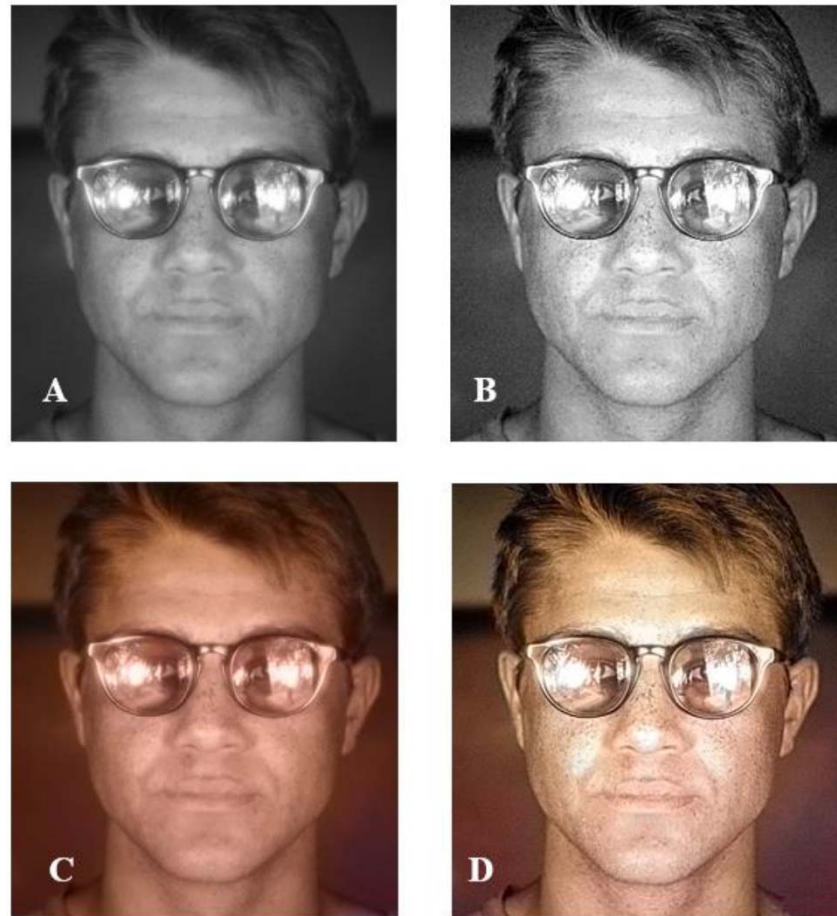


Figure-10. (A) Original image, (B) enhanced image, (C) CNN based Colorized original image, (D) CNN based Colorized enhanced image (with glasses)



Setup I images before and after Sunscreen applied

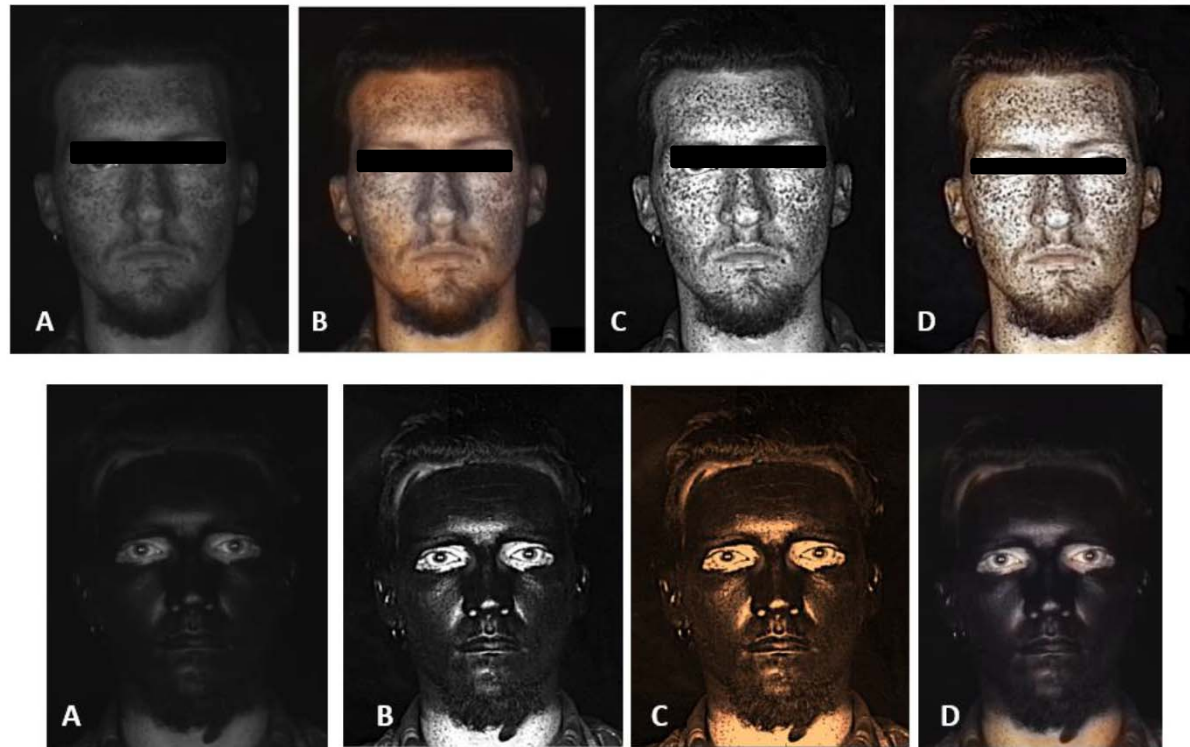


Figure-11. (A) Original image, (B) CNN based Colorized original image, (C) enhanced image, (D) CNN based Colorized enhanced image



Face regions that are missed during sunscreen application



Chin	95.8%
Maxilla	93.75%
Nose tip	89.6%
Nasolabial folds	91.7%
Mandibular	91.7%
Nose wings	87.5%
Temple	75%
Under eyebrows	75%
Under lips	68.8%
Lips corners	72.9%
Above the lips	70.8%
Between eyebrows	70.8%
Top of forehead	64.6%
Lips	60.4%
Eye corners	41.7%
Eyelids	43.8%
Under eyes	39.6%
Ears	14.6%
Neck	8%
Other regions	100%

Figure-15. Facial map showing the areas and how many percent of subjects applied a sunscreen on them. Regions with yellow tagged as other regions were covered by all participants.



Monitoring of Respiration Rate using the FLIR ONE thermal camera

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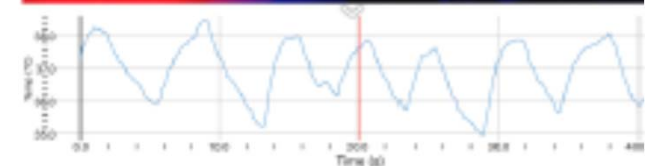
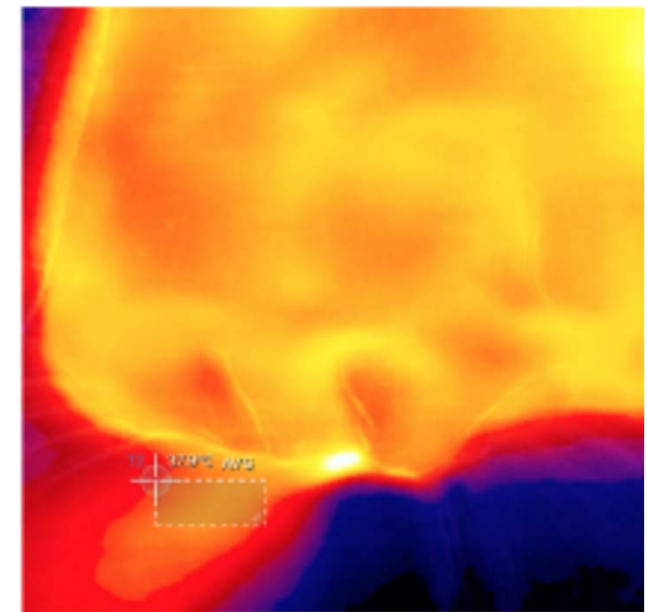
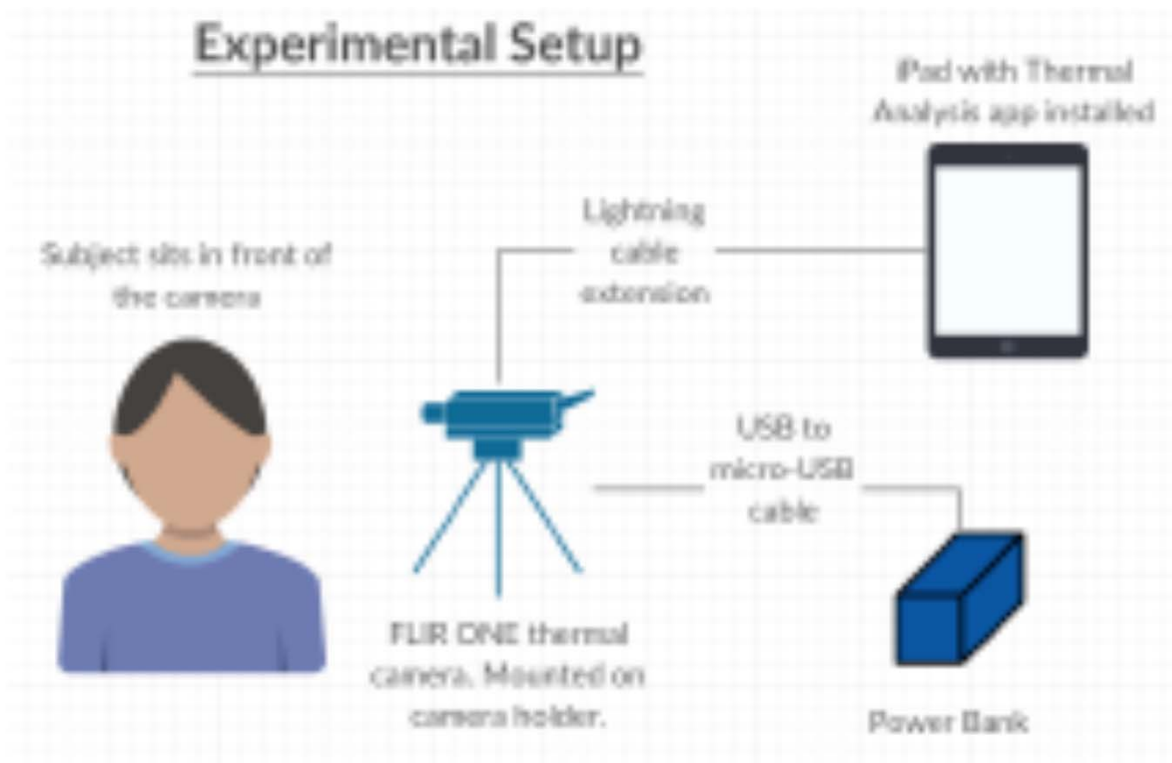
<http://www.colourlab.no>





Thermal imaging system setup

Experimental Setup





The Norwegian
Colour and Visual Computing
Laboratory



Multispectral Imaging in Tracking Psoriasis

Lingcong Zhao

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Faculty of Computer Science and Media Technology

Norwegian University of Science and Technology

Gjøvik, Norway

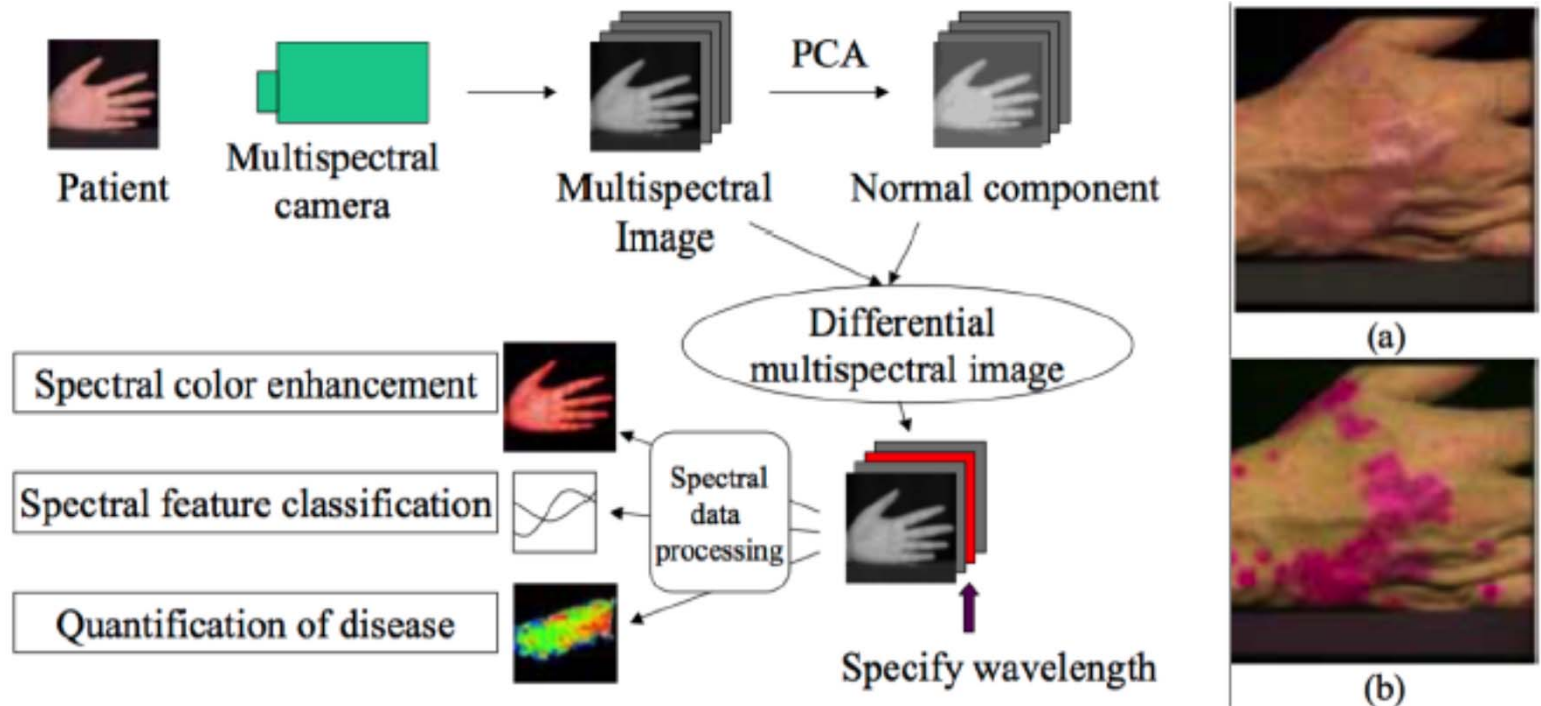
<http://www.colourlab.no>





Multispectral imaging of psoriasis

- Goal is to find an automatic way to quantitatively evaluate and track psoriasis from multispectral images





Real-time heart rate monitoring using a HD webcam

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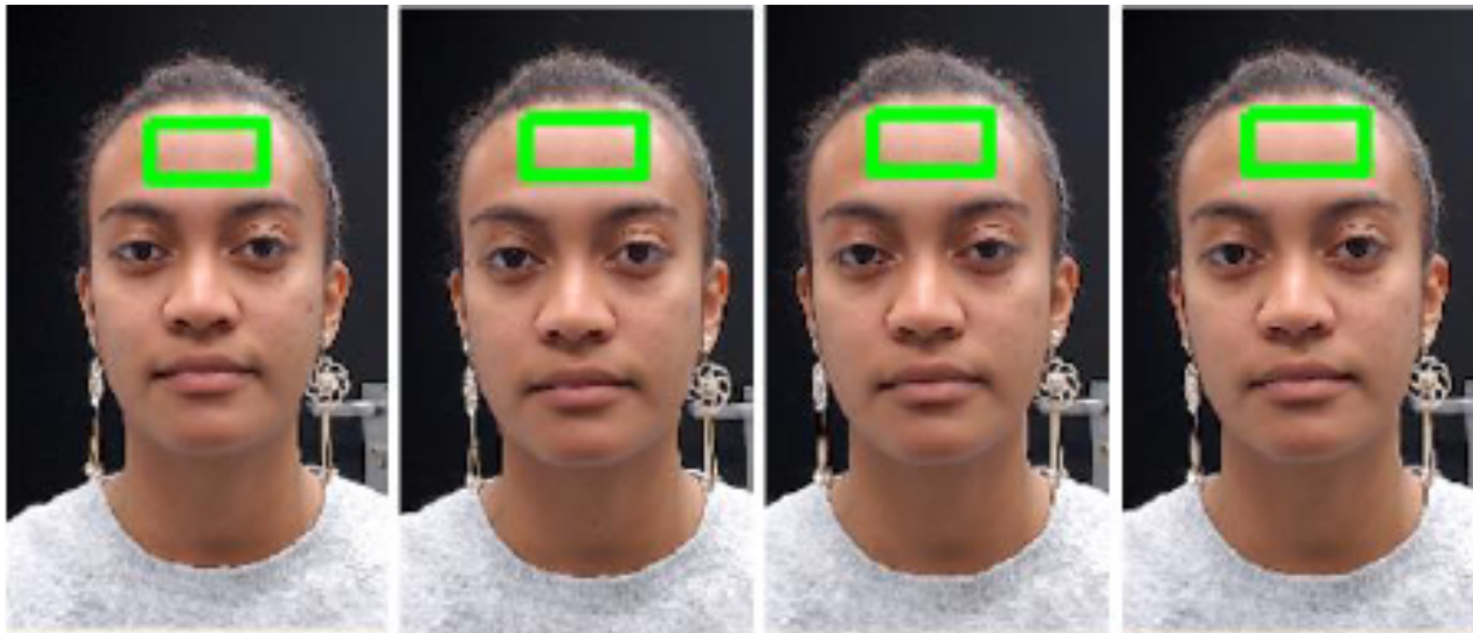
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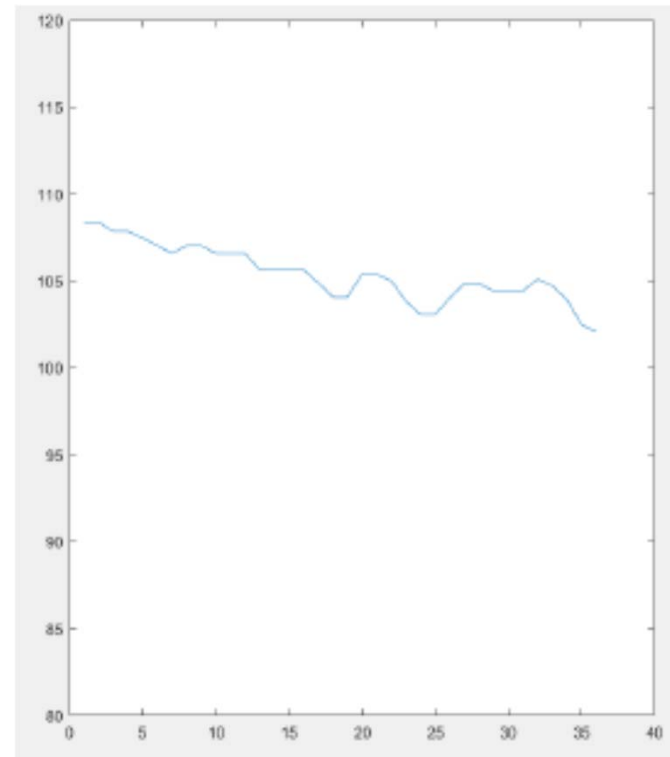
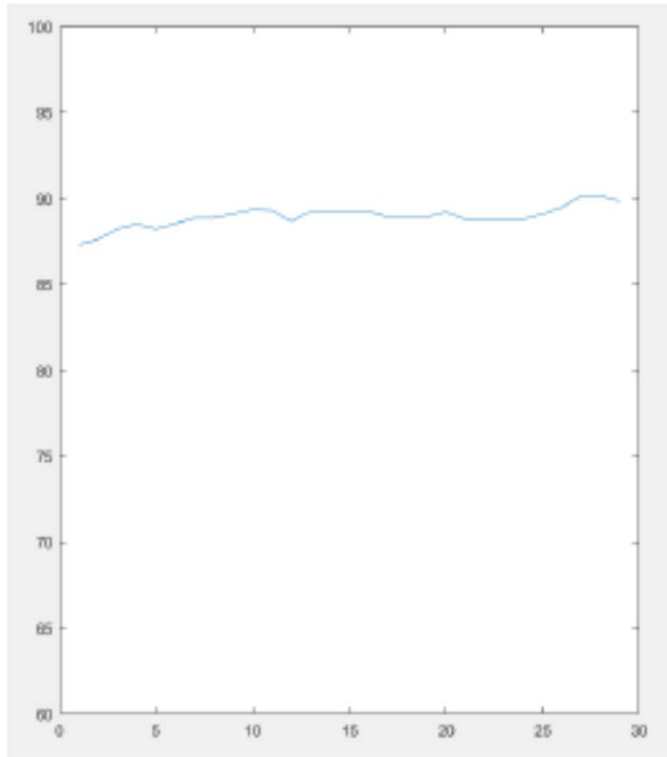
Webcam setup

- Goal is to use a non-contact method of monitoring heart rate
- Challenge is to establish stable consistent ROI on patient
- Developed algorithm for real-time processing of video stream





Results



Measured heart rate for rest and elevated states



Thermal detection of pigment lesions

NADILE NUNES DE LIMA

The Norwegian Colour and Visual Computing Laboratory

Faculty of Computer Science and Media Technology

Norwegian University of Science and Technology

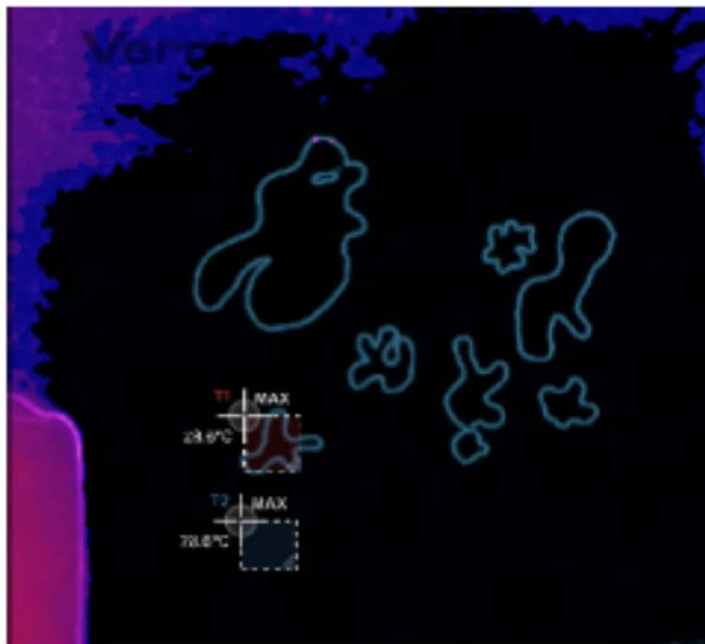
Gjøvik, Norway

<http://www.colourlab.no>

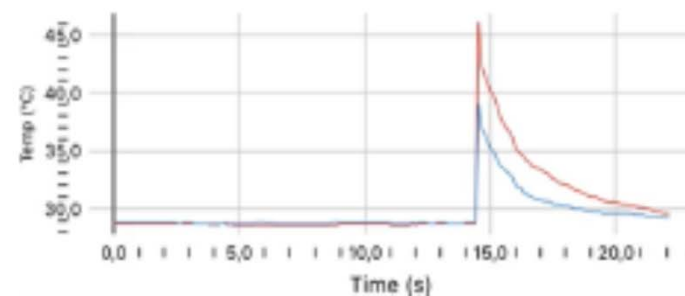




- Used intense flash light for quantification of concentration, depth and layer thickness of melanin
- Lesions are believed to cool differently after heating by flash light



(c) Experiment 2



(d) Time x Temp for experiment 2



Contrast enhancement of oxyhemoglobin concentration using multispectral imaging

Cristian da Costa Rocha

The Norwegian Colour and Visual Computing Laboratory

Faculty of Computer Science and Media Technology

Norwegian University of Science and Technology

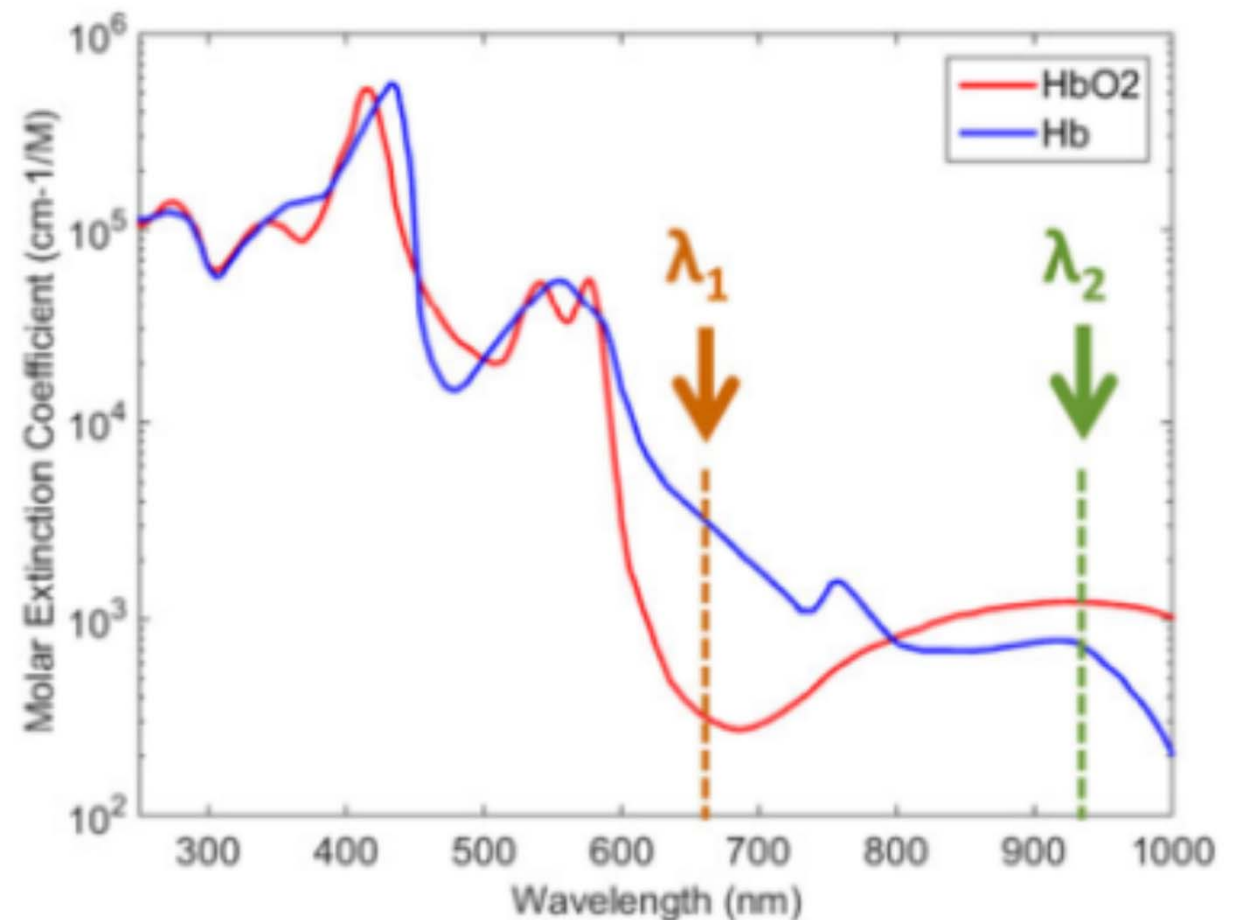
Gjøvik, Norway

<http://www.colourlab.no>





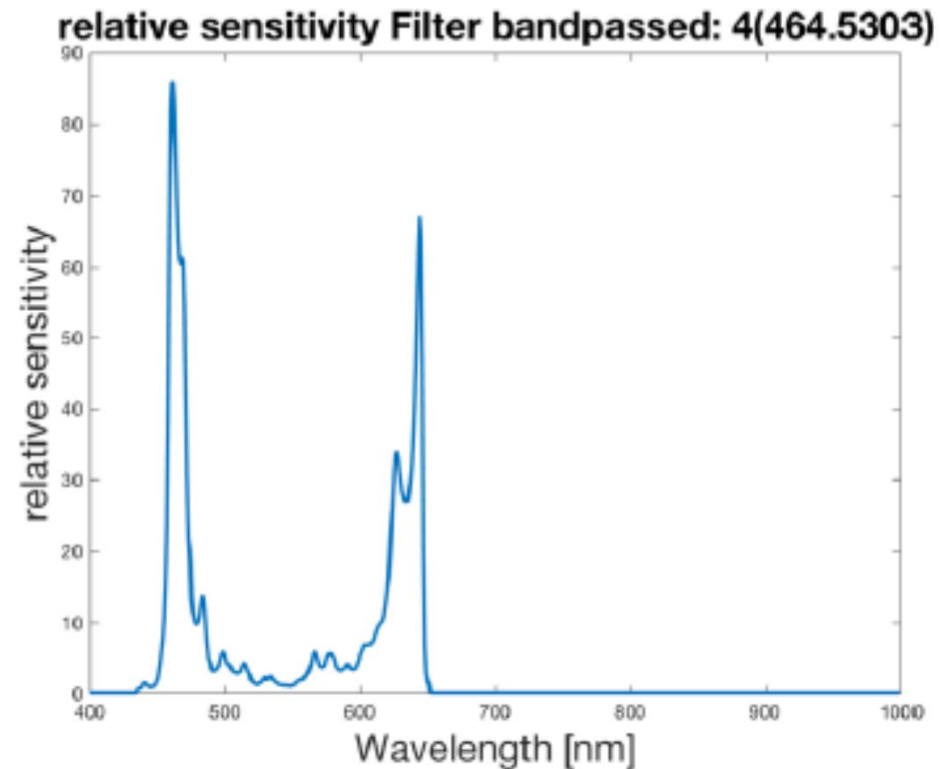
Goal is to enhance contrast between oxyhemoglobin and deoxyhemoglobin





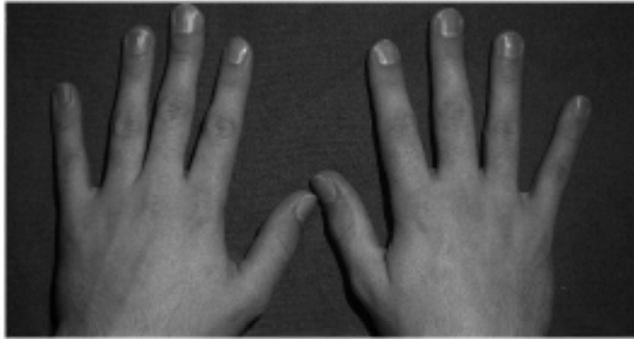
Ximea SFA multispectral camera with dual sensitivity peak

- Spectral correction required to give 601nm image
- Used PCA to difference between normoxic and hypoxic states

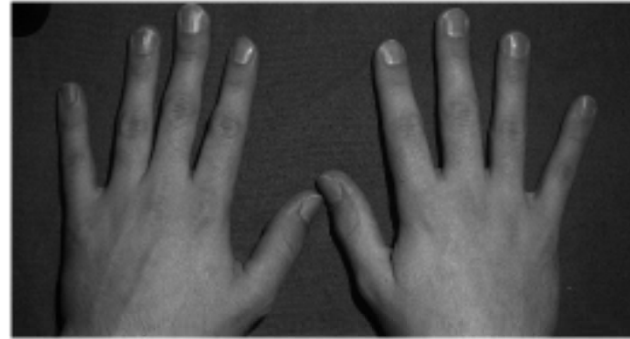




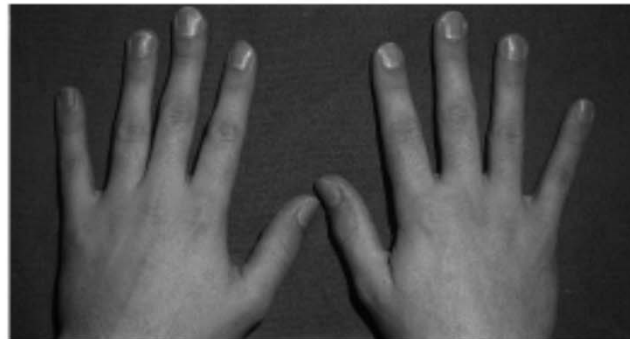
Images at 601nm



(a) Normoxic



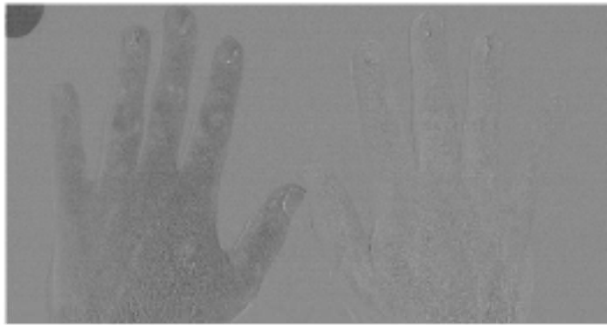
(b) Hypoxic



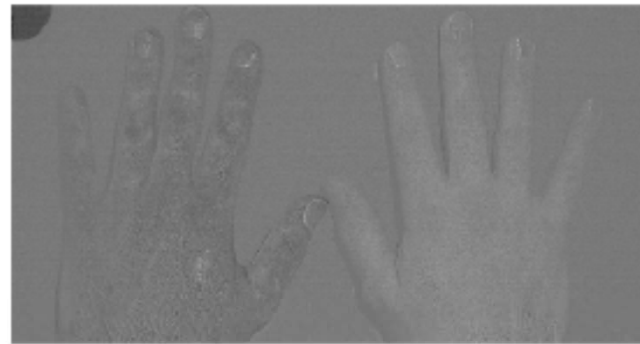
(c) Reperfusion



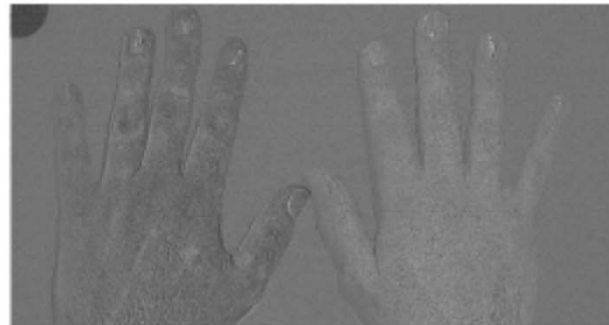
Hypoxic – normoxic state using different configurations



(a) PCA on the whole cube



(b) PCA on the last 3 bands



(c) Wavelength band 601nm



- Some projects to be submitted for publication at SPIE Medical Imaging, 2019 and Colour & Visual Computing Symposium, 2018
- Projects for 2018 cohort in development – collaborators welcome

SpectraCal

Medical Display Calibration using Active Clients

A description of the SpectraCal CalMED application

Portrait Displays – SpectraCal



- **Portrait Displays**

- An application software provider and middleware developer for monitors, notebooks, all-in-one computers, tablets, and smartphones
- For over 25 years, a proven and trusted software outsource supplier to the leading OEM manufacturers throughout the world

- **SpectraCal**

- World's leading provider of video display calibration software for both professional and consumer needs
- For 10 years, CalMAN software has been critically acclaimed for broadcast, video production, post production, commercial A/V, home theater, medical imaging, and geospatial intelligence

The Components of a typical stand alone calibration system

- Calibrated Video Generator
- Calibrated Light Meter or Spectral Device
- The Target Display and Target Display Controller

SpectraCal

Calibration Software

SpectraCal CaIMED

Medical Workstation Calibration Software

CaIMAN 5 Development (in-house use only)

CaIMAN 5

History 1 +

SpectraCal C6 LCD (CCFL)

CaIMED 3 Pattern Generator

CaIMED 3 Display Profiler DELL 2009W 2 Standard

DDC ?

CaIMED+

Imaging Technical QC

The CaIMED Imaging Technical QC workflow guides you through the process of conformance testing and calibrating radiology imaging monitors to industry standards.

Complies with DICOM PS-3.14, AAPM TG18, and ACR Resolution 39 (2014) practice guidelines and technical standards.

Compatible with grayscale and color monitors for all radiology modalities in diagnostic, clinical review, mammography, dentistry, and veterinary applications.

SpectraCal - Committed to Image Fidelity

SpectraCal is dedicated to optimizing the fidelity of electronic images in broadcast, production, post-production, residential, entertainment, commercial, corporate, government, and medical venues. To this end, we consider the variables of the display/projector, the source, the environment and human perception, with the part that each plays in the attainment of that goal.

The SpectraCal team is focused on display metrology and the accurate measurement and optimization of displays and has developed software and hardware solutions to permit display calibrators, from beginner to experts, to optimize video and graphics systems' image fidelity in their unique environments.

CaIMAN 5

Next »

PORTRAIT
DISPLAYS

What is a Client architecture and what are the advantages?

SpectraCal

- The client architecture treats the display and the connected computer as the video generator / target display combination.
- The client monitors the physical setup continuously and loads the proper look up tables and Virtual Control Panel Settings that were determined during initial calibration.
- The client monitor shut down events, screen saving events, and manual adjustments made outside of calibration.
- The client software saves considerable dollars and licensing issues. One application can be configured to work with many clients.
- Client cost per seat is under \$50 dollars for 10 seats.

What functions does CaMED provide?

SpectraCal

Two Imaging Workflows:

Radiology Imaging

Scanner-sourced, non-visible energy

X-ray, CT, nuclear, PET/SPECT, ultrasound, MRI, etc.

Medical Video

Camera-sourced, visible light

Endoscopy, surgical, ophthalmology, dermatology, microscopy, etc.

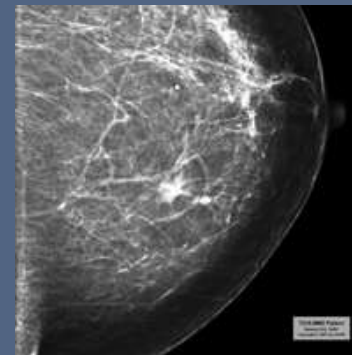
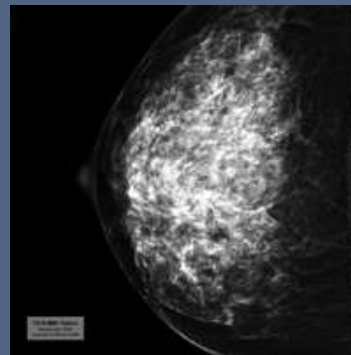
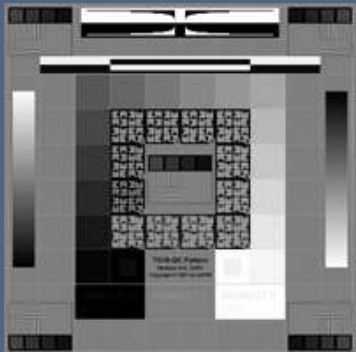
-

Basic Functionality:

- Visual Assessment
- Certification
- Calibration
- Reporting

Qualitative Visual Tests

Visual assessment of overall clinical image quality
(TG18-QC, SMPTE, AAPM Anatomical)



Certification

Runs from the Host Server

SpectraCal



Radiology Imaging Calibration Workflow

Optimize Display Controls

Dynamic Range;
Contrast control

If the display
manages DDC/VCP
commands, this can
be automated

Note that ambient luminance and display
reflection can also be measured.

CalMAN 5 Development (in-house use only)

CalMAN 5

Imaging Technical QC

- 1. Initial Setup
 - Introduction
 - Device Connect
 - Ambient Luminance
- 2. Workstation Analysis
 - Visual QC Tests
 - Conformance Test
- 3. Display Optimization
 - Dynamic Range**
 - RGB Adjust
 - Luminance Adjust
- 4. Workstation Calibration
 - DICOM LUT

Dynamic Range

If the monitor has a Contrast control, perform the steps below to adjust Contrast for maximum dynamic range, without losing bright gray image details.

1. Set the monitor's Contrast control to its default or normal setting.
2. Click the **Read Series** button to show dynamic range results on the chart at right. The red, green and blue lines on the chart should each be nearly linear and parallel.
3. If one of the lines shows flattening at the upper right, reduce the monitor's Contrast control slightly and retest, until the RGB lines are each nearly linear and parallel.

Note: The red, green, and blue lines will be merged later, in the Monitor Optimization and Calibrate LUT steps.

If the monitor does not have a Contrast control:

- Skip this page.

Note: Do not make adjustments in the video adapter control utility.

Click Next to continue.

Help

Luminance

Contrast 70

230 235 240 245 250 255

Back Next

Radiology Imaging Calibration Workflow

SpectraCal

Optimize Display Controls

- White Point;
 - RGB Gain controls
- If the display manages DDC/VCP commands, this can be automated

The screenshot displays the CalMAN 5 software interface. The title bar reads "CalMAN 5 Development (in-house use only)". The main window is titled "CaIMAN 5" and shows a "History 1" tab. The interface is divided into several sections:

- Imaging Technical QC:** A sidebar menu with sections: 1. Initial Setup (Introduction, Device Connect, Ambient Luminance), 2. Workstation Analysis (Visual QC Tests, Conformance Test), 3. Display Optimization (Dynamic Range, RGB Adjust, Luminance Adjust), and 4. Workstation Calibration (DICOM LUT).
- RGB Adjust:** The main content area with instructions:
 - If there are RGB Gain controls on this page:
 - Click the *AutoCal™* button to automatically adjust RGB Balance.
 - If there are no RGB Gain controls on this page, but there are RGB Gain/Color Temp controls in the monitor's OSD picture menu:
 1. Click the *Read Continuous* button.
 2. Select level 255 on the bottom *Source Level* tabs. Adjust the RGB Gain controls in the monitor's OSD menu. Reduce the level of the two higher color bars on the RGB Balance chart, to match the level of the lowest color bar (leave the lowest color at its default setting).
 3. Then, if the monitor also has RGB Offset controls, select level 76 on the bottom *Source Level* tabs. Adjust the Red and Blue Offset controls to balance the Red and Blue bars to the center Green bar.
 - If there are no RGB Gain controls on this page and there are no RGB controls in the monitor's OSD picture menu:
 - Skip this page.
 - Automatic RGB adjustments will be made on the Calibrate LUT page.

Note 1: RGB controls may be available only with certain viewing modes.
Note 2: Do not make adjustments in the video adapter control utility.

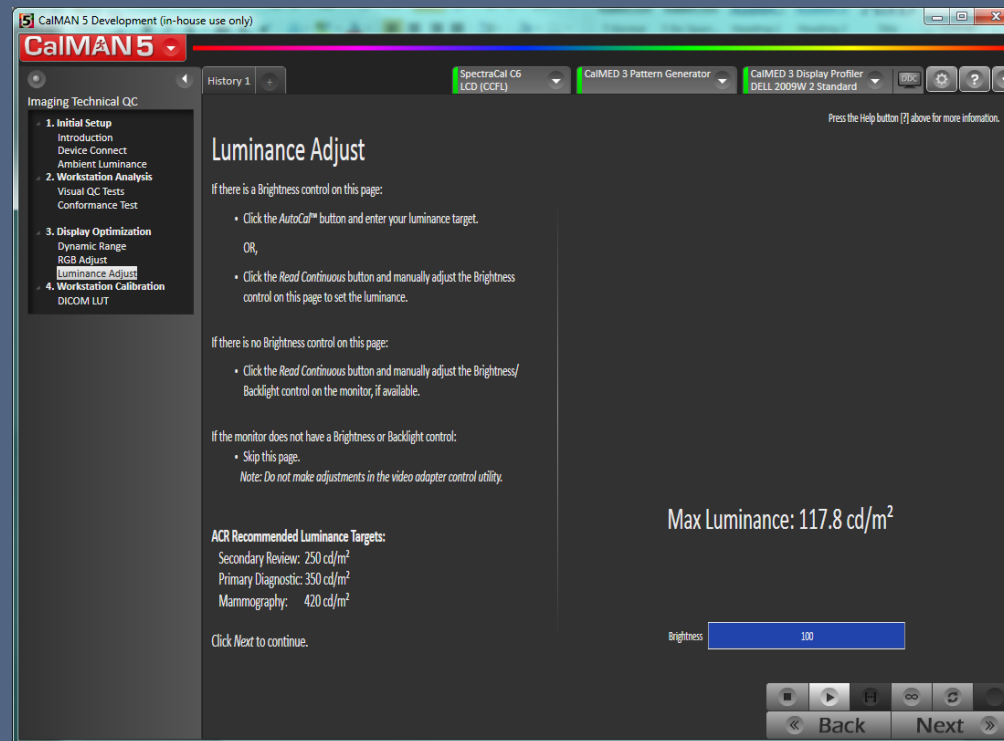
Click *Next* to continue.
- RGB Balance Chart:** A bar chart titled "RGB Balance" showing three bars (Red, Green, Blue) for two different levels: 76 and 255. The y-axis ranges from 70 to 130. At level 76, the Red bar is at approximately 98, Green at 105, and Blue at 98. At level 255, the Red bar is at 100, Green at 100, and Blue at 98.
- Color Temperature Preset:** A dropdown menu set to "User 2".
- Gain Controls:** Three horizontal sliders for "Red Gain" (set to 87), "Green Gain" (set to 88), and "Blue Gain" (set to 100).
- Navigation:** A "Back" button and a "Next" button are visible at the bottom right.

Radiology Imaging Calibration Workflow

SpectraCal

Maximum Luminance
Adjust Display
Contrast Control

If the display
manages DDC/VCP
commands, this can
be automated



SpectraCal

Radiology Imaging Calibration Workflow

Calibrate the LUT

Process takes about 1 minute

Calibration is based upon absolute luminance



Radiology Imaging Calibration Workflow

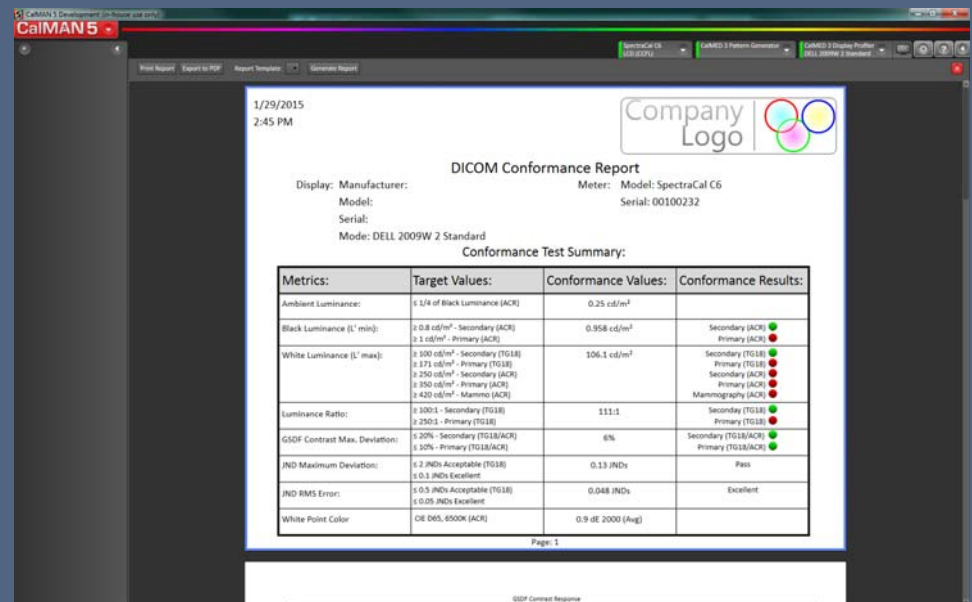
SpectraCal

Check Conformance



PORTRAIT
DISPLAYS

Generate and save report



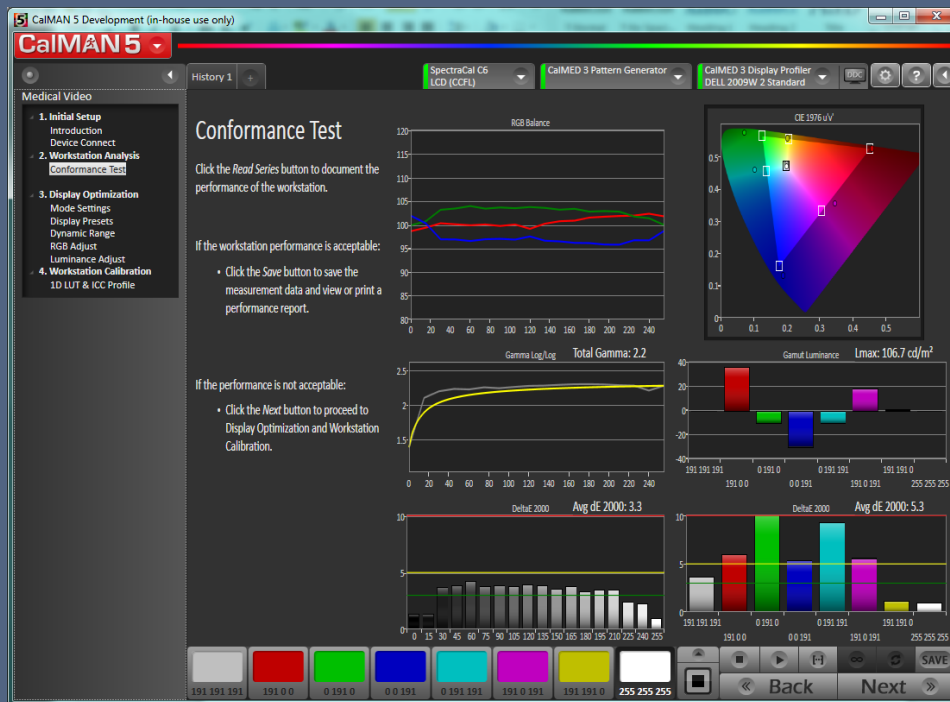
Medical Video Workstation Calibration

SpectraCal

Analyze Conformance

Luminance gamma, Lmax, DeltaE;
Chromaticity, DeltaE

Save and Print report



PORTRAIT
DISPLAYS

