Deterioration estimation of artworks by means of a novel 3D-hyperspectral imaging system

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Instrument (Hardware + Software)

LCTF

LED and DMD

CCD camera

CAD design of the prototype

(GUI) automatic mode

Design Operational Architecture

Analysis of HSI data

Analysis of 3D data

IR Source

IR Camera

AOTF
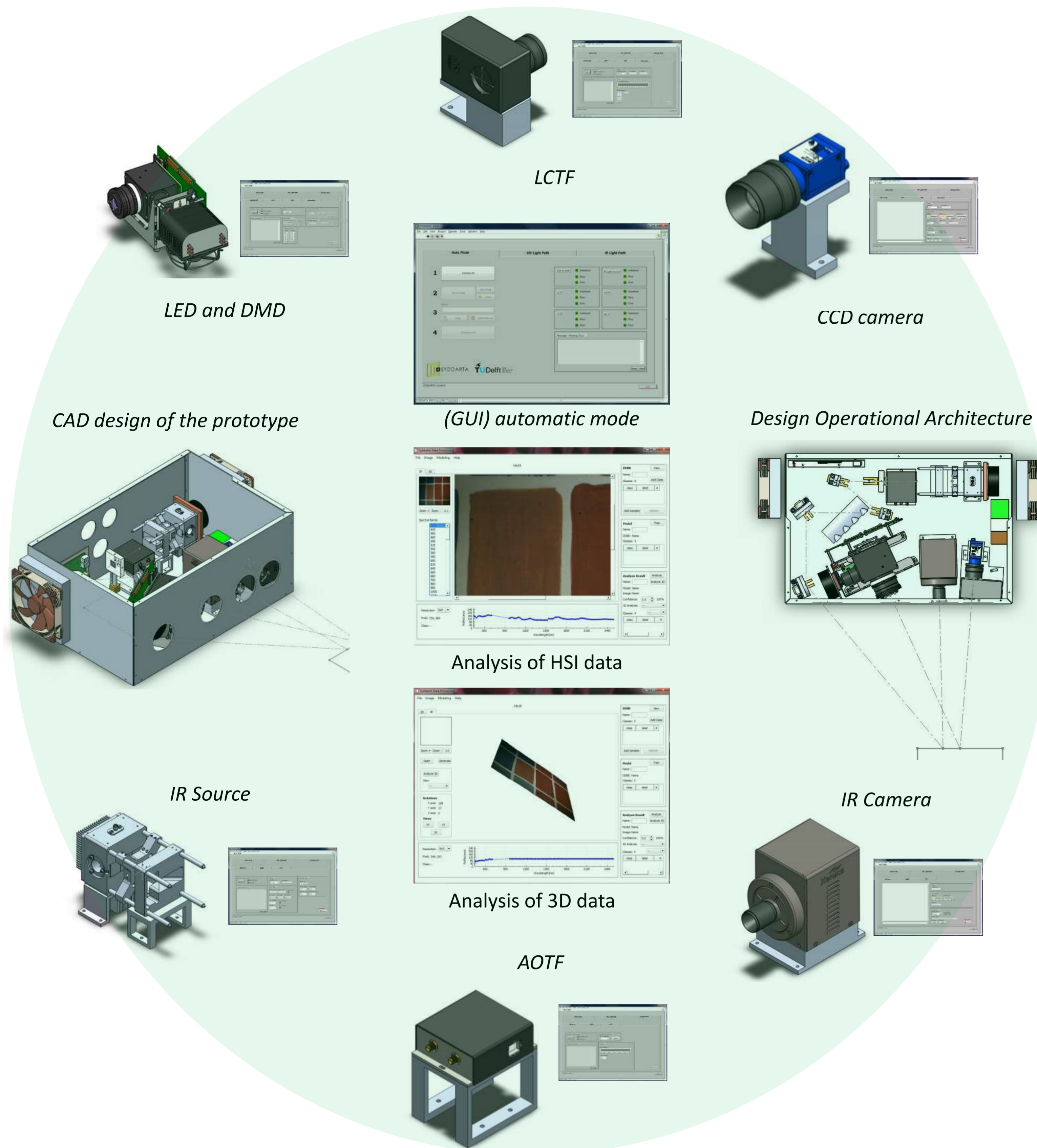
SYDDARTA Prototype Specifications			
Parameter	Visible	Infrared	
Spectral Sensitivity	400nm - 700nm	900nm - 2500nm	
Color Depth	8bit	10bit	
Spatial Resolution	2048×2048	320×240	
Spectral Resolution	10nm		
Scanning Speed	1minute		

Final Prototype

During Measurements at IPCHS

Projection of SWIR measuring area

## Materials

PIGMENTS IN DIFFERENT BINDERS, MIXTURES, PARTICLE SIZE
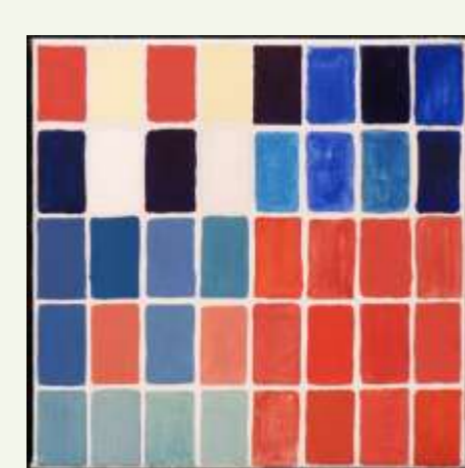
DIFFERENT PARTICLE SIZE:
V1 – vermilion (Natural cinnabar, particle size 63 – 100 μm)
V2 – vermilion (particle size 27 μm)
V3 – vermilion (particle size 14 μm)
V4 – vermilion (particle size 5 μm)
V5 – vermilion (particle size 50 μm)
V6 – vermilion (Natural cinnabar particle size < 63 μm)

PIGMENT MIXTURES:
PM1: lead white : Prussian blue (9:1)
PM2: lead tin yellow type I : Prussian blue (9:1)
PM3: lead white : Prussian blue : Lead tin yellow type I (8:1:1)
PM4: lead white : vermilion (1:1)
PM5: azurite : lead tin yellow type I (1:1)
PM6: azurite : lead tin yellow type I: lead white (3:3:4)

SUPPORT:
S = linen canvas with
AG = animal glue (rabbit) preparation
GROUND:
G=White Gesso: Composed of calcium sulfate dihydrate (gypsum) and calcium carbonate (calcite)in animal glue (rabbit).
PAINT LAYERS:
BINDERS:
B1: non fatty egg tempera (egg yolk)
B2: linseed oil
PIGMENTS FOUND IN SELECTED CASE STUDIES
P1 – vermilion
P2 – lead tin yellow type I
P3 – Prussian blue (non soluble)
P4 – lead white
BLUE PIGMENTS:
B1 – Prussian blue (soluble)
B2 – Ultramarine
B3 – Azurite
B4 – Smalt

PAINT LAYERS SUPERIMPOSED AND VARNISHED
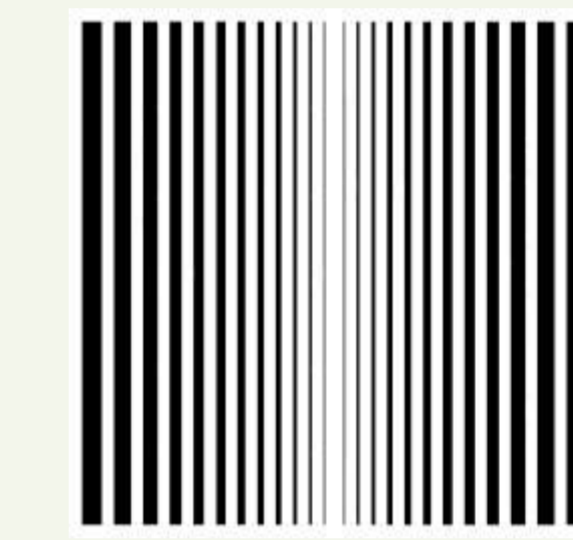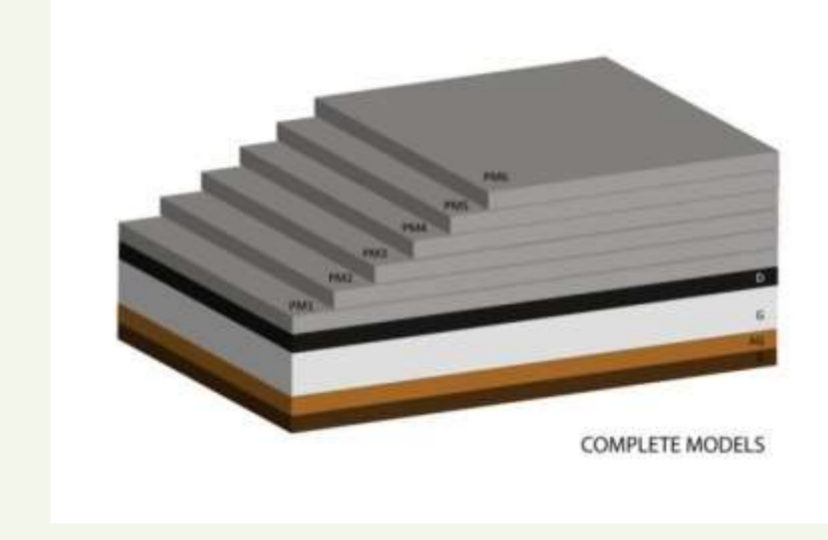
COMPLETE MODELS
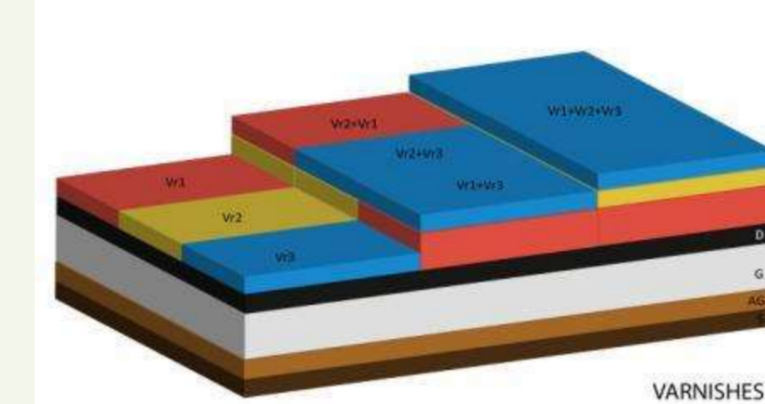
SUPPORT:
S = linen canvas with
AG = animal glue (rabbit) preparation
GROUND:
G=White Gesso: Composed of calcium sulfate dihydrate (gypsum) and calcium carbonate (calcite) in animal glue (rabbit).
DRAWING: charcoal fixed with 3,5 % of rabbit glue solution
BINDER: non fatty egg tempera (egg yolk)
PIGMENT MIXTURES:
PM1: lead white : Prussian blue (9:1)
PM2: lead tin yellow type I : Prussian blue (9:1)
PM3: lead white : Prussian blue : Lead tin yellow type I (8:1:1)
PM4: lead white : vermilion (1:1)
PM5: azurite : lead tin yellow type I (1:1)
PM6: azurite : lead tin yellow type I: lead white (3:3:4)
VARNISH:
Vr1: egg white
Vr2: mastic

### WOODEN PANELS: POPLAR AND OAK WOOD (RADIAL AND TANGENTIAL CUT)
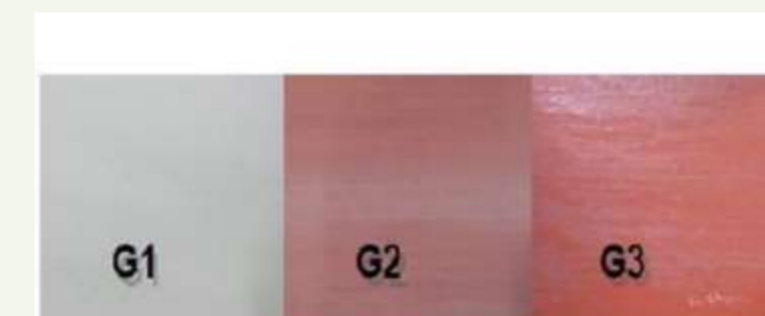
1) Three different grounds on stable and non stable wood
G1 - white gesso, composed of calcium sulfate dihydrate (gypsum) and calcium carbonate (calcite) in animal glue (rabbit),
G2 - composed of caolinite, hematite, calcite, lead white, carbon black in animal glue and another
G3 - composed of caolinite, hematite, calcite, lead white, carbon black in animal glue and oil.

2) Varnish model structure with superimposed varnish layers.
LEGEND:
SUPPORT: two types of wood, poplar and oak wood
GROUND: White Gesso: Composed of calcium sulphate dihydrate (gypsum) and calcium carbonate (calcite) in animal glue (rabbit).
DRAWING: charcoal
VARNISH:
Vr1: egg white
Vr2: Mastic
Vr3: Venice Turpentine

VARNISHES

Database
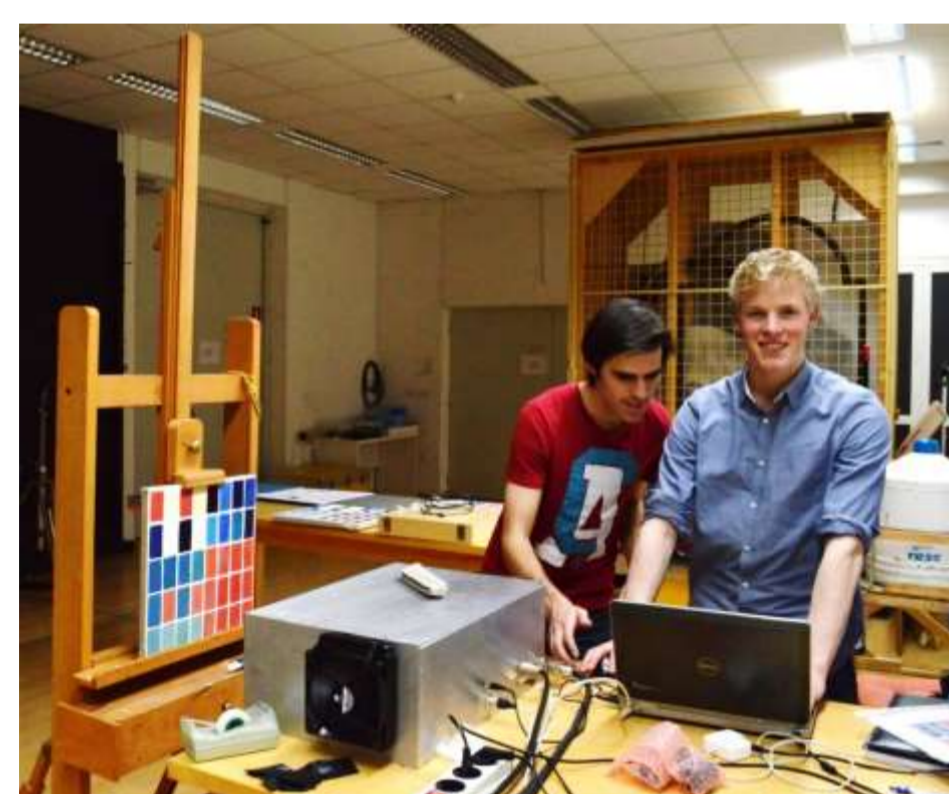
Reflection Spectra
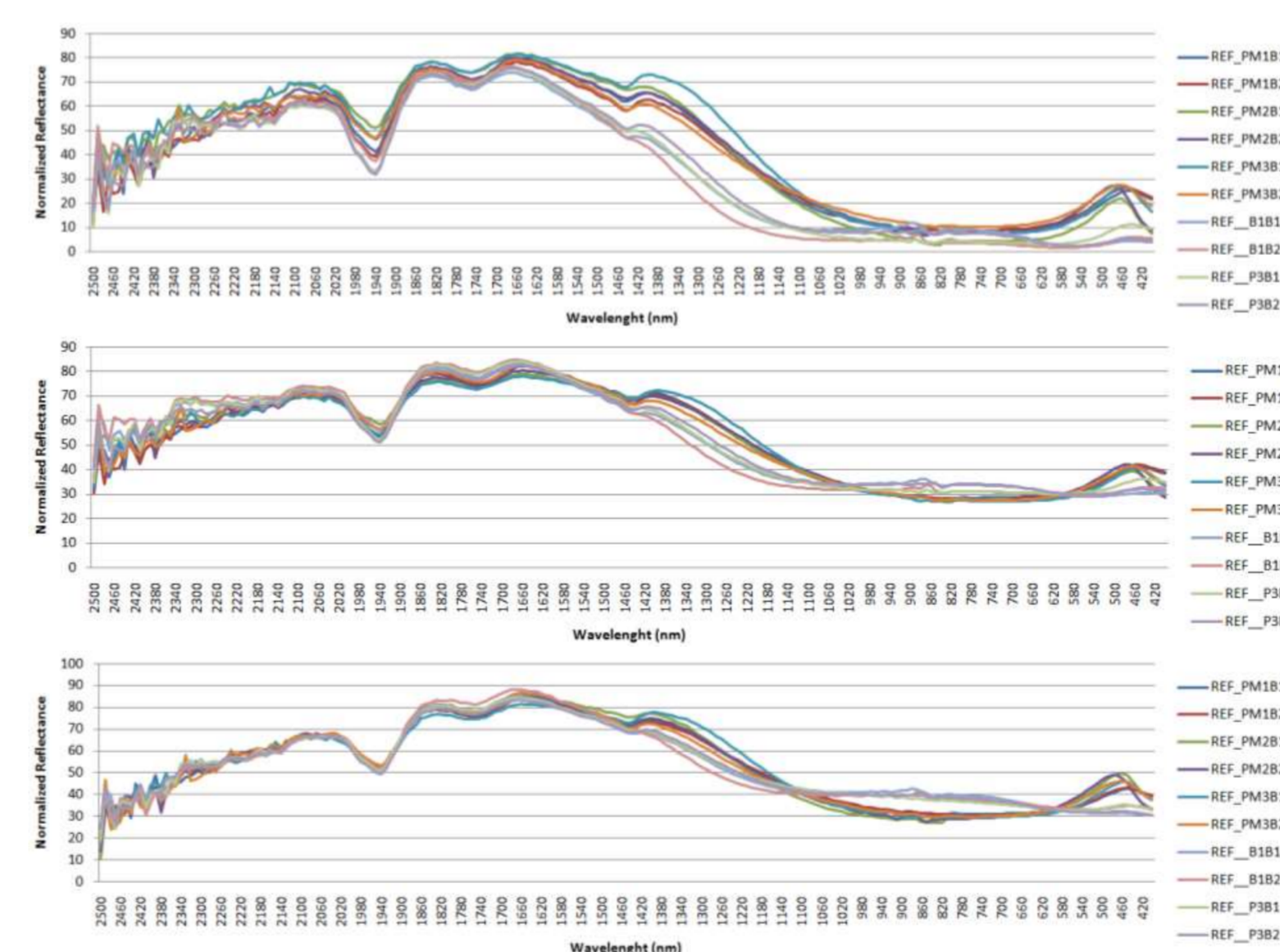

Deterioration Study

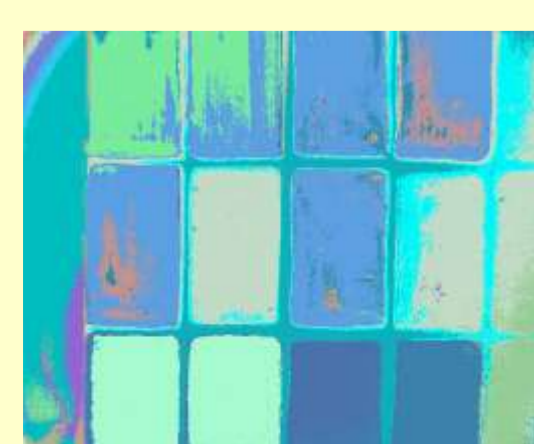

REF sample

THD sample

UVD sample
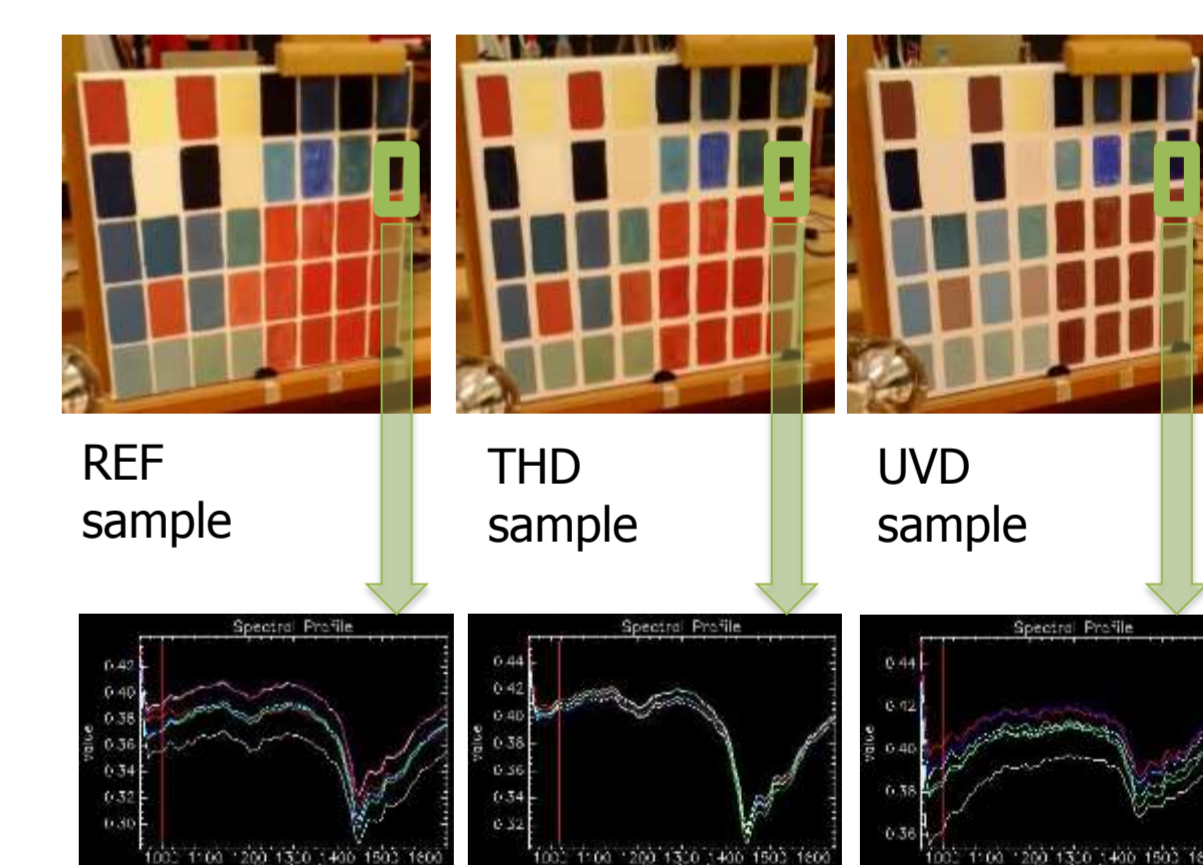
Ultraviolet aging (UVD), but not thermal aging (THD) changes can be identified in 950-1650 nm spectral range

Results

PCA Analysis and Mapping

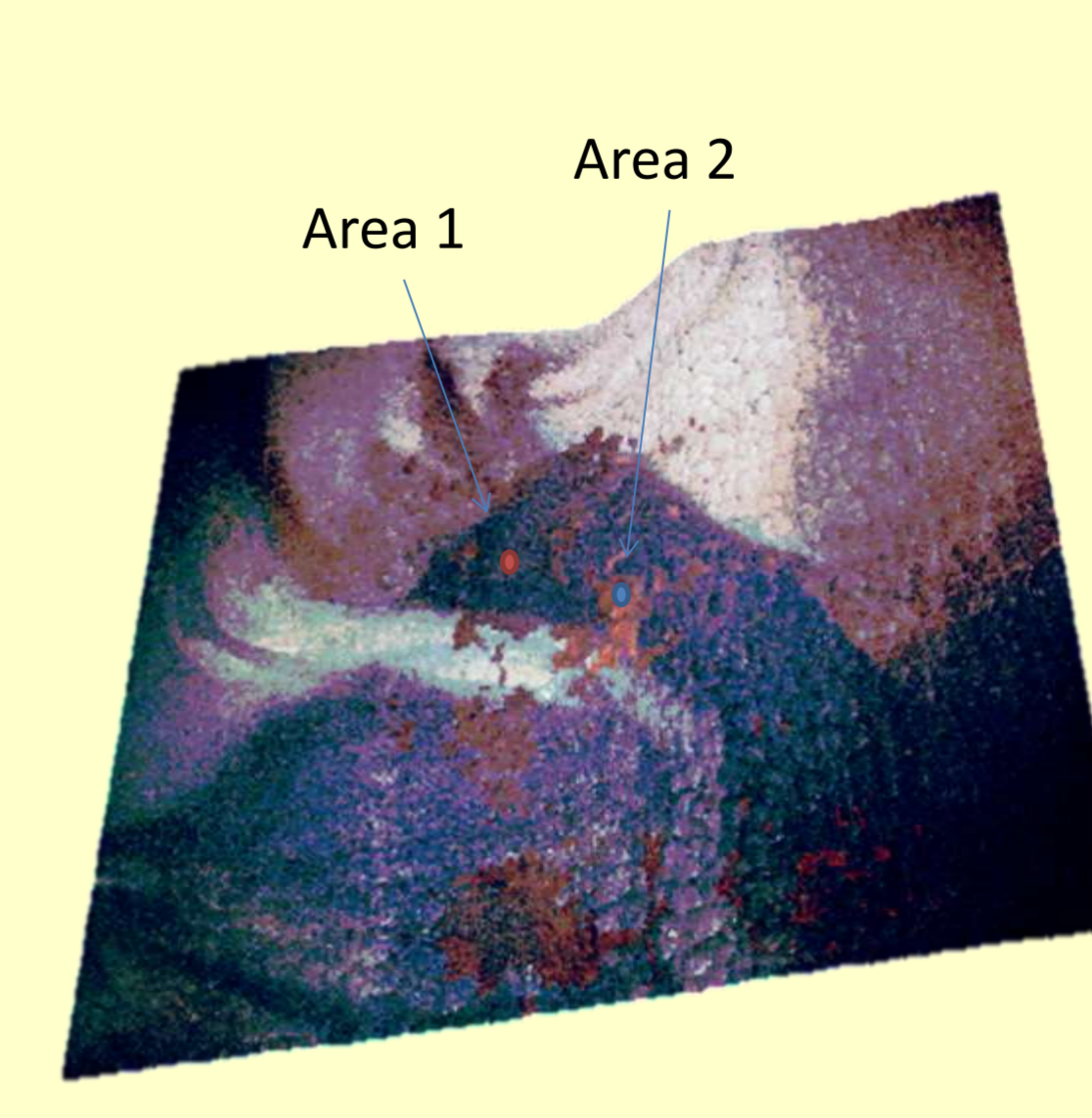| Classes (k-means)	Dimensions (PCA)	Classification method								
		#1	#2	#3	#4	#5	#6	#7_0	#7_1	#7_2
10	10	97.5	97.5	96.7	85.8	98.3	88.3	95.8	96.7	95.8
	30	97.5	92.5	96.7	60.8	98.3	86.7	96.7	96.7	96.7
20	10	95.0	93.3	89.2	80.0	94.2	87.5	95.8	97.5	95.8
	30	95.0	85.8	89.2	60.8	94.2	82.5	97.5	95.0	97.5
30	10	90.8	87.5	82.5	65.8	89.2	76.7	85.0	95.0	85.0
	30	92.5	79.2	82.5	51.7	89.2	77.5	87.5	91.7	87.5
40	10	90.0	87.5	82.5	75.0	90.0	84.2	86.7	92.5	87.5
	30	90.8	77.5	81.7	51.7	90.0	80.8	88.3	93.3	88.3

REF sample
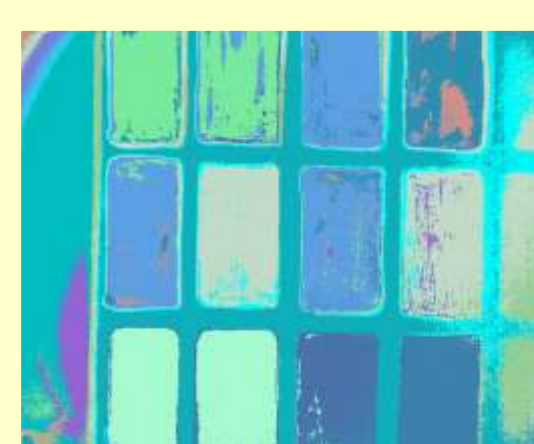
THD sample

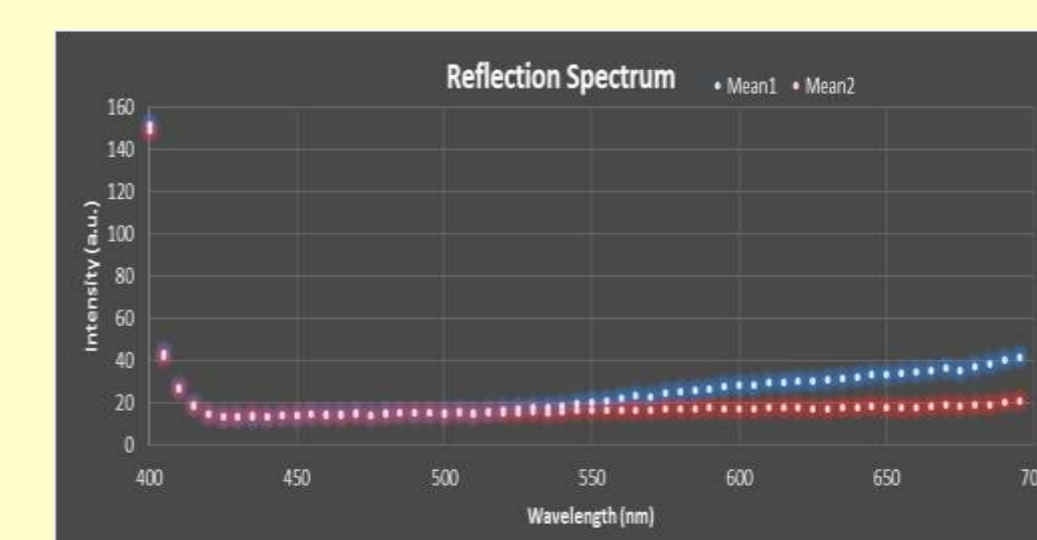UVD sample

Mechanical Stress Detection

Generated 3D mesh surface with colour information, detected shape deformation is labelled with red marker on the surface
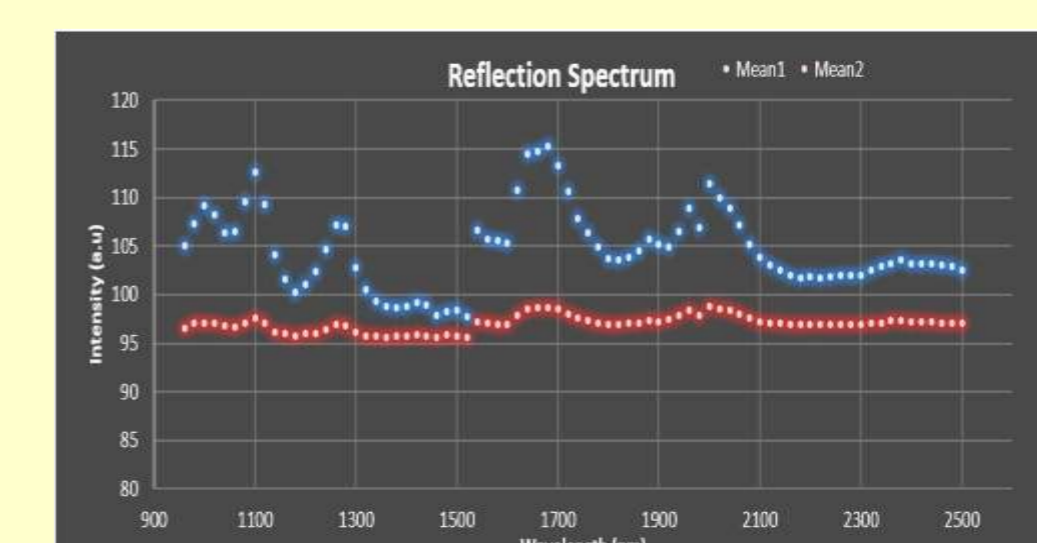
Chemical deterioration Detection

Area 1

Area 2

3D reconstruction

Reflection Spectrum

Visible Spectrum of two points in the center of the image

Reflection Spectrum

The relative Infrared Spectrum

SYDDARTA

SEVENTH FRAMEWORK PROGRAMME

AIDO | FORTH | TUD | CNR-ISAC | XENICS | VIALUX | AVANTES | G&H | SIGNINUM | IPCHS | RABASF

TUDelft