Manual PLDviewer7.0.05

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General

PLD: Portable Light Dome
Viewer: Built by ESAT – KU Leuven
Imaging method: Multi-Light Reflectance (MLR) imaging or single camera, multi-light imaging
Websites:

- https://www.esat.kuleuven.be/psi/research/portable-light-dome
- http://www.minidome.be[1]
- http://www.heritage-visualisation.org/

Blog:

- https://portablelightdome.wordpress.com

The foremost method to consult the cun- or zun- files which contain the datasets of the White Light (WL) and Multi-spectral (MS) PLD recordings is by using the auto-running viewer interface on your PC (so-called desktop viewer): the most recent full function version is PLDviewer 7.0.05.[2]

With this viewer all viewing and analyzing features developed for the PLD system can be generated. An alternative is http://www.heritage-visualisation.org/viewer/;[3] this is an online viewer which works from within a browser window. It is slower (needs a sufficiently fast internet connection) and has a more number of processing abilities, mainly only those which have a pure visual nature (i.e. virtual relighting and the rendering of the various shaders).

To allow consultation, viewing and analysis, for all recordings the original raw datasets have been digitized into cfd-, zun- or cun-file. Zun- and cun-files are single file datasets which conceal all the basic information in the original high definition to perform all the visual renderings and most of the analytic calculations. In the zun/cun files the original data in compressed to facilitate consultation and distribution of the datasets. For some computers and/or recordings these full frame compressed high resolution zun/cun files might be very demanding. Therefore, it has been made possible to generate results with half – or even less – of the original resolution (to perform, see *sampling* below).

Selection of relevant publications on the system and its viewing interfaces:

- WATTEEUW L., VAN BOS M., G. TATIANA, VANDERMEULEN B., HAMEEUW H. 2019: An applied complementary use of Macro X-ray Fluorescence scanning and Multi-light reflectance imaging to study medieval

[1] In the near future this online module will be updated, as a consequence this original online viewer can be offline and only the open access viewer on http://www.heritage-visualisation.org/ can be operational.
[2] The viewer interface software can be obtained via https://portablelightdome.wordpress.com/software/, or by contacting the authors of this concise manual. It can be forwarded on simple request via a zip-file. Unzip it into any new folder on your PC computer/laptop. By double clicking the “PLDviewer7.0.05” shortcut the viewer interface opens itself on your computer, for Windows 7 that is assured, for Windows 10 the settings on your system might block this automated executable, in that case your ICT-support should been able to help. If this desktop viewer does not work on your system, the most likely reason is an insufficient powerful processor or graphical card.
[3] To open a zun- or cun-file in the online viewer: click ‘open local file’ (upper right corner) and select one of the zun/cun-files on your computer system or external memory disk.

illuminated manuscripts. The Rijmbijbel of Jacob van Maerlant, in: *Microchemical Journal* 155 (June 2020), 104582. (DOI: 10.1016/j.microc.2019.104582)

- VANDERMEULEN B, HAMEEUW H., WATTEEUW L., VAN GOOL L., PROESMANS M. 2018: Bridging Multi-light & Multi-Spectral images to study, preserve and disseminate archival documents, in: *Archiving2018: Final Program and Proceedings*, Springfield - Society for Imaging Science and Technology, 64-69. (DOI: 10.2352/issn.2168-3204.2018.1.0.15)
- VAN DER PERRE A., HAMEEUW H., BOSCHLOOS V., DELVAUX L., PROESMANS M., VANDERMEULEN B., VAN GOOL L., WATTEEUW L. 2016: Towards a combined use of IR, UV and 3D-Imaging for the study of small inscribed and illuminated artefacts, in: Homem P. M. (ed.), Lights On … Cultural Heritage and Museums!, Porto, 163-192.
- WATTEEUW L., HAMEEUW H., VANDERMEULEN B., VAN DER PERRE A., BOSCHLOOS V., DELVAUX L., PROESMANS M., VAN BOS M., VAN GOOL L. 2016: Light, shadows and surface characteristics: the multispectral Portable Light Dome, in: *Applied Physics A Materials Science & Processing* 122: 976, 1-7. (DOI:10.1007/s00339-016-0499-4) [IF: 1.444]
- WILLEMS G., F. VERBIEST, W. MOREAU, H. HAMEEUW, K. VAN LERBERGHE & L. VAN GOOL 2005: Easy and cost-effective cuneiform digitizing, in: M. Mudge, N. Ryan & R. Scopigno (eds), *The 6th International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST 2005)*, Pisa, 73-80.

WL and MS

The datasets which can be uploaded in the PLDviewer7.0.05 can be derived from a White Light (WL) PLD system or from a Multispectral (MS) PLD system. Both datasets will be visualized in the same interactive interface. As a consequence, not all provided tools in the viewer interface will be applicable with each type of dataset. The MS datasets allow the practice of more incorporated tools compared to WL datasets.

In general, for the WL datasets only one set of calculations was made; i.e. the one based on the set of acquired images all made with the white light LEDs. In the MS datasets the calculations of 5 different spectra are concealed: 'IR' or sometimes even shortened to 'I' (infrared), 'R' (red), 'G' (green), 'B' (Blue) and 'UV' or sometimes even shortened to 'U' (ultraviolet). As a consequence, the MS datasets are larger and handling them will be more demanding for a computer system.

Viewing and consulting

In advance: To consult a dataset, that can be done by 1. uploading a **compressed** (single-file) .cun- or .zun-file[4] or 2. by uploading the full (**uncompressed**) set of data.[5] With the first compressed datasets most of the developed interactions can be performed; only for generating reflection maps and histograms (see below), the second approach – an upload of the uncompressed datasets – is needed. For these two tools the original images (samples) must therefore be part of the uploaded dataset. The uncompressed dataset is much bigger (in includes all raw data) compared to the compressed datasets; the ratio for WL recordings can be 1:45-1:60, for MS recordings 1:15-1:20. To convert an uncompressed dataset into a compressed cun- of zun-file choose in PLDviewer7.0.05:

[4] To open/upload a zun- or cun-file in the desktop viewer interface: 'File/Load virtual object' or 'Ctrl+L'.
[5] To open a cfd-file, you must first determine where that data is to be found on/via your computer system: 'File/Select data directory' and choose the folder in which the cfd-file and subfolder with all the other information on that item is stored, that file and that subfolder will have the same name. The data directory which has been selected can be seen in Fig. 1: frame 1 in this manual. Finally, to upload the uncompressed dataset via a cfd-file in the desktop viewer interface: 'File/Load digitized object' or 'Ctrl+A'.

'File/Save virtual object' (=.cun) or 'File/Save web object' (=.zun). A zun-file is slightly larger than a cun-file.

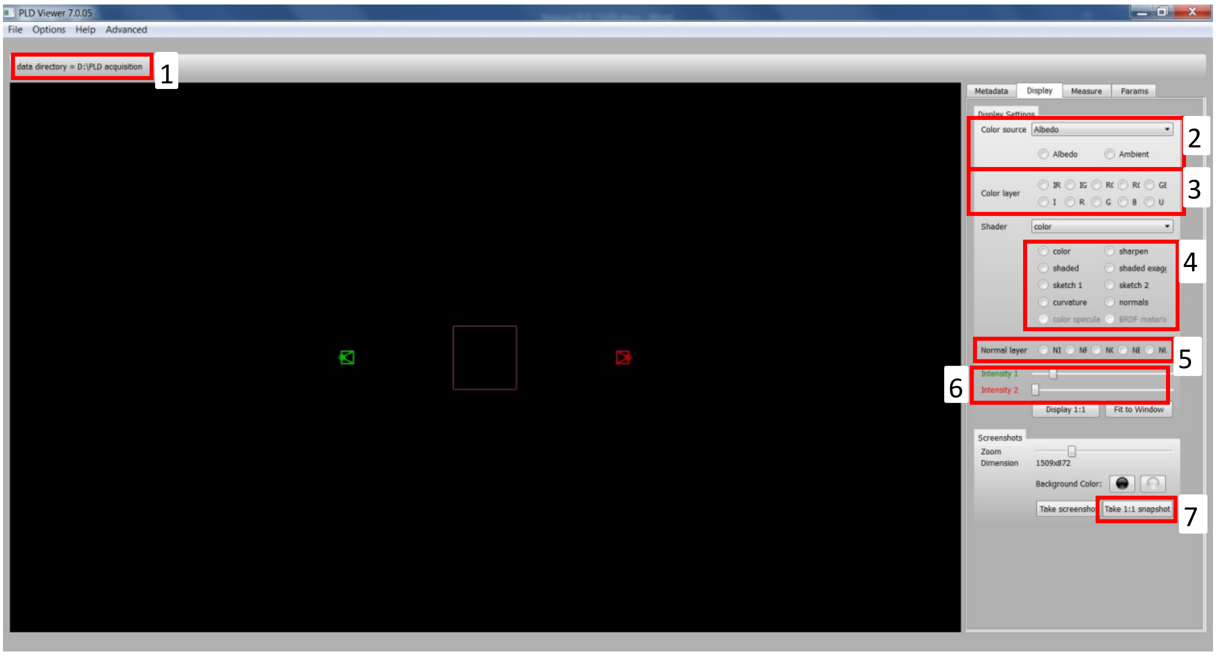


Fig. 1 - The viewing interface when opened, before uploading a dataset

<u>Standard viewing controls</u>

Tip: To consult/view a result in the most comfortable manner it is wise to use an external mouse with a scroll-wheel. It will allow easy and precise manipulations.

Under 'Help/Controls' all the important viewing controls to be used with the help of the mouse and keyboard are being listed: For each recorded face it can be turned 90 by 90 degrees (shift+scroll); one can pan over the surface (shift+left button mouse); zoom (scroll) and virtually relight. The relighting can be performed with the help of two virtual light sources: colored green and red; the intensity of both light sources can be changed with two (again green and red) slide bars (see Fig. 1: frame 6). By clicking the left button on the mouse the green and red icons of the two virtual light sources can be dragged all over the viewing zone. By doing so, the angle of these light sources towards the surface change accordingly (=virtual relighting).

<u>Multiple recorded views within one dataset</u>

In most cases, especially for flat media, a PLD dataset conceals the recording of only one face (one viewpoint); differentiation between a front and back view is made by producing two datasets, in which the file name clarifies which face/side/view of the item it conceals. However, for full 3D objects and to allow a facilitated, more fluent, consultation of that 3D character up to 6 views can be included in one and the same dataset (that is an action which has been made during the recording phase). In case of such a dataset, in the PLDviewer all the recorded views will be visualized (i.e. 5+1) at once; the one which is activated[6] in the viewing zone is framed with a thin red quadrilateral. To switch between activated views, use the arrow-keys.

Viewing Tools and Functions

- An uploaded item (dataset) can be viewed with different '**Color sources**' (see Fig. 1: frame 2); this defines the general conditions in which the recorded surface in the viewer interface will be illuminated. In PLDviewer7.0.05 two color sources are incorporated: Albedo and Ambient. The albedo gives the diffuse reflection of the surface only, whereas ambient lighting illuminates the surface as if it lays in an actual room, wherein the available light (independent from the by the PLD system managed and directed light sources) plays it role as well in the illumination of the surface. In most cases, the ambient color source will represent the surface more like how it appears to the human eye. Both the WL and MS datasets can be viewed with those color sources.
- The '**Color layers**' (see Fig. 1: frame 3) have been specifically developed for the MS datasets. They allow to consult the results with the separately computed information from the different spectral bands, that is the reflective data. In row 1. five different false colors can be generated, as the three color channels are being combined across the information of the five spectral bands; from left to right: IRG (IR-Red-Green); IGB (IR-Green-Blue); RGB (i.e. resemble a normal visual representation); RGU (Red-Green-UV); GBU (Green-Blue-UV). In row 2. the reflective data of the five bands can be visualized separately.
- All of the WL and MS datasets can be visualized with the help of various '**Shaders**' (see Fig. 1: frame 4).[7] The standard setting is a visualization in RGB (see above *color layers*), with the color source (also see above) Albedo and with the 'color' shader activated. When the different shaders are activated, the function of the slide bars – as highlighted in Fig. 1: frame 6 – change as well (no longer for both the function will be intensity, as what is the standard setting for the color shader).
- Specifically developed and only useful for the MS datasets are the '**Normal layers**'(see Fig. 1: frame 5). The geometrical data derived from the MS recordings is stored in the (un)compressed datasets in five (in concordance to the 5 applied spectral bands) separately computed normal maps. Via 'normal layers' these five results in IR, R, G, B & UV can be activated. In combination with the shaders that will each time influence the results. Remark: the normal map based on the IR sub-dataset will represent an estimation of the surface's geometry deeper into the surface compared to the normal maps based on the datasets which have used spectral bands with shorter waves, so towards blue and ultraviolet.

Saving a view

At any moment during the viewing process with the various color, shader and normal tools a full quality screenshot of what is seen in the viewing zone can be generated. To do so, click the 'Take 1:1 snapshot' button (see Fig. 1: frame 7). In a pop-up save as… window the location and file name for a

[6] Virtual relighting and the 'Take 1:1 snapshot' only apply on the activated view. The tools 'color source', 'color layer', 'shaders', 'normal layers' and the analytic calculations/measurements, when activated, are applied on all the views at once.

[7] The bottom two shaders "color specular" and "BRDF materials" are two tools which have not yet been activated in the public version of PLDviewer7.0.05; they are displayed in grey.

new to generate png, tiff or jpeg file can be chosen (if no file extension is typed out the file will be written as .png)

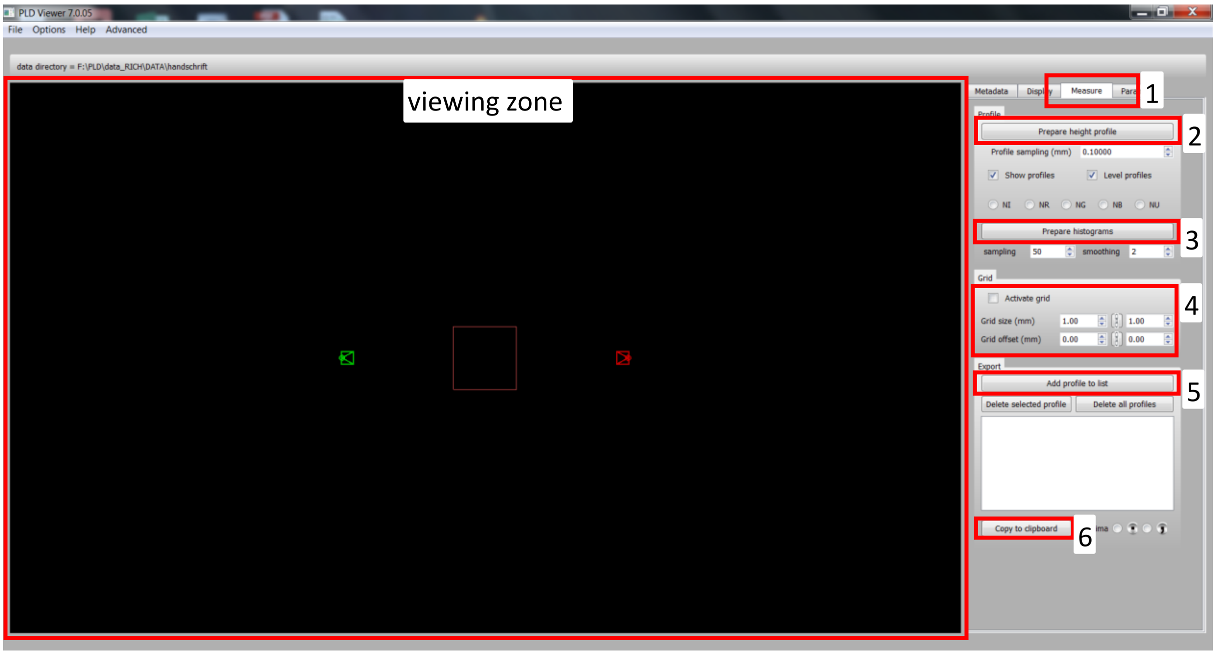
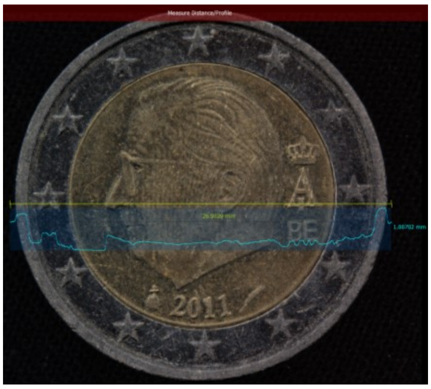


Fig. 2 - The viewing interface when opened, before uploading a dataset, with the Measure tab open

Analyzing

- Measuring



To use the measure tool only the desktop viewer, such as the PLD viewer7.0.05 interface, can be used. It can be generated with both the compressed (zun/cun) as with the uncompressed (cfd) datasets. Go to the 'measure' tab (see Fig. 2: frame 1) and click 'Prepare height profile' (see Fig. 2: frame 2, this information will now be calculated in the background, it will take some time).[8] Now toggle M on the keyboard to activate the 'Measure Distance/Profile' tool in the viewing zone. By dragging lines on the surface the geometric information across that line is plotted.

Below the 'Prepare height profile' button in the Measure tab the sampling per mm of the profile can be adjusted; and the profile can be leveled horizontally. The latter can be very helpful to facilitate a trustful appearance of the actual profile. When not activated, and the surface was not perfectly leveled before acquisition (which it almost never is), it might give a distorted representation.

[8] The same tool can be activated via 'Advanced/Prepare height profiles'.

- In one and the same viewing zone <u>multiple measurements</u> can be generated. When a line is dragged and a profile is plotted in the viewing zone, add the measurement to the export-list; to do so click on the 'Add profile to list' (see Fig. 2: frame 5). Now multiple extra profiles can be generated with the Measure Distance/Profile tool by repeating this action. At any moment these profile lines can be <u>exported</u> by clicking 'Copy to clipboard' (see Fig. 2: frame 6), these chart line coordinates can thereafter for example be pasted into a txt-file and uploaded into excel or any other software package to generate charts.

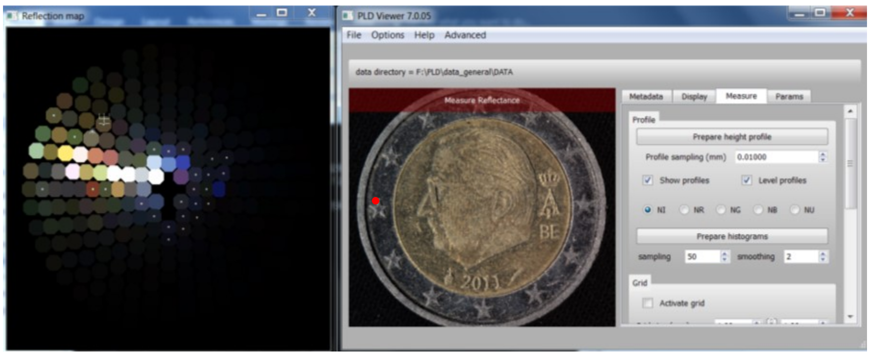
- It is also possible to add a <u>grid</u> on top of the viewing zone. Activate the grid in the measure tap under 'Grid' (see Fig. 2: frame 4), it will only work when the Measure Distance/Profile tool (shortcut 'M' on the keyboard) is active. This can be used throughout every color, shader and normal map modus. When the grid is activated, the lines dragged in the Measure Distance/Profile tool will jump from one grid junction to the other. This 'Grid size' and 'Grid offset' can be changed as is pleased (see Fig. 2: frame 4).

- Reflectance Maps

The tool 'Measure Reflectance' is a first step incorporated in the PLDviewer7.0.05 interface to allow BRDF (Bidirectional Reflectance Distribution Function) analysis; it is still under development but a first output in that direction has nevertheless already been added to this version of the PLD viewer. This tool only works with the uncompressed datasets, so only when the data is uploaded via a cfd-file.

The visual output of this tool will differ across the types of datasets (WL or MS), but will also depend on with which PLD acquisition dome the surface was recorded (one with 228 or 260 LEDs). In the visual output the intensity of the reflectance triggered by the emitted light per LED (so from that direction) for one particular tapped pixel will be given in what was labeled a reflection map.

To generate such a local reflection map go to 'Advanced/Prepare bRDF view RGB' (for a WL dataset) or 'Advanced/Prepare bRDF view Multispectral' (for a MS dataset). A new pop-up window will now be available; resize the window of the viewer interface to make both windows visible.



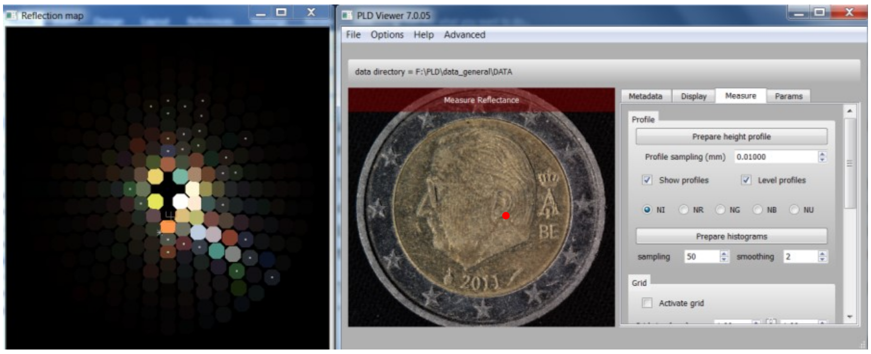


Fig. 4 - 2 pixels (red dots for their position on the coin) and their reflection map, result with a WL 260 LED dataset

Next, activate the 'Measure Reflectance' tool in the viewing zone by toggling 'B' on the keyboard. Tap any pixel on the recorded surface, and for that pixel a reflection map will be generated in the pop-up window. For the WL visualization the variations in the reflectance percentage is translated in the intensity of a RGB sensitive pallet of colors (see above). In the MS visualization the five spectral bands are translated in five corresponding visual colors (IR=dark red, R=red, G=green, B=blue, UV=dark blue); the variations in the reflectance percentage is translated in the intensity of these colors (see below). For both, the distribution pattern of the lights in these reflection maps also reveal information on the geometry of the surface at the specific tapped pixel.

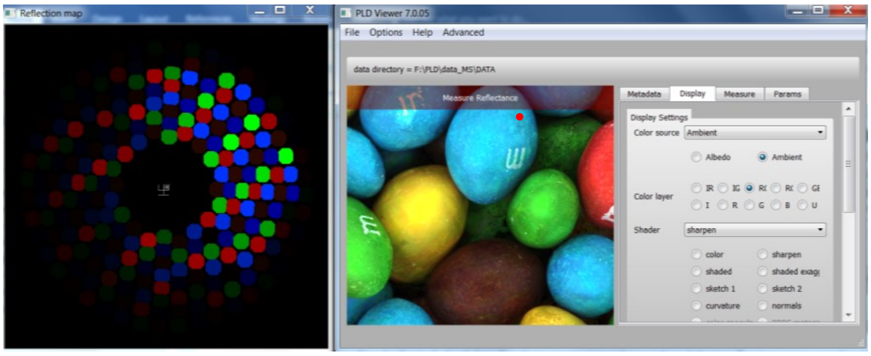


Fig. 5 - 1 pixel (red dot for its position on the M&Ms) and its reflection map, result with a MS 228 LED dataset

- Histograms

For both the WL (RGB) and MS (IR-R-G-B-UV) datasets the spectral information can also be visualized by a manner of histograms. This tool only works with the uncompressed datasets, so only when the data is uploaded via a cfd-file. A generated histogram shows the distribution of the calculated albedo responses for each of the spectral bands.

To generate a histogram go to the 'measure' tab and click 'Prepare histograms' (see Fig. 2: frame 3); now, in the background, the system calculates the needed information to fuel this tool. Toggle 'H' on your keyboard to activate the 'Measure Histograms' tool in the viewing zone. By dragging a rectangular zone with the mouse (left click) on the imaged surface a histogram for that zone or pigment will be plotted. Use the + or - keys on your keyboard to change the size of the histogram plot-area (standard that area is small); toggle 4 (←) or 5 (→) and 8(↑)or 2 (↓) to spread out the curves of the histogram over the plot-area.

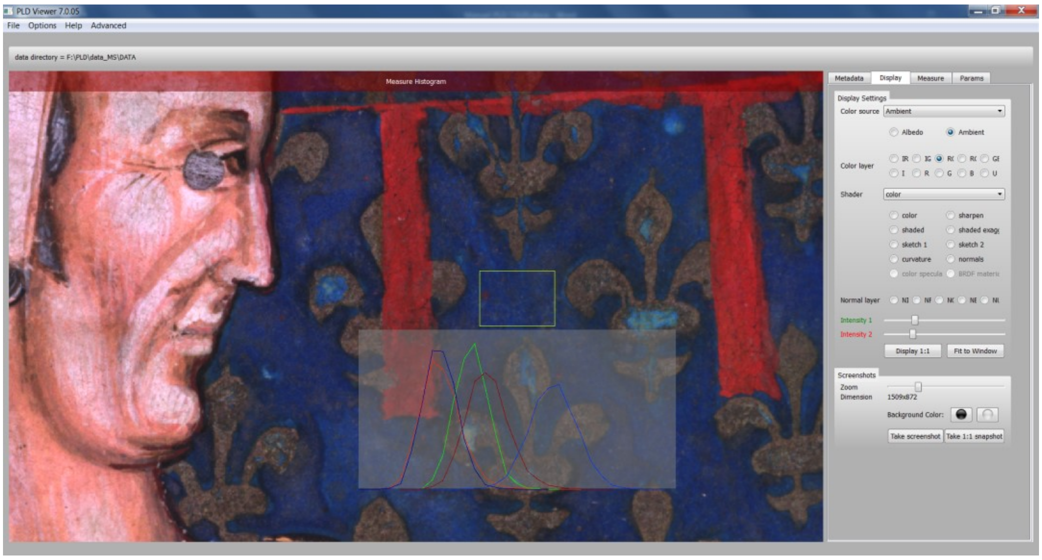


Fig. 5 – Example of a generated histogram on a detail of an illuminated manuscript

To interpret the histograms, the albedo response is given by the x-axis, while the y-axis gives the probability distribution for each of the spectral components for the given area. The more the different bands are being plotted to the right, the higher their reflective response was for the selected area. Two settings can be changed: the 'sampling' and 'smoothing' of the curves; the standard settings for these are 50 and 2 respectively.

3D models

To generate 3D models of the imaged surfaces go to 'Options/Create 3D Models' (this option will generate a 3D model, a ply-file, based on the information in the dataset). In a pop-up window the location where to save the 3D model will be given. Be aware, in that folder a 3D model of each of the recorded views incorporated in the dataset will be generated (in most cases that is only one, but that can be up to six).

Note: With a MS dataset the 3D information will be derived from the IR normal map. In PLDviewer7.0.05 it is not yet possible to select another normal map to generate these 3D models.

When the WL or MS PLD are equipped with a high resolution light sensor (camera), this 3D model will be extremely detailed, and consequently 'heavy' for your computer system. In that case consider first sampling (see below) the PLD dataset.

These 3D ply-files can be consulted by most 3D viewers, including many free solutions such as blender, meshlab, …

Sampling

If your system is unable to handle the (too) large datasets, open the original (uncompressed) dataset of the imaged item and downsample it (i.e. reduce the number of pixels). This can be done in the desktop viewer interface (cf. PLDviewer7.0.05).

- First determine the location of the cfd-file and subfolder with the original pictures (see above Viewing and Consulting).
- Now downsample by: 'File/Misc/Load and subsample digitized object', select the imaged item of interest, i.e. its cfd-file, and determine in a small pop-up window according to which factor the item should be downsampled, '2' or '3' should suffice.
- Save this downsampled result: "File/save as…", and choose an appropriate name. It is wise to include the downsample factor in this file name.

Bugs

1. Some of the real-time calculations can be very demanding for your system, especially when successive uploads within one session are performed, the system gets overloaded and the software crashes when particular actions are made. In those cases, restart the software and perform the required action immediately (so before other secondary actions). Likewise, it might be an option to reboot your computer.
2. When particular actions seems impossible to perform, the dataset might just be too demanding for your system. Remark that many of the PLD recordings were made with a 30 million pixel camera; especially when combined with MS recordings; those datasets can be very big. In those cases, you should downsample your dataset, see above *sampling*.
3. When 3D models are being generated (i.e. a demanding action for the software and your system) it is best to perform that action at the start of the consultation, so immediately after the upload, before any other handling. Otherwise, it is a known issue in PLDviewer7.0.05, the texture/color will not be generated correctly in the provided 3D model.