Spectraloc Operations Guide rev. 2

Frequently asked questions

How do I start Spectraloc program? Double-click Spectraloc.exe in the Sepctraloc directory or launch Spectraloc.app from Finder→Applications in the Mac version. This will open Spectraloc with the graphical workspace in which all light creation and control operations are performed and where data is presented.

How do I close Spectraloc? Click on the “close program” icon in Spectraloc.

Where are the luminaire characterization files located? The files are in `./gui/data/luminaire_char/`. When the user receives a new luminaire from Telelumen, the associated characterization file will have to be placed into this directory.

Why can’t I connect to the luminaires? Check that your computer and the luminaires are on the same network. For example, your luminaires may be physically connected to a router while your computer may be on a company network. If your computer is on the same network as the luminaires, and you still cannot connect, power-cycle the luminaires and the router, restart Spectraloc and click discover again.

Why did the match fail? There are several reasons for a failure. Target luminous output may be higher than the highest level the luminaire is capable of, for a given target spectral distribution. It is also possible that one or more channels have reached maximum output to make the requested spectrum, and a higher output level is not possible without sacrificing color fidelity. Alternatively, target luminous output may be so low that the luminaire cannot match the target due to finite resolution of the very low drive levels. Finally, color coordinates of the target may be at the boundary or outside of the gamut available to the luminaire. Luminous output of the target may be modified by using *Target Luminous Output* increment control in *Target Illumination* widget (see Fig. 1). When the match fails a diagnostic message appears in the status bar.

Why are the controls grayed out and disabled? Whenever the currently selected luminaire is playing a lumenscript, the software is in “play state”. Most controls are not accessible in this state; drive levels, plots and metrics are not displayed. In order to resume control of the luminaire, edit lumenscripts, or change group assignment, the user should switch to “default state” by pausing or stopping the player in *Play Lumenscripts* widget. On discovery, all luminaires are in the default state.

Glossary

Frame	A target spectral power distribution and duration that a luminaire should match. A sequence of (frame, duration) pairs may be arranged to create a lumenscript
Luminaire channel	An independently addressable group of LEDs having a particular spectral power distribution. There are 24 color channels in a Dittosizer luminaire.
Luminaire characterization file	A luminaire-specific JSON file containing measured light emission data for each channel
Channel drive level	LED output scaled from 0 to 1
Lumenscript	A sequence of frames which can be loaded, edited in the frame buffer, and saved to a lumenscript source file (LSS)
Frame buffer	The working area in memory used to create and edit sequences of frames. Lumenscript LSS files are created in and saved to and from the frame buffer
Lumenscript source file (LSS)	A human-readable file that stores lumenscripts
Lumenscript object file (LSO)	A binary luminaire-specific file that contains a compiled lumenscript in a format the luminaire can use directly
Compiling a lumenscript	The process of calculating luminaire channel drive levels for each frame of the lumenscript, for a specific luminaire, and writing the result to an LSO file suitable for playing on a luminaire
Palette	A specific set of test color samples
Palette matching	Finding channel drive levels to match the palette appearance under the target light
Play state	The program is in play state when the currently selected luminaire is playing a lumenscript object file (LSO). Most controls are not accessible; plots and metrics are not displayed. The selected luminaire needs to be paused or stopped in order to exit this state
Spectrum matching	Calculating channel drive levels to approximate the spectral power distribution of the target light. Depending on luminaire type, several match modes may be available: (1) “spectrum” mode for the best approximation of the target spectral power distribution in the RMS sense, (2) “color-corrected spectrum” for the best match to target spectral power distribution under the constraint that the tristimulus values of the approximated spectrum must equal those of the target, and (3) “palette” for the best match to appearance of a given palette under target light, with tristimulus values of the approximated spectrum equal those of the target. Each match mode has an associated configuration file which defines wavelength ranges of participating channels and match criteria.

Spectraloc layout

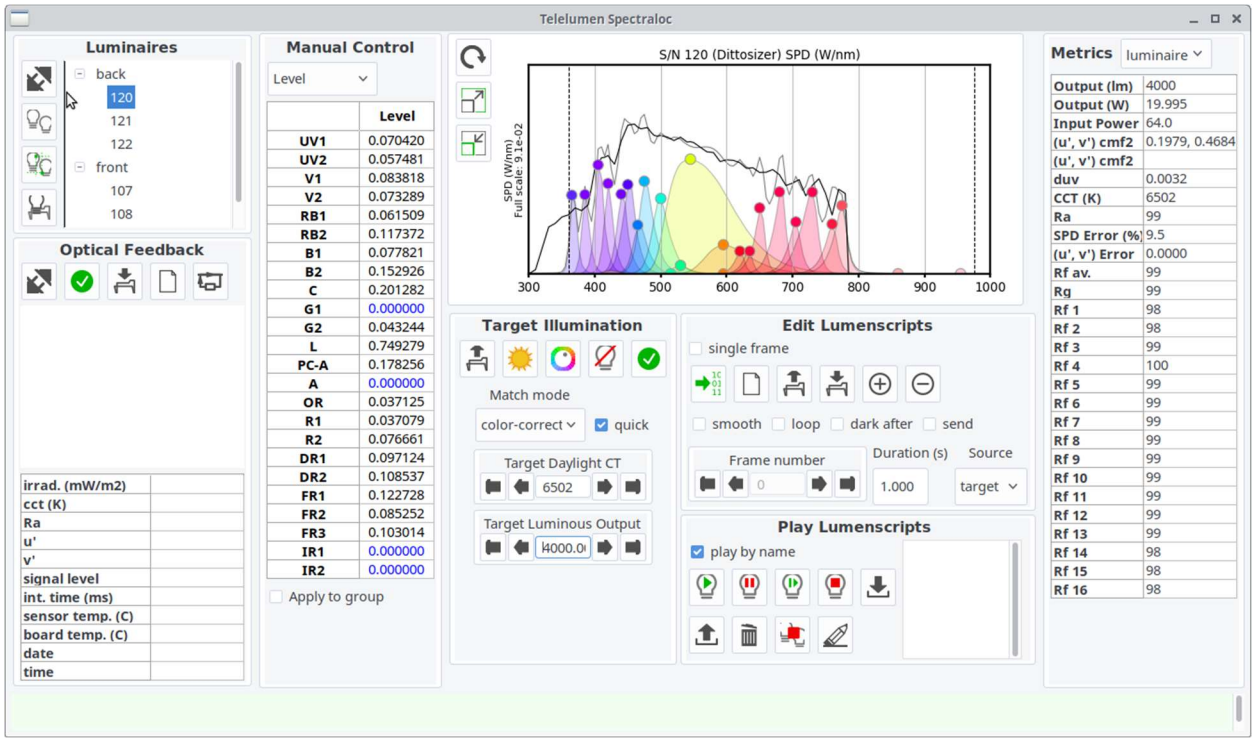

Figure 1. Spectraloc widgets

Controls, indicators and graphic elements

The following are definitions of icon controls grouped by widget (see figure 1)

Icon	*Tool tip*	*Description*
Luminaires Widget		
	connect	Discover and connect to all luminaires on the network
	group	Open a dialog to group luminaires
	ungroup	Open a dialog to ungroup luminaires
	open luminaire from file	Open a luminaire in emulated mode
Play Lumenscripts Widget		
	play	Play the lumenscript on the luminaire selected in *Luminaires* widget. The lumenscript will play on the selected luminaire and all luminaire it is grouped with, if any
	pause	Pause the lumenscript
	resume	Resume the paused lumenscript
	stop	Stop playing the lumenscript. The selected luminaire and all luminaires grouped with the selected luminaire (if any) will go dark
	save	Download an LSO file from the selected luminaire
	load	Upload an LSO file to the selected luminaire and to all luminaires grouped with the selected luminaire (if any)
	delete LSO from luminaire	Delete an LSO file from the selected luminaire and from all luminaires grouped with the selected luminaire (if any)
	stop all luminaires on network	Stop all luminaires on the network
		Format (erase all scripts from) the selected single luminaire

Edit Lumenscripts Widget		
	create a new lumenscript source file	Create a new lumenscript. This erases any frames in the current frame buffer and sets current frame number to zero
	load lumenscript source file	Load a lumenscript from an LSS file into the frame buffer
	save lumenscript source to file	Save the frame buffer into a lumenscript LSS file
	compile lumenscript source	Compile a lumenscript from the last saved LSS file to create LSO for the selected luminaire and for all luminaires grouped with the selected luminaire (if any), and (optionally) upload LSO files to respective luminaires
	insert a frame at current index	Insert a frame at index displayed in frame number control
	delete current frame	Delete a frame at index displayed in frame number control
Target Illumination Widget		
	load target spectrum	Load target spectral power distribution and match the output of the selected luminaire and all luminaires grouped with the selected luminaire to this target
	create thermal or daylight target	Match the output of the selected luminaire and all luminaires grouped with the selected luminaire to a thermal or daylight target
	create chromaticity target	Match the output of the selected luminaire and all luminaires grouped with the selected luminaire to a regularized target specified by luminous output and chromaticity
	turn off selected luminaire	Turn off the selected luminaire and all luminaires grouped with the selected luminaire (if any)
	match to target	Re-match the output of the selected luminaire and all luminaires grouped with the selected luminaire (if any) to target
Graphics Widget		

	increase vertical scale resolution	Expand the vertical scale of spectral power distribution plot
	decrease vertical scale resolution	Shrink the vertical scale of spectral power distribution plot
	Next plot type	Plot selector: display SPD plot, CIE (u', v') diagram or color vector graphic
(Optional) Optical Feedback		
	connect to spectrometer	Connect to GL Spectis 1.0 Touch spectrometer
	measure spectrum	Measure and display spectrum and metrics
	save measured spectrum	Saved measured spectrum as a tab-delimited file
	initialize / reset feedback	Re-initialize optical feedback after output change by the user (for example, after matching a new target)
	do one iteration of optical feedback	Measure the spectrum, compare to target, and adjust luminaire drive levels to reduce the discrepancy in color coordinates, if any

Luminaires Widget

This widget is used for discovering luminaires on the network, grouping and ungrouping luminaires, loading characterization data for model luminaires that are not present on the network and selecting a luminaire for display of its current output characteristics in tables and graphs.

Play Lumenscripts Widget

This widget is used for uploading lumenscripts to or deleting lumenscripts from the luminaire file system, selecting a lumenscript from the playlist; playing, stopping, pausing, and resuming the selected lumenscript. Note that actions *play*, *pause*, *resume*, *stop*, *upload LSO to luminaire*, and *delete the currently selected lumenscript from the luminaire* apply to all luminaires grouped with the currently selected luminaire; while actions *download LSO from luminaire* and *format luminaire drive* applies only to the currently selected luminaire, and action *stop all luminaires on network* applies to all luminaires on the network regardless of grouping.

Edit Lumenscripts Widget

This widget is used to create, edit, load, browse, save lumenscripts, and perform a variety of related support tasks such as creating and transferring native binary-format LSO script content to and from luminaires. The widget uses a frame buffer to act as the "assembly area" where scripts are built.

Target Illumination Widget

Target Illumination widget is used for configuring a selected luminaire (or a group of luminaires if the selected luminaire belongs to a group) to match a given target.

Metrics Widget

Various characteristics of the target light and the light synthesized by the luminaire selected in *Luminaires Widget* are displayed in this widget. For example, in figure 1, the selected luminaire is S/N 120. It is grouped with luminaires 121 and 122.

Characteristics shown in the table are defined as follows:

	Target	**Selected luminaire**
Output (lm)	Luminous output	
Output (W)	Radiant output	
Input Power (W)		Estimate of the input electrical power consumed by the luminaire
(u', v') cmf<X>	Coordinates of the spectrum in the color space selected by the user. The color matching functions are specified in `./gui/spectraloc.yaml` and defined in `./common/config.json`	
(u', v') cmf2	Coordinates in CIE 1976 space	
duv	Distance from Planckian locus	
CCT (K)	Correlated color temperature	
Ra	CRI average index	
SPD Error (%)		RMS difference between target and luminaire spectra divided by target radiant output. The wavelength range for this calculation is from left edge (half-maximum) of the shortest wavelength channel to the right edge of the longest wavelength channel (indicated by dashed vertical lines in SPD plot
(u',v') Error		Color mismatch: the difference between target and luminaire spectra in (u', v') color space

Rf av	Average IES TM-30-15 color fidelity index
Rg	IES TM-30-15 gamut index
Rf1 through Rf16	Partial IES TM-30-15 color fidelity indices

Graphics Widget

When interactive spectral power distribution plot is displayed, this widget is used for viewing the spectral power distribution currently outputted by the selected luminaire, and for graphically editing channel outputs. The target spectrum, if assigned, is shown by black line. Gray line is a sum of spectra of individual channels. Colored circles shown at spectral peaks can be used to change outputs of individual channels by clicking the circle, moving the mouse up or down, and unclicking. Channel output will change, and the corresponding drive level value in the *Manual Control Widget* will be updated accordingly.

If a channel is operated at the maximum drive level, its spectral power distribution will be shown in red.

Icons  and  are used to shrink and expand the vertical scale of the spectral power distribution plot. Icon  is used to select the plot displayed in this widget: the interactive spectral power distribution plot, the interactive CIE (u', v') diagram, and the non-interactive color vector graphic.

All plots display graphical representations of the output of currently selected luminaire. When spectral power distribution plot is displayed, this widget controls the currently selected luminaire only. It does not modify the output of any other luminaires that may be grouped with the currently selected one.

When the interactive CIE (u', v') diagram is displayed, a user may click the luminaire gamut area to change the color coordinates of the luminaire spectrum. This action applies to all luminaires grouped with the currently selected one. Note that chromaticities close to the gamut boundary may not be accessible at large target luminous output values, since only a few channels are participating.

Manual Control Widget

Manual control widget controls the currently selected luminaire only, unless "Apply to group" checkbox is checked. In the latter case, this widget also modifies the output of luminaires grouped with the selected one.

This widget is used for editing channel drive levels or radiant outputs, or viewing peak wavelengths. The values displayed in the table alternate between normalized drive levels (0 to 1), radiant outputs (in W) or peak wavelengths (in nm) in response to user selection in the drop-down list (Level / Rad. Out / Peak).

A drive level is displayed in blue if it is below the lowest drive level for which characterization data exists; channel luminous outputs at such levels are extrapolated from the measurement at the lowest drive level. Note that in the low range of drive levels, the level output by a luminaire may differ from that entered by a user due to finite bit resolution of PWM modulation.

Maximum drive level is displayed in red to indicate maximum output.

Optical Feedback Widget (Optional)

This widget works with GL Spectis 1.0 Touch spectrometer by GL Optic ®. Spectis IP address of the spectrometer should be set in user configuration file `./gui/spectraloc.yaml` before Spectraloc is started. To connect, click “connect to spectrometer” icon . Once the connection is established, the user can measure the spectrum in auto integration time mode by clicking . When the measurement is completed, the plot and the table of metrics in the widget will be updated. The measured spectrum in tab-delimited format can be saved by clicking “save measured spectrum” icon . The radiant output of the saved SPD will be set to 1W, and the spectrum will be saved in `./gui/data/targets`; the measurement timestamp will be used as file name. The measured spectrum can be then loaded as a target for the luminaire (see *Target Illumination widget*).

If the measured color coordinates of the matched luminaire output deviates from the target – due to high operating temperature, or to presence of background light – the optical feedback functionality can be used to minimize the mismatch. The feedback functionality has to be initialized by clicking first, *and reinitialized every time the luminaire drive levels are changed manually by the user or by a new match*. On initialization, the feedback widget notes the luminaire drive levels and compares the measured output spectrum to the output spectrum expected from the characterization data. On iterating the feedback, the channel drive levels are adjusted to minimize the difference in color coordinates between the measured and the expected output.

To run one iteration of optical feedback, click “do one iteration of optical feedback” icon . Drive levels of the luminaire will be adjusted to bring the measured spectrum closer to the target, and the plot and the table of metrics in this widget will be updated. Note that the metrics and graphs that relate to luminaire output in other widgets are calculated from the luminaire characterization file, and they may not agree with those displayed in this widget.

The feedback functionality works well with smooth targets, such as warm white 2800K, D65, etc., but may not work well with peaky targets like RGB white.

The serial number of the “active” luminaire that is being controlled by optical feedback is set in `./gui/spectraloc.yaml` under OpticalFeedback/Active. The spectrometer should be on the same network with the luminaire; its IP address should agree with the value in the YAML file under Spectis/Address.

Status Bar

Status bar is used by the application for displaying errors, notifications, and tool tips.

Discovering and grouping luminaires

Clicking icon in the *Luminaires Widget* starts the luminaire discovery process. Characterization files corresponding to the discovered units will be loaded automatically upon discovery for each luminaire from `./gui/data/luminaire_char` directory; the progress of adding luminaires will be shown in the log window. If the characterization file with the CPU ID matching that of a discovered luminaire is not in `luminaire_char`, the corresponding luminaire will not be added to the list. Characterization files are in JSON format.

On discovery, the luminaires are paused if they were playing a lumenscript, and are put in default state. When the currently selected luminaire is in default state, all tables and graphs display the data that is current for the selected luminaire.

When the currently selected luminaire is playing a script (is in play state) *Play Lumenscript Widget* is enabled while other widgets are disabled. In order to control luminaires, edit lumenscripts, or change group assignment,

the user should exit play state by clicking the bottom right icon  , which stops all luminaires on the network that are playing a script, so that they can all be controlled. Alternatively, a selected luminaire – along with all other luminaires that may be grouped with the selected luminaire – can be paused by clicking the pause icon  , or stopped by clicking icon  . This will enable all widgets that are disabled in play state.

Luminaires can be grouped and ungrouped by clicking icons  and  which will open grouping and ungrouping dialogs. Groups can be created and deleted, but not edited. For example, in order to reassign a grouped luminaire to a different group, the existing group will have to first be disbanded, and a new group will have to be created. On discovery, all discovered luminaires are added to "main" group.

The software can be operated in emulation mode by opening characterization files from `luminaire_char` directory by clicking the icon  in *Luminaires Widget*. Whenever an emulated luminaire is selected in the *Luminaires Widget*, the *Play Lumenscript Widget* is disabled. Emulated and live luminaires cannot be grouped together.

Editing frames

There are several methods of creating a frame:

1. Assign a target spectrum to a frame

2. Match to target, or manually change drive levels and assign the spectrum of the selected luminaire to a frame. For example, one could manually adjust drive levels, freeze some channels at their present drive levels, rematch to the target spectrum, and assign the spectrum of the selected luminaire to a frame

3. Load a previously defined frame

In all cases frame duration should be set by entering the number of seconds into “Duration (s)” control.
The resolution is 0.001 second increments (1 ms).

Choosing the match mode

Depending on the luminaire type, the match mode may be toggled between *palette*, *color-corrected spectrum*, and (RMS error minimizing) *spectrum* mode, by making a selection in drop-down list “Match mode”. In *palette* and *color-corrected spectrum* modes, the color coordinates and the lumen value of the luminaire output spectrum are constrained to those of the target, within the allowed tolerance.

Only those match modes are presented that make sense for the type of the selected luminaire. For example, *fluorescent palette* match mode is not applicable to a luminaire that does not have any spectral content in the UV. As another example, *color-corrected spectrum* mode does not make sense for a luminaire composed of IR channels only.

In *spectrum* and *color-corrected spectrum* modes the optimization program minimizes the RMS deviation of the luminaire output spectrum from the target spectrum.

In *palette match* modes the optimization program will minimize the differences in appearance of reference samples comprising the palette, under the target and under luminaire illumination. In *fluorescent palette* match mode, both reflectance and fluorescence of color samples are included in optimization. See the Glossary section for definition of terms.

The *spectrum* mode may be used when spectral shape fidelity is important; for most applications in illumination, *palette* and *color-corrected spectrum* modes are used.

To rerun optimization on changing the match mode or modifying drive levels the user should click the “rematch” icon.

Each match mode has an associated configuration file which defines wavelength ranges of participating channels and match criteria; see in `./cms/solver_configs`.

Setting the target spectrum

1. Target spectrum may be loaded from a tab-delimited file containing two columns: wavelength in nm and spectral power distribution in W/nm by clicking icon in the *Target Illumination* widget. Spectral power distribution files in Konica-Minolta ® CAS ISD format are also accepted. Example spectrum target files may be found in `./gui/data/targets`.

2. Alternatively, a white light target can be created by clicking icon, which will open a dialog window for the user to enter the color temperature, luminous output, and indicate whether a thermal or daylight target is desired.

3. A target can be created by clicking chromaticity control icon, which will open a dialog window for the user to enter the color coordinates and luminous output. The checkbox labeled “xy” can be used to toggle between CIE 1931 (x, y) and CIE 1976 (u’, v’) color spaces. For a luminaire with more than 3 channels, matching a target specified by just 3 parameters – chromaticity and luminous output – is an underdefined optimization problem. We regularize this by requiring the output illumination to approach the daylight spectrum, as the target chromaticity approaches the daylight locus.

4. The target defined by color coordinates as described above can be also set by clicking a point in color space diagram. Using , select CIE 1976 (u’, v’) diagram, and click any point within the selected luminaire gamut shown by a polygon. Note that the match may fail if current luminous output is too high for the specified chromaticity, or if the clicked target is too close to the gamut boundary (the latter is not constant and may change with the values of channel drive levels).

Luminaire output may be modified by using increment control labeled “Target <Daylight | Thermal> CT” and “Target Luminous Output”. Color temperature control sets target to thermal or daylight spectrum with a given color temperature. Toggle between thermal and daylight modes by clicking the CT increment control label.

On loading or creating a target spectrum, the luminaire will automatically attempt to match its output to target. If match to target fails due to, for example, target color coordinate falling outside the gamut of the luminaire, or target luminous output being too high, the error message will be displayed in the status bar, and the channel drive levels will not change from their values before the attempted match.

Freezing channel drive levels

A user may intentionally distort the match to a target spectrum, for example, by over-saturating the output with red content while keeping the color coordinates of the output fixed to those of the target. For example, create a daylight target by clicking and entering 6500K and 4000 lm in the fields of the pop-up dialog, and clicking the “Daylight” checkbox. The resulting spectrum will be shown by a black curve in the *Graphics widget*, and the optimal drive levels shown in the table of *Manual Control widget* (see Figure 1).

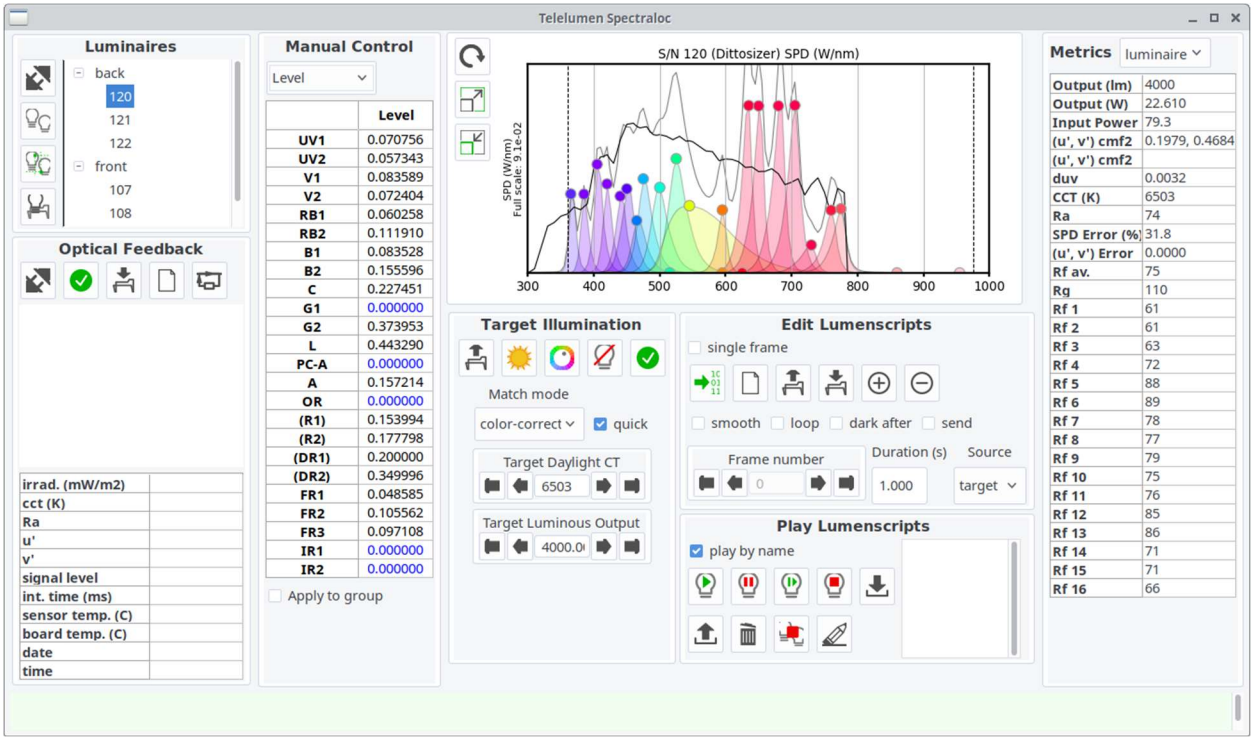

Figure 2. An example color-corrected spectrum match to D65 with channels R1, R2, DR1, and DR2 (red to deep red) intentionally frozen at higher output levels than the optimum for the D65 target.

Increase the drive levels of R1, R2, DR1, and DR2 channels and freeze the outputs of these four channels by clicking channel labels “R1”, “R2”, “DR1”, and “DR2” in the table. The parenthesis around the channel labels will indicate that these channels are frozen, and that their values cannot be changed until a user clicks the corresponding labels again to unfreeze them or resets the luminaire by clicking .

Now with four channels frozen at drive levels higher than the optimum for this target, re-run optimization by clicking . The new solution will be displayed as shown in Figure 2. Compare the new values in the table with those in Figure 1: the luminous output and color point (*u’*, *v’*) of this solution closely match those of the target, as they should, but TM-30 index Rf drops to 75 from 99, while the gamut index Rg increases from 99 to 110. The SPD error increases from 9.5% to 31.8%

Using increment controls

Target illumination for a group of luminaires may be modified by using color temperature increment control in *Target Illumination widget*: by either entering color temperature value in the box or using slow or fast increment (and) or decrement (and) icons. On color temperature change all luminaires in a group will be matched to thermal or daylight spectra having the color temperature entered and the current value of the light output. *Note that modifying the color temperature will force target spectrum change to thermal or daylight*, depending on the value of the clickable label of color temperature control. In other words, there is no mechanism for modifying color temperatures of other types of spectra, e.g., recordings of natural light.

Dimming action can be achieved by using the luminous output increment control in *Target Illumination widget*. Changing the luminous output target will apply to all luminaires in the group to which the currently selected luminaire belongs.

Creating lumenscripts

Theory

A frame is a particular illumination spectrum played back for a specified duration. For example, a frame is 1000 lumens of thermal radiation at 2700K that lasts 1.2 seconds. Frames can be joined together in a sequence to create dynamic content.

A lumenscript specifies the sequence of frames that you use to implement your design objective. Once defined, this scripted content can be played back over and over again.

Lumenscripts are built in the frame buffer, an area of memory where frames can be added, edited, deleted, and browsed until they appear in the desired sequence. You can save the frame buffer to a file as a lumenscript at any time using the "save lumenscript" icon.

Edit Lumenscripts widget is used to create or load these frames. Frames thus created can then be added one by one into the frame buffer with the "insert a frame" icon of the Edit Lumenscripts widget. Alternatively, an entire lumenscript can be loaded directly into the frame buffer with the "load lumenscript" icon.

The visual appearance of the illumination sequence can be evaluated by stepping through the frame buffer with the up and down arrow icons of the frame number control in *Edit Lumenscripts widget*.

Once you have created the desired sequence in the Edit Lumenscripts widget widget by inserting and deleting frames, you can save the frame buffer to a lumenscript LSS file using the "save lumenscript source to file" icon. Because the frame buffer doesn't persist when the program is terminated, saving your work periodically is good practice. Note that the lumenscript LSS file can be loaded back into the frame buffer at any time using the "load lumenscript" icon.

Once the desired sequence is saved to a lumenscript LSS file, it's possible to send this script to the selected luminaire or a group of luminaires by pressing the "compile" icon. Compiling takes the human-readable lumenscript LSS file and translates it to the native binary-format understood by Telelumen luminaires, with file extension LSO. Once a lumenscript has been compiled and sent to a luminaire, it is possible to preview the playback in real time by selecting the name of the lumenscript in the Lumenscript Player widget and clicking "play" .or double-clicking on the filename.

A special single-frame mode exists to roll all of the required actions into a single icon click in the simplified case where the target script is a single frame. More on these topics below.

Creating, loading, and saving lumenscript source files

The Edit Lumenscripts widget is used to create, edit, load, browse and save lumenscripts, and perform a variety of related support tasks such as creating and transferring native binary-format LSO script content to and from luminaires. This widget uses a frame buffer to act as the "assembly area" where scripts are built up frame-by-frame.

On start-up, the "single frame" mode is displayed, to simplify the common case of creating a script that is one frame of a fixed SPD and of infinite duration. In this simple case, a single frame is created or loaded in the Edit Lumenscripts widget, and the "compile" icon is pressed to accept that frame, save the script's SPD to a lumenscript LSS file, and send the binary format LSO file to the selected luminaire or group of luminaires for immediate playback.

For making a single static color temperature script, single frame mode is ideal.

When the “single frame” mode is unchecked, the full functionality of the Edit Lumenscripts widget is unlocked.

The current sequence in the frame buffer can be “browsed” at any time using the arrow keys to change current frame number, and when the finished sequence looks good, it can be saved to a lumenscript LSS file, and optionally “compiled” and sent to the luminaire or group of luminaires selected for immediate or later playback. Several “compiler flags” are available to set additional characteristics related to playback.

Because the frame buffer does not persist when the software is terminated or the computer is shut down, it’s wise to periodically save the frame buffer to a lumenscript file using the “save lumenscript” feature of the Edit Lumenscripts widget. The frame buffer can be saved to or loaded from a lumenscript LSS file using the “load lumenscript” or “save lumenscript” icons in the Edit Lumenscripts widget.

Detailed description

To start a fresh frame buffer, click to clear the frame buffer of any previous contents, and then either load an existing lumenscript that you wish to start as a baseline and modify, or start adding frames using the *Edit Lumenscripts widget*, the current frame number selection arrows, and the insert function. Of course, frames can also be deleted.

A grayed-out (empty) frame always follows the last frame of the lumenscript. The grayed-out number is equal to the total number of frames in the currently loaded lumenscript. By default, the last frame is duplicated to the frame just past the last frame, for continuity purposes. The fact that it is grayed out is the only indication that this frame is not currently in the frame buffer and is simply being displayed.

When the user clicks “Add frame” icon ⊕, a new frame is created at the selected index. When the user clicks “Delete frame” icon ⊖, the frame at the displayed index is deleted.

To visualize this more clearly, imagine the frame buffer as a series of frame “slots” numbered from 0 and arranged so frame 0 is on the left and the last frame is on the right.

A deletion shifts everything “left one slot” into the index slot and replaces the frame in the index slot with frame previously at the next index up. The total number of frames decreases by one.

Slots to the left of the deletion index, if any, are unaffected.

An insertion “pushes” everything rightward at and including the indexed slot, making room for the new frame. Frames to the left of the insertion point are unaffected. The total number of frames increase by one.

Deleting a frame

The ⊖ icon deletes the contents of the displayed frame number and moves higher numbered frames one slot leftward. If there are no higher-numbered frames, the current frame display will display a greyed-out box to indicate there is no longer any frame occupying this position.–When the last remaining frame is deleted, all frame numbers will display as greyed out to indicate there are no contents in any of the frame buffer slots.

Inserting a frame

The ⊕ icon adds the current frame at the frame index displayed in the Frame number box. The contents of frame previously occupying this slot and all higher numbered frames are shifted to the right.

The general strategy is to first select the position at which you wish to do an edit, then either delete or create and insert the frame. When an empty frame is selected, the previous output is unchanged, but the index displays as greyed out to indicate there is no frame in this location.

When adding a frame, note the “source” selection in the *Edit Lumenscripts widget*. The options are “target” and “luminaire”.

If “luminaire” is selected, the source of the new frame is the luminaire spectrum created by actual current drive levels as displayed. If “target” is selected, then the frame represents the best match to the requested target spectrum.

Make sure the status widget does not report a match failure before adding the spectrum to your lumenscript. Remember to save a lumenscript using the “Save lumenscript” icon prior to attempting to compile and send it to the luminaires. The compiler works off of the LSS lumenscript file, not the internal frame buffer.

Browsing the lumenscript

Increment (and) and decrement (and) controls of the frame browser allow the user to view the lumenscript frame by frame. The currently selected luminaire – along with the rest of the luminaires in the group, if the current luminaire is part of the group – will match its output to the spectrum stored in the frame. All colorimetric calculations, drive levels, and the graphics in *Spectral power distribution widget* will be updated to the current frame.

Choosing compiler options, compiling and uploading to luminaires

The current lumenscript should be saved before compilation by clicking the “save lumenscript” icon . The lumenscript will be stored in lumenscripts directory. The user can compile the lumenscript by clicking “Compile” icon E4.

Options represented by checkboxes in the *Edit Lumenscripts widget* should be selected before compiling the lumenscript. Select “smooth” to turn on smoothing between frames. Smoothing provides a linear interpolation between frames to prevent sudden changes in output illumination. Select “loop” to play the currently selected lumenscript continuously and repeat from the start, once its last frame has been played. Select “dark after” to play the dark frame on completion of the lumenscript (all channel outputs will go to zero at the end of script). If “dark after” is not selected, the lumenscript will continue playing the last frame indefinitely, which is appropriate for general lighting applications. Checkbox “send” should be selected in order to upload compiled lumenscripts to luminaires; otherwise an LSO will be created, but not uploaded to luminaires. If “send” is not selected, the player’s “load lumenscript” feature can be used to send the scripts manually later.

All the luminaires in the selected group receive a compiled luminaire-specific version of the current lumenscript. The user will be alerted to compilation errors in the status bar; detailed error log will be added to log window.

On compilation, luminaire-specific LSO files for each luminaire in the current group are stored in `./gui/data/lumenscripts/lso/<luminaire serial number>/<lumenscript name>.lso`, and the files are (optionally) uploaded to their respective luminaires. Once an LSO successfully uploads to all luminaires in the group, the lumenscript will start playing, and the user interface will go into play state.