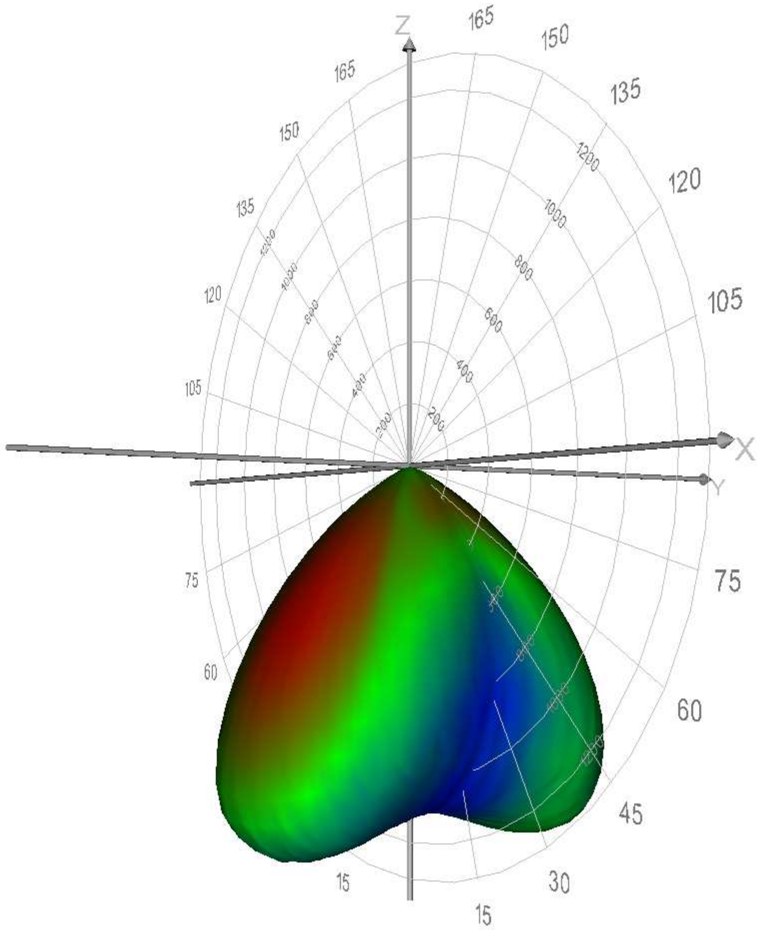
LID – Match
Operating manual

Software designed for LID comparison



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Contents

1. Fundamentals

1.1. General

The ‚LID-Match‘ software has been designed for the numerical just as the visual comparison of Luminous intensity distributions (LID). The results of comparison allow an objective evaluation which is independent of the respective user, the measuring systems generating the LIDs, the parameters and also the characteristics of the LIDs. A comparison is always made with exactly two LIDs. The deviations discerned always relate to that LID serving as reference-LID. The other LID is called actual LID.

For quantifying the differences between the LIDs, a number of different calculation rules are available. Global distance measures are calculated on the basis of all luminous intensity values of a distribution whereas local distance measures only consider the luminous intensity values of a limited angular range. For calculating the distance measures, different resolutions of the reference- and the actual LID are taken into account. The comparison results are then saved in a protocol file.

As the distance measures hardly provide any data concerning the position or the distribution of the differences on the LID, those differences are additionally visualised in different ways.

Before the actual LID comparison is carried out, any undesired or disturbing properties of LIDs resulting from measuring practices, such as alignment uncertainties, deviations of the total luminous fluxes or data noises can be corrected by means of suitable preprocessing operations.

1.2. Basic procedure

The basic procedure in the LID comparison includes the following steps: ‚Preprocessing‘, ‘Difference generation and calculation of distance measures‘ and ‚Visualisation and logging‘.

The partial steps of the preprocessing are of an optional character. The implementation of these steps depends on the properties of the LIDs as well as on the requirements of the concrete task setting on which the LID comparison is actually based. Essential elements of the preprocessing of the LIDs are the luminous flux adaptation, smoothing and coordinate alignment. The alignment of the coordinate systems of the reference- and the actual LID is necessary when the LIDs present different orientations or are found in different coordinate systems. If the relative rotation of the actual LID is known, only a one-off rotation and a new sampling of the actual LID turn out to be necessary for correction. On the contrary, if the relative position is unknown, an automatic coordinate integration is a complex processing step which, in turn, requires the continuous tracking of any valid definition ranges, coordinate transformations, the new sampling of the actual LID and also the calculation of LID distance measures.

When calculating the distance measures, the LIDs are compared with each other point by point through difference generation. If the LIDs are not in the same polar sphere coordinate grid, the corresponding luminous intensity values of the actual LID will be interpolated with the sampling points of the reference-LID. Then, on the basis of the differences, different distance measures are calculated.

Afterwards the Difference-LID is visualised and the calculated distance measures are logged.

The basic procedure of an LID comparison is shown in Fig. 2.1 as a flow chart:

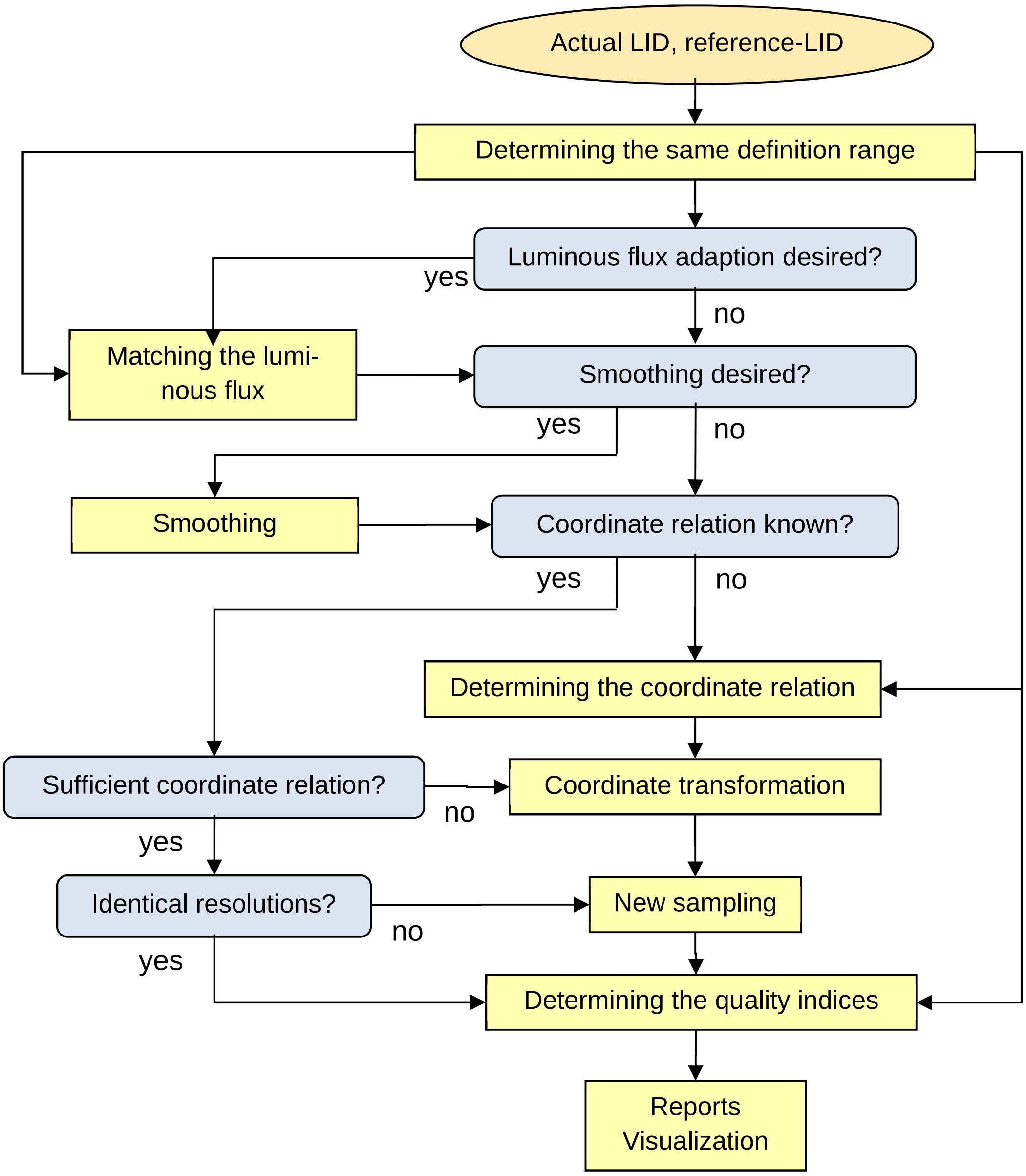

Fig. 1.1: Basic procedure of an LID comparison

<u>Invalid luminous flux values or LID-ranges</u>

Due to the necessary mounting of the measuring objects, there are angular regions hidden by their socket / holders. Within these regions, it is not possible to measure any luminous intensity. Since the typical LID file formats (different IESNA specifications, EULUMDAT) in general contain complete luminous intensity distributions, the LIDs have to be considered to be complete in purely formal terms, but contain regions with invalid luminous intensity values (in TechnoTeam‘s own LID format (*.ttl), the valid LID regions are given explicitly).

For the LID comparison, invalid luminous intensity values must not be considered since the automatic alignment of coordinate systems would be affected, and the distance measures would be distorted by them. Since the luminous intensity regions concerned cannot be determined automatically by means of their luminous intensity values, either the user has to define manually the definition ranges of the actual and the reference-LIDs to be excluded from the comparison, or the invalid 0 value regions must represent directions that do not contain any luminous flux portions. Then, the calculated difference measures including invalid regions are correct. In the case that a coordinate alignment must be carried out, then, in addition, those space directions which are adjacent to the invalid regions must not contain any significant luminous intensities in order to ensure that the differences will not change during a LID-rotation, and the error measures will not be affected.

For presetting those definitions ranges which are to be excluded from comparison, some corresponding masks are provided in the user interface of the LID comparison software (in the current version, however, not realised yet, cf. paragraph 2.1.). The definition range for the LID comparison is calculated then as the average of the valid ranges of the actual and reference-LIDs.

1.3. Preprocessing

1.3.1. Luminous flux adaptation

For luminous flux adaptation, the total luminous fluxes of the LIDs to be compared are matched to each other through scaling of the actual LIDs. Thus, it can be prevented that luminous fluxes which differ from each other because of different applications (differing measurement conditions and parameters, changes occurring to the measuring object, if different objects were measured: different properties of the measuring objects, the use of different measuring systems, etc.) affect the subsequently calculated distance measures. The scaling factor F_I is calculated by

Different total luminous fluxes come into effect for the error index calculation as an additional offset. In case the luminous flux difference is not desired, it can be eliminated by scaling the actual LID before the LID comparison. The scaling factor F_I is calculated by

$$\mathrm{F_I} = \frac{\Phi_{\mathrm{Ref}}}{\Phi_{\mathrm{Ist}}} = \frac{\sum_{\mathrm{k}=0}^{\mathrm{N}} \sum_{\mathrm{l}=0}^{\mathrm{M}} \mathrm{I_{Ref}}(\vartheta_{\mathrm{k}}, \varphi_{\mathrm{l}})\, \Omega_{\mathrm{k,l}}}{\sum_{\mathrm{k}=0}^{\mathrm{N}} \sum_{\mathrm{l}=0}^{\mathrm{M}} \mathrm{I_{Ist}}(\vartheta_{\mathrm{k}}, \varphi_{\mathrm{l}})\, \Omega_{\mathrm{k,l}}}. \tag{1}$$

Attention has to be paid to the fact that, in the case of a luminous flux adaptation, also measurement deviations can possibly be compensated for, and new measurement deviations may result at another point.

1.3.2. Smoothing

If the luminous intensity values exhibit random fluctuations (noise), then the random fluctuations lead to an increase in the calculated error indices. If the LID differences of interest are within the order of magnitude of the noise, an elimination or suppression of the noise is desirable and can be realised by smoothing the luminous intensity values. For a uniform noise reduction the smoothing operation has to be performed with geodetically constant filter width. In general, the systematic deviations of the LIDs are conserved during the smoothing operation since their local frequencies are normally smaller than those of the noise patterns.

1.3.3. Alignment of coordinate systems

<u>General</u>

If the user cannot start out from a common or also sufficiently well-known coordinate relation of the actual and the reference-LID, such relation must be established before the LID comparison by rotating the actual LID into the reference coordinate system. Then, the correction of the data is achieved by rotating the sampling points of the actual LID and subsequently resampling in the polar sphere coordinate grid of the reference-LID. The exact coordinate alignment is a prerequisite for calculating correct differences. Any errors occurring in the coordinate alignment will have an influence on the distance measures calculated. These are particularly strong in LID ranges with high luminous intensity gradients (e.g. of spot luminaires).

Manual alignment

If the relative twisting of the actual LID against the reference-LID is known, integration is achieved by a manual rotation, with the angles of rotation being preset.

Automatic alignment

If basing the actual and reference-LIDs on the same or sufficiently exact coordinate relation is not possible, it is necessary to generate it by rotating the actual LID into the nominal coordinate system before the LID comparison. Since no further information exists, the rotation parameters can be determined only from the data of the LIDs themselves.

As agreed, a common coordinate system is only seen as realised when the difference between the actual and reference-LIDs is minimal. Therefore, the actual LID has to be rotated appropriately. The determination of the rotation angles represents the solution of an optimization task. The searched rotation is the one for which the average square distance of the rotating actual LID to the reference-LID is minimal. The optimization problem is nonlinear since the LID difference as the optimizing criterion over trigonometric functions depends nonlinearly on the rotation angles as the optimizing parameter. The optimizing criterion used for the coordinate alignment basically corresponds to the distance index developed for the LID comparison in chapter 1.4.2, equation (5). For the distance calculation, attention should be paid to regions with invalid luminous intensity values since they may not have any influence on the distance minimization.

One of the standard methods to solve practical nonlinear least-squares problems is the Levenberg-Marquardt Algorithm (LMA). Due to the positive practical characteristics of the method, the coordinate alignment was realised using this method.

Since the Levenberg-Marquardt algorithm used for the coordinate alignment of the Actual and reference-LIDs does not converge obligatorily, the user has to indicate appropriate start values for the rotation of the actual LID in case the rotation of the LIDs against each other is too big. The indication of rotation angles by the user is problematic because the understanding and imagination of the three-dimensional coordinate transformation in form of a series of three individual rotations are required.

Automatic determination of initial values

For determining initial values, the automatic system which employs the principal component analysis and is described in the following is helpful.

The principal component analysis can be seen geometrically as an approximation of a point cloud through a hyper ellipsoid. The calculated eigenvectors correspond to the directions of the axes of the ellipsoid. The quantities of the eigenvectors indicate the variances of the data points in direction of the ellipsoid axes and are therefore an index for the length of the semi axes. In case the eigenvectors are arranged as a rotation matrix, the point cloud can be aligned with this matrix parallel to the axis by rotation.

As for the safe determination of the orientation of a point cloud the principal component analysis presupposes different degrees of rotation of the axes of the approximating ellipsoid, the procedure is either not or merely restrictedly applicable – in the present application – in the case of rotationally symmetric or point-symmetric LIDs, as they occur in spots, Lambertian or isotropic radiators. In these cases, the starting values for the coordinate axes concerned must be preset manually.

1.4. Calculation of distance measures

1.4.1. General

The purpose of LID distance measures is to make quantitative statements concerning the similarity of two LIDs. For the calculation, the LIDs are compared with each other point by point through difference generation. If the LIDs are not in the same polar sphere coordinate grid, the luminous intensity values of the actual LID corresponding with the sampling points of the reference-LID must be interpolated. As in the case of coordinate alignment, only values from valid LID ranges are allowed to be included in the calculation of luminous intensity differences.

1.4.2. Global distance measures

1.4.2.1. RMSE based distance measures

For the LID comparison, the square distance between measuring variables observed and a parameterisable function (method of root-mean-square deviation RMSD or root-mean-square error RMSE) used as the standard distance measure in the error and compensation calculation is employed. The squared luminous intensity difference is weighted additionally with the solid angle of the reference-LID cell concerned. The weighting causes a consideration of the size of the sampling point intervals so that the value of the distance measure does not depend on the position of the LID in the polar coordinate system. The basic equation of the weighted RMSE applied to the LID comparison is:

$$f'_{\mathrm{I_{abs}}} = \sqrt{\frac{1}{\sum_{k=0}^{N}\sum_{l=0}^{M}\Omega_{k,l}}\sum_{k=0}^{N}\sum_{l=0}^{M}\left(\mathrm{I}(\vartheta_k,\varphi_l)-\mathrm{I_R}(\vartheta_k,\varphi_l)\right)^2\,\Omega_{k,l}} \qquad (2)$$

To get relative distance measures, the RMSE can be normalised to the mean of the model values (CV(RMSE) - coefficient of variation of the RMSE). Applied to the case of the luminous intensities of the reference-LID the equation of the CV(RMSE) is:

$$f'_{\mathrm{I_{rel}}\,\overline{I_R}} = \frac{f'_{\mathrm{I_{abs}}}}{\overline{\mathrm{I}}_{\mathrm{R}}}100\% = f'_{\mathrm{I_{abs}}}\frac{\sum_{k=0}^{N}\sum_{l=0}^{M}\Omega_{k,l}}{\Phi_{\mathrm{R}}}\,100\% \qquad (3)$$

with $\overline{I_R} = \frac{\Phi_R}{\sum_{k=0}^{N}\sum_{l=0}^{M}\Omega_{k,l}}$ and $\Phi_R = \sum_{k=0}^{N}\sum_{l=0}^{M} I_R(\vartheta_k, \varphi_l)\,\Omega_{k,l}$. Another possibility is to normalise the RMSE to the maximum of the model values (NRMSE - normalised RMSE). Applied to the case of the LID comparison, the equation of the NRMSE is:

$$f'_{I_{rel\,I_{R_{max}}}} = \frac{f'_{I_{abs}}}{I_{R_{max}}} 100\% = f'_{I_{abs}} / \max_{k,l} |I_R(\vartheta_k, \varphi_l)|\ 100\% \qquad (4)$$

When calculating the sum of squared errors, it is necessary to correct the scaling of the sum, introduced through the weighting, by a scaling to the sum of the weights. However, a scaling of such kind is problematic in the weighted squared luminous intensity difference. Scaling to the sum of the solid angles entails a dependence of the distance measure on the valid solid angle range of the LIDs. This is formally correct since either some additional or fewer readings are included in the calculation, and the standardization factor must be matched accordingly. However, the comparability of measurements of the same light source with different solid angle ranges is no longer guaranteed in the case of a scaling to the actual solid angle range. For the LID-comparison, this is important because usually in practice measurements are made with a limited angular range. The reasons for this are, among other things, limited movement range depending on the measuring system, which generally result from the necessary fixing of the light source, shortening of measuring times due to reduced angular ranges or limited radiation areas of the light source that do not require full sphere measurement.

For carrying out a LID comparison measurements at a limited angular range are basically permitted provided that all spatial directions containing significant luminous flux portions are recorded. If the angular range of a permissible measurement is enlarged, the sum of squared errors remains constant as the additional luminous intensity differences are very small (noise) or are zero. However, the sum of the weights increases thus leading to a decrease of the distance measure. This means that weighted squared luminous intensity differences remain comparable only for identical solid angle ranges of the measurements. Since it is difficult to comply with such a requirement in practice, it is agreed for the measure to be defined that each measurement made with limited angular range is to be interpreted as a full sphere measurement (anyway, all significant flux portions must be contained for a correct LID-comparison). The intensities of unmeasured spatial directions are assumed to be zero. Thus, scaling can always be carried out to the solid angle of the solid sphere $\sum_{k,l}\Omega_{k,l} = 4\pi\ sr$. The calculated mean square luminous intensity difference relates always to a solid sphere, regardless of the actual angle range.

The distance measure $f_{I_{abs}}$ defined on the basis of the mean square luminous intensity difference yields the mean deviation of the luminous intensities of the LID cells:

$$f_{I_{abs}} = \sqrt{\frac{1}{4\pi\ sr}\sum_{k=0}^{N}\sum_{l=0}^{M}\left(I(\vartheta_k, \varphi_l) - I_R(\vartheta_k, \varphi_l)\right)^2 \Omega_{k,l}} \qquad (5)$$

Additionally, the error term can be related to the mean luminous intensity $\overline{I_R}$ by applying the factor $\frac{1}{\overline{I_R}} = \frac{4\pi\ sr}{\Phi_R}$, or to the maximum of the luminous intensity values of the reference LID $max_{k,l}|I_R(\vartheta_k, \varphi_l)|$. It should be noted that, here too for the scaling, always the entire solid angle range or also the total luminous flux must be used. The modified distance measure

$f_{I_{rel\,\overline{I_R}}}$ indicates the mean percentage deviation from the average luminous intensity (equivalent to the mean percentage deviation from the total luminous flux) of the reference-LID

$$f_{I_{rel\,\overline{I_R}}} = \sqrt{\frac{1}{4\pi\ sr}\sum_{k=0}^{N}\sum_{l=0}^{M}\left(I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)\right)^2 \Omega_{k,l}}\ \frac{4\pi\ sr}{\Phi_R}\ 100\% \qquad (6)$$

or the percentage deviation from the maximum luminous intensity of the reference-LID:

$$f_{I_{rel\,I_{R_{max}}}} = f_{I_{abs}} / max_{k,l}|I_R(\vartheta_k,\varphi_l)|\ 100\% \qquad (7)$$

For the practical use of normalised values it should be noted that the average luminous intensity depends strongly on the shape of the reference-LID and, therefore, different LID shapes are only partially comparable. Here, especially the size of the area of significant luminous intensity values has a strong influence on the magnitude of the relative maximum error. In the case of a spot-lamp, for example, the average luminous intensity is at least one order of magnitude smaller than the maximum luminous intensity and, consequently, the relative errors are significantly greater than in the case of a scaling to the maximum value of all luminous intensities of the reference-LID.. In the case of a scaling to the average luminous intensity of the reference-LID, it would be an advantage that here the same reference as in the case of the distance measure $f_{I,_{rel}}$ is present, and, thus, that $f_{I,_{rel}}$ and $f_{I_{max,rel}}$ would be comparable.

In case the actual and the reference-LID exist in different resolutions, the luminous flux values of the actual LID are determined newly by linear interpolation at the sampling points given by the reference-LID.

As another distance measure, the maximum deviation of the luminous intensities is defined with

$$f_{I_{max,\ abs}} = max_{k,l}|I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)| \qquad (8)$$

Analogous to $f_{I_{rel\,\overline{I_R}}}$ in equation (8) and $f_{I_{rel\,I_{R_{max}}}}$ in equation (9), the scaling of the maximum absolute differences can be transferred to the mean or maximum luminous intensity of the reference-LID:

$$f_{I_{max,\ rel\,\overline{I_R}}} = max_{k,l}\ |I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)|\ \frac{4\pi\ sr}{\Phi_R}\ 100\% \qquad (9)$$

$$f_{I_{max,\ rel\,I_{R_{max}}}} = max_{k,l}\ |I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)|\ \frac{1}{max_{k,l}\ I_R(\vartheta_k,\varphi_l)}\ 100\% \qquad (10)$$

1.4.2.2. Improvement of the method by Bergen

Bergen proposes a measure which is based on the squared differences of the luminous intensities and derived from the Michelson fringe visibility (Bergen ASJ. A practical method of comparing luminous intensity distributions. in: Lighting Research and Technology, March 2012, vol. 44, no. 1: 27-36.). The value range covered values from 0% (no consistency, e.g. comparison of up- and downlight) to 100% (exact match). However, the distance measure does not take into account the different densities of the sampling points conditioned by the spherical coordinate system. Luminous intensity differences occurring near the poles are evaluated exactly in the same way as those occurring near the equator. As there is no weighting, the calculated distance measure depends on the position of the measurement objects in the coordinate system of the measuring system.

This dependence can be abolished through a weighting of the differences or also sums of the luminous intensities with the solid angle of the LID cells concerned. A weighting of such kind is permitted as the solid angle describes the expansion of a LID cell, and is proportional to the distance between the sampling points (or also inversely proportional to the density of the sampling points). The solid angle of a LID cell can be calculated as follows:

$$\Omega_{\mathrm{k,l}} = \Delta\varphi\left(\cos\left(\vartheta_{\mathrm{k}} - \frac{\Delta\vartheta}{2}\right) - \cos\left(\vartheta_{\mathrm{k}} + \frac{\Delta\vartheta}{2}\right)\right)\ \mathrm{sr} \qquad (11)$$

Then, the measure modified through the solid angle weighting reads (notation according to Bergen):

$$f_{lumi\_w} = 100\left(1 - \sqrt{\frac{\sum_{C=0}^{360}\sum_{\gamma=0}^{180}\Omega(C,\gamma)\left(I_1(C,\gamma) - I_2(C,\gamma)\right)^2}{\sum_{C=0}^{360}\sum_{\gamma=0}^{180}\Omega(C,\gamma)\left(I_1(C,\gamma) + I_2(C,\gamma)\right)^2}}\right) \qquad (12)$$

1.4.3. Local distance measures

During the tests and analysis for the LID comparison it was shown that small local deviations do not always become evident in the global distance measures. The fluctuations of the global distance measure due to random measuring errors are predominant here. In certain cases, however, the definition of local distance measures makes sense. Taking into account the global distance measures defined in the preceding paragraph, local measures can be derived by limiting the angle ranges.

However, for such local measures the restrictions concerning the comparability of distance measures in the case of limited angle ranges, as mentioned in the preceding paragraph are valid. In addition, the zonal measures – unlike the global distance measures – do not depend on the position of the LID curve pairing in the coordinate system. They always depend on the orientation of the LIDs in the coordinate system.

A specialisation of the local distance measures with any solid angle range can be realised by limiting the solid angle range to complete zones with constant ϑ (error of the k-th gamma plane) or also constant φ (error of the l-th C-plane). According to equations (5), (6) and (7), the zonal distance measures f_{I_{abs},φ_l}, f_{I_{abs},ϑ_k}, $f_{I_{rel\,\overline{I_R}},\varphi_l}$, $f_{I_{rel\,\overline{I_R}},\vartheta_k}$, $f_{I_{rel\,I_{R_{max}}},\varphi_l}$ and $f_{I_{rel\,I_{R_{max}}},\vartheta_k}$ can be defined:

$$f_{I_{abs},\varphi_l} = \sqrt{\frac{1}{\Omega_{\varphi_l}} \sum_{k=0}^{N} \left(I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)\right)^2 \Omega_{k,l}} \tag{13}$$

$$f_{I_{abs},\vartheta_k} = \sqrt{\frac{1}{\Omega_{\vartheta_k}} \sum_{l=0}^{M} \left(I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)\right)^2 \Omega_{k,l}} \tag{14}$$

$$f_{I_{rel\,\overline{I_R}},\varphi_l} = \sqrt{\frac{1}{\Omega_{\varphi_l}} \sum_{k=0}^{N} \left(I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)\right)^2 \Omega_{k,l}} \; \frac{4\pi\, sr}{\Phi_R} \; 100\% \tag{15}$$

$$f_{I_{rel\,\overline{I_R}},\vartheta_k} = \sqrt{\frac{1}{\Omega_{\vartheta_k}} \sum_{l=0}^{M} \left(I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)\right)^2 \Omega_{k,l}} \; \frac{4\pi\, sr}{\Phi_R} \; 100\% \tag{16}$$

$$f_{I_{rel\,I_{R_{max}}},\varphi_l} = \sqrt{\frac{1}{\Omega_{\varphi_l}} \sum_{k=0}^{N} \left(I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)\right)^2 \Omega_{k,l}} \; \frac{1}{I_{R_{max}}} \; 100\% \tag{17}$$

$$f_{I_{rel\,I_{R_{max}}},\vartheta_k} = \sqrt{\frac{1}{\Omega_{\vartheta_k}} \sum_{l=0}^{M} \left(I(\vartheta_k,\varphi_l) - I_R(\vartheta_k,\varphi_l)\right)^2 \Omega_{k,l}} \; \frac{1}{I_{R_{max}}} \; 100\% \tag{18}$$

It should be noted that the scaling of weights similar to the error measure $f_{I_{abs}}$ must take place at the full solid angle of the relevant zone error measure. $f_{I_{abs,\varphi_l}}$, $f_{I_{rel\,\overline{I_R}},\varphi_l}$ and $f_{I_{rel\,I_{R_{max}}},\varphi_l}$ are normalised to the solid angle of a spherical digon (or spherical lune) with the interior angle $\Delta\varphi$ and $f_{I_{abs,\vartheta_k}}$, $f_{I_{rel\,\overline{I_R}},\vartheta_k}$ and $f_{I_{rel\,I_{R_{max}}},\vartheta_k}$ are normalised to the solid angle of a spherical segment with the boundary angles $\vartheta_k = \pm\Delta\vartheta/2$. The solid angle calculated for $f_{I_{abs,\varphi_l}}$, $f_{I_{rel\,\overline{I_R}},\varphi_l}$ and $f_{I_{rel\,I_{R_{max}}},\varphi_l}$are $\Omega_{\varphi_l} = 2\Delta\varphi\, sr$ and for $f_{I_{abs,\vartheta_k}}$, $f_{I_{rel\,\overline{I_R}},\vartheta_k}$ and $f_{I_{rel\,I_{R_{max}}},\vartheta_k}$ with $\Delta\varphi = 2\pi$ are $\Omega_{\vartheta_k} = 2\pi[cos(\vartheta_k - \Delta\vartheta/2) - cos(\vartheta_k + \Delta\vartheta/2)]\, sr$. In order to make the local measures of different solid angle zones, which are normalised to the maximum luminous intensity, comparable with each other, they are normalised to the global maximum luminous intensity of the reference-LID.

1.5. Visualisation

1.5.1. 3D-Visualisation of differences

Although the distance measures defined in the previous chapter supply some information about the average or maximum deviations of the luminous intensities from one another, they hardly give any information on the position or distribution of the differences on the luminous intensity distribution (zonal measures, location of the maximum deviation). Therefore, additionally to the reporting of the distance measures, a graphic display of the luminous intensity differences is helpful and in plenty of cases even necessary. When the systematic LID differences are within the dimension of the noise or are limited to a very small region, they hardly have any effect on the distance measures, and a visual inspection will then be the only possibility to detect some individual differences.

In the visualisation windows of the software, LIDs can be represented three-dimensionally from any observation perspective. Based on the luminous intensity values and positions, a networked closed 3D user interface is triangulated, and the interface elements are coloured according to the luminous intensity values. The applied colour palette was scaled to the maximum value of the luminous intensity values of the LID concerned.

3D representation of the reference-LID with colour-coded differences

The simplest form of representing the LID differences is their direct visualisation using a 2D-image. A spatial representation, however, is only possible for the values of the deviations. Nevertheless, a colour coding of the luminous intensity values allows the signed deviations to be indicated.

The direct visualisation of the LID differences gives only a little impression of their spatial arrangement. Therefore, the visualisation was expanded in such a way that the colour coding of the reference-LID shows the luminous intensity differences instead of the reference luminous intensities. Due to the direct visual allocation of the colour-coded differences to the corresponding spatially represented luminous intensity values of the reference-LID, their position and distribution can be captured intuitively and quickly by the user. In this way, also the signed differences can be represented. In order to point out small LID differences, the linear scaling of the colour palette can be replaced by a logarithmic scaling, if necessary.

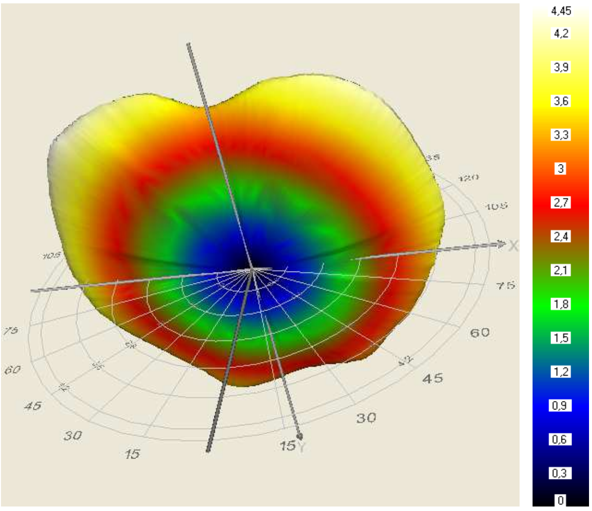

Fig. 1.2: Reference-LID

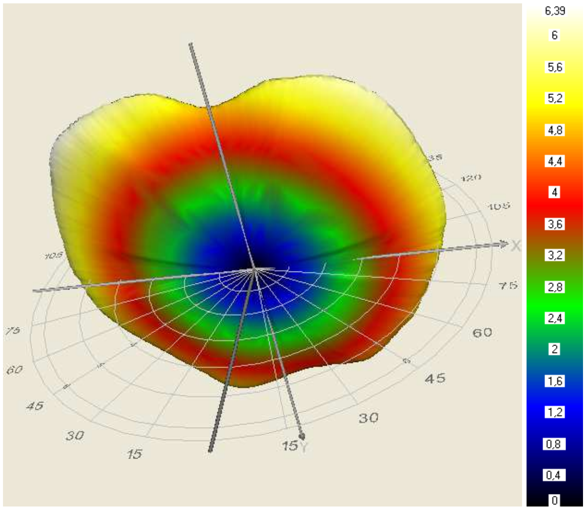

Fig. 1.3: Actual LID

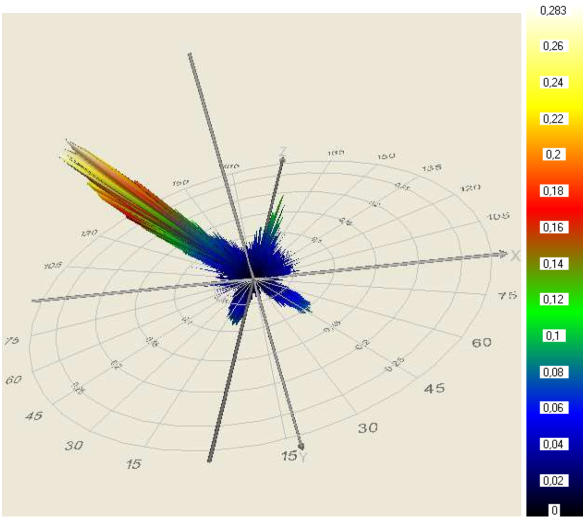

Fig. 1.4: Difference-LID, absolute values

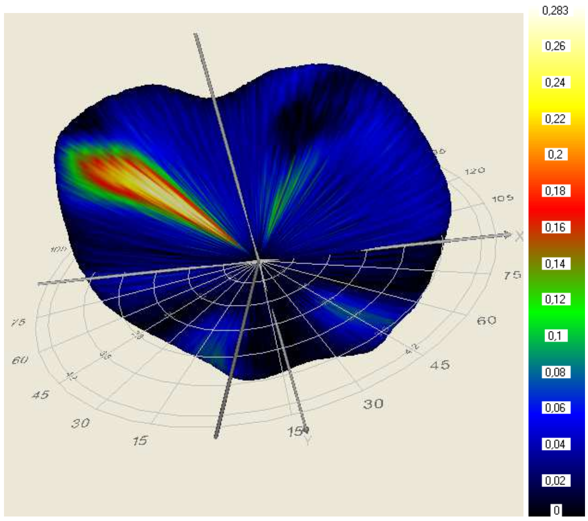

Fig. 1.5: Difference-LID, absolute values, mapped to the reference-LID

Fig. 1.2 and Fig. 1.3 show exemplarily two LIDs of the same measuring object (widely irradiating LED) measured with different operating parameters (operating currents of 80 mA and 120 mA). Fig. 1.4 represents the absolute values of luminous flux differences calculated after a matching of the luminous fluxes. Here, distinct systematic deviations can clearly be seen. The allocation to luminous flux values of the actual LID is, however, difficult.

Logarithmic representation, representation of signed differences

Fig. 1.5 also shows the reference-LID. However, the coded colours of the absolute values of the luminous flux differences were mapped onto the corresponding values of the reference-LID. In this representation, the assignment of the differences to the corresponding values of the actual LID can be realised without problems.

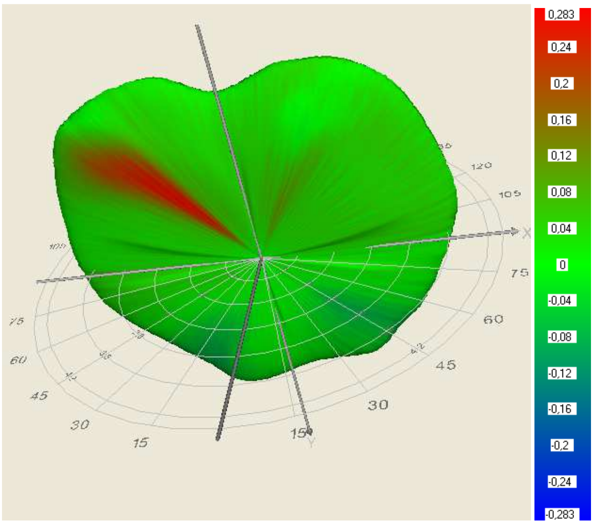

Fig. 1.6: Difference-LID, mapped to the reference-LID, zero-point symmetric colour palette

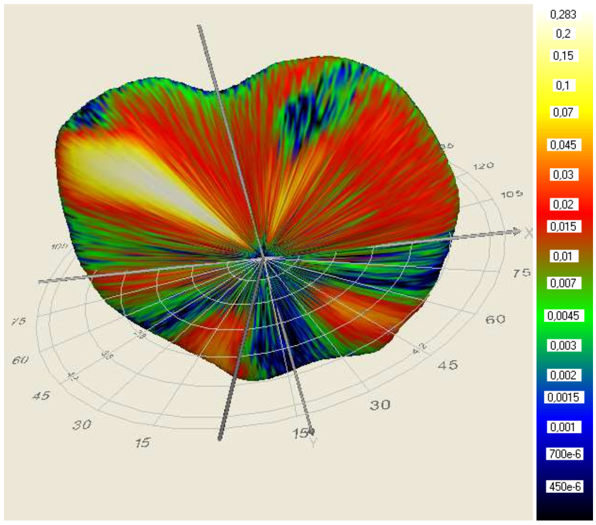

Fig. 1.7: Difference-LID, absolute values, mapped to reference-LID, logarithmic display

Fig. 1.6 shows the same way of representation as Fig. 1.5 using, however, the signed luminous flux differences and another colour palette. The sample colour palette is set up symmetrically concerning the luminous intensity difference 0. Positive differences are represented in red and negative differences in blue. The red region in Fig. 1.6 signals a distinct local increase of luminous intensities. In the lower regions of the 3D graphics, slightly blue-coloured regions show a small reduction of luminous intensities.

Fig. 1.7 finally complies with the way of representation of Figure 5 except for the logarithmic scaling of the colour palette. Due to logarithmic scaling, hardly visible small differences are clearly perceivable.

<u>Representation of relative differences</u>

For certain applications, it may be helpful to present the individual differences in relation to the corresponding luminous intensity values of the reference-LID. However, these relative deviations may assume very large values at low luminous intensity values of the reference-LID. To hide those disturbing values in the illustration, a threshold value must be used. A relative deviation is set to zero when the corresponding luminous intensity value of the reference-LID is less than the threshold.

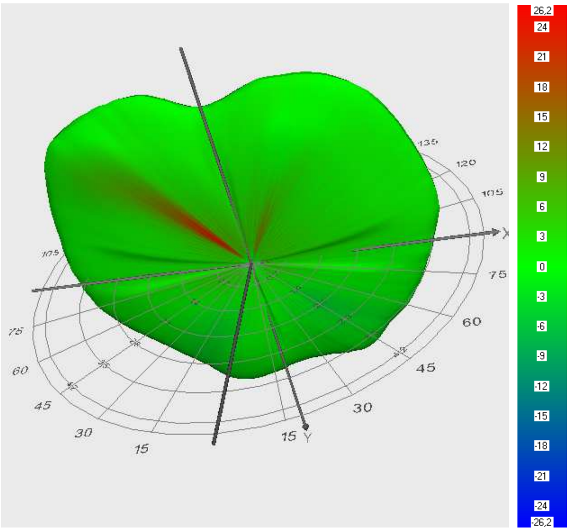

Fig. 1.8: Differenz-Lvk in Relation zur Referenz-Lvk, auf Referenz-Lvk gemappt, nullpunktsymmetrische Farbpalette

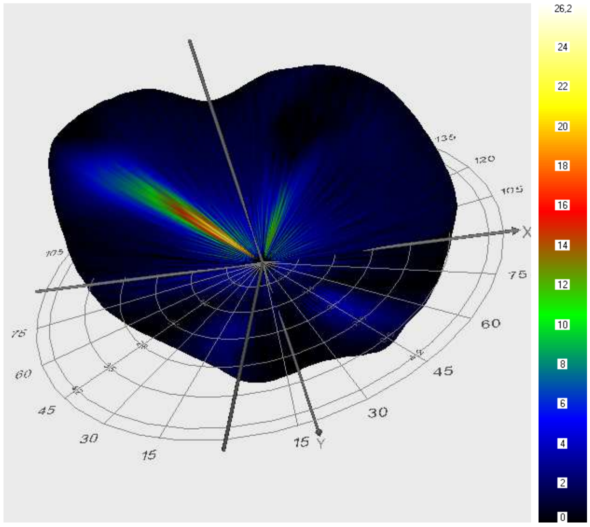

Fig. 1.9: Differenz-Lvk, Absolutbeträge in Relation zur Referenz-Lvk, auf Referenz-Lvk gemappt, logarithmische Anzeige

Fig. 1.8 und Fig. 1.9 show exemplarily the two absolute representations of Fig. 1.6 und Fig. 1.5 in relative terms. Differences of reference-LID luminous intensity values less than 10% of the maximum luminous intensity of the reference-LID be shown with the value zero.

1.5.2. Displaying zonal distance measures in the form of a diagram

The zonal distance measures $f_{I_{abs,\varphi_l}}$, $f_{I_{abs,\vartheta_k}}$, $f_{I_{rel\,\overline{I_R},\varphi_l}}$, $f_{I_{rel\,\overline{I_R},\vartheta_k}}$, $f_{I_{rel\,I_{R_{max}},\varphi_l}}$ and $f_{I_{rel\,I_{R_{max}},\vartheta_k}}$ defined in paragraph 1.4.2.2 according to Eqs. (13), (14), (15), (16), (17) and (18) yield a distance value for each gamma-plane and for each C-plane. These measures can well be represented in the form of a diagram which allows the user to gain a quick visual overview of the behaviour of the distance measures as a function of the index or also the angle of the gamma- or also C-plane.

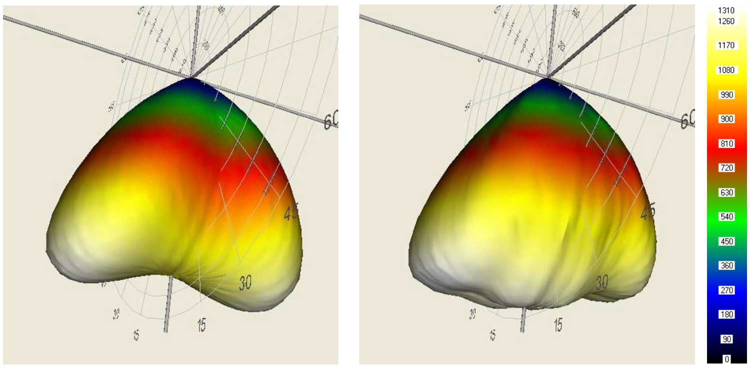

Fig. 1.10: Reference- and actual LID

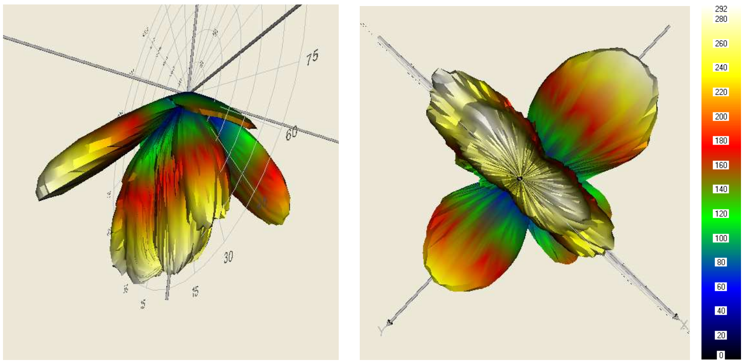

Fig. 1.11: Difference LID, absolute values in different 3D perspectives

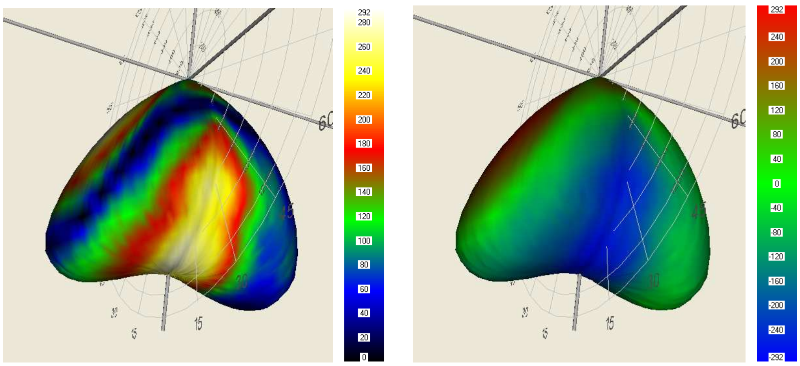

Fig. 1.12: Difference LID mapped onto reference-LID, left: absolute difference values mapped; right: difference values mapped, zero point-symmetrical colour palette

The figures of the current section show in an exemplary way the luminous intensity differences in a 3D-form (Fig. 1.11 and Fig. 1.12) as well as the behavior of the relative zonal errors $f_{I_{rel}\,\overline{I_R},\varphi_l}$ and $f_{I_{rel}\,\overline{I_R},\vartheta_k}$ according to Eqs. (15) and (16) for the LID – pairing, used above.

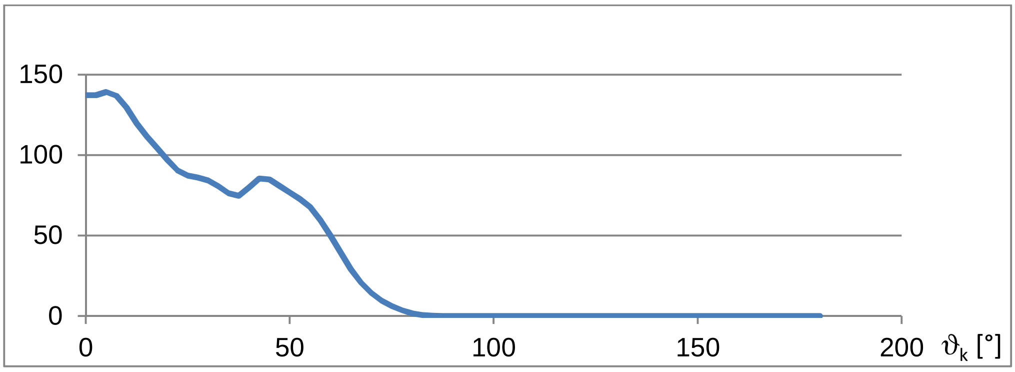

Fig. 1.13: Relative zonal luminous intensity differences $f_{I_{rel}\,\overline{I_R},\vartheta_k}$ of the gamma-planes

The relative zonal error $f_{I_{rel}\,\overline{I_R},\vartheta_k}$ of the gamma-planes of the selected example LIDs shown in Fig. 1.13 tends to decrease the further the gamma-plane concerned is away from the pole. At $\vartheta_k = 45°$ it increases again, which is due to the local "wings" of the LID differences at this angle position (clearly recognizable in the left-hand section of Fig. 1.11 and Fig. 1.12).

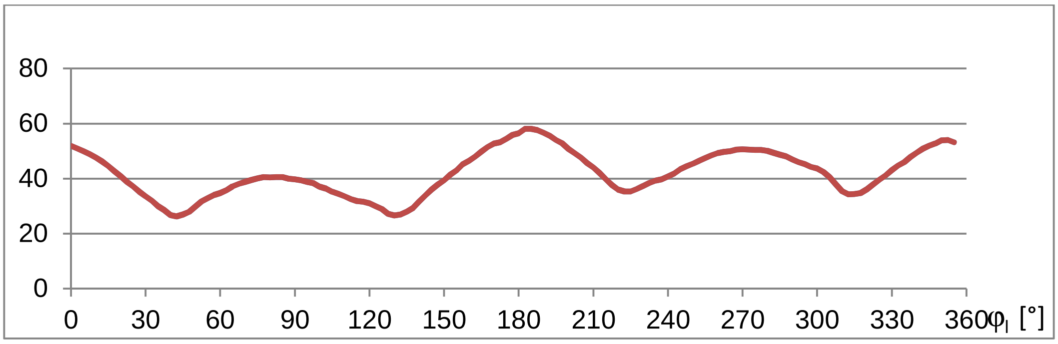

Fig. 1.14: Relative zonal luminous intensity differences $f_{I_{rel}\,\overline{I_R},\varphi_l}$ of the C-planes

Due to the dominant local differences in the $C0^0$-180^0-plane, the relative zonal error $f_{I_{rel}\,\overline{I_R},\varphi_l}$ of the C-planes, shown in Fig. 1.14, has its maximum at approximately $\varphi_l = 0°$ and approximately $\varphi_l = 180°$. Local maxima additionally appear at the local ‚wings' of the LID differences at approximately $\varphi_l = 90°$ and approximately $\varphi_l = 270°$.

2. Operating instructions

2.1. Overview

Fig. 2.1 shows the dialog-based program interface:

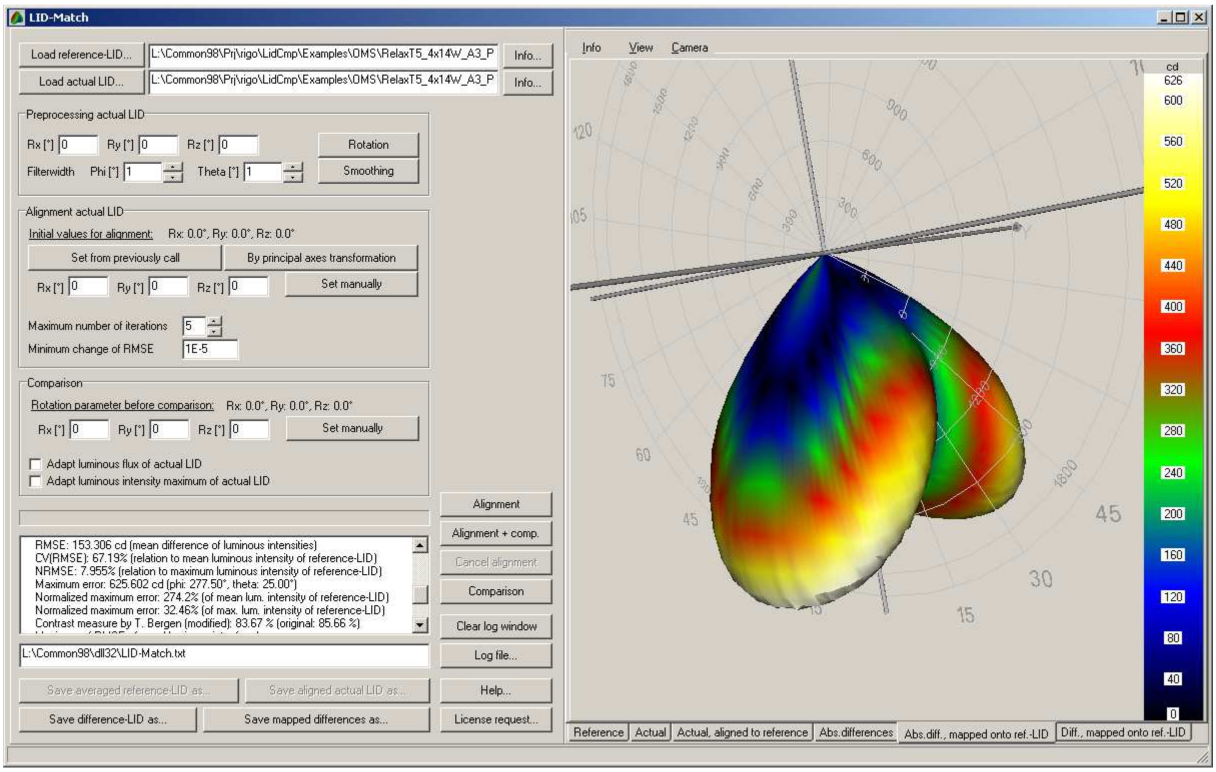

Fig. 2.1: User interface of the program ‚LID-Match‘

The left-hand dialog region contains the elements for the parameterization, execution, logging, Licensing and numerical representation of the results of a LID comparison. In the right-hand region of the dialog, the starting and the result data are shown three-dimensionally and in a colour-coded form. The LID comparison itself is based on the procedure described in paragraph 1.2. However, in the current version, no restriction of the definition range of the raw of data is possible. Here, in the case of global measures, a comparison is carried out always by including all LID cells of a solid sphere, or also in the case of the zonal measures of a complete antipodal digon or also a closed spherical zone. In the case of incomplete LIDs, a luminous intensity of 0 cd is assumed for the missing cells. Incomplete LID regions must be taken into account for the calculation of distance measures as their luminous intensity values are included in the difference generation, thus influencing the error measures.

2.2. LID selection

By pressing the buttons „LOAD REFERENCE-LID“ or „LOAD ACTUAL LID...“ the dialogs for loading the source LIDs are opened. LID files of the formats TechnoTeam Luminous intensity distribution (*.ttl), Eulumdat (*.ldt) and IES LM-63-02 (*.ies) can be read. By means of the corresponding buttons „INFO...“, the luminous intensity values can be displayed in tabular form, 2D-LID curves can graphically be represented and any additional information contained in the source files can be displayed in the form of a text.

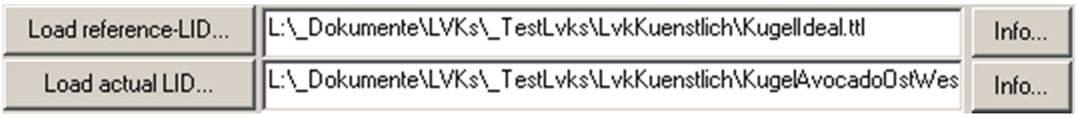

Fig. 2.2: Control elements for actual and reference-LID selection

The dialog for loading the reference-LID supports the simultaneous selection of several reference-LIDs with identical definition range and the same angular resolution. If several LIDs are selected, the reference-LID will be calculated by averaging the selected LIDs.

After loading, the actual and the reference-LIDs are displayed in the corresponding tab windows „ACTUAL“ and „REFERENCE“ of the 3D-visualisation range.

2.3. Manual preprocessing

The loaded actual LID can optionally be preprocessed by pressing the buttons „ROTATION“ and „SMOOTHING“ of the group „PREPROCESSING ACTUAL LID“ before coordinate alignment and the calculation of distance measures.

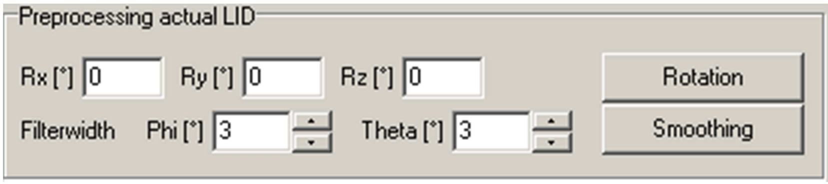

Fig. 2.3: Control elements for preprocessing the actual LID

By pressing the button „ROTATION“, the actual LID is rotated sequentially around the x-, y- and z-axes according to the rotation angles α, β and γ set. The button „SMOOTHING“ allows the separated smoothing of the actual LID, according to the filter widths set, in ϑ- and φ-direction. The filter width of the φ-direction is defined for the spherical zone of the equator (ϑ = 90°) and is successively extended during smoothing in polar direction in such a way that the geodetic filter width remains constant.

2.4. Coordinate alignment

If the actual and the reference-LID do not lie in the same coordinate system, the coordinate alignment can either be entered in the form of rotation angles or it can be calculated on the basis of the distribution of the luminous intensity values of the source LIDs. When carrying out the LID comparison, the actual LID is rotated according to the given or also calculated rotation angles before the distance measures are calculated. In particular, the software offers the following options for the coordinate alignment of the actual LID with the reference-LID coordinates:

Manual presetting

If the coordinate alignment is known, it can be set in the group field „COMPARISON“ by pressing the button „SET MANUALLY“ according to the rotation angles of the neighbouring edit fields.

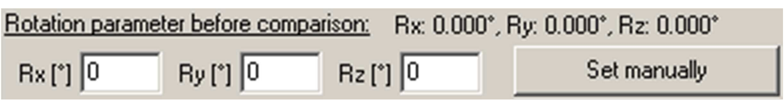

Fig. 2.4: Control elements for the manual parameterization of coordinate alignment

<u>Automatic calculation</u>

If the coordinate alignment is unknown, it can be calculated by applying the nonlinear compensation method described in paragraph 1.3.3. In doing so, the actual LID is rotated – starting with an initial rotation – step by step in such a way that the distance between the actual and the reference-LID is reduced successively. If the actual LID is rotated against the reference-LID at an angle greater than about 15 °, an initial rotation is necessary to ensure the convergence of the method. In the group field „ALIGNMENT ACTUAL LID“, the initial values can either be manually preset using the button „SET MANUALLY“, or they can be roughly estimated using the button „BY PRINCIPAL AXIS TRANSFORMATION“ through the method of principal component analysis, or they can be equated with the result angles of the last coordinate alignment using the button „SET FROM PREVIOUSLY CALL“.

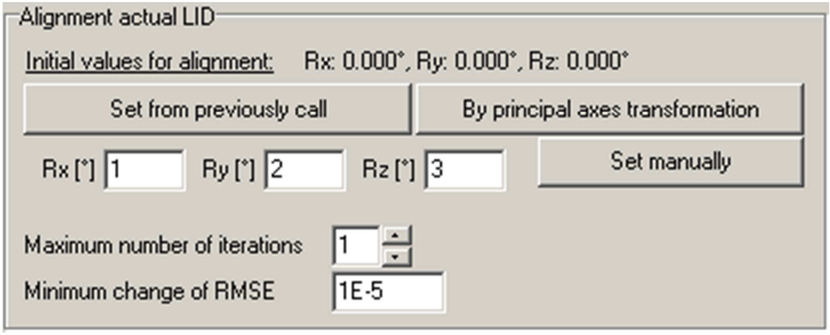

Fig. 2.5: Control elements for the parameterization of automatic coordinate alignment

The automatic calculation of the coordinate alignment by means of the compensation method must be controlled by two abort criteria. In the edit field „MAXIMUM NUMBER OF ITERATIONS“, a maximum number of rotation steps must be set, appropriately between 5 and 20 iterations. The more inexact that starting values are, the higher the number set here should be. The edit field „MINIMUM CHANGE OF RMSE “ determines a minimum threshold for changing the distance between the actual and the reference-LID. If the difference of the global distance measures of two successive iterations is lower than this threshold value, the calculation of the coordinate alignment will be terminated due to too slow convergence. The values of this minimum threshold should appropriately lie between about 10^{-10} and 10^{-14}.

Fig. 2.6: Buttons for controlling automatic coordinate alignment

The automatic calculation of the coordinate alignment is started by pressing the button „ALIGNMENT“. By activating the button „ ALIGNMENT + COMP.“, the calculation of the coordinate alignment and also the subsequent calculation of the distance measures will be started automatically. The process of coordinate alignment is displayed by a progress bar. The calculation can be aborted by pressing the button „CANCEL ALIGNMENT“. After aborting this process, the user can decide in a dialog-based way whether he wants to go on with the calculation of the distance measures. Coordinate alignment will then be carried out on the basis of the rotation angles available at the time of abort.

In certain situations, the nonlinear compensation method used is numerically not able to continue the optimization. The resulting abortion of coordinate alignment is indicated by an appropriate message in the information window. To perform in such a situation automatic coordinate alignment anyway, different starting values must be used. In many cases modified starting values by 1 ° are sufficient here.

2.5. Luminous flux adaptation

Before the LID distance measures are calculated, the total luminous flux of the actual LID can be adapted, if necessary, to the total luminous flux of the reference-LID. Adaptation can be effected in two versions.

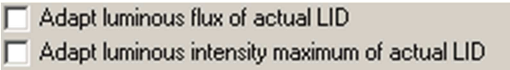

Fig. 2.7: Selection boxes for selecting the mode for luminous flux adaptation

If the selection box „ADAPT LUMINOUS FLUX OF ACTUAL LID“ is activated, the actual LID is scaled such that the actual LID and the reference-LID present identical total luminous fluxes when calculating the distance measures. Activating the selection box „ADAPT LUMINOUS INTENSITY MAXIMUM OF ACTUAL LID“ allows the scaling to be effected in such a way that the luminous intensity maximum of the actual LID is adapted to the maximum of the reference-LID.

2.6. Limit evaluation range

LIDs often have invalid or incomplete data areas. For example, luminaires for a LID measurement have to be mounted or suspended in the measuring system. No measured values can then be detected in the area of the luminaire support.

By specifying an angular range, the data range for the LID comparison can be restricted. The automatic coordinate alignment is not affected. This always works on the complete LID.

Fig. 2.8: Dialog elements for parameterizing the limited evaluation range

If the "LIMIT EVALUATION RANGE" checkbox is activated, only data within the specified angular range are evaluated. The interval limits for Phi are 0° - 360° and for Theta 0° - 180°. The interval limits belong to the evaluation range. The evaluation range must contain at least one valid LID cell.

2.7. Threshold for relative differences

In the representation of the differences in relation to the corresponding luminous intensity values of the reference-LID a threshold for hiding differences with little corresponding luminous intensity values is always applied. This threshold is set by a dialog via the popup menu of the relevant tabsheets:

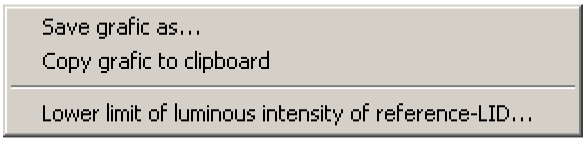

Fig. 2.9: Popup menu for threshold adjustment for relative differences

In the settings dialog, the threshold can be specified as a percentage based value (relative to the maximum of the luminous intensity of the reference-LID) or as an absolute luminous intensity value:

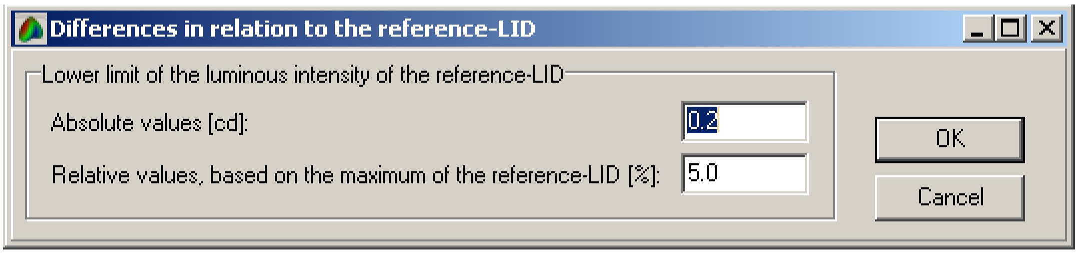

Fig. 2.10: Dialogue for threshold adjustment for relative differences

2.8. LID comparison

The calculation of the difference LID and distance measures is started by pressing the button „COMPARISON“. By pressing the button „ALIGNMENT + COMP.“, the distance measures are calculated after the preceding automatic coordinate alignment.

The calculation results are displayed numerically in the information window in the lower left-hand section of the dialog (distance measures) and graphically in the right-hand section of it. Additionally, the content of the information window is saved in a protocol file. The protocol file can be specified by pressing the button „LOG FILE…“. If the flag „AUTOSAVE“ of the LID-comparison program initialization file is active (see paragraph 3.2), some result data are saved in separate text- or ttl-files.

<u>Information window</u>

The information window or also the protocol file contains the following information for each LID comparison:

- Name of the actual and the reference-LID
- Difference between and ratio of the total luminous fluxes of the actual and the reference-LID
- RSME: mean absolute deviation of the luminous intensities $f_{I_{abs}}$, Eq. (5)
- CV(RMSE): mean percentage deviation from the average luminous intensity of the reference-LID, $f_{I_{rel\,\overline{I_R}}}$ Eq. (6)
- NRMSE: mean percentage deviation from the maximum luminous intensity of the reference-LID $f_{I_{rel\,I_{R_{max}}}}$, Eq. (7)

- Maximum absolute deviation of the luminous intensities $f_{I_{max,\ abs}}$, Eq. (8), in addition, the maximum positive deviation and the maximum negative deviation of the luminous intensities
- Maximum percentage deviation from the average luminous intensity of the reference-LID $f_{I_{max,\ rel\,\overline{I_R}}}$, Eq. (9), in addition, the maximum positive percentage deviation and the maximum negative percentage deviation from the average luminous intensity of the reference-LID
- Maximum percentage deviation from the maximum luminous intensity of the reference-LID $f_{I_{max,\ rel\,I_{R_{max}}}}$, Eq. (10), in addition, the maximum positive percentage deviation and the maximum negative percentage deviation from the maximum luminous intensity of the reference-LID
- Maximum percentage deviation from the corresponding luminous intensities of the reference-LID based on the corresponding luminous intensities of the reference-LID; in addition, the maximum positive percentage deviation and the maximum negative percentage deviation from the corresponding luminous intensities of the reference-LID based on the corresponding luminous intensities of the reference-LID
- ϑ- and φ-direction of all maximum deviations
- Contrast measure by T. Bergen (modified by scaling on total solid angle) f_{lumi_w}, Eq. (12)
- Maxima of the mean absolute and percentage zonal deviations and their φ- and ϑ- directions: zonal distance measures $f_{I_{abs,\varphi_l}}$, $f_{I_{abs,\vartheta_k}}$, $f_{I_{rel\,\overline{I_R},\varphi_l}}$, $f_{I_{rel\,\overline{I_R},\vartheta_k}}$, $f_{I_{rel\,I_{R_{max}},\varphi_l}}$ and $f_{I_{rel\,I_{R_{max}},\vartheta_k}}$, Eqs. (13), (14), (15), (16), (17) and (18)

Result LIDs

The following LIDs are displayed in the tab windows of the visualisation area:

- Tab window „ACTUAL, ALIGNED TO REFERENCE“: actual LID after coordinate alignment
- Tab window „ABS. DIFFERENCES“: LID of the absolute values of the differences between actual and reference-LID
- Tab window „ABS. DIFF., MAPPED ONTO REF.-LID“: reference-LID, colour coding of the absolute values of the differences between actual and reference-LID
- Tab window „DIFF., MAPPED ONTO REF.-LID: reference-LID, colour coding of the signed differences between actual and reference-LID
- Tab window „ABS. DIFF. IN REL. TO REF.-LID“: reference-LID, colour coding of the absolute values of the differences between actual and reference-LID in relation to the luminous intensity values of the reference-LID
- Tab window „DIFF. IN REL. TO REF.-LID: reference-LID, colour coding of the signed differences between actual and reference-LID in relation to the luminous intensity values of the reference-LID

Automatic saving of comparison results

If the flag „AUTOSAVE“ is active (see paragraph 3.2), the following result data of the most recent LID-comparison are saved in the directory, specified by the entry “AUTOSAVEDIR“ (note: the files are overwritten by each new LID-comparison).

File	Content
LidMatchReference.ttl LidMatchActual.ttl	Actual und reference-LID
LidMatchLumFluxesReference.txt LidMatchLumFluxesActual.txt	Luminous flux portions of the LID-cells of the actual und reference-LID in the section „[Lvk/DataLFlux]“ (data order same like in TechnoTeam‘s own LID format (*.ttl))
LidMatchActualRotManually.ttl	Rotated actual LID
LidMatchActualSmoothManually.ttl	Smoothed actual LID
LidMatchActualRotBack.ttl	Actual LID transformed by the principal component analysis
LidMatchRMSEZonal.txt	Zonal measures (see paragraph 1.4.2.2)
LidMatchAbsDistances.ttl	Absolute values of the Difference-LID,
LidMatchDistancesMapped.ttl	Difference-LID, mapped to the reference-LID
LidMatchAbsDistancesMapped.ttl	Absolute values of the Difference-LID, mapped to the reference-LID
LidMatchRelDistancesMapped.ttl	Difference-LID in relation to the reference-LID, mapped to the reference-LID
LidMatchRelAbsDistancesMapped.ttl	Absolute values of the Difference-LID in relation to the reference-LID, mapped to the reference-LID

2.9. Save result LIDs

The result LIDs can be saved by pressing the buttons "Save averaged reference-LID as ...", "Save aligned actual LID as…", "Save difference-LID as..." and "Save mapped differences as..." in the formats mentioned in paragraph 2.2.

Fig. 2.11: Buttons for saving the result LIDs

2.10. Visualisation

The source and the result LIDs are visualised in the right-hand section of the dialog. Each LID (cf. paragraph 2.6, Result LIDs) is indicated in a tab window which is named accordingly. The luminous intensity values of a LID are represented as a three-dimensional closed surface. The surface elements are coloured according to the luminous intensity values of the LID. The correspondences between luminous intensity and colour shade are defined through a selectable colour palette displayed in the right-hand margin of the visualisation window.

<u>Observer’s perspective</u>

The observer's perspective (zoom, rotation, and shift) can be changed in an interactive way by means of the mouse or keyboard as follows:

- Left mouse button + mouse movement: rotation
- Right mouse button + mouse movement: zoom
- Mouse wheel: zoom
- Shift-key + left mouse button + mouse movement: shift
- Ctrl-key + left mouse button + mouse movement: rotation around the normal of the screen
- Double-click on left mouse button: shift and zoom to initial state
- Double-click on left mouse button + Ctrl- or Shift- or Alt-key: shift and zoom to initial state, selection of predefined observer's directions (cf. main menu entry „CAMERA")

Visualisation of the light intensity of a LID-cell

If the mouse pointer is located inside the area of the displayed LID-body, the display of the light intensity of the LID-cell, which is located closest to the mouse pointer, is activated by pressing the 'p'- or the 'P'-key (Fig. 2.12). It is disabled, when the 'p'- or the 'P'-key is pressed and the mouse is located outside of the visualised LID-body.

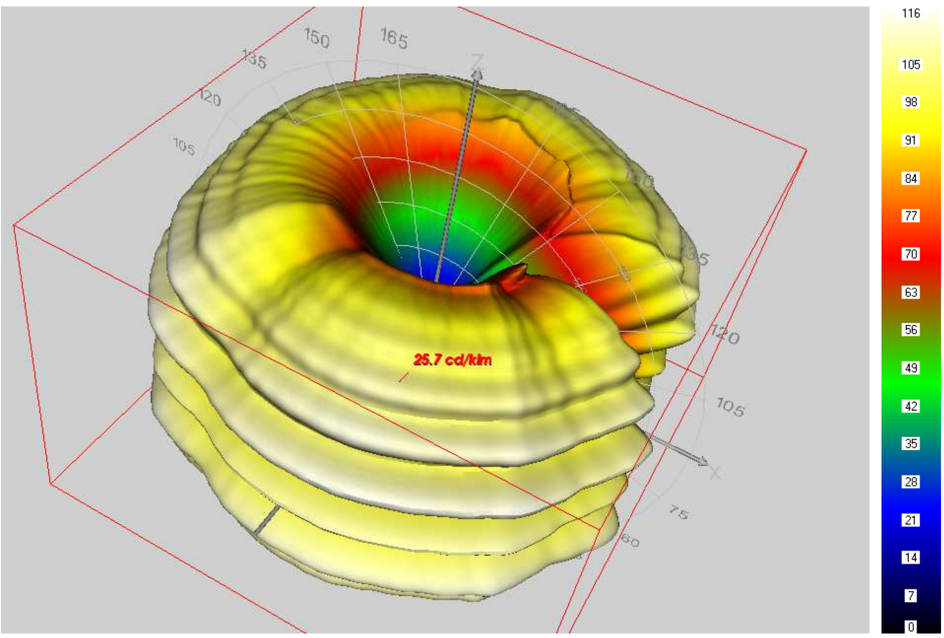

Fig. 2.12: Visualisation of the light intensity of single LID-cells

Menu of the visualisation window

The entries in the menu of the visualisation window in the upper window margin have the following meaning:

Main menu entry „INFO"

- „DETAILS…": cf. paragraph 2.2, buttons „INFO..."

Main menu entry „VIEW"

- „Representation | Surface, Grid, Dots“: representation of the LID entries as surface, grid or points
- „Representation | Normalisation | …“: offers different kinds of normalisation of the LID values.
    - „… | Off [cd]” displays the absolute luminous intensity values.
    - „… | Lamp luminous flux 1000 lm [cd/klm]” displays the luminous intensity values standardised to a lamp luminous flux of 1000 lm (common representation in lighting planning).
    - „… | Maximum luminous intensity [%]”displays procentual normalisation to the maximum luminous intensity.
    - „… | Mean luminous intensity [%]” displays procentual normalisation to the mean luminous intensity.
- „Representation | Consistent LID scaling “: identical display of all tab windows scaled to the maximum of all LIDs, or individual scaling to the maximum of the respective LID
- „Representation | LID smoothing“: display of a smoothed surface on/off
- „Representation | Logarithmic scaling“: logarithmic scaling of the colour palette on/off
- „Components | cartesian coordinate system “: display of the Cartesian coordinate system on / off
- „Components | Polar coordinate system…“: display of a sub-dialog for selecting the C plane indicated
- „Components | LID surface“: display of the LID surface on / off
- „Colors | Coordinate axes, Background“: dialog-based selection of the colours of the coordinate axes or also of the window background
- „Colors | Color palette“: selection of the colour palette

Main menu entry „Camera“

- „Views“: selection of predefined observation directions or also rotations („Top“ (0°,0°), „Bottom“ (0°,180°), „Left“ (90°,180°), „Right“ (90°,0°), „Front“ (0°,270°), „Back“ (0°,90°), „SW isometric“ (45°,45°), „SE isometric“ (45°,45°), „NE isometric“ (45°,45°), „NW isometric” (45°,45°),
- „Position…“: submenu for the dialog-controlled modification of the observer’s perspective
- „Uniform camera settings”: identical observer’s perspective of all visualisation windows or individual observer’s perspective

<u>Context menus</u>

Fig. 2.13: Popup- menus of the LID visualisation window and of the colour palette

By pressing the right mouse button in the region of the visualisation window, a context menu is displayed which allows the user to copy the current graphic illustration into the Windows clipboard or to save this illustration in different formats. Via the context menu of the colour palette, the palette can be hidden or another colour palette can be selected.

Visualisation of the LID-differences

As explained in paragraph 1.5, besides the direct visualisation of the LID differences, also the display of the reference-LID together with a colour coding of the LID luminous intensity differences - rather than the display of the luminous intensity values of the reference-LID – is advantageous for determining the position and distribution of local deviations. Furthermore, such a representation permits the differences to be illustrated with a sign. In addition to the display of the absolute values of the difference LID, the differences are displayed in the above-mentioned representation with two different colour codings in two additional visualisation windows. Some relevant explanations and examples are given in paragraph 1.5.

3. Other

3.1. Licensing

The use of the functionality of the LID comparison program requires a valid license. In the case of an invalid license, the program can only be used to display the LID data. The type of the license is a computer-bound multi-user license. If necessary, the license is temporary limited. For the production of a license the software must be installed on the target machine. Then the user has to create a request file by pressing the button "MANAGE LICENSE..." of the main dialogue and the button "CREATE LICENSE REQUEST..." of the following dialogue. The request file contains information about the licensee and the hardware of the computer. On the basis of the request file the company TechnoTeam generates a license file (TechnoTeam license file, *.tlf). The license file (default name "LID-MATCH.TLF") must be copied by the user into the installation directory of the lid-comparison software by running the installation file "SETUPLICENSE.EXE". Alternatively, the license can be installed by pressing the button "MANAGE LICENSE..." of the main dialogue and the button "INSTALL LICENSE..." of the following dialogue. If the name of the license file (e.g. "FILENAME.TLF") differs from the default name, the entry "LICENSEFILE=FILENAME.TLF" must be added to the section "[APPLICATION]" of the initialization file "LID-MATCH.INI" of the LID comparison program or the entry should be amended accordingly. When the installation is performed via the dialogue button "INSTALL LICENSE...", this entry is automatically amended.

3.2. Initialisation file

In the initialization file „LID-MATCH.INI“ the current settings of the program interface and various parameters for controlling the procedures of the LID-comparison are stored. The file is located in the installation directory of the software ‚LID-Match‘. The initialization file is a text file in the Windows INI format, which means the file is divided into sections and each section can have multiple entries in the form of key-value pairs. The order of the sections is arbitrary. The initialization file entries have the following meaning:

Section	Key	Value
[CONTROLS/…]		Parameters of the controls in the left dialog area
[VTKLVKVIEW/…]		Display tab settings for the visualisation of the source and result LIDs in the right dialog area
[APPLICATION]	COMPARISONINDEX	Continuous index of LID-comparison
[APPLICATION]	LOGFILE	Name and location of the log file (default: LID-Match.txt)
[APPLICATION]	LICENSEFILE	License file name (default: LID-Match.tlf)
[APPLICATION]	AUTOSAVE	Flag for the automatic saving of comparison results (0 / 1 - Saving on / off, default: off)
[APPLICATION]	AUTOSAVEDIR	Directory for automatic storing of comparison results (default: installation directory)