# Luminous Intensity Distribution Curve Effect on Luminaire Placement

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## Abstract

The paper discusses a way to deploy a given number of point light sources in the interior to provide required illuminance levels and uniformity of the working plane by using a genetic algorithm. Furthermore a genetic algorithm has been used to generate a proper luminous intensity distribution curve of multiple luminaires to meet the given criteria for the reference plane of the model room for predefined luminaire positions.

## The model room

For this project an administrative model room has been chosen of dimensions 10 m x 5 m, 4 meters high with light sources 3.5 m above the floor. This model room has been chosen to serve for handwriting, writing on typewriters, reading and processing data according to reference number 5.26.2 in ČSN EN 12464 - 1. For this instance there are several conditions that had to be met:

$E_m$ ... Maintained Average Illuminance of 500 lx at least
$UGR_L$ ... Unified Glare Rating of 19 at most
$U_0$ ... Lighting Uniformity of 0.6 at least
$R_a$ ... General Color Rendering Index of 80 at least

To meet the mentioned standard, average illuminance of the reference plane 75 cm above the floor must be greater than the defined level Em at all times. The maintenance factor MF, defining the depreciation of design level luminous flux over the course of operation, has not been taken into account for the chosen model room. Also UGRL and Ra were not included into considered.

As it has been expected, the wider the luminous intensity distribution curves are, the more distant from walls the light sources will be placed by the genetic algorithm.
For very narrow curves there appeared a regular grid pattern as the optimal solution (1). The grid pattern can be found also in case of the cosine light source (2), although the grid is rotated. This rotation was probably caused by the restriction to get an exact light uniformity value.
The greatest distances between ligth sources are found in case of solution 3. The GA always tried to set the sources in the diagonals of the room for several runs of the algorithm. It was difficult to design the positions with light uniformity exatly 0.6 here. So it would be suitable to make some changes in the requirements or decrease the count of sources in this solution.

## The paper deals with two tasks of lighting system design:

- a) Parameters of light sources are known (luminous intensity distribution curves), number of used light sources is also known. Variable is only the light source placement and a luminous intensity multiplication factor.
- b) Position and number of light sources is known. Design consists of finding an appropriate luminous intensity distribution curve.

Luminous intensity distribution curves in rows 5 to 8 were found for specified positions. Solutions 5 and 6 consist of six light sources and solutions 7 and 8 consist of four light sources. As seen on these figures, the greater the distance of the light sources from the walls, the wider the luminous intensity distribution curves.

## Radiosity

Radiosity is a global illumination algorithm used in 3D computer graphics rendering. Radiosity and the chosen model room surfaces use the same Lambertian reflectance making it possible to use Radiosity procedures within this project.
After applying the finite element method (dividing the surfaces of the model room into smaller facets), the initial luminous flux incident on the facets can be calculated, which is used to calculate the following reflections. It has been decided to use three subsequent reflections not to make the calculations too time consuming.

The luminous intensity distribution curve generated by GA for the situation from row 8 has been reused as an input for the previous placement design. Light sources have been placed similarly to the same coordinates

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## Genetic algorithm definition (Freebase)

In the computer science field of artificial intelligence, a genetic algorithm is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems. Genetic algorithms belong to the larger class of evolutionary algorithms, which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover.

Genetic algorithms have been used to place defined symmetrical model light sources into a model room of 5 m x 10 m and 4 meter height with the goal to design a lightning system complying with ČSN EN 12464 - 1. Another goal has been to design the light sources' luminous intensity distribution curves for the same model room if their positions were known again to comply with the same czech standard.

a) light source position design

b) luminous intensity distribution curve design