Road lighting design by means of genetic algorithm

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Project goals

- Road lighting design for lighting situation C1 and lighting class S4
- Meeting requirements of standards:
  - Maintained average horizontal illuminance

    $$\bar{E}_M \geq 5\,lx$$

  - Minimum maintained illuminance

    $$E_{min,M} \geq 1\,lx$$

  - Uniformity – given by maximal illumiance

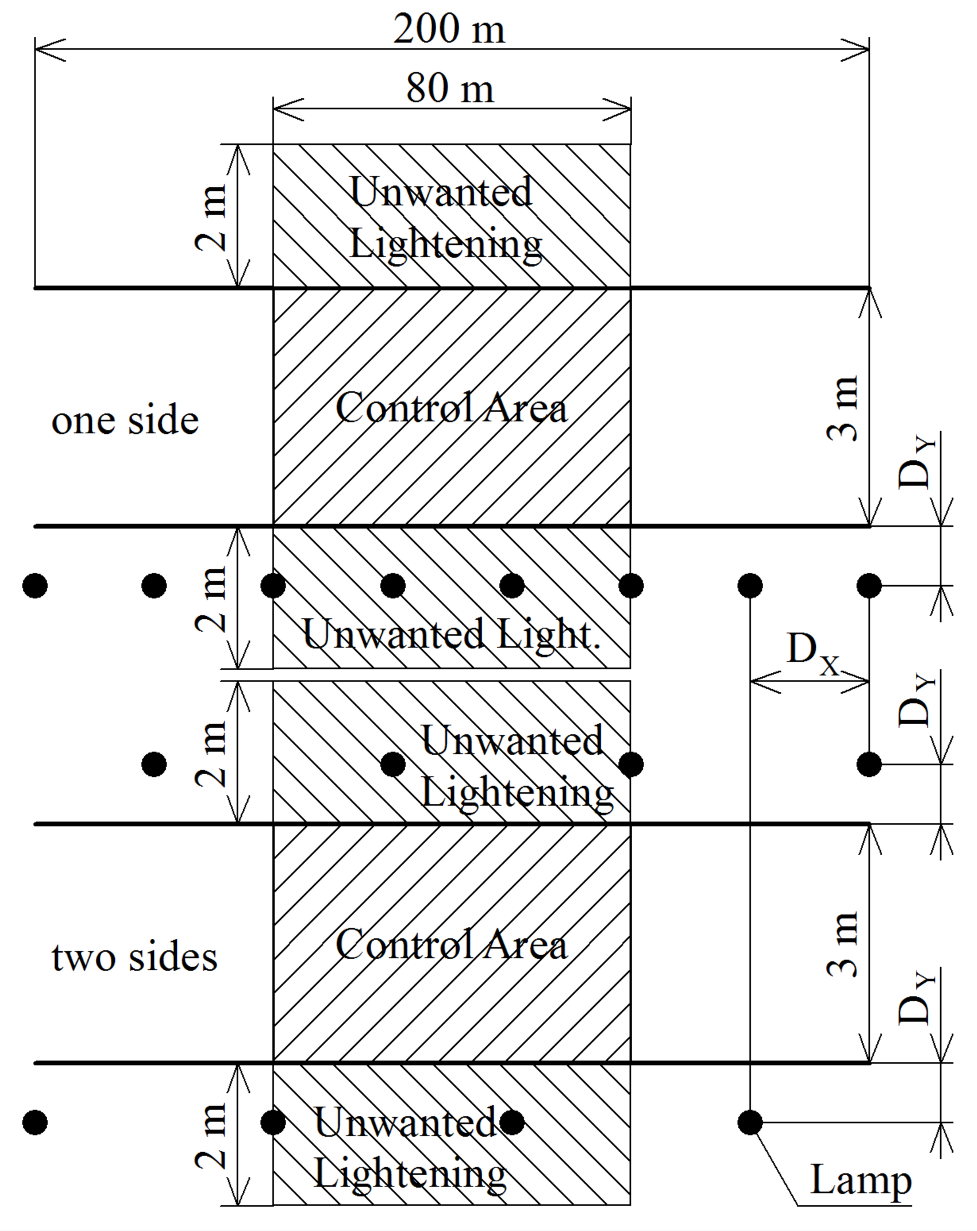
    $$E_{max,M} = 7.5\,lx$$

Input variables

- Dx - distance between pillars
- Dy - sidewalk lamp overlap
- Z - pillar high
- α – lamp tilt
- Single-side vs. two-side lamp placement

Situational overview

Dimensions:
total sidewalk length 200 m
sidewalk width 3 m
control area length 80 m
unwanted lighting area
width 2 m



Used luminaires

- Schréder Atos types A1 – A4, B1 – B4, C1 – C4
- Power consumption 50 W to 150 W
- Designed for pedestrian zones, cycleways, emergency lanes, etc.

Optimalization method

- A genetic algorithm has been used using Matlab
- Output data validity has been confirmed by comparison with Dialux output

Genetic algorithm settings

- Amount of generations: 60
- Population elements: 200
- Crossover probability: 80 %
- Mutation probability: 5 %
- Parent selection: roulette

Fitness function

$$fitness = w_1 \cdot w_2 \cdot w_3 \cdot w_4$$

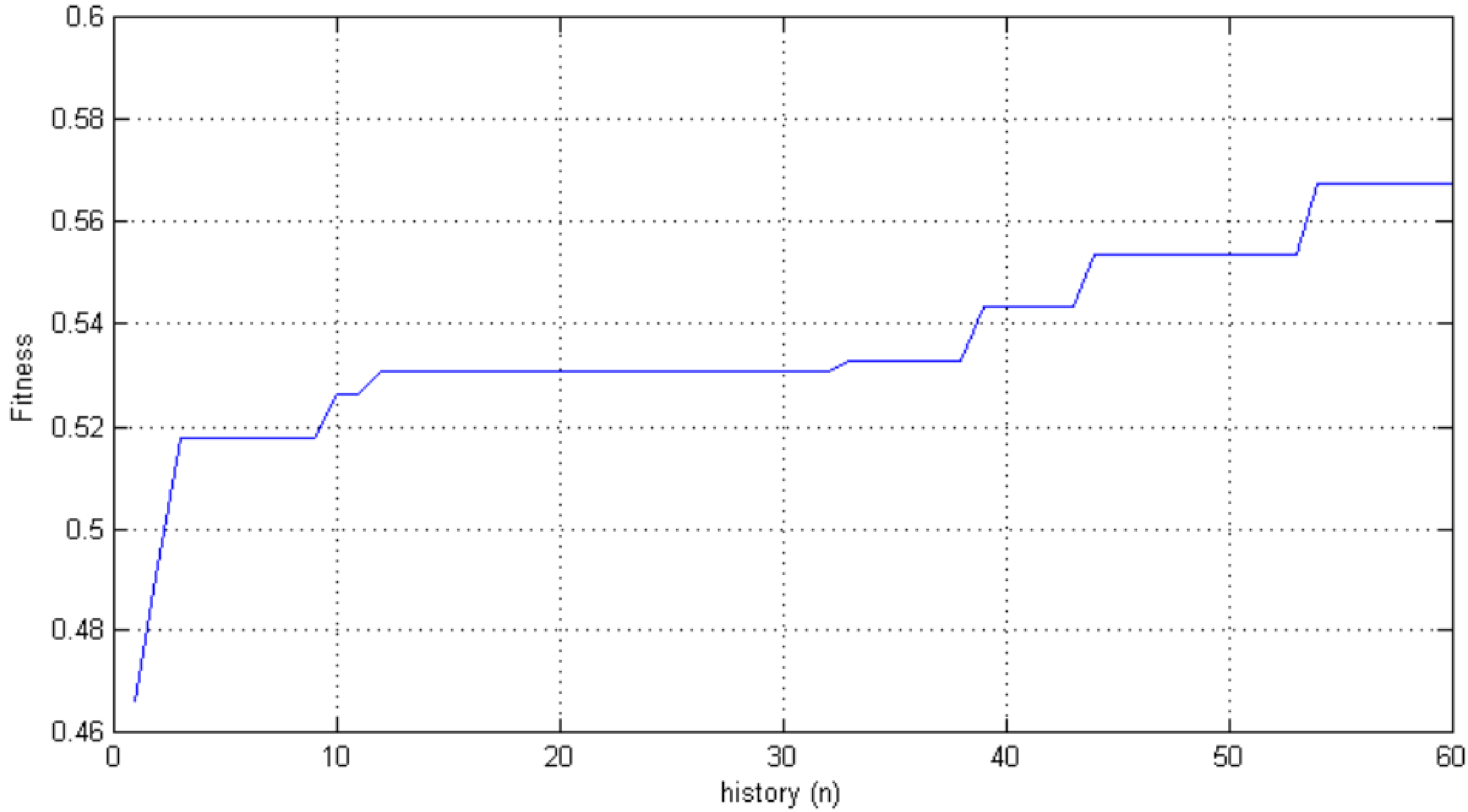
$$w_1\left(E_{min}\right) = \begin{cases} e^{10\cdot(E_{min}-E_{mT})} & , \langle 0, E_{mT} \rangle \\ e^{\frac{E_{mT}-E_{min}}{10}} & , \left(E_{mT}, \infty\right) \end{cases}$$

$$w_2\left(\overline{E}\right) = \begin{cases} e^{\overline{E}-\overline{E}_T} & , \langle 0, \overline{E}_T \rangle \\ e^{\overline{E}_T-\overline{E}} & , \left(\overline{E}_T, \infty\right) \end{cases}$$

$$w_3\left(\overline{E}_o\right) = e^{\frac{\overline{E}_o}{100}}$$

$$w_4\left(D_X\right) = \left(\frac{D_X}{D_{XM}}\right)^2$$

Fitness function curve during optimization



Optimization results

Type	D_X (m)	D_Y (m)	Z (m)	α ($^\circ$)	$\overline{E}$ (lx)	E_{min} (lx)	$\overline{E}_o$ (lx)
ATOS 70W A1	39.8	0.67	6.22	3.15	8.14	1.31	7.40
ATOS 70W A2	41.8	-0.73	[illegible]	2.43	8.13	1.42	7.25
ATOS 70W A3	44.9	-1.69	[illegible]	3.34	8.15	1.36	6.86
ATOS 70W B4	49.5	-1.59	7.69	2.54	8.13	1.72	6.76
ATOS 70W C1	37.6	-0.60	6.23	6.57	8.13	1.38	7.65
ATOS 70W C2	41.14	-0.59	6.72	1.86	8.14	1.50	7.30
ATOS 70W C3	45.1	-0.75	6.56	5.49	8.14	1.31	6.91
ATOS 70W C4	48.0	0.03	6.85	6.70	8.14	1.36	6.92

Type	D_X (m)	D_Y (m)	Z (m)	α ($^\circ$)	$\overline{E}$ (lx)	E_{min} (lx)
ATOS 70W A1	39.8	0.67	6.22	3.1	8.52	1.36

Conclusions

- After a few generations an optimal solution could be found (60 generations).
- All GA end results were close to results calculated by DIALux and are satisfactory in terms of the required standards.
- The given requirements can be met by multiple solutions. Finding specific solutions can be accomplished by adjusting the fitness function.

Thank you for your attention