OPTIMIZATION OF INDOOR ENVIRONMENTAL QUALITY IN RESIDENTIAL BUILDING USING NON-TRADITIONAL OPTIMIZATION

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ABSTRACT

Overall indoor environmental quality (IEQ) in terms of an occupant’s acceptance has not been considered in many residential buildings neither it is optimized. In this paper, the overall IEQ of residential apartments which are naturally ventilated at the Karunya Institute of technology quarters in Coimbatore was evaluated by 102 occupants in four aspects, namely thermal comfort, indoor air quality, equivalent noise level and illumination level. All the offices considered are naturally ventilated buildings. The results showed that the operative temperature, carbon dioxide concentration, equivalent noise level and illumination level had important effects on the overall IEQ acceptance. Empirical expressions were proposed to approximate the occupant acceptance. The values are optimized using ten different non-traditional optimization techniques. Here, ten non-traditional optimization algorithms were presented. These include: GA, SA, PS, PSO, GL, FMINCON, EA, LGO, glcCluster, glcSolve. A brief description of each method is presented along with a pseudo code to facilitate their implementation. MATLab programs were written to implement each algorithm. The IEQ problem for the Residential buildings of the Karunya University was solved using all algorithms, and the comparative results were presented.

Key words: Indoor Environmental quality, Optimization, GA, SA, PS, PSO, GL, FMINCON, EA, LGO, glcCluster, glcSolve.


1. INTRODUCTION

Indoor environmental quality (IEQ) and occupant comfort are closely related. IEQ parameters are interdependent and must be considered interactively. Other than the office people spend most of the times in their residences. If the residences are also thermally comfortable then their health and other related things like production and so on will not be affected. In the case
of residences also, we have considered only residences where natural ventilation is preferred and closing and opening of the windows and using of fans is maximum.

2. FIELD MEASUREMENTS

Subjective as well as objective evaluations of indoor environmental conditions made by 102 occupants from 11 typical residential apartments in Karunya University were collected through individual interviews. The interviewees were mainly those occupants staying at the quarters of Karunya University the longest time (as compared with other activities), and the housing samples covered 11 residential flats. The inclusion of various apartment types could cover a wide range of probable indoor environmental conditions. The apartments varied in size from 330 m² to 1336.17 m² and were equipped with window.

The indoor physical parameters describing the indoor environmental quality of a space were CO2 concentration (ppm), horizontal illuminance level (lux) and sound pressure level (dBA). Therefore, the measured IEQ data could sufficiently reflect the real-time exposed indoor environment to the respondent. The number of measurements was determined based on the arrangement and partitioning of the specific apartment and the distribution of occupants.

Unlike the measurement approach in office, each assessment sample in residential housing did not necessarily require a separate 15 min physical measurement due to the small living area. In this case, two physical measurements carried out in both dining/living room and bedrooms were considered representative for the assessment of the example apartment case. The IEQ data logged in the dining/living room were considered to be applicable to the individual occupant within the group. Such condition was judged, depending on the space between each occupant.

Being the base for evaluating the energy benchmarking models, effective measurements were essential and thus accurate and reliable data could be obtained through a dichotomous assessment scale, the occupant acceptance of the perceived indoor environment was recorded in the form of direct feedback using the question ‘Is the thermal environment/ indoor air quality/noise level/illumination level being perceived in the residential environment acceptable to you?’ [42] The ranks ‘1(1) Yes, acceptable’ and ‘0(0) No, not acceptable’ were self-explanatory. In order to confirm the validity of a response, each respondent had to use a semantic differential evaluation scale for the subjective assessment of thermal environment and IAQ, and a visual analogue assessment scale for the evaluation of aural and visual comforts. At the end of the survey, an overall IEQ acceptance was determined.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Occupant’s votes on acceptance of a perceiving indoor environmental quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall acceptance $\Theta$</td>
<td>Thermal environment $\varphi_1$</td>
</tr>
<tr>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>U</td>
<td>8</td>
</tr>
<tr>
<td>A</td>
<td>95</td>
</tr>
<tr>
<td>TOTAL</td>
<td>102</td>
</tr>
</tbody>
</table>

U – Unacceptable; A – Acceptable
The overall IEQ acceptance $\theta$ for a resident environment perceived by an occupant expressed by a multivariate logistic regression model is proposed

$$\theta = 1 \quad \frac{1}{1 + \exp (C_{0,0} + \sum_{i=1}^{4} C_{i,0} \phi_i(\xi_i))}$$

Where the regression constants determined from the 102 occupant evaluations; Values of the constants confirm the relative importance of the four contributors to $\theta$, the larger the value, the greater the importance. Occupants were very sensitive to the operative temperature when compared to the other three parameters. Regression coefficients can be evaluated with surveyed occupant responses from residential environment for the overall IEQ acceptance. $C_{0,0}$ and $C_{i,0}$ are the regression constants which can be determined from filed measurements, $\varphi_i$ is the occupant acceptance correlated with the thermal sensation vote $\xi_1$, $\text{CO}_2$ concentration $\xi_2$ (ppm). The equivalent sound pressure level $\xi_3$ (dBA) and the horizontal illumination level $\xi_4$ (lux).

The thermal environment acceptance $\varphi_1$, with the maximum acceptance $= 0.95$, is given below, where $C_{0,1}$ and $C_{1,1}$ are the regression coefficients,

$$\varphi_1 = 0.95 \exp(-(C_{0,1} \xi_1^2 + C_{1,1} \xi_1^3))$$

The acceptances $\varphi_2$, $\varphi_3$ and $\varphi_4$ are expressed by logistic regression models with regression coefficients $C_0i$ and $C_{1j}$

$$\varphi_j = 1 \quad \frac{1}{1 + \exp(C_{0j} + C_{1j} \xi_j^i)}; \quad j = 2, \ldots, 4$$

<table>
<thead>
<tr>
<th>No</th>
<th>variable</th>
<th>$C_{0j}$</th>
<th>$C_{1j}$</th>
<th>$C_{2j}$</th>
<th>$C_{3j}$</th>
<th>$C_{4j}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$\Phi_0$</td>
<td>-33.24</td>
<td>21.95</td>
<td>1.614</td>
<td>11.779</td>
<td>21.90</td>
</tr>
<tr>
<td>1</td>
<td>$\Phi_1$</td>
<td>0.03353</td>
<td>0.2179</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>$\Phi_2$</td>
<td>45.21</td>
<td>0.0257</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3</td>
<td>$\Phi_3$</td>
<td>23.82</td>
<td>0.2981</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>5</td>
<td>$\Phi_4$</td>
<td>-14.08</td>
<td>0.9043</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Various combinations of contributors $i=1, 2, 3, 4$ and the corresponding overall IEQ acceptance were considered. A total of $2^4$ possibilities were found. Taking the binary notation for the acceptance i.e., 0 for ‘unacceptable’ and 1 for ‘acceptable’ the predicted acceptance of IEQ ($\theta$) is calculated.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Survey Sample</th>
<th>Contributors</th>
<th>Predicted acceptance of IEQ $\theta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0 0 0 0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0 0 0 1</td>
<td>$1.188 \times 10^{-5}$</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0 0 1 0</td>
<td>$4.8 \times 10^{-10}$</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0 0 1 1</td>
<td>0.608</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0 1 0 0</td>
<td>$1.18876 \times 10^{-5}$</td>
</tr>
</tbody>
</table>
3. ALGORITHMS

3.1. Genetic Algorithm

3.1.1. Stopping Criteria Reached

The options and the stopping criteria which are set are same as that for the IEQ Office Buildings problem. This case also reaches the final solution by the stopping condition, "the change in the final value of the system is less than $10^{-6}$". Hence we say that the global optimum solution is obtained naturally.

3.2. Simulated Annealing

3.2.1. Stopping Criteria Reached

The options and the stopping criteria which are set are same as that for SA in the IEQ Office Buildings problem. Though the iterations are of large number, this case also reaches the final solution by the stopping condition, "the change in the final value of the system is less than $10^{-6}$". The large number of iterations is because that the SA algorithm is Metaheuristics type. Hence we say that the global optimum solution is obtained naturally.

3.3. Pattern Search

3.3.1. Stopping Criteria Reached

The solution is reached by the stopping condition, “difference in function value less than $10^{-6}$” and also comparatively the iterations are of less in number, this indicates quick convergence. The final value of the solution is naturally obtained.

3.4. Particle Swarm Optimization

3.4.1. Stopping Criteria Reached

The options and the stopping criteria which are set are same as that for PSO in the IEQ Office Buildings problem. This case also the final solution reaches by the stopping condition, “the change in the final value of the system is less than $10^{-6}$” but the specialty is the elapsed time which is less than other solvers. The global optimum solution is obtained without any other stopping conditions.

3.5. GODLIKE

3.5.1. Stopping Criteria Reached

The options and the stopping criteria which are set are same as that for GODLIKE in the IEQ Office Buildings problem. This case also the final solution reaches by the stopping condition, “the change in the final value of the system is less than $10^{-6}$”. The solver exchanges
the population among the solvers hence the iteration indicates number of times the population is exchanged. The global optimum solution is obtained without any other stopping conditions.

3.6. Fmincon

3.6.1. Stopping Criteria Reached

The options and the stopping criteria which are set are same as that for Fmincon in the IEQ Office Buildings problem. This case also the final solution reaches by the stopping condition,” the change in the final value of the system is less than $10^{-6}$”. The global optimum solution is obtained without any other stopping conditions. The exception is that the elapsed time is high comparatively; this is due to the traditional technique modified version of using lagranges multipliers.

3.7. Direct Evolution

3.7.1. Stopping Criteria Reached

The options and the stopping criteria which are set are same as that for DE in the IEQ Office Buildings problem. This case also the final solution reaches by the stopping condition,” the change in the final value of the system is less than $10^{-6}$”. It is seen from the results that the final vectors (parameter values) is not consistent, this is because DE uses different type of cross over method. The global optimum solution is obtained without any other stopping conditions.

3.8. LGO

3.8.1. Stopping Criteria Reached

The options and the stopping criteria which are set are same as that for LGO in the IEQ Office Buildings problem. The global solution reaches by the stopping condition,” the change in the final value of the system did not improve”. The elapsed time is close to that of other Direct algorithm solvers but it does not use Lipchitz constant

3.9. glcCluster

3.9.1. Stopping Criteria Reached

The default options are taken from the solver from the previous run of the IEQ Office Buildings problem. The global solution reaches by the stopping condition,” the change in the final value of the system is less than $10^{-7}$”. Though glcCluster uses Clustering algorithm in addition it has very less elapsed time.

3.10. glcSolve

3.10.1. Stopping Criteria Reached

The options and the stopping criteria are taken from the previous run of IEQ Office Building problem. The final solution reaches by the stopping condition,” the change in the final value of the system is less than $10^{-6}$”. glcSolve uses one of the complex algorithm and even after giving long range values for parameters (which is not recommended) it takes little time to complete optimization.
Table 4 Comparative results of optimization methods for Resident IEQ.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Thermal sensation vote</th>
<th>Co2 concentration</th>
<th>Sound pressure level</th>
<th>Horizontal Illumination</th>
<th>IEQ</th>
<th>Time</th>
<th>Iterations</th>
</tr>
</thead>
<tbody>
<tr>
<td>GA</td>
<td>0.003</td>
<td>678.9818</td>
<td>67.1265</td>
<td>773.53238</td>
<td>1</td>
<td>0.6949</td>
<td>51</td>
</tr>
<tr>
<td>SA</td>
<td>0</td>
<td>915</td>
<td>67</td>
<td>854.5</td>
<td>1</td>
<td>1.1147</td>
<td>2000</td>
</tr>
<tr>
<td>PS</td>
<td>0</td>
<td>915</td>
<td>67</td>
<td>854.5</td>
<td>1</td>
<td>0.1331</td>
<td>20</td>
</tr>
<tr>
<td>PSO</td>
<td>0.006</td>
<td>967.495</td>
<td>67.0004</td>
<td>769.92745</td>
<td>1</td>
<td>0.1259</td>
<td>55.35</td>
</tr>
<tr>
<td>GODLIKE</td>
<td>0.00001</td>
<td>880.7472</td>
<td>67</td>
<td>896.74398</td>
<td>1</td>
<td>1.5573</td>
<td>4</td>
</tr>
<tr>
<td>fmincon</td>
<td>0</td>
<td>901.235</td>
<td>67.0000</td>
<td>884.59</td>
<td>1</td>
<td>5.1069</td>
<td>3208.4</td>
</tr>
<tr>
<td>DE</td>
<td>0.00268</td>
<td>1079.772</td>
<td>68.6362</td>
<td>1605.31387</td>
<td>1</td>
<td>0.004</td>
<td>40</td>
</tr>
<tr>
<td>LGO</td>
<td>0.0027</td>
<td>497.0895</td>
<td>67</td>
<td>931.8641</td>
<td>1</td>
<td>0.4675</td>
<td>3223</td>
</tr>
<tr>
<td>glcCluster</td>
<td>0.00105</td>
<td>882.688</td>
<td>67.4026</td>
<td>1111.1647</td>
<td>1</td>
<td>0.770</td>
<td>1286.98</td>
</tr>
<tr>
<td>glcSolve</td>
<td>0</td>
<td>915</td>
<td>67.611</td>
<td>1299.5</td>
<td>1</td>
<td>0.3379</td>
<td>1529</td>
</tr>
</tbody>
</table>

4. COMPARISON OF RESULTS
The IEQ values for all the ten optimization is 1 and that is the optimum value. The elapsed time is maximum for DE and minimum for PS. The carbon dioxide concentration, sound pressure level and illumination level are more or less the same for all methods. The thermal sensation is neutral for few methods.

5. PARAMETERS
5.1. Thermal Sensation
Thermal comfort is that condition of mind which expresses satisfaction with the thermal environment. Thermal environment encompasses characteristics of the environment which affects a person’s heat loss. In terms of bodily sensations, thermal comfort is a sensation of hot, warm, slightly warmer, neutral, slightly cooler, cool and cold.

5.2. Carbon Di-Oxide
Carbon dioxide (CO2) is the chief greenhouse gas that results from human activities and causes global warming and climate change. Though carbon dioxide is not toxic in itself, the amount found in the indoor environment is used as an indicator for human comfort. Elevated levels of carbon dioxide indicate that an insufficient amount of fresh, outdoor air is being delivered to the occupied areas of the building. This also indicates that other pollutants in the building may exist at elevated levels since there is not enough fresh air to dilute them. Since carbon dioxide is an unavoidable, predictable, and easily measured product of human occupancy, it is used as a marker for other pollutants emanating from humans or other sources.
in the building. Carbon dioxide is mostly a threat to health, when the concentration is high enough to displace the oxygen, which can lead to suffocation in a confined space.

![Figure 2 Graph for Carbon Dioxide results in all 10 methods](image)

**Figure 2** Graph for Carbon Dioxide results in all 10 methods

![Figure 3 Comparative graph for residence thermal comfort](image)

**Figure 3** Comparative graph for residence thermal comfort

### 5.3. Sound Pressure Level

Acoustics is the interdisciplinary science that deals with the study of all mechanical waves in gases, liquids, and solids including vibration, sound, ultrasound and infrasound. The perception of sound in any organism is limited to a certain range of frequencies. Hearing loss due to prolonged exposure to noise is well documented. Excessive noise also has an adverse effect on personal health and wellbeing, ability to perform quiet tasks, and productivity in general. Because land is becoming scarcer, buildings are being constructed closer together and closer to noise sources such as highways, railways, and airports. As a result, sound or acoustic control is becoming increasingly important. The reduction of airborne sound through a wall is called sound transmission loss (STL).

http://www.iaeme.com/IJCIET/index.asp 384 editor@iaeme.com
5.4. Horizontal Illumination

Lighting or illumination is the deliberate application of light to achieve some aesthetic or practical effect. In some design instances, materials used on walls and furniture play a key role in the lighting effect. Surfaces or floors that are too reflective create unwanted glare. Specification of illumination requirements is the basic concept of deciding how much illumination is required for a given task. Clearly, much less light is required to illuminate a hallway or a bathroom compared to that needed for a word processing workstation. Generally speaking, the energy expended is proportional to the design illumination level. Beyond the energy factors being considered, it is important not to over-design illumination, lest adverse health effects such as headache frequency, stress, and increased blood pressure be induced by the higher lighting levels. In addition, glare or excess light can decrease worker efficiency.
5.5. IEQ

![Graph for IEQ results in all 10 methods](image)

**Figure 6** Graph for IEQ results in all 10 methods

5.6. Elapsed Time

CPU time is the time for which the CPU was busy executing the task. It does not take into account the time spent in waiting for I/O (disk IO or network IO). Since I/O operations, such as reading files from disk, are performed by the OS, these operations may involve noticeable amount of time in waiting for I/O subsystems to complete their operations. This waiting time will be included in the elapsed time, but not CPU time. Hence CPU time is usually less than the elapsed time.

![Graph for Elapsed time results in all 10 methods](image)

**Figure 7** Graph for Elapsed time results in all 10 methods

5.7. Iterations

Iteration is a computational procedure in which a cycle of operations is repeated, often to approximate the desired result more closely. Iteration means the act of repeating a process usually with the aim of approaching a desired goal or target or result. Iteration in computing is the repetition of a process within a computer program. It may also refer to the process of iterating a function i.e. applying a function repeatedly, using the output from one iteration as
the input to the next. Another use of iteration in mathematics is in iterative methods which are used to produce approximate numerical solutions to certain mathematical problems.

Figure 8 Graph for Iterations results in all 10 methods

Table 5 Comparative table for parameters in all 10 methods

<table>
<thead>
<tr>
<th>Variables</th>
<th>GA</th>
<th>SA</th>
<th>PS</th>
<th>PSO</th>
<th>GL</th>
<th>fmincon</th>
<th>DE</th>
<th>LGO</th>
<th>Glc Cluster</th>
<th>Glc Solve</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMV</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CO2</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>915</td>
<td>915</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sound</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>67</td>
<td>67</td>
<td>X</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Illumination</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
<td>854.5</td>
<td>854.5</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>✓</td>
</tr>
<tr>
<td>IEQ</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>TIME</td>
<td></td>
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<td></td>
<td>0.13</td>
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<td>ITERS</td>
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<td>✓</td>
<td>20</td>
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<td>X</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

✓ - Represents the parameters are consistent for all the 20 trials and the corresponding parameter values are given in the respective cell.

X - Represents the parameters are not consistent for all the 20 trials

In case of iterations and elapsed time only the two or three minimum values alone are given.

6. RESULT AND DISCUSSION

With the two extreme values of parameters from survey, the optimization is carried out with different solvers. As they are of stochastic type their results may vary from trial to trial so and the problem is made to run for 20 trials (Elbeltagi, Tarek Hegazy, & Grierson, 2005) and an average of all trials is taken as the final value of the parameter, by the solver. The solvers are compared with different criteria.
Consistency
The consistency table gives the parameters that remain constant for all the trails. All the solvers give the same value of IEQ for all the runs. Which in turn indicate that the quality requirements are in the acceptable range.

Thermal – PS (0), NL (0), SA (0), glcSolve (0), glcCluster (0), LGO (0.0027)
CO₂ – PS(915), SA(915), glcSolve (915), LGO (497)
Sound - PS(67), SA(67), glcSolve (67.611), glcCluster (67.611), LGO (67)
Illumination - PS(854.5), SA(854.5), glcSolve (1299.5), LGO (931.86)

So we see that the solvers SA, Pattern Search, glcSolve, glcCluster & LGO remain constant throughout their runs.

Minimum Run Time
For minimum run time of the problem we got PSO (0.12 seconds), Pattern Search (0.13 seconds).

Minimum Evaluation
This criterion will determine the effectiveness of the algorithm. From the result table we see that the Pattern Search and GODLIKE algorithms have minimum evaluation of 20 and 4 respectively

Simplicity of Algorithm
Of all the algorithms we have taken the Pattern Search algorithm is the most simplest followed by GA, PSO, DE, Simulated Annealing, GODLIKE, Non-Linear, Direct algorithm.

Results according to Standards
This is the most important criterion that determines whether the solver is practical or not. We got the standard values from ASHRAE, IES, Guidance for employers on the Control of Noise at Work Regulations 2005 as:

- Thermal comfort: -3 to 3
- Carbon dioxide: less than 1000 ppm
- Sound level: 40 dBA to 70 dBA
- Illumination level: 800 lux to 1200 lux

With the above standards the solvers which adhere to the standard are:

- Thermal comfort: GA, SA, PS, PSO, FMINCON, DE, GL, LGO, glcCluster, glcSolve
- Carbon dioxide: GA, SA, PS, PSO, FMINCON, GL, LGO, glcCluster, glcSolve
- Sound level: GA, SA, PS, PSO, FMINCON, DE, GL, LGO, glcCluster, glcSolve
- Illumination level: SA, PS, FMINCON, GL, LGO, glcCluster,

The following table gives a summary of all the criteria for the solvers:
Table 6 Summary of all the criteria for the solvers

<table>
<thead>
<tr>
<th>Criteria</th>
<th>GA</th>
<th>SA</th>
<th>PS</th>
<th>PSO</th>
<th>Fmincon</th>
<th>DE</th>
<th>GL</th>
<th>LGO</th>
<th>glcClus</th>
<th>glcSolve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>75%</td>
<td>100%</td>
<td>75%</td>
<td>100%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
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<tr>
<td>Consistency</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Min-Run Time</td>
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<td>✓</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>Min-Evaluation</td>
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<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
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<td>-</td>
<td>✓</td>
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<td>-</td>
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<td>-</td>
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</tbody>
</table>

Thus it is seen that the Pattern Search solver satisfies all the criteria and scores 100% for its practicality in giving result according to ASHRAE, IES, Guidance for employers on the Control of Noise at Work Regulations 2005. So the appropriate algorithm, for optimization of thermal comfort is suggested as **Direct search algorithm** & the solver is **PATTERN SEARCH**

7. CONCLUSIONS

Overall indoor environmental quality (IEQ) in terms of an occupant’s acceptance has not been considered in many residential buildings neither it is optimized. In this study, the overall IEQ of residential apartments which are naturally ventilated at the Karunya University quarters in Coimbatore was evaluated by 102 occupants in four aspects, namely thermal comfort, indoor air quality, equivalent noise level and illumination level. All the offices considered are naturally ventilated buildings. The results showed that the operative temperature, carbon dioxide concentration, equivalent noise level and illumination level had important effects on the overall IEQ acceptance. Empirical expressions were proposed to approximate the occupant acceptance. The values are optimized using ten different non-traditional optimization techniques.

Here, ten non-traditional optimization algorithms were presented. These include: GA, SA, PS, PSO, GL, FMINCON, EA, LGO, glcCluster, glcSolve. A brief description of each method is presented along with a pseudo code to facilitate their implementation. MATLAB programs were written to implement each algorithm. The IEQ problem for the Residential buildings of the Karunya University was solved using all algorithms, and the comparative results were presented.

REFERENCES


