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The Role of Artificial Intelligence and its Capabilities in the Process of Conceptualizing a Lighting Design

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Degree Project in Architectural Lighting Design

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Abstract

Artificial Intelligence (AI) has been developing rapidly and is currently being used in many industries, including design and architecture. Lighting design is one of these industries where AI can be a valuable tool for developing concepts and designs. This study focuses on the available AI platforms that can be used for the conceptualization of lighting designs and explores the role that AI can play in the design process of a lighting designer.

To evaluate this, ChatGPT was trained to provide image generation prompts which can be used in Midjourney to achieve lighting design concepts as an image. This image was then evaluated and modelled in 3D using DIALux to achieve quantitative parameters, such as illuminance levels, uniformity, unified glare ratings, and other standards mentioned in the EN 12464-1:2021.

In conclusion, although the AI-generated design may appear traditional and outdated, the study highlights that AI can be a valuable tool for conceptualizing lighting designs and can serve as a source of inspiration for designers. However, it is important to note that significant groundwork is still required from the designer. The research further investigates the various capabilities and limitations of AI in the context of lighting design, aiming to identify its true potential in the field.

Key Words:
Artificial Intelligence, Artificial Lighting, Lighting Concepts and Designs, Midjourney, ChatGPT

1. Introduction

Artificial Intelligence (AI) is developing rapidly, with many image processing capabilities that are currently being used to generate interior designs and architectural conceptual output images with just a few keywords. AI platforms such as Midjourney (1) have been developed extensively for this purpose. Architects and designers are already using these platforms to generate conceptual designs for building structures, interiors and also illustrative purposes. Figure 1 is an example of a lecture hall reimagined by Midjourney in the style of Zaha Hadid.

Figure 1: A lecture hall in the style of Zaha Hadid Architect - Created using Midjourney
AI platforms can immensely reduce time spent on conceptualizing designs and can also help develop styles that have become obsolete. Merging different styles of different eras or architects is also a possibility. Indeed, the possibilities are endless with these AI platforms. Architectural and interior designs have already been explored with these platforms allowing for design concepts that have not been explored before. Conceptualizing a design is a complex procedure that requires past experience and creativity, but these platforms can simplify it by using only prompts that are carefully constructed to achieve the required output. The platforms are user-friendly and are also free to use up to a certain extent. This means that even non-professionals in the design field can get a visual idea from key words to achieve a design task.

Architects and designers have been exploring the advantages of AI in their respective fields, and it has been observed that AI has the potential to reduce the time spent on conceptualizing designs, leading to faster development of concepts (2). Despite the advantages of AI in architecture and design, there are concerns among professionals that AI may eventually make their professions obsolete. As Neil Leach, a renowned architect, stated, "AI is putting our jobs as architects unquestionably at risk" (3), and this risk also extends to the field of lighting design. While human creativity, intuition, and critical thinking are essential for architecture and other professions, the rapid development of AI is starting to worry many professionals.

An image generated by AI may be colourful and surreal, but it may not be as actionable as a detailed plan. For instance, an image of a structurally complex building generated by AI that looks aesthetically appealing may pose concerns about its feasibility in terms of accuracy, structural possibility, and costs. AI-generated design concepts raise concerns about the practicality and quality of the concepts provided by these platforms. While these platforms can provide design concepts as images, the designs must also be functional. Moreover, AI-generated designs may lack the human touch and creativity that can make a design unique.

The accuracy and effectiveness of a lighting design are highly important. Although AI can produce images, it is essential to ensure that the illuminance levels, uniformity, and compliance with standards are achieved for the design to be practical and visually comforting. All AI-generated lighting concepts will require human modifications to ensure practicality, realism, and visual comfort. Despite the rapid development of AI platforms, they cannot currently provide accurate design concepts without human intervention. Human involvement is necessary for factors such as luminaire selection, colour temperature selection, evaluating and avoiding flicker, and considering daylight conditions that contribute to visual comfort. This study evaluates the AI's ability to generate a lighting design which can provide inspiration for a lighting designer to develop a design concept.

The aim of this study is to train ChatGPT (4), a text generating chatbot, to provide prompts for Midjourney to create images of a lecture hall in a university which will then be constructed in 3D in DIALux (5). The simulated results in DIALux will be evaluated for illuminance levels, uniformity, and other measurable data to ensure compliance with the EN12464-1 Standards.

With AI as a tool, the design process and the conceptualizing aspects of projects can be made a lot easier and would save time and effort in creating efficient lighting designs. This in result can achieve the UN sustainability Goal 9: “Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation” (6). The use of AI in lighting design is an innovative approach in the industry and will also develop new and creative lighting concepts that are sustainable and efficient. This involves supporting research and development, promoting development and creativity,
and encouraging the adoption of new technologies and practices. As this goal includes developing and improving critical infrastructure that is vital to economic activity and social well-being, lighting will play a significant role in this development as lighting levels, colour temperatures and CRI levels have an impact on cognition and mood (7). This goal also emphasizes the importance of fostering innovation which includes artificial intelligence, which is essential for driving economic growth, improving living standards, and solving global challenges. Resilient infrastructure can involve designing lighting systems that can withstand natural disasters and other disruptions to the power grid, ensuring that essential lighting is available even in emergency situations.

1.1. ChatGPT

ChatGPT is an AI-based conversational agent or chatbot that has been trained on large amounts of text data using the transformer-based language model called GPT (Generative Pre-trained Transformer). It can understand natural language inputs and generate responses to a wide range of queries and questions, and even draw its own conclusions. In this study, ChatGPT 3.5 was used to generate prompts that can be used in Midjourney. An example of ChatGPT in use is shown in Figure 2.

For this work, various inputs such as lighting descriptions and various requirements for a visual comforting lighting design will be provided to ChatGPT to register and examples of Midjourney prompts will be provided so it can generate prompts with more focus on the lighting requirements.

![Figure 2: An example of a response from ChatGPT - Own Image](image)

1.2. Midjourney

Midjourney is an artificial intelligence model that can generate or modify images in real-time. It uses machine learning algorithms to analyse large amounts of data and learn patterns and rules that direct image generation. These algorithms are trained on massive datasets of images and texts, allowing them to recognize and reproduce specific design features and styles. Midjourney takes input in the form of natural language descriptions referred to as prompts and utilizes the machine learning algorithms to create the prompted images. Users can input keywords or phrases related to design styles or aesthetics, such as "minimalist" or "modern", and Midjourney generates images based on these inputs, which can be further customized and refined by the user. It can also incorporate the styles of different architects and generations of different eras of architecture. Prompts such as "Animation", "Outer Space", and "Futuristic" are also possible options to generate concept images. And example image generated by Midjourney is shown in Figure 3.
Midjourney was used in this study as the image generating AI platform with the use of the prompts generated by ChatGPT.

With the use of these AI generators, this study will evaluate a lighting scenario generated by an AI and will take into consideration the possibilities of how AI can be an inspirational and conceptualizing tool to lighting designers.
2. **Method and Process**

The study involved several steps to obtain the desired output, including training ChatGPT to generate prompts for use in Midjourney, creating renderings of a lecture hall using Midjourney, evaluating the results to identify the required light effects and the luminaires needed to achieve them, and simulating a similar scenario in DIALux to evaluate the light levels and obtain measurable data for comparison with the EN 12464-1 (8) Standards.

A flow chart of the work process is shown in the below flow chart in Figure 4.

![Flow chart of method and process](image)

*Figure 4: Flow chart of method and process - Own Image*
2.1. Training ChatGPT to Generate Prompts

In the process of training ChatGPT, information about Midjourney's functioning and an example prompt were provided to help the chatbot understand the format of Midjourney prompts. Afterward, details of lighting standards for a lecture hall/auditorium were fed to the chatbot, enabling it to prioritize and incorporate these standards into the prompts generated.

To train ChatGPT, a conversation was initiated with the chatbot, where questions were asked, and information was fed to it. Subsequently, ChatGPT was programmed to operate as a prompt generator. These prompts were later utilized to generate images in Midjourney. More details on the procedure of training ChatGPT for the prompts can be found in Annexure A.

2.2. Generating Images on Midjourney

Once the prompt was generated, it was then used to generate images on a Midjourney. To run Midjourney, a dedicated server for the Midjourney bot was set up using the Discord (9) application on a desktop computer running Windows 10. The latest version available at the time of the study, Midjourney Version 5, was used for image generation. It is important to note that a paid subscription is required to access Midjourney Version 5.

Midjourney by default provides four different image options for a prompt as shown in Figure 5 which were the results of the first set of images generated for the prompt.

![Figure 5: Initial image Generated by Midjourney with the prompt generated by ChatGPT](image-url)
Multiple variations were generated using Midjourney in order to achieve the desired output, which is shown in Figure 6 which includes all 4 images which Midjourney provided by default. Further variations and a few editing steps were taken to achieve the final image that was used for the evaluation.

The image generating process and the various trials and evaluations processed concerning this has been detailed further in Annexure B.
2.3. **Luminaire Selection**

Once an image was selected from the images generated by Midjourney, the process of luminaire selection was done by evaluating the physical appearances and the photometric distributions of the light effects. The selected image and light effects are illustrated as in the Figure 7. The evaluations of the light are also as below:

- For the diffused general lighting, a luminaire with a diffused light distribution was identified which provided uniform illumination throughout the space.
- For the downlights, luminaires with a wide beam angle were chosen to mimic the distribution depicted in the image generated by Midjourney.
- A cove lighting system was selected to provide indirect illumination for the front wall behind the whiteboard.
- Finally, a wall washer luminaire with a narrow beam angle was chosen to provide accent lighting on the whiteboard.

![Identified Light Distributions and Luminaire Types - Own Image](image)

Considering these light distributions, luminaires available in the market were selected to keep the experiment realistic. No modifications to the fixtures were made when using the selected luminaire in DIALux.
2.4. **DIALux Simulation**

Once the luminaires were selected, the construction of the space in 3-dimensions were one in DIALux.

The dimensions of the space were assumed to be 10m in length, 10m in width and 4m in height. The colour finishes were considered as beige for the walls as per one of the results of a generated prompt, ceiling in white and the floor in a carpet finish of a grey finish. The reflection factors were kept as 70, 50 and 20 for the ceiling, walls and floor respectively. The DIALux utilization profile was also set to EN 12464-1:2021, Educational Building, Lecture Hall setting.

It is important to note that in the PL1 fixture, although the image generated depicts a single linear luminaire, with the available luminaire in the market, two fixtures must be kept next to one another to create the scheme which is depicted in the AI generated image. This creates a fixture with the dimensions of 300×2400mm.

The reflected ceiling plan considered for the lecture hall is shown in Figure 8.

![Figure 8: Floor plan considered for the lecture hall. Dimensions in millimetres - AutoCAD - Own Image](image-url)

Furniture models were selected or constructed to make the appearances of the space as similar as possible and to keep the simulation simple so avoid large loads for the software. As the back wall and the right wall are not visible in the image generated by Midjourney, the right wall was assumed to be
the same as the left wall which is visible, and the back wall was considered a plain white wall like the front wall. The projector and the cove lighting were also excluded from the back wall. As students will be looking forward during the lectures, the downlights to illuminate the walls were not considered for the back wall as well.

The LED strip for the front ceiling cove that was shown as “Detail A” in Figure 8 is shown in Figure 9.

![Figure 9: “Detail A” of ceiling cove considered at the front wall. Dimensions in millimetres - AutoCAD - Own Image](image)

Further DIALux simulation considerations are illustrated and detailed in Annexure C.

### 2.5 Limitations

Certain limitations were imposed on the study to simplify the data that would be compared to the standards and to generate visualizations from the AI. Daylight was one of the main factors that was excluded in the study due to the complexity of the data that needs to be calculated to validate the image generated by the AI. This is because natural lighting is variable due to many reasons, such as sun path, weather, location of the building, and the direction the building is facing. As the AI image generator cannot represent these factors, daylight was excluded.

Dimensions cannot be provided by Midjourney. Dimensions were approximately considered by comparing actual sizes of furniture and testing different room sizes to replicate the reference image as accurately as possible.

The luminaire selected is subjective to the designer. If selection is done by a different lighting designer, the brands and the products can be different, which could result in different light qualities in the DIALux simulation.

Despite AI platforms and applications being advanced and updated on a daily basis, some features are available only through paid subscriptions. Despite Midjourney being accessed via a paid subscription, a higher valued plan has better features that could result in more accurate images. ChatGPT is also a free version that was used, and if the paid subscription of GPT-4 were used, the prompts generated by ChatGPT could have been more accurate and with more details.
3. Results

3.1. ChatGPT prompt

The final prompt generated by ChatGPT is shown in Figure 10.

![Figure 10: Prompt generated by ChatGPT for Midjourney image generator - Own Image](image)

3.2. Midjourney Image Generated

After attempting many variations from the initial image generated by Midjourney (Figure 5), the result used for the evaluation was decided to be Figure 11. The following aspects of the image are noteworthy:

- This figure was specifically selected due to its realistic appearance, with lighting being more uniform and effects being more varied in the same space.

- Recessed panel lights were chosen for general lighting, wall washers for the whiteboard/projector screen, downlights for the walls, and cove lighting for the perimeter.

- The dimensions of this space were considered to be 10×10m with a ceiling height of 4m after testing with default furniture provided in DIALux to make the space spacious and practical.

- Once the image was evaluated for the light distributions and the physical appearances of the luminaires, specifications were made to source similar luminaires available in the market.

- Furniture layouts, surface colours, and shadow evaluations were also taken into account to understand the light distribution scenario provided by the AI image generator.
Figure 11: Final image considered for the evaluation and DIALux Simulation - Own Image
3.3. Luminaire Selection

3.3.1. General Light (PL1)

The most suitable luminaire for the General Lighting was a recessed diffused panel light, despite the rendered image showing a surface mounted fixture. A recessed mounted luminaire was selected as it is more likely to be used in a practical application.

In appearance, the fixture was similar to a 1200×300mm panel light. Therefore, a fixture with this appearance was selected from a leading brand in Sweden, Fagerhult (10).

![Article Number: 23403
Specification:
Mounting Type: Recessed Mounted.
IP Rating: IP44/20
System Power Consumption: 24W
Colour Temperature: 4000K
Beam Angle: Diffused light distribution
Lumen Output: 2485lm
CRI: CRI 90
SDCM: Step 3
Dimensions: 1200×300mm
Finish: White finish.]

![Figure 12: Recessed Panel Light Article 23403 - Fagerhult]

3.3.2. Recessed Downlight (DL1)

A downlight with a wide beam angle was selected as the luminaire to illuminate the wall panels. This luminaire has been placed as a decorative element, but its purpose is also important as it provides more illuminance on the walls, which could help achieve the standards. As the illumination of this element does not appear to be too bright, a luminaire with a moderate lumen output was selected. A black reflector was considered to avoid glare, and the selected luminaire is from Fagerhult.

![Article Number: 73006-402
Specification:
Mounting Type: Recessed Mounted.
IP Rating: IP64/20
System Power Consumption: 10W
Colour Temperature: 4000K
Beam Angle: Wide light distribution
Lumen Output: 1017lm
CRI: CRI 80
SDCM: Step 3
Dimensions: 143×98mm
Finish: White finish with black reflector.]

![Figure 13: Recessed Downlight. Article 73006-402 - Fagerhult]
3.3.3. **Cove Lighting (LL1)**

A cove lighting installed at the edge of the wall at the front of the lecture room is visible in the image generated by the AI. The functionality of this lighting effect is primarily decorative, as it does not provide sufficient illumination on the work surfaces, nor does it significantly illuminate the wall surfaces. Nevertheless, it has the potential to reduce the luminance ratio between the projector screen and the adjacent walls, which can improve the visual comfort in the space. A LED strip from Linea Light (11) was selected for this application.

![LED Strip](image1)

**Figure 14: LED Strip. Article 98012 - Linea Light**

<table>
<thead>
<tr>
<th>Article Number: 98012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification:</td>
</tr>
<tr>
<td>Mounting Type: Surface Mounted</td>
</tr>
<tr>
<td>IP Rating: IP20</td>
</tr>
<tr>
<td>System Power Consumption: 4.8 W/m</td>
</tr>
<tr>
<td>Colour Temperature: 4000K</td>
</tr>
<tr>
<td>Beam Angle: Diffused light distribution</td>
</tr>
<tr>
<td>Lumen Output: 570 lm/m</td>
</tr>
<tr>
<td>CRI: CRI 80</td>
</tr>
<tr>
<td>SDCM: Step 3</td>
</tr>
<tr>
<td>Dimensions: 10×2.4mm</td>
</tr>
<tr>
<td>Finish: Aluminium Channel &amp; Diffuser</td>
</tr>
</tbody>
</table>

3.3.4. **Wall Washer (WW1)**

The wall washer appears to be quite ambiguous as it does not seem to be illuminated in the same way as the other light distributions. However, the illuminated spot on the whiteboard suggests that the object in front of the whiteboard is an asymmetrical wall washer. This design decision is suitable for providing uniformity to the walls, and thus, the use of the wall washer was included in the evaluation of the space. After considering these factors, a luminaire was selected from Fagerhult, which provided the required light effect.

![Wall Washer](image2)

**Figure 15: Recessed Wall Washer. Article 21949 - Fagerhult**

<table>
<thead>
<tr>
<th>Article Number: 21949</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification:</td>
</tr>
<tr>
<td>Mounting Type: Recessed Wall Washer.</td>
</tr>
<tr>
<td>IP Rating: IP20</td>
</tr>
<tr>
<td>System Power Consumption: 24W</td>
</tr>
<tr>
<td>Colour Temperature: 4000K</td>
</tr>
<tr>
<td>Beam Angle: Asymmetric distribution</td>
</tr>
<tr>
<td>Lumen Output: 2485lm</td>
</tr>
<tr>
<td>CRI: CRI 90</td>
</tr>
<tr>
<td>SDCM: Step 3</td>
</tr>
<tr>
<td>Dimensions: 1200×300mm</td>
</tr>
<tr>
<td>Finish: White finish.</td>
</tr>
</tbody>
</table>
3.4. DIALux Simulation

After selecting the luminaires, defining the size of the space, and considering the furniture that will be used in the lecture hall, the space was modelled in 3D using DIALux to obtain measurable data that can be compared to the standards. The parameters required for DIALux, such as the calculation objects and working planes, were established, and the simulation was run with the selected luminaires at the default 100% setting. The resulting DIALux simulation is shown in Figure 16.

![Figure 16: DIALux Simulation Image - Own Image](image)

The results measured to compare with the standards are shown in Table 1.

<table>
<thead>
<tr>
<th>Measured Data</th>
<th>DIALux Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Maintained Illuminance ( \bar{E}_{m,R} ) lx</td>
<td>508 lx</td>
</tr>
<tr>
<td>Upper Maintained Illuminance ( \bar{E}_{m,U} ) lx</td>
<td>508 lx</td>
</tr>
<tr>
<td>Minimum Illuminance Uniformity ( U_0 )</td>
<td>0.55</td>
</tr>
<tr>
<td>Maximum UGR Limits ( R_{UGL} )</td>
<td>&lt;17</td>
</tr>
<tr>
<td>Minimum Cylindrical Illuminance ( \bar{E}_z ) lx</td>
<td>244 lx</td>
</tr>
<tr>
<td>Minimum Average Illuminance On Walls ( \bar{E}_{m,wall} ) lx</td>
<td>206 lx</td>
</tr>
<tr>
<td>Minimum Average Illuminance On Ceilings ( \bar{E}_{m,ceiling} ) lx</td>
<td>136 lx</td>
</tr>
<tr>
<td>Colour Rendering Index</td>
<td>Fixtures selected are CRI &gt;80</td>
</tr>
</tbody>
</table>
4. Discussion

4.1. Prompt Generated by ChatGPT

The prompts generated by ChatGPT had certain characteristics that were improvised and added by the bot itself. For example, the room was described as having audio-visual equipment, using sleek and modern furniture, and walls painted in calming colours. This shows that the bot has its own reasoning skills which helps provide more details to the prompts when necessary.

Training the chatbot had various complications. The first prompts that ChatGPT generated did not provide accurate image results on Midjourney. Initially the prompts which included illuminance and uniformity levels, did not provide an accurate image related to a lecture room. This was due to the AI's inability to illustrate differences in lighting levels. Initially, the prompts that included the number of students were also not accurately interpreted, but after multiple variations, the number of students was automatically illustrated. To generate more detailed prompts, further study is required to understand how ChatGPT can be trained for more accurate lighting interpretations. It should also be noted that extensions such as AIPRM (12) have been developed to automate this process further, where only keywords need to be provided to the extension, and then ChatGPT automatically provides the Midjourney prompt without having to train the chatbot. However, this approach was tested and the results were not as accurate or detailed as when the bot was trained to create the prompts. It is possible that in the future, these extensions will be developed further and training ChatGPT may no longer be necessary. Instead, only keywords will need to be provided.

4.2. Image Generated by Midjourney

The image generated by Midjourney required many variations of the initial images that were generated because certain parameters such as "no windows" were not illustrated. After some variations, the image was of expected quality, which was usable for the DIALux simulation. However, it must be noted that the design provided by the AI was traditional and in a style that has become obsolete in many ways. For example, use of LED panel lights is an outdated method of lighting up a space, while many modern methods could have been illustrated, considering the vast number of luminaire options available in the market. The placement of these panel luminaires was also very symmetrical, and the grouping could have been improved for a more aesthetically appealing manner. The furniture arrangement suits more of a school and a traditional teaching style than a modern university, where different seating arrangements are used depending on the function of the room. The carpet finish is also not common in Europe, whereas it may be used in modern university buildings in the UK or South Asia.

The images generated by the AI without specific prompts, but with the freedom to illustrate a contemporary university lecture room, provided designs that were quite extreme in terms of futuristic aspects. These images were impractical for an evaluation focused on lighting due to the vast number of design elements that needed to be considered and depicted unrealistic setups. Moreover, the dimensions prompted were not accurately depicted in the AI-generated image, and the proportions of the space in comparison to the 3D model were not accurate in terms of the viewing angle.

Despite the traditional setup, placements, and overall design, the generated image had good lighting qualities and accurately interpreted photometric distributions in detail. The image represented a layer of ambient luminescence, focal glow, and a play of brilliants, which can be considered key elements for good lighting design.
The ambient luminescence was achieved by the panel lights installed in the ceiling. However, the placements of these luminaires could have been improved in terms of their grouping. Additionally, the shadows visible from the furniture were soft, which indicated that the lighting was diffused and provided ambient illumination to the space. These soft shadows and the ambient luminescence are clearly shown in Figure 17. Although the use of panel lights is a typical traditional lighting setup, a more contemporary design solution could have been a better outcome.

![Panel Lights providing ambient luminescence.](image1)

*Figure 17: Ambient Luminescence.*

The downlights located near the walls were considered as the focal glow since they provide more illuminance on the walls, while also drawing attention to them. While this is not an ideal situation for a lecture room, it balances the illuminance contrasts between the walls and the space as a whole. As the walls are also darker than the front wall where most attention is directed during a lecture, the light will be absorbed even though there is visible contrast. The focal glow is illustrated in Figure 18.

![Downlights fulfilling the layer of focal glow.](image2)

*Figure 18: Focal Glow*
There is no directly identifiable play of brilliants in Figure 19. However, the whiteboard or the projector screen can be considered as the play of brilliants. If the whiteboard is used as a projector screen, the projected visual itself can be considered as the play of brilliants. At other times when it is used as a whiteboard, the wall washers that are directed at it will illuminate it more than the rest of the elements in the room, making the whiteboard function as the play of brilliants. This is illustrated in Figure 19.

The cove lighting located at the back of the projector can be considered a decorative element that plays the role of a subtle focal glow, balancing the illuminance contrast between the brightly illuminated whiteboard and the empty white wall.

Even though the evaluated design was traditional and boring, it had potential to be practical and functional. The design had vast potential for a more modern and contemporary feel, which could be achieved in the near future with the rapidly developing AI platforms. These advancements could include better image generation with realistic results, AI that can understand numeric values, improved interpretations of lighting effects, and more focused keywords for better results. In addition, there are experimental AI platforms being developed for 3D spaces that could have greater potential for spatial awareness and interpreting lighting effects. By integrating AI into software such as DIALux, these advancements could quickly be developed to make lighting designs more effective and practical.
4.3. DIALux Simulation

The DIALux simulation provided a lighting distribution that was visually very similar to the AI-generated image. The comparison results between the AI-generated image and the DIALux simulation are shown in Figure 20.

![Figure 20: Side by side comparison of AI image (left) and DIALux Simulation (right)](image)

The measurable data obtained from the DIALux simulation was also accurate, providing values that were nearly identical to the EN 12464-1 standards. The only notable noncompliance was the failure to achieve the upper maintained illuminance level and uniformity. However, achieving the required uniformity is possible with some adjustments in the placements of the luminaires and the lumen outputs of the general lights. Table 2 presents a comparison between the standards and the DIALux simulation results.

<table>
<thead>
<tr>
<th>Measured Data</th>
<th>Standard</th>
<th>DIALux Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Maintained Illuminance $\bar{E}_{m,R} \text{lx}$</td>
<td>500 lx</td>
<td>508 lx</td>
</tr>
<tr>
<td>Upper Maintained Illuminance $\bar{E}_{m,U} \text{lx}$</td>
<td>750 lx</td>
<td>508 lx</td>
</tr>
<tr>
<td>Minimum Illuminance Uniformity $U_0$</td>
<td>0.60</td>
<td>0.55</td>
</tr>
<tr>
<td>Maximum UGR Limits $\text{R}_{UGL}$</td>
<td>19</td>
<td>&lt;17</td>
</tr>
<tr>
<td>Minimum Cylindrical Illuminance $\bar{E}_z \text{lx}$</td>
<td>150</td>
<td>244 lx</td>
</tr>
<tr>
<td>Minimum Average Illuminance On Walls $\bar{E}_{m,wall} \text{lx}$</td>
<td>150</td>
<td>206 lx</td>
</tr>
<tr>
<td>Minimum Average Illuminance On Ceilings $\bar{E}_{m,ceiling} \text{lx}$</td>
<td>50</td>
<td>136 lx</td>
</tr>
<tr>
<td>Colour Rendering Index</td>
<td>80</td>
<td>Fixtures selected are &gt;80</td>
</tr>
</tbody>
</table>

The AI-generated image's visual appearance is not an exact match to the DIALux simulation, and it should be noted that the discrepancies are due to inaccurate visualizations in the AI-generated image. This is because the physical dimensions and proportions were not accurate, resulting in a different view of the space. Additionally, the materials used in the AI-generated image do not appear accurately in DIALux because the rendering quality of DIALux is not advanced enough to accurately illustrate the material colours and textures. Further details on this are explained with the difficulties of achieving similar visual images in Annexure D.
5. Further Study

Further study is required to evaluate the daylight qualities of the space. Daylight was not included in this study to simplify the process. There is vast potential for AI to provide a lighting scheme that takes daylight into consideration. To achieve this, factors such as window sizes, required glazing type, sun path, location, and orientation of the space need to be considered. With all these factors taken into account, a daylight factor and illuminance calculation can be made, incorporating daylight during the solar noon hours for the four different seasons of the year, and implemented into the design.

It should be possible for AI to generate a lighting design over an image uploaded by a user. However, further investigation is required to determine the extent to which it can replicate the image with modifications made only to the lighting. This may be possible with more advanced AI platforms that require more expensive subscriptions and with more focused prompts. Detailed testing and evaluation will be required.

The use of dimensions for a space is also a requirement that needs further study. AI should be able to provide a design based on a sketch of a space, taking into account that not all spaces are rectangular or square.

6. Conclusions

In this degree project, a basic and traditional lighting design was developed using ChatGPT and Midjourney to simplify the design process and to understand the potentials of AI. The results showed that AI can be useful for conceptualizing a design, but humans still need to perform much of the groundwork. This includes selecting the luminaire, fine-tuning lamp placement, choosing the correct lumen outputs, selecting control systems and schemes, and validating the design itself.

The results of this study shows that AI cannot visualize a space with dimensions accurately, and the proportions of the space are not always precise. The style of the design provided by AI can be extreme, either too modern or too traditional, as was the case in the design evaluated in this study. Despite accurate and good lighting distributions and quantitative aspects, the qualitative aspect can still be improved. AI, in its current state, can be used as a tool to help conceptualize a design and as a visualizing tool to present a design concept to a client.

It is possible that in the near future, AI will be able to do more, such as evaluating an image provided by a platform like Midjourney and providing luminaire options from manufacturers. Software dedicated to lighting, such as DIALux, AGi32 (13), and Relux (14), could be possible options for these future developments. A time may come when only the dimensions of the space are needed, and software or platform will provide the design with a rendering and calculations, along with the luminaire used, which can be used in a practical situation. However, as of now, human intervention is required to implement the lighting design and practically use it in an actual space and AI can only be used as a conceptualizing tool for initial design stages.

Even today, there are many other benefits to consider when using AI in lighting design. These benefits include using AI to increase the accuracy of a lighting design through precise luminaire placements and design implementations that prioritize human well-being and energy consumption. AI can also help avoid light pollution and glare where necessary. With the use of new technologies and AI, automating lighting control systems purely through AI will provide a significant change in terms of sustainability and efficiency. Other benefits include customization options for users, cost-saving benefits, and the optimization of luminaires, as well as providing luminaire maintenance predictions.
With further developments and the processing of vast amounts of data, AI has the potential to provide faster, more accurate, energy-efficient, and flexible lighting design proposals than human designers. AI can consider aspects that may not be easily identifiable by designers in a single study, which can lead to enhanced accuracy in lighting design. AI has the ability to process all available data in the world and provide a design that considers which aspects are more important to focus on in different scenarios, which is nearly impossible for a human designer to achieve.

Overall, AI has the potential to revolutionize the lighting design industry and contribute to achieving the UN sustainability Goal 9: "Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation." AI algorithms can analyse and process vast amounts of data, enabling designers to create more efficient and effective lighting systems. By reducing energy consumption, increasing efficiency, and promoting innovation, AI can help create a more resilient and sustainable lighting industry. Achieving this will involve supporting research and development, promoting creativity and development, and encouraging the adoption of new technologies and practices. Additionally, AI can automate the lighting design process, saving time and improving productivity. With the help of AI, designers can quickly generate multiple design options, allowing them to explore more creative and innovative solutions. These innovative approaches with the use of AI in lighting design can lead to more sustainable and inclusive practices, aligning with UN sustainability Goal 9.
7. Acknowledgement

I would like to express my gratitude and acknowledge my tutor, Ken Appleman, for the many hours spent reading my work and providing valuable feedback from the very beginning of the thesis. Without his guidance, this achievement would not have been possible. I would like to thank our lecturers, Foteini Kyriakidou, Federico Favero, Rodrigo Muro, Gerhard Rehm, and Ute Besenecker, for sharing their valuable knowledge with us throughout the master's program, guiding us to grow and to become professionals in the lighting industry. I’d also like to mention Jamie Rinder from the Centre of Academic Writing for providing valuable feedback to improve this paper.

I am also grateful to my classmates who have provided continuous motivation and support throughout the master's program, making the journey even more enjoyable.

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10. **Annexure A**

The Annexure A is focused on the details of training ChatGPT to function as a prompting generator for Midjourney.

10.1. **Training ChatGPT**

This task consists of feeding information to ChatGPT to be able to generate prompts that can be used to generate images in Midjourney.

The initial step was to provide information to ChatGPT on the Lighting standard EN 12464-1 relevant to an educational auditorium and lecture hall as shown in Table 3.

<table>
<thead>
<tr>
<th>Ref. no.</th>
<th>Type of task/activity area</th>
<th>$I_m$ required $\text{lx}$</th>
<th>$U_q$</th>
<th>$\rho_a$</th>
<th>$\rho_{DQL}$</th>
<th>$I_{m,\text{max}}$ $\text{lx}$</th>
<th>$I_{m,\text{wall}}$ $\text{lx}$</th>
<th>$I_{m,\text{ceiling}}$ $\text{lx}$</th>
<th>Specific requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.1</td>
<td>Classroom - General activities</td>
<td>500</td>
<td>1,000</td>
<td>0,60</td>
<td>19</td>
<td>150</td>
<td>150</td>
<td>100</td>
<td>Lighting should be controllable, see 6.2.4, for different activities and scene settings. For classrooms used by young children, an $I_m$ required of 300 $\text{lx}$ may be used by dimming (see 5.3.3). Ambient light should be considered, see Annex B, room brightness, see 6.7.</td>
</tr>
<tr>
<td>44.3</td>
<td>Auditorium, lecture halls</td>
<td>500</td>
<td>750</td>
<td>0,60</td>
<td>19</td>
<td>150</td>
<td>150</td>
<td>50</td>
<td>Lighting should be controllable, see 6.2.4, to accommodate various A/V needs, room brightness, see 6.7.</td>
</tr>
<tr>
<td>44.4</td>
<td>Attending lecture in seating areas in auditoriums and lecture halls</td>
<td>200</td>
<td>300</td>
<td>0,60</td>
<td>19</td>
<td>75</td>
<td>75</td>
<td>50</td>
<td>Reduction by dimming. DSE work, see 5.9.</td>
</tr>
<tr>
<td>44.4</td>
<td>Black, green and white boards</td>
<td>500</td>
<td>750</td>
<td>0,70</td>
<td>19</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Vertical illuminances. Spacial reflections shall be prevented. Presenter/teacher shall be illuminated with suitable vertical illuminance.</td>
</tr>
</tbody>
</table>

A conversational method was used to provide the information to ChatGPT to receive the relevant outcome. Examples of similar prompts from experts were also provided to train the chatbot more accurately.

The chat process was as below;

Me: I want you to act as a prompt generator for Midjourney AI. your job is to describe a scene as concisely as possible and always give me 3 options of the prompts. Before we start, i will provide information on how you should generate the prompts. If you understand, reply with "OK".

ChatGPT: OK, I understand. Let's get started!

Me: Firstly, this is information on Midjourney. OK?

ChatGPT: OK, please provide me with the information on Midjourney.
Me: Basic Parameters that are required to be used at the end of a prompt with --

The Basic Parameters;

Aspect Ratios

--aspect, or --ar Change the aspect ratio of a generation.

Chaos

--chaos <number 0–100> Change how varied the results will be. Higher values produce more unusual and unexpected generations.

No

--no Negative prompting, --no plants would try to remove plants from the image.

Quality

--quality <.25, .5, 1, or 2>, or --q <.25, .5, 1, or 2> How much rendering quality time you want to spend. The default value is 1. Higher values cost more and lower values cost less.

Seed

--seed <integer between 0–4294967295> The Midjourney bot uses a seed number to create a field of visual noise, like television static, as a starting point to generate the initial image grids. Seed numbers are generated randomly for each image but can be specified with the --seed or --sameseed parameter. Using the same seed number and prompt will produce similar ending images.

Stop

--stop <integer between 10–100> Use the --stop parameter to finish a Job partway through the process. Stopping a Job at an earlier percentage can create blurrier, less detailed results.

Style

--style <4a, 4b or 4c> Switch between versions of the Midjourney Model Version 4

Stylize

--stylize <number>, or --s <number> parameter influences how strongly Midjourney's default aesthetic style is applied to Jobs.

Uplight

--uplight Use an alternative "light" upscaler when selecting the U buttons. The results are closer to the original grid image. The upscaled image is less detailed and smoother.

Upbeta

--upbeta Use an alternative beta upscaler when selecting the U buttons. The results are closer to the original grid image. The upscaled image has significantly fewer added details.

Reply with OK

ChatGPT: OK, I understand the basic parameters and will generate prompts accordingly.
Me: Now I will provide you with an example prompt related to architecture which has the parameters used OK?

ChatGPT: OK, please provide me with the example prompt related to architecture, and I will generate prompts using the parameters you provided earlier.

Me: Example prompt: A landscape image of a modern church located in Sweden in the style of Zaha Hadid. Highly detailed textured 8k, white building structure with landscape, high detail illustration, wooden elements included --ar 16:9 --q 2 –seed 1234

ChatGPT: OK, I understand. The prompt has the parameters --ar (aspect ratio) set to 16:9 and --q (quality) set to 2. The second prompt has the parameters --v (version) set to 5, --q (quality) set to 2, and --stylize set to 1000.

Me: Now i will give you details on architectural lighting design parameters which should be complied when generating prompts ok? Answer with OK

ChatGPT: OK, please provide the details on architectural lighting design parameters.

Me: Horizontal Illuminance levels should be maintained at 500lux at working plane which is 0.85m from floor level and the vertical illuminance levels on the walls should be maintained at 150 lux. The lighting should be uniform with a uniformity ratio of 0.6. The lighting must be natural white with a colour temperature of 4000K. Is this "OK"?

ChatGPT: OK

Me: With these information can you now provide a prompt for a lecture room

ChatGPT: Sure! Here's an example prompt for a lecture room based on the parameters you provided: a well-lit lecture room with natural white lighting, maintaining 500 lux of horizontal illuminance at working plane 0.85m from floor level and 150 lux of vertical illuminance on walls, with a uniformity ratio of 0.6 --ar 16:9 --quality 1 --seed 1234

Note that I added --seed 1234 to provide a specific seed number, which can be used to reproduce similar results if needed. Feel free to adjust any of the parameters as necessary to generate the desired output.

Me: Provide another prompt for a lecture room for 25 students with dimensions of 12m×10m and 4m height. Consider an architectural rendering and the room to be underground with no windows. should be visual comforting as well

ChatGPT: Sure, here's a prompt for a lecture room with more architectural details:

A 3D architectural rendering of a lecture room for 25 students with dimensions of 12m×10m and 4m height, with natural white lighting that has a uniformity ratio of 0.6 and illuminance levels of 500 lux at the working plane (0.85m from floor level) and 150 lux on the walls. The room is located underground with no windows, but the lighting should be designed to be visually comforting, with warm color accents and soft shadows. --ar 16:9 --quality 1.5 --stylize 500

Me: Provide another prompt for the lecture room for 25 students but include more architectural details such as audio-visual equipment in the room, the paint on the walls, mood of the room and the room has to be underground without windows and more priority on the lighting. Use the aspect ratio 1:1

ChatGPT: Sure, here's a prompt for a lecture room with more architectural details:
Prompt: An architectural rendering of a lecture room for 25 students with a spacious and modern design, featuring high-quality lighting that enhances the learning environment. The lighting design is optimized to provide horizontal illuminance levels of 500 lux at the working plane, which is 0.85 meters from the floor level. The vertical illuminance levels on the walls are maintained at 150 lux to ensure a well-lit and comfortable atmosphere. The lighting is uniformly distributed with a uniformity ratio of 0.6, creating a consistent brightness throughout the room. The lighting color temperature is natural white at 4000K, providing a comfortable and conducive environment for learning. The room features state-of-the-art audiovisual equipment, including a high-resolution projector and high-quality sound system, which can be seen and heard clearly from every corner of the room. The design incorporates sleek and modern furniture, including comfortable chairs and spacious tables, allowing students to focus on their studies without any distractions. The walls are painted in a calming shade of beige, providing a sense of serenity and tranquility. There are no windows in the room, as it is located underground.

Me: can you provide the same prompt again but without the technical values but other details and in layman terms

ChatGPT: An architectural rendering of a lecture room for 25 students with a spacious and modern design, featuring high-quality lighting that enhances the learning environment. The lighting design is optimized to provide horizontal illuminance levels and the vertical illuminance levels on the walls in a ratio of 1:3 to ensure a well-lit and comfortable atmosphere. The lighting is uniformly distributed creating a consistent brightness throughout the room. The lighting color temperature is natural white providing a comfortable and conducive environment for learning. The room features state-of-the-art audiovisual equipment, including a high-resolution projector and high-quality sound system, which can be seen and heard clearly from every corner of the room. The design incorporates sleek and modern furniture, including comfortable chairs and spacious tables, allowing students to focus on their studies without any distractions. The walls are painted in a calming colour, providing a sense of serenity and tranquility. There are no windows in the room, as it is located underground.

This was the final chat session with ChatGPT after many interactions and prompts that were generated and experimented with. The technical values were removed as the generated images were unrealistic with the values included in the prompts and the AI cannot understand the different values and does not interpret these accurately. The only limitation for the space used was the number of students in the space which appears to have been understood and implemented accurately.

10.2. Considerations for the Prompts

Different chat responses were received after training the chatbot for prompts initially. Each were different depending on the various interpretations of how the lighting was explained to the chatbot. However, these did not provide accurate image generations on Midjourney due to various reasons. Prompts generated by ChatGPT that included the standards did not provide accurate Midjourney results mainly due to the numerical values included in the prompts, which Midjourney is yet to understand. For example, when discussing uniformity, the ratio of 0.6 is not understandable by Midjourney. Instead, this can be explained in simple language by saying "the lighting needs to be evenly distributed". After testing various prompts, it was found that only simple design descriptions of the space can be understood by Midjourney. Grammar and numerical values cannot be understood by the image generator. The more precise the details provided, the more accurately Midjourney can interpret the space. Details such as the subject, environment, quality of light (soft, ambient, overcast, neon, studio lights, etc.), mood, and composition are some key parameters that must be included to achieve a good image result. These parameters can be separately fed to ChatGPT to obtain more precise prompt results.
11. **Annexure B**

Annexure B has a focus on the image generating AI platform Midjourney and the tests done regarding to lighting on this platform and the tests on other image generating platforms.

11.1. **Generating prompts in Midjourney**

The images were generated using Midjourney Version 5. Midjourney is accessed through the Discord application, where a separate server is built and linked to Midjourney via Discord to generate the images using prompts and parameters defined by platform. A paid subscription was necessary to access Midjourney Version 5, as at the time of this work, only paid subscribers were able to access the latest version, which is more accurate.

The final prompt generated by ChatGPT as resulted in ‘10.1 Training ChatGPT’ was used with the parameters suitable to generated in the Midjourney AI platform.

The initial result from the above prompt is shown in Figure 21.

![Figure 21: Midjourney Image Generated with the prompt given by ChatGPT](image-url)

By default, Midjourney provides four different options which can be upscaled, or different versions of one of the four images generated can be regenerated for variations.
Different variations and upscales were tested to achieve a more accurate result. Despite the lighting being quite similar, certain changes were visible in the furniture arrangements and the wall designs.

With different variations, the final output which was used for the evaluation is as shown in Figure 22.

*Figure 22: Result generated by Midjourney which was used for further editing*
11.2. **Image Generation Tests and Results**

This is an approach to test different prompt methods to evaluate the results generated by Midjourney.

Prompts without specific details provided very abstract output results. Despite the image represented a lecture room, lighting was not considered as all the 4 images provided provide by Midjourney were with natural lighting and not with artificial lighting. A prompt which instructs only to generate an image of a lecture hall in a university is shown in Figure 23.

This is evident that more details are required to achieve an image with a result that provides focus on the lighting.

*Prompt used: A lecture room in a university*

![Figure 23: Image generated by Midjourney without a detailed prompt](image1)

Prompts with the focus of ambient lighting is shown in Figure 24. This result provides details focused on the artificial lighting. Yet the lighting is quite traditional and provides no exciting elements or different lighting effects.

*Prompt used: A lecture room in a university with ambient lighting*

![Figure 24: Image generated by Midjourney with the focus of Ambient Lighting](image2)
Dimensions were provided in the prompt to test if Midjourney can represent the space in accordance to the provided proportions. The result shown in is not as per the provided proportion which means the AI cannot yet deliver images understanding numeric variables.

*Prompt used: A lecture room in a university with ambient lighting, 10 meters in width and length and 4m ceiling height*

A prompt was used to generate an output image of a contemporary lecture room with the focus on ambient lighting. However, the resulting images provided many design elements in the room, with more focus on the architecture than the lighting. It was difficult to recreate these images using 3D DIALux rendering, as each individual design element needed to be addressed for accurate validation. The results are illustrated in Figure 26.

*Prompt used: A lecture room in a university with ambient lighting in a contemporary setting.*
11.3. Failed generations with images uploaded and prompts to provide lighting effects

An attempt was made to achieve a lighting design for an existing space by providing vague prompts to an image uploaded to Midjourney. To test this, an image of a lecture room was edited using Photoshop to remove all visible luminaires and windows. The reason for doing this was to prevent the AI from identifying these luminaires and providing a design based solely on their presence. The input image is shown in Figure 27. The output result from Midjourney is Figure 28.

![Figure 27: Actual Input photo (left) Input image edited via Photoshop as a location reference for Midjourney (right)- Own Images](image1)

Prompt used: ‘Link to Input image’ university lecture hall with architectural lighting and ambient lighting, realistic.

![Figure 28: Output result from Midjourney](image2)

As an alternative approach, the original input image was reverse prompted by uploading it to Midjourney. This generated a prompt which was then combined with the original input image to regenerate a lighting scheme including the required lighting keywords and parameters.

The result of the prompt generated by Midjourney was;

*An empty classroom full of chairs, in the style of monolithic structures, bentwood, neo-concrete, Norwegian nature, tondo, polished concrete, theatre academia.*
This prompt with lighting keywords were provided to Midjourney along with the link to the original image for an output and the result is shown in Figure 29.

Prompt used: ‘Link to Input image’ An empty classroom full of chairs, in the style of monolithic structures, bentwood, neo-concrete, Norwegian nature, tondo, polished concrete, theatre academia with artificial ambient lighting.

With this experiment, it was evident that an image reference cannot be modified without the AI interpreting the image on its own and providing its own understanding of the space.

11.4. Lighting Parameters Understood by Midjourney

Only certain keywords/prompts related to lighting can be recognized by Midjourney, such as soft, ambient, overcast, neon, studio lights, etc. Additionally, there are various other keywords used in the vocabulary of a lighting designer that need to be tested to see if Midjourney can understand them. A few different lighting effects were randomly selected, assuming they are the most commonly used.

a) Wall Washing - This effect involves placing a light fixture away to a wall and directing the light upwards or downwards to create a uniform illumination of the wall. Midjourney

b) Wall Grazing - Wall grazing is placing a light fixture close to a wall and directing the light upwards or downwards to create a dramatic effect.

c) Accent Lighting - This effect can be described as placing a light fixture to highlight a particular feature or object in a room, such as a sculpture or a piece of artwork.

d) Uplighting - Uplighting is a lighting technique where light is directed upwards towards a surface or object to highlight its architectural features.

e) Linear Lighting - Linear lighting refers to a type of lighting that consists of a continuous strip or row of light fixtures that create a linear, uniform source of light.
a) Figure 30 illustrates the image generated by Midjourney for the wall wash effect.

*Prompt used: Empty white wall with uniform wall washing light effect*

The result did not depict the effect of a wall washing effect but has different approaches of lighting effects. Even with fine tuning and further prompts, it might be difficult to achieve the effect required.

![Figure 30: Midjourney image output for wall washing lighting effect](image)

b) Figure 31 illustrates the image generated by Midjourney for the wall grazing effect.

*Prompt used: Brick wall with wall grazing light effect*

The result has certain accuracy in depicting lighting characteristics, including accurate illustrations of the shadows created by the bricks themselves. But the images 1, 2 and 4 provide very closely similar effect to wall grazing. With more variations and targeted keywords, the wall grazing effect appears to have the potential to be achieved.

![Figure 31: Midjourney image output for wall grazing lighting effect](image)
c) The image generated for the prompt focusing on accent lighting is illustrated in Figure 32.

Prompt used: Accent lighting on a plant in empty room

The result is evident that despite it does not illuminate the plant itself, the AI is interpreting an accent lighting effect. The shadows are also not accurately depicted. But with further fine tuning and prompts this has potential to be improved.

![Figure 32: Midjourney image output for accent lighting effect](image)

d) Figure 33 depicts the image generated by Midjourney for the uplighting effect.

Prompt used: Colonial columns with uplighting effect

The result is quite accurate and interprets the effect very well in images 2 and 3. The columns are not exactly colonial, but maybe with more defined keywords this could be accurate. Despite this, the image generated proves that this effect is understood by the AI image generator and can be used for visualizations.

![Figure 33: Midjourney image output for uplighting effect](image)
e) Linear lighting effect was also tested and the results is as per Figure 34.

*Prompt used: Linear lighting effect on a concrete floor*

The result was accurate even though the ceiling also has the linear light effect. The reflections are also not accurate. But the conclusion is that the AI understands the effect and can interpret it if prompted.

![Figure 34: Midjourney image output for linear lighting effect](image)

### 11.5. Testing Other Image Generating Platforms

There are many other image generating AI platforms and a selected few were tested with the same prompt used for the Midjourney final result. The first image that generated has been presented here. It must also be noted that the versions used for the testing of these platforms are free versions. Therefore, the images generated by these could be less advanced than their paid versions.

#### 11.5.1. BlueWillow

BlueWillow (15) is a similar AI Image generator which functions in the same way as Midjourney. In this example, even though the same prompt was entered to BlueWillow, the result is not accurate as Midjourney was. The Figure 35 which was generated represents more of a conference room and not a lecture hall. With more simple prompts the generation was quite accurate and provided an image of a lecture hall. This concludes that the prompts have to be much simpler for BlueWillow to understand and to generate images accordingly.

![Figure 35: Image generated by BlueWillow](image)
11.5.2. Stable Diffusion

Stable Diffusion (16) is another AI image generator which uses text-to-image diffusion models to create realistic image generations. The results were quite animated than realistic in comparison to Midjourney. These images provided a variety of lighting effects. The image 1 illustrated an abstract diffused lighting on the ceiling which was in the arrangement of a spiral. The image 2 had diffused linear lighting formed in the shape of grids. The Image 3 did not provide any lighting illustration. Image 4 however had a basic lighting which was just diffused panel lighting. This is conclusion that Stable Diffusion has the ability to understand certain lighting effects but the realistic appearance of the image has to be improved.

11.5.3. Midjourney Version 4

The free version of Midjourney, the version 4 was also tested with the same prompt. Despite the realism, the lighting effects were quite interesting with variations of diffused linear lighting, downlights, cove lighting and even downlights to highlight walls were illustrated. The version 5 provided more accurate light distribution qualities whereas this version was quite minimal. But with more variations and other focused parameters, this could have been improved.

In addition to these above text-to-image generating AI platforms, Craiyon V3 (17), DALL•E (18) and DreamStudio (19) were also tested. Due to the limited character count for the prompt and inaccuracy of the generated images, they have not been displayed here.

This concludes that Midjourney version 5 provided the most accurate, realistic and useable images which can be used for a lighting design.
12. Annexure C

The Annexure C Focuses on the parameters considered for the DIALux Simulation which includes the working planes and the calculation objects.

12.1. DIALux Simulation

Various considerations are required when simulating the lighting of a space. Reflection values, height of the calculation objects, the wall zone values, positions considered for the UGR values are some examples. These considerations are mentioned more in detail below.

The reflection values of the ceiling, walls and floor were considered as 0.7, 0.5 and 0.2 respectively.

12.1.1. Working Plane

Height of the working plane in the space was considered as 0.8m from floor level same as the height of the tables and a wall zone of 0.5m were considered from the edges. The working plane considered is illustrated in Figure 38.

12.1.2. UGR Calculation Object for Students

A calculation object in the size of 7.9×7.9m was considered with a height offset of 1.2m from the floor level for the sitting students. Step width was considered as 10°. The number of points considered for the calculation were considered as 20×20 points as students can move from the chairs and different positions of the chairs can be used. The calculation object considered with the points are illustrated in Figure 39.
12.1.3. UGR Calculation Object for Lecturer

A calculation object in the size of 1.2×7.9m was considered with a height Offset of 1.6m from the floor level for the standing lecturer who can also be moving in the space in the front while performing the lecture. Step width was considered as 10°. The number of points considered for the calculation were considered as 30×5 points. The calculation object considered with the points are illustrated in Figure 40.

Figure 40: UGR Calculation Object for Lecturer

12.1.4. Cylindrical Illuminance

A calculation object in the size of 7.5×7.5m was considered with the height of 1.2m from floor level as default from DIALux. The area was designated to the sitting area of the students as the main working area. The calculation object considered for the cylindrical illuminance is illustrated in Figure 41.

Figure 41: Calculation Object Considered for Cylindrical Illuminance

12.1.5. Wall Illuminance and Ceiling Illuminance

The function ‘Results on Surface’ was used to measure the average values of the 4 walls and the ceiling. The range provided in the results are after inspecting the results on the left wall, right wall and the back wall.
13. **Annexure D**

This Annexure D is descriptive explanation on the difficulties of achieving a realistic rendering in 3D in comparison to the 2D image.

13.1. **Inaccurate Proportions**

The proportions in the AI-generated images were not accurate. The tests in Annexure B showed that the AI generator did not understand numeric values and was unlikely to understand dimensions. It did not provide an accurate result for a basic prompt provided for a space with dimensions. Further study is required to test if certain numerical values, such as the dimensions of a space, the number of users of a space, and other numerical values, can be illustrated by the AI.

Due to the inaccurate representation of the space dimensions, the proportions of the space are not accurate in the two-point view image generated by Midjourney. This makes it nearly impossible to achieve a visually accurate 3D space that is similar to the 2D AI-generated image.

13.2. **Lack of 3D Files**

The furniture and other objects in the output image are not commonly available as 3D files that can be used in DIALux for simulations. Therefore, only the most similar 3D files can be used for the 3D simulation. It must also be noted that due to the different proportions, the sizes of these 3D objects cannot be accurately interpreted. Therefore, recreating these objects separately in other software such as Sketchup can also be difficult. However, to a certain extent, this is achievable. For this study, similar 3D files were used for the DIALux simulation to make it appear as similar as possible, but there are clear differences in certain objects such as the chairs used for the 3D simulation.

13.3. **Similarities of Colours and Material of the Space**

Colours and materials are important factors that need to be considered in DIALux simulations. The reflectance factor and reflective coating percentages are crucial parameters that must be matched with the 2D image for an accurate result. However, it is impossible to obtain these values from the 2D image, which makes it challenging to achieve an accurate 3D result in any software, including DIALux.