

FlairGPT: Repurposing LLMs for Interior Designs

flairgpt.github.io

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Figure 1: We investigate if large language models (LLMs) can be used as interior designers. We show that LLMs can be systematically probed and combined with traditional optimization to produce aesthetically-pleasing and functional interior designs. In these examples, our method FlairGPT, starting from text probes, produces the final layouts including object selection, their placement, as well as their styles.

Abstract

Interior design involves the careful selection and arrangement of objects to create an aesthetically pleasing, functional, and harmonized space that aligns with the client's design brief. This task is particularly challenging, as a successful design must not only incorporate all the necessary objects in a cohesive style, but also ensure they are arranged in a way that maximizes accessibility, while adhering to a variety of affordability and usage considerations. Data-driven solutions have been proposed, but these are typically room- or domain-specific and lack explainability in their design design considerations used in producing the final layout. In this paper, we investigate if large language models (LLMs) can be directly utilized for interior design. While we find that LLMs are not yet capable of generating complete layouts, they can be effectively leveraged in a structured manner, inspired by the workflow of interior designers. By systematically probing LLMs, we can reliably generate a list of objects along with relevant constraints that guide their placement. We translate this information into a design layout graph, which is then solved using an off-the-shelf constrained optimization setup to generate the final layouts. We benchmark our algorithm in various design configurations against existing LLM-based methods and human designs, and evaluate the results using a variety of quantitative and qualitative metrics along with user studies. In summary, we demonstrate that LLMs, when used in a structured manner, can effectively generate diverse high-quality layouts, making them a viable solution for creating large-scale virtual scenes. Code will be released.

CCS Concepts

- Computing methodologies → Shape analysis; Natural language processing; Machine learning;

1. Introduction

Interior designing is the art of creating balanced, functional, and aesthetically pleasing spaces based on intended space usage and adjusted to individual preferences. The goal is to propose a selection of objects, both in terms of the type and style of the objects along with their arrangement, that best serves the project brief provided

by the client. A good design not only considers the aesthetic look of the objects, but also factors in the flow of the designed space, taking into consideration affordability of the objects along with their functionality and access space.

The design task is challenging, as one has to balance aesthetics, functionality, and practicality within a given space while consid-

ering the user’s needs, preferences, and budget. It is particularly difficult to identify, keep track, and balance a variety of conflicting constraints that arise from ergonomics and usage while harmonizing furniture, lighting, and materials. Hence, users often take shortcuts and fall back to a rule-based or preauthored solution that best fits their specifications. However, achieving a customized, cohesive, visually appealing and functional design requires creativity, technical expertise, and remains difficult for most users.

To gain inspiration, we first studied how interior designers approach the problem. Upon receiving project briefs, they divide the space into *zones* according to their intended function. They then begin by selecting and placing the *focal* objects for the key zones, before arranging other objects around them. Throughout this process, they carefully consider design aspects to ensure that objects are easily accessible and usable and that the room has *good flow* to facilitate movement. Finally, they incorporate lighting and decide on the style of the objects, as well as the wall and floor style to create a harmoniously designed space. The most non-trivial aspect is the variety of spatial and functional considerations that designers consider and conform to while designing the space.

In this paper, we ask if large language models (LLMs) can be repurposed for interior design. We hypothesize that LLMs that have been trained on various text corpora, including design books and blogs, are likely to know about layout design concepts. We ask how explicit these concepts are and how good they are in quality. Directly querying LLMs to produce room layouts based on text guidance (e.g., ‘Please design a drawing room of size $4m \times 5m$ for a teenager who loves music’) regularly produced mixed results that had good design ideas but not usable in practice (see Figure 2). Although the output images of the room looked aesthetically pleasing, closer inspection revealed many design flaws. Unfortunately, when asked for output floorplans, LLMs produced rather basic layouts that did not meet expectations.

Interestingly, we found that LLMs have good knowledge of individual design considerations, including non-local constraints. For example, when asked about ‘the most important design consideration for a kitchen’ LLMs described the *kitchen work triangle*, which is an important design consideration that many of us are unaware of and can easily get wrong, severely affecting the functionality of the space. Encouraged by this and inspired by interior designers’ workflow, we break the interior design task into stages. Instead of directly using LLMs to get the final layout, we progressively probe the LLMs, in a structured fashion, to first zone the given space and then extract a list of objects to populate the different zones. More importantly, we also elicit a list of intra-object and inter-object constraints along with descriptive attributes for the selected objects. Then, using a symbolic translation, we organize the LLMs output into a layout constraint graph by converting the textual constraints to algebraic constraints in terms of the object variables (i.e., their size and placement). We then obtain the layout by solving the resultant constrained system. Finally, we retrieve objects to populate the designed layout using the object-specific types and attributes obtained from the LLMs to produce the final layouts. Figure 1 presents a selection of example outputs from our method, FlairGPT: Functional Layouts for Aesthetic Interior Realisations.

We evaluated our method in a variety of interior design settings. We compared ours with the latest interior design alternatives (e.g., ATISS [PKS*21], Holodeck [YSW*23], LayoutGPT [FZF*24]) and against user-designed layouts. We compared the quality of our

Room Layout
Bed (1.4m x 2m):
Position: Against the 5m wall (long side).
Type: A full-sized bed with built-in storage drawers underneath to save space.
Headboard: Shelves or cubbies for books, alarm clocks, or decor.
Study/Desk Area:
Position: Opposite the bed, along the 4m wall.
Desk Size: 1.6m long desk.
Storage: Floating shelves above the desk for books and decorative items.
Lighting: Task lamp or overhead lighting to brighten the workspace.
Wardrobe/Closet (2m x 0.6m):
Position: Along the wall near the door.
Type: Sliding doors to save space, and built-in organizers for clothes, shoes, and accessories.
Seating Area/Bean Bag:
Position: Near a window (if available).
...
This layout balances study, storage, and relaxation, making the room both practical and comfortable for a teenager.



Figure 2: *Layouts Generated by ChatGPT [cha24]*. (Top) Directly querying LLMs to generate room layouts yields useful guidance but not a floorplan. (Bottom-left) Asking for a floorplan results in an overly simplistic one, with very few objects and impractical proportions—such as a TV unit nearly as long as the bed. Additionally, essential objects, like a chair for the desk, are missed. (Bottom-right) When prompted to generate design images, the results, while aesthetically pleasing, are often functionally impractical, as shown in the image on the right. For instance, the desk and chair are incorrectly oriented, rendering the chair inaccessible.

designs and those produced by competing methods using different user studies. Users consistently preferred our generations over the others, including those done by novice users, and scored ours well with respect to adhering to design specifications as well as producing functionally useful layouts. We also evaluate perform quantitative evaluation on the generated layouts. In addition, we report our findings on the aspects of the design process where LLMs offer significant value and those that are best managed, at least for now, by human expertise. Code will be released upon acceptance.

2. Related Works

Optimization-based layouts. Interior design relies on spatial arrangement, human-centric aesthetics, and functional optimization [Ale18]. Early computational approaches for generating simple layouts [HWB95, MP02] concentrated on manually defining local constraints and employing optimization techniques to solve for optimal spatial arrangements. Later, inspired by established interior design guidelines, Merell et al. [MSL*11] introduced an interactive system that allowed users to define the shape of the room and a selected set of furniture, after which the system generates design layouts that adhere to specified design principles. Make it home [YYT*11] employed hierarchical and spatial relationships for furniture objects with ergonomic priors in their cost function to yield more realistic furniture arrangements. In a recent optimization method, Weiss et al. [WLD*19] use physics-based principles to create room layouts by treating objects as particles within a physical system. The method emphasizes both functionality and harmony in the room by applying specific constraints to ensure walk-

ways, maintain balanced visual appeal around a focal point, etc. However, it still requires users to manually specify constraints.

Data-driven layouts. Rather than relying on hard coded rules for optimization, modern data-driven methods aim to learn such concepts automatically [RWL19, WSCR18, TNM*23]. For example, ATIIS [PKS*21] treats indoor scene synthesis as an unordered set generation problem, to allow flexibility by avoiding the constraints of fixed object orderings. ATIIS uses a transformer architecture to encode floorplans and object attributes to sequentially place objects based on category, size, orientation, and location. While visually appealing, ATIIS suffers from practical limitations such as overlapping objects. To enhance practicality, LayoutEnhancer [LGWM22] integrates expert ergonomic knowledge—such as reachability, visibility, and lighting—directly into the transformer model for indoor layout generation. However, the method falls short in considering stylistic elements, limiting its ability to generate complex aesthetically tailored designs. SceneHGN [GSM*23] creates a hierarchical graph of the scene to capture relationships among objects to produce visually coherent 3D environments. Tell2Design [LZD*23] reformulates the task of generating floor plans as a sequential task where the input is language instructions and the output is bounding boxes of rooms. Although data-driven methods can produce good results, they are limited in diversity and creativity due to their reliance on curated datasets and are often restricted to special types of rooms and/or objects.

LLM-based layouts. With advances in capabilities of Large Language Models [Bro20, TAB*23, TLI*23, JSR*24], LLMs are being increasingly used to solve a plethora of complex tasks such as reasoning [MP24], programming [RGG*23], discovering mathematical concepts [RPBN*24], conducting scientific research [LLL*24], etc. Building on this success, the integration of LLMs in scene synthesis offers the ability to generate context-aware designs by interpreting and applying textual descriptions directly to the synthesis process. This enables a more dynamic and flexible approach, allowing for the integration of complex design principles that are often difficult to encode through conventional algorithms.

Holodeck et al. [YSW*23] utilize LLM to expand user text prompts to generate a scene into actionable scene elements. However, the actual placement and relationship of objects are governed by a set of predefined spatial rules hard-coded into the system that can limit the flexibility and creativity of the system to adapt to unconventional or complex designs. In a very recent system, Layout-GPT [FZF*24] uses LLMs to generate scene layouts by treating elements within the scene as components that can be described and adjusted programmatically akin to web elements in CSS. In another notable effort, Aguina-Kang et al. [AKGH*24] employ LLMs to create more detailed scene specifications from simple prompts, identify necessary objects and finally generate programs in domain specific language to place those objects in the scene. After establishing one of ten relationships between objects from a library, the final placement is obtained using gradient descent based optimization. LLplace [YLZ*24] fine tunes Llama3 [TLI*23] on an expanded 3D-Front Dataset [FCG*20] to allow users a more interactive way to add and remove objects in a conversational manner. I-Design [CHS*24] uses multiple LLMs to convert a text input into a scene graph and obtain a physical layout using a backtracking algorithm. Strader et al. [SHC*23] leverage LLMs to build “spatial

ontology” (to store concepts), which is used in node classification systems of 3D scene graphs.

While LLMs have made it easier to automate the application of interior design principles, the complexity of spatial relationships and functional constraints remain a significant hurdle and do not yet capture the depth and realism of actual spaces. In contrast, our approach draws heavily on traditional interior design practices to guide layout generation, ensuring that each layout is both functional and aesthetically balanced. By doing so, we aim to bridge the gap between automated systems and the nuanced decision making process that human designers bring to their work.

3. Design Considerations

In this section, we briefly summarize the process followed by interior designers as documented in design literature books [BS13, Mit12, Ale18].

The process starts with a *design brief* where the clients describe how they plan to use the space, provide background on their preferences, and detail the current layout of the space (e.g., walls, doors, windows). Budget and time frames are also discussed in this stage, but we ignore these in our setup.

Space planning, the next phase, is the most challenging. This involves creating functional layouts and optimizing the use of space. Specifically, they determine the choice and arrangement of furniture while considering flow, accessibility, and ergonomics. Designers typically start by collecting measurements of the space and noting the features of the room such as doors, windows, and electrical outlets. Next, they *zone* the space by partitioning the region into distinct areas based on its functions. For example, in an open-plan layout, designers allocate areas for dining, working, and socializing without the need for physical barriers. In this stage, they also take traffic flow into account to create pathways or circulation areas that avoid overcrowding and allow a smooth transition between zones. Having zoned the space, designers then select and place key pieces of furniture, usually referred to as *primary objects*, in strategic positions. Large items (e.g., sofas, tables, beds) are first positioned in order to anchor the space. Designers use their experience to balance functionality and aesthetics to create visual interest and harmony in the space. Next, they incorporate *secondary objects* (such as chairs, appliances, etc.) around the primary objects to ensure the regions are functional. At this point, artificial lighting is also added if necessary. Besides selecting the types and sizes of objects, designers also consider their color and finish to create a cohesive look in the designed space while maintaining its functionality.

Finally, during *design development*, designers collect client feedback based on previsualization of the space and iterate on the design to better align the space to their clients’ vision.

4. Algorithm

Our method consists of three key phases. In the first phase, the *Language Phase*, we progressively query the LLM to make informed decisions about the room’s layout and design. The model identifies all relevant objects for the space along with their dimensions (width and length). More importantly, the LLM provides a set of spatial constraints that governs the positioning and arrangement of these objects. In the second phase, the *Translation Phase*, we convert the language-based constraints obtained from the LLM into executable function calls, drawing from a predefined library of con-

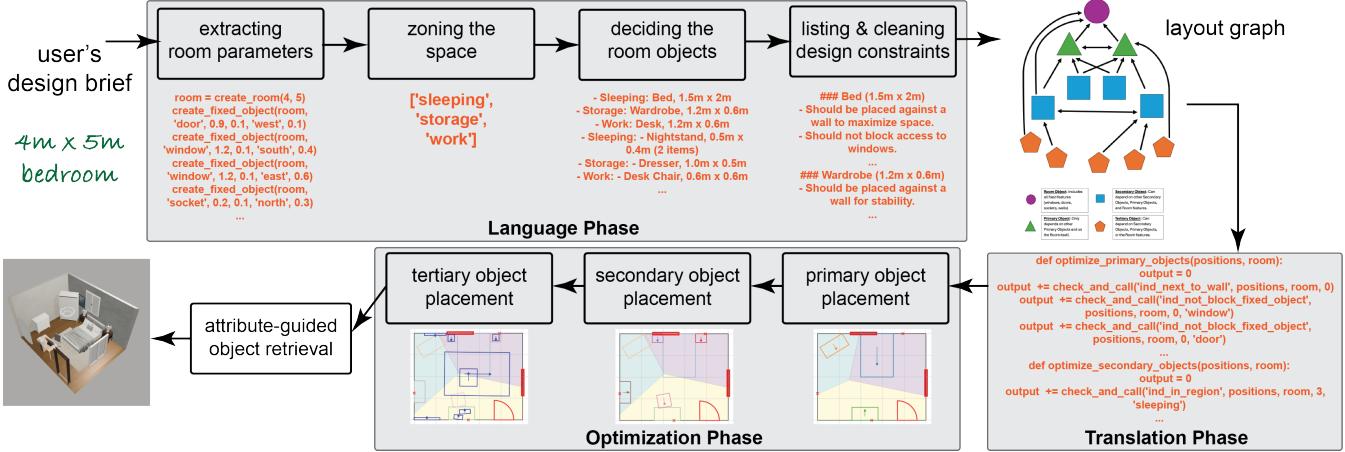


Figure 3: **Method overview.** FlairGPT begins by taking the user’s design request as a text prompt and querying an LLM to extract key room parameters, such as dimensions and the location and number of windows, doors, and sockets. Next, following a designer’s workflow, the LLM generates an ordered list of zones, specifying the functional purpose of different areas within the room. Based on these zones, a prioritized list of required objects is generated, complete with descriptions and dimensions. These objects serve as the nodes of a layout graph, with inter- and intra-object constraints—defined by the LLM—forming the edges. The natural language constraints provided by the LLM are translated into algebraic forms by querying the LLM to map these constraints to a predefined library of cost functions. Once these cost functions are established, the placement and orientation of objects are progressively optimized according to their hierarchical importance. Finally, objects are retrieved, based on their descriptions, and incorporated into the scene.

straint cost functions thus forming a layout constraint graph. Finally, in the *Optimization Phase*, we use an optimization (SLSQP) to find a minimal-cost solution that satisfies the combined set of constraints. We stagger this phase into multiple iterations with different initial configurations. Upon completion, we obtain the full specification of all objects, including their style, dimensions, positions, and orientation. We now provide details on each phase.

4.1. The Language Phase

User input. We expect the user to provide a textual description of the room they wish to generate. This input can range from simple prompt, such as “a bedroom,” to more detailed specifications like, “a 5 × 5m bedroom for a young girl who enjoys painting while looking out of her window.” This flexibility allows users to define a wide variety of room configurations.

A. Extracting room parameters. Once the user input has been provided, we query the LLM to establish the fundamental parameters of the room that serve as the fixed boundary condition for the rest of the stages. The model generates the dimensions of the room (width and length), with the height fixed at 3 meters by default. The LLM also prescribes how many windows, doors, and electrical sockets the room requires, as well as their placements (which wall they should be on and their horizontal position along that wall). Additionally, the model provides the width of the windows and doors. Note that we designed a fixed schema to convert user specifications to queries for the LLM. Please see supplemental for details. Users can alternatively bypass this step if they prefer to directly input the room specifications.

B. Zoning the space. Next, similar to how human designers proceed, we query the LLM to determine the core purposes of the room, which define its *zones*. The number and type of zones vary depending on the room’s size and intended use. The LLM outputs

an ordered list of zones, ranked by significance. For example, in a bedroom, the zones can include {sleeping, storage, dressing} areas. We denote this ordered list by $\mathcal{Z} := \{z_1, \dots, z_k\}$. Note that we do not partition the room into zones at this stage.

C. Deciding the room objects. Our next major design task is to decide which objects to include in the room along with their size and textual description. Again, following designers’ workflow, we proceed in stages.

(i) *Listing the primary objects.* We define a primary object as the most essential object required for each zone to fulfill its intended purpose (these are often referred as *focal* objects). Again, we query the LLM to determine the primary objects, along with their dimensions (see supplemental for query schema). The output is an ordered list where each entry includes the primary object p_i corresponding to zone z_i , as well as the object’s width (w_i) and length (l_i). Thus, the list of primary objects takes the form $\mathcal{P} := \{(p_1, w_1, l_1), \dots, (p_k, w_k, l_k)\}$. So far, we have obtained the type, width, and length for each primary object, but not their height.

(ii) *Listing the secondary objects.* We then query the LLM to identify secondary objects, defined as additional items that enhance the functionality of each zone, provided they are floor-based (excluding rugs). The output is an ordered list of secondary objects \mathcal{S} , where each object s_i includes its width (w_i), length (l_i) and the corresponding zone $z(s_i)$ to which it belongs. Note that each zone can have multiple secondary objects. In addition, the output specifies how many of each object are needed. For example, four dining chairs or two nightstands might be required in a given zone. Thus, we have, $\mathcal{S} := \{(s_1, w_1, l_1, z(s_1)), \dots, (s_{n_s}, w_{n_s}, l_{n_s}, z(s_{n_s}))\}$ with n_s being number of secondary objects.

(iii) *Listing the tertiary objects.* We then query the LLM to generate the final set of objects, the tertiary ones. Such objects are ‘attached’ to specific primary/secondary objects or room boundary.

Example of a Blank Constraint Cost Function for Individual Constraints

```
## Throughout, the sides of the objects are defined as follows:
# 'back' of the object would be the headboard of a bed, or the back of a chair
# 'front' of the object would be the foot of a bed, or the front of a wardrobe (the side with the doors)
# 'left' would be the left side of the object, when standing behind it
# 'right' would be the right side of the object, when standing behind it

def is_next_to_wall(positions, room, object_index):
    """ This function ensures an object is next to a wall in a room. Specifically the back of the object.
    Example constraint: "The tv should be against a wall." """

    Args:
        positions: list of floats, x, y, theta values for all objects in the room
        room: rectangular Room object
        object_index: int, index of the object in the room's object list

    """
    return

Example of a Blank Constraint Cost Function for Inter-Object Constraints

def is_next_to(positions, room, object1_index, object2_index, side1 = None, side2 = None):
    """ DO NOT USE THIS WITH is_surround, IT WILL BE REDUNDANT OR CONTRADICTORY.
    This function ensures that two objects are next to each other in a room.
    This should only be used when necessary e.g. for nightstands and a bed, or a desk and desk chair.
    This should not be used for dining chairs around a table or similar relationships, for that use is_surround.
    If side1 is given, the specific side of object1 will be used. If side2 is given,
    the specific side of object2 will be used. E.g. the 'front' of the chair should be next to the 'front' of the desk.
    If no side is given, then any of the sides will be used.

    Args:
        room: rectangular Room object
        object1: Object object
        object2: Object object
        side1: string, one of 'top' or 'back', 'bottom' or 'front', 'left', 'right', defines which side of object1 to use
        side2: string, one of 'top' or 'back', 'bottom' or 'front', 'left', 'right', defines which side of object2 to use
    """
    return
```

Figure 4: Doc string for library functions. An example of our docstrings which contain usage examples and thorough descriptions of each function’s purpose and its parameters. Note that the underlying implementation of the functions is absent. The LLM is tasked to map each language-based constraint to a corresponding cost function within the library during the language phase.

These include ceiling-mounted objects (e.g., chandeliers), wall-mounted objects (e.g., paintings), objects placed on surfaces (e.g., table lamps), and rugs. While majority of the tertiary objects are decorative, functional items such as computers and lighting can also be suggested at this stage. We also query the LLM for detailed placement instructions, specifying how and where these objects should be positioned relative to other objects or zones within the room. For example, the LLM might suggest, “place a painting on the wall above the bed.”

The output is an unordered list \mathcal{T} of tertiary objects, each described in relation to another object (either Primary or Secondary), a boundary wall, or simply a specific zone. For each tertiary object t_i , we also obtain its type (type_i), one of wall, floor, ceiling, or surface, along with its width (w_i), length (l_i), and a language-based placement constraint (c_i). The final output is an unordered list $\mathcal{T} := \{(t_1, w_1, l_1, \text{type}_1, c_1), \dots, (t_n, w_n, l_n, \text{type}_n, c_n)\}$, where type_i specifies the object type, c_i provides the placement instructions, and n_t being the number of tertiary objects.

The language constraints (c_i) are treated separately from those of primary and secondary objects, as tertiary objects can be positioned in ways that others cannot — such as on the ceiling, walls, atop other objects, or underneath primary or secondary objects.

(iv) *Determining style for the objects.* Having listed all the objects, we move on to determine the style of the room and the individual objects using the given description for the room. We query the LLM to specify the style of the room and each individual object. The LLM provides textual details such as materials, colors, and patterns for the walls and floors. For instance, it might suggest “dove grey paint with an accent wall featuring a subtle geometric wallpaper.” Each object, including windows and doors, is further described by the LLM in terms of material, color, and overall aesthetic.

D. Listing of design constraints

So far we have the specification of the room boundary and a textual list of the objects to be placed in the room. The list of objects $\mathcal{P} \cup \mathcal{S} \cup \mathcal{T}$ forms the nodes of our layout graph. Next, we use the LLM to list all the relevant inter- and intra-object constraints, which become the (undirected) edges of our layout graph. We only consider pairwise constraints in our setup.

(i) *Intra-object constraints.* These constraints refer to those that apply to a single object, either a primary or secondary object, and any features of the room (including walls, windows, doors, and sockets). These constraints govern the positioning and usability of an individual object. For example, the LLM might specify, “the bed should have its headboard against the wall,” or “the bed should not be too close to a window to avoid drafts.” This category also includes accessibility requirements, such as determining which sides of the object must remain accessible for it to function properly. At this stage, we query the LLM to generate all such constraints by looping over all the nodes in $\mathcal{P} \cup \mathcal{S}$ and collect them for all the primary and secondary objects in natural language.

(ii) *Inter-object constraints.* These constraints involve relationships between pairs of primary and secondary objects. For instance, the LLM might suggest, “the mirror should not face the bed,” or “the bed should be placed between the two nightstands.” When the constraint applies only between primary objects, we encourage the LLM to create simple spatial relationships such as “near to” or “far from,” since these objects often belong to different zones.

(iii) *Constraint cleaning.* The final step in the Language Phase serves as a self-correction tool. We query the LLM to review and refine the generated constraints. This involves merging any similar constraints, removing duplicates, and simplifying the constraints into more straightforward language to minimize errors during the Translation Phase. The LLM also identifies and eliminates any contradictory constraints. Additionally, we use the LLM to split constraints that contain multiple pieces of information. For example, “the bed should not block windows or doors” would be split into “the bed should not block windows” and “the bed should not block doors”. This is not applied to the tertiary constraints, due to there only being one constraint per tertiary object.

4.2. The Translation Phase

Next, we convert the language constraints into algebraic forms. For this phase, we created a “blank” version of our library of constraint cost functions. This blank version contains the names of the functions, along with detailed docstrings for each function. These docstrings include usage examples and thorough descriptions of each function’s purpose and its parameters. Note that these strings only provide function names and lists of variables to the LLMs, but not the underlying implementation of the functions. [Figure 4](#) shows an example; more details are provided in the supplemental.

The purpose of these blank functions is to utilize the natural language processing capabilities of the LLM to map each language-based constraint to a corresponding cost function within the library. This process is carried out in three distinct stages: one for Individual or Intra-Object constraints, one for Inter-Object constraints, and one for tertiary constraints. By processing these constraints separately, we ensure the correct type of function is applied, reducing the risk of using the wrong function for a particular constraint.

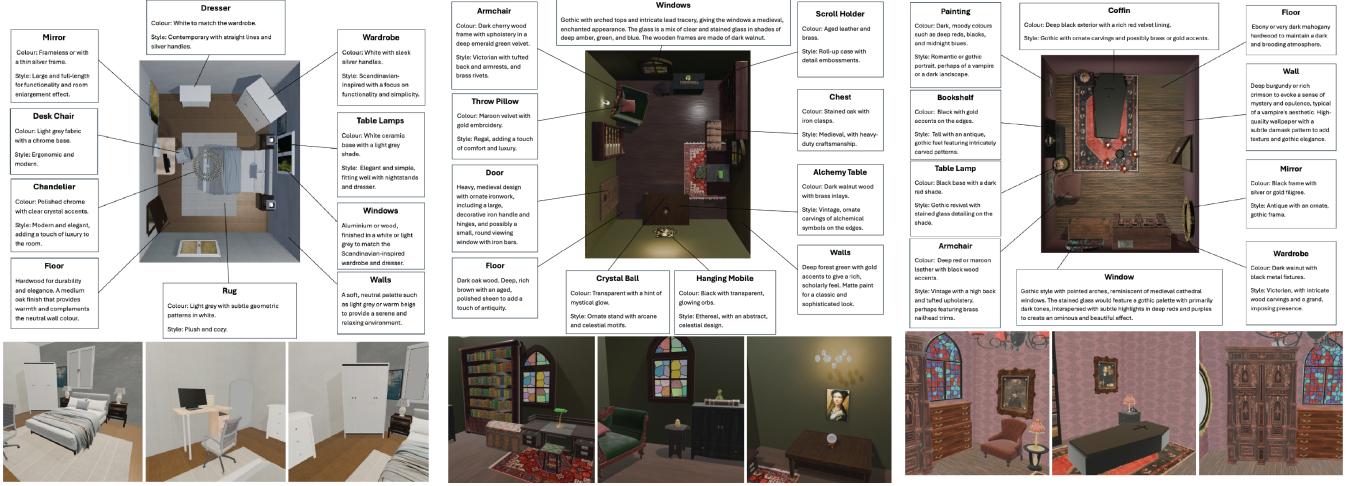


Figure 5: **Generated layouts by FlairGPT.** We present varied layouts designed by FlairGPT for three distinct prompts (from left to right)- “4m x 5m bedroom”, “small workroom for a wizard”, and “bedroom for a vampire”. Alongside each layout, we include descriptions of selected objects provided by the LLM, which closely align with the user’s design brief. Notably, FlairGPT makes creative and context-appropriate object choices, such as a scroll holder and a crystal ball for a wizard’s workroom, and a coffin in place of a traditional bed in the case of a vampire’s bedroom, reflecting the thematic style of the input prompts.

If no suitable matching function can be found for a given constraint, we discard the corresponding language constraint. Additionally, if the parameters provided to the function do not match the expected inputs, we ensure the function safely returns a cost value of 0, reducing errors in the subsequent optimization process.

Example of language constraints being translated into code

```
### 1. Bed (1.6m x 2m)
- Should be placed against a wall for headboard support.
- Should not block any doors or windows.
- Should have clear access on at least two sides for ease of getting in and out (usually the longer sides).
- Ensure there are no electrical sockets directly behind the head area to avoid tangling cords.
- Ideally, position it such that there is space for nightstands on either side.

def optimize_primary_objects(positions, room):
    output = 0
    output += ind_next_to_wall(positions, room, 0)
    output += ind_away_from_fixed_object(positions, room, 0,
                                         fixed_object_type='door')
    output += ind_away_from_fixed_object(positions, room, 0,
                                         fixed_object_type='window')
    output += ind_accessible(positions, room, 0,
                           sides=['bottom', 'left'])
    output += ind_away_from_fixed_object(positions, room, 0,
                                         fixed_object_type='socket', min_dist=2.0)
    output += in_bounds(positions, room)
    output += no_overlap(positions, room)
    output += aligned(positions, room)
    output += balanced(positions, room)
    output += wall_attraction(positions, room)
    return output
```

4.3. The Optimization Phase

Finally, we are ready to place the objects by determining the coordinates (x, y) of the centroid and the orientation (θ) of each object. Given the highly constrained nature of the problem, we split the optimization process into several steps, progressively solving for the layout. For each step, we compute a combined cost using all relevant constraint cost functions, as provided by our library functions, and find the optimal solution using a Sequential Least Squares Quadratic Programming (SLSQP) solver. To improve robustness, we repeat each optimization with different initializations

for the variables, and take the best solution. For each object i , we optimize its position (x_i, y_i) and orientation θ_i . Note that we define orientation with respect to forward-facing direction of each object.

In addition to the combined cost function that is derived from all language constraints C_{lang} , as defined above, we include five additional cost functions for the first two stages of the optimization (i.e., primary and secondary object placement). They are,

- A no-overlap cost C_{over} which penalizes intersections between objects. In [Equation 1](#), we show the formulation where, for every pair of objects i and j , we find the projected 2D polygon formed by their intersection (poly_{ij}). We then apply a function f , which sums the squared lengths of the sides of this polygon. This calculation is also applied to every object i in relation to any doors d , ensuring that no object intersects with a door, and for this term we add a scaling factor λ_1 (we use 100 in our experiments). In particular, the cost term is as follows,

$$C_{\text{over}} := \sum_i \left[\sum_{j > i} f(\text{poly}_{ij}) + \lambda_1 \sum_d f(\text{poly}_{id}) \right]. \quad (1)$$

- An in-bounds cost C_{bound} which penalizes objects that extend beyond the room’s boundaries. In [Equation 2](#), we show the formulation for object i , where we iterate over its corners c_{ij} ; I_{cij} is an indicator variable that takes a value of 1 if the corner c_{ij} lies within the room boundary, B , otherwise it is 0.

$$C_{\text{bound},i} := \sum_{j=0}^3 (1 - I_{cij}) \text{dist}(c_{ij}, B)^2. \quad (2)$$

- An alignment cost C_{align} which weakly penalizes orientations that deviate from the cardinal directions. Namely, we use

$$C_{\text{align},i} := \frac{\sin^2(2\theta_i)}{5}. \quad (3)$$

- A balanced placement cost C_{bal} that penalizes deviations of

the weighted centroid of all of the objects from the center of the room. The formulation of this is shown in [Equation 4](#), where w and l are the width and length of the room, and for object i , a_i is the area of the bounding box.

$$C_{\text{bal}} := \left(\frac{\sum_i a_i x_i}{\sum_i a_i} - \frac{w}{2} \right)^2 + \left(\frac{\sum_i a_i y_i}{\sum_i a_i} - \frac{l}{2} \right)^2. \quad (4)$$

- (v) A wall-attraction cost C_{wall} which weakly encourages objects to be near the walls. This is to prevent ‘floating’ objects from being placed centrally in the room. The formulation is shown in [Equation 5](#), where if the distance of object i , o_i , from the closest wall is greater than a given threshold T , a penalty is applied. We find that scaling this cost with a factor (λ_2) works better. We use $\lambda_2 = 20$ in all of our experiments.

$$C_{\text{wall},i} := \frac{1}{\lambda_2} \left(\min(T - \min_{\omega \in \text{walls}} \text{dist}(o_i, \omega), 0.0) \right)^2. \quad (5)$$

These functions account for all objects that are present in the room at the time of optimization. For instance, during the first optimization step, only overlaps between the primary objects are considered. Subsequently, intersections involving the newly added secondary objects are evaluated, along with any intersections between the secondary and previously placed primary objects.

A. Primary object placement. We begin by optimizing the locations and orientations of the primary objects ($i \in \mathcal{P}$). These locations and orientations are influenced by room features such as walls, windows, doors, and sockets, as well as by the positioning of other primary objects. We solve the following SLSQP, where $\lambda_i, i \in 1, 2, 3$ are tunable parameters. We use $\lambda_3 = 5, \lambda_4 = 10$ and $\lambda_5 = 10$ in all of our experiments.

$$\min_{\{x_i, y_i, \theta_i\}_{\mathcal{P}}} C_{\text{pri}} := \lambda_3 C_{\text{Cover}} + \lambda_4 C_{\text{bal}} + \sum_{i \in \mathcal{P}} (C_{\text{lang},i} + \lambda_5 C_{\text{bound},i} + C_{\text{align},i} + C_{\text{wall},i}) \quad (6)$$

Once the positions and orientations are determined, we initialize the zones, setting each initial centroid as the position of the corresponding primary object’s. We then use Voronoi segmentation based on these centroids to define the corresponding zones (z_i).

After optimizing the primary objects, we record the name, width, length, style description, coordinates of its centroid, and orientation ($p_i, w_i, l_i, \text{style}_i, x_i, y_i, \theta_i$) of each object. These values are held fixed during subsequent optimizations.

B. Secondary object placement. At this stage, the initial zones have been defined, and the positions and orientations of the primary objects are fixed. We then proceed zone by zone, to add the secondary objects ($i \in \mathcal{S}$). The positioning and orientation of these secondary objects are influenced by room features (such as walls, windows, doors, and sockets), the primary objects, and other secondary objects. We carry forward any accessibility constraints from the first stage, in order to ensure that the primary objects remain accessible. We add a default constraint C_{zone} with a scaling factor λ_6 (we use $\lambda_6 = 10$ in all our experiments) to ensure that objects are

encouraged to stay within the correct zones,

$$C_{\text{zone},i} := \sum_{j \neq i}^k \min(\text{dist}(s_i, z_j) - \text{dist}(s_i, z_i), 0.0)^2. \quad (7)$$

The overall optimization takes the form,

$$\min_{\{x_i, y_i, \theta_i\}_{\mathcal{Z}_k}} C_{\text{sec},k} := \lambda_3 C_{\text{Cover}} + \sum_{i \in \mathcal{Z}_k} (C_{\text{lang},i} + \lambda_5 C_{\text{bound},i} + C_{\text{align},i} + C_{\text{wall},i} + \lambda_6 C_{\text{zone},i}). \quad (8)$$

Note, compared to [Equation 6](#) we add a constraint for zoning here and remove C_{bal} . Once the secondary objects are fixed for a zone, we update the zone centroids by calculating the mean coordinates of all objects (primary and secondary) within that zone. We then redefine the zone boundaries using a new Voronoi segmentation based on the updated centroids.

After the secondary objects have been placed in all zones, we proceed to incorporate the tertiary objects.

C. Tertiary object placement. For this step, we use an altered set of default constraints that ensures that objects of the same type cannot overlap, and that tertiary objects that should be wall-mounted are both on the wall (ω) and that they are avoiding intersections with doors and windows.

In the final stage of optimization, we find the location and orientation (x_i, y_i, θ_i) of all of the tertiary objects ($i \in \mathcal{T}$) at once, regardless of zone. We do these all at once since each object has only one constraint making the optimization simpler. In [Equation 9](#) and [Equation 10](#), $C_{\text{over}[i,j]}$ is the cost only between objects i and j , λ_7 and λ_8 are tunable parameters (we use 500 for both in our experiments), $I_{\text{type}_i=\text{type}_j}$ is an indicator variable that has value 1 if objects i and j have the same type, otherwise 0, and I_{ω} is an indicator variable that has value 1 if the object is wall-mounted, otherwise 0.

The optimization takes the form,

$$\begin{aligned} \min_{\{x_i, y_i, \theta_i\}_{\text{ter}}} C_{\text{ter}} := & \sum_{i \in \text{ter}} [C_{\text{lang},i} + \lambda_7 C_{\text{bound},i} + C_{\text{align},i} + I_{\omega} C_{\text{on_wall},i} \\ & + \sum_{j \in \text{ter}, j > i} (I_{\text{type}_i=\text{type}_j}) C_{\text{over}[i,j]}]. \end{aligned} \quad (9)$$

with the wall alignment cost being defined as,

$$C_{\text{on_wall},i} := \sum_{j \in \text{doors} \cup \text{windows}} \lambda_8 C_{\text{over}[i,j]} + \prod_{\omega \in \text{walls}} \left(\text{dist}(t_i, \omega) + (\theta_i - \theta_{\omega})^2 \right). \quad (10)$$

4.4. Object Retrieval and Visualization

Having generated the final layout, we retrieve the objects based on their generated descriptions and add them to the scene for visualization. For each object (including windows and doors), we search, using text, for an asset that matches the style description generated, as described before. We scale the retrieved objects based on target width/depth, while proportionally scaling the height. We orient the objects based on the target angle θ_i assuming the objects have consistent (front) orientation. We source these assets using BlenderKit [?], and apply the same process for the wall and floor materials. In isolated cases, we manually modify the materials of the assets to better align with the descriptions produced by the LLM. (The only other manual adjustments made in this phase are for adding lighting for rendering.) We note that this

phase can be better automated using CLIP [RKH^{*21}] for object retrieval, leveraging text-image similarity scores to fetch objects from Objaverse [DSS^{*23}], as employed in competing methods like Holodeck [YSW^{*23}]. Also, linking to a generative 3D modeling system will reduce the reliance on the models in the database – this is left for future exploration.

5. Evaluation

We compare our approach with two recent LLM-based methods, namely LayoutGPT [FZF^{*24}] and HoloDeck [YSW^{*23}], and with transformer-based layout generator ATISS [PKS^{*21}]. We quantitatively evaluate the layouts on practical measures such as accessibility (pathway), area of overlapping objects, and area occupied by objects that are out of bounds. We also conduct a user study to qualitatively compare the quality of layouts and see how ours performs compared to layouts created by amateurs. We also conduct an ablation study to prove the effectiveness of our design choices.

5.1. Metrics

- (i) *Pathway cost*: We design a cost function to evaluate the clearance of pathways in a room to measure accessibility/walkability. The pathway is generated using the medial axis of the room boundary and the floor objects (primary and secondary objects) and is then expanded to a width of 0.6m. This pathway is represented as a set of points (P), and for each primary or secondary object, we check if any of these pathway points lie within their bounding box B_i . If a point is inside the bounding box, we compute the squared distance from the pathway point to the nearest object boundary (∂B_i), as

$$C_{\text{pathway}} := \sum_{i \in \{\text{pri}, \text{sec}\}} \sum_{p \in P \cap B_i} [d(p, \partial B_i)]^2. \quad (11)$$

- (ii) *Object overlap rate (OOR)*: In a good design layout, there should be no overlap between objects. We calculate the rate of overlapped objects as follows:

$$OOR := \frac{\sum_i \sum_{j > i} A_{\text{over}[i, j]} + \sum_q \sum_{r > q} A_{\text{over}[q, r]} (I_{\text{type}_q = \text{type}_r})}{w \cdot l} \quad (12)$$

where $A_{\text{over}[i, j]}$ is the area of overlap between objects i and j (including intersections with door buffers that account for the door swing area), $I_{\text{type}_q = \text{type}_r}$ is an indicator variable that has value 1 if tertiary objects q and r have the same type, otherwise 0; w and l are the width and the length of the room respectively.

- (iii) Out of Bounds Rate (OOB): All objects must fit fully inside a room for practicality. We measure the rate of area occupied by objects, which is out of bounds as follows:

$$OOB := \frac{\sum_i A_{\text{bound}[i]}}{w \cdot l} \quad (13)$$

where $A_{\text{bound}[i]}$ is the area out of bounds for object i .

5.2. Quantitative Evaluation

We compare our FlairGPT with both closed-universe and open-universe LLM-based layout generation methods—LayoutGPT [FZF^{*24}] and HoloDeck [YSW^{*23}], respectively. The comparison is based on the three metrics outlined

in subsection 5.1, with results presented in Figure 10. FlairGPT significantly outperforms both baseline methods across all metrics. LayoutGPT, as a closed-universe approach, is constrained to generating standard layouts for bedrooms and living rooms, lacking the flexibility to create more stylized or unique designs. Please note that our method does not explicitly add cost functions for pathway (C_{Pathway}) but we ensure walkability as a result of our wall-attraction cost, which encourages suitable objects to be near the wall as well as our customizable accessibility constraints mapped by the LLM during the language phase.

5.3. Qualitative Evaluation

We present the results of our method in Figure 6, showcasing layouts generated from a variety of prompts. These range from traditional bedroom and living room designs to more specialized spaces, such as a sewing room, and stylized concepts like “A small workroom for a wizard.” FlairGPT also demonstrates its ability to meet specific client-driven functional and aesthetic requirements, such as “A bedroom that is 5x5 for a young girl who likes to paint whilst looking out of her window” or “An office for a bestselling writer in New York who likes to write Fantasy books”.

We compare our method against baseline approaches—LayoutGPT [FZF^{*24}] and HoloDeck [YSW^{*23}]—in Figure 9. Our results demonstrate a closer alignment with the input prompt for stylized designs. For instance, in the prompt “A bedroom for a vampire,” the generated layout replaces the traditional bed with a coffin, showcasing FlairGPT’s creative and context-aware object selection to match the thematic style of user prompts. Video results are available on the supplemental webpage. Additionally, FlairGPT can generate multiple distinct layouts for the same input prompt, as seen in Figure 8, offering versatility and a range of design options that cater to individual preferences and specific requirements.

User Study I. In this study, we asked users to compare FlairGPT against three methods: the first two approaches are computational (LayoutGPT [FZF^{*24}] and ATISS [PKS^{*21}]), the third one being novice human designers. We were unable to run ATISS directly as the model weights are not publicly available, so we used the results reported in their paper instead.

To compare our method against novice human designers, we recruited 5 participants to design 2 layouts each. Each participant was provided with two blank floorplans containing windows and doors positioned identically to those in our method (see supplemental for details). They had 15 minutes per floorplan to draw bounding boxes for each object in the room (along with forward direction), without guidance on object sizing. From these designs, we selected 4 layouts (2 for each prompt) and reconstructed them in Blender using the same objects as our method. If a participant included objects that were not present in our room inventory, we selected assets that matched the specified style.

For the computational methods, we study three different prompts, for the human method, two:

- Computational:

- (i) “A bedroom that is 3m x 4m.”
- (ii) “A bedroom that is 3.225 x 4.5m.”
- (iii) “A living room that is 8m x 4m.”

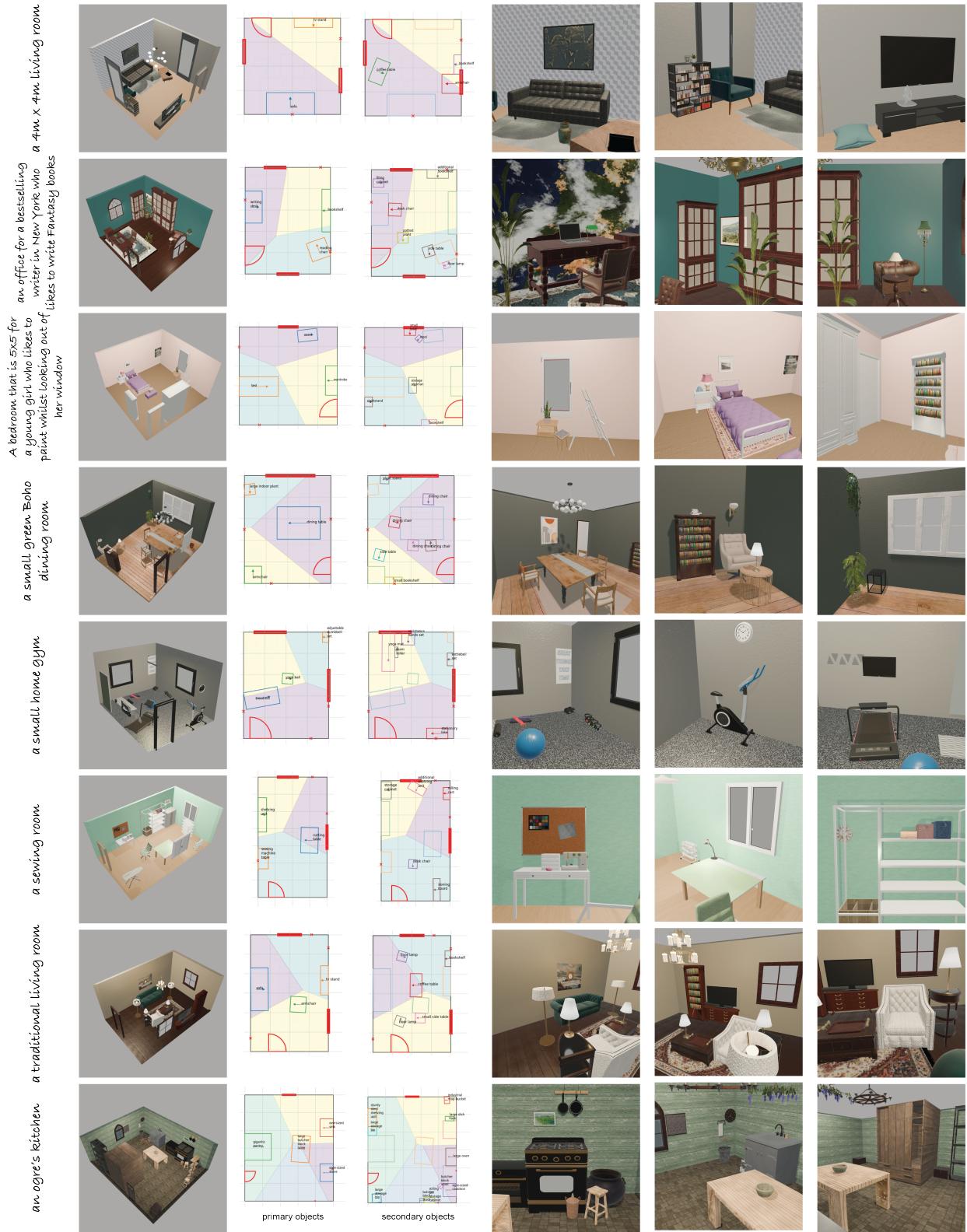


Figure 6: Results. We showcase a diverse range of layouts generated by FlairGPT, covering a wide range of prompts—from traditional bedroom and living room designs to more specialized spaces like a sewing room, as well as highly stylized concepts. From left to right, the visualizations include the text prompt, a three-quarter view, a floor plan highlighting primary objects, a floor plan detailing secondary objects (tertiary ones are not shown on floorplan), and close-up views for finer detail. See supplemental for walkthroughs.

Table 1: **Comparison.** Quantitative comparison against different methods measuring the functionality of the generated layouts in terms of object accessibility (OOB), object overlap (OOR), and access pathway ($C_{Pathway}$).

Prompt	LayoutGPT [FZF*24]			Holodeck [YSW*23]			FlairGPT (ours)		
	$OOB \downarrow$	$OOR \downarrow$	$C_{Pathway}$	$OOB \downarrow$	$OOR \downarrow$	$C_{Pathway}$	$OOB \downarrow$	$OOR \downarrow$	$C_{Pathway}$
“A bedroom that is 3m x 4m.”	0.773	3.973	12.315	0.890	0.332	3.764	0.095	0.000	0.291
“A bedroom that is 3.225m x 4.5m.”	4.752	0.000	12.617	1.630	1.532	1.163	0.215	0.004	2.916
“A bedroom that is 4.3m x 6m.”	2.920	3.518	4.173	1.518	0.000	2.828	0.009	0.008	1.406
“A bedroom that is 5m x 5m.”	0.000	0.811	10.569	2.013	1.242	5.129	0.010	0.012	0.000
“A bedroom that is 3m x 8m.”	1.129	10.080	1.843	1.412	0.000	5.650	0.005	0.003	3.678
“A living room that is 5m x 5m.”	2.040	6.480	2.958	0.996	0.000	6.240	0.000	0.004	0.740
“A living room that is 3m x 4m.”	0.001	7.046	2.010	2.013	2.200	6.712	0.074	0.000	0.204
“A living room that is 4m x 6m.”	4.427	1.282	0.852	1.611	3.215	8.021	0.019	0.008	0.050
“A living/dining room that is 6m x 3m.”	7.978	7.582	3.092	2.191	0.000	0.605	0.061	0.007	5.154
“A living room that is 8m x 4m.”	0.000	5.488	10.843	1.022	0.079	17.479	0.048	0.030	1.027
“A bedroom that is 4m x 5m.”	2.219	9.138	8.993	1.840	1.949	6.463	0.007	0.017	0.735
“A sewing room.”	X	X	X	1.317	0.000	10.699	0.007	0.000	1.033
“A small green boho dining room.”	X	X	X	1.971	2.150	10.674	0.100	0.011	2.394
“An office for a bestselling writer in New York who likes to write Fantasy books.”	X	X	X	1.659	0.365	6.176	0.010	2.588	2.262
“A bedroom for a vampire.”	X	X	X	1.683	0.302	3.982	0.043	0.094	2.469
Mean Scores	2.385	5.036	6.388	1.584	0.891	6.372	0.047	0.186	1.736

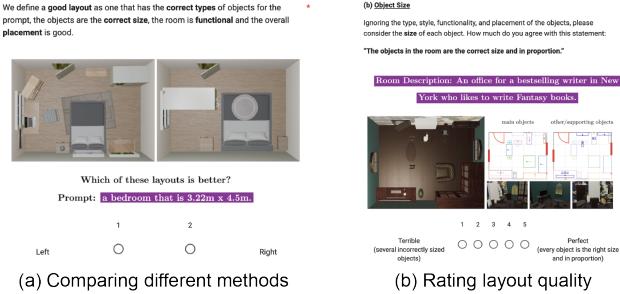


Figure 7: **Screen Capture of User Studies.** In User Study I (Figure (a)), participants compared FlairGPT with LayoutGPT, ATISS, and novice designers. In User Study II (Figure (b)), participants rated layouts by FlairGPT and novice designers across multiple criteria.

- Human:

- (iv) “A bedroom that is 4m x 5m.”
- (v) “An office for a bestselling writer in New York who likes to write Fantasy books.”

Participants were shown bird’s-eye renderings of each method and condition, similar to Figure 7 (a). In an unlimited-time, two-alternative forced choice task, they were asked to choose the “better layout” based on aesthetics, functionality, and adherence to the prompt. A total of 21 participants participated in this experiment, with the outcomes presented in Table 2.

We see that subjects prefer our results on average across prompts in 88.9% of the cases over LayoutGPT, in 79.4% of the cases over ATISS, and in 63.2% of the cases over a human result (significant, $p < 10^{-6}$, binomial test). Similar conclusions can be drawn when looking at individual prompt conditions (significant, $p < 0.01$, binomial test).

User Study II. Study 2 uses the same methods and similar viewing conditions as study 1, using the same prompts for the human baseline, but 5 prompts for our method:

- P1. “A bedroom that is 4m x 5m.”
- P2. “An office for a bestselling writer in New York who likes to write Fantasy books.”
- P3. “A sewing room.”
- P4. “A small green boho dining room.”
- P5. “A bedroom for a vampire.”

Participants were shown a single result of a single method (as can be seen in Figure 7 (b)) and asked to rate with unlimited time on a five-point Likert scale according to five criteria: “object type”, “object size”, “object style”, “object functionality”, and “overall placement”. We compare the four layouts drawn by novice human designers against the same four prompts picked from our generated results. A total of 17 participants participated in this experiment, where FlairGPT performed well across all criteria, as shown in Figure 10. For the direct comparison between our layouts and the human-designed ones, we excluded the style criterion since the rooms were constructed using the style produced by our method. Participants rated our method, aggregated across four criteria and all rooms, at 4.19 compared to 3.82 for human designs (difference significant at $p < 0.0001$, t -test).

LLM-based assessment. In our research, we aimed to test the ability of LLMs to evaluate the quality of a layout. Specifically, we sought to determine whether an LLM could classify a layout as “good” or “bad” and identify potential flaws in the design. To explore this, we conducted an experiment with 24 bedroom layouts, some intentionally flawed and others well-designed. Four human participants labeled each layout as either “good” or “bad” and provided reasoning for their classifications.



Figure 8: **Diversity in Generated Layouts.** FlairGPT demonstrates impressive versatility in scene generation for the same input prompt—“A 5m x 3m home office”, producing a wide range of layouts driven by variations in the selection of objects and style (guided by the LLM), and placement of windows, doors, and sockets. These elements significantly influence the arrangement of objects during our optimization phase, resulting in diverse and dynamic room configurations. We show primary and secondary objects on the left and on the right we show tertiary objects.

We extended this evaluation to both GPT-4o and SigLIP [ZMKB23] using the same set of layouts. For this, we created four representations of each bedroom: a bounding box representation, a top-down 2D view, a top-down 3D view, and a perspective view from an angle chosen (for best visibility) within the 3D room. Each representation was individually presented to GPT-4o, which was tasked with listing the pros and cons of the layout before classifying it as either good or bad.

For SigLIP, we employed the same bedroom representations, pairing each with three captions: a positive caption (“a good layout for a bedroom”), a neutral caption (“a layout for a bedroom”), and a negative caption (“a bad layout for a bedroom”). We calculated similarity scores between the captions, denoted as G_i for good, N_i for neutral, and B_i for bad, and the images. A layout was classified as good if $2G_i - N_i - B_i > 0$.



Figure 9: **Room layout comparison against baselines.** Comparison of layouts generated by FlairGPT and baseline methods, highlighting differences in object arrangement, spatial organization, and overall design quality.

Table 2: **User Study Findings.** Users preferred layouts generated by FlairGPT over those by LayoutGPT or ATISS. When compared against human designers, ours was preferred for more complex/creative prompts (P5), while human designers were better in the simple/standard scenario (P4).

(a) FlairGPT vs LayoutGPT and ATISS across three prompts.

Prompt	P1	P2	P3	Average
vs LayoutGPT	85.7%	100%	81.0%	88.9%
vs ATISS	81.0%	100%	57.1%	79.4%

(b) FlairGPT vs novice human designers across two prompts.

Prompt	P4	P5	Average
vs Human	29.4%	94.1%	63.2%

Our findings revealed that both GPT-4o and SigLIP performed best when using the 3D top-down view of the room. However, the accuracy of correct classifications was insufficient for practical use, with GPT-4o achieving 63%

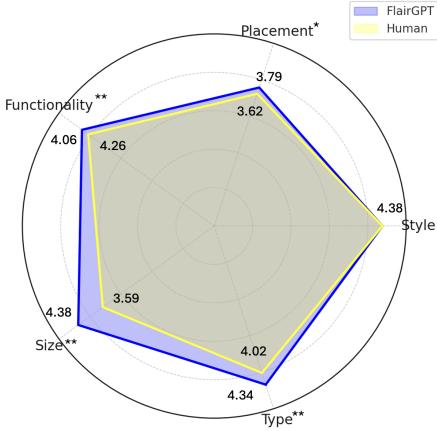


Figure 10: User Study II: Score comparison between FlairGPT and layouts designed by novices. Mean scores (out of 5) are shown for object type, object size, object style, object functionality and overall placement. Each criterion was rated on a scale from 1 (terrible) to 5 (perfect). Since we used the assets chosen by our method for the human designed layouts, we use our score for both FlairGPT and the human designs. For three criteria, the difference was significant at $p < 0.001$ (***) and for one, it was significant at $p < 0.01$ (*).

5.4. Ablation

We ablate our choice of cost constraints- C_{bound} and C_{over} as well as our hierarchical structure and cleaning step in [Table 3](#). Specifically, we compare our method without the boundary cost (C_{bound}), without the overlap cost (C_{over}), without the constraint cleaning phase, and with all objects optimized simultaneously rather than following our proposed hierarchical structure (for this, we allowed the optimization to run for 1.5 hours before taking the best result; for comparison, ours takes 10-15 minutes on average). We evaluate these variants using the same out of bounds (OOB) and object overlap rate (OOR) as described earlier. We also measure translation errors (TE) which is described as $\frac{\text{number of translation errors}}{\text{number of uncleaned constraints}}$.

Table 3: Ablation. Our ablation results underscore the critical role of the additional cost constraints, our hierarchical optimization structure, and the cleaning step in enhancing the overall performance of our method.

Method	OOB ↓	OOR ↓	TE ↓
w/o C_{bound}	9.20	0.01	N/A
w/o C_{over}	0.03	3.68	N/A
w/o Hierarchy	8.84	2.18	N/A
w/o Cleaning	0.04	0.23	19.24
FlairGPT	0.03	0.54	15.70

6. Conclusion

We have presented FlairGPT as an LLM-guided interior designer. We demonstrated that LLMs offer a rich source of information that can be harnessed to help decide which objects to include for a target room along with their various intra- and inter-object constraints. We described how to convert these language constraints into algebraic functions using a library of pre-authored cost functions.

Having translated the functions, we solve and extract final room layouts, and retrieve objects based on the LLM-based object attributes. Our evaluations demonstrate that human users favorably rate our designed layouts. The generated layouts are explainable by construction, as users can browse through the constraints used in the design process and optionally adjust their relative priority.

Limitations. Our study has several limitations that future work could address. First, FlairGPT designs are currently limited to rectangular rooms. Exploring application to irregularly shaped rooms, possibly by approximating them with union of (axis-aligned) rectangles, would be an interesting direction. However, one has to come up with a canonical naming convention for the walls to interact with the LLM to extract room-specific constraints.

Second, we pre-authored a set of cost functions for translating the LLM-specified constraints. In future work, we would like to investigate LLMs' generative capabilities to propose new cost functions for the library. Currently, we find that the algebraic reasoning skills of LLMs are inconsistent, making it challenging to develop an automated library generation capability. It is worth noting that our approach was zero-shot, as we did not fine-tune the LLM with example library functions.

Third, the object attributes do not have height associated with them, making it challenging to enforce constraints that prevent wall-mounted items from being placed behind taller objects — for example, a painting behind a wardrobe.

Finally, as described, we leave it to the LLM to decide and handle conflicting constraints in the constraint cleanup stage. Also, we fix the object size early in the pipeline when the LLM lists the room objects – this restricts possible adjustments in the subsequent optimization phase. In the future, when LLMs can quantitatively evaluate layouts, or their descriptions, then one can imagine an outer loop to backpropagate errors to update the list of selected objects and/or their relevant constraints, and decide which objects or constraints to drop.

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Supplementary Material for FlairGPT: Repurposing LLMs for Interior Designs**Contents**

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7. Statistics For Experiments

Table 4: Statistics for our experiments including: the number of primary (P), secondary (S), and tertiary (T) objects per scene; the number of constraints before cleaning, after cleaning, and after translation (function calls); the number of errors including Language errors, Cleaning errors, Translation errors, and Optimization errors; and the time (minutes) for the Language and Translation phase combined, the Optimization phase, and the total time to generate each layout.

Prompt	Objects			Constraints			Errors					Time (mins)		
	P	S	T	Uncleaned	Cleaned	Function Calls	Language	Cleaning	Translation	Contradiction	Optimization	Language + Translation	Optimization	Total
"A bedroom that is 4m x 5m."	3	4	7	49	52	57	1	2	6	0	1	0.82	7.20	8.02
"A living room that is 4m x 4m."	2	3	10	43	45	48	1	2	7	1	1	1.16	7.60	8.76
"A sewing room."	3	5	11	59	62	70	0	1	11	2	1	1.06	12.71	13.76
"A small home gym."	3	5	7	52	48	53	1	0	6	1	0	1.56	14.45	16.01
"A small green boho dining room."	3	7	9	58	65	68	1	1	24	2	0	1.05	24.35	25.41
"A traditional living room."	3	5	10	64	73	72	0	2	7	1	3	1.37	8.17	9.54
"An office for a bestselling writer in New York who likes to write Fantasy books."	3	4	11	60	62	63	1	3	4	0	1	1.08	13.04	14.12
"A bedroom that is 5x5 for a young girl who likes to paint whilst looking out of her window."	3	5	8	62	62	61	0	3	16	1	1	1.03	6.97	8.00
"A bedroom for a vampire."	3	4	9	49	47	47	0	0	0	2	2	0.85	6.68	7.53
"A small workspace for a wizard."	3	6	10	65	64	65	0	0	6	1	1	1.24	10.85	12.08
"A kitchen for an ogre."	4	10	10	72	73	79	0	7	3	2	1	1.61	12.13	13.73
Mean values	3.00	5.27	9.27	57.55	59.36	62.09	0.36	1.91	8.27	1.18	1.09	1.17	11.29	12.45

We define 5 types of errors that can occur throughout our method:

- Language Error: This type of error arises purely from the output of the LLM during the language generation phase. It includes incorrect object sizing, nonsensical constraints (e.g., “put the table lamp on the armchair”), or other errors in the initial LLM output.
- Cleaning Error: These errors occur during the cleaning phase. Examples include the unintended removal of constraints or the omission of crucial information from a constraint.
- Translation Error: This is the broadest category of errors and can occur at any point during the translation phase. It may involve matching a language constraint to a similar but suboptimal constraint (e.g., selecting “away from window” instead of “not blocking a window”), completely misinterpreting the constraint, missing applicable constraints that have matching functions, or using incorrect parameters. Translation errors are the most frequent type of error.
- Contradictory Constraint Error: This error occurs when two or more constraints are chosen that are mutually exclusive, making it impossible to satisfy all of them simultaneously within the solution.
- Optimization Error: An optimization error arises when an object is placed in a position that does not align with its constraints, and yet the optimization process fails to find a better solution throughout the optimization process.

While there are many places for errors to arise, they are not all critical. For example, the most common translation error that we have seen is choosing “ind_away_from” instead of “ind_not_block” which are similar constraints and will achieve the object not blocking the window. When incorrect types of parameters are used, the function returns 0 so that constraint is lost. This can occur when choosing the sides of an object (one of “left”, “right”, “front” or “back”) with the LLM choosing something like “longer side”. The most problematic errors are the contradictory constraint errors and the optimization errors. These are the most visible in the outputs, however these are also far less frequent than translation errors.

8. User Study 1 Responses

9. User Study 2 Responses

(a) Object Type Ignoring the style, placement, shape, and size of the objects, please consider the type (e.g. bed or desk) of each object in the room. How much do you agree with this statement: "The objects in the room are in the correct size and in proportion." 4 4 4 3 4 4 4 4 5 3 4 4 4 2 2 3
(b) Object Size Ignoring the type, style, functionality and placement of the objects, please consider the size of each object. How much do you agree with this statement: "The objects in the room are in the correct size and in proportion." 5 2 3 2 4 2 2 4 4 4 3 5 1 4 2 4 3
(c) Object Style Ignoring the size, style, functionality and placement of the objects, please consider the style (colour, material, overall style e.g. minimalist) of each object in the room. How much do you agree with this statement: "The style of the objects in the room is cohesive and matches the room description well." 4 5 4 3 3 4 2 4 1 4 4 5 2 5 3 3 5
(d) Object Functionality Ignoring the type, size, style and placement, please consider the functionality of all the objects in the room. Can the wardrobe doors open? Can you walk to the sofa and sit down? How much do you agree with the following statement: "I am able to use every object in the room." 3 2 4 4 5 3 2 4 3 3 3 2 5 3 4 3 5
(e) Object Placement Ignoring the type, size, style, and functionality of the objects, please consider the placement of all the objects in the room. How much do you agree with the following statement: "The objects in the room are placed in a way that makes sense." 3 2 2 2 4 3 4 4 2 3 4 1 3 4 2 3 4
(f) Object Type Ignoring the style, placement, shape, and size of the objects, please consider the type (e.g. bed or desk) of each object in the room. How much do you agree with this statement: "Given the description of the room, each object in the room should be there, and there are no objects in the room that should not be there." 5 5 5 5 5 5 4 4 5 4 5 4 5 4 4 4 5
(g) Object Size Ignoring the type, size, functionality and placement of the objects, please consider the size of each object. How much do you agree with this statement: "The objects in the room are in the correct size and in proportion." 5 5 3 4 5 5 2 4 5 5 4 5 5 4 4 4 5
(h) Object Style Ignoring the size, style, functionality and placement of the objects, please consider the style (colour, material, overall style e.g. minimalist) of each object in the room. How much do you agree with this statement: "The style of the objects in the room is cohesive and matches the room description well." 4 5 4 5 4 4 2 4 4 5 4 5 5 4 4 4 5
(i) Object Functionality Ignoring the type, size, style and placement, please consider the functionality of all the objects in the room. Can the wardrobe doors open? Can you walk to the sofa and sit down? How much do you agree with the following statement: "I am able to use every object in the room." 3 4 4 4 5 2 2 2 5 5 4 5 5 4 4 4 5
(j) Object Placement Ignoring the type, size, style, and functionality of the objects, please consider the placement of all the objects in the room. How much do you agree with the following statement: "The room is laid out well and the objects are placed in a way that makes sense." 4 4 3 1 4 3 4 3 3 4 3 4 3 3 2 4 2
(k) Object Type Ignoring the style, placement, shape, and size of the objects, please consider the type (e.g. bed or desk) of each object in the room. How much do you agree with this statement: "Given the description of the room, each object in the room should be there, and there are no objects in the room that should not be there." 4 5 4 5 5 3 2 4 5 5 5 5 5 4 5 5 5
(l) Object Size Ignoring the type, size, functionality and placement of the objects, please consider the size of each object. How much do you agree with this statement: "The objects in the room are in the correct size and in proportion." 5 5 5 5 5 5 3 4 5 5 5 5 5 5 5 5 5
(m) Object Style Ignoring the size, style, functionality and placement of the objects, please consider the style (colour, material, overall style e.g. minimalist) of each object in the room. How much do you agree with this statement: "The style of the objects in the room is cohesive and matches the room description well." 4 5 5 5 5 5 4 2 4 4 5 4 5 5 5 5 5
(n) Object Functionality Ignoring the type, size, style and placement, please consider the functionality of all the objects in the room. Can the wardrobe doors open? Can you walk to the sofa and sit down? How much do you agree with the following statement: "I am able to use every object in the room." 4 5 4 5 5 5 3 4 5 5 5 5 5 5 5 5 5
(o) Object Placement Ignoring the type, size, style, and functionality of the objects, please consider the placement of all the objects in the room. How much do you agree with the following statement: "The room is laid out well and the objects are placed in a way that makes sense." 3 4 4 5 5 5 2 4 3 5 2 3 5 4 4 3 5
(p) Object Type Ignoring the style, placement, shape, and size of the objects, please consider the type (e.g. bed or desk) of each object in the room. How much do you agree with this statement: "Given the description of the room, each object in the room should be there, and there are no objects in the room that should not be there." 4 5 5 5 5 5 5 4 4 5 5 5 5 4 5 5 5
(q) Object Size Ignoring the type, size, functionality and placement of the objects, please consider the size of each object. How much do you agree with this statement: "The objects in the room are in the correct size and in proportion." 4 3 2 2 3 3 2 3 5 5 2 2 5 2 4 5 3
(r) Object Style Ignoring the size, style, functionality and placement of the objects, please consider the style (colour, material, overall style e.g. minimalist) of each object in the room. How much do you agree with this statement: "The style of the objects in the room is cohesive and matches the room description well." 5 5 4 4 5 5 3 3 5 5 4 4 5 5 4 5 5
(s) Object Functionality Ignoring the type, size, style and placement, please consider the functionality of all the objects in the room. Can the wardrobe doors open? Can you walk to the sofa and sit down? How much do you agree with the following statement: "I am able to use every object in the room." 3 4 3 5 4 5 2 4 3 5 2 3 5 4 4 3 5
(t) Object Placement Ignoring the type, size, style, and functionality of the objects, please consider the placement of all the objects in the room. How much do you agree with the following statement: "The room is laid out well and the objects are placed in a way that makes sense." 4 3 2 4 4 3 1 3 4 1 3 3 4 5 2 4 3
(u) Object Type Ignoring the style, placement, shape, and size of the objects, please consider the type (e.g. bed or desk) of each object in the room. How much do you agree with this statement: "Given the description of the room, each object in the room should be there, and there are no objects in the room that should not be there." 5 4 4 4 5 5 3 4 4 5 1 4 4 5 5 4 5
(v) Object Size Ignoring the type, size, functionality and placement of the objects, please consider the size of each object. How much do you agree with this statement: "The objects in the room are in the correct size and in proportion." 4 4 4 4 5 5 2 4 5 2 3 2 4 5 4 5 5
(w) Object Style Ignoring the size, style, functionality and placement of the objects, please consider the style (colour, material, overall style e.g. minimalist) of each object in the room. How much do you agree with this statement: "The style of the objects in the room is cohesive and matches the room description well." 4 5 4 5 5 5 3 3 2 2 5 4 5 5 3 2 5
(x) Object Functionality Ignoring the type, size, style and placement, please consider the functionality of all the objects in the room. Can the wardrobe doors open? Can you walk to the sofa and sit down? How much do you agree with the following statement: "I am able to use every object in the room." 4 5 4 5 5 5 3 3 2 2 5 5 5 5 4 5 5
(y) Object Placement Ignoring the type, size, style, and functionality of the objects, please consider the placement of all the objects in the room. How much do you agree with the following statement: "The room is laid out well and the objects are placed in a way that makes sense." 4 3 4 4 5 3 1 4 2 1 5 5 5 5 3 2 5

(a) Object Type Ignoring the type, style, functionality, shape, and size of the objects, please consider the type (e.g. bed or desk) of each object in the room. How much do you agree with this statement: "Given the description of the room, each object in the room should be there, and there are no objects in the room that should not be there."	5	5	4	4	5	5	4	4	4	4	5	5	4	5	5	4	4	4	4
(b) Object Size Ignoring the type, style, functionality, and placement of the objects, please consider the size of each object. How much do you agree with this statement: "The objects in the room are the correct size and in proportion."	4	5	4	4	5	5	4	4	4	4	5	5	4	5	5	4	5	3	3
(c) Object Style Ignoring the type, style, functionality and placement of the objects, please consider the style (colour, material, overall style e.g minimalist) of each object in the room. How much do you agree with this statement: "The style of the objects in the room is cohesive and matches the room description well."	5	5	5	5	4	5	5	4	5	5	5	5	4	5	5	4	5	4	4
(d) Object Functionality Ignoring the type, size, style and placement, please consider the functionality of all the objects in the room. Can the wardrobe door open? Can you walk to the sofa and sit down? How much do you agree with the following statement: "I am able to easily use every object in the room."	4	5	4	5	2	5	4	4	4	4	5	5	4	5	5	4	4	4	3
(e) Object Placement Ignoring the type, size, style, and functionality of the objects, please consider the placement of all the objects in the room. How much do you agree with the following statement: "The room is laid out well and the objects are placed in a way that makes sense."	4	5	3	5	5	5	4	4	3	2	4	4	5	4	4	4	4	4	4
(f) Object Type Ignoring the type, placement, shape, and size of the objects, please consider the type (e.g. bed or desk) of each object in the room. How much do you agree with this statement: "Given the description of the room, each object in the room should be there, and there are no objects in the room that should not be there."	5	5	4	5	5	4	4	4	3	5	5	4	5	5	3	4	4	4	4
(g) Object Size Ignoring the type, style, functionality, and placement of the objects, please consider the size of each object. How much do you agree with this statement: "The objects in the room are the correct size and in proportion."	3	4	2	4	2	2	3	2	4	5	5	3	2	4	4	4	4	3	3
(h) Object Style Ignoring the type, style, functionality and placement of the objects, please consider the style (colour, material, overall style e.g minimalist) of each object in the room. How much do you agree with this statement: "The style of the objects in the room is cohesive and matches the room description well."	4	5	4	5	5	5	4	3	5	4	4	5	5	4	5	4	5	4	4
(i) Object Functionality Ignoring the type, size, style and placement, please consider the functionality of all the objects in the room. Can the wardrobe door open? Can you walk to the sofa and sit down? How much do you agree with the following statement: "I am able to easily use every object in the room."	4	5	3	5	5	2	4	3	2	4	5	5	3	5	4	3	5	4	3
(j) Object Placement Ignoring the type, size, style, and functionality of the objects, please consider the placement of all the objects in the room. How much do you agree with the following statement: "The room is laid out well and the objects are placed in a way that makes sense."	4	4	3	5	5	3	4	3	2	5	5	4	5	3	3	4	3	3	3

10. Human Forms for User Studies and Human Drawn Layouts

Example: "A living room."

- Arrows indicate the front side of corresponding objects
- Reference grid lines are spaced to be 1 meter apart

Key	
✗	Socket
□	Door
■	Window

M = Must Have, S = Should Have, N = Nice to Have

1. Sofa (M)
2. Coffee Table (S)
3. TV Stand (S)
4. Armchair (S)
5. TV (M)
6. Painting (N)

"A bedroom that is 4m x 5m."

Please add up to 15 objects into the room. Label each object with a number and fill out the spaces below with the name of the object. Please follow the name with either M, S, or N.

M = Must Have
S = Should Have
N = Nice to Have

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.
- 11.
- 12.
- 13.
- 14.
- 15.

"An office for a bestselling writer in New York who likes to write Fantasy books."

Please add up to 20 objects into the room. Label each object with a number and fill out the spaces below with the name of the object. Please follow the name with either M, S, or N.

M = Must Have
S = Should Have
N = Nice to Have

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.
- 9.
- 10.
- 11.
- 12.
- 13.
- 14.
- 15.
- 16.
- 17.
- 18.
- 19.
- 20.

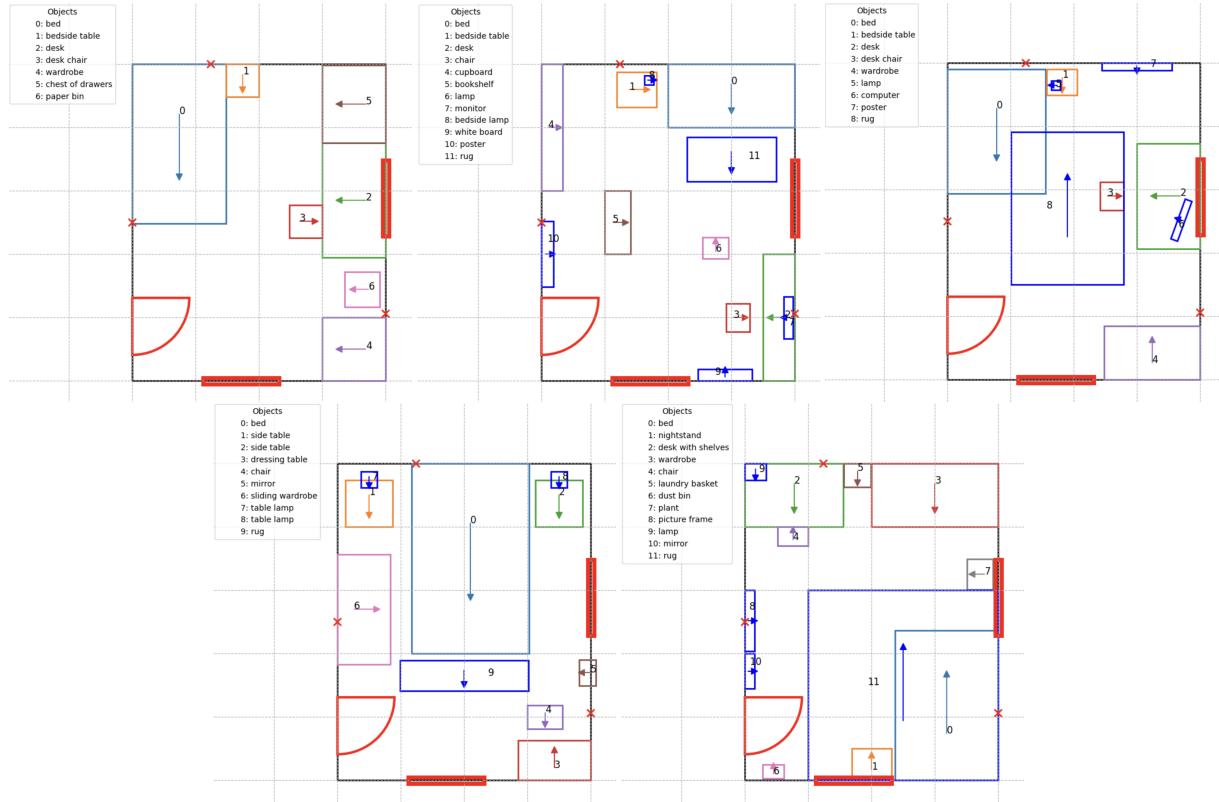


Figure 11: Layouts designed by 5 novice human designers for the prompt: “a bedroom that is 4m x 5m.”



Figure 12: Two layouts chosen from Figure 11, rendered in Blender [Ble18], using assets from BlenderKit [Ble24].

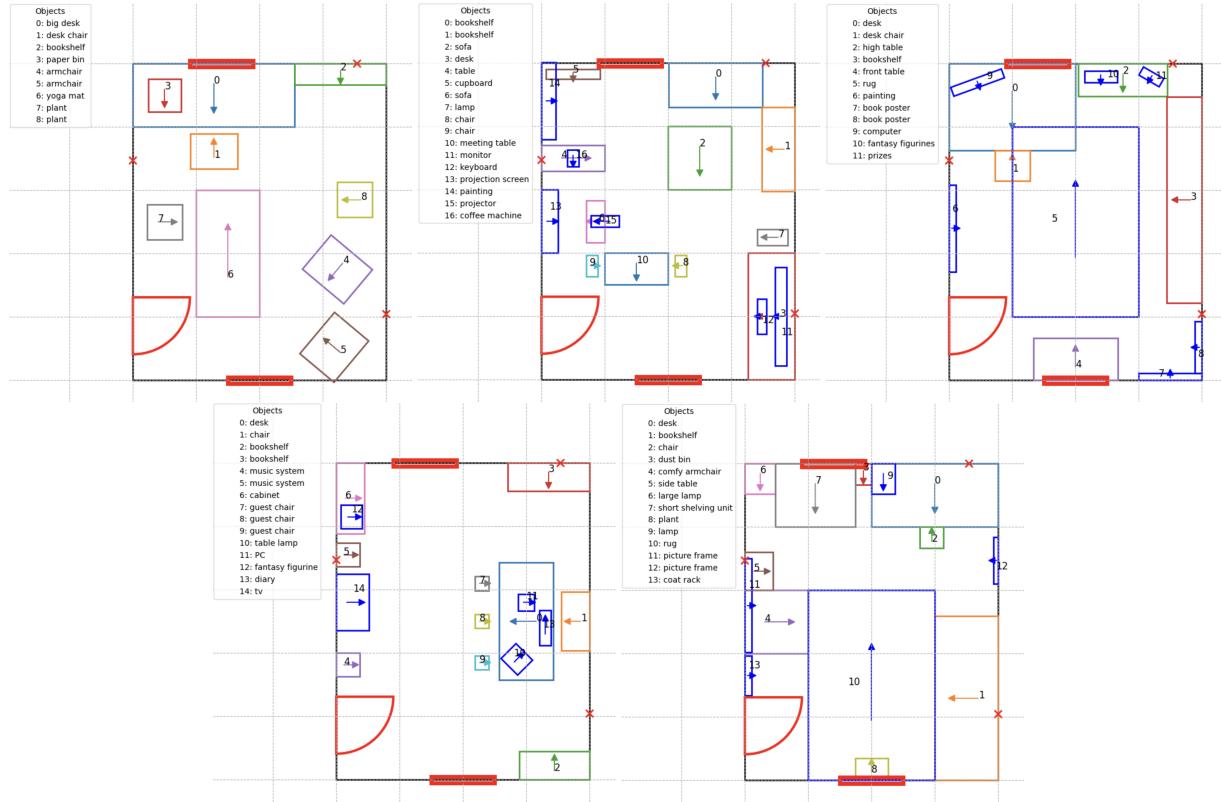


Figure 13: Layouts designed by 5 novice human designers for the prompt: “an office for a bestselling writer in New York who likes to write Fantasy books.”

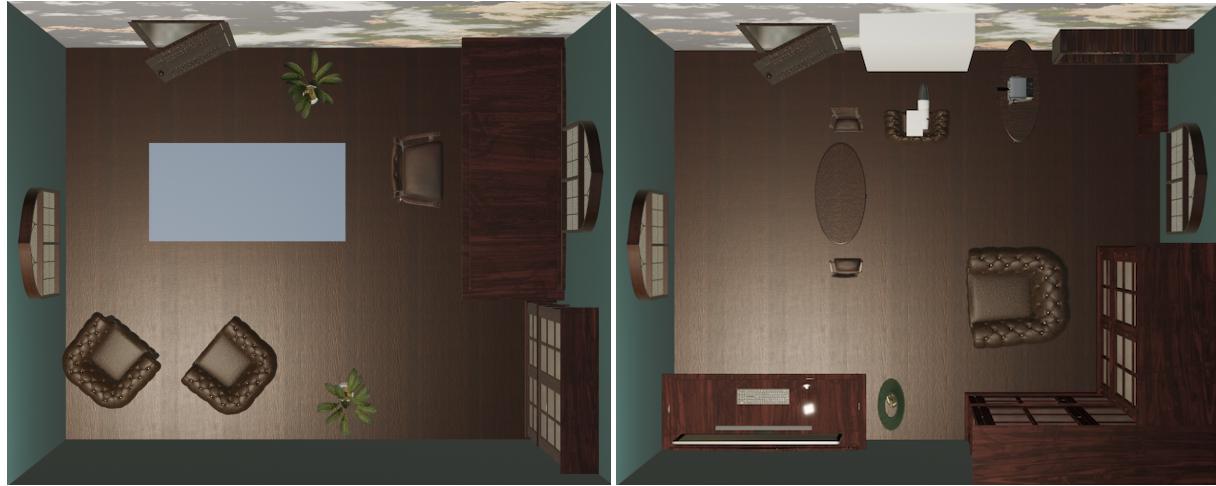


Figure 14: Two layouts chosen from Figure 13, rendered in Blender [Ble18], using assets from BlenderKit [Ble24].

11. Blank Constraint Cost Functions

1 Blank Constraint Cost Functions for Individual Constraints

```

1  from Class_Structures import *
2  from shapely.geometry import Polygon
3
4  """ Throughout, the sides of the objects are defined as follows:
5  # 'back' of the object would be the headboard of a bed, or the back of a chair
6  # 'front' of the object would be the foot of a bed, or the front of a wardrobe (the side with the doors)
7  # 'left' would be the left side of the object, when standing behind it
8  # 'right' would be the right side of the object, when standing behind it
9
10 def ind_next_to_wall(positions, room, object_index):
11     """ This function ensures an object is next to a wall in a room. Specifically the back of the object.
12     Example constraint: "The tv should be against a wall."
13
14     Args:
15         positions: list of floats, x, y, theta values for all objects in the room
16         room: rectangular Room object
17         object_index: int, index of the object in the room's object list
18
19     """
20
21     return
22
23
24 def ind_near_wall(positions, room, object_index, side = 'back', max_dist = 0.5):
25     """ This function ensures an object is near to a wall in a room (within a specific distance, NOT next to).
26     The specific side of the object will be used. If no side is given, the back of the object will be used.
27
28     Args:
29         positions: list of floats, x, y, theta values for all objects in the room
30         room: rectangular Room object
31         object_index: int, index of the object in the room's object list
32         side: string, one of 'back', 'front', 'left', 'right' defines which side of the object to check e.g back of bed
33         max_dist: float, maximum distance the object should be from the wall
34
35
36     """
37     return
38
39 def ind_close_to_fixed_object(positions, room, object_index, fixed_object_type, side = None, max_dist = 0.5):
40     """ The function ind_close_to_fixed_object is used for 3 purposes:
41         1) an object should be next to a window (fixed_object_type = 'window')
42         2) an object should be next to a door (fixed_object_type = 'door')
43         3) an object should be next a socket (fixed_object_type = 'socket')
44
45     If side is given, the specific side of the object will be used.
46
47     Args:
48         positions: list of floats, x, y, theta values for all objects in the room
49         room: rectangular Room object
50         object_index: int, index of the object in the room's object list
51         fixed_object_type: string, type of fixed object to check. One of 'window', 'door', 'socket'
52         side: string, one of 'back' (for things like headboard of bed, or back of bookshelf), 'front'
53             (for things like foot of bed or front of bookshelf), 'left', 'right', defines which side of the object to check
54             e.g back of bed
55         max_dist: float, maximum distance between the object and the fixed object to be considered close to it.
56         Write this as a float e.g. 2.0.
57
58     """
59     return
60
61 def ind_away_from_fixed_object(positions, room, object_index, fixed_object_type, min_dist = 2.0):
62     """ This function is used for 3 purposes:
63         1) an object should be away from a window (fixed_object_type = 'window')

```

```

64     2) an object should be away from a door (fixed_object_type = 'door')
65     3) an object should be away from a socket (fixed_object_type = 'socket')
66
67     Args:
68     positions: list of floats, x, y, theta values for all objects in the room
69     room: rectangular Room object
70     object_index: int, index of the object in the room's object list
71     fixed_object_type: string, type of fixed object to check. One of 'window', 'door', 'socket'
72     min_dist: float, minimum distance between the object and the fixed object to be considered away from it.
73     Write this as a float, e.g. 2.0.
74 """
75
76     return
77
78 def ind_accessible(positions, room, object_index, sides, min_dist = None):
79     """ This function ensures that an object is accessible from given sides. It can also ensure that
80         there is nothing too close to a given side of an object (e.g. if there needs to be clearance around something).
81         If no sides are given, the front side is used. If min_dist is given, then this function
82         will act as a clearance constraint. If you want all the sides to be accessible,
83         sides = ['front', 'back', 'left', 'right'].
84
85     Args:
86     positions: list of floats, x, y, theta values for all objects in the room
87     room: rectangular Room object
88     object_index: int, index of the object in the room's object list
89     sides: a list of strings, each one one of 'front', 'left', 'right', defines which side of the object to check
90     min_dist: float (optional), minimum distance clearance for the object on the sides given.
91     Write this as a float, e.g. 1.0.
92 """
93
94     return
95
96 def ind_central(positions, room, object_index, both = False):
97     """ This function ensures that an object is centrally placed in the room.
98     Args:
99     positions: list of floats, x, y, theta values for all objects in the room
100    room: rectangular Room object
101    object_index: int, index of the object in the room's object list
102    both: bool (optional), if True, then the object should be placed centrally in both x and y. For example for a bed,
103        but for a dining table, it should be True.
104 """
105
106     return
107
108 def ind_not_block_fixed_object(positions, room, object_index, fixed_object_type):
109
110     """ This function is used for 2 purposes:
111         1) an object does not block a window (fixed_object_type = 'window')
112         2) an object does not block a door (fixed_object_type = 'door')
113
114     Args:
115     positions: list of floats, x, y, theta values for all objects in the room
116     room: rectangular Room object
117     object_index: int, index of the object in the room's object list
118     fixed_object_type: string, type of fixed object to check. E.g one of 'window', 'door', 'plug'
119 """
120
121     return
122
123 def ind_under_window(positions, room, object_index):
124
125     """ This function ensures that the object will be placed underneath a window.
126         For example, you might want a desk or a dresser below (but not blocking) a window. You would NOT use this for any
127         objects that would be tall, for example a wardrobe or a fridge. Example constraint "The desk should be under
128         the window", "The desk should look out the window". Don't use with ind_not_block_fixed_object for a window
129

```

```

130     and the same object.
131
132     Args:
133     positions: list of floats, x, y, theta values for all objects in the room
134     room: rectangular Room object
135     """
136
137     return
138
139 def ind_facing_into_room(positions, room, object_index):
140     """ ind_facing_into_room is a function that ensures and object faces into the center of the room.
141     E.g. an armchair might face into the room.
142
143     Args:
144     positions: list of floats, x, y, theta values for all objects in the room
145     room: rectangular Room object
146     object_index: int, index of the object in the room's object list
147
148     """
149
150     return
151
152 def ind_in_region(positions, room, object_index, region_name, weight = 5.0):
153     """ This function ensures that an object is in a given region. This should NOT be used with the
154     optimize_primary_objects function.
155
156     Args:
157     positions: list of floats, x, y, theta values for all objects in the room
158     room: rectangular Room object
159     object_index: int, index of the object in the room's object list
160     region_name: string, name of the region for the object to be in
161     weight: float, weight of the constraint
162
163     return
164
165
166 def ind_not_against_wall(positions, room, object_index, min_dist = 0.5):
167
168     """ ind_not_against_wall is a function that ensures an object is not against a wall.
169     For example "the rug should not be touching the wall" or "the dining table should not be against the wall".
170
171     Args:
172     positions: list of floats, x, y, theta values for all objects in the room
173     room: rectangular Room object
174     object_index: int, index of the object in the room's object list
175     min_dist: float, minimum distance the object should be from the wall. Please write this as a float, e.g. 2.0.
176
177     return
178
179
180 def ind_in_corner(positions, room, object_index, side = 'back', max_dist = 0.5):
181     """ This function can be used to ensure that an object is placed into a corner.
182     The back of the object will always be placed closest to the corner.
183
184     Args:
185     positions: list of floats, x, y, theta values for all objects in the room
186     room: rectangular Room object
187     object_index: int, index of the object in the room's object list
188     max_dist: float, maximum distance the object should be from the wall
189
190     return

```

2 Blank Constraint Cost Functions for Inter-Object Constraints

```
1 import numpy as np
2 from Class_Structures import *
3 from shapely.geometry import Polygon
4
5     ### Throughout, the sides of the objects are defined as follows:
6     # 'top' or 'back' of the object would be the headboard of a bed, or the back of a chair
7     # 'front' or 'bottom' of the object would be the foot of a bed, or the front of a wardrobe (the side with the doors)
8     # 'left' would be the left side of the object, when standing behind it
9     # 'right' would be the right side of the object, when standing behind it
10
11
12
13 def io_next_to(positions, room, object1_index, object2_index, side1 = None, side2 = None):
14     """DO NOT USE THIS WITH io_surround, IT WILL BE REDUNDANT OR CONTRADICTORY.
15     This function ensures that two objects are next to each other in a room.
16     This should only be used when necessary e.g. for nightstands and a bed, or a desk and desk chair.
17     This should not be used for dining chairs around a table or similar relationship, for that use io_surround.
18     If side1 is given, the specific side of object1 will be used. If side2 is given,
19     the specific side of object2 will be used. E.g. the 'front' of the chair should be next to the 'front' of the desk.
20     If no side is given, then any of the sides will be used.
21
22     Args:
23         room: rectangular Room object
24         object1: Object object
25         object2: Object object
26         side1: string, one of 'top' or 'back', 'bottom' or 'front', 'left', 'right', defines which side of object1 to use
27         side2: string, one of 'top' or 'back', 'bottom' or 'front', 'left', 'right', defines which side of object2 to use
28     """
29     return
30
31 def io_away_from(positions, room, object1_index, object2_index, min_dist = 2.0):
32     """ This function ensures that two objects are away from each other in a room.
33     For example, a bed should be away from a desk.
34
35     Args:
36         positions: list of floats, x, y, theta values for all objects in the room
37         room: rectangular Room object
38         object1_index: int, index of object1 in the room
39         object2_index: int, index of object2 in the room
40         min_dist: float, minimum distance between the two objects. Please write this as a float, e.g. 2.0.
41
42     """
43     return
44
45 def io_near(positions, room, object1_index, object2_index, max_dist = 3.0):
46     """ This function ensures that two objects are within a certain distance to each other.
47     They are not necessarily next to each other, but they are close. This might be for a bookshelf
48     and an armchair, or a mirror and a wardrobe.
49
50     Args:
51         room: rectangular Room object
52         object1_index: Object object
53         object2_index: Object object
54         max_dist: furthest distance between the two objects. Please write this as a float, e.g. 3.0.
55
56     """
57     return
58
59 def io_parallel(positions, room, object1_index, object2_index, center_object_info = None, max_dist = 2.0):
60     """ This function ensures that two objects have the same orientation in a room.
61     That is, that they are parallel to each other. It does not handle distance, so if
62     proximity is important, please combine this function with io_near, or io_next_to, or even io_between.
63
```

```

64     Args:
65     positions: list of floats, x, y, theta values for all objects in the room
66     room: rectangular Room object
67     object1_index: int, index of object1 in the room
68     object2_index: int, index of object2 in the room
69     """
70     return
71
72 def io_facing(positions, room, object1_index, object2_index, both = False):
73     """ This function ensures that object1 is facing object2 in a room.
74     If both is True, then object2 will also be facing object1.
75     For example, a sofa and tv should face each other, so in that instance both would be True.
76
77     Args:
78     positions: list of floats, x, y, theta values for all objects in the room
79     room: rectangular Room object
80     object1_index: int, index of object1 in the room
81     object2_index: int, index of object2 in the room
82     both: bool, if True, object2 will also be facing object1
83     """
84     return
85
86 def io_infront(positions, room, object1_index, object2_index, dist = 0.8, parallel = False):
87     """ This function ensures that object1 is in front of object2 (both moving_objects i.e. not windows or doors).
88     E.g a coffee table should be in front of a sofa.
89
90     Args:
91     positions: list of floats, x, y, theta values for all objects in the room
92     room: rectangular Room object
93     object1_index: int, Object object
94     object2_index: int, Object object
95     dist: float, desired distance between two objects. E.g. if its a sofa and a coffee table, the distance should
96     be around 0.8m, if its a sofa and a fireplace, the distance should be around 2m/2.5m.
97     parallel: bool, if True, object1 will be parallel to object2. This would be used for a coffee table in front
98     of a sofa, but not for a sofa in front of a fireplace.
99     """
100    return
101
102 def io_perp(positions, room, object1_index, object2_index, center_object_index = None):
103     """ This function ensures that two objects are aligned in a room perpendicularly.
104     If center is given, the objects will be aligned about that point. For example, a sofa and chair might be aligned
105     perpendicularly about a coffee table or a side table.
106
107     Args:
108
109     positions: list of floats, x, y, theta values for all objects in the room
110     room: rectangular Room object
111     object1_index: int, index of object1 in the room
112     object2_index: int, index of object2 in the room
113     center_object_index: int, index of object in room.moving_objects to be used as the pivot for the alignment
114     (e.g. a coffee table or a table)
115     """
116
117    return
118
119 def io_surround(positions, room, central_object_index, object_indices):
120     ## IF YOU USE THIS FUNCTON, DO NOT ALSO USE "IO_NEXT_TO" AS IT WILL BE REDUNDANT OR CONTRADICTORY.
121     """ This function ensures that central_object is surrounded by all the objects in object_indices.
122     This would be used for chairs around a dining table. This should NOT be combined with io_next_to,
123     as that would be redundant or
124     it would contradict.
125
126     Args:
127     positions: list of floats, x, y, theta values for all objects in the room
128     room: rectangular Room object

```

```

130     central_object_index: int, Object object
131     object_indices: list of ints, indices of Object objects
132     """
133
134     return
135
136 def io_not_facing(positions, room, object1_index, object2_index):
137     """ This function ensures that object1 is NOT facing object2 in a room.
138     For example, a bed should not face a mirror.
139     Args:
140         positions: list of floats, x, y, theta values for all objects in the room
141         room: rectangular Room object
142         object1_index: int, index of object1 in the room
143         object2_index: int, index of object2 in the room
144     """
145
146     return
147
148 def io_between(positions, room, object1_index, object2_index, object3_index):
149     """ This function ensures that object1 is in between the two objects object2 and object3.
150     This would be used for something like a side table being between two chairs, or maybe a bed being
151     between two nightstands. Or a nightstand going between two beds.
152
153     Args:
154         positions: list of floats, x, y, theta values for all objects in the room
155         room: rectangular Room object
156         object1_index: int, index of object1 in the room (** this is the object that will go
157             in between the other two objects)
158         object2_index: int, index of object2 in the room
159         object3_index: int, index of object3 in the room
160     """
161
162     return

```

3 Blank Constraint Cost Functions for Tertiary Constraints

```

1  ## All the Individual Object constraint functions are defined here
2  from Class_Structures import *
3  from shapely.geometry import Polygon, Point
4  from shapely import distance
5  from Individual import *
6  from Setup_Functions import *
7  from Global import *
8  from scipy.optimize import minimize
9
10
11 def rug_under_central(positions, room, rug_index, object_index):
12
13     """ This function ensures that the rug is placed under the central object.
14
15     Args:
16         positions: list of floats, x, y, theta values for all objects in the room
17         room: rectangular Room object
18         rug_index: int, index of the rug object in the room.tertiary_objects list
19         object_index: int, index of the central object in the room.moving_objects list
20
21
22     return
23
24 def rug_under_central_forward(positions, room, rug_index, object_index):
25
26     """ This function ensures that the rug is placed under the central object, oriented correctly,
27     and moved slightly forward. E.g. this would be used for a rug that is placed under a bed.
28

```

```

29     Args:
30     positions: list of floats, x, y, theta values for all objects in the room
31     room: rectangular Room object
32     rug_index: int, index of the rug object in the room.tertiary_objects list
33     object_index: int, index of the central object in the room.moving_objects list
34     """
35     return
36
37 def on_top_central(positions, room, tertiary_index, other_index):
38
39     """ This function ensures that the tertiary object is placed on top of the central object.
40     This would be used for placing a table lamp on top of a nightstand, for example.
41
42     Args:
43         positions: list of floats, x, y, theta values for all objects in the room
44         room: rectangular Room object
45         tertiary_index: int, index of the tertiary object in the room.tertiary_objects list
46         other_index: int, index of the central object in the room.moving_objects list
47     """
48     return
49
50 def on_top_corner(positions, room, tertiary_index, other_index, corner = 'tl'):
51
52     """ This function ensures that the tertiary object is placed on top of the central object, at a specific corner.
53     This would be used for placing a lamp on the top left corner of a desk, for example.
54
55     Args:
56         positions: list of floats, x, y, theta values for all objects in the room
57         room: rectangular Room object
58         tertiary_index: int, index of the tertiary object in the room.tertiary_objects list
59         other_index: int, index of the central object in the room.moving_objects list
60         corner: str, corner of the central object where the tertiary object should be placed.
61         Options are 'tl', 'tr', 'bl', 'br'
62     """
63
64     return
65
66 def on_wall_near(positions, room, tertiary_index, other_index):
67
68     """ This function ensures that the tertiary object is placed on the wall near the central object.
69     This would be used for placing a painting on the wall near a dining table, for example.
70
71     Args:
72         positions: list of floats, x, y, theta values for all objects in the room
73         room: rectangular Room object
74         tertiary_index: int, index of the tertiary object in the room.tertiary_objects list
75         other_index: int, index of the central object in the room.moving_objects list
76     """
77
78     return
79
80 def on_wall_in_region(positions, room, tertiary_index, region_name):
81     """ This function is used to place a tertiary object on the wall in a specific region of the room.
82     This would be used for placing a painting on the wall in the living region, for example.
83
84     Args:
85         positions: list of floats, x, y, theta values for all objects in the room
86         room: rectangular Room object
87         tertiary_index: int, index of the tertiary object in the room.tertiary_objects list
88         region_name: str, name of the region where the tertiary object should be placed
89         (e.g. 'living', 'dining', 'bedroom')
90     """
91     return
92
93 def center_ceiling(positions, room, tertiary_index):
94

```

```
95     """ This function ensures that the tertiary object is placed in the center of the ceiling.  
96     This would be used for placing a chandelier/ceiling light in the center of the room.  
97  
98     Args:  
99         positions: list of floats, x, y, theta values for all objects in the room  
100        room: rectangular Room object  
101        tertiary_index: int, index of the tertiary object in the room.tertiary_objects list  
102    """  
103    return  
104  
105 def ceiling_above(positions, room, tertiary_index, other_index):  
106     """ This function ensures that the tertiary object is placed on the ceiling above the central object.  
107     This would be used for placing a ceiling fan above a bed, or a chandelier above a dining table for example.  
108  
109     Args:  
110         positions: list of floats, x, y, theta values for all objects in the room  
111         room: rectangular Room object  
112         tertiary_index: int, index of the tertiary object in the room.tertiary_objects list  
113         other_index: int, index of the central object in the room.moving_objects list  
114     """  
115    return  
116
```

12. Full example for “A bedroom that is 4m x 5m.”

Input: “A bedroom that is 4m x 5m.”

Extracting Parameters

Prompt 1: I am designing the layout for a bedroom that is 4m x 5m. Give me the dimensions of the room, as well as the number of windows, doors, and sockets. For each of these, tell me the dimensions in meters, which wall it should be on, as well as where on the wall it should be (a value between 0 and 1 determining how far along the wall it should be). Here is an example for a room and window set up:

{Room: width = 5, length = 6}, {Object type: window, width = 1, length = 0.1, wall = south, position = 3}. The windows and doors should all have length 0.1. Ensure that every object has dimensions, position, and wall. No other text please. Just the list with no commentary or explanation.

Prompt 2: The functions in the following file are used to create a room and out objects in it: + file_contents1. The room is described as “a bedroom that is 4m x 5m”. For every element in this list, fixed_objects, translate it into a function call using the file attached.

For example, given the room descriptor 'a small kitchen' as well as the list: {Room: width = 5, length = 6}, {Object type: window, Number: 1, width = 1, length = 0.1, wall = south, position = 0.3}, the output would be:

kitchen = create_room(5, 6), create_fixed_object(kitchen, 'window', 1, 0.1, 'south', position = 0.3). Return only the python script.

No other text. Please ensure the correct number of inputs are given for each function.

Output 1:

```
room = create_room(4, 5)
create_fixed_object(room, 'door', 0.9, 0.1, 'west', 0.1)

create_fixed_object(room, 'window', 1.2, 0.1, 'south', 0.4)

create_fixed_object(room, 'window', 1.2, 0.1, 'east', 0.6)

create_fixed_object(room, 'socket', 0.2, 0.1, 'north', 0.3)

create_fixed_object(room, 'socket', 0.2, 0.1, 'west', 0.5)

create_fixed_object(room, 'socket', 0.2, 0.1, 'east', 0.2)
```

Regions

Prompt1: I am designing the layout of a “a bedroom that is 4m x 5m”, that is 4m x 5m. Interior designers suggest that a good layout will have different regions in the room for different functions. What regions should I use, and how many regions (minimum is 1 region - small rooms, e.g. 3x3, 2x3, etc, should only have 1 region, small medium sized rooms will have 2, 3x4, 4x3, 4x4, medium will have 3, etc) should there be based on the description, as

well as the size of the room. Make sure to not add too many regions as this causes overcrowding (very few rooms will have more than 4 regions). Return this as a simple bullet list of regions to include. Return these in list of priority order. Do NOT add too many regions. Only return the list of regions. No other information please.

Output: ['sleeping', 'storage', 'work']

Prompt 2: Given the room name: room_name , and the regions: regions, using the function region_setup defined below, initialise each region. For example 'eating region' might output 'region_setup(kitchen, 'eating', 0). Where possible the region name ('eating') should be only one word. No other text please, only the python script. Don't include the function in the output. The function is:

```
def region_setup(room_name, name, index):
```

''A function that initialises the regions in a room randomly.

Inputs:

room_name: Room obj (this should be the name of the room)

name: str, the name of the region e.g 'sleeping' index: int, the index of the region (0, 1, 2, ...). First one must be 0, and the rest must be in order.

'''

```
return
```

Primary Objects, Secondary Objects

Prompt 1: The room is described as "a bedroom that is 4m x 5m". Now for each one of the regions: regions, what is the most important object to include (keep in mind the room description), and what are its dimensions (give width of back of object and length of side of object but not height) in meters. ONLY one object per region. Don't include any objects that go on the walls, e.g. wall art, and don't include any rugs/mats. The size of the room is 4m x 5m, bear this in mind when choosing the objects and the size of the objects (i.e. put small objects in small rooms). Give no other information please.

Output:

- Sleeping: Bed, 1.5m x 2m
- Storage: Wardrobe, 1.2m x 0.6m
- Work: Desk, 1.2m x 0.6m

Prompt 2: Given a room described as: "a bedroom that is 4m x 5m", with size: 4m x 5m with these regions within it: regions, and these primary objects already in it: primary_objects, what other objects should be added in?

Give me 0-4 objects per region (depending on the size of the room - fewer objects for smaller rooms, and more objects for larger room) that should be added into the room (so make sure they are the most appropriate/necessary objects for their regions). Ensure to add objects that are necessary,e.g. if there's a desk, always add a desk chair. Try not to give objects that are redundant, e.g. if there is a tv stand in the room, you don't need a media console. Objects should be things like furniture or plants or other objects that sit on the floor.For each one,

make sure that they make sense to go into one of the regions, and tell me which region they should go into. There can be more than one of each object kind (eg. multiple dining chairs or multiple nightstands) so make sure to specify how many of each object. Make sure to also give the dimensions of every object in meters (width of the back of the object and length of the side of the object but NOT HEIGHT). Remove any objects that are not placed directly on the floor, e.g. table lamp, and remove any objects that are mounted on the wall (e.g. paintings). Don't include rugs. Only give objects that get placed onto the floor. Give no other text in the response. Only the list of objects.

Output:

- Sleeping:
 - Nightstand, 0.5m x 0.4m (2 items)
- Storage:
 - Dresser, 1.0m x 0.5m
- Work:
 - Desk Chair, 0.6m x 0.6m

Primary Objects, Secondary Objects Constraints

Prompt1: For each of these objects: primary_objects, tell me all of the considerations and constraints for its placement within the room described as “a bedroom that is 4m x 5m”, with size: 4m x 5m that depend only on fixed features in the room like walls, windows, doors, sockets, etc. and return these as a bullet list for each object. Include practical things like whether it should be against a wall, or which side should be accessible for use (most objects will need an accessible constraint e.g. front of wardrobe needs to be accessible - however very few objects need all of their sides to be accessible and very few need their back to be accessible.) or if its tall, maybe it shouldn't block a window, etc. Bear in mind the size of the room, for example if the room is large, then the front, left, and right of the bed should be accessible, but if the room is very small, maybe only one side of the bed needs to be accessible. Only give these constraints and considerations, no other information.

Output:

Bed (1.5m x 2m)

- Should be placed against a wall to maximize space.
- Should not block access to windows.
- Should not block access to doors.
- Front side should be accessible.
- Should allow for at least 60 cm of free space on one side for ease of getting in and out.
- Avoid placing under low-hanging fixtures if the ceiling is not uniformly high.

Wardrobe (1.2m x 0.6m)

- Should be placed against a wall for stability.
- Should not block access to windows.
- Should not block access to doors.
- Front side should be accessible for opening doors/drawers.
- Avoid placing it where it will block electrical sockets, unless not in use.

- Ideally placed in a corner to save space.

Desk (1.2m x 0.6m)

- Should be placed against a wall to maximize space.
- Should not block access to windows to ensure sufficient natural light.
- Should not block access to doors.
- Front side should be accessible for seating and working.
- Ideally positioned near electrical sockets for easy access to power supply.
- Should not block airflow from vents or radiators if present.

Prompt 2: Tell me all of the constraints and considerations between the objects in this list, primary_objects, that depend only on each other. These objects are for different regions, so the constraints should only really be about them being away from each other or near each other, nothing more specific. For example, maybe a desk should not be close to a bed, etc. The room is described as "a bedroom that is 4m x 5m", with size 4m x 5m. Only give the constraints and considerations between objects, no other information.

Output:

1. The bed should not be close to the desk.
2. The bed should not be close to the wardrobe.
3. The desk should have enough space around it to allow for comfortable work.
4. The wardrobe should be accessible without obstruction by the bed or desk.
5. Ensure there is sufficient walking space between the bed, desk, and wardrobe.

Prompt 3:

For each of these objects, secondary_objects, tell me all of the considerations and constraints for its placement within the room that depends only on fixed features in the room like walls, windows, doors, sockets, etc. (return these as a bullet list for each object). Include practical things like whether it should be against a wall and what side of the object (one of: left, right, back, front) or if it should be against a wall, or which side should be accessible for use (Most objects will have an accessible constraint - this would be something like the wardrobe needs to be accessible from the front so that the doors can open, or the bed needs to be accessible from the sides - but only give necessary accessible constraints. If an object can have its side against something, then don't say its side needs to be accessible e.g. for a nightstand, etc). The room is described as "a bedroom that is 4m x 5m". Don't include any constraints that depend on other objects. Only give these constraints and considerations, no other information.

Output:

Sleeping:

Nightstand (0.5m x 0.4m) (2 items)

- Can be placed against a wall.

Storage:

Dresser (1.0m x 0.5m)

- Should be placed against a wall.
- Front should be accessible for use.

Work:

Desk Chair (0.6m x 0.6m)

- Should not block any doors or windows.
- Should be near a wall socket for power if needed (e.g., for a computer).
- Should have enough space around it to pull out and sit down (at least 0.6m of free space in front).

Prompt 4:

Tell me all of the constraints and considerations between the objects in this list, secondary_objects, as well as in this list primary_objects. For example, a desk chair should have its front against the front of the desk, or the left side of one of the nightstands should be against the right side of the bed, etc. Be specific with relationships between objects to include sides (one of: left, right, back, front) if appropriate, or minimum/maximum distances between objects etc. The room is described as "a bedroom that is 4m x 5m". Only give the constraints and considerations between objects, no other information.

Output:

1. ****Bed and Nightstands:****

- The left side of one nightstand should be against the right side of the bed.
- The right side of the other nightstand should be against the left side of the bed.
- The nightstands should be positioned so they are aligned with the headboard of the bed.

2. ****Desk Chair and Desk:****

- The front of the desk chair should be against the front of the desk.
- Ensure there is adequate space behind the desk chair for movement (minimum of 0.5m).

3. ****Dresser and Wardrobe:****

- The dresser and wardrobe should be positioned in a way that allows for ease of access.
- Maintain at least 0.5m of space in front of both the dresser and wardrobe for access.
- The dresser and wardrobe should not be placed next to each other to avoid crowding.

4. ****Bed and Dresser:****

- Maintain a minimum distance of 0.5m between the bed and the dresser for ease of movement and access.

5. ****Bed and Wardrobe:****

- Maintain a minimum distance of 0.5m between the bed and the wardrobe for ease of movement and access.

6. ****Desk and Bed/Nightstands:****

- The desk should be positioned so there is a minimum distance of 0.5m from the bed and nightstands to avoid obstruction.
- The desk should be placed along a wall opposite to or adjacent to the bed to avoid obstruction.

7. ****Desk and Other Storage (Dresser/Wardrobe):****

- The desk should have a minimum distance of 0.5m from the dresser and wardrobe to allow for ease of movement and access to storage items.

****Note:**** Ensure that all furniture placement considers the need for adequate circulation space and ease of access to various parts of the room.

Prompt 5:

Given this list of primary objects: primary_objects, and this list of secondary objects: secondary_objects, use the file attached to create the objects with the correct parameters. The room name is: room_name the region names are: regions.

The room is already set up, only add in the objects using the 'create_moving_object' function. Ensure that each objects index is unique and that the indices begin from 0. The objects should be added in the correct regions. Add in all of the primary objects first. This is the file: file_contents1. No extra text, only the function calls. Don't have 'python' at the start of the code. Do not define ANY functions, only call them.

Output:

```
create_moving_object(room_name, 'bed', 1.5, 2.0, 'sleeping', 0)
create_moving_object(room_name, 'wardrobe', 1.2, 0.6, 'storage', 1)
create_moving_object(room_name, 'desk', 1.2, 0.6, 'work', 2)
create_moving_object(room_name, 'nightstand', 0.5, 0.4, 'sleeping', 3)
create_moving_object(room_name, 'nightstand', 0.5, 0.4, 'sleeping', 4)
create_moving_object(room_name, 'dresser', 1.0, 0.5, 'storage', 5)
create_moving_object(room_name, 'desk chair', 0.6, 0.6, 'work', 6)
```

Tertiary Objects + Positioning

Prompt 1: Given a room described as: “a bedroom that is 4m x 5m”, with size: 4m x 5m, with these regions within it: regions, and these objects already in it: primary_objects + secondary_objects, suggest any rugs, other decorations or objects (these are things that go on top of other objects) that should be placed in the room. For example, a tv to go on the tv unit, a painting above the bed, a table lamp on the nightstand, a chandelier over the dining table, a computer to go on the desk, etc. Don't give any furniture or objects that go on the floor (other than rugs). Everything should either go on the wall, on the ceiling, or on top of a piece of furniture. Don't include curtains. Tell me the dimensions of the objects (width and length not height - in meters). If it is a wall object, its length should be 0.1m. Tell me how they should be placed (with respect to one object. e.g. painting should be placed near the dining table or lamp should be placed on a nightstand). Don't give too many objects and don't include multi-object objects e.g. gallery walls or shelves.

Output:

Certainly! Here are a few additions that can enhance the room, along with their dimensions and placement suggestions:

Sleeping Area:

1. **Table Lamp**
 - **Dimensions**: 0.3m x 0.3m
 - **Placement**: One on each nightstand.

2. **Painting**

- **Dimensions**: 1.0m x 0.1m
- **Placement**: Centered above the bed

Storage Area:

3. **Mirror**

- **Dimensions**: 1.2m x 0.1m
- **Placement**: Hang it above the dresser.

Work Area:

4. **Desk Organizer**

- **Dimensions**: 0.4m x 0.2m
- **Placement**: On the desk for holding pens, papers, etc.

5. **Computer Monitor**

- **Dimensions**: 0.5m x 0.2m
- **Placement**: Centered on the desk.

General Decorations:

6. **Chandelier**

- **Dimensions**: (Round) 0.8m diameter (Height should be adjusted according to ceiling height)
- **Placement**: Centered in the room.

7. **Rug**

- **Dimensions**: 2.0m x 3.0m
- **Placement**: Under the bed, extending outward to provide a soft landing spot for feet.

These additions will make the room more functional and aesthetically pleasing without overcrowding it.

Prompt 2:

Given this list of tertiary objects: tertiary_objects, use the function attached to create the objects with the correct parameters. The room name is: room_name. The room description is: "a bedroom that is 4m x 5m". The room is already set up, only add in the objects using the 'create_ternary_object' function. Ensure that each objects index is unique and that the indices begin from 0. The object names should be simple and short. The objects should be given the correct tertiary type (ceiling, floor, wall, or table). Wall objects should all have length 0.1m. Ensure that the parameters are set correctly. This is the function:
"""

```
def create_ternary_object(room, name, width, length, tertiary, index):
    " A function that creates and places a tertiary object
    Inputs:
        room: Room for the object to be put in
        name: str, name of the object all lowercase. E.g. 'painting'
        width: float, width of the object (m)
        length: float, length of the object (m)
        tertiary: str, tertiary object type, one of "wall" (for objects that go on the wall e.g.
        painting),
```

"floor" (for objects that go on the floor e.g. rug), "ceiling" (for objects that go on the ceiling e.g. chandelier),

"table" (for objects that go on a surface e.g. lamp).

index: int, index of the object in the room's tertiary object list

" " "

No extra text, only the function calls. Don't have 'python' at the start of the code. Do not define ANY functions, only call them.

Output:

```
create_tertiary_object(room_name 'lamp', 0.3, 0.3, 'table', 0)
create_tertiary_object(room_name 'lamp', 0.3, 0.3, 'table', 1)
create_tertiary_object(room_name 'painting', 1.0, 0.1, 'wall', 2)
create_tertiary_object(room_name 'mirror', 1.2, 0.1, 'wall', 3)
create_tertiary_object(room_name, 'organizer', 0.4, 0.2, 'table', 4)
create_tertiary_object(room_name, 'monitor', 0.5, 0.2, 'table', 5)
create_tertiary_object(room_name, 'chandelier', 0.8, 0.8, 'ceiling', 6)
create_tertiary_object(room_name, 'rug', 2.0, 3.0, 'floor', 7)
```

Style

Prompt:

Given the description of the room: " a bedroom that is 4m x 5m ", with size: 4m x 5m, with these objects within it: primary_objects + secondary_objects + tertiary_objects, tell me the colours of the walls and whether there should be wallpaper/paint/some other wall material. Tell me the style and colour of the windows and doors. Tell me the material and colour of the floor, and for each object, one by one, describe its colour, style, material etc. Make sure that all of the objects are cohesive together and match the description of the room.

Output:

Based on the dimensions provided (4m x 5m) and the list of objects, we'll create a cohesive and aesthetically pleasing bedroom design with thoughtful selections for wall treatments, flooring, and each object.

Walls:

- **Colour:** A soft, neutral palette such as light grey or warm beige to provide a serene and relaxing environment.
- **Treatment:** High-quality paint for a clean, modern look. Avoid wallpaper to maintain simplicity and versatility.

Floor:

- **Material:** Hardwood for durability and elegance.
- **Colour:** A medium oak finish that provides warmth and complements the neutral wall colour.

Door:

- **Colour:** A matching dark walnut finish, consistent with the bed frame and nightstands.

- **Material**: Solid wood for durability and a high-quality feel.
- **Style**: Modern with a clean, flat panel design, featuring sleek silver hardware that ties in with the wardrobe handles. The door should maintain simplicity to blend seamlessly with the room's overall aesthetic.

Windows:

- **Colour and Material**: Aluminum or wood, finished in a white or light grey to match the Scandinavian-inspired wardrobe and dresser.
- **Style**: Casement windows with clear glass, providing a modern, sleek appearance while also offering excellent insulation.

Objects:

1. **Bed:**

- **Size**: Queen-sized for proportionate fitting in the room.
- **Colour**: Dark walnut frame with a soft grey upholstered headboard.
- **Style**: Modern with clean lines and minimalist design.

2. **Wardrobe:**

- **Colour**: White with sleek silver handles.
- **Style**: Scandinavian-inspired with a focus on functionality and simplicity.

3. **Desk:**

- **Colour**: Light wood top with white metal legs.
- **Style**: Minimalist, providing a clutter-free workspace.

4. **Nightstands (2):**

- **Colour**: Matching the bed frame, dark walnut.
- **Style**: Modern with a single drawer for a clean appearance.

5. **Dresser:**

- **Colour**: White to match the wardrobe.
- **Style**: Contemporary with straight lines and silver handles.

6. **Desk Chair:**

- **Colour**: Light grey fabric with a chrome base.
- **Style**: Ergonomic and modern.

7. **Lamp (2):**

- **Colour**: White ceramic base with a light grey shade.
- **Style**: Elegant and simple, fitting well with nightstands and dresser.

8. **Painting:**

- **Colour**: A modern abstract piece with predominant shades of grey, blue, and white to add a pop of colour.
- **Style**: Framed in a sleek black frame for a gallery-quality look.

9. **Mirror:**

- **Colour**: Frameless or with a thin silver frame.

- **Style:** Large and full-length for functionality and room enlargement effect.
10. **Organizer:**
- **Colour:** Soft beige fabric bins with white wooden frame.
 - **Style:** Practical and minimalistic.
11. **Monitor:**
- **Colour:** Black.
 - **Style:** Sleek and modern, with a small footprint on the desk.
12. **Chandelier:**
- **Colour:** Polished chrome with clear crystal accents.
 - **Style:** Modern and elegant, adding a touch of luxury to the room.
13. **Rug:**
- **Colour:** Light grey with subtle geometric patterns in white.
 - **Style:** Plush and cozy, placed under the bed extending slightly beyond it.

Cohesion and Harmony:

The selections ensure a cohesive design that blends modern, minimalist, and Scandinavian elements. The soft neutral walls and medium oak flooring create a warm and balanced foundation. Each piece of furniture and accessory has been chosen for its simplicity, elegance, and ability to create a tranquil, aesthetically pleasing bedroom.

Constraint Cleaning

This prompt is used 4 times: for the primary individual constraints, for the primary inter-object constraints, for the secondary individual constraints, and the secondary inter-object constraints.

Prompt 1: I am going to give you a list of constraints. I want you to merge any similar constraints and also remove any duplicate constraints. Each constraint should be simplified, so that it is said in the most basic terms. I want you to remove any constraints that are contradictory e.g. should be near a window AND should be away from a window. If there is an "or" statement in the constraint, choose one of the options. Finally, each bullet constraint should only specify one constraint. For example if there is a bullet point that says an object should not block windows and doors, change this into 2 bullets - one for blocking doors, and one for blocking windows. Remove any constraints that have if statements, and any that involve height. If there are constraints for objects to be accessible from all sides that are unnecessary, change them to be which sides you think ARE necessary. If there are constraints with "or" in them, choose between the options. Return the list of cleaned constraints. Here is the list of constraints: constraints.

Output 1:

Cleaned Constraints:

Bed (1.5m x 2m)

- Should be placed against a wall.
- Should not block access to windows.
- Should not block access to doors.
- Front side should be accessible.
- Should allow for at least 60 cm of free space on one side.

Wardrobe (1.2m x 0.6m)

- Should be placed against a wall.
- Should not block access to windows.
- Should not block access to doors.
- Front side should be accessible.
- Avoid placing it where it will block electrical sockets.
- Ideally placed in a corner.

Desk (1.2m x 0.6m)

- Should be placed against a wall.
- Should not block access to windows.
- Should not block access to doors.
- Front side should be accessible.
- Ideally positioned near electrical sockets.
- Should not block airflow from vents.

Output 2:

Here are the cleaned and simplified constraints based on your requirements:

- The bed should not be close to the desk.
- The bed should not be close to the wardrobe.
- The desk should have enough space around it to allow for comfortable work.
- The wardrobe should be accessible without obstruction by the bed.
- The wardrobe should be accessible without obstruction by the desk.
- Ensure there is sufficient walking space between the bed and the desk.
- Ensure there is sufficient walking space between the bed and the wardrobe.
- Ensure there is sufficient walking space between the desk and the wardrobe.

Output 3:

Here is the cleaned list of constraints:

Sleeping:

- #### #### Nightstand (0.5m x 0.4m) (2 items)
- Can be placed against a wall.

Storage:

- #### #### Dresser (1.0m x 0.5m)
- Should be placed against a wall.
 - Front should be accessible for use.

Work:

Desk Chair (0.6m x 0.6m)

- Should not block any doors.
- Should not block any windows.
- Should have enough space around it to pull out and sit down.

Output 4:

Cleaned Constraints:

1. **Bed and Nightstands:**

- One nightstand should be to the right of the bed.
- One nightstand should be to the left of the bed.
- The nightstands should be aligned with the headboard of the bed.

2. **Desk Chair and Desk:**

- The front of the desk chair should be against the front of the desk.
- Ensure there is adequate space behind the desk chair for movement.

3. **Dresser and Wardrobe:**

- Maintain at least 0.5m of space in front of the dresser for access.
- Maintain at least 0.5m of space in front of the wardrobe for access.
- The dresser and wardrobe should not be placed next to each other to avoid crowding.

4. **Bed and Dresser:**

- Maintain a minimum distance of 0.5m between the bed and the dresser for ease of movement.

5. **Bed and Wardrobe:**

- Maintain a minimum distance of 0.5m between the bed and the wardrobe for ease of movement.

6. **Desk and Bed/Nightstands:**

- The desk should be positioned so there is a minimum distance of 0.5m from the bed and nightstands.
- The desk should be placed along a wall opposite the bed.

7. **Desk and Other Storage (Dresser/Wardrobe):**

- The desk should have a minimum distance of 0.5m from the dresser.
- The desk should have a minimum distance of 0.5m from the wardrobe.

General Note: Ensure that all furniture placement considers the need for adequate circulation space and ease of access to various parts of the room.

Translation

Prompt 1:

Given the room_name room_name, as well as the primary objects: primary_objects, their indices primary_indices, and these constraints: primary_individual_cons, using the script attached, transform each constraint into a SINGLE function call that will ensure that the primary objects are set up correctly. Match each constraint to the closest function in the script file by using the docstrings. Ensure that every constraint is mapped to a function call, unless there is not one that matches. Here is the first script: file_contents2. For the second script, I want you to transform each pairwise constraint into a function call. Here is the second script: file_contents3, and here is the list of pairwise constraints: primary_io_cons. I want the output to begin with: def optimize_primary_objects(positions, room): \n output = 0, followed by each constraint function call added to the output, and then the output returned (everyline should begin with 'output +=' except for the final line). Go object by object, and then pairwise. No extra text please, only the functions and the output. If there is only 1 primary object, there should be no pairwise calls. Do not define ANY functions, only call them. ENSURE that all parameters match docstrings.

Output:

```
def optimize_primary_objects(positions, room):
    output = 0
    output += check_and_call('ind_next_to_wall', positions, room, 0)
    output += check_and_call('ind_not_block_fixed_object', positions, room, 0, 'window')
    output += check_and_call('ind_not_block_fixed_object', positions, room, 0, 'door')
    output += check_and_call('ind_accessible', positions, room, 0, ['front'])
    output += check_and_call('ind_accessible', positions, room, 0, ['left', 'right'], 0.6)
    output += check_and_call('ind_next_to_wall', positions, room, 1)
    output += check_and_call('ind_not_block_fixed_object', positions, room, 1, 'window')
    output += check_and_call('ind_not_block_fixed_object', positions, room, 1, 'door')
    output += check_and_call('ind_accessible', positions, room, 1, ['front'])
    output += check_and_call('ind_away_from_fixed_object', positions, room, 1, 'socket')
    output += check_and_call('ind_in_corner', positions, room, 1)
    output += check_and_call('ind_next_to_wall', positions, room, 2)
    output += check_and_call('ind_not_block_fixed_object', positions, room, 2, 'window')
    output += check_and_call('ind_not_block_fixed_object', positions, room, 2, 'door')
    output += check_and_call('ind_accessible', positions, room, 2, ['front'])
    output += check_and_call('ind_close_to_fixed_object', positions, room, 2, 'socket')
    output += check_and_call('ind_away_from_fixed_object', positions, room, 2, 'vent')
    output += check_and_call('io_away_from', positions, room, 0, 2, 2.0)
    output += check_and_call('io_away_from', positions, room, 0, 1, 2.0)
    output += check_and_call('io_away_from', positions, room, 1, 2, 2.0)
    output += check_and_call('io_away_from', positions, room, 1, 0, 2.0)
    output += check_and_call('io_next_to', positions, room, 1, 0)
    output += check_and_call('io_near', positions, room, 2, 0, 3.0)
    output += check_and_call('io_near', positions, room, 1, 2, 3.0)

    output += wall_attraction(positions, room)
    output += in_bounds(positions, room)
    output += no_overlap(positions, room)
    output += aligned(positions, room)
    output += balanced(positions, room)
    return output
```

Prompt 2:

Given the primary objects: primary_objects, and their indices: primary_indices, as well as the secondary objects, along with their indices and their regions: [(s_i, ind_i, r_i), ..], their individual constraints: secondary_ind_cons, and the region names: regions. Using the script attached, transform each constraint into a SINGLE function call that will ensure that the secondary objects are set up correctly. Match each constraint to the closest function in the script file by using the docstrings. Ensure that every constraint is mapped to a function call, unless there is not one that fits. Here is the first script: file_contents2. For the second script, I want you to transform each pairwise constraint into a SINGLE function call. Here is the second script: file_contents3, and here is the list of pairwise constraints: s_io_cons. I want the output to begin with: 'def optimize_secondary_objects(positions, room): \n output = 0\n', followed by each constraint function call added to the output, (each line should begin with 'output +='). Go object by object, and then pairwise. Also ensure to use ind_in_region for each object. Do not define ANY functions, only call them. No extra text please, only the functions and the output.

Output:

```
def optimize_secondary_objects(positions, room):
    output = 0

    output += check_and_call('ind_in_region', positions, room, 3, 'sleeping')
    output += check_and_call('ind_next_to_wall', positions, room, 3)
    output += check_and_call('ind_in_region', positions, room, 4, 'sleeping')
    output += check_and_call('ind_next_to_wall', positions, room, 4)
    output += check_and_call('ind_in_region', positions, room, 5, 'storage')
    output += check_and_call('ind_next_to_wall', positions, room, 5)
    output += check_and_call('ind_accessible', positions, room, 5, ['front'], min_dist = 0.5)
    output += check_and_call('ind_in_region', positions, room, 6, 'work')
    output += check_and_call('ind_not_block_fixed_object', positions, room, 6, 'door')
    output += check_and_call('ind_not_block_fixed_object', positions, room, 6, 'window')
    output += check_and_call('ind_accessible', positions, room, 6, ['front', 'back'], min_dist = 0.6)
    output += check_and_call('io_next_to', positions, room, 3, 0, side1='right')
    output += check_and_call('io_next_to', positions, room, 4, 0, side1='left')
```

```

output += check_and_call('io_parallel', positions, room, 3, 4, max_dist=0.5)
output += check_and_call('io_next_to', positions, room, 6, 2, side1='front', side2='front')
output += check_and_call('ind_accessible', positions, room, 6, ['back'], min_dist=0.6)
output += check_and_call('ind_accessible', positions, room, 5, ['front'], min_dist=0.5)
output += check_and_call('ind_accessible', positions, room, 1, ['front'], min_dist=0.5)
output += check_and_call('io_away_from', positions, room, 5, 1, min_dist=0.5)
output += check_and_call('io_away_from', positions, room, 5, 0, min_dist=0.5)
output += check_and_call('io_away_from', positions, room, 1, 0, min_dist=0.5)
output += check_and_call('io_away_from', positions, room, 2, 0, min_dist=0.5)
output += check_and_call('io_away_from', positions, room, 2, 4, min_dist=0.5)
output += check_and_call('ind_next_to_wall', positions, room, 2)
output += check_and_call('io_away_from', positions, room, 2, 5, min_dist=0.5)
output += check_and_call('io_away_from', positions, room, 2, 1, min_dist=0.5)

```

```

output += wall_attraction(positions, room)
output += in_bounds(positions, room)
output += no_overlap(positions, room)
output += aligned(positions, room)
return output

```

Prompt 3:

Given all the objects in the room: primary_objects + secondary_objects, and their indices: primary_indices + secondary_indices, as well as the region names: regions, here are the tertiary objects and how they should be placed: tertiary_output. These are there indices: tertiary_indices. Using the script attached, transform each placement into a SINGLE function call that will ensure that the tertiary objects are placed correctly. If there is not a function that fits, then choose another. Here is the script: file_contents4. I want the output to begin with: 'def optimize_tertiary_objects(positions, room): \n output = 0\n', followed by each function call added to the output, (each line should begin with 'output +='). Do not define ANY functions, only call them. No extra text please, only the functions and the output.

Output:

```
def optimize_ternary_objects(positions, room):  
    output = 0  
  
    output += check_and_call('on_top_central', positions, room, 0, 3)  
    output += check_and_call('on_top_central', positions, room, 1, 4)  
    output += check_and_call('on_wall_above_central', positions, room, 2, 0)  
    output += check_and_call('on_wall_above_central', positions, room, 3, 5)  
    output += check_and_call('on_top_central', positions, room, 4, 2)  
    output += check_and_call('on_top_central', positions, room, 5, 2)  
    output += check_and_call('center_ceiling', positions, room, 6)  
    output += check_and_call('rug_under_central_forward', positions, room, 7, 0)  
  
    output += check_and_call('t_valid', positions, room)  
    return output
```