COMPUTER GRAPHICS -1

Literature Review -3

Vishal Gadiraju

01672049

vishal_gadiraju@student.uml.edu

Convertible Furniture Design

(Primary Paper)

Abstract:

Convertible furniture is used widely because of its multi-purpose and space-saving properties, but substantial professional skills are required to design practical convertible furniture. In this study, we introduce a system that allows unskilled users to design convertible furniture objects. By using a set of desired furniture units as inputs, our system generates a group of suggested convertible furniture objects, which can collapse into a compact form. The geometric problem involves connecting the furniture units via junctions so they occupy the smallest space in their compact form while still fulfilling the desired function in the expanded form. This optimization problem is non-trivial because of the very large discrete search space of the connected structures. Furthermore, there is a huge continuous space of geometric parameters where the connected units make contact due to the complex dependencies of their movements. We propose an efficient algorithm based on a tree selection approach and pre-computed junction-dependent configuration spaces to accelerate the optimization process in a highdimensional, mixed discrete–continuous search space. We evaluated our system based on a wide range of inputs and a series of convertible furniture objects were generated. The experimental results demonstrate that our system can provide design suggestions as well as inspiring creativity among users.

Summary:

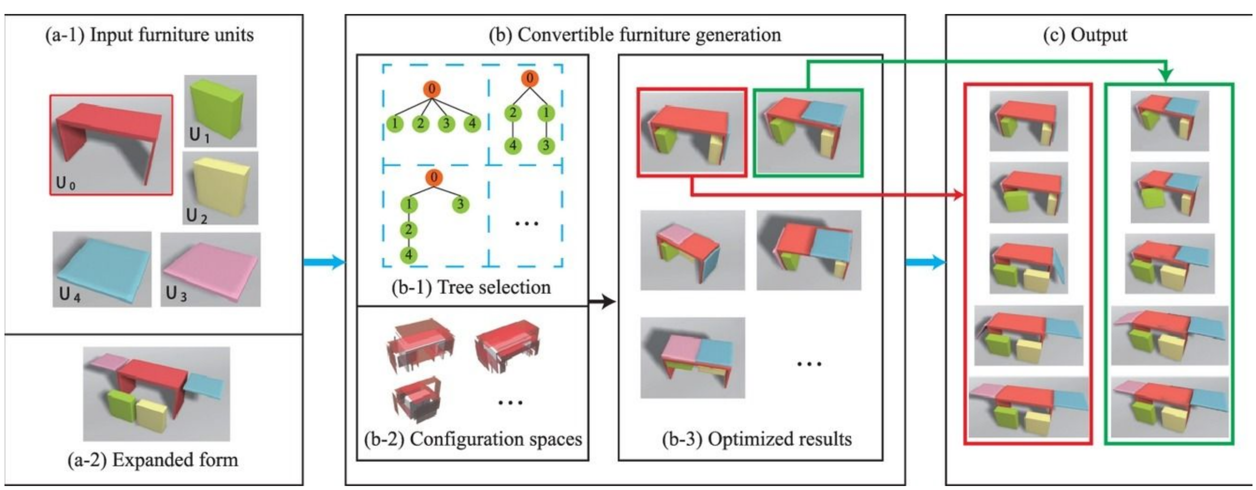
When living in a confined space convertible furniture can be very useful to save space. It is widely used as it can be stowed away in a compact form. Due to its spacesaving capabilities, convertible furniture has attracted much interest from designers, especially furniture manufacturers.

However, in order to understand the specific method required to design practical furniture objects professional skills are required. Therefore, computer-assisted furniture design systems have attracted much attention in the area of computer graphics for decades.
The most difficult task for any system is designing mechanical structures that can be folded into a compact form and unfolded to execute all the desired functions. The underlying geometry problem involves computing the connections between user-selected furniture units to facilitate the transition between its compact and expanded forms.

In this paper, an automatic and efficient algorithm is developed to help the users create convertible furniture objects comprising multiple units by providing suggestions that users may explore.
The describe a method largely composed of two components:
1) A tree selection algorithm is proposed for efficiently selecting the connection structures between all furniture units from a very large discrete space.
2) A junction-dependent configuration space is proposed to accelerate the complex optimization of the junction parameters and the relative positions between units, which allows multiple suggestions to be produced that users may explore.

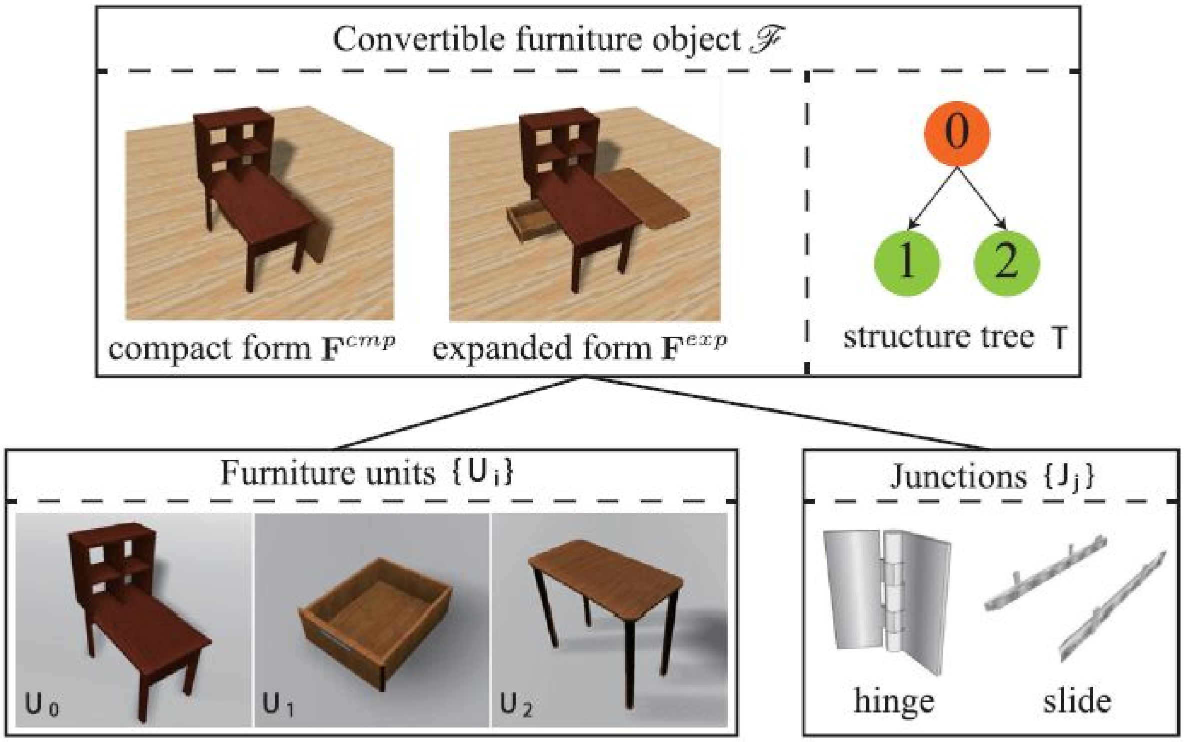
Their methods build on previous work which included furniture arrangement, furniture manipulation, and linkage-based object design.
However they claim that, their proposed system is the first computational approach for designing convertible furniture from a set of given individual furniture units which allows user to design convertible furniture objects.

Their system overview can be understood by looking at the figure below:



Output: The system generates multiple suggestions for the convertible furniture object with diverse structures that the user can select. The user can browse the suggested furniture objects by clicking on each to view the simulated expansion process before finally selecting one.

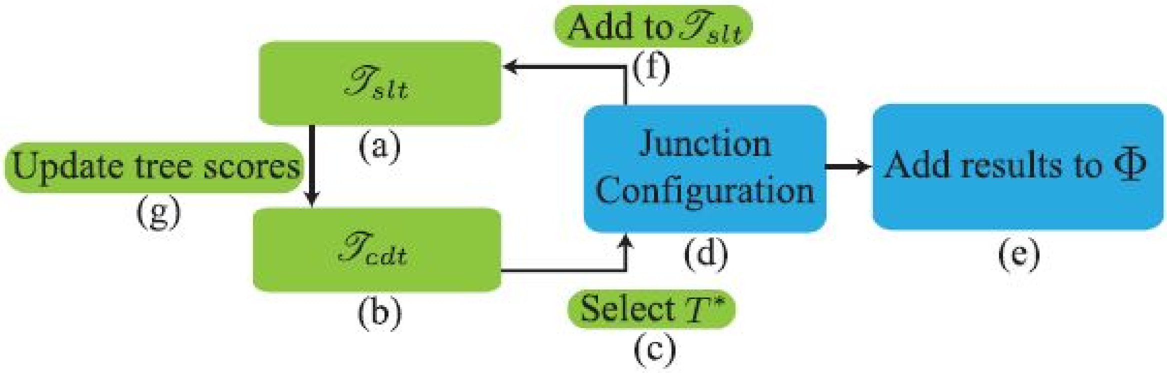
A convertible furniture object F comprises a set of furniture units {Ui} and junctions {Jj}. The object has a compact form $\mathbf{F}^{cmp}$ that occupies limited space and an expanded form $\mathbf{F}^{exp}$ The connections between the units are represented by a structure tree T.



Methodology:

It comprises of tree selection (green) and junction configuration (blue) processes.
(a) Tslt represents the tree set that has been optimized.
(b) Tcdt is the set of structure tree candidates after tree pruning. In each iteration, a tree with the highest score is selected to obtain Tcdt as T∗
(c) and we optimize its junction parameters
(d). Each junction configuration step generates L furniture objects and they are added to the results collection
(e). After step (d), T∗ is added to Tslt (f) and this Tslt is used to update the scores for the tree candidates in Tcdt
(g). Finally, Mmax trees has been optimized and they rank the furniture objects in as the suggested furniture objects.

Optimization framework is shown in the figure below:



The results of a series of experiments were presented where convertible furniture was designed by unskilled users. The results were evaluated on the parameters such as User interaction, Multi-suggestion results, Multiple expanded forms and Time performance.

The scale and computational time for the results are shown in the table below:

Scale and computational time for the results.

	N_U	$N_{\mathscr{T}_{slt}}$ / $N_{\mathscr{T}_{cdt}}$	Time (s)
Fig. 12(a)	5	17 / 17	13.113
Fig. 12(b)	5	20 / 20	7.358
Fig. 12(c)	12	20 / 30800	34.519
Fig. 12(d)	8	20 / 38	30.509
Fig. 13(a-1)	9	20 / 255	23.77
Fig. 13(a-2)	9	20 / 255	24.958
Fig. 13(b)	7	20 / 345	21.98
Fig. 14	9	20 / 5704	19.703
Fig. 15(a)	5	15 / 15	13.542
Fig. 15(b)	5	20 / 23	7.999

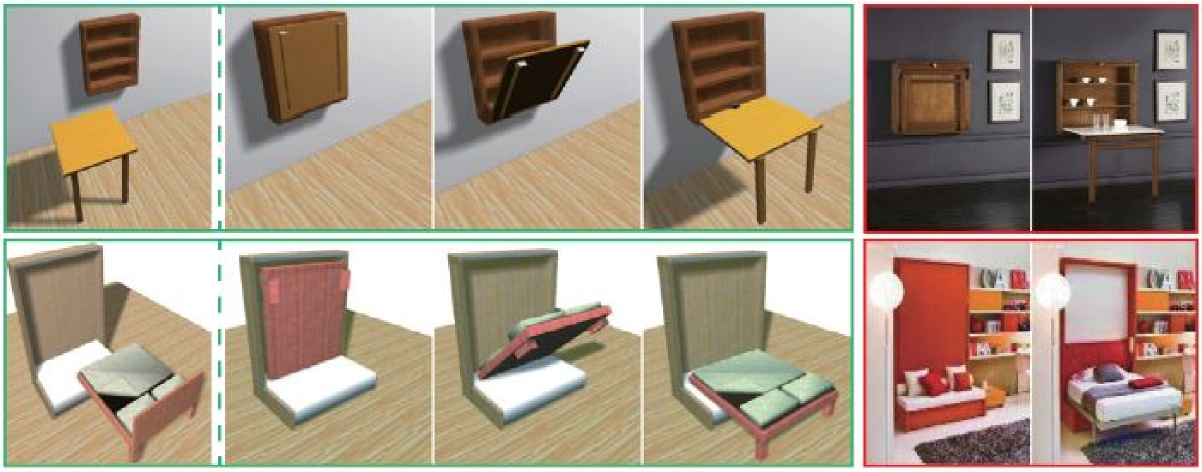


Fig. 20. Two convertible furniture objects generated by our system. From left to right: user input, our optimized compact form, an intermediate state during expansion, the expanded form, and photographs of similar objects designed by artists.

An efficient algorithm is proposed for solving a high-dimensional, mixed discrete and continuous optimization problem in order to simultaneously minimize the space occupied and produce a desired convertible furniture object. However many issues still need to be addressed and this system can be further extended for complex objects.

Computer Simulation of Furniture Layout when Moving from One House to Another

(Secondary Paper)

Abstract:

We present a system that automatically suggests the furniture layout when one moves into a new house, taking into account the furniture layout in the previous house. In our method, the input to our system comprises the floor plans of the previous and new houses, and the furniture layout in the previous house.
The furniture layout for the whole house is suggested. This method builds on a previous furniture layout method with which the furniture layout for a single room only is computed. In this paper, we propose a new method that can suggest the furniture layout for multiple rooms in the new house. To deal with this problem, we took a heuristic approach in

developing a cost function by adding some new cost functions to the previous method. We show various layouts computed using our method, which demonstrates the effectiveness of it. Keywords: house-moving, interior design, interior generation, furniture arrangement.

Summary:

This paper focuses on using computer simulation to design the furniture layout when one moves into a new house. It is important to place the set of furniture items in appropriate places in each of the rooms when moving into a new house.
Usually, the floor plan in the new house is different to that in the previous one. Therefore it is necessary to design a new layout for the set of furniture items used in the previous house
Some methods have been proposed previously to automatically design furniture layout. These methods, however, mainly focus on designing the layout for a single room and assume that each item has been assigned to a particular room in advance. Therefore, these methods cannot be applied to laying out the furniture in the whole house, since this needs to be done for multiple rooms and for furniture items that have not been assigned.Thus, automatic assignment of each item to a room in the new house is needed.

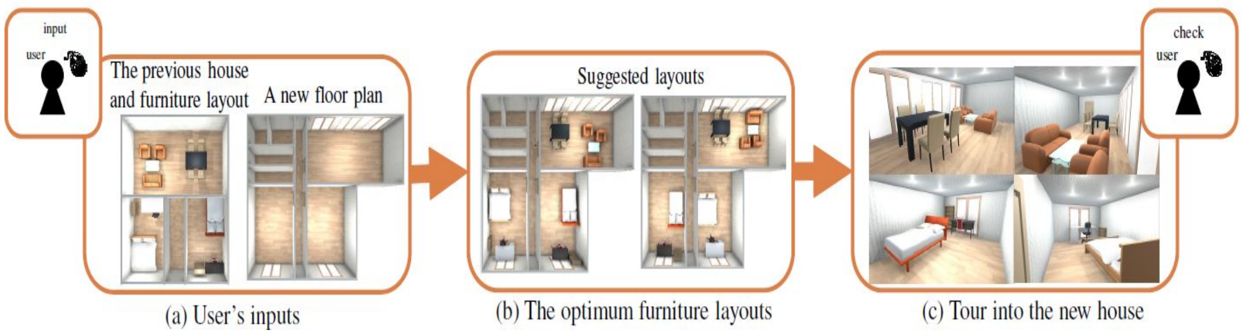
Manual assignment of each furniture item to each room is a tedious task, especially for a large amount of furniture and a large number of rooms. Furthermore, in designing the furniture layout for the new house, the previous methods do not take into account the spatial relationships between the furniture items in the previous house.

To automatically assign each item to a room in the new house, the method described in this paper uses the correspondence between the furniture item and the function of the room (e.g. living room, dining room, and bedroom). That is, the set of furniture items located in a particular room in the previous house is assigned to a room having the same or similar function in the new house.
The approach can be summarized as follows:

There are four user’s inputs to the system:
1) a 3D model of the previous house
2) a 3D model of the new house
3) labels for the rooms, and
4) the furniture layout in the previous house.

The user creates 3D models of the previous and new houses by simply placing 3D walls, doors, and windows according to the floor plans (Fig. 1(a)). The user then assigns a label to each room: the labels signify the type of room, e.g., ”Living-Dining”, ”Bedroom”, etc.
The user specifies the furniture layout of the previous house by interactively placing 3D furniture items using our system (Fig. 1(a)-left).

When the user presses the ‘Optimization’ button, the optimum furniture layouts are automatically computed for the new house, and these are presented to the user (Fig. 1(b)). This computation takes tens of seconds in our current implementation.
Finally, this system allows the user to do a tour around the new house with the suggested furniture layout



They propose a global cost function that finds a correspondence between rooms in the new and previous houses, and the furniture layout in each room.
Global cost function is given by the following equation:

φ(F, C) = φc(C) X N i=1 {φs(Fi) + φm(Fi)}

where Fi is a subset of the furniture items placed in room ci . φc evaluates the room correspondence C, φs the similarity between the new layout in room ci and the previous layout in room i, and φm the visual/functional quality of the layout.

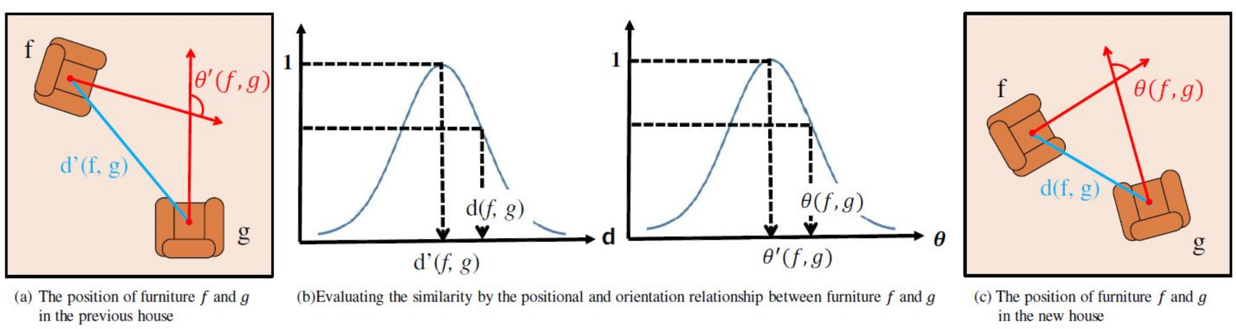


Figure 2: Evaluating the similarity by the positional and orientational relationships between items of furniture.

They also define two global cost functions φc and φs, φc evaluates the quality of the room correspondences and φs evaluates the similarity of the furniture layouts between the previous and new houses. Although the method successfully suggests layouts that are similar to those in the previous house, there are some drawbacks. This system does not allow a furniture item to move from one room to another which limits the variations of the layouts produced by our system

In conclusion, they have proposed a method for automatically computing the furniture layout when one moves into a new house. The layout in the new house is computed by assessing the similarity to the original layout in the previous house by taking visual quality and the functionality of the layout into account. The usefulness and effectiveness of the method are demonstrated by several examples with different floor plans.

Relation between two papers:

The primary paper primarily focuses on creating convertible furniture objects for saving valuable space whereas the secondary paper is more about computing the furniture layout when one moves to new house. The primary paper studies about techniques such as object arrangements which is used in the secondary paper and uses its as a foundation for further expansion.