Annexure A
Floor plan datasets ROBIN and S-ROBIN

Dataset plays a pivotal role in any image processing problem. Availability of a public dataset sometimes makes the life of a researcher easy. However, this is true for only generic problems, and not so for problems which are of some specific nature. Floor plan image analysis is such a problem where a large collection of samples is hardly available. For this reason two public datasets have already been proposed by researchers. They are: (i) SESYD [Delalandre *et al.*, 2010b] and (ii) CVC-FP [de las Heras *et al.*, 2015]. The former has 10 classes of floor plans, where there are 100 samples/class. The latter has 122 scanned floor plan documents divided into 4 categories based on the origin and style. The SESYD dataset is inappropriate for application to a retrieval task due to very less difference between a pair in a class of floor plan images. Also, in the CVC-FP dataset, the samples are insufficient in number for the task of floor plan retrieval.

To train and evaluate the contributions presented in this thesis, two floor plan databases, named Repository Of BuildIng floor plaNs (ROBIN) and Sketched-Repository Of BuildIng floor plaNs (S-ROBIN) are created. S-ROBIN are the sketch replicas of the ROBIN dataset containing floor plan images. These datasets have significantly aided in the content analysis and retrieval of similar floor plans as proposed in this thesis. The primary motivation while creating the ROBIN dataset was to have: i) sufficient number of sample to execute the experiments, and ii) variation (inter and intra class) among the samples. While searching for a dream house, the customer generally has the follwing sequence of requirements in his/her mind; i) the number of rooms inside the house, ii) the global shape of the house, iii) what is the pattern in which the rooms are connected to each other, and iv) if a user is looking for a well furnished home. then which furniture should be placed in the house and in which arrangement. In the following subsections, each of the points mentioned above are elaborated in detail.

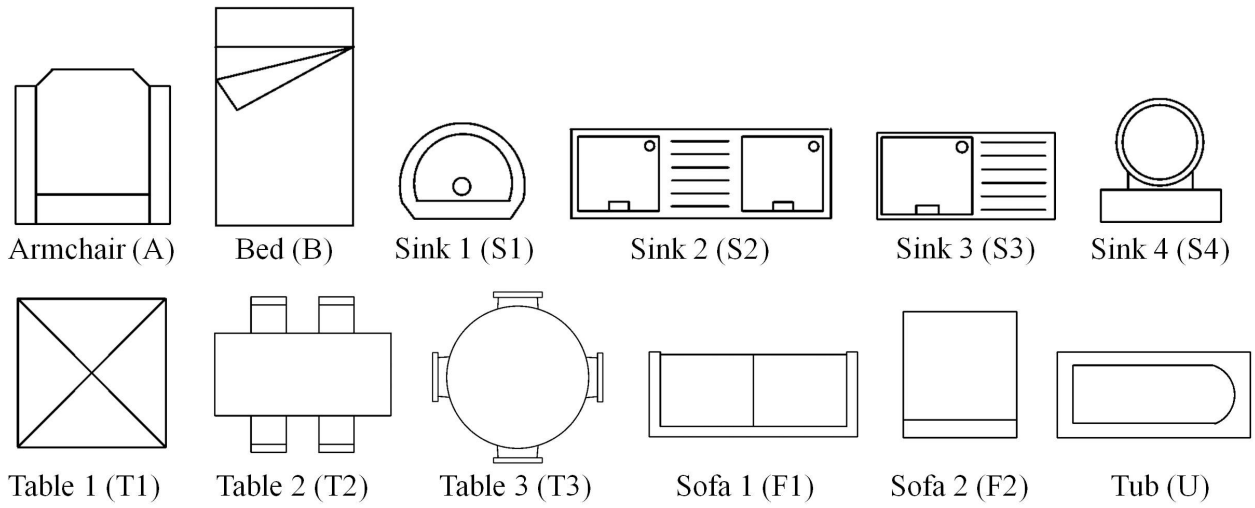

Figure A.1. : Symbol set used as furniture in ROBIN and S-ROBIN dataset.

A.1 NUMBER OF ROOMS

In ROBIN there are three categories of floor plans, depicting the three broad classes of houses. There are houses with 3, 4 and 5 rooms. The purpose and the subsequent label of each room varies depending on the various decors present in them. To be consistent with the existing floor plan datasets, the furniture symbols used in ROBIN dataset are similar to the ones used in SESYD dataset [Delalandre *et al.*, 2010a] as shown in Fig. A.1.

A.2 GLOBAL SHAPE OF THE HOUSE

The second important criteria kept in mind while designing the dataset was the global or overall shape of the layout. To design the floor plans the rooms were arranged either in the horizontal or the vertical direction with respect to each other. While designing, due consideration was given to the fact that, there is no arbitrary shaped floor plan image and also that curvilinear structures in the layout walls are avoided. Moreover, to increase the variability among the samples, difference in arrangement of rooms across 3, 4 and 5 room layout categories was also introduced. Figure A.2 (a), (b) and (c) depict the example of variation in global shapes across a layout category.

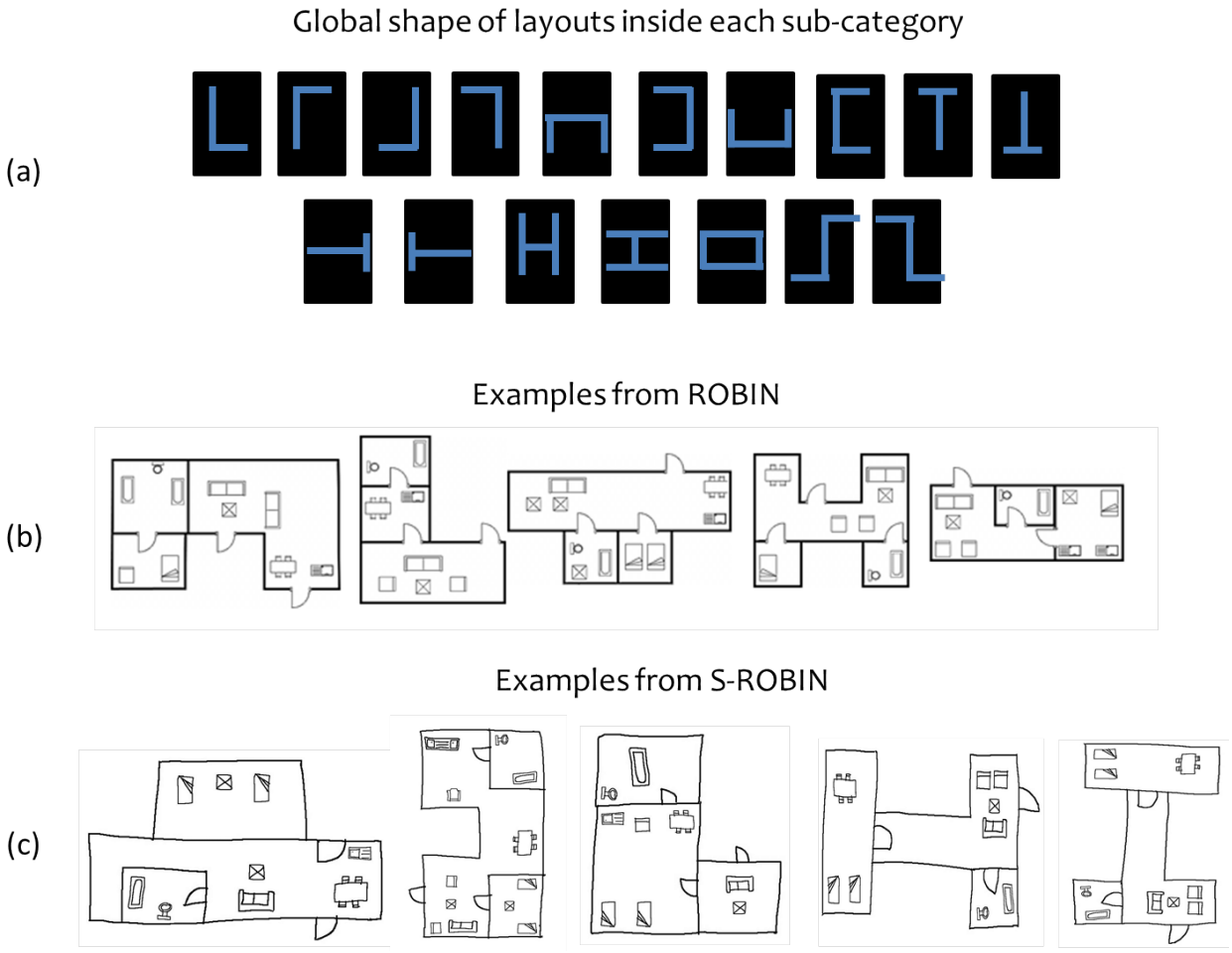

Figure A.2. : 3-Room layouts in the ROBIN and S-ROBIN dataset.

A.3 CONNECTIVITY WITHIN A HOUSE

Doors are placed at the desired places in the floor plans to ensure connectivity between the rooms. Orientation of each door is given special consideration to ensure proper direction of movement within the house. For every floor plan, there is atleast one door lying on the outer wall of the floor plan that opens inside the house and provides entry/exit for the house. Windows are appropriately placed on the walls of the floor plan to ensure proper ventilation and aesthetics. This makes the floor plan more realistic. Figure A.3 (b) can be observed for the arc-type door symbols satisfying entry-exit criteria in the floor plans.

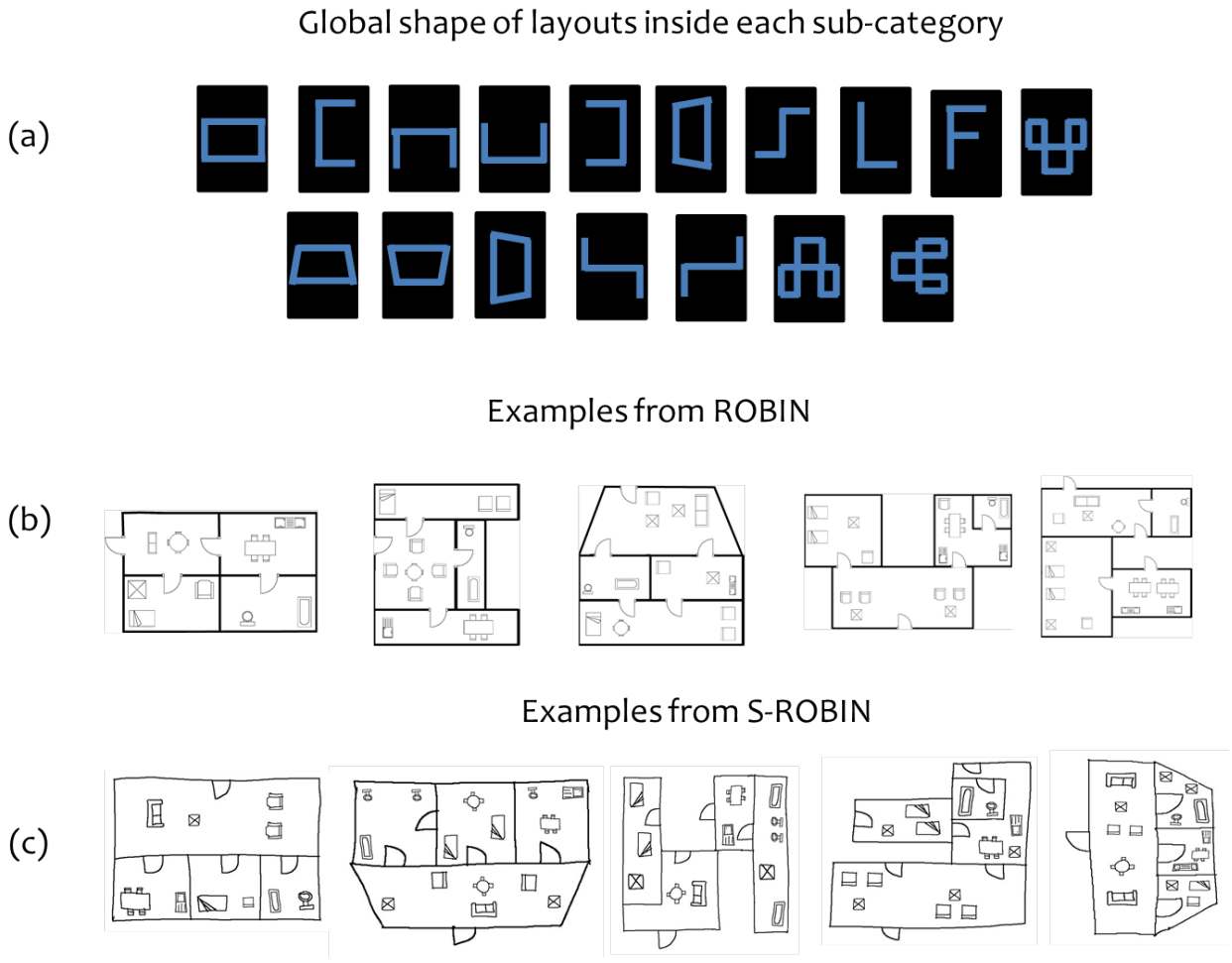

Figure A.3. : 4-Room layouts in the ROBIN and S-ROBIN dataset.

A.4 PLACEMENT OF FURNITURE

Furnitures or decors are inseparable part of a floor plan. To make the floor plans of ROBIN realistic, decor symbols as proposed by Delalandre *et al.* [2010a] were utilized. As shown in Fig. A.1, there are 12 different floor plan symbols. In each floor plan a subset of the entire symbol set was chosen and placed inside every room to give a definition to the room. As the furnitures are indicators of the purpose of the rooms, therefore, while designing, sufficient care has been taken to ensure that a house contains a i) kitchen, ii) bedroom, iv) washroom and a v) lobby. Moreover,

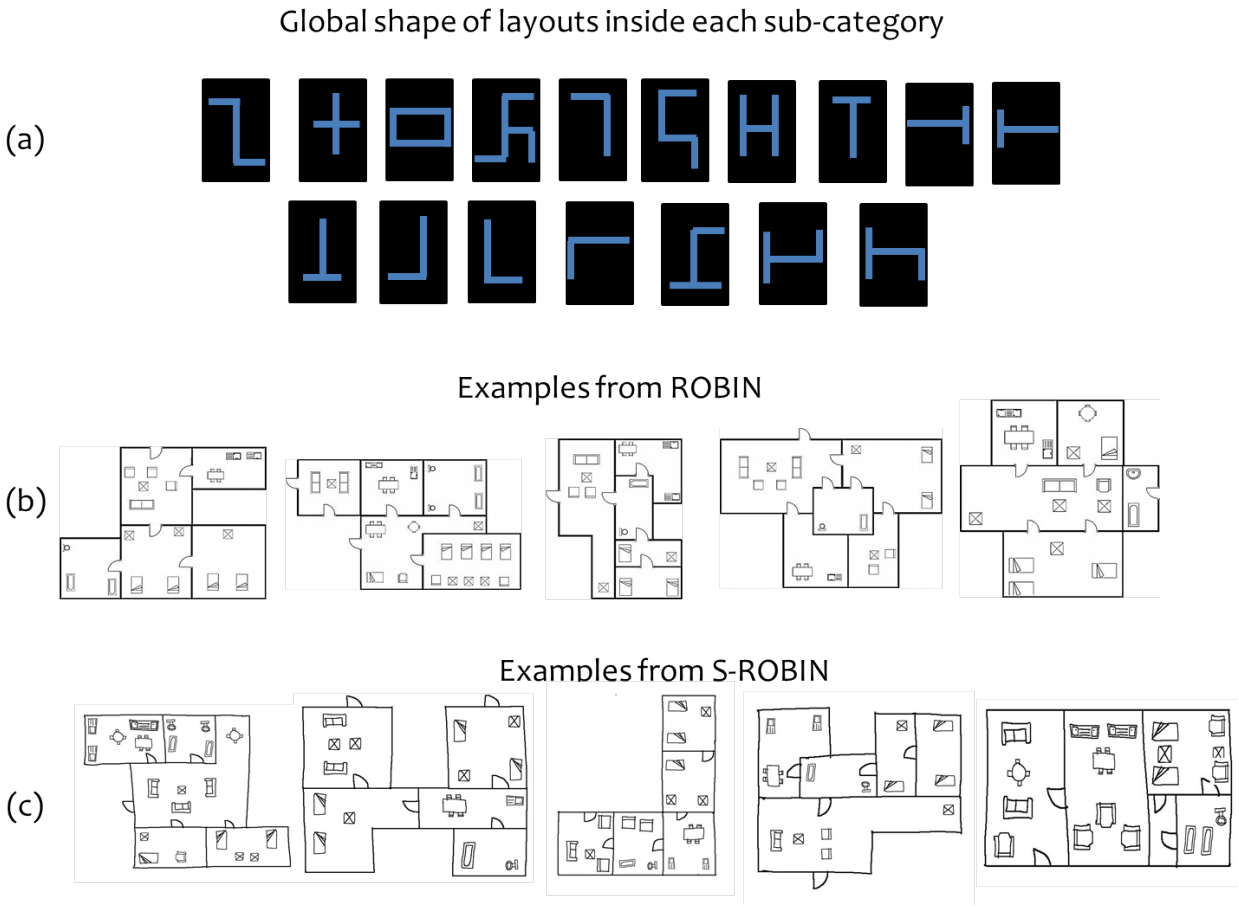

Figure A.4. : 5-Room layouts in the ROBIN and S-ROBIN dataset.

special consideration was given to the fact that the furniture is not placed in an arbitrary manner. For example, furniture should not be placed in a way that it blocks the door. Also, sufficient area should be left vacant after the furniture placement for navigation purposes.

A.5 DATASET CREATION PROCESS

ROBIN dataset was created on similar lines as the SESYD dataset [Delalandre *et al.*, 2010a]. Basic room structure of the floor plan was built using rectangular shape in Microsoft powerpoint. Thickness of each wall was kept uniform to be around 40 pixels. The decor symbols were inserted inside the rooms from the symbol library and door symbols were carefully placed on the room walls. On the other hand, to capture hand drawn sketched floor plans in S-ROBIN, volunteers were asked to draw the floor plans on a digital platform using a Wacom tablet. Wacom tablet is an interactive tool, where the user can draw on a board like tablet using a pen stylus conveniently and the resultant floor plan sketch is captured on the Microsoft paint software by adjusting the thickness of the strokes of the pen stylus. Since, offline mode is being used, the hand drawn floor plans are stored as an image and used for experimentation.

A.6 STATISTICS OF THE DATASET

Both the datasets contain 510 floor plans divided into 3 categories of layouts each with 17 sub categories. The unique characteristic of the datasets is that they are designed keeping in mind the need of a potential buyer. Every prospective buyer wants to have certain amenities and functionalities in their house. Thus, in the dataset, there are three broad categories, which are different from each other in terms of the number and type of rooms present in a floor plan. The broad categories are layouts with 3-rooms, 4-rooms and 5-rooms each which differ in the global shape of layout across their sub-categories. Each broad category is further classified into 17 sub-categories depending upon the global layout shape of the floor plan. Standard notations as mentioned by Delalandre *et al.* [2007], are followed for all the floor plans so that the datasets can be used for other floor plan analysis tasks as well, and not only for retrieval. The dataset has 12 different categories of furnitures inside each layout. These datasets help in better visualization of the floor plans and aid in efficient capturing of various high-level features while fine-grained retrieval. Illustrations of the various sub-categories in the floor plans and how their shapes are modeled are shown in Fig. A.2, Fig. A.3 and Fig. A.4. The size of the floor plans in ROBIN vary from 825×708 to 2916×1845 whereas the resolution in S-ROBIN dataset ranges from 591×517 pixels to 1483×884.

A.7 CONCLUSION

The rationale behind the creation of ROBIN and S-ROBIN dataset was to create a floor plan repository that can be used for research purposes by the Document Analysis and Retrieval (DAR) community. Both ROBIN and S-ROBIN dataset are sufficient for carrying out tasks like, retrieval, semantic segmentation, door to door navigation, etc. The entire dataset along with the annotations can be downloaded from [S-ROBIN, 2018].

Annexure B

GUI for floor plan analysis and retrieval

In this Chapter, a software interface for the task of content-based floor plan retrieval is discussed. The software works in the following manner:

1. The user chooses a sample floor plan image and uploads it to the server.
2. The retrieval engine extracts features from the query sample and matches with all the samples of the database.
3. The retrieved samples are rank ordered and shown to the user.

The software has a Graphical User Interface (GUI) with which the user can interact with the system and retrieve similar floor plans from the database. The software has two operational modes, which are (i) detailed mode, and (ii) direct mode. In the detailed mode, depending on the users' choice the intermediate steps of floor plan retrieval such as, segmentation, graph creation with nodes as segmented rooms and adjacencies as relations between the rooms, and finally retrieval based on the features extracted from the floor plans are shown in this GUI. On the other hand, in the direct mode the intermediate steps are not shown, and only the final result is displayed.

B.1 SYSTEM ARCHITECTURE

The web-based interface, which runs in a client server mode, has been developed to facilitate the framework for semantic retrieval of floor plans. The proposed system runs on Windows 7/XP and requires a few seconds to retrieve the rank-ordered results from the repository of floor plans. Figure B.1 shows the overall architecture for the framework. Developed under a client-server paradigm, the retrieval framework has two types of users to access the application, namely normal user and the administrator. A normal user is allowed to browse the system and perform queries, select whether he/she wants to get results of all the intermediate steps in the framework or only the final retrieval results, place a request to add a new floor plan to the repository, etc. An administrator on the other hand has all the access of the functionalities provided to a normal user, and in addition has the privilege to see the repository updation requests sent by the normal user and add/remove user accounts etc. The types of user access are controlled by a backend user database maintained using Microsoft Access. The retrieval portal is developed using HTML5, JavaScript, CSS. Apache webserver hosts the webpages, while Tomcat Java Server hosts Java servlets for receiving the query provided by the user.

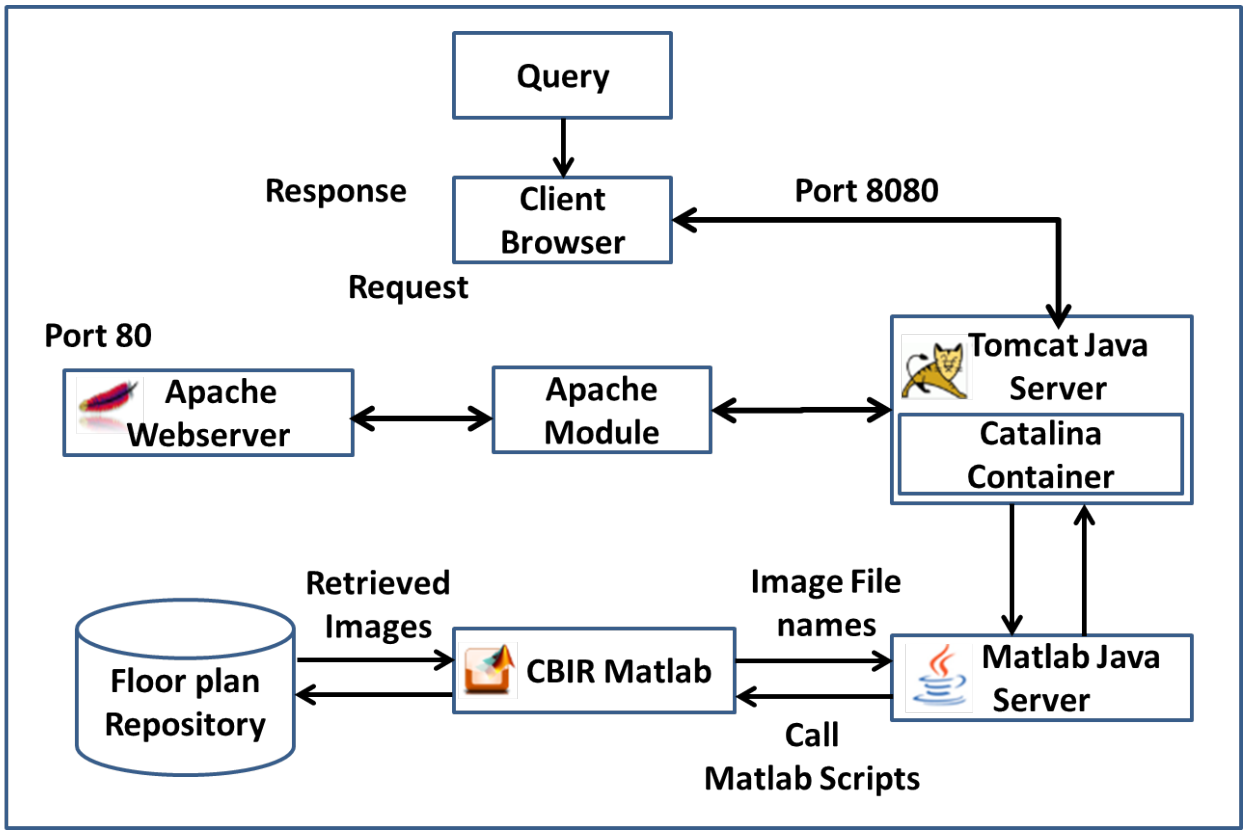

Figure B.1. : Architecture of the developed software for floor plan retrieval.

B.2 SOFTWARE FUNCTIONALITY

Figure B.2 depicts the sequence diagram of the developed software. There are five primary objects. They are: (i) user, (ii) host computer, (iii) Graphical User interface (GUI), (iv) Matlab workspace, and (v) the floor plan database. The user initiates the interaction between the software and the outside world by selecting a query floor plan image from the host computer. Through the GUI the query image is submitted to the Matlab workspace. All the necessary modules are developed in Matlab as .m files. The feature extraction, segmentation, matching and rank ordered list is done in the Matlab workspace. Based on the rank ordered list, floor plans are retrieved from the database and shown to the user. The software also has a functionality to allow the user to choose the number of floor plan samples to be displayed. Depending upon the users' choice (the value of k), the appropriate number of floor plans are shown to the user. In the next section, screen-shots of the key components of the software and their description is presented.

B.3 SCREEN-SHOTS OF THE FLOOR PLAN RETRIEVAL FRAMEWORK

Initially, when the user launches the application he/she comes across the basic screen prompting the user to select a floor plan from the repository to query into the retrieval framework as shown in Fig. B.3. As shown in Fig. B.3, there are three place holders to host the three different type of images. It can be observed that the "Search" button at the bottom of the interface is disabled at the beginning to ensure that the search is not made on null objects.

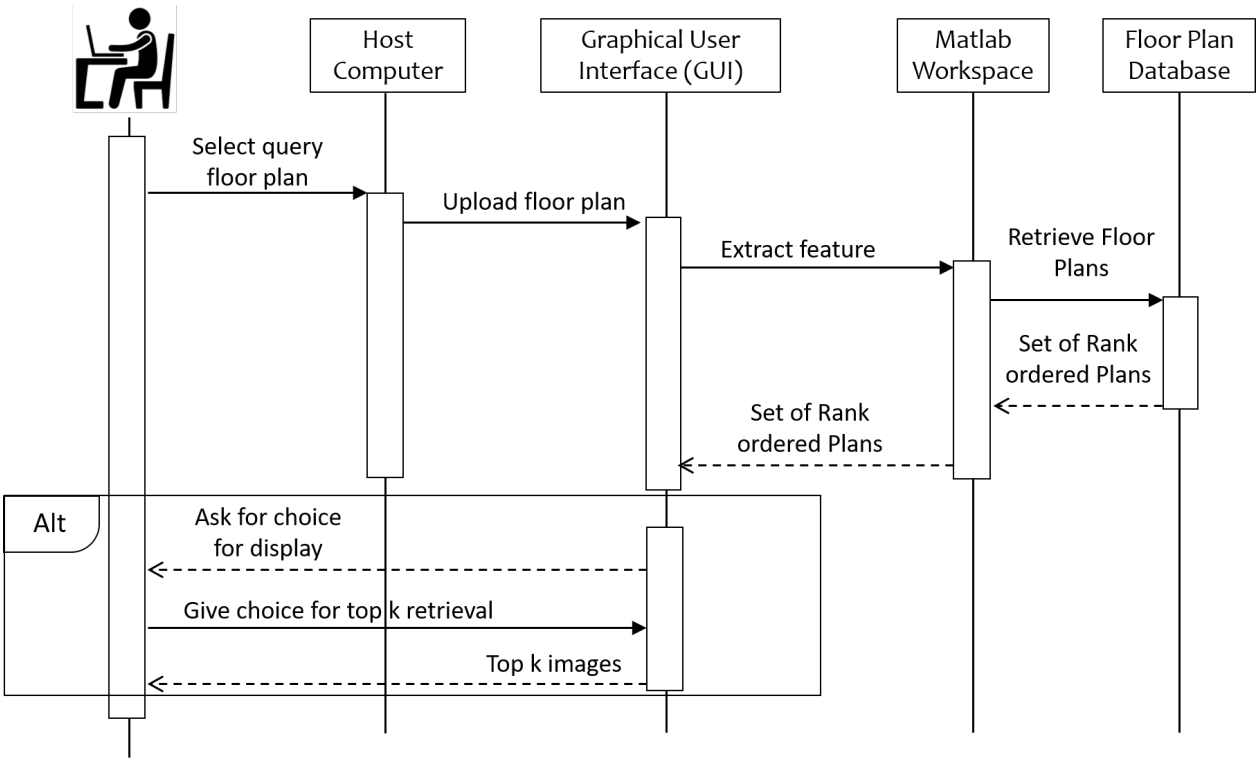

Figure B.2. : Sequence diagram depicting the overall flow of the software.

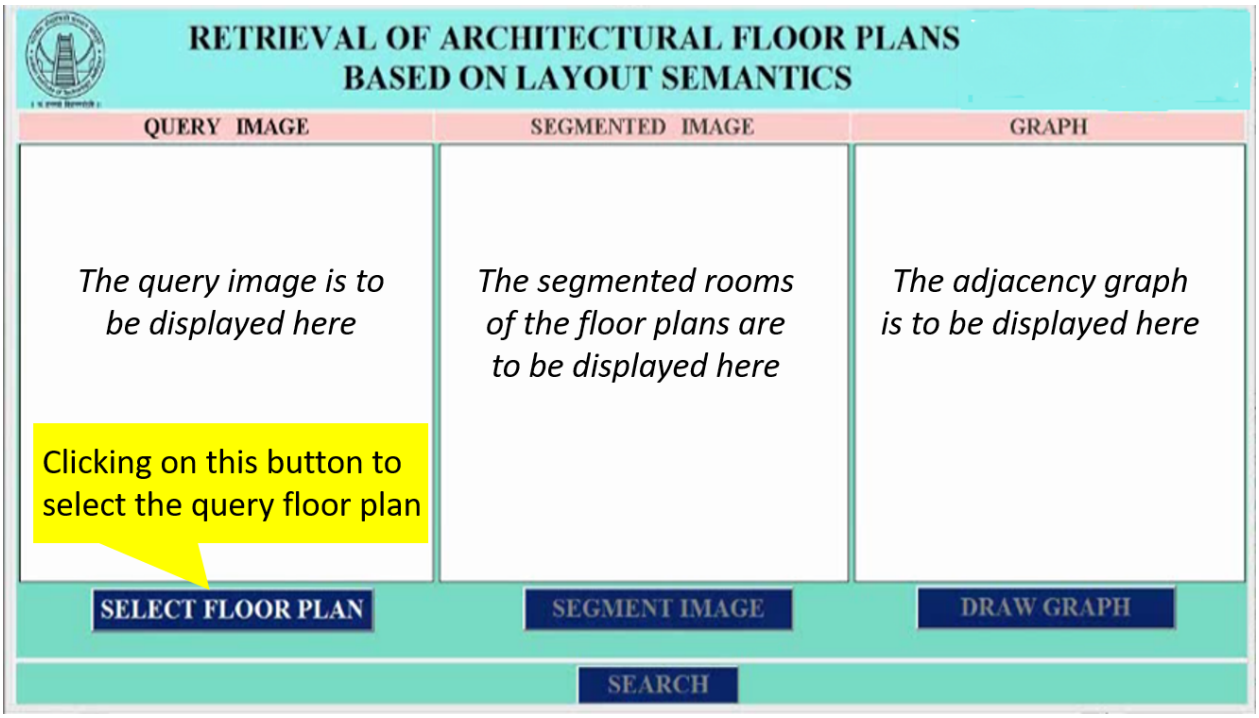

Figure B.3. : Screen prompting the user to select a floor plan of his/her choice.

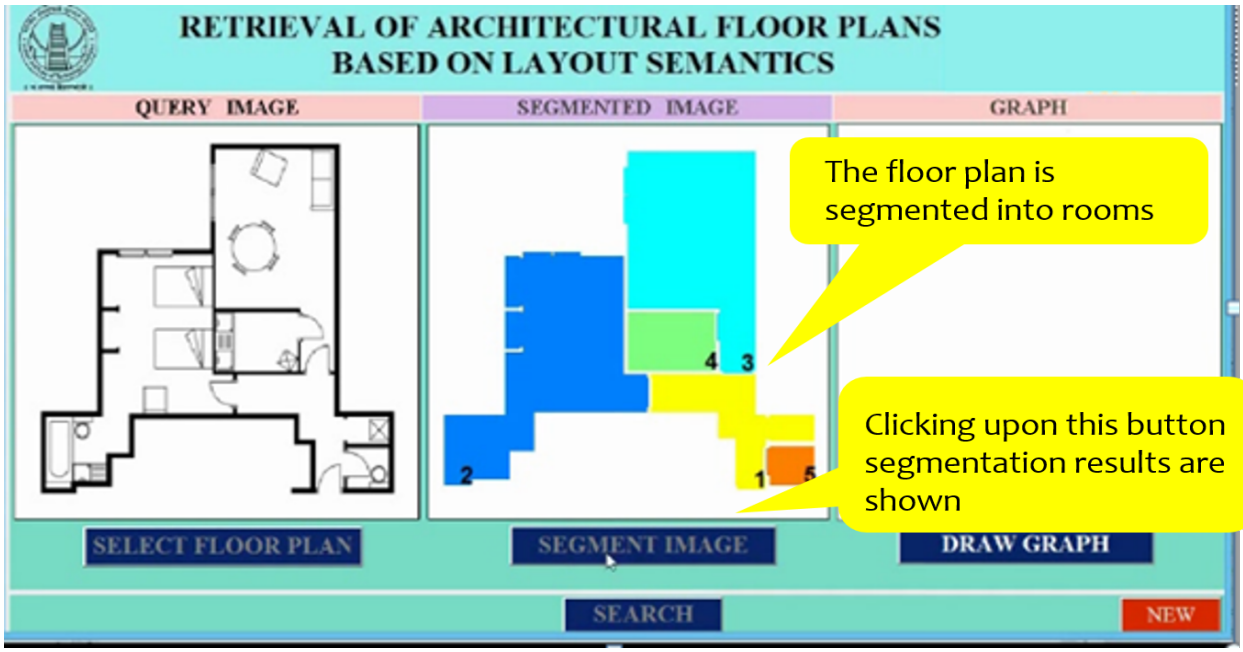

Figure B.4. : Segmentation of the selected plan into labeled rooms

Once the floor plan is chosen and shown in the appropriate place holder the user has the option to choose one of the two modes, i.e. direct or detailed mode. If the user chooses the detailed mode then the intermediate results will be shown in the appropriate place holders. Under the detailed mode, the next task is to segment the floor plan into meaningful entities like rooms and separating it from the decor elements present inside the rooms to further derive the relations between them. Figure B.4 depicts such a scenario, where the intermediate result is shown. Since

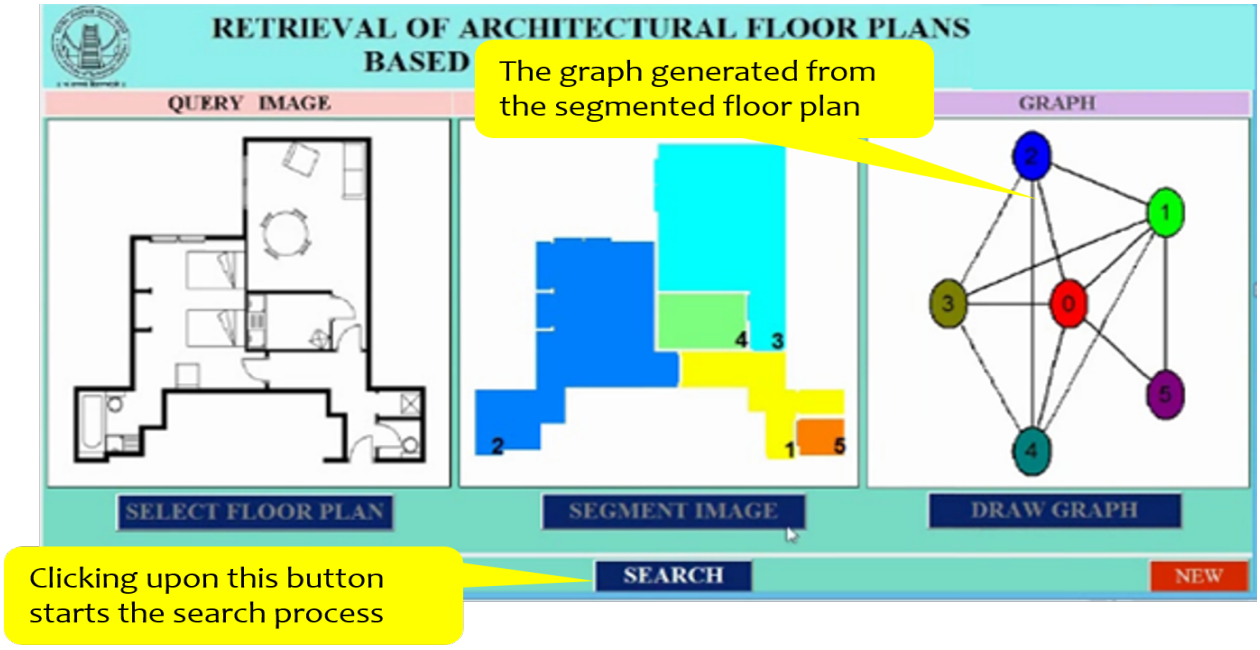

Figure B.5. : Graph embedding of the room level structure of the floor plan.

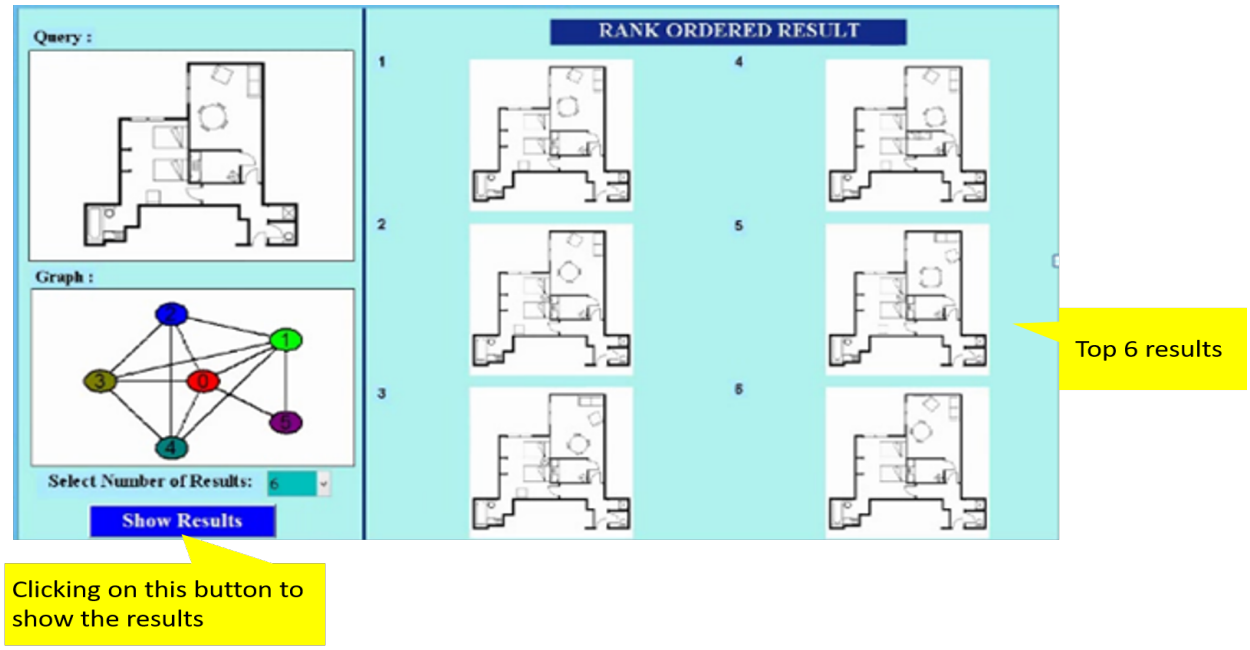

Figure B.6. : Selecting how many results to be displayed while retrieval.

the user has chosen detailed mode, the "Search" button is still disabled as one more step, i.e. the graph creation process is pending.

The next important user experience is shown in Fig. B.5. After the segmented floor plan is obtained with numbered labeling on each room, the next task is to obtain a relationship between these rooms. Therefore, adjacency is used as a parameter to define relationships between them. A graph is created where nodes represent rooms and edges represent which rooms are adjacent to each other. As shown in Fig. B.5, the "Search" button is now activated as the software is ready to do the matching between the query feature and the database features to show the retrieved result.

After the required graph is obtained, spectral analysis of the adjacency matrix is done in the back-end for the query floor plan as well as the database floor plans. The floor plans with similar adjacency are clustered together in the spectral space and thus, the GUI redirects to the second page for retrieval of similar floor plans as shown in Fig. B.6. As shown in Fig. B.6, there are three place holders in the interface. On the left hand side top the query floor plan is shown, while the corresponding graph is shown at the bottom. Just below the graph, there is a drop down list using which the user can choose the value of the number of floor plans to show as result. Upon the selection of number of results to be displayed, the rank ordered retrieval results are displayed as shown in Fig. B.7.

Figure B.7 depicts the final result for top 6 results. As seen in the results the retrieved results are numbered as per their position in the rank ordered list. After the results are displayed, the user can always change the number of results to be displayed. The user needs to choose an appropriate number from the drop-down list and then click the "'Show Results" button. The number of floor plans shown as results are updated accordingly.

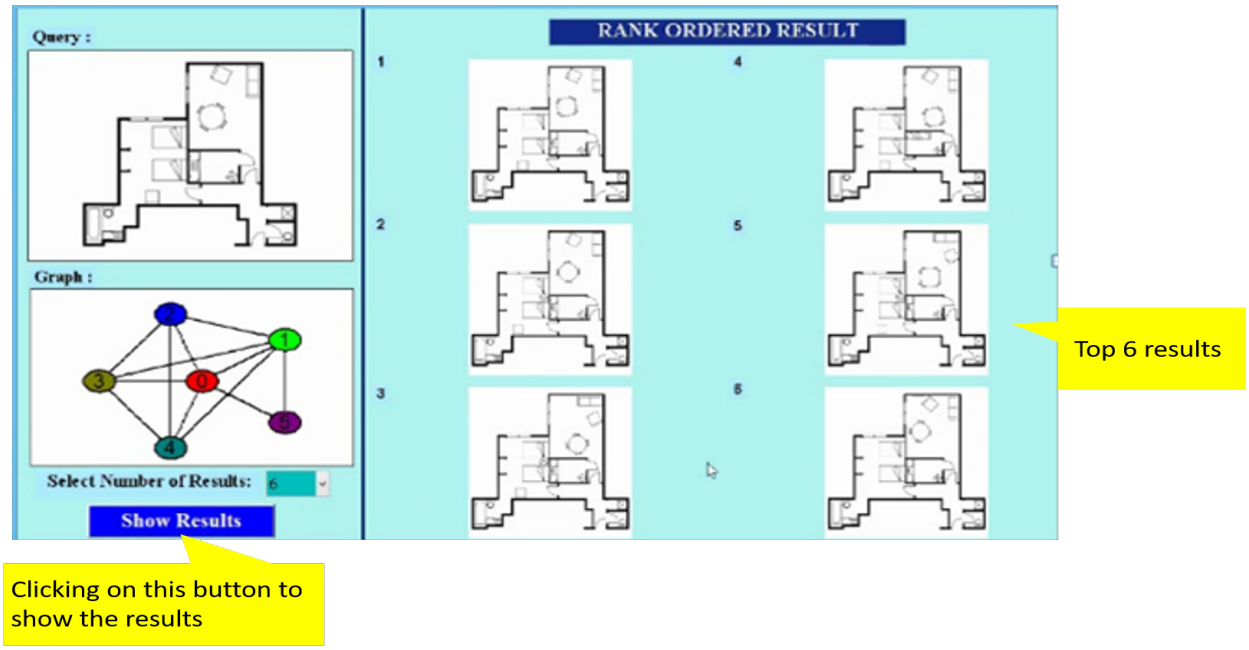

Figure B.7. : User's required floor plans on display as per their similarity from the query floor plan.

B.4 CONCLUSION

This is an initial version of a platform developed for content based floor plan retrieval. At present, the software runs on system with Matlab installed in it or a system that has a Matlab plugin installed. An extension could be to have a mobile version of the same that can be used easily without any specific software prerequisites.

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