Abstract:

The system first processes the current image from the camera, using predefined known furniture colors to detect the furniture. Then it compares the currently detected furniture with previously detected furniture to account for any occluded furniture. Finally, the detected furniture is matched with the database. The room corresponding to the best matching image will be used and the lights will change accordingly.



Summary:

The color range of each furniture type (chairs & tables) under various lighting conditions is determined empirically.

An image frame from the camera is first passed through a median filter to smooth out similar colors while preserving edges. The *filtered image* is then passed through a range filter where pixels within the range of the predetermined colors will be set to white while others will be set to black to create a *binary blob image* corresponding to locations in the image where color is similar to that of the furniture. Distance transform is carried out on the binary image followed by simple thresholding to obtain another image which represents the center location of each major blob. This will be the *foreground marker* for the foreground-background segmentation later on. Note that each center foreground pixel is marked with a different non-zero value. The binary image from the range filter is also passed through a dilation filter which expands the white regions. This will be the *background marker* for the foreground-background segmentation. With the foreground markers and background markers, foreground-background segmentation with the watershed algorithm is carried out. The output is a *foreground segmented image* with each furniture object marked in a different color. PCA is carried out per furniture to find the min area bounding box enclosing most of the pixels. This concludes the furniture detection of a single frame.



There are cases where the furniture detection fails to detect a furniture. Namely, when large objects are placed on the furniture, e.g. person sitting on the chair, objects placed on the table. To tackle this, the furniture detector keeps track of previously detected furniture. If a furniture suddenly could not be tracked, the detector looks at the last known location of the furniture and checks if there are furniture-colored pixels within the last known location. If there are, the last known location is assumed to be the current location of the furniture. If there are no furniture-colored pixels, the detector determines that the furniture has been removed from the scene. This relies on the assumption that people / objects on the furniture will not completely occlude the furniture. This system allows for a degree of persistence while still allowing self correction of wrongly detected furniture. Note that tracking will fail if the furniture is completely occluded, e.g. putting a blanket over the tables.



After the current position of the furniture is determined, the system runs template matching for different orientation and scale to match the current furniture layout with the furniture layout in the database. The room type of the most similar furniture layout is set to the current room type and the lights are changed accordingly.

Further Improvements:

* Non-reflective floor
  + Reflection of ceiling and surrounding light on the floor occasionally created patches of colors that were similar to furniture colors. This caused occasional false detection of furniture at those locations.
* Higher contrast between table and chair color
  + Similar color between table and chair increased difficulty when differentiating between the two furniture. Misidentification of furniture decreased accuracy when matching detected layout with layouts in database.
* Depth camera
  + Due to the distinctive and constant height of the furniture, using a depth camera can increase furniture detection accuracy by incorporating height of furniture into the detection algorithm
* More uniform lighting configuration
  + Varying light colors as well as uneven illumination of the detection area created inaccuracies in finding furniture. Using a more uniform light color and more even illumination can improve detection accuracy.