Indoor Localization

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Abstract

The GPS signal in room is extremely weak and the accuracy is not enough for indoor localization. Our project is dedicated to achieve indoor position with LEDs so that people can be located in supermarket by cellphone without any modulation. We just use the camera in cellphone to capture the frequency of LEDs, due to rolling shutter effect of camera. The differences of frequencies can be used to distinguish LEDs. Then the AoA algorithm is used to calculate the position of people.

Our works

- *We take the pictures that can represent the rolling shutter* . We use an app to take a picture by Huawei honor 7.
- *We get contour of each image and pick out a little pieces in which only one light is contained, then using fft to analyze the frequencies of lights. Using the frequencies of each lights from the image to get the corresponding lights'* coordinates.
- *Finally, we use the AoA algorithm to locate cellphone.*

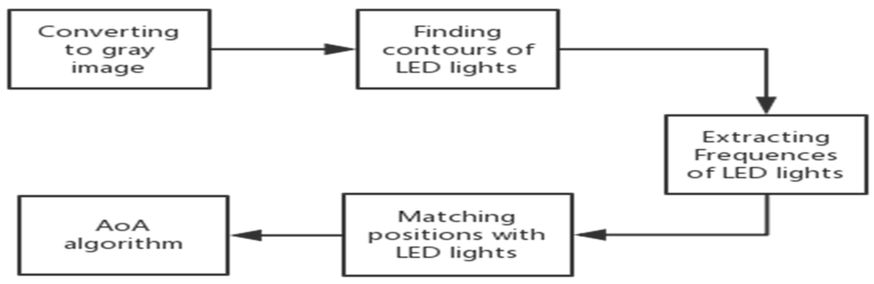

Figure 1: the flow block diagram

Implementation

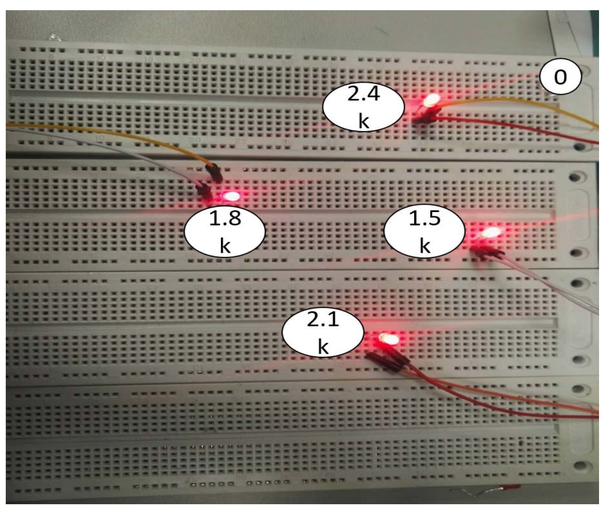

Figure 3: positioning testbed

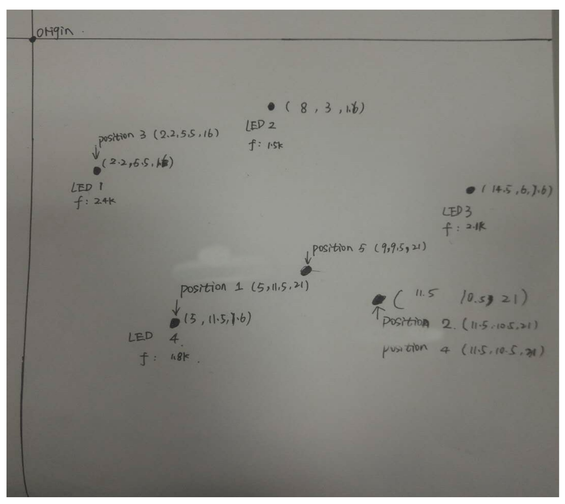

Figure 4: room measurement

An image at position 2

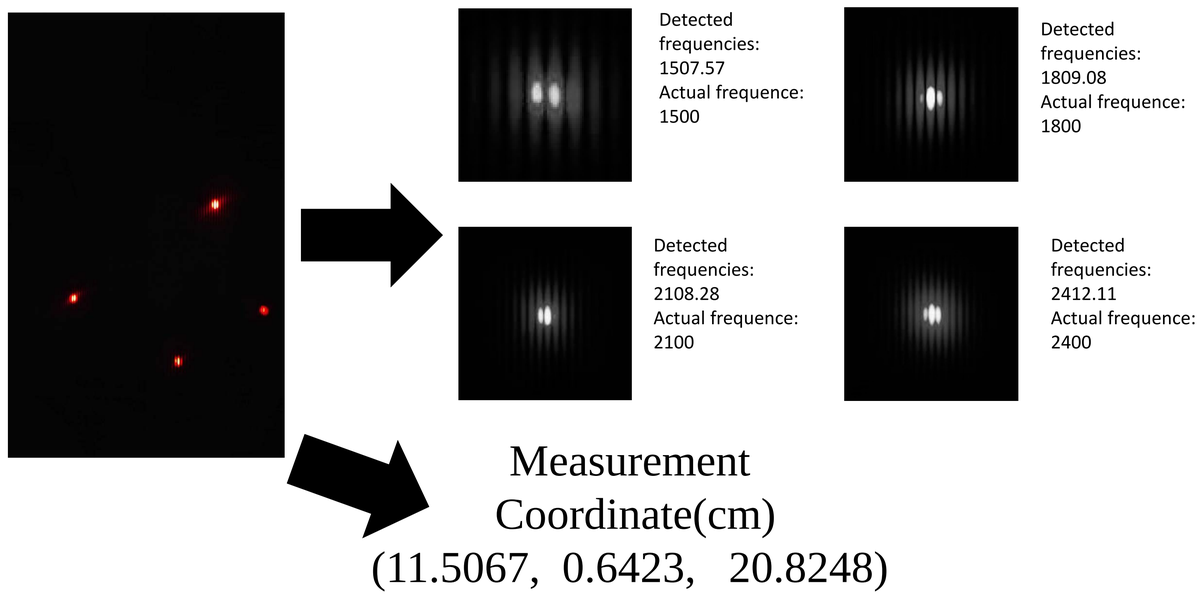

Figure 2: the image process result

- Explain 2.1: Set experimental setup. Four LED are mounted 1.6 cm above the panel for experiments, as figure 3 shown.
- Explain 2.2: Set the transmitters' global frame of reference. Take a picture at the position that we have measured its actual coordinate.
- Explain 2.3: image process, match the images in the picture with the lights and get the information of the lights. After that, calculate the coordinate of the position and compare it with its actual coordinate. The error is $\pm$8cm

- Explain 1.1: First the entire program environment is under python 3.5, The main files include image_preprocess, match_frequencies and AoA algorithm.
- Explain 1.2: image_preprocess is used to detect the contour of each LED lights and split the image pieces of LED as the above pictures show, then using fft to calculate the frequencies of LED. Match_frequencies uses the frequencies from image to match the real positions of LED. AoA can calculate the position and orientation of camera.

Results

Position	Measurement Coordinate(cm)	Actual Coordinate(cm)	Transmitters Coordinate(cm)
1	(-4.7474, 5.3423, 19.7286)	(5, 11.5, 21)	1500 : (8, 3, 1.6)
2	(11.5067, 0.6423, 20.8248)	(11.5, 10.5, 21)	1800: (5, 11.5, 1.6)
3	(14.6026, 4.1348, 21.119)	(2.2, 5.5, 15)	2100 : (14.6, 6, 1.6)
4	(17.6014, 4.3116, 30.34367)	(11.5, 10.5, 31)	2400 : (2.2, 5.5, 1.6)
5	(15.268, 4.076, 21.429)	(9, 9.5, 21)	

$$\arg_T \min(|(T_x - x_m)^2 + (T_y - y_m)^2 + (T_z - z_m)^2 - K_m^2(a_m^2 + b_m^2 + z_f^2)|)$$

From the above formula, we can calculate optimally the position of camera T. From the above table, there still exists error that is $\pm$8cm.

Discussion

We also have done a lot of tests at different positions. We find that the AoA can correctly figure out the Z coordinates of comera positions. Because of the difference between k value and actual k, there are some deviations in X and Y coordinates. But we still can get the positions roughly. The accurate of localization closely depend on the optimization algorithm. we optimize the k value and then using it to optimize the location and the rotation .

So far we can using cellphone to capture the rolling shutter effect in short distance and the frequency can be calculated. Given the coordinate of LEDs, the AoA can roughly figure out the positon and rotation matrix.