Intelligent home appliance

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1 Background

In recent years, Internet od Things(IoT) becomes more and more popular, this gives a big oppurtunity of the development of the intelligent home appliance, such as automatical lighting, heating and air conditioner. So what is the intelligent appliance? In general, intelligent home appliance is the traditional home appliance combine with micro CPU technology, sensor technology and wireless communication technology, etc. They can sense the house sptial information, their own state information and other home appliances' work state automatically.

There are many feature of the intelligent home appliances, for example, intelligent home appliances are connected to network, this can achieve that they can communicate and share information with each other; they can sense the different environment and work in different states sutomatically, such as smart air-conditioner, it can adjust its working state to the best accoding to the season, region, temporature and power; intelligent home appliances must have high compatibility, because they might be produced by different companies; they are people-oriented, so they must be easy to use.

2 Limitations

Although the intelligent home appliances is developing quickly, there are many limitations of them, such as the price. Intelligent home appliances are much more expensive than traditional home appliace due to the unmature technology. From the technology aspect, there are four major limitations. The first one is intrusive installation. It means that if we use intelligent home appliances, our privacy is exploded to the network and very easy leaked. So the privacy is a problem. Secondly, right now the intelligent hoem appliances in the situation that lack of network interoperability. Home appliances are not individual anymore, they have work as a team to service user. The problem is how to make them work together. Thirdly, One type of home appliance can be used is many different environment, for example, the light on the desk and the light in the classroom are in different work state: power, number of lights, etc. Designer have to design a large number of work states to sdjust different environments. The last one is security. If the network is attacked, the whole house will be paralysis. So security is very important to the intelligent home appliances.

3 General steps

There three general steps to achieve smart home. (1) Transform limited information into distance between each pair of devices. (2) Transform relative distance to relative position. (3) Detect the movement of devices and relocate them.

3.1 Transform limited information into distance

There are two popular localization technology in this step: RSSI based self-localization and CSI based self-localization. RSSI means Receied Signal Strenth Indication, it has high universality, it can be used in most of the adpater, but its accuracy suffers from multipath effect. CSI means Channel State Information, compared with RSSI, it has higher accuracy but only available for several adpater.

3.1.1 RSSI Localization

In RSSI localization, we use distance estimation model:

$$PL(d) = PL(d_0) + 10nlog(\frac{d}{d_0}) + \epsilon$$

PL(d) is the path loss of distance d we want, $PL(d_0)$ is the path loss of the unit distance d_0, n is the path loss exponent, ϵ is the error term which distributed by Guassian distribution. We can use the method of machine learning to calculate n and ϵ, like least square.

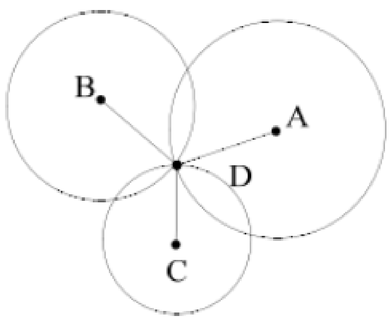
$$RSSI = P_t + G_t - PL(d)$$

After we get RSSI, we can use the equation above to calculate d. P_t is the power of the transmitting signal, G_t is the gain of the antenna.

In reality, obstructions like walls will affect the signal, so we add the number of obstructions n and the material of the obstruction m as the parameter in th model.

3.2 From relative distance to relative position

After we get the diatance d, we can take next step, to calculate the relative position. There are many ways the transform distance to position, like trilateration, multidimensional scaling. In trilateration, we first set three APs in the region: $A(x_1, y_1), B(x_2, y_2), C(x_3, y_3)$, and the point $D(x, y)$ is what we want. Now we get the distance between AD, BD and CD, $d_1, d_2 and d_3$. We can solve the group equations below to get the position of D.



$$\sqrt{(x-x_1)^2+(y-y_1)^2}=d_1$$
$$\sqrt{(x-x_2)^2+(y-y_2)^2}=d_2$$
$$\sqrt{(x-x_3)^2+(y-y_3)^2}=d_3$$

To reduce the error of the model, we can set more than 3 APs in the system and calculate more than one group equations, and get the mean of the results.

3.3 Dynamic Detection

As the time passes by, the RSSI on a certain distance is changing; similarly, RSSI is different on different distances at a certain time, so the trade-off between temporal dynamicity and spatial dynamicity is necessary.

With the increase of the testing time, the accuracy is higher, but meanwhile, the delay time is also bigger. So the trade-off between accuracy and delay time is also needed.

4 Reference

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