Poster: Intelligent Management of Chemical Warehouse with RFID Systems

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Abstract

In order to realize the intelligent management of chemical warehouse, reduce the burden on managers, we propose an intelligent system called RF-Detector. It combines robotics and RFID technology, and achieves two functions: one is to detect the remaining amount of chemicals, the other is to locate chemicals, so managers can find the chemicals with insufficient remaining amount quickly. During preliminary experiments, it achieves about 85% detection accuracy and 88% positioning accuracy.

1 Introduction

The management of chemical inventory in the traditional chemical warehouse is difficult. Thousands of chemicals are displayed in any chemical warehouse. Managers need to check the remaining amount of chemicals every day and replenish them that are almost exhausted timely. This management method will require large manpower, and may also result in statistical errors due to management mistakes, it may cause difficulties in subsequent searching and use. Hence, the remaining amount management and positioning of chemicals have become a problem that must be solved.

2 Detection and Positioning Method

2.1 Remaining Amount Detection

Although the RF signal used in RFID technology can penetrate paper, wood, plastic and other materials, it is still affected by many factors, such as solid, liquid and other materials, they will absorb some RF signals. Therefore, when the RF signal passes through some objects, the RF signal received by the reader will change significantly. Based on this feature, we can use the RSSI indicator to detect the remaining amount of chemicals in the container.

We measure the RSSI of the tag corresponding to every chemical, and observe the change in RSSI as the liquid level drops to the plane of the tag. The measurement result is shown in Figure 1. We find that the changes in RSSI of these six chemicals are different when the volume changes. As the liquid level rises, the RSSI of each chemical is also increasing, but the slope of the RSSI value of each chemical is different. The RSSI value of the solid decreases faster as the liquid level rises, the RSSI value of the liquid is reduced relatively slowly.

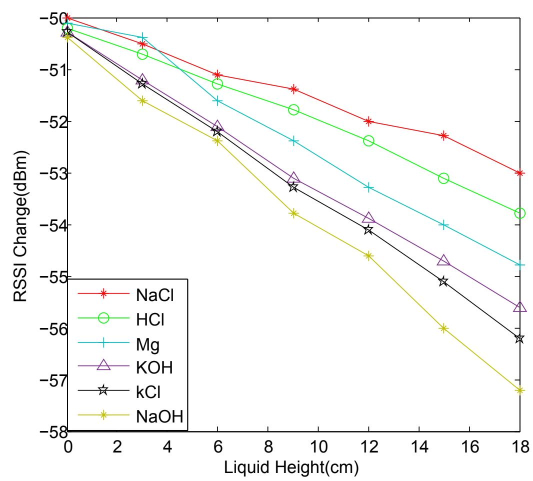

Figure 1: RSSI changes vs liquid heights

2.2 Localization of Chemicals

As the robot moves along the shelf, the reader continually scans the tags[1]. Each time the tag is scanned by the reader, a phase value is obtained, so with the reader accesses continuously, it obtains a series of phase values of the tag. During the movement of the reader antenna along the chemical shelf, for a certain tag on the shelf, the distance d between the antenna and the tag is first decreased and then increased, so the phase value of the tag is first decreased and then increased. We can perform period compensation for the jump of the phase curve to remove the periodicity of the phase profile[2]. So all the phase curves are connected into a line, and we get a super phase profile.

When the reader scans for chemicals, we set the starting point of each row of shelves as the origin of the coordinates, and establish a coordinate system in the plane parallel to the shelf. The moving speed of the antenna along the X axis is

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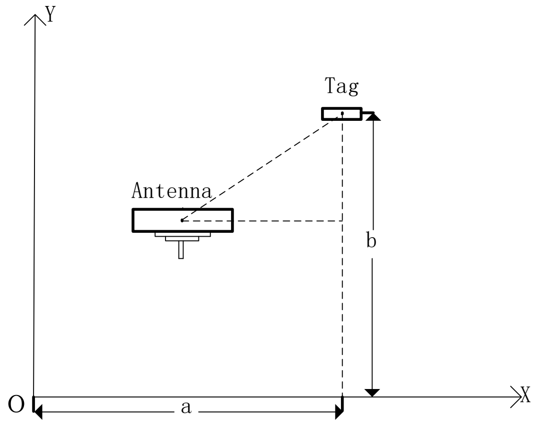

Figure 2: The distance between the antenna and the tag

v. Assuming that the height between the shelf layer and the layer is h, each time the antenna raises one level along the y axis, the height of the antenna is increased by h, and the robot can record the number n of layers raised by the antenna. As shown in Figure 2, if the coordinate of a certain tag is (a, b), the position of the antenna at time t is (vt, nh), the phase value can be expressed as

$$\theta = \frac{4\pi}{\lambda}\sqrt{(a - vt)^2 + (b - nh)^2} + \mu. \qquad (1)$$

In(1), a and b are of concern to us, λ, μ, ν, n and h are known, t and θ are variables. The above formula can be changed as follows:

$$\frac{(\theta - \mu)^2}{\left(\frac{4\pi}{\lambda}\right)^2 (b - nh)^2} - \frac{\left(t - \frac{a}{v}\right)^2}{\frac{(b-nh)^2}{v^2}} = 1. \qquad (2)$$

Formula(2) is a form of hyperbolic function, which is fitted by a hyperbolic model, and finally the values of a and b are obtained to determine the position of the tag. The larger a is, the farther the chemical is from the starting position of the shelf; the larger b is, the higher the number of layers in which the chemical is located. According to the a and b, the location of the chemical can be obtained, combined with the shelf number recorded during the robot navigation process, managers can quickly find the chemicals they are looking for.

3 Performance Evaluation

We use an Impinj Speedway R420 reader and cheap (i.e., 5 cents per tag) Alien tags in our experiments, as shown in Figure 3. We conduct experiments in an open area of a lab-office environment. In our experimental scenario, we repeat 20 trials and change the remaining amount and location of the chemical after every five experiments to maximize the mimicking of the chemical warehouse scenario. Figure 4 shows the user interface of our system. Chemicals less than 20ml are considered insufficient. The location information is the shelf number, the layer number, and the distance from the starting point in cm. The experiment can initially reach the expected result, however, there is still an improvement in detection accuracy and positioning accuracy. Moreover, the positioning accuracy will be affected by the distance between the chemicals. When the distance between adjacent tags is less than 3cm, the positioning accuracy of the system is low. Therefore, in the next study, we need to consider how to improve the positioning accuracy of the tags with close distance.

Figure 3: Experiment environment

Chemical Management Platform

Serial#	Number	Name	Specification	Remaining	Sufficient	Location
1	01010001	NaCl	300ml	205ml	Yes	1, 2, 10
2	01010013	HCl	250ml	12ml	No	3, 1, 30
3	01010205	Mg	200ml	14ml	No	5, 2, 10
4	01033004	KOH	300ml	55ml	Yes	6, 1, 20
5	01010235	KCl	200ml	80ml	Yes	1, 2, 70
6	01630004	NaOH	300ml	105ml	Yes	3, 2, 10

Figure 4: Chemical management interface

4 Acknowledgement

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5 References

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