Using RFID to realize Human Computer Interaction

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Abstract

This paper proposes a human computer interface which is based on Radio frequency identification (RFID) technique to let human communicate with computer by analyzing the signal from tags. For retrieving those signals from tags, how to decreasing the noises created by surrounding environment and detecting useful information from variant signals are the most important. In our proposed method, we adopt a train procedure as pre-processing to categorize all of signals into two categories: noise and real data. After the real data is retrieved, we use "music director" as an application to let user play with computer. The experimental results show the proposed method can analyze the signals from tags successfully with high detection rate.

Key Words: RFID; Human Computer Interface; Received Signal Strength Indication.

1. Introduction

In the past few years, Radio Frequency IDentification (RFID) techniques is often used to identify object's identity such as warehousing, pet tracking, car anti-thefting, payment system[3] and access controlling system[4]. In some research topics of local sensing, an object position can be estimated by analyzing the signal sent by tags to corresponding readers. However, due to the radio frequency is easy effect by obstructions such as walls, tables and metal objects, so there are also many researchers emphasis on how to improve the obstructing problems [1,2,5,6].

In this paper, we integrate the RFID technique and the concept of designing human computer interface to proposed a system which break through the limitation of above systems [1,2,5,6] and let user play with computer successfully. At the core of our proposed algorithm, we adopt a procedure of signal identifying by analyze the distance between identification tag and reader. The problem of signal obstructing is also improved by using our proposed signal categorizing procedure. But, due to the price of active-RFID device is expensive, so our goal is only using limited active-RFID devices to accomplish this system. In our implementation, we only are using one active-reader and some active-tags. For improving the categorizing rate, we add another reference tags.

"A Dream music director system" is a real application of our proposed system. We let user play as director of a musical group. The characteristic of this system is that whole music group only has one role: the director. User needs to hold the active-tag in their hand to act the pre-defined posture for controlling the music group. During the user change their posture, our system will detect the variance of signal then play the corresponding music file. By the way, user needs to finish an initial process which is used to determine the acceptable range of signal before they play. Different style of music can be generated and played by using our system.

The advantage of our proposed algorithm is that we can only using the estimation result of distance measurement to identify the posture of user successfully. Those categorized meaningful signal can be a guidance to let user control their computer. The proposed algorithm can easy be use in any kind of application.

This paper is organized as following. All of related works are discussed in section 2. The main methodology of the proposed system is described in section 3. The experimental results and conclusion is shown in section 4 and 5 separately.

2. Related works

In this section, we will talk about how the RFID system works and reviewing some related researches. The main concept of how to implement a user-friendly interface will also be discussed in this section.

2.1. Active-RFID and Passive-RFID

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There are four major devices constituting a RFID system: Reader, Tag, Client and Server. Figure 1 shows the flow chart of RFID system. The connection between client and reader is build by using USB port or RS232. There are two categories of RFID device: Active-RFID and Passive-RFID. The work flow of Active-RFID device is described as follows. In the beginning, tags will send radio frequency to reader continuously. When the reader received those radio frequencies, it will translate them into some useful signals by using local device and show the results on the client PC by middleware. After that, the client will send the tag's Identification or the message from tag to the sever side and then compare with the information in database. Since the comparison process is completed, server will response the request to the client. The work flow of Passive-RFID is almost same with Active-RFID. The only difference between Active and Passive is that user needs to put those tags near to reader. Those Passive-tags will work if and only if they are in the active range of reader.

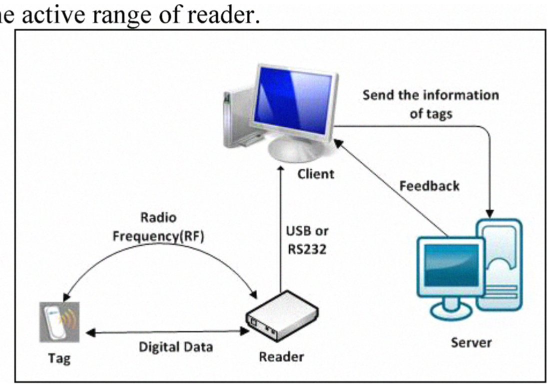

Figure 1. Work flow of RFID system.

2.2. Related works of locate sensing and object tracking by using RFID technique.

2.2.1 SpotON[6] :

Authors have created SpotON to investigate ad-hoc location sensing, a exible alternative to infrastructure-centric location systems. SpotON tags use received radio signal strength information as an inter-tag distance estimator.

This paper designed and built hardware that will serve as object location tags, part of a project called SpotON. SpotON tags use received radio signal strength information (RSSI) as a sensor measurement for estimating inter-tag distance. Using many collocated nodes, the measured positional accuracy can be improved through algorithmic techniques and erroneous distance measurements caused by signal attenuation (e.g. by metal objects in the area) can be automatically factored out.

2.2.2 LANDMARK[1]:

A location sensing prototype system that uses Radio Frequency Identification (RFID) technology for locating objects inside buildings. The major advantage of LANDMARC is that it improves the overall accuracy of locating objects by utilizing the concept of reference tags. Based on experimental analysis, we demonstrate that active RFID is a viable and cost-effective candidate for indoor location sensing.

LANDARC (Location Identification based on Dynamic Active RFID Calibration) system employs the idea of having extra fixed location reference tags to help location calibration.

These reference tags serve as reference points in the system (like landmarks in our daily life).

the simplest way to find the nearest reference tag to the tracking tag is to use the coordinate of the reference tag with the smallest Euclidian-distance value as the unknown tag's coordinate. When use k nearest reference tags' coordinates to locate one unknown tag, we call it k-nearest neighbor algorithm.

2.2.3 LEMT[7] :

Present a novel algorithm, known as Location Estimation using Model Trees (LEMT), to reconstruct a radio map by using real-time signal-strength readings received at the reference points. This algorithm can take real-time signal-strength values at each time point into account and make use of the dependency between the estimated locations and reference points.

2.3. Discussion of Human Computer Interface Designment.

Tovi et al. propose a 3D user interface [8] which is base on the concept of human computer interaction. Fingerprint-based techniques consist of two phases: an offline training phase and an online localization phase In the offline phase, a radio map is built by tabulating the RSS measurements received from signal transmitters at predefined locations in the area of interest. In the online localization phase, the real-time RSS samples received from signal transmitters are used to search the radio map to estimate a user's current location based on the learned model.

The human computer interaction technique also can be used in learning. Bravo et al. [9] propose a system which is using ubiquitous computing technology. In this paper, authors use passive-RFID reader and tags to let user interact with computer. They also design two user interfaces for both teacher and students.

3. System architecture and Experiment process

3.1. System architecture

Due to the signals will easy effect by humidity, obstructing problems and noise created by air, we gather the statistics from variance of signals and RSSI values to determine whether the tag is moving or not. The proposed system will record every signal during each time slot. After that, all of signals will be categorized according to those computed statistics. Hence, the proposed system is not easy effect by surrounding environment. The identification rate more precise, the output music plays smoother.

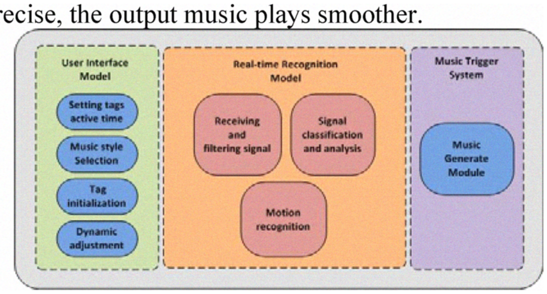

Figure 2. Work flow of RFID system.

3.1.1. User Interface Model

According to the proposed system is used as a human computer interface based on RFID techniques, so how to let user easy to use is the most important part during the implement process. Figure 2 shows all of components included in our proposed system. We provide four functionalities for user to tuning our system in different environment:

1. Setting tags active time.
2. Music style selection.
3. Tag initialization.
4. Dynamic adjustment.

3.1.2. Real-time Recognition Model

This part is not only the core of our propose system but also a most complicate module. The real-time recognition model consist three major parts:

1. Receiving and filtering signal: this functionality is used to receive signal and filter out the noise create by surrounding environment. For implementing this part, we modified the API which is provided by factory owner and make it more compatible for different kinds of environment.
2. Signal identification and analysis: This functionality is used to identify the useful information from all of received signals. We will classify received signals according to the active range of each reader.
3. Motion recognition: Since the useful information is identified in previous step, we can use those obtained information to recognize user's posture and trigger the player.

3.1.3. Music Trigger System

For playing different music simultaneously and reducing the computation cost of system, we use DirectSound proposed by Microsoft as base unit to build up our music trigger system. Table 1 shows the compatibility of DirectSound.

Table 1. Wave format

File format	File Size	Number of sound track	Sample frequency
WAV	8bit	Single channel and Signal track	8KHz 、11KHz
	16bit	Double channel and Stereo sound	22KHz 、44KHz

3.2. Experiment process

The proposed system use active-RFID devices as input to let user command the computer. User can control computer by acting some pre-defined posture. Figure 3 shows the flow chart of our system. There are several functionalities consist our system and described as follows.

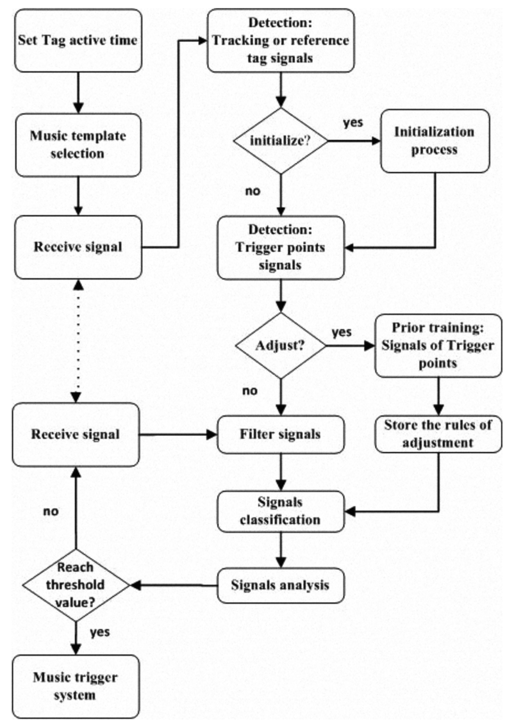

Figure 3. Flow chart of the proposed Music trigger system.

3.2.1. Initialization

Before user use our system to direct the computer play music, user have to trigger the initialize button for initializing our system. In this stage, the system will analyze twenty to thirty signals to get the maximum and minimum strength value of each tag. This step will raise up the identification rate.

3.2.2. Data collecting and integration

Due to the signals sent by RFID tags are easy effect by surrounding environment, all of received signals in a time slot must be recorded and identified. Since the useful information is identified, we will collect them into a reference point set to help the system to decide if the music can be played or not. Those reference points also can be viewed as interaction trigger points.

I. Trigger point design

Table 2 shows an example of trigger point design. We put the reader on the table and the distance between user and reader is 40cm. The frequency of tag is 0.6 sec. User hold only a tag and acts the pre-defined posture.

Table 2. An example of trigger point design.

Trigger points	Description of action	RSSI Range(0-255)	Sample signal
Ref. point-1	Tag is held at right-hand side. User's right hand needs is at front of neck and unbends toward right.	130－140	100
Ref. point-2	User swings their right hand to the top of reader.	150－160	100

II. Design of adding reference tag to the trigger point

Because of the number of human postures will be limited by the number of tags used in our system, so we add a reference tag to let the system receive more signals and identify more postures. Table 3 shows the definition of trigger point which added a reference tag. All of settings are same as previous design.

Table 3. The definition of trigger point-adding reference tag.

Trigger points	Description of action	SSI(0-255)	Sample signal
Ref. point-1	Tag_A is held at right-hand side. User's right hand needs is at front of neck and unbends toward right.	Tag_A ： ： 140-150	100
	User held Tag_B at left hand side and swing to the top of reader.	Tag_B ： ： 160-170	
Ref. point-2	Right hand swing back to the top of reader.	Tag_A ： ： 160-170	100
	Left hand held Tag_B and unbend toward left.	Tag_B ： ： 140-150	
Ref. point-3	Right hand held Tag_A and unbend toward right.	Tag_A ： ： 130-140	100
	Left hand held tide Tag_B and stop at point-2.	Tag_B ： ： 90-110	

4. Experimental results

In this section, we provide two experimental results for two different experiments: without and with prior training.

4.1. Analysis of only using tracking tag without prior training

In this experiment, all of settings, environments and used device are same as mentioned in section 3.2.2. The proposed system will average the strength of received signals (about four signals) every three seconds. The total number of signals is 100 times. As shown in figure 4, the identification rate (accuracy) at Ref. point-1 is 0.08. The miss detection rate (error) is 0.2. The field of exception means that the system cannot determine out the human action. As you can see, the system cannot identify human action correctly without prior training.

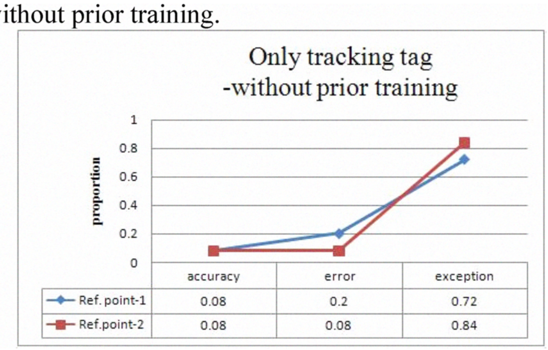

Figure 4. Using single tag and without prior training.

Figure 5 shows the another analysis which at the situation of adding a reference tag but still without prior training.

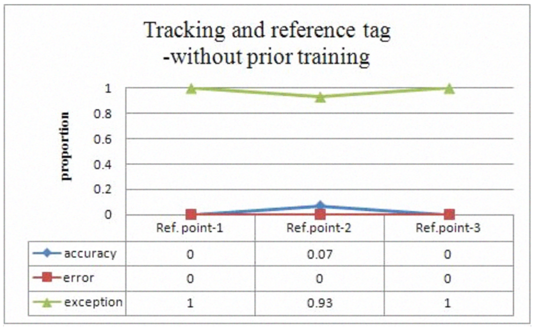

Figure 5. Adding reference tag but without prior training.

4.2. Analysis of experiments with prior training : using adjustment rules.

Figure 4 and 5 show that the system is unstable because the user did not trigger the initial button to training our system. Even though the received signals are the same, the proposed system still cannot recognize human actions. Hence, in this paper, a pre-processing step is adopted in our system to improve the accuracy in identification process.

Figure 6 and 7 shows the results after we adopt some adjustment rules in pre-processing step. They are quite different with Figure 4 and 5. The identification rate is improved and the exception rate is reduced.

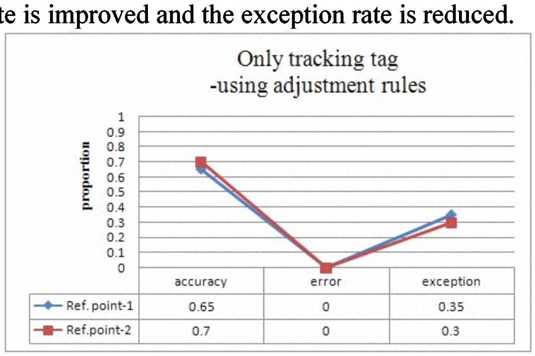

Figure 6. Using single tag and adjustment rules

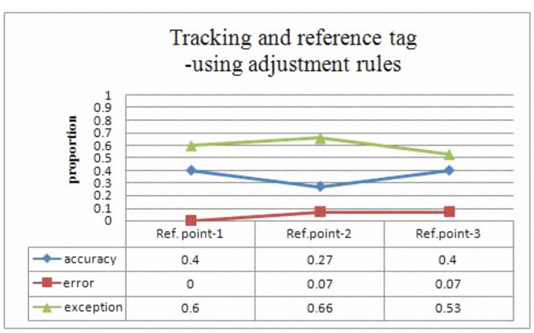

Figure 7. Add reference tag and both with adjustment rules.

5. Conclusion

In this paper, we propose a new system which is based on RFID techniques and conform to the main concept of human computer interaction. Designing and adding a pre-processing mechanism before user interacts with computer can increase the correct rate of trigger events and reduce the incidents of wrong identification. In the future, we will try to build an environment that utilizes more readers or tags enhance the lack of the number of interaction and improve our user interface.

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