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Multi-Touch Table With Rfid Technology For Hotels

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ABSTRACT

With the introduction of multi-touch, a new form of human computer interaction is introduced. Due to recent innovations multi-touch technology has become affordable. Unlike interaction on a desktop computer multi-touch allows multiple users to interact with the same device at the same time. To demonstrate the vast possibilities of multi-touch technologies an '*interactive RFID-based Multi-touch Device*' can be constructed which can be utilised in a hotel. The objective of the project is to enhance the customer's dining experience and to provide an enjoyable and user friendly interface thereby reducing human effort and time. The multi-touch table constructed is a camera based multi-touch device which is designed using front-side illumination technique. Card associated with a RFID tag will be used, priced to a specific amount which is issued to the customer at the reception desk. Each order table at the restaurant will have a multi-touch device along with the RFID reader. Customer can now interact with the multi-touch device by showing his RFID card and place an order by selecting from the menu displayed on the order table. This project proposes the methodology of designing an interactive system along with applications to verify the effectiveness of the same.

Keywords - multi-touch, RFID, interactive, front-side illumination

1. INTRODUCTION

Multi-touch (or multitouch) denotes a set of interaction techniques which allow computer users to control graphical applications with several fingers. Multi-touch consists of a touch screen (screen, table, wall, etc.) or touchpad, as well as software that recognizes multiple simultaneous touch points, as opposed to the standard touch screen (e.g. computer touchpad, ATM), which recognizes only one touch point. This effect is achieved through a variety of means, including but not limited to: heat, finger pressure, high capture rate cameras, infrared light, optic capture, tuned electromagnetic induction, ultrasonic receivers,transducer microphones,laser rangefinders, and shadow capture. Multi-touch displays are interactive graphics devices that combine camera and tactile technologies for direct on-screen manipulation. Multi-touch technology is not entirely new, since the 1970s it has been available in different forms. Due to the improvement of processing power of modern desktop computers, it no longer requires expensive equipment. Modern computer interaction consists of a monitor, keyboard and a mouse. Limited by the operating system, it allows us only to control a single pointer on the screen. With multi-touch, multiple input pointers are introduced to the system which all can be controlled independently. Depending on the size of the display multi-touch allows multiple persons to interact with the same display at the same time.

Radio-frequency identification (RFID) is the use of a wireless non-contact system that uses radio-frequency electromagnetic fields to transfer data from a tag attached to an object, for the purposes of automatic identification and tracking. It has been extensively applied to various fields such as product surveillance, supply chain, automobile parts tracking and telemedicine. A RFID system is composed of three major components, including reader, tag and middleware. Unlike traditional bar-code system, RFID systems can carry dynamic as well as static data. Some tags require no battery and are powered and read at short ranges via magnetic fields (electromagnetic induction). Others use a local power source and emit radio waves (electromagnetic radiation at radio frequencies).Tag contains electronically stored information which may be read from up to several meters away. Unlike a bar code, the tag does not need to be within line of sight of the reader and may be embedded in the tracked object.

The project will consist of a *multi-touch table* containing **a** *RFID reader*. A card associated with a *RFID tag* will be used. Two computer systems will be required, one to be used as a client and other one as server. Network connectivity needs to be established between the reception desk, multi-touch table or order table and chef desk. This whole setup can be utilised in a hotel/restaurant. A customer can buy a card (with the RFID tag) priced to a specific amount which he thinks is required or necessary for future transactions. Each table in a restaurant will have a multi-touch device along with the RFID reader . Customer will show the card on this device and his details will be displayed along with the menu card on the table. He can then place the order according to the balance left in his card. This order will be sent to the chef's system. A database will be needed for this purpose. Using queries the chef will be able to identify the table from which the request has been made and confirm the order.

2. System Overview

In this section, we will overview the proposed rfid-based multi-touch interactive system from two different angles. Figure 1 shows the structure of the proposed rfid based interactive display system. One is the hardware configuration that contains two main components, RFID reader and multi-touch table. The rfid reader is user to identify the user or customer which uses the rfid tag and the multi-touch table is an interface for user to operate the proposed interactive display system. The other part is from software viewpoint where the client and server are connected in an *ad-hoc network* and applications are run on both sides along with the blob tracker for multi-touch.

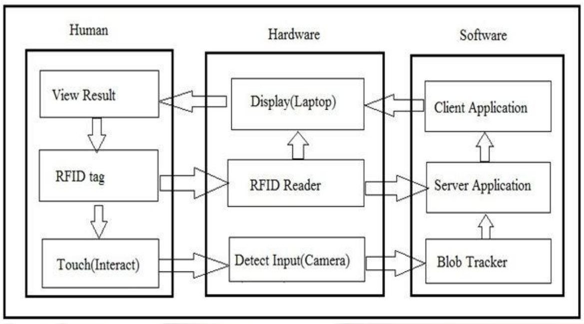

Fig. 1 A graphical overview of RFID-based multi-touch interaction pipeline

Figure 2 shows the flowchart of the rfid-based interactive multi-touch system. The receptionist at the reception desk will login into the system by entering the appropriate username and password. The customer arriving at the Reception Desk has two options: New Registration, for a new customer or Recharge for an existing customer. Accordingly details like first name, last name, email id, mobile no, amount and the rfid tag unique identification number for the customer will be added or updated in the existing database of the hotel. Now the customer is ready to place an order at the restaurant. The rfid reader is connected to the system available at the customer side which is also in conjunction with the multi-touch table. At the same time connection needs to be established between the customer table and the chef system using adhoc(computer-to–computer) network by manually configuring the IP addresses of both the systems. The customer will show his rfid card issued to him before at the reception to the rfid reader at the restaurant table. As soon as she shows the card, user details will be displayed including the amount present in his account along with the menu card. Now the customer will place the order by selecting different options available on the menu using the multi-touch table according to the amount available in his account. As soon as he places the order, the ordered amount will be deducted from customer's account updating the database and timer will start showing the estimated time required for the service to be processed. The customer's request will be sent to chef system. After receiving the order, estimated time required for processing the request (preparing the order) will be sent to the customer table by the chef.

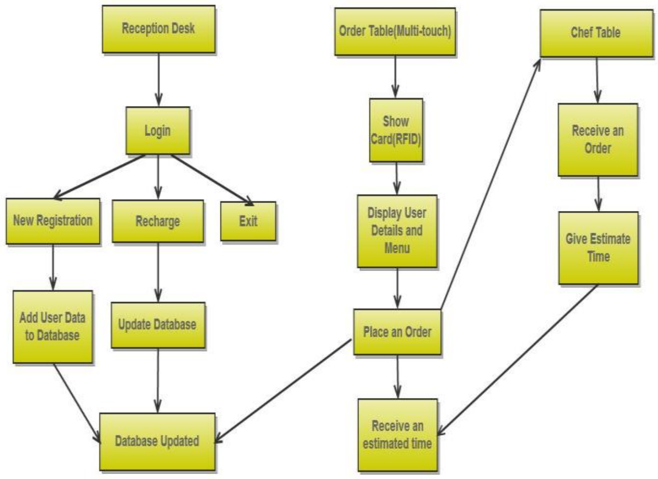

Fig. 2 A flowchart of the proposed interactive RFID-based multi-touch device.

3. Hardware and Software Configuration

This project aims at developing the rfid based multi-touch interactive system which combines display technology with sensors which are capable of tracking multiple points of input. The idea is that this would allow users to interact with the computer in a natural way .Using this display more than one user can interact with the system simultaneously.

Hardware and software specifications for this project are as follows:-

Hardware Requirements:-

- Web Camera of minimum resolution 640 X 480
- Acrylic sheet or glass(thickness ~6-10 mm)
- Two computer systems with minimum of 1 GB RAM.
- Light source for increasing light intensity when ambient light is not sufficient and to overcome shadow problem.
- RFID-Reader module with RS232 output.
- RFID tag/cards.
- USB to serial adapter.
- A display projector (if needed).

Software Specifications:-

- Touchlib, free open source multi-touch framework libraries like CONFIG.BAT, GATEWAY.BAT AND SERVER.BAT are required for configuring this multi-touch device.
- VISUAL BASIC-6.0 and Video Ocx Tools have been used in application development for the multi-touch device.
- Hyper terminal to test connection with rfid reader.
- Client and server side applications using VB6.0 for reception, table and chef desk.
- Windows socket programming used for both client and server side applications.

3.1 Design considerations of the rfid-based multi-touch device.

There are various techniques available for the construction of the multi-touch device. But from the starting of this project, my prime area of consideration was the camera based multi-touch techniques. The camera based multi-touch techniques have been widely utilized in various multi-touch devices. Microsoft Surface which released previously and created a lot of fuss was based on a camera based multi-touch technique (precisely saying rear-side illumination technique).Front-side illumination technique is camera based multi-touch technique but because of its impreciseness and low reliability, its potential has not been fully utilized. In my project I have used front-side illumination technique only but with certain modifications so as to increase the reliability and preciseness of the technique. Before designing a multi-touch device one has to consider various factors such as the environment in which the device would be used, the target audience, the cost which would be involved in the construction of the device, etc. The following considerations were kept in mind while making the device: There may be a case when the surrounding light may not seem sufficient. To tackle that case an array small bulbs are put on the boundary of the touch sensitive surface. The cost of construction of the device needed to be kept low; hence I decided not to use the projector. Instead the camera inputs are directly supplied to the computer.

Fig. 3 Multi-touch table outside and inside view.

3.1.1 Camera-based multi-touch techniques

Camera based multi-touch devices share the same concept of processing and filtering captured images on patterns. The pipeline begins when the user views the scene on the panel and decides to interact. To interact with the device, the user touches the device panel. On the hardware level the camera registers touch. Because the captured frame might not only include the contact points but also a (static) background, it is required to perform image processing on each captured frame. The captured frame is converted to a gray scale image and the static background is removed by subtracting the current frame with a reference frame. As a result the frame only shows white contours (blobs) which are the points of contact. By tracking these blobs the system becomes capable of sensing touch. In order to track the blobs, the positions are transmitted to the blob tracker which matches blobs from earlier frames with the current frame.After processing, events will be triggered which can be used in a multi-touch capable application. The application modifies objects in the current scene according to the new blob positions. The result is returned to the user through the display. The performance of a camera based multi-touch device depends on the used hardware and software. When a user touches a multi-touch device, it expects the device to respond directly. The responsiveness of the device depends on the time it needs to process the user's input and present the users a result through the display. In the interaction pipeline two levels are important, the hardware and the software level. Using a camera which is capable of 30 frames per second allows smooth interaction with the system. However, this requires a system that can handle image processing and blob tracking in 1/30 of a second. A combination of smart algorithms implemented in software and fast hardware helps to minimize the latency and increase the responsiveness of the device.

3.1.1.1 Front-side illumination technique

A technique for designing a touch interface, based on diffused illumination is known as Front-side Illumination (FI). This technique is based on light being diffused. However instead of using infrared light sources, it depends on the ambient light from the environment. With FI the diffuser is attached to the front side of the display. The ambient light illuminates the diffuser, which from the camera's point of view, results in an evenly colored rectangle. By touching the surface, shadows will appear underneath the fingertips because the ambient light cannot reach it. These points are detected by the camera and a touch is registered. Figure 4. shows a basic setup for FI. Because the used touch library requires touched spots to be colored white, a simple invert filter is being applied. FI can be seen as the cheapest way of creating a camera based multi-touch capable device.

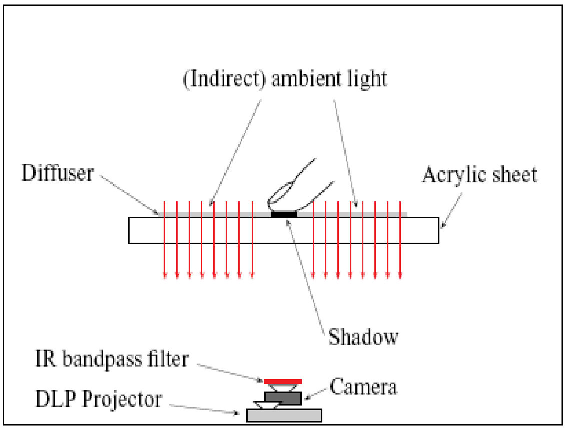

Fig. 4 Schematic view of the multi-touch panel using front side illumination

3.1.2 Choosing an appropriate camera device

When choosing a camera it is recommended to find out which sensor is used and whether the data sheets are available for this sensor. Whilst high-end consumer USB cameras are capable of transmitting images of VGA resolution (640X480 pixels) at reasonable frame rates, they often introduce latency. Because this reduces the responsiveness of the multi-touch devices, it is recommended to use a FireWire based camera instead. Depending on the size of the display and the projected image it is recommended to use at least a camera running a VGA resolution because of precision. The frame rate should be at least 30 frames per second to allow smooth interaction.

3.2 Multi-touch detection and processing.

To perform camera based multi-touch detection and processing several frameworks are available. In this paper we describe the used multi-touch framework, how a multi-touch framework connects to a multi-touch application and the different types of gestures.

3.2.1 TouchLib

Our multi-touch system uses Touchlib which is a free open source cross platform multi-touch framework which provides video processing and blob tracking for multi-touch devices based on FTIR and DI. Video processing in Touchlib is done through the Intel's OpenCV graphics library. Touchlib currently runs on MS Windows, Linux and Mac OS X. When Touchlib is used for the first time (in an application) it stores a copy of the current frame into the memory. This frame is used as a reference frame and used to perform background subtraction on the next frames. Front-side illumination requires more video processing filters before blob tracking can be applied. First a capture filter is selected depending on the used interface (USB or Firewire). If the system uses FI it is required to add an invert filter because Touchlib expects white colored blobs. The next filter is the background subtraction filter. After removing the (static) background a highpass filter is applied. This filter compares the contrast in the image and only allows `high' values to pass through (depending on a pre-set value). As a result only the touched spots will be visible. Depending on the used diffuser and infrared LEDs the result might show weak blobs, in this case we can add a scaler filter to amplify the brightness of the blobs. Finally, the rectify filter is applied resulting in clear blobs ready for tracking. It is used to filter out noise and reduce the gray scale image to a black and white image only displaying the actually touched areas.

An example of the Touchlib image processing results can be found in Figure 5.

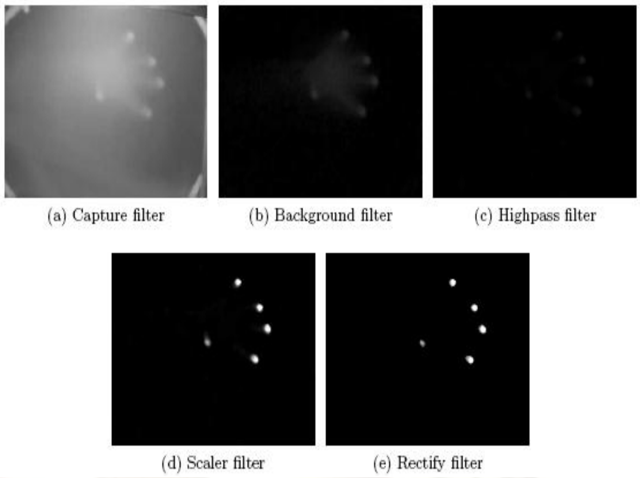

Fig. 5. Example of Touchlib filter chain using front side illumination

3.2.2 Blob detection and tracking

In Touchlib the blob tracker handles the blob detection and tracking. Blob detection is done to detect touch in a camera image. In order to follow the movement of touch, the blob tracker compares the detected touch locations in a frame with the positions of the previous frame. In each time step, Touchlib requests a frame from the video camera. After a frame has been processed, the resulting image is used to perform blob tracking. By using the OpenCV function cvFindContours() we obtain a list of contours found in the current frame. All found contours (and their properties) are stored in a contours list. Each contour is checked on whether it is a fiducial marker or a touch. On each contour Touchlib tries to fit a polygon which matches the outlines of the contour. If the fitted polygon is build out of four points (we are talking here of square fiducial marker) it might be a possible fiducial marker. Next it will check whether the angle of all the corners matches approximately 90 degrees. If the result is true, the contour is considered a fiducial and the position (center) will be calculated. It will also assign a unique tag identifier based on the pattern found within the square. If the polygon is more complex than four points, it is assumed to be a touch. Touchlib will fit an ellipse on the contour. The properties of the ellipse are used to determine the position, orientation and the size of a blob. If the size of the blob fits the minimum and maximum requirements on height and width, the blob will be added to the blob list.

In order to track blobs it is required to have at least two data sets that contain blobs in different states. We first define the two data sets.

The first data set contains the blob list from a previous frame and is defined as follows:

$p_1; p_2; p_3; \ldots\ldots\ldots\ldots\ldots; p_n$

where n is the number of active blobs in the previous frame. The second set contains the blobs list of the current frame and is defined as follows:

$c_1; c_2; c_3; \ldots\ldots\ldots\ldots\ldots\ldots; c_m$

where m is the number of active blobs in the current frame.

After each frame, the data from set p is replaced by set c. Set c will be filled with the new blob list.

3.2.3 Generating events

In the last part of the blob tracking, Touchlib prepares the events to be triggered. First Touchlib walks through the list of currently active blobs. If a blob is new in the current frame (it did not match with a blob in the previous frame) it will contain an ID with the value -1. In that case a new ID will be generated and assigned. After the assignment a "touch event" of the blob will be dispatched. If a blob in the current frame matches a blob of the previous frame, it will use the same identifier of the previous frame. Depending on the amount of movement an update event will be dispatched. If the delta of movement is higher than the set value of distanceThreshold it means the blob 'traveled' over a larger distance than one would assume to be correct. In this case instead of an update event a "touch event" is dispatched instead. If the delta of movement from the current and the previous frame is below the value of minimumDisplacementThreshold, no update event will occur. After Touchlib processed the list of currently active blobs, it compares the list with the blob list of the previous frame. If a blob was active in the previous frame but has not been found in the current frame, the blob is marked for deletion and a "touch up event" will be dispatched.

3.2.3 Programming Language Interfaces

The client side or reception desk module will consist of programs and algorithms which are written in accordance with communication performed over a ad-hoc network. The serial communication ports will be able to transfer and receive the data via the RFID reader and the same informed can be sent via the network to the server side or the chef system using windows socket programming. The coding parts are written in Visual Basic 6.0 which creates several forms or applications to be used by the interactive system and are implemented in conjunction with the Touchlib software designed for the multi-touch table. The three modules for the reception desk, multi-touch table ,chef table are integrated using the algorithms specially designed for this purpose and various forms which demonstrate the use of such an application is shown in the project. Figure 6 shows the various modules developed for RFID integrated multi-touch device.

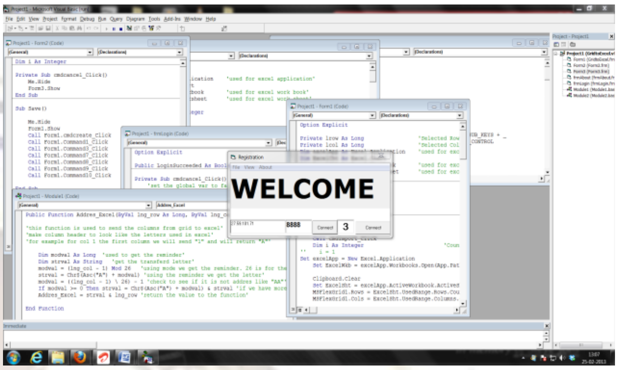

Figure 6(a) Reception desk module.

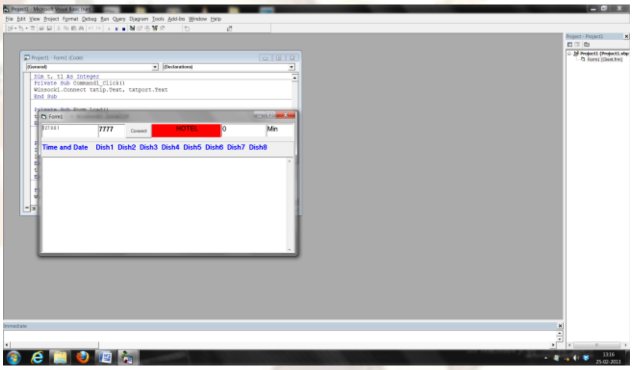

Figure 6(b) Chef desk module.

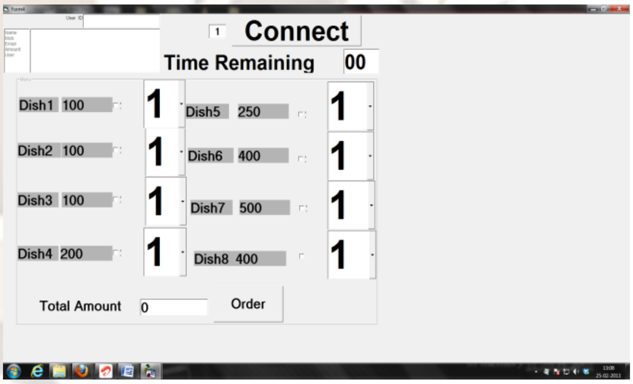

Figure 6(c) Order table module.

3.3 RFID Reader/RFID tag

An RFID system consists of a tag reader (also called the interrogator) and a tag. All communication between the tag and reader occurs completely through a wireless link that is sometimes called an air interface. Through a sequence of commands sent and received between both devices (called the inventory round), an RFID reader can identify the electronic product code (EPC) of an

RFID tag. For passive tags, the basic idea is that the interrogator initiates an interrogation round with a query command. The query command essentially "wakes up" the tag, which responds with the appropriate information. Figure 7 shows a basic block diagram of the tag/reader system. Figure 8 shows the RFID reader with RS 232 port used in the project.

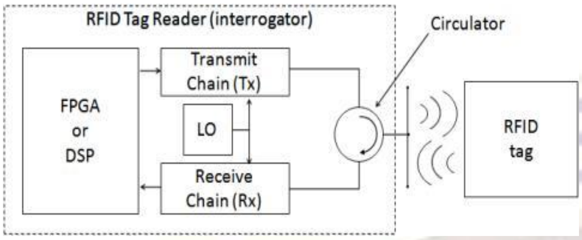

Fig. 7 Block diagram of typical RFID tag/reader system

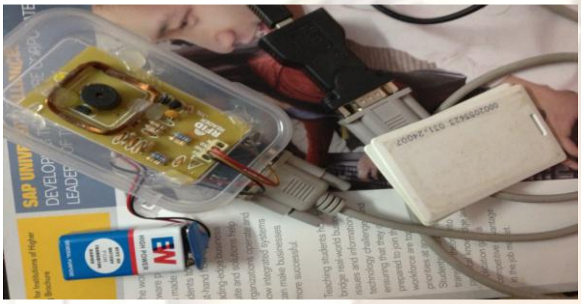

Fig. 8 RFID reader with RS 232 kit.

Note from Figure 7 that many RFID readers and measurement systems actually use a three-port RF component called a circulator that gives both transmit and receive front ends the ability to use the same antenna. Note that with many RFID, standards, timing information between transmit and receive commands is defined by strict guidelines. In fact, a sort of "handshaking" is required between the tag and reader to complete an interrogation round. This actually creates a unique test challenge because the instrumentation must be capable of the same behaviour. On an interrogator, an embedded processor is required to decode and generate commands within a tight timing interval. As discussed in a later section, this design is quite similar to field-programmable gate array (FPGA)-enabled RFID measurement systems, which use similar embedded processing to fully emulate either a tag or a reader. *RFID tags* come in many shapes and sizes each suited to a specific application, but all RFID tags can be generally grouped into two main categories, regardless if they are encased, a sticky label or just a solid button like tag .RFID tags are either "*passive*" (no battery) or "*active*" (self-powered by a battery). RFID tags also can be read-only (stored data can be read but not changed), read/write (stored data can be altered or rewritten), or a combination, in which some data is permanently stored while other memory is left accessible for later encoding and updates. *Passive RFID Tags* have no internal power supply. An electrical current induced in the antenna by the incoming radio frequency signal provides just enough power for the integrated circuit (IC) in the RFID tag to power up and transmit a response. RFID tags communicate in various ways with the RFID reader. The aerial (antenna) has to be designed to both collect power from the incoming signal and also to transmit the outbound signal. Lack of an onboard power supply means that the passive RFID tag can be quite small: commercially available products exist that can be embedded under the skin.
In this project I will be using a *passive RFID tag*. These do not require batteries and have an unlimited life span. As we have already seen there are two important components of a RFID tag – A microchip and a coil (antenna). The antenna receives power and RF signals from the RFID reader and sends those signals to the chip. The chip receives those signals, computes them and sends back the data to RFID reader. We can figure out the precise working of a RFID tag through this diagram.

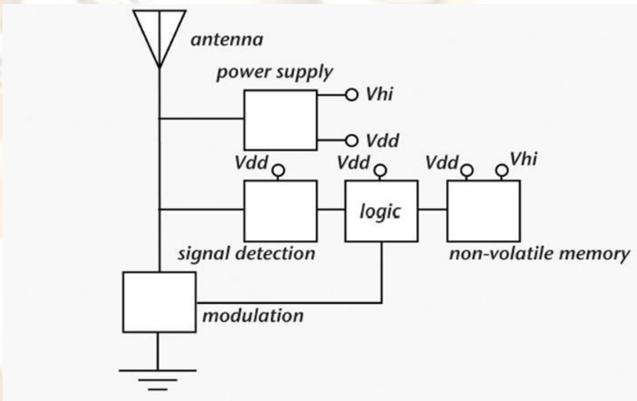

Fig. 6 Working of RFID tag.

To recognize the identity of an *RFID tag*, RFID reader sends radio signals which is captured by the coil (working as antenna) for the tag. The coil receives these signals as alternating current and passes to the chip. The chip extracts both the power and the information from this alternating current. By communicating with the non volatile memory of the chip that stores unique id as well as other information, it sends back the required signal to the antenna which is then transmitted to the RFID reader. There are three main roles a RFID reader plays other than signalling RFID tag to transmit desired information back to the RFID reader. Firstly, a RFID reader has the responsibility of keeping RFID tags powered up. Secondly, a RFID reader demodulates incoming signals from the RFID tag down. This process slows the incoming signals down enough so that the RFID reader is able to process the signals. Finally, after the incoming signals are slowed down, RFID then has the responsibility of decoding the incoming signals into the words people can interpret

4. CONCLUSIONS AND FUTURE WORK

A novel interactive system that integrates RFID and multi-touch technologies is proposed in this paper. Customers can now have a whole new experience by using the touch interface for ordering their food at restaurants and paying via the RFID card issued to them. With the construction of our own camera based multi-touch table we have demonstrated that multi-touch technology has become affordable. The precision, reliability and responsiveness of a multi-touch table depends on the used hardware. Because of the use of a camera based multi-touch technology, ambient light has a large influence in the tracking performance. Compared to desktop applications, users were able to manipulate objects in a natural way of touch. Instead of correcting the entire camera image, it is also possible to apply position correction on the output of the blob tracker. Currently image processing is done on the CPU. In order to reduce the load on the CPU it is possible to use graphics processing units (GPU) for image processing. The current blob tracker used in Touchlib is not scalable. Depending on the used hardware, Touchlib will fail to track fifty or more blobs in real-time. A smarter algorithm would not only take the distance into account but also the region and direction of a blob. It would also be interesting to use the GPU for blob tracking. Based on our own experiences the touch surface should be improved. The friction with the acrylic makes it hard to use the system for a longer period of time.

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[11] Configuration http://www.avitresearch.co.uk/USBTTL/hyperterminal.html
[12] http://www.tradeindia.com/fp641264/Rfid-Reader-Kit-Rs232-Interface.html RFID reader kit with RS 232 interface