Smart Cart
An Enhanced Shopping Experience

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Introduction

- The Smart Cart provides an efficient shopping checkout system cutting down waiting times at the counters.
- The system combines commonly available hardware to provide a cost effective solution for our sponsors Wal-Mart.
Features

- Compatibility with various barcode systems
- Real time weight monitoring to detect pre-payment theft
- Robust communication system between cart and store to detect non-payment theft
- PC/LCD Serial Interface
- Modular and expandable design
The Smart Cart
System Overview

- **Hardware**
  - Alarm buzzer circuitry
  - PC/LCD Interface
  - FlexiForce weight sensor circuitry
  - ZigBee wireless modules

- **Software**
  - Arduino control for barcode reading and matching
  - Arduino program for weight monitoring
  - Alarm triggers
Block Diagram

Power Supply (Batteries)

On-Cart Component
- FlexiForce Sensor
- Arduino UNO
- USB Host Shield
- Arduino ZigBee Shield With Module

In-Store Component
- Arduino ZigBee Shield With Module
- Alarm Buzzer
- Arduino UNO

Power Supply (Mains)

Barcode Scanner
Hardware Overview

- FlexiForce circuitry
  - Takes non linear sensor output and converts it to a linear input at the Arduino

- Alarm buzzer
  - Sets of an alarm upon receiving a defined signal from the Arduino

- ZigBee modules
  - Take certain data from the Arduino microcontroller serial output and communicate the data wirelessly
FlexiForce Sensor Circuitry

- FlexiForce Sensor
- LM324N Single Rail Op-Amp
- Sends output to Arduino
FlexiForce Sensor Circuit Schematic

\[ V_{OUT} = -V_T \times \left( \frac{R_F}{R_S} \right) \]
ZigBee (Xbee) Wireless Modules

- Takes serial output from Arduino
- Establishes serial wireless communication with second module
- Sends output to Arduino
ZigBee Module Schematic
Factors Affecting ZigBee Communication

- Background noise
- Other ZigBee networks
- Wi-Fi and Bluetooth
Antenna Comparison (Xbee)
Xbee Testing Results (Error)
Xbee Testing Results (Error-Free)
FlexiForce Sensor Operation

Graph showing the relationship between force (lbs) and resistance (K-Ohms) for a 100lb sensor. The graph indicates that as force increases, resistance decreases. The conductance, denoted as $1/R$, is also shown.

Another graph displays the voltage output ($V_{out}$) in volts versus force in pounds, showing a linear relationship.
Factors Affecting Sensor Sensitivity

- Conditioning
- Feedback resistor
- Object placement
Sensor Recommendations

- Condition sensor with 110% of rated weight
- Place sensor on flat surface
- Object must be on sensitive area
- Place object on a puck to concentrate weight
Why Condition the Sensor?

- Linearity errors
- Greater hysteresis
- Greater response time

<table>
<thead>
<tr>
<th>TYPICAL PERFORMANCE</th>
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<tbody>
<tr>
<td>Linearity Error</td>
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<tr>
<td>Repeatability</td>
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<td>Hysteresis</td>
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<td>Drift</td>
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<td>Response Time</td>
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Software Description

- Arduino Software
  - Barcode read
  - Product Info Retrieval
  - Weight monitoring
  - Xbee module control
  - Alarm triggers
Barcode Read

- Scanner connected to Arduino through USB host Shield
- USB host shield uses SPI interface which requires digital I/O pins 8, 10, 11, and 12 of Arduino
- Arduino receives data from the scanner through a UART serial communication port
- The UART transmits the bits in a sequential fashion
Product Info Retrieval

- Use SD card to store product database
- Store current barcode scanned on Arduino EEPROM
- Compare the scanned barcode with barcodes stored in the database
- If compare successful, display product’s attributes
Product Retrieval Output

$COM5$

13026229140709 ainitializing SD card...initialization done.
found
Name: Notebook
Price:$1.60
Weight Monitoring

- Theft detection Criteria: Weight on cart > Total Scanned Weight
- If unscanned product is placed on the cart, then the sensors detect a weight mismatch which sets off the buzzer
- The buzzer doesn’t stop until the weight discrepancy is fixed which requires scanning the product or removing it from the cart
void setup() {
    pinMode(4, OUTPUT); // set a pin for buzzer output
}

void loop() {
    buzz(4, 2500, 500); // buzz the buzzer on pin 4 at 2500Hz for 1000 milliseconds
    delay(1000); // wait a bit between buzzes
}

void buzz(int targetPin, long frequency, long length) {
    long delayValue = 1000000/frequency/2; // calculate the delay value between transitions
    long numCycles = frequency * length/ 1000; // calculate the number of cycles for proper timing

    for (long i=0; i < numCycles; i++) { // for the calculated length of time...
        digitalWrite(targetPin,HIGH); // write the buzzer pin high to push out the diaphragm
        delayMicroseconds(delayValue); // wait for the calculated delay value
        digitalWrite(targetPin,LOW); // write the buzzer pin low to pull back the diaphragm
        delayMicroseconds(delayValue); // wait again for the calculated delay value
    }
}
Alarm Buzzer Circuit

- Takes an input from Arduino
- Buzzer sets off upon input
- Noise determined by Resistor connected to the buzzer
- Higher resistance gives lesser noise but low resistance can damage buzzer due to high current
Alarm Buzzer Schematic
Future Hardware Developments

- Improved battery life
  - Lower power barcode scanner
  - Set up Xbee on lower power rating

- Alternative sensor
  - Find a sensor with fewer sensing restrictions
  - Better high frequency characteristics
Future Software Developments

- **Improved User Interface**
  - Responsive to user input
  - More than just a display

- **On cart payment Processing**
  - Possible smartphone application
  - If possible, a hardware solution
Challenges Faced

- Limited scope of Arduino
  - Lack of interfaces with various protocols
  - Integration made difficult
- FlexiForce sensor
  - Limited sensing area
  - Non-linear output
SWOT Analysis

- **Strengths**
  - Modular design, expandable
  - Cost effective
  - Real time

- **Weaknesses**
  - Difficult integration

- **Threats**
  - RFID tag systems
  - Smartphone applications

- **Opportunities**
  - Fast lane for checkouts
  - Smart Cart
Credits

- Professor P. Scott Carney
- Justine Fortier, our TA
- Google
Thank you

- Questions???