Automated Corn Quality Measurement Kit

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1 Introduction

This project is an interdisciplinary research collaboration between the Beckman Institute for Advanced Science and Technology and the Institute for the Prevention of Postharvest Loss in the College of Agricultural, Consumer and Environmental Sciences (ACES).

1.1 Statement of Purpose

The project involves the implementation of Information and Communication Technology to address the problem of food loss, vital for developing countries such as India and Brazil, due to inadequate grain storage and quality monitoring methods. With the proper resources, smallholder farmers in developing countries would be able to analytically show the quality their product, reducing loss and giving farmers the ability to adjust the price of the product based on its quality.

1.2 Objectives

A portable Grain Measurement Quality (GMQ) Kit would be developed to automatically collect and transmit testing data on corn quality. The only similar type of test kits are for rice and are manually conducted with the documentation of the results are handwritten. Our test kit would contain electronic sensor systems and methods equipped with data recording capabilities for measuring grain quality. It will also include documented specifications for conducting the tests that are easy to follow for farmers in developing countries. These test kits will enable field testing and automated transmission of the result data to a local university for tracking and analysis, making for a more efficient and reliable system.

The kit will be in the form of a briefcase-like carrying case. It will have a microcontroller and display to record show the test data. There will be two distinct sections of the kit; the first will be used for temperature, humidity, and impurity measurements. The sample of appx. 100 kernels will be poured into this section where they will pass through layered sieves. A scale will be at the bottom of the layered sieves, and the data will be recorded by the microcontroller via a wired connection. The sieves will then be removed by the user and new data points will be recorded to show the impurity percentage by weight of the sample. A temperature and humidity sensors in the center of the kernels will allow us to acquire the temperature and humidity of the corn as well as determine the equilibrium moisture content (EMC). The second section will be adjacent to the first and focus on corn color. An RGB color sensor connected to the tablet will be used to acquire the color of an individual kernel placed on the covered sensor. All the data recorded will be compared to quality standards (provided by an agriculture professor on the project) and the results given back to the user on the display as well as sent wirelessly to the farmers portal via GSM.

1.3 Benefits to the End User

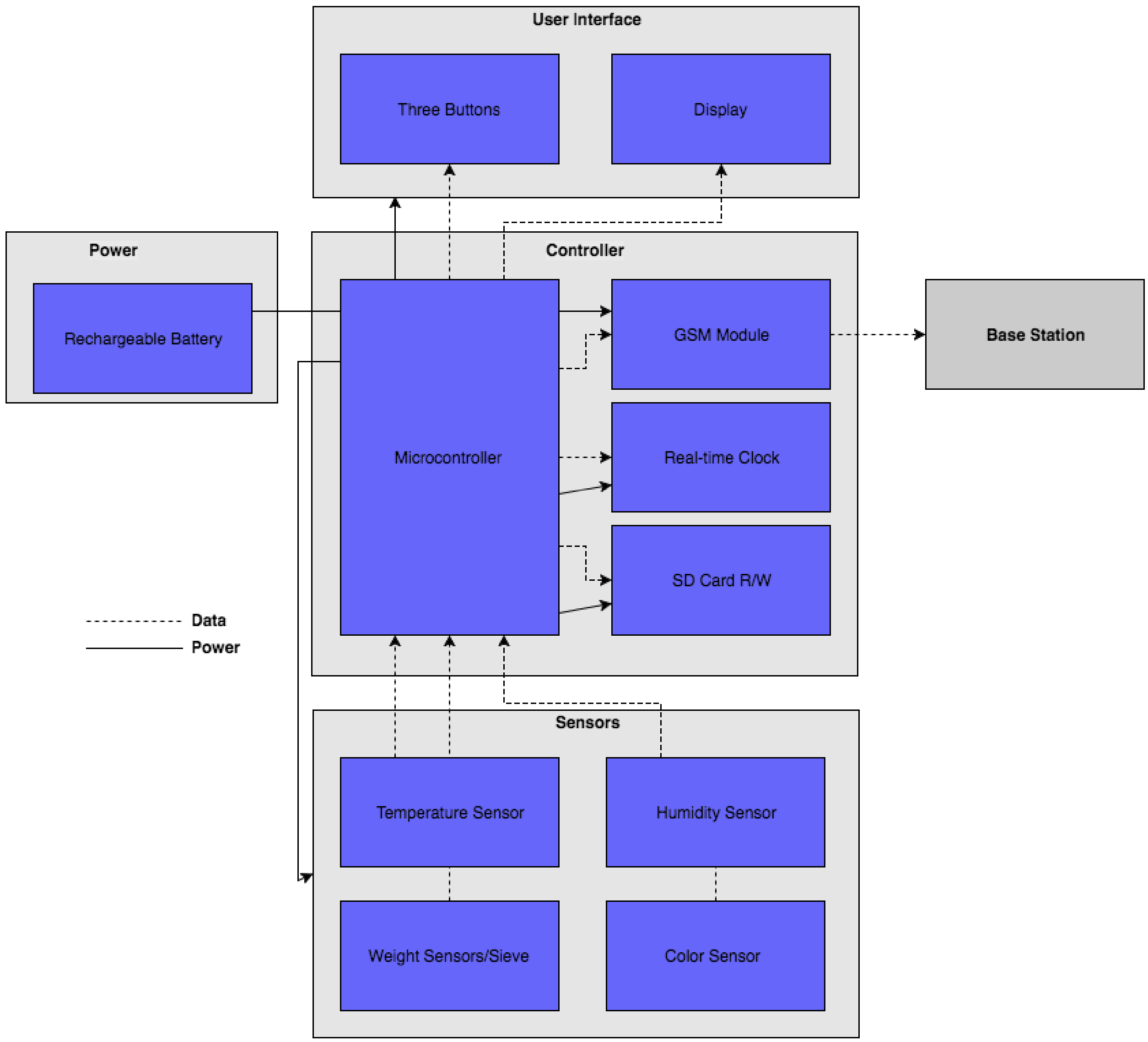
- Provide a simple, reliable, cost-effective way to analytically measure the product
- Support increased revenue in correspondence with grain quality standards
- Increased efficiency due to automated and electronic methods of assessment
- Provide the means to store and display data to the user and send to local teams for feedback

1.4 Product Features

- Accurate measurements for corn humidity, temperature, impurity of sample of 100 kernels, and color
- Automatically record and store data on the device
- Wirelessly transmit data using GSM
- Battery powered, rechargeable
- Durable waterproof case
- Design of kit allows for ability to include implementation of other quality measurements

2 Design

2.1 Block Diagram



2.2 Block Descriptions

Power::Rechargeable Battery

- Battery that can be charged from a gas generator/solar panels via USB
- Must output 9V @ 2A to power the controller
- Will be hidden under foam covering in test kit

User Interface::Three Buttons

- Three button interface: Next, Previous, Cancel
- Buttons will be connected to microcontroller I/O pins and output of pins will be shown on attached display

User Interface::Display

- Color display that will output instructions using pictures and basic English
- Display will connect to IO Pins on microcontroller

Controller::Microcontroller

- Takes in power from rechargeable battery
- Collects data from sensors
- Gets time from RTC Module
- Saves and stores test using SD Card Module
- Wirelessly transmits data using GSM Module
- Takes input from buttons
- Outputs results to display

Controller::GSM Module

- Connects to microcontroller IO pins
- Transmits data to university's farmer web portal via GSM wireless

Controller::Real Time Clock Module

- Keeps current time when not connected to GSM or the device is off

Controller::SD Card Reader

- Used to store recent test results for the case when the kit is unable to send them wirelessly

Sensor::Temperature

- Temperature sensor reads data from corn sample
- Measure and record 1 temperature data point over a span of 2 seconds upon command

Sensor::Humidity

- Humidity sensor reads data from corn sample
- Measure and record 1 humidity data point over a span of 2 seconds upon command

Sensor::Weight Sensor/Sieve

- A pressure sensor placed underneath the corn sample would calculate the weight
- Sieve separates corn from impurities/other

Sensor::Black box/color sensor

- Color sensor wrapped in closed black box for accurate measurements

3 Requirements and Verification

Power Supply	
Requirement	Verification
1. Battery must be rechargeable in end-user environment	1. Simulate test-environment of end-user by charging the device using a sample solar cell from the research group.
2. Battery must supply 9V @ 2A to microcontroller	2. Use multimeter to test actual current operation within 2.5% of desired operating point 3. Battery has output connector that has a male micro-usb end

Interface::Buttons Module	
Requirement	Verification
1. Button press must output logical high to microcontroller 90% of the time	1. After 100 samples, pressing down on button must output an acceptable current to microcontroller 90 times
2. No button press must output logical low 90% of the time	2. After 1 hour on standby, button must not send a logical high value to the microcontroller for longer than a total of 6 minutes
3. Three individual buttons corresponding to: Next, Previous, and Cancel Entry	3. Buttons must be connected to individual data pins on microcontroller and individual button presses must light its own individual LED for testing
4. Only one button input can be processed at a time	4. If two buttons are pressed within 1 ms of each other, neither output will be registered/no LED will light

Interface::Display	
Requirement	Verification
1. Display must respond to valid button input within 1 second of press	1. After 100 samples, pressing down on button must output an acceptable current to microcontroller 90 times

2. UI must accurately display actions to accurate measure grain samples, >80% success rate	2. Give system to 5 subjects, if 4 subjects can properly use kit, device works

Controller::Microcontroller	
Requirement	Verification
1. Must process incoming data from only one sensor/module at a time	1. Initialize and interact with two sensors commanded in a small time frame (e.g. temperature and impurity, <2 seconds). Check all combinations of sensors/modules and time restraints for each, record and restrict user.
2. UI must accurately display actions to accurately measure grain samples, >80% success rate	2. Give system to 5 subjects, if 4 subjects can properly use kit, device works.

Controller::GSM Module	
Requirement	Verification
1. Send out post data with >90% delivery	1. Test over multiple trials, record results.

Controller::Real-time Clock	
Requirement	Verification
1. Must provide accurate time stamp to data entry	1. Check sd card data structure for corresponding data entry, time entered must meet time of entry give or take 5 minutes 90% of the time

Controller::SD Card R/W	
Requirement	Verification
1. Must store program and data structures after/before sending out data to base station	1. Check sd card data structure for corresponding data entry, entries must be valid within 10% of recorded measurement 90% of the time after 25 samples 2. Will take measurement by hand to validate accuracy of stored data

Temperature Measurement	
Requirement	Verification
1. Measure and record instantaneous temperature, expected range 50 to 110 degrees F	1. Determine if amplification is necessary by testing extremes of the sensor and comparing to expected temperature ranges.
2. Report to user with >90% accuracy	2. Use IR thermometer of known accuracy and compare its value to the sensor value over multiple trials.

Humidity Measurement	
Requirement	Verification
1. Measure and record relative humidity, expected range values TBD by ACES	1. Determine if amplification is necessary by testing extremes of the sensor and comparing to expected humidity ranges.
2. Average data and report to user with >90% accuracy	2. Use thermometer with humidity measurement capabilities (or similar) of known accuracy and compare its value to the sensor value over multiple trials.

Color Assessment	
Requirement	Verification
1. Measure and record 5 RGB values within 1 second upon command	1. View live data upon command in conjunction with the first ten stored data points.
2. Average data and report to user with >90% accuracy	2. Compare RGB values paint scale over multiple trials.

Impurity Measurement	
Requirement	Verification
1. Measure and record weight of kernels, unwanted material, and sieves upon command, expected weights TBD by ACES	1. View live data upon command in correspondence with visual text cues given to the user. Ensure proper timing and utilize messages to simplify the process for the user.

2. Report weight of impurities and kernels as total weight and percentages by weight with 1/10 g accuracy	2. Utilize analytical balance or scale or digital scale of known desired accuracy (1/10 or 1/100 g) and compare its weight of each part (sieves, impurities, kernels) of test samples to the values of the kit system.

4 Tolerance Analysis

Critical Component: Impurity Measurement System

Acceptable Tolerance: Current is limited to 1mA/cm^2 of applied force, or 31.54mA for the surface of the used pressure sensor. To meet this tolerance, a measuring resistance must be chosen. This measuring resistance is connected to ground, with the positive terminal of an op-amp connected between Rm and the FSR and the negative terminal connect to the op-amp output. Thus, Rm limits current and controls the voltage sensitivity according to VOUT = (V+) / [1 + RFSR/RM].

Test Procedure: Replicate the circuit shown in the FSR integration guide and use a digital multimeter to measure the current flowing into the FSR.

Presentation of Results: Results will be reported in the form of a table of data with annotations.

5 Cost and Schedule

5.1 Cost: Labor, Parts, Grand Total

The table below lists expected parts and labor costs for the kit.

Part	Description	Cost
Analog Temperature and Humidity Sensor	DHT22	$9.95
Analog Pressure Sensor	Square Force-Sensitive Resistor	$7.95
Color Sensor	RGB Color Sensor with IR filter	$7.95
Real Time Clock	Keeping time when off	$7.95
SD Card Reader	Reading/writing data to SD card	$7.50

SD Card	Storing test results	$9.95
Atmega328P Microcontroller	Microcontroller	$5.95
Display	2.8” TFT LCD	$39.95
GSM Module	Mini Cellular GSM	$39.95
GSM Sim Card	Used for testing	$9.99
Sieves	Sieves with openings large enough to separate corn (l = ½”) from impurities	$13.95
PCB Labor	Integrating all modules to connect with board	N/A
Internal Casing Labor	Shell to protect PCB/electronic components in house	N/A
External Case	Shell capable for rural transport	$30

5.2 Schedule

The schedule below goes through anticipated weekly goals for the project and what team member is primarily responsible for completing the given tasks. Meetings approximately every week will take place between the team and faculty from ACES and Beckman to monitor progression and direction of the project throughout the semester.

Focus	**Date**	**Member(s)**
Prepare Mock-Up	9/19	Joan Brown
Finalize measurement designs	9/19	Kevin Villanueva
Purchase necessary parts	9/20	Adam Long
Assemble Impurity Measurement system	9/25	Adam Long
Assemble Color Measurement system	9/29	Kevin Villanueva
Assemble Temperature/Humidity system	9/29	Joan Brown

Prepare Design Review	10/2	Joan Brown
Design GSM:Controller interface and driver	10/7	Adam Long
Design GSM:Base station interface and driver	10/7	Kevin Villanueva
Integrate design	10/7	Joan Brown
Design Internal Casing	10/14	Adam Long
Design PCB	10/14	Kevin Villanueva
Create temperature/humidity driver	10/14	Joan Brown
Create temperature/humidity driver	10/21	Joan Brown
Create Color Sensor Driver	10/21	Adam Long
Design PCB Part 2	10/21	Kevin Villanueva
PCB Take 2	10/26	Kevin Villanueva
Design GUI	10/26	Joan Brown
Design Display/button Driver	10/26	Adam Long
PCB Take 3	11/4	Kevin Villanueva
Design pressure sensor driver	11/4	Joan Brown
Finalize user interface	11/4	Adam Long
Integrate drivers	11/10	Adam long
Prepare Mock Demo	11/10	Kevin Villanueva
Start Mock Presentation	11/17	Joan Brown
Start Final Paper	11/17	Joan Brown
Integrate system/finalize demo	11/17	Adam Long
Finalize Demo	11/25	Adam Long

Continue Paper	11/25	Joan Brown
Finalize Mock Presentation	11/30	Kevin Villanueva
Continue Final Paper	11/30	Joan Brown
Continue Presentation	11/30	Adam Long
Finalize Presentation	12/4	Joan Brown
Finalize Paper	12/6	Kevin Villanueva