ECE 445

SENIOR DESIGN LABORATORY

PROJECT PROPOSAL

Automatic Cat Litter Box

Team 12
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Fall 2023
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Introduction

1.1 Problem

Modern automatic cat litter boxes automate waste removal but frequently neglect the crucial issue of odor control. Over time, as these systems accumulate waste, odors can intensify, causing discomfort for both cats and owners. Given cats' highly sensitive sense of smell, they detect these odors well before humans do. This oversight poses a challenge for maintaining a fresh and hygienic litter box environment, which can create an unpleasant living environment, pose health concerns, reduce usability and contribute to stress and anxiety.

Current automatic litter boxes also often lack the capability to track the duration and frequency of a cat's litter box usage. This information is crucial for monitoring the health of the cat. Changes in litter box behavior such as prolonged visits or increased frequency of use can indicate potential health concerns such as urinary tract infections or digestive issues. Without the ability to capture and analyze this data, cat owners miss out on valuable insights that could help them proactively address their pet's well-being.

1.2 Solution

The proposed solution centers around a cat litter box with a motorized raking mechanism for scooping.

Weight sensors will be positioned beneath the litter box. These sensors are responsible for initiating the motorized raking process upon detecting the entry and exit of the cat. Beyond triggering waste disposal, these sensors will also act as the means to monitor the cat. By continuously capturing data, they quantify the duration of each cat visit, the frequency of visits and the weight of the cat itself. This information will be communicated to the user through their phone.

Odor sensors will be placed within the hood of the litter box, designed to detect and monitor the buildup of odors in real-time. As the sensors detect increasing levels of ammonia and other odor-producing compounds, they will trigger an automated odor-neutralizing process. This proactive approach aims to tackle unpleasant odors as soon as they emerge, ensuring a fresh environment for the cats and allowing time for the owner to combat the odor once they receive the alert.

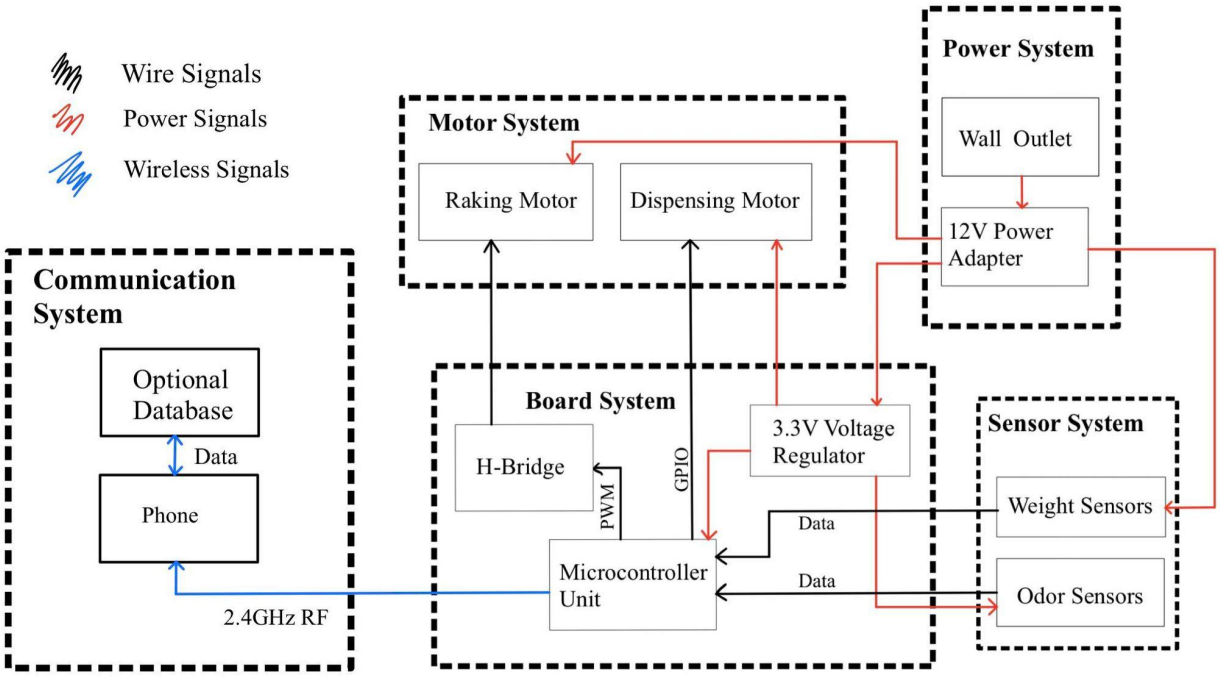
1.3 Visual Aid

1.4 High-level requirements list

- The litter box should accurately detect the cat's weight, frequency of use, and the duration with an accuracy of 70% or higher.
- The rake should be able to rake the majority of waste into the disposal area (>70%).
- The user should be notified in a timely manner, within 5 minutes of the designated time.

Design

2.1 Block Diagram



2.2 Subsystem Overview and Requirements

Board Subsystem:

This subsystem has an ESP32 microcontroller as the core, and any needed peripherals attached. It will be used for connecting and interfacing with the motors, sensors and the user.

- 2.4GHz Antenna to communicate with phone
- H-Bridge to properly control motor

Motor Subsystem:

This subsystem bridges the functionality of the code and data to the actual litter box. It is directly controlled by the MCU and is used for cleaning and odor repelling.

- Good frame/mounting for smooth raking
- Enough power to rake through any resistance of waste (~40W)

Sensor Subsystem:

This subsystem gives the MCU the signal to start any process to ensure a tidy litter box. It is also the sole provider of any information collected concerning the health of the cat and the state of the litter box. The weight sensors will need to be recalibrated after every visit from the cat to ensure the loss of litter will not affect the accuracy.

- Weight sensors can withstand weight of entire system (~50 Pounds)
- Odor sensors can detect and only detect compounds released from the cat waste and not other compounds in the air.

Communication Subsystem:

This subsystem allows for the notification to the user. It communicates and transmits data from the MCU to the phone, giving insight to anything the user may need to know.

- Has proper settings to allow wifi communication with the MCU

Power Subsystem:

The backbone to any electrical equipment. Takes incoming AC voltage and transforms it to DC voltage at different voltage levels, ensuring safe and stable power throughout the litter box for every component that needs power.

- Be able to output different voltages levels (3.3V, 5V, 12V)

2.4 Tolerance Analysis

The odor sensor's reliability is influenced by multiple factors. Commonly for an ammonia sensor, its manufacturer-rated accuracy is ±10ppm within a 0-100ppm range. Fluctuating humidity levels can compound this inconsistency, potentially introducing an additional deviation of up to ±25ppm. Furthermore, there's a natural degradation over its lifecycle, leading to a potential error of ±12ppm over a year. Collectively, when these potential errors are considered, the sensor's reading might exhibit a significant total deviation of up to ±47ppm under certain conditions.

To counter these challenges, regular calibration can be used to counteract both the sensor's inherent degradation and any external inconsistencies. Employing sensor redundancy, such as using multiple sensors and averaging their readings or maintaining a backup, can significantly improve measurement reliability. It's also beneficial to position the litter box in areas with stable humidity to reduce fluctuation-induced errors. We will implement these strategies for consistent and dependable performance.

2.5 Ethics and Safety

The project will be developed under the ACM Code of Ethics, upholding, privacy, transparency, accountability, and minimizing harm. The design will focus on the user and pet wellbeing to responsibly improve pet care.

Relevant standards like UL 60335-1, FCC RF guidelines, and CA Prop 65 will be followed to mitigate risks like electric shock, tip-over, pinching, and interference. Vetted components, housing design, fail-safes, and testing will ensure safety. We will consult experts and research existing products to ensure the design is safe for animals.