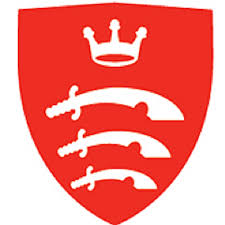
**Design report**



**University:** Middlesex University of Mauritius

**Module:** [PDE3413 Systems Engineering for Robotics](https://mdx.mrooms.net/login/index.php?saml=on)

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**Introduction**

The incorrect disposal of cigarette butts is a persistent concern in the field of environmental conservation, as it contributes significantly to pollution in both urban and natural ecosystems worldwide. Cigarette remnants continue to be one of the most common types of litter, despite growing public awareness of the harmful impacts of littering and the serious risks they pose to ecosystems and public health.

Since cellulose acetate and other non-biodegradable materials are the main components of cigarette filters, they take years to break down and frequently release toxic compounds into the soil and water systems. Cigarette butt litter is so commonplace that it has a negative influence on human health, marine life, and wildlife, underscoring the urgent need for efficient waste management solutions.

The discarding of cigarette butts also has serious impacts such as:

**\*Environmental pollution:** Cigarette butts are a common form of litter, and they pose a significant environmental hazard. They do not biodegrade quickly, and the toxic chemicals in cigarette filters can leach into the soil and water, harming ecosystems.

**\* Fire risk:** Discarded cigarette butts can pose a fire risk in dry or flammable areas.

**\*Aesthetic degradation:** Littered cigarette butts are unsightly and can negatively affect the aesthetics of public spaces.

**\*Increased cleaning cost:** governments spend significant resources on manual litter cleanup.

**Proposed Solution:**

The creation of a novel robotic device designed especially for gathering abandoned cigarette butts in public areas is the suggested remedy. By implementing an autonomous and effective collection system, this project seeks to address the ongoing problem of cigarette butt littering by using breakthroughs in robotics, artificial intelligence, and environmental conservation.

**Aim & Objectives**

**Aims:**

The proposed solution aims to use an autonomous robot that can travel through different terrains and public spaces on its own to gather hazardous waste products in order to address cigarette butt littering. The robot will distinguish cigarette butts from other trash items by using cutting-edge sensor technology and AI algorithms, guaranteeing accurate and focused collecting.

**\*Environmental aim:**

According to the American Burn Association, about 900 people in the United States die each year in fires started by cigarettes butts. Wildfires are often caused by cigarette butts too thus being a dangerous hazard and this project aims to minimize this danger.

**\*Public Health aim:**

Cigarette butts, especially in public spaces, can serve as a visual cue and influence young individuals to start smoking. Exposure to cigarette litter can normalize smoking behavior, which can contribute to youth initiation of smoking and its associated health risks.Reducing cigarette butt litter and discouraging smoking in public areas can have a positive impact on public health by decreasing exposure to toxic chemicals and creating cleaner, safer environments.

**Objectives:**

\* Construct a small, nimble robot that can go across a variety of settings and terrains to efficiently gather cigarette butts.

\*Use AI and sensors to give the robot the ability to distinguish cigarette butts from other waste products.

\* Create a strong collection system to collect and safely store cigarette butts inside the robot.

\* Integrate self-navigating technologies to move about and cover assigned regions more effectively.

\*Thorough testing and optimisation are necessary to guarantee the robot's dependability, robustness, and effectiveness in practical situations.

**Background research on existing solutions**

Different robots have been built over the years which relate to the theme of our project, such as Beachbot and Cigbot. Both robots reduce human labor through Automation. They also cover specific areas efficiently.

**Beachbot**

\***Description & features**

It has two cameras located at the front and rear. Under the robot, there are two arms that can pick up cigarette butts. The waste will be identified thanks to AI, and more precisely thanks to visual recognition and image detection algorithms.

\***strengths**

BeachBot has successfully picked 10 cigarette butts in 30 minutes in its first demo. It was successful because it uses AI that has been specifically developed to detect cigarette butts effectively.

\***Limitations**

Limited scalability in handling widespread littering.

Dependence on user compliance or human intervention.

Cannot operate in bad weather or when its raining as robot is not waterproof.

\***Improvements**

The beach bot could first make sure that the cigarette butt has stop burning before putting it in the internal bin as a fire could spread from there.

Advanced Sensor Technology: Developing sensors specifically tuned to detect and differentiate cigarette butts from other waste.

**CigBot**

\***Description & features**

Safely drive around the sidewalks in the city. Collect and dispose of the cigarette butts. Use a Raspberry Pi and a Pi Camera to take pictures of cigarettes, process the image, and then output coordinates of the location of the cigarette for the robot.

\***strengths**

The cigbot was successful as solid works were used to design the chassis, roller/sweeper-mechanism, and mounts for the camera of the robot. For the robot, VEX parts were used to assemble it. Also the mount was 3D-printed based on the solid works model.

\***Limitations**

The cigbot had a few limitations such as it cannot go on various terrains, though cigbot is made for the sidewalk, it may encounter rough terrain, A more powerful battery or motor could be an improvement.

Cannot operate in bad weather or when its raining as robot is not waterproof.

\***Improvements**

Robotic Precision: Designing robots with precise collection mechanisms and AI that specifically target and collect cigarette butts without missing them.

A waterproof casing for the whole electronic parts of the robot would be great against rain or water pools on the road.

An alarm system if the robot is robbed by someone as the electronic parts might be expensive.

These improvements could significantly elevate the efficacy of existing solutions and move closer toward mitigating the environmental hazards caused by cigarette butt littering.

**System proposal and concept behavior**

**Proposed solution**

This project aims to address the persistent issue of cigarette butt litter by providing a technological solution that complements existing waste management practices. Through the implementation of an autonomous robot, the objective is to significantly reduce the environmental impact caused by discarded cigarette butts.

This creative solution not only tackles the problem of cigarette butt litter, but it also fits in with larger initiatives to support environmentally friendly practices and responsible trash disposal especially at the beach.

Additionally, the design will concentrate on producing a small, nimble, and intuitive robot with the similar appearance of a crab outfitted with strong electronic devices for gathering/collecting and safely storing cigarette butts as the main zone of work for the robot is the beach. The robot's efficiency and coverage within the assigned collection zones will be improved by the integration of autonomous navigation technologies and cigarette butts detection will be implemented using AI.

**Key Features of Proposed System**

**Sensors and camera:** The sensors that will be used to build the robot include ultrasonic distance sensor which will be used to detect presence of obstacles in front of the robot. Infrared sensor will also be used to detect human presence and the robot will act accordingly (stops and wait for the human to be out of the infrared sensor range). The camera will use object and image detection software to identify cigarette butts in the environment.

**Collection system**: To collect and store cigarette butts, a gripper powered by servo motors in front of the robot will be used. After identification of cigarette butts the gripper will position itself at the top of the cigarette butt before moving downwards to collect it and dispose it in a container found below the robot’s core.

**Communication**: To interact with humans the robot shows its state that is the battery percentage and whether the storage container is full or not using LEDs as display.

**Mobility:** Since the robot will resemble a crab as its targeted zone is the beach, the robot will have four legs powered by servo motors to allow the robot to move forwards, backwards, to rotate itself and to allow it to move over various types of surfaces.

**Functional Components and their Interconnection**

**Arduino Microcontroller:** the arduino mega will be used in this project and it serves as the brain of the whole robot. It is the arduino microcontroller that upon processing the codes we upload and the sensor data received, control the robot's movements and actions by activating actuators.

**Sensors and camera:** Infrared Sensors, Ultrasonic Sensors and the camera detect the presence of people, obstacles and cigarette butts respectively and send this data to the arduino microcontroller which then processes it to know what to do next (activates actuators).

**Servo Motors:** servo motors are used a lot in this project. The microcontroller enables the servo motors to activate and rotate when the camera detects a cigarette butt. Think about the joints in the leg of a crab the servo motors acts as such and are used for navigation as well as for the gripper to collect the cigarette butts.

**Power Supply:** Batteries will Supply power to the Arduino, servo motors, and other components for those electronic components to work.

**LEDs:** these will be programed via the microcontroller to blink when the battery in nearly low and set to red or green depending if the storage is full or not. The robot is expected to contain a maximum of 30 cigarette butts.

**Push button**: a push button will activate and also switch off the whole robot as the push button will interrupt the power supply to any of the electronic components used.

**Interaction**

**Robot-Human Interaction:** through the LED lights the robot can interact with the user to indicate that its battery is nearly dead by blinking or the robot can turn the LEDs red to indicate that storage is full and that the user needs to empty the robot’s container manually.

**Human-Robot Interaction:** users may interact with the robot by providing the initial setup program that will enable the robot to achieve the expected task or for maintenance. The user can also interact with the robot using the push button to switch the robot on or off before uploading new codes or before empting the robot’s container. This push button also serves as a security system for the user.

**Robot-Environment Interaction:** The robot uses sensors to navigate across the area and identify obstructions and cigarette butts. It stays clear of obstacles in its route and gathers cigarette butts while also detecting human presence and stop briefly to prevent bumps or collisions

.

**Logical diagram for functional components**

Push button

LEDs

Gripper servo motors

Movement servo motors

Arduino

battery

sensors

camera

**Physical construction**

Careful consideration goes into the physical building of a robot intended to gather cigarette butts, including the choice of development board, connection diagrams, and component configuration.

**Components Selected**

**Infrared Sensor: (**HC-SR501 PIR Sensor**)** used for detecting human presence to avoid accidents with the robot.

**Arduino mega board:**(Arduino Mega 2560) Selected for its ease of use, numerous pin outlets and It provides an ideal platform for integrating electronic components.

**Gripper Actuator:** makes use of servo motors for the collection of cigarette butts.

**Servo motors: (**Futaba S3003) servo motors are used for the legs and the gripper to enable movement through the rotation of the servo motors.

**Ultrasonic Sensor: (**HC-SR04**)** in used in obstacle avoidance during navigation.

**Camera: (**Module v2**)** used to detect cigarette butts through image and object detection software using rasbery pi.

**Rasbery pi:** (Pi 4 Model B) used to host the software nessesary for the cigarette butt imge detection. Also needed for the robot visual recognition of cigarette butts in the environment.

**Battery: (**Panasonic CR2032**)** used to power the whole robot even the arduino board.

**LEDs:** (Kingbright KB-2750SGD) used to signal user when battery is low or storage is full.

**Push button: (**Omron B3F Series**)** used to switch on and off the robot.

**Physical Configuration**

Arduino mega placed at the core, serving as the central control unit.

Sensors (infrared and ultrasonic) positioned in front on the robot's body for efficient detection.

Servo motors responsible for movement in the legs of the robot and the servo motor powered gripper actuator responsible for collecting cigarette butts.

Camera connected to rasbery pi, and arduino for correct cigarette butt identification.

Battery connected to arduino board to power the whole robot.

Leds connected to arduino board to blink when appropriate.

Push button connected to the arduino board to switch on or off the robot.

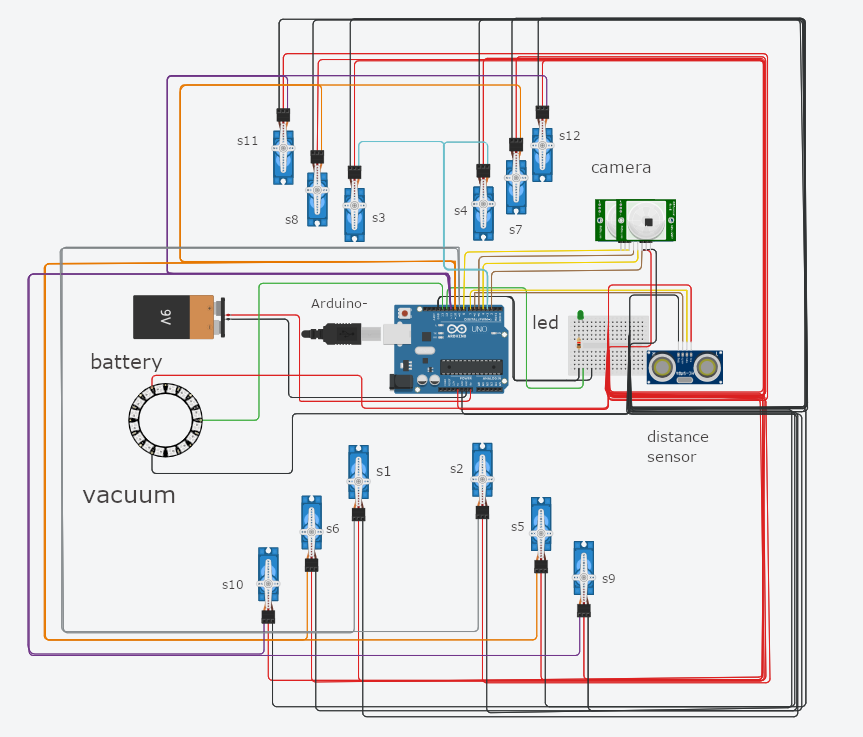
**Development board**

The development board that will be used in this project is the arduino mega development board and the reasons for using this development board are below.

\*More Pins: When compared to the Arduino Uno, the Mega has a substantially higher number of digital and analogue I/O pins. Larger projects or those requiring a high number of sensors, actuators, or components will benefit from this.

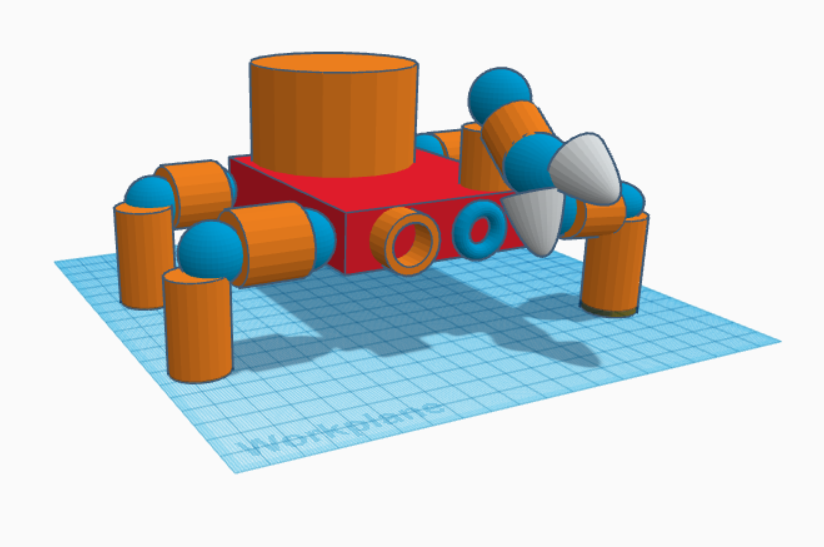
\*Greater Processing Power: Compared to the Uno, the Mega has a microcontroller with greater processing power, which enables it to perform calculations and handle more complicated tasks. This makes it appropriate for applications like robotics and data processing.

**Connection diagram & pinout table**

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|  |  |  |
| --- | --- | --- |
| Features | Color wire | pin |
| battery | Red, black | Gnd, v1 |
| Led light | Green | Gnd, 12 |
| Proximity sensor | Brown, yellow | 6, ~7 |
| camera | Brown, yellow | 8, ~5, 4, 2 |
| Servo motor 1& 2 | grey | ~9 |
| Servo motor 3 & 4 | blue | ~3 |
| servo 5,6,7,8 | Orange | ~10 |
| Servo 9,10,11,12 | Purple | ~11 |
| vacuum | Green | 13 |

**3D diagram of model**

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**Functionality test cases**

**\*Components - Technical & Calibration Testing**

**Infrared Sensor Calibration**

Check the infrared sensor array's sensitivity and precision in terms of identifying cigarette butts.

To guarantee reliable detection, place different cigarette butt samples at varying distances and angles.

**Ultrasonic Sensor Accuracy**

Check the ultrasonic sensor's accuracy in identifying obstructions.

To test the accuracy of the sensor's obstacle avoidance, place barriers of various sizes and materials at different distances.

**Actuator Functionality:**

To ensure that it can securely gather and hold on to cigarette butts, test the gripper.

Make sure it runs without dropping the items that have been gathered.

**Microcontroller functionality:**

Try to upload simple code for led light on the board to light up, try different pin numbers to ensure all pin numbers are working.

**Servo motor actuator:**

Test each servo motor by uploading codes and test accuracy of rotation of each servo motors.

**\*Functional Parts - Case Scenarios**

**Navigation and Detection**

Scenario case: The robot moves through its given area where there is cigarette butts scattered over and some rocks as obstacles.

Expected Output: The robot’s camera accurately locates the cigarette butt and moves towards the cigarette butt without colliding with obstacles placed over the area.

**Collection and Storage**

Scenario: The robot has located the cigarette butt and is about to start the collection process using the gripper.

Expected Output: The gripper successfully positions itself on top of the cigarette butt before moving downwards and picking it up without letting it fall down. The gripper then releases the cigarette butt in the storage container of the robot.

**Obstacle Avoidance**

Scenario: The robot is placed on a surface with a lot of obstacles of different sizes.

Expected Output: The robot appropriately identifies obstacles using the ultrasonic sensor and adjusts its path to avoid collisions.

**Full storage**

Scenario: the robot has collected a number of cigarette butts and is now full.

Expected output: the robot’s LED light start blinking to alert any nearby user to empty its container.

**Robot stop/go:**

**Scenario:** the user presses the push button as he/she wants to upload new codes or the user wants to empty the storage of the robot.

**Expected output:** the robot stops or the robot starts to work.

**\*Whole System - Case Scenarios**

**Robot System Testing**

Scenario: Use the robot at the assigned environment to run the entire system. Including the collection, navigation, and detection of cigarette butts.

Expected Output: The robot does the assigned duties by effectively detecting, gathering, and navigating without any issues.

**Different Environmental Adaptability:**

Scenario: Test the robot in different outdoor environments.

Expected Output: The robot maintains its function of detecting and collecting cigarette butts across different types of environment.

**Battery Test:**

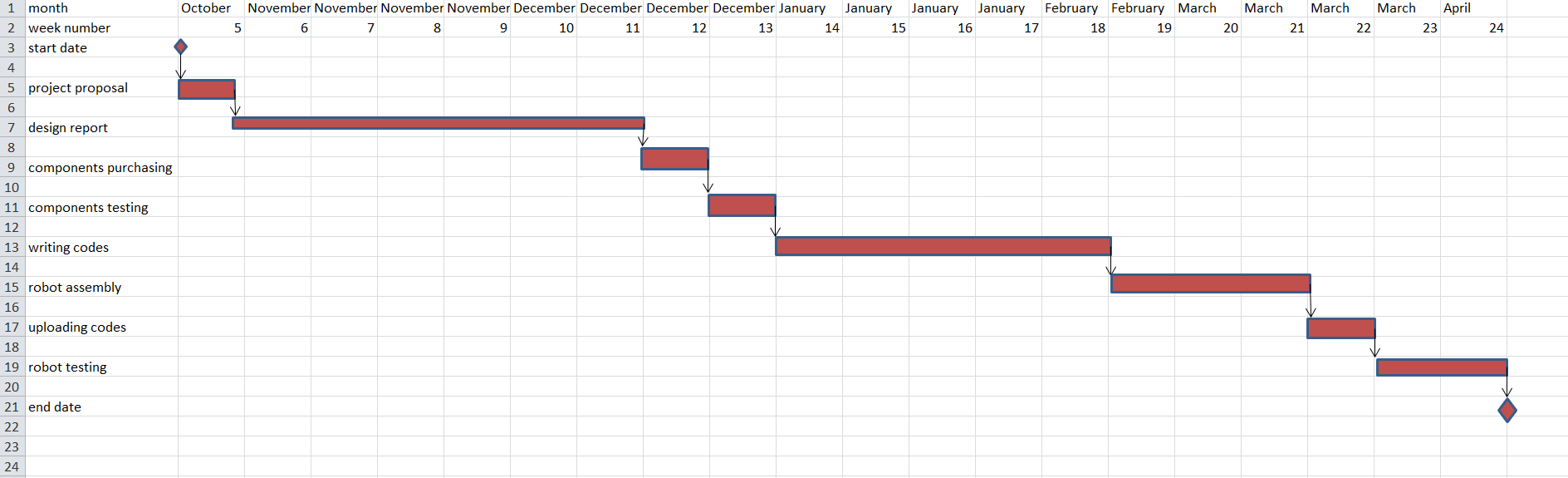
Scenario: Run the robot continuously for an extended period of time to assess its battery life.

Expected Output: The robot operates efficiently without battery depletion in the specified time limit.

These test cases aim to validate the functionality of individual components, functional aspects, and the entire system in different scenarios, ensuring the robot's reliability and effectiveness in collecting cigarette butts.

**Project plan**

The Gantt chart below illustrates the main goals to achieve for the robotics project to be successful.

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**Bill of materials**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **components** | **Make & model** | **quantity** | **Price(Rs)** | **Supplier** |
| **Arduino mega board** | **Arduino Mega 2560** | **1** | **800** | **Local** |
| **Servo motors** | **Futaba S3003** | **20** | **60** | **Local** |
| **ultrasonic sensor** | **HC-SR04** | **1** | **200** | **Local** |
| **Camera** | **Module v2** | **1** | **210** | **Local** |
| **Battery** | **Panasonic CR2032** | **4** | **300** | **Local** |
| **Led lights** | **Kingbright KB-2750SGD** | **1** | **38** | **Local** |
| **Jumper cables** | **10cm** | **30** | **16** | **Local** |
| **Rasbery pi** | **Pi 4 Model B** | **1** | **7000** | **Local** |
| **Infrared sensor** | **HC-SR501 PIR Sensor** | **1** | **360** | **Local** |

**Conclusion**

**Problem Being Solved:** The incorrect disposal of cigarette butts which is a persistent concern in the field of environmental conservation, as it contributes significantly to pollution in both urban and natural ecosystems worldwide. Cigarette remnants continue to be one of the most common types of litter, despite growing public awareness of the harmful impacts of littering and the serious risks they pose to ecosystems and public health.

**Proposed Solution:** The proposed solution aims to use an autonomous robot that can travel through different terrains and public spaces on its own to gather hazardous waste products in order to address cigarette butt littering. The robot will distinguish cigarette butts from other trash items by using cutting-edge sensor technology and AI algorithms, guaranteeing accurate and focused collecting.

**Limitations of project**

\*Meteorological circumstances, such rain, snow, or extremely high or low temperatures, could compromise the robot's longevity and functionality.

\*The robot's storage capacity for collecting cigarette butts may be limited, requiring frequent emptying or disposal by user or nearby people.

\*The small and compact robot might get stolen as electronic parts are quite expensive.

\*The small and compact robot might not be robust enough and can be damaged due to people walking or colliding with the robot.

**Potential Implementation Problems Foreseen**

Cost of components: Cost of components might affect the scalability and accuracy of the robot.

Technical Difficulties: During development, the whole system working together compromising of multiple components such as sensors may present technical challenges.

**Further Development Opportunities**

To make the robot waterproof a casing around the electronic components could be a good improvement.

Developing the robots capability to transport a bigger and heavier battery will enable the robot to work and have a longer life span for its battery.

Navigation upgrade could also be a further development such as the integration of more powerful components for navigation amongst different obstacles. The robot could also be trained to navigate different complex and rough grounds.

Increased Capacity: Could focus on increasing the robot's collection capacity.

In conclusion, even if the suggested robotic method seeks to solve the problem of cigarette butt litter, there may be drawbacks and difficulties with implementation. We can help ensure that these solutions are scalable and effective in reducing the pollution that cigarette butt litter causes to the environment by doing thorough testing and development.

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