Smart Garbage Bin

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1. Introduction: Purpose & motivation

My motivation for this project started from the occasional annoyances that occurred when using the garbage bin. The usual instance of dirtying the lid while trying to open it or not knowing when the bin was at maximum capacity determined the implementation of this project. Although automatic garbage bins are nothing unheard of, they do not necessarily represent a cheap option or fulfill all the desired functionalities. Therefore, the purpose of the project is to minimize most of the inconveniences of the daily task of using the garbage bin, while also providing an easy solution that can be implemented at home. The main functionalities of this smart garbage bin are automatic opening of the lid if the user is within short distance of it and the announcement by a led and buzzer of the level of the trash surpassing a certain threshold inside the bin.

2. Bibliographic research

Garbage bins with automatic lids for home use, that open upon movement detection, can be found online from as little as 60 RON. Level detectors however are not as popular and as far as my research shows, are not sold for individual home use, but rather for larger commercial or community use. Therefore, their price cannot be approximated. All the components needed for this project (without the actual garbage bin, which can be chosen by the user to suit their preferences) cost approximately 70 RON, but if we only want to compare the automatic lid functionality the components cost about 60 RON. Although the online version also provides the user with the garbage bin, the solution provided by this project can be adapted to any size and shape of bin the user wants to use. Also, in case of problems occurring, this proposed system is easier to troubleshoot compared to the bought version, which often results in throwing the whole garbage bin away. Additionally, both solutions run on batteries, so the difference in power consumption is not noticeable. All the previously discussed comparisons between the found and the proposed solution can be found summarized in the table below.

Perspective	**Bought garbage bin**	**Proposed project solution**
Main function	Automatic lid opens on movement detection	Automatic lid opens on movement detection and can optionally include level detection

Typical availability	Automatic-lid bins are common online	Components are easy to source; assembled by the user
Cost (automatic lid functionality)	From ~60 RON (includes the bin)	~60 RON in components (bin not included)
Cost (full project)	Not available to buy for home use	~70 RON total components for the full project (bin not included)
Fill-level (level detector) availability	Level detectors are not sold for individual home use; only commercial/community use	Can be implemented as part of the project with the ~70 RON components estimate
Power consumption	Battery-powered	Battery-powered
Difficulty to implement	Very easy: unpack and use	Medium: requires assembly and integration
What the user receives	A complete product including the garbage bin	A system that can be attached to a bin the user already has
Adaptation to user's needs (size/shape)	Limited: you're constrained to available bin models/sizes	High: can be adapted to any size/shape of bin the user wants
Troubleshooting / repair	Often difficult to repair; failures may lead to discarding the whole bin	Easier troubleshooting: individual parts can be replaced (less likely to throw everything away)
Long-term flexibility / upgrades	Low: closed product, harder to modify	High: can be expanded/adjusted (sensors, behavior, mounting, etc.)
Usage when lid sensor is broken	Probably unusable	Lid can be used even if sensor or other components are faulty

3. Proposed solution & implementation

As explained in the previous chapters, the proposed implementation of a smart garbage bin includes an automatic lid and a fill-level detection system. The automatic lid was implemented using an ultrasonic sensor that detects when the user is within a short distance (in my implementation it is set to 30cm) and signals to the servo motor, that has an extension attached to it, to open the lid by moving 90 degrees. Before opening, however, the system checks if no object inside the garbage bin is blocking the lid from executing its opening motion. If this is the case, the lid will not open and a passive buzzer will emit a short note to alert the user followed by the lighting up of a red LED. The latter one will stay on until the user tries to open the lid again and the level detection is reevaluated (the user either took the trash out and the LED will turn off, or it will remain on and the buzzer will alert the user once more, while still keeping the lid closed). If the opening is successful, the lid stays that way as long as it detects

an object in its proximity. If the sensor stops detecting any object, the system will wait 3 seconds before closing the lid.

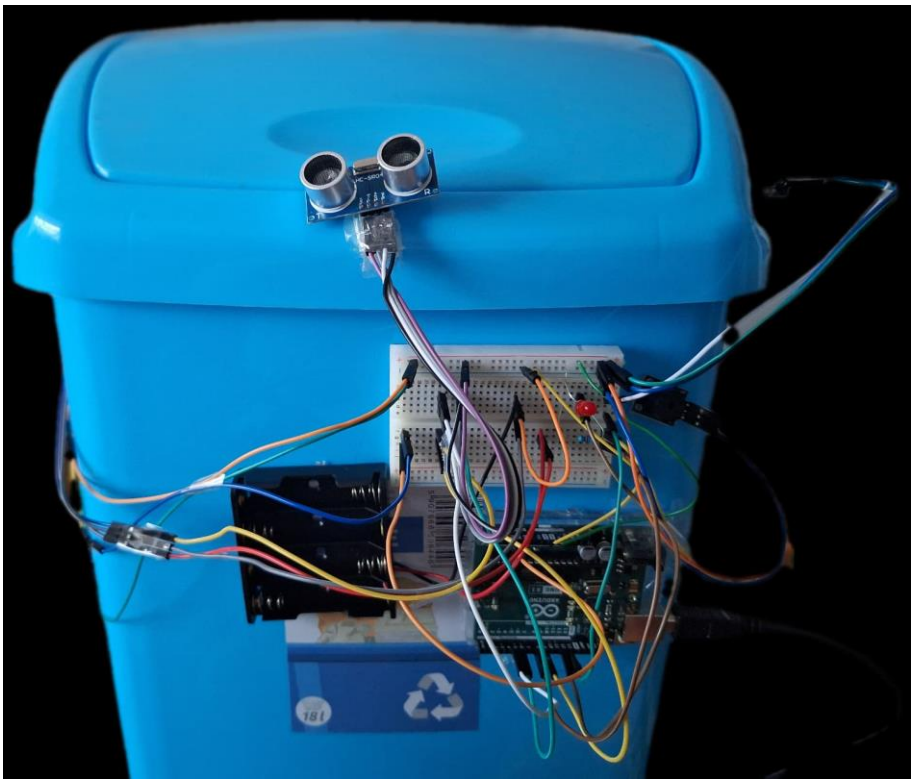

Figure 1: Front view of smart garbage bin

The internal level detection is implemented using a laser module and a photoresistor, whose resistance increases significantly if the laser beam is broken by some object and stops reaching the light-dependent resistor. In my implementation I chose to use the level detection part of the project to protect the servo motor from forcing against objects that might be blocking the lid from opening. Additionally, setting all the components that are needed inside the bin on its lid makes it less likely for them to be damaged or dirtied during the use. Nevertheless, they can be set at different levels inside the bin, according to the user's wishes. How the components are arranged on the lid can be seen in Figure 2. The main connections of the whole project are illustrated in Figure 3 with the mention that the platform used did not have the laser module and the simple photoresistor, which were replaced by the blue LED and the photoresistor module respectively.

Figure 2: Side view of the project with open lid

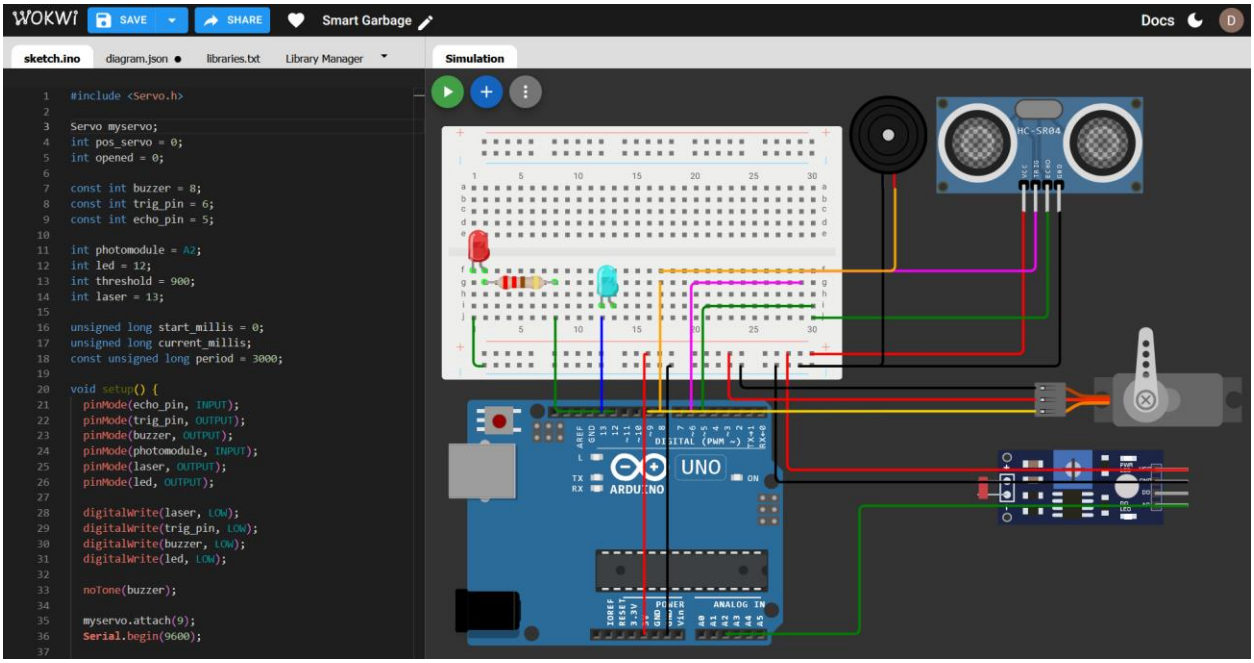

Figure 3: Components' connections

4. Testing & validation

The first problem that was encountered was the implementation of the level detector, which I initially wanted to implement using an IR emitter and receiver. After more rigorous research I realized that IR light can easily pass through some materials, so it was not a suitable option for this project. Then I wanted to use a photoresistor module, but while testing it realized that it was at full capacity even in normal daylight, so the laser beam was not causing any change in values, thus being unusable in this context. At last, I chose a simple photoresistor and connected it alongside a 10KΩ resistor in a mini breadboard to the rest of the circuit.

Another problem that I encountered was the need of an additional power source, since the Arduino 5V pin would not have been able to power the servo motor, assuming the latter one would encounter the resistance of the lid and could draw significant amounts of mA, causing jittery or no movement at all.

Additionally, solving edge cases when programming sometimes also proved difficult. For example, not allowing the servo motor to move according to the received sensor data in the first few seconds after initialization proved to be very important, alongside making sure the servo does not try moving if it's already in the destination position. Both solutions stopped the servo from having unexplained jittery movements and gave the project a clean and professional flow of operations.

5. Conclusion

The purpose of this project was fulfilled, as the prototype reduces the main inconveniences of daily bin use by opening the lid automatically when a user approaches (30 cm in this implementation) and warning when the trash level exceeds a set threshold using a red LED and a buzzer. To reach a valid solution, multiple tests and adaptations were needed, especially for level detection and servo motor movement. Reliability was also improved by adding an external power source for the servo motor and refining software edge cases, which eliminated jitter and made operation smoother.

This solution is useful for anyone who wants a low-cost, repairable, and easy to adapt solution to any bin size or shape, since the user supplies the bin and can adjust thresholds in software or by moving the position of sensors. Some practical improvements include stronger mounting (i.e. using 3D-printed parts), extending level detection to multiple fill stages instead of a single threshold and even adding a weight sensor to determine when the garbage must be taken out. Nonetheless, this project represents a practical prototype for a useful and easy to implement household appliance.