Smart Collection of Waste Bread in Algeria Using the Internet of Things

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Abstract-Algerians are among the largest consumers of bread throughout the year and produce large amounts of bread waste. As bread is made from imported wheat, these losses on currency are a heavy loss for the national economy. To minimize these losses, Algeria needs to encourage the recycling of stale bread to minimize the cost of importing soft wheat and valorize it for farmers. This paper presents a framework based on the Internet of Things (IoT) to monitor and collect waste bread from recycling bins. This system could assist Small and Medium Enterprises (SMEs) in Algeria in bread waste collection, by monitoring the level of filling of the outdoor waste bins. The proposed system's architecture used a Mega 2560 microcontroller, HC-SR04 ultrasonic sensors, and SIM 808/900 modules.

Keywords-waste bread; recycling; smart city; IoT; Arduino

I. INTRODUCTION

Algerian consumers are among the people who consume the most bread throughout the year. University restaurants, hospitals, and school canteens are considered the largest waste cells that affect daily bread consumption. The absence of consumption culture increases bread waste, causing problems for poultry farmers, livestock, and garbage management. The waste of bread made with imported wheat in foreign currency is a serious loss to the national economy [1]. Algeria should promote the recycling of stale bread to minimize these economic losses. The recycling process is based on several steps starting with the collection of waste through its sorting and processing to the marketing of the recycled products. The collecting operations of each country are carried out in different ways, according to their level of civism and industrialization. Waste collection in developed countries is performed in a selective way called "selective sorting", while this operation is performed manually in underdeveloped countries by people or employees while sorting the waste by nature according to the demand [2, 3].

Today, the world is witnessing an increasing use of the Internet of Things (IoT) which uses devices that collect massive amounts of data and attracts the interest of both academia and industry [4]. The enhanced capability of applications, cloud services, and databases to communicate with IoT devices produces a vast number of new interconnections between current and new systems. IoT devices are expected to reduce the cost of waste collection using the information exchanged among bins, containers, and trucks [5]. This study aims to investigate the recycling and recovery of waste bread by reviewing IoT techniques for the smart collection of stale bread systems and proposes an efficient management method to improve the collection systems in the source area, which is the most important stage of waste management, and can lead to a reduction in the bill for importing soft wheat and animal food products.

II. MATERIALS AND METHODS

A. Bread Waste Situation

The Algerian Ministry of Commerce revealed that during the period between April 13 and 24, 2021, only the first 12 days of Ramadan, 535 tons of bread (2,139,884 breads) equivalent to 45 tons/day (178,323 breads) were wasted at national level, with a financial value estimated at 20 million Algerian dinars [6]. Official statistics show that an average of 2.7 million breads are not consumed daily. The financial value of the wasted quantities was estimated by the Ministry of Commerce at 20 million Algerian dinars, which represents more than 1.5 million Algerian dinars per day. Table I presents the provinces that recorded the highest rate of waste bread.

TABLE I. HIGHEST RATES OF WASTE BREAD

No	Province	Quantity of breads(units)
1	Blida	321,924
2	Bechar	161,648
3	Tlemcen	150,696
4	Djelfa	139,364
5	Annaba	118,680
6	Tebessa	115,152
7	Oran	108,200

Moreover, Algeria imports large quantities of soft wheat to ensure the production of flour destined for bakeries. Table II illustrates a yearly account of soft wheat imports. On the other hand, there is the problem of covering the food needs of farms (bovine/ovine and poultry), whose numbers are large and their

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annual import bills for corn, soya, and are increasing. The collection and processing of stale bread can be a solution to this problem by using automatic recovery solutions and resulting in environmental protection and sustainable development. Some waste collection establishments sort bread from other waste to restore and sell it to cattle and poultry breeders.

TABLE II. COST OF IMPORTED SOFT WHEAT

Year	Quantity (tons)	Cost of imported soft wheat (billion $)
2017	6,832,777	1.4
2018	7,179,399	1.6
2019	5,800,844	1.3

B. Methodological Approach

The rapid evolution of technology has led to the development of increasingly complex systems, capable of processing information flows of diverse nature and origin and whose access must remain nevertheless simple and fast [7]. The proposed system could assist Algerian SMEs in collecting waste bread by monitoring the fullness status of outdoor bins with a list of requirements. Several studies examined the domain of smart waste management (household/solid) using different materials and techniques [8-17]. In this context, this study adopted an appropriate approach to the specificity of the product, stale bread, the area, and the country. The solution framework is based on wireless sensor nodes connected to the intelligent bins manager with a monitoring station by sending the bins filling level status for analysis and control of waste. This solution involves the following features:

- Optimal fill level setting: This allows the user or system operator to specify the fill level they consider optimal. Exceeding this limit will result in notifications for collection.
- Check bin status: This allows a user to view at any time the fill level of a bin using a web application.
- Notifications: This feature allows the users to be notified whenever the fill level exceeds the specified optimum levels.
- Reports: This feature allows the system to generate reports when needed.

After successful installation and login, the user can request the system to display the status of a bin from a web application. This request should trigger actions to check the bin filling level and pass the values through an Arduino microcontroller to the user's device browser. The user must register and then log in to interact with the system. Using smart bins and IoT, data should be collected and presented in a meaningful way to waste managers, as described in the proposed conceptual IoT infrastructure model. Figure 1 shows the flowchart of the proposed approach after starting the system and connecting composites. The IoT infrastructure model works in the following manner:

1. Citizens fill the smart bins.
2. The filling height is measured with an ultrasonic sensor.
3. The height is transmitted to the cloud via SMS or WiFi or a hybrid system with a GSM module.
4. The server receives the data.
5. A notification for a transporter is sent.
6. The bin is emptied.
7. The transporter goes to the sorting and grouping center.
8. The bread is unloaded and the stock status is changed.
9. The stock status is transmitted to the system to notify recyclers.

Fig. 1. Architecture of the proposed system.

Fig. 2. The smart bin.

An ultrasonic sensor, a GSM Module SIM808/SIM 900 MHz Quad-Band, and an Arduino UNO microcontroller should be installed on the upper part or the bin cover, as shown in Figure 2. The system would be active when the garbage is in a closed position and the ultrasonic sensor should detect any changes in the height of the garbage volume. The data of the garbage height are then processed by the Arduino Uno microcontroller Mega 2560 and then sent to a firebase real-time database using the HTTP protocol and the GPRS Network via the GSM SIM808/SIM 900 module [18]. To enable wireless connectivity and sensing capabilities, a microcontroller was installed in each collection box. Figures 3 and 4 show the three main components. The ultrasonic sensor is capable of determining the level of the collection box. The Arduino board supplies power for the ultrasonic sensor and allows for a customized program to control the sensor and the Wi-Fi module. The ultrasonic sensor will then operate and scan for any changes in the level of the collection box.

Fig. 3. Arduino Uno (Mega 2560) connected with the HC-SR04 ultrasonic sensor.

The Wi-Fi module board connects the Arduino board with the Wi-Fi network and the database server to store the measured waste level via the ultrasonic sensor.

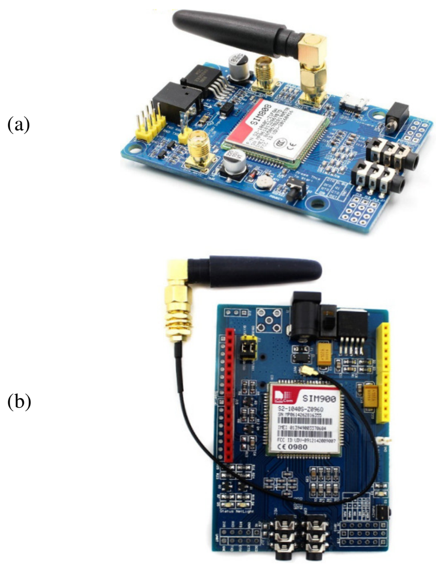

Fig. 4. (a) Module SIM 808, (b) Module SIM 900.

Following the collection, the products are sent to a sorting facility where they would be sorted mechanically to optimize the operations of transformation. This operation can also be completed by manual sorting using a conveyor belt. Once the operation of sorting is finished, the waste is ready to be integrated into the transformation operation by factories that will transform it into ready-to-use materials.

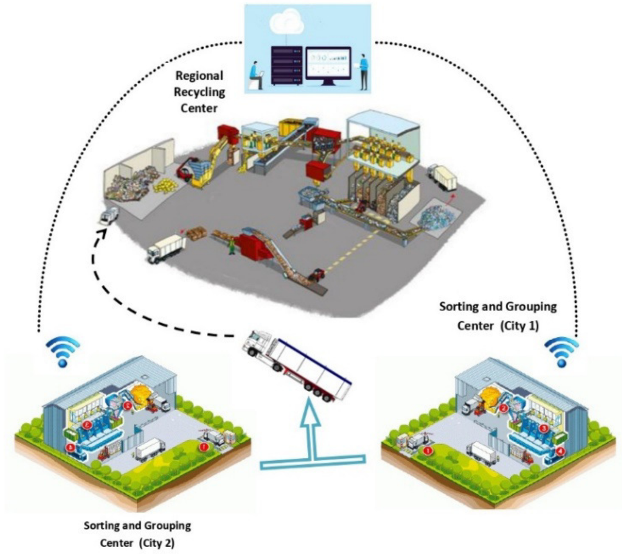

Fig. 5. Transportation to the regional recycling center.

III. RESULTS AND DISCUSSION

The proposed system was designed to assist Algerian SMEs in collecting waste bread by monitoring the filling status of outdoor recycle bins. IoT devices are expected to reduce the cost of waste collection by using the information exchanged between bins, containers, and trucks. These devices enable automation and accelerate the identification of waste for processing. As there are no similar studies on using IoT for smart collection of stale bread, the proposed system was compared with studies on recycling other products. This study utilized the same communication technologies with [5, 6, 17] for solid and [10-16, 18] for household waste. The architecture design adopted a model that responds to:

- The specificity of the product: To avoid the high cost of the system as the main objective was to recycle at a lower cost.
- The specificity of the region and the lack of Internet connection in some collection sites: This was accomplished by a hybrid architecture using a SIM 808 reader for sending SMS and SIM 900 which supports GPRS internet connection.

The proposed architecture can be implemented in a metropolitan area. The main advantage of this system is that it is very independent and transparent. Instead of using GSM and GPRS modules, the server could directly send the messages and the hardcoded coordinates. This could reduce the working and maintenance cost of these embedded bins.

IV. CONCLUSION

This paper discussed a smart collection system of waste bread in Algeria, proposing a solid waste monitoring system. A framework based on IoT and Arduino was presented for collecting waste bread from the bins to the recycling establishment. The system was designed to assist Algerian SMEs to collect waste bread by monitoring the fullness status of outdoor bins. This system's features are:

- It can monitor the fill level in a short time.
- It can notify the persons in charge simply and with good interactivity.
- It is a secure system with access restrictions.
- It can provide usage reports

The level of waste in each bin is monitored and transmitted to a central management platform and can be accessed remotely to check and perform the collection process in any web browser. In future work, the proposed architecture will be extended to other actions that could encourage and promote the collection of waste bread by integrating them into the system platform.

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