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Review on Efficient Food Waste Management System Using Internet of Things

T. Bharath Kumar^{1,2}, Deepak Prashar¹

¹School of Computer Science and Engineering (SCSE), Lovely Professional University, Jalandhar, Punjab, India; ²Assistant Professor, Department of Computer Science and Engineering, B V Raju Institute of Technology, Narsapur, Telangana, India.

ABSTRACT

The present situation of food waste in the country is increasing from time to time which is from restaurants, households, and related industries. On the other side, to control food waste many techniques have been using from different perspectives. In recent years, one of the well-known technologies that reach new heights and showing considerable growth in all research areas is the Internet of Things (IoT). This article presents the review of the present standings of IoT in the field of food waste management by the contribution of various researchers and academicians. This article also discussed different methods like conducting questionnaires, reducing plate size in the hotel, smart garbage systems, intelligent refrigerator, strengthening the food supply chain, etc. These methods gave good results in minimizing food waste. Furthermore, different challenges and factors also mentioned during food waste at household or restaurants with future directions to researcher those who are working on this domain.

Key Words: Food Waste, IoT, Intelligent Refrigerator, Food Supply Chain, Sensors

INTRODUCTION

Meeting the food needs of an increasing population sustainably one of humanity's major problems in the coming decades is to be focused on scarce resources while protecting the environment. Present demographic patterns and consumption habits will continue to raise food demand for at least a further 40 years. Approximately one-third of the edible portions of world food generated, it is projected that human intake is missed or unused. In reaction to this vulnerability, the FAO has The Food Loss Index has been developed to measure how much food is lost. Until it hits the retail level, output or in the supply chain 14 per cent of food is diverted across the supply chain, according to FAO 2019, Before having hit the supermarket stage.

This paper is organized into different sections. The introduction is under section I, Internet of Things under section II, Aim of the Review is under Section III, Key findings of the Review Article is under Section IV, Research gap Identification/Future Directions are under Section V, Discussion is under Section VI and Conclusion in Section VII.

Internet of Things tells about connecting physical objects like mobile phones, vehicles, home appliances etc. to the

internet to exchange data from anywhere to anywhere. By having this type of technology human intervention will be reduced a lot and works will be done easily. At present by 2020 approximately 50 million devices are connected to the internet and this number will be increased from day to day [Figure 1]. The applications of IoT include health, homes, cities, energy systems, retail, logistics, industry, agriculture sector, etc. The following figure 2 shows various IoT communication technologies and figure 3 shows the current IoT enabled technologies. The goal of this literature review is to provide participants with a way to reduce food waste. It would ideally evoke more studies on IT applications for the elimination of food waste.

KEY FINDINGS

The following table 1 shows key findings in the Literature and future challenges also mentioned.

RESEARCH GAP IDENTIFICATION/FUTURE DIRECTIONS

1. Increasing the incentives for the workers of supermarkets, packaging, etc. to control the food waste.

Corresponding Author:

T Bharath Kumar, B V Raju Institute of Technology, Narsapur-502313, Telangana, India.

Email: bharathphd2019@gmail.com

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2. Research on different policies to control food waste.
3. Finding the loss estimates of other commodities like dried fruits, dairy products etc.
4. Find other algorithms for processing, Shipment and Quality Management.
5. Improving the quality of the food items inside the smart refrigerator.
6. Investigation of food waste into bio-fuel with simple and clean methods.
7. Improvisation of better efficiency of HSGB'S.
8. Better connectivity and using protocols for communication to improve begins to collect food waste.
9. Improve the security and privacy concerns to minimize the chances of hacking the smart refrigerator.
10. Concentrate on high-quality resolution cameras for quality photos inside the smart refrigerator.
11. Use of Big data to enhance food security.
12. Improving the shelf life to minimize food waste in the supply chain.
13. Improving food tackling the methods for measuring food waste.
14. Updating the Photodiodes to RFID technology for identifying the presence of objects inside the fridge
15. Use more sensors to install on the raspberrypi3 to reduce the need for a plug system and apply this methodology for cabinets and living rooms.

DISCUSSION

In this review article, we can observe many ways to control food waste in different situations. The majority of the papers are focusing on food waste control in the food supply chain because this chain consists of many modules like processing, preparing, packaging, classifying, transportation and distribution. So whenever control starts in this chain automatically there will be a change in food waste before consumption. The intelligent refrigerator also takes a major portion in reducing the food waste at household and restaurants because of inbuilt sensors and machine learning technique used in the implementation. The design of smart garbage systems also played a better role in collecting food waste and sending information to the higher authorities for further action.

CONCLUSION

The Internet of Things (IoT) involvement is increasing in reducing and updating the food waste across the country from time to time. Because of the availability of many sensors and communication technologies in IoT. This article provides an extensive survey of food waste management techniques/ methods. The major concern is about reducing food waste to accommodate more number of people across the country. The researcher(s) can concentrate on the above gaps to improve food availability and reduce wastage.

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There is no conflict of Interest.

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T. Bharath Kumar: Literature review, Writing Manuscript, and Comparison of results.

Dr Deepak Prashar: Reviewed the complete article.

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Figure 1: IoT Devices Connectivity growth [Source: Cisco IBSG, April 2011].

Figure 2: IoT Communication Technologies.

Figure 3: IoT Enabled Technologies.

Table 1: Review of Literature Methodologies

S. no.	Title/Citation Reference	Method/Technique/Component used	Results	Future Challenges
1	Mary Griffin et al ¹	Interviews and Observation in Acquisition used.	Food Waste Reduction	Future analyses may reveal changes as well as identify trends in food system waste streams.
2	Jean C et al ²	Proper Packaging, Proper maintenance of temperature in the store and Training	Food Loss Reduction in Vegetables, Fruits, Poultry and Seafood.	Finding the loss estimates of other commodities like dried fruits, dairy products etc.
3	Bing Jia et al ³	PFQC & Matching algorithm	Food Quality is monitoring to reduce food waste	The blend and conduct of the variables that influence food quality should be resolved for additional investigation.
4	G. Subramanya Nayak et al ⁴	IEEE 802.3U Ethernet technology, IR Sensor, LCD Display and Buzzer	Food Item Waste control in the refrigerator	Future work suggested focusing on the quality of the food items
5	Fu Ying et al ⁵	Quality Safety monitoring system and Cloud Technology	Food Quality and Safety	
6	Steffen Kallbekken et al ⁶	Reducing plate size in hotel	Food waste was reduced by 20%	
7	Sanjib Kumar Kar-mee et al ⁷	Lipid and carbohydrate extraction	Biofuel generation from the extraction of Lipid and Carbohydrate	Future research should be focused on investigating the food waste into biofuel with simple and clean methods.
8	Insung Hong et al ⁸	Smart Garbage Bin and RFID Technology	Reduces food waste by 33%	Improvisation of better efficiency of HSGB'S.
9	Leonidas Matsakas et al ⁹	Food Waste and Sugar contents as raw material for extraction of methanol	Methanol extracted from Food Waste	

Table 1: (Continued)

S. no.	Title/Citation Reference	Method/Technique/Component used	Results	Future Challenges
10	Reiner Jedermann et al ¹⁰	Intelligent Shelf life using sensors	Food loss reduction	
11	Jessica Aschemann-Witzel et al ¹¹	Using expert interviews	Motivated to reduce consumer food waste.	Further research into consumers and food waste can contribute to the sharpening of consumer behaviour theories and the application of these theories to sustainable consumption and the interactions observed in consumer's food wastage.
12	Ali Chalak et al ¹²	Redistributing the surplus food & Ordinary Least Squares (OLS) mechanism	Reduced food waste at the household level	Further work will be focused on household waste across the country and promoting quantification techniques
13	Ella Graham-Rowe et al ¹³	Extended Theory of Planned Behavior(ETPB)	Reducing food waste at house level	To increase the number of items measuring food waste.
14	W Leal Filho et al ¹⁴	Educating the people about food waste occurrence and guidelines to minimize and conducting surveys	Reducing food waste	
15	MV Massow ¹⁵	Mathematical estimation (the LP model) and photographic evaluation	Reducing food waste in plates at restaurants	Future research focused on calculating plate waste in different hotels or food centres.
16	David Pearson et al ¹⁶	Qualitative Interviews	Food waste reduction	Future work depends on the results of the present approach used in this paper.
17	Varsha Jain ¹⁷	eBin using Raspberry Pi, Arduino	Collecting food Waste at Student Hostel.	Extending the work to accommodate more people to reduce food waste
18	Guillermo Garcia-Garcia et al ¹⁸	The used methodology depends on some indicators to measure the food waste like Edible, state, packaging, Treatment and complexity etc.	Reducing food waste	
19	Aaron Ciaghi and Adolfo Villafiorita ¹⁹	Surplus Recoverability Waste (SRW) framework and ICT tools	food waste reduction and encouraging surplus food sending to charities or needy people	Future work should focus on implementing these interfaces for other Geographical regions.
20	Aadhya Bhatt et al ²⁰	AWS platform, RapberryPi Kit and User Interface	Food item availability and food item waste reduction	Focus on improving the models.
21	Zahir Irani et al ²¹	Fuzzy cognitive Map	Enhanced food security	Use of Big data to enhance food security
22	Zongguo Wen et al ²²	RFW IoT enabled system	Reduced food waste in restaurants in the city of Suzhou, china	RFID Technology should be renewed
23	K. Jayalakshmi et al ²³	IoT enabled smart garbage system	Reduction of food waste at house, academia, industry	

Table 1: (Continued)

S. no.	Title/Citation Reference	Method/Technique/Component used	Results	Future Challenges
24	Shouming Qiao et al ²⁴	Intelligent Refrigerator using cloud server and RFID technology	Refrigerator controlling to reduce food waste	
25	Sraisth ²⁵	Solar cold Storage Technology	Reducing food waste.	Find the other efficient model to improve cold storage market standards.
26	Leo Sakaguchi ²⁶	Used a method to improve the Operational efficiencies to monitor and measures food waste, resizing the landfill bins.	Food Waste Reduction at Restaurants	Future work should be focused on improving food tackling the methods for measuring food waste.
27	Shweta AS ²⁷	Artificial Intelligence & HSV Model	Conversion of Traditional Fridge to Smart and Items waste reduced	Recommended to focus on the quality of the products inside the fridge.
28	Matthew Edward ²⁸	Raspberry Pi3, Node MCU, Photo Diode, temperature Sensor & Android Application	Conversion of the traditional fridge to the smart fridge and reducing the food item waste	Further work recommended updating the Photodiodes to RFID technology for identifying the presence of objects inside the fridge
29	Hsin-Han Wu ²⁹	Used RaspberryPi3, Light Sensor, IR Distance Sensor, cloud service which is Google firebase, touch screen and Android GUI.	Conversion of the traditional fridge to the smart fridge and reducing the food item waste	Further work suggested using more sensors to install on the raspberrypi3 to reduce the need for a plug system and apply this methodology for cabinets and living rooms.
30	Shivani Dalmia ³⁰	Real-Time information update regarding food waste in canteens	Food Waste Reduction In College	
31	Laura Michelin et al ³¹	Sharing for Money, Charity and Community	Distribution of food waste to charities, Communities.	Identify suitable models to reduce waste.
32	Ayesha Anzer et al ³²	firebase storage & app	Food waste reduction in Restaurants	Extending our app to have many types of donating users either from organizations such as restaurants, or a family or a single user.
33	L.Principato ³³	Planning, Pre-consumption, In-store are for Waste in House and Interviews conducted for outside home	Reducing food at House Level and outside House	Analysts are urged to fill the system with different factors and impacts that sway on inefficient conduct.
34	MM McCullough ³⁴	Described the models to reduce waste.	Reducing food waste in the supply chain	
35	S Jagtap et al ³⁵	Food waste tracker using Intelligent scale & Cloud Storage	Digitization of Food waste reduction tracking system	
36	SP Lakshmi Narayan et al ³⁶	MQTT Broker & Arduino Desktop & Android Application	Real-Time monitoring of Kitchen room	The data could give bits of information into the typical utilization of the kitchen products, and can be used to upgrade the system of fundamental need obtaining
37	G. Elavarasai et al ³⁷	MQ3 sensor, DHT11 & Arduino	Fresh fruit sensing for reducing food waste	Usage of these sensors for the boxes at the bottom.

Table 1: (Continued)

S. no.	Title/Citation Reference	Method/Technique/Component used	Results	Future Challenges
38	Grace Phiri et al ³⁸	Food Trek App using Smart Technology	Food waste reduction using the app	Further research is necessary to initiate permanent behaviour change.
39	Huiling Fan ³⁹	Theory of framework is discussed	Food safety and reduction of waste	
40	Hitendra Patel et al ⁴⁰	Cloud-based system for monitoring temperature	Food poisoning avoided	Automation for the adjustments in the hotter or cooler change the temperature in like manner
41	Rodolfo Garcia-Flores et al ⁴¹	Smart packaging and Flexible expiry dates and other technologies like BlockChain & IoT	Food Waste and loss at household and outside the house	
42	Liegeard J et al ⁴²	Intelligent packaging and Intelligent fridge	Food loss and food waste	Further examination ought to be attempted to investigate the socio specialized issues.
43	S Jagtap et al ⁴³	Convolution neural network (CNN), Image Processing and IoT.	Reducing potato waste in food processing	Further work will focus on the ability to handle multiple types of food waste at a higher speed and improve the performance of the system.
44	Matías Miguez et al ⁴⁴	IoT-based electronic price-tag	Reduction of food loss in the food supply chain	
45	Kun Wang et al ⁴⁵	Picture Sharing method using Image Processing and IoT.	Reducing food waste and Energy consumption	
46	Jason Kim et al ⁴⁶	Conducted online survey by keeping the following questions : Left over usage, awareness campaign and reducing fruit and vegetable waste	Reducing food waste	
47	G Venkatesan et al ⁴⁷	land fill model using IoT	Food Waste reduction	
48	Xiaoyan Gao ⁴⁸	SSD Detection Algorithm of Artificial Intelligence	Identifying food inside the fridge in turn waste item reduction	
49	Emiliano Lopez Barrera et al ⁴⁹	Based on the Food Availability (FA), Estimates of physical activities (EPA), basal metabolic rates (BMR) and Body Mass Index (BMI)	Impact of food waste across the globe on the perception of income.	
50	Tammara Soma et al ⁵⁰	Education campaigns: Hangouts, community engagement approach and gamification approach.	Food waste Reduction	
51	Debarghya Saha ⁵¹	YOLOv3 machine learning detection algorithm & RaspberryPi3	Food Item Detection and update of stock inside the refrigerator	To add more categories of items as well as continue improving our to better train the model for even more accuracy.
52	Pitchai ⁵²	Described Convolution Neural Network	To increase the production of potato.	To build the novel model and compare the results.