SMART SHOPPING SYSTEM FOR BILLING AUTOMATION

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ABSTRACT

Today's information era aims at digitalizing data and implementing efficient, intuitive and user friendly systems to simplify human life. Creating a smart cart that takes care of instantaneous billing is a leap towards a futuristic and fully automated shopping experience. Buying product in large grocery stores with a vast variety of products is a tedious and time consuming process which can be improved by automating the billing system. The smart shopping cart consists of a portable computational device (like raspberry pi) and an automatic product identification technology (like the radio frequency identification technology). Instant billing without long queues at counters and keeping track of expenditure real time are the two objectives of this intelligent cart. This paper is based on developing a project with the aim to reduce time spent on shopping of everyday items and making the process less tedious. Furthermore, it enables the consumers to utilize their time on other fruitful and more important activities.

Index Terms— Radio frequency identification, Raspberry Pi, digitizing, Smart Cart.

INTRODUCTION

The grocery industry is very important and many revolutionary inventions in this field have made shopping easier and a blissful experience. The recent evolution in technology and peoples understanding and acceptance of the technical advancements has made it possible to develop comfort in the grocery industry by making it systematic and fast paced. Also consumers' perception of privacy, trust and efficiency in present commerce systems highlight that the proliferation of electronic commerce technologies has massively transformed the way businesses are conducted.

Currently, products are lined up in stores and shoppers select through them. Customers fill their shopping carts according to the requirement and wait in long queues to pay the bill. It has been found that 80% of shopping time is spent in queues [6]. Furthermore, customers later may realize they have stuffed in their cart more than they can afford or they need. With that starts the segregation of 'important' and 'less important' items adding further to the time already spent. The unavailability of exact change starts another round of loitering and reduces customer satisfaction affecting the stores popularity and valued customer experience. In this work, we take the particular case of supermarkets. We propose shopping carts based on our

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smart cart design to address the following issues.

1) Customer dissatisfaction due to long waiting time during the check-out process.
2) Involvement of a lot of man-power and resources at the billing counters, which is expensive.

In order to address the above mentioned issues, we have come up with a smart shopping cart design that automates the billing procedure thereby saving the customers' time as well as reducing the stores annual expenditure and simplifying its resource management.

Automation has its own problems. Absence of human operators can potentially lead to inconvenience when the underlying technology fails. It may also lead to dishonest behavior of the customers. We propose and discuss the implementation of a solution that has redundancy built into it in order to reduce the probability of failure and keep any discrepancy in check.

The proposed smart futuristic shopping system combines existing technology like radio frequency identification (RFID) tags with scanners resulting in very low implementation cost. This idea is monetarily inexpensive and sustainable. It can be implemented quickly without the need of any prior experience by the store owner and customer.

The organization of this paper is as follows: Section II showcases past works and implementations related to the field. III gives an overview of the proposed idea followed by Section IV that presents the detailed system design. Section V gives the implementation details, Section VI discusses the result and feasibility issues, and Section VII concludes the paper by discussing the results of a survey for better understanding and interpretation of customers' views.

RELATED WORK

In [1] the authors have presented their idea in which each commodity in a mall will be attached with a RFID tag and each trolley will be attached with RFID reader which would be working on the ZigBee wireless module. A centralized system is present for any help and queries and for the billing transaction of the products by the customers. Even the exit gates of the mall are laced up with the RFID readers for detecting any theft. However, there is no user interface and hence it is not a user friendly system.

Vrinda et al in [2] have featured a cart equipped with   an RFID reader, a ZigBee transceiver and an LCD display. This smart shopping cart keeps an account of the bill made by keeping running total of the purchases. An LCD screen shows the total bill of the items present in the cart. However, this system does not have a user interface and ZigBee is used instead of a Wi-Fi module. This work, however, lacks built in security checks for discrepancies.

The smart shopping with the trolley application in [4] states that creation of an automated and centralized billing system can be used in malls and supermarkets. The customers need not wait in the queue at the billing counters for their bill payment because by the use of online payment portals via mobile application they would be able to pay the bill online without any queue. Customers have an additional option for bill payment using their credit or debit cards. But, like the work in [2], this structure is not user friendly and efficient as it assumes customers to be honest and has no built in verification system.

Authors in [3] featured that, the time spent at the queues for the bill payment in the shopping

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complexes can be cut off by the self scanning methodologies. Expiry date of a product is displayed while scanning. But there is no web application for user to communicate.

Authors in [5] have proposed shopping assistants that help the customers in locating the products inside the store, if any product has any discounts on the move of the customers inside the shopping mall. However, the assistant serves the purpose of simply locating products and not billing them. Hence, the problem of time being wasted in long queues remains unaddressed.

Overall, the existing systems have the following limitations:

1) They offer a regular cart without any system integrated to it.
2) There is no display of product details on the cart.
3) A limit on the budget and alerting system is absent.
4) They allow for scanning of products only at the check- out counter with the help of barcode on the product.
5) They require that the barcode should be noticeable on the top of commodities. Otherwise the product will not be read. However, the legibility of barcodes can be hindered by soil, humidity, water, corrosion.
6) The employees or owner of the mart should manually check for demand or depreciation in stock of a particular product.
7) Manpower is required to guide the customers through the mart to find the product of the product required.
8) Payment is made only at the counter after waiting in long queues.

PROPOSED SOLUTION- SMART SHOPPING CART

Our solution address the problem of long waiting times
And eliminates the limitations of existing solutions discussed in section I by offering three main benefits.

1) It creates a better, faster and more efficient shopping experience for the customers.
2) It minimizes the man-power required at the shopping mall, as the billing process at the check-out counters is eliminated altogether.
3) It monitors and notifies cases of discrepancies and deception, if any, thereby making the system attractive not only to the customers but also to the store owners.

Every Shopping Cart is equipped with a low powered raspberry pi running on Raspbian OS that serves as a host for local processing and bill generation and verification. A load- cell fitted at the base of the trolley measures the weight of the carts contents. A portable radio frequency identification scanner fitted onto the cart serves the purpose of scanning the RFID tag of individual item for identification .The cart also contains a secondary camera to cross verify the products providing verification in case of discrepancy using advance image recognition algorithm. Hence, the system handles the case of damaged barcodes. An alarm present in the cart is set off in case of emergency/discrepancy and a led sensor glows in case the actual weight on the cart does not match the weight calculated according to the bill generated in real time via the mobile application made available to the customer. This is depicted in figure 1

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Fig. 1. Smart Shopping Process

When a customer starts shopping, s/he must first login to their mobile app. Then, the customer needs to activate the cart by scanning their barcode which is displayed on the users' dashboard of the mobile application to the secondary camera fixed on the cart. The smart cart then connects to the server that contains the database that stores information of all the products of the store. Also, user specific information like the users shopping history can be accessed. Once the cart is activated, the customer can scan the RFID tag of the product via the RFID scanner available on the cart and add it to their shopping cart. The system generates detailed information of offers or discounts (if any) regarding the products bought by a particular customer by their previous bills (stored and maintained in the server) using data analytics and displays them on their dashboard as recommendations. After the customer finishes shopping, s/he then proceeds to the online/mobile payment such as android pay. In case of suspected fraud and discrepancy detected by the system, the customer is assisted by an attendant.

The capabilities of the proposed Smart Shopping Cart are

1) Instant generation of customer bill when products scanned.
2) Policing of fraudulent activities by measuring the weight of the products in the cart in real time. Fraud detected is indicated by a glowing LED and alarm on the shopping cart.
3) Recommend products related to past billings and display availability, popular offers and discounts via notifications.

4) Quick and secure check-out mechanism by offering mobile payment services like android pay and paytm [8].

DETAILED DESCRIPTION OF THE SMART SYSTEM

A. System Design

As the goal of the Smart Shopping System is automation, the first requirement is to have a portable scanner attached to every shopping cart. Hence, this design includes a portable RFID scanner, which is fitted to the cart. The RFID scanner is required to identify a product so that its price can be determined from the database, which stores all the relevant information about all the products includes its name, price expiration date and weight and other essential details. The weight attribute of a product has been chosen as a way to double-check the identity of the product in order to detect deception in the system. A load-cell has been configured   as a weight sensor. The output of the load-cell is used in the decision making process of the cart. If the weight of a product estimated by the load-cell is not the same as the actual weight of the product, it is interpreted as a   case of discrepancy and sets off the led, later an alarm as a precautionary step. The design involves a third level of check to further enhance the decision-making process, which makes use of Advance Image Processing Algorithms.

After the product is scanned and is being placed onto the cart, a picture of the product is taken by the secondary camera. After the weights of both the items are found to be same then a image comparison algorithm is run and compared to collection of images of the same product from different angles existing on the database verifying if they are the same products. This is similar to face recognition used for security purposes. If the image recognition test fails, it is interpreted as discrepancy and sets off the led for the customer. The processing, final billing and weight detection are all done in the cart making it

1) energy-efficient
2) have minimal network traffic
3) Reduce latency and computational load over low powered systems like raspberry pi.

This also ensures that the system maintains its performance even with a lot of customers in the store shopping   at the same time. If a person wants to exchange this product with another, they can remove current item from the billing list on the app and remove the product from cart to switch off the led light that will be set, and then continue by scanning the RFID of new item.

B. Operation of the Smart Shopping System

A typical trolley is expected to look like the one shown   in Figure 2. The functioning of the system is listed below.

1) A customer enters the Smart Shopping Center. On entering, s/he picks a Smart Shopping cart.
2) Every customer has to activate the cart by scanning their barcode, available on logging into the mobile application on the user dashboard, to the secondary camera.
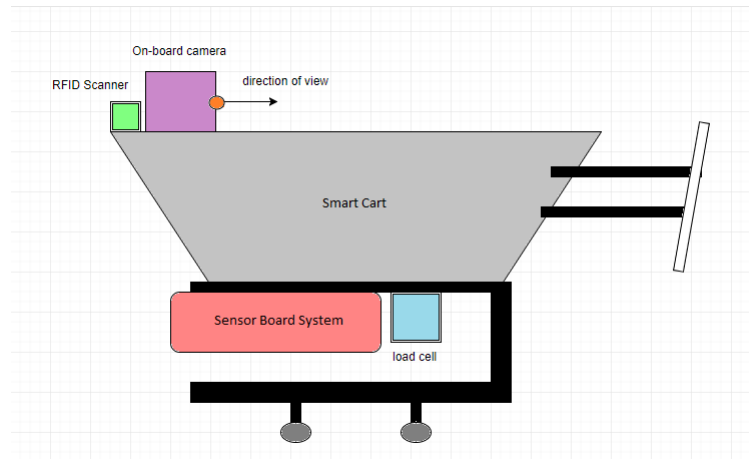
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Fig. 2. Smart Cart

3) When the customer picks up a product that s/he wishes to purchase, s/he first scans the RFID tag of the product using the scanner and then places it in cart. While the customer is scanning the product, a picture of the product is taken while placing it into the cart and checked in with the centralized database.

4) The sensor node is connected to database and can process billings. This information is then used to fetch relevant information about the product from the database corresponding to the RFID. The database consists of the following details: the product Id, name of the product, price and weight. The weight and price fields corresponding to the received RFID are extracted and added to the customers shopping list after verification.

5) An image recognition algorithm is performed once the image of the product via secondary camera is received by the raspberry pi. If the images do not match according to the scanned item, the led glows indicating a discrepancy else the product gets added to the customer's bill.

This procedure is repeated for every product the customer purchases. Finally, when the customer finishes shopping and the total weight of the cart is equal to the estimated weight of the items from the billing list, the payment options are accessible to the user. The customer can exit by paying and scanning system generated successful payment confirmation message through a scanner placed at the entrance. The customer id scanned to cart by the user prior shopping will be erased if the cart stays idle for more than 20 minutes   or after successful payment. This cart will automatically disconnect from the database and require activation thus be used by other customer.

On the other hand, in case of discrepancy, the led glows immediately and an alarm sets off after 5 minutes disabling all payment portals, preventing the customer to check out and notifying the shop owner. In case the customer decides to cancel a selected item s/he can do so by clicking on the cross mark available next to the item on list of items displayed on the mobile app. This will set off the led light which can be disabled by removing the same item out of the cart. The item removed is also scanned and checked if it matches the item removed on the list using the same image recognition algorithm used when adding an item. Then the change of weight is also measured and if matched the led turns off, the customer can continue shopping, check out or contact the manager in case of assistance.
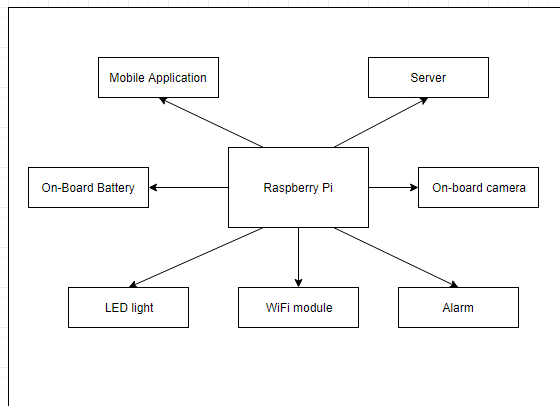
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Fig. 3. Smart System Internal Map

IMPLEMENTATION

A prototype has been made based on the design described in figure 3 .The various components that are used in the implementation along with the respective important considerations and justification of the choices made are explained in detail.

A. Portable RFID Scanner

The prototype uses a portable RFID scanner for implementation, scans the tag and sends details to the raspberry pi to compute the product details like weigh and other details. After a successful scan is done the app generates a green tick mark and adds the item to its billing list.

B. Weight Sensor

A load-cell is configured as a weight sensor. A load cell is a transducer which is used to convert a force into electrical signal, an analog output voltage. The load cell CZL601-3kg shown in figure 4 has been used, where 3kg denotes the Rated Capacity of the load cell. This is chosen as it is seen to be ideal for grocery stores.

Fig. 4. Load cell CZL601-3kg

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The cost of the load-cell depends on its precision; higher the precision, higher the price. The load cell is supplied with a DC voltage of 9 Volts with the help of a battery. The maximum output voltage that can be provided by this load cell is 1.948 mV X 9V = 17.532 mV. The load cell gives an output voltage which is almost proportional to the weight that is applied as seen in figure 5. It is not exactly linearly proportional to the weight due to many external factors such as hysteresis error, repeatability and temperature effects but can be calibrated accordingly and works as close to one in real time scenarios.
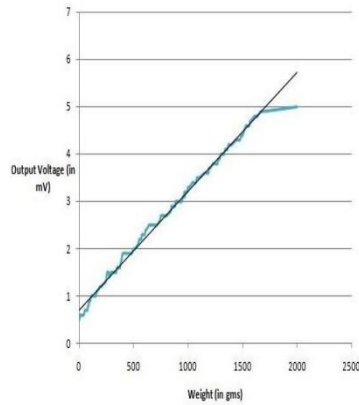

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Fig. 5. Load cell's output Voltage vs. weight applied.

C. Image Recognition

Deep learning is a subset of machine learning which automates traditional manual feature extraction from data. It can be classified as either

1) supervised(labeled dataset),
2) semi-supervised(partially   labeled and unlabeled datasets)
3) Unsupervised learning (unlabeled dataset).

Convolution Neural Network is a computing system inspired by the biological neural network. Such a system progressively learns and improvises by analyzing labeled datasets and uses analytics for better results.

Neurons in CNN are generally represented by real numbers, typically between 0 and 1. Neurons and synapses may also have a weight that varies as learning proceeds, which can increase or decrease the strength of the signal that it sends downstream. Each synapse between neurons can transmit a signal to another neuron. Further, they may have a threshold such that only if the aggregate signal is below (or above) that level is the downstream signal sent. Different layers may perform different kinds of transformations on their inputs. Signals travel from the first (input), to the last (output) layer, possibly after traversing hidden layers multiple times. Unlike neural networks where the input is a vector, input is a multi-channeled image usually 3 in regular cases. We take a filter and slide it over the complete image and along the way take dot product between the filter and chucks of the input image. The result of every dot product is a scalar and converges into a single value. The model built can now be validated and tested.

Deep Learning applications like Image recognition and speech processing requires working with huge matrices in parallel. In this study, Tensor flow with its powerful matrix processing functions, library implementing deep convolution neural networks for image recognition and big developer's forum is used for the implementation.

Transfer learning or inductive transfer is a research problem in machine learning that focuses on storing knowledge gained while solving one problem and applying it to a different but related problem. 'Bottleneck' is the penultimate layer just before the final output layer that actually does the classification. This layer contains the information on classifying different objects trained previously. By saving this layer which is a softmax regression we can train our new data on the pre-trained model thus reducing training time in long run with better

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accuracy.

Transfer learning helps in reducing the required computation power and time required in building a new model from scratch. Transfer learning is thus a quicker way to implement a classifier with small amounts of data. We use this technique to quickly train a model. We test and discuss the accuracy of adding 60, 75,150 and 300 images in the bottleneck layer of the trained inception_v3 model in section VI.

D. Processor

All the Shopping Carts are equipped with low cost Rasp- berry Pi running Raspbian Operating System equipped with a wireless LAN card, load sensor and a portable RFID scanner and a secondary camera that stays attached to the Cart. The pi is powered by a power bank for mobility which can last for a 24hrs on a single charge even under heavy usage. The system is programmed to calculate the weight as the product is being sensed by the load cell so that even if the product is dropped with a great force into the cart, it does not estimate a wrong weight based on the initial momentary thrust on the load-cell. Only after proper verification will the user is able to pay.

E. Database

The database which contains the information of all the products that are present in the store, resides on a server. For simplicity MySql database is being used. It consists of two main tables, one for storing details of products and other for storing customer details. The Products table consists of the following fields

- Products unique RFID (Primary key)
- Name of the product
- Price
- Weight of the product

The customer table consists of the following fields

- User ID (Primary key)
- User Barcode ID
- User name
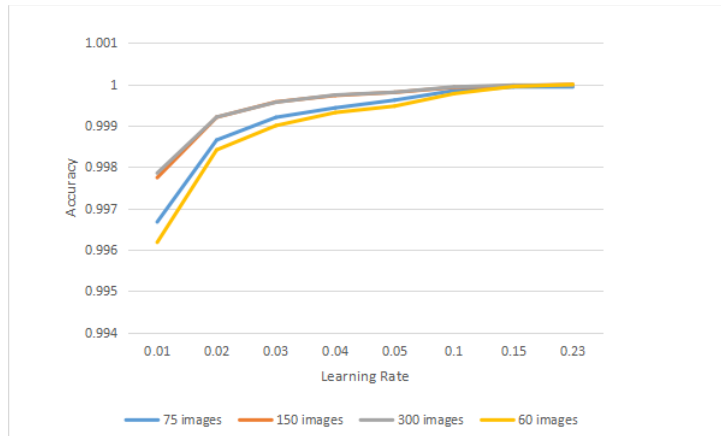- Password
- Past Bills.

Fig. 6. Accuracy vs. learning rate

The mobile application also supports a 'assist' button, meant to help the customers by alerting the attendant.

RESULTS AND FEASIBILITY

For product identification, CNN extracts feature points of the object in the image to provide a detailed description of the object. The implementation with deep CNN works well even if the customer places the product on the cart in a different angle or in poor lighting. The image identifier is built using transfer learning using 60, 75, 150 and 300 images and the accuracy is measured for each. This is plotted in Figure 6.   It is clear that with a larger number of training images, the accuracy with which images are identified is higher.

On 24th July 2017, a survey was conducted among 45 people from all walks of life. The purpose of the survey was to discover the average time spent on shopping and if automation can help in making the process less of a hassle for both customers as well as the shopkeepers. The survey consisted on two parts. The first dealing with customer details and shopping behavior. This included user age, occupation and shopping routine. The second part described to users   the smart shopping system and users were asked to rate the automation process, give their feedback and how it can be improved. From the data collected, the most significant insights are as follows. 90% of the survey takers were undergraduate students who either lived on campus or off campus, remaining 10% were working professionals. 27% preferred to order online via mobile applications like big basket [7] and other services. 73% preferred buying groceries and regularly visited their nearby shop at least once a day spending an average of 30-40 minutes finding it very time consuming.

The result of the survey is shown in figure 7. 70% are strongly convinced that the automated billing system shall be helpful. 20% found it to be good alternative but would need assistance in using a smart cart for the first time. 8% felt ambiguity in the system such as system response in case of power failures and wished for more simple-to-use option. A meager 2% were not convinced by the effectiveness of the system and thought it to be a costly setup.
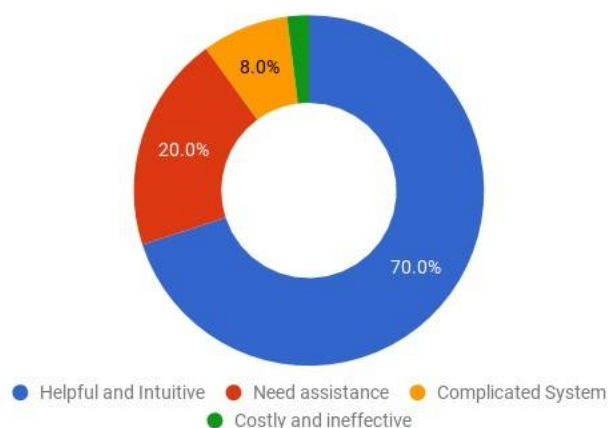
Fig. 7. Customer Response to Smart Shopping Cart.

Overall, majority took automation of billing counters with positive response and found it to be more efficient and less time consuming. Also giving the customer an option to pay using mobile/online was welcomed by many as it would be faster/economical and eco-friendly than standing in long queues on counters and help in digitization and transparency.

CONCLUSION

The project demonstrates the possibility of developing a Smart Shopping System which automates the entire billing procedure. The system proposed and the prototype built is highly reliable, fair, and cost-effective and hassle free. It is reliable and fair owing to the effectiveness of individual raspberry pi systems combined with a highly reliable Image Processing and Comparison technique using convolution neural networks. The system is also energy efficient. The decision making processes are done locally within the cart and requires activation by scanning the customers Barcode to process .The system is cost-effective as it requires only one passive sensor (the load-cell) and a RFID scanner that can be placed on a holder available on the cart. In the bigger picture, it improves customer shopping experience in stores while reducing the man-power requirements of the stores.

REFERENCES

[1] Mr. P. Chandrasekar and Ms. T. Sangeetha Smart Shopping Cart with Automatic Billing System through RFID and ZigBee, IEEE, 2014.

[2] Ms.Vrinda, Niharika, Novel Model for Automating Purchases using Intelligent Cart, e-ISSN: 2278-0661, p- ISSN:;1; 2278- 8727Vol- ume16,Issue 1, Ver. VII (Feb. 2014), PP 23-30.

[3] KalyaniDawkhar, ShraddhaDhomase, SamruddhiMahabaleshwarkar Electronic Shopping Cart

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For Effective Shopping based on RFID, International Journal of Innovative Research In Electrical, Electronic, Instrumentation And Control Engineering Vol. 3, Issue 1 pp 84-86, January 2015.

[4] Zeeshan Ali, ReenaSonkusare, RFID Based Smart Shopping and Billing, International Journal of Advanced Research in Computer and Communication Engineering, Vol. 2, Issue 12, December 2013.

[5] Dr.Suryaprasad J, Praveen Kumar B O, Roopa D Arjun A K, A Novel Low-Cost Intelligent Shopping Cart, Proceedings of the 2nd IEEE International Conference on Networked Embedded Systems for Enterprise Applications, NESEA 2011, Perth, Australia, December 8- 9, 2011

[6] Bauer, Alfred, et al.Shop floor control systems: from design to implementation. Springer Science & Business Media, 2012.

[7] https://www.bigbasket.com/

[8] https://paytm.com/

[9] Podolsky, Leon. "Smart Billing System." U.S. Patent Application No. 13/859,393.

[10] Randelman, Robert E., and Ronald R. Chance. "Automatic vehicle recognition and customer billing system." U.S. Patent No. 5,072,380. 10 Dec. 1991.

[11] Shekar, Sangeetha, Prashant Nair, and Abdelsalam Sumi Helal. "iGro- cer: a ubiquitous and pervasive smart grocery shopping system." Proceedings of the 2003 ACM symposium on Applied computing. ACM, 2003.

[12] Kahl, Gerrit, et al. "IRL SmartCart-a user-adaptive context-aware in- terface for shopping assistance." Proceedings of the 16th international conference on Intelligent user interfaces. ACM, 2011.

[13] Peck, Robert Michael, Charles Bauer, and Matthew Killian Carruthers. "Universal Fit Tablet Computer, Smartphone, Electronic Device Hold- ing Display Unit that Fits onto Grocery or Shopping Carts." U.S. Patent Application No. 13/615,376.

[14] Prater, Edmund, Gregory V. Frazier, and Pedro M. Reyes. "Future impacts of RFID on e-supply chains in grocery retailing." Supply Chain Management: An International Journal 10.2 (2005): 134-142.

[15] Simonyan, Karen, and Andrew Zisserman. "Very deep convolu- tional networks for large-scale image recognition." arXiv preprint arXiv:1409.1556 (2014).

[16] He, Kaiming, et al. "Deep residual learning for image recognition." Proceedings of the IEEE conference on computer vision and pattern recognition. 2016.

[17] Khotanzad, Alireza, and Yaw Hua Hong. "Invariant image recognition by Zernike moments." IEEE Transactions on pattern analysis and machine intelligence 12.5 (1990): 489-497.

[18] LeCun, Yann, Yoshua Bengio, and Geoffrey Hinton. "Deep learning." Nature 521.7553 (2015): 436-444.

[19] Schmidhuber, Jrgen. "Deep learning in neural networks: An overview." Neural networks 61 (2015): 85-117.

[20] Wu, Ren, et al. "Deep image: Scaling up image recognition." arXiv preprint arXiv:1501.02876

7.8 (2015).

[21] LeCun, Yann, Yoshua Bengio, and Geoffrey Hinton. "Deep learning." Nature 521.7553 (2015): 436-444.