

Smart Supermarket Cart – An EPS@ISEP 2023 Project

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Abstract. The technological revolution experienced over the last two decades in developed countries, together with changes in shopping behaviour, has led supermarkets to consider smart shopping trolleys. In recent years, several companies have tested and implemented smart services and devices, such as smart shopping carts with scanners, automatic payment methods, or self-payment locations, to maximise supermarket profits by reducing staff and improving the customer experience. In spring 2023, a team of six students enrolled in the European Project Semester at the Instituto Superior de Engenharia do Porto proposed the FESmarket, an innovative smart shopping cart solution. The user-centred design focused on making the shopping interaction and experience more efficient, comfortable, and satisfactory. Form (balancing aesthetics with innovation), function (selecting functionalities based on the most disruptive technologies), market (fulfilling the identified needs), sustainability (minimising the use of resources), and ethics (respecting human values) are the pillars of the project. FESmarket proposes a smart shopping trolley with a built-in touch screen with real-time information on the products and their location, cameras for product identification, an audio assistance system, a refrigeration chamber, and a mobile app interface for the customer. Finally, a proof-of-concept prototype was assembled and tested to validate the viability of the solution.

Keywords: Engineering education · European Project Semester · Smart shopping cart · Technology · Customer Experience · Supermarkets.

1 Introduction

The European Project Semester (EPS) is an educational and exchange program designed for students in engineering and related disciplines. EPS gives students the opportunity to work in international and multidisciplinary teams to tackle real projects. For this project, six students from different European countries came together in Porto, Portugal, to work on an EPS at the Instituto Superior de Engenharia do Porto (ISEP) [10].

From the initial smartifying of an everyday object project challenge, the team evolved to the smartification of a shopping trolley. Focusing on this problem, the

team concluded that smart shopping trolleys are new and have yet to become firmly established in supermarkets. Users either do not accept the product or do not find it very useful, efficient, and accessible. The question is then how to provide customers with an efficient, convenient shopping experience in a sustainable way?

Supermarkets have a strong interest in obtaining real-time customer data and shopping behaviour, as well as seeking customer loyalty. Automatic payment systems, scanners, shopping trolley prototypes, and supermarket apps are observed. FESmarket seeks to unify all these elements and bring them together in a coherent and efficient way. The intelligent shopping trolley integrates a camera and scales to detect products. A touch screen allows the user to find products, and know the status of purchases and discounts in real-time. It includes novel elements such as a refrigeration area inside the basket, as well as a side door to introduce heavy products. Inclusiveness is a key element of the product, which is why it includes a hearing aid system for the visually impaired, as well as haptic feedback on the trolley handle when the product is found. The product is designed to be sustainable, with fully recyclable and recycled materials, as well as a fully sustainable charge through solar energy. The mobile app allows the user to create and transfer the shopping list to the shopping cart, as well as view previous purchases, accumulated discounts, and product offers. Therefore, on the one hand, the shopping cart user will enjoy an efficient, pleasant, and intuitive shopping experience, while the supermarket will gain more customers, more brand loyalty, and will obtain huge amounts of real-time data that will be vital to increase its economic benefits. The product has been named FESmarket, a combination of the terms Fast-Efficient-Sustainable (FES), and market, all of which relate to the value proposition underpinning the product.

This article documents the development of the product and is divided into preliminary studies, which include related work, in this case, more market studies and concepts included in the solution, ethical concerns, marketing approaches, and sustainability. Next, the proposed solution is studied in detail, with the concept and design. Finally, the prototype is presented and the conclusion is drawn.

2 Preliminary Studies

In this chapter, the concepts of “smart shopping cart” and “user experience” are defined to provide a comprehensive understanding of intelligent shopping experiences in supermarkets. The focus is on their significance within the modern retail landscape. Furthermore, an exploration of existing market solutions and academic research endeavours is undertaken, contributing valuable insights for the development of innovative approaches to enhance the shopping experience.

Supermarkets, which emerged in the early 1900s, have become integral to modern societies, serving as central hubs for grocery shopping. As technology swiftly evolves, supermarkets seek to leverage these advancements to maximise economic benefits and elevate the overall user experience. However, a crucial

question arises: What constitutes a remarkable user experience? According to the ISO 9241-210 standard [11], the user experience encompasses an individual’s perceptions and responses derived from either using or anticipating the use of a product, system, or service. Consequently, various elements have emerged to optimise this experience, with intelligent shopping carts gaining significant attention.

Smart carts, equipped with cutting-edge computer and radio frequency identification (RFID) technology, seamlessly integrate into the shopping journey, offering multifaceted assistance to customers. They go beyond their traditional role as mere vessels for carrying items, transforming into intelligent companions that empower shoppers with unprecedented convenience and efficiency. Leveraging RFID technology, smart carts provide real-time information, such as the precise locations of items on a pre-defined shopping list. Additionally, they suggest alternative products based on personalised preferences, dietary restrictions, or real-time promotions. These carts also offer invaluable insights into nearby shelf displays, alerting customers to discounted items, fostering a sense of informed decision-making [3].

To enhance the collective understanding, an exploration of the state of the art in this domain is undertaken. By surveying existing market solutions and scientific literature, valuable insights are gained, serving as a solid foundation for the ambitious FESmarket project. This comprehensive examination of the current landscape identifies gaps, challenges, and emerging trends, ultimately paving the way for the conceptualisation and realisation of innovative solutions that effectively address these concerns.

2.1 Related Works

As mentioned above, numerous technological advances have taken place over the last few years. Within supermarkets, patents have been developed and companies have emerged to meet market needs. Focusing on the market, a number of companies have embarked on the investment and development of smart shopping trolleys. These products and ideas like Veeve [19], Amazon [18], Caper Inc. [2] and Tracxpoint [17] smart carts are very recent. While they attempt to improve user shopping experience, they have not yet taken off among users and supermarkets possibly because they do not fully meet the needs or suffer from inconsistencies. Below is a comparison table of all of them, from which useful conclusions can be drawn.

The comparison table between the different products on the market showing their features and weaknesses illustrates some very interesting results. All of them feature product scanning systems, interactive displays, weight sensors, and cameras. Despite implementing very advanced technologies, they lack work on aspects such as accessibility, design, and achieving coherence and uniformity of the elements. In other words, different technologies should not appear to have been forcibly joined together in a standard trolley, and there should be a relationship between form and function. On the other hand, aspects such as energy efficiency or sustainability hardly exist in these products.

Table 1. Smart Shopping Carts comparison

Smart shopping cart	Features	Weaknesses
Veeve	Intelligent item recognition	Limited availability and market presence
	Mobile app integration	Non accessible
	Integrated barcode	High cost
Amazon Dash Cart	Automatic item scanning	Requires an Amazon account and smartphone for use
	Integrated scale to accurately	High cost
Caper AI	Built-in touchscreen display for product information	Reliance on stable internet connection for real-time information
	Automated checkout and payment processing	Non accessible
Tracxpoint	Dynamic pricing and promotions	Limited availability and market presence
	Seamless integration with retailer's existing point of sale	Technical expertise needed
5mart	RFID tagging	Requires specialised infrastructure for RFID integration

In the realm of cutting-edge research, an exploration of the subject matter has yielded fascinating insights, enriched our understanding, and expanded our horizons. As we delve into this realm, we encounter a tapestry of remarkable innovations, each contributing to the evolution of shopping cart technology.

A notable contribution by Kumar et al. (2017) [13] unveiled a revolutionary shopping cart that employs RFID technology to scan items effortlessly. Gone are the days of manual scanning; instead, the mere presence of a product in the vicinity triggers its automatic detection and swift addition to the cart. Furthermore, customers are granted the convenience of viewing the immediate total and even removing scanned items from the bill at their discretion.

Enter the ingenious proposal by Wang and Yang (2016) [20], who advocate for the utilisation of Wireless Sensor Network (WSN) technology to monitor client actions in real-time. By doing so, the system can dynamically respond by presenting tailored promotions for specific products. Moreover, this visionary concept encompasses an interactive cart that not only provides customers with product information but also enables them to send queries, fostering a truly engaging shopping experience. The article further advocates for the deployment of wireless routers on each shelf, ensuring seamless navigation for customers, and averting chaotic crowds.

In a similar vein, Mekruksavanich (2020) [15] provides an innovative solution to the challenges faced by contemporary supermarkets. With the proposed shop-

ping cart, customers can effortlessly navigate to their desired items while being serendipitously exposed to current promotions along the way. Real-time billing calculations facilitate the hassle-free removal of additional goods. Remarkably, this implementation also equips the store with valuable insights regarding the availability of each item, empowering them to optimise their inventory management.

Mekruksavanich (2019) [14] further dazzles us with a shopping cart that boasts a built-in weight sensor, ingeniously integrating the scanning and billing processes. By recording the total weight of the goods and comparing it to the scanned items, a seamless and accurate billing process is initiated, revolutionizing the checkout experience.

Khairnar and Gawali (2017) [12] present a captivating notion—an expenditure limit that cannot be surpassed. Through a budget-setting feature, shoppers are alerted by a buzzer notification when their purchases reach the predefined budget threshold, ensuring fiscal prudence without sacrificing convenience.

Drawing from the realm of convenience and seamless transactions, Faisal et al. (2021) [9] propose a novel payment method utilising membership cards. This groundbreaking approach eliminates the need for traditional payments at the counter or cashier, streamlining the checkout process and enhancing efficiency. Additionally, a dedicated entrance gate exclusively for users of smart shopping carts is introduced, elevating the shopping experience to unprecedented heights.

Meanwhile, Zhang et al. (2022) [21] captivate our attention with a smart shopping cart that prioritises safety. Equipped with an emergency brake system, this innovative cart measures the space between objects ahead of the customer and relays commands to the controller to activate the brake system when the distance falls below a predetermined threshold. By safeguarding against collisions, this technology ensures a secure and accident-free shopping expedition.

Arciuolo and Abuzneid (2019) [1] bring forth a concept that simplifies the bagging process within the realm of smart shopping carts. By incorporating pre-placed bags directly into the cart, this ingenious design eliminates the need for separate bagging stations, providing shoppers with a seamless and efficient bagging experience.

In their quest to assist supermarkets in harnessing the potential of intelligent shopping carts, Mohanapriya et al. (2018) [16] proposes an intriguing solution. Leveraging the power of membership cards and Near Field Communication (NFC) technology, these visionary researchers envision a smart shopping cart that springs to life upon recognising an NFC-enabled membership card. This dynamic activation imbues the cart with intelligent capabilities, enhancing the overall shopping experience while maintaining compatibility with conventional usage when an NFC card is absent.

After a thorough analysis of the state of the art, a broader perspective of the subject matter has been achieved, accompanied by a comprehensive comprehension of the currently available resources. Consequently, this endeavour has facilitated the formulation of certain conclusions that will aid in the establishment of the necessary prerequisites. The key points of these conclusions can be

summarised as follows: *(i)* all smart trolleys have an interactive display, contactless payment and scanners; *(ii)* the system relies on barcodes or Artificial Intelligence; *(iii)* some include a supermarket mapping system; *(iv)* none has voice assistance; and *(v)* none uses recyclable materials.

2.2 Ethics

FESmarket recognises the importance of ethical engineering practices and aims to ensure that its contributions to society are both beneficial and aligned with ethical standards. The team understands that maintaining a positive reputation and attracting new clients requires conducting sales and marketing activities in a fair and honest manner. FESmarket commits to clearly communicating the advantages of its smart shopping cart without resorting to misleading methods or deceptive advertising practices.

Furthermore, FESmarket is dedicated to protecting the environment and actively takes steps to minimise its carbon footprint. The team prioritises the use of easily recyclable materials in the manufacturing of the smart shopping cart. To reduce carbon emissions and dependency on fossil fuels, FESmarket harnesses solar energy and utilises recycled plastic sourced from the ocean. Additionally, the team supports local providers to minimise transportation-related greenhouse gas emissions.

Safety, compatibility, and regulatory compliance are paramount considerations in the development of the smart shopping cart. FESmarket adheres to relevant European Union Directives to ensure the product meets necessary standards. These directives include the Electromagnetic Compatibility Directive [4], Low Voltage Directive [6], Radio Equipment Directive [5], Consumer Rights Directive [8], and General Data Protection Regulation [7]. Adhering to these guidelines guarantees the mitigation of side effects, ensures health and safety, prevent interference, and safeguards data security and privacy. FESmarket places great importance on transparency and accountability regarding data collection. Detailed information regarding the type of data collected, its purpose, and who has access to it will be provided to customers. The smart shopping cart will undergo thorough design and testing processes to ensure safety, reliability, and the integration of privacy and security measures.

2.3 Market

The team embarked on the development of a product focused on a target group between 18 and 40 years old. People with an intermediate notion of technological products and with an interest in wanting to improve their shopping experience in supermarkets, making it more efficient. FESmarket presents a smart shopping cart that improves the user experience in the supermarket unlike other current shopping carts, our FESmarket is intuitive, attractively designed, and sustainable.

The study of the current context for shopping carts identified a unique situation to enter the market. Since the last decade, there has been a very pronounced growth in market size. Figure 1 illustrates the 10-year forecast.

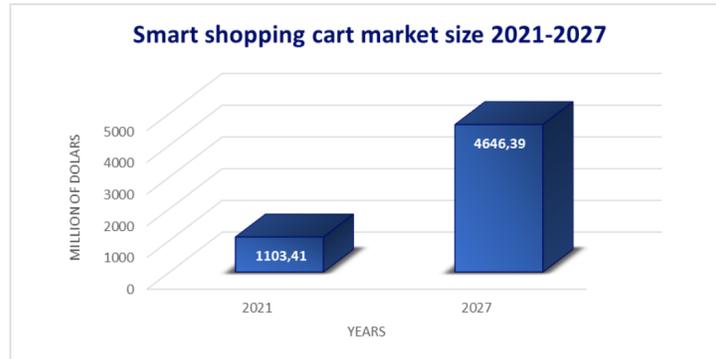


Fig. 1. Market value growth graph of the smart shopping carts sector

Not only has it been important to study the needs of supermarket users, who demand an accessible, intuitive, efficient, and cost-saving shopping experience. But the buyer of the product, in this case, the supermarkets, must also be taken into account. Therefore, after an analysis of the big brands, a generalised trend of investment in smart shopping trolleys has been observed. But in most cases, these are prototypes that are being tested.

In terms of competition, FESmarket wants to be ahead of the competition in terms of design and inclusiveness. These two elements are weak points of the other products, which open a gap in the market for the brand.

The Political, Economic, Social, Technological, Legal, and Environmental analysis has led to some very interesting conclusions. Basically, FESmarket presents a product with great interest in social and economic areas, providing a new shopping dynamic that on the one hand benefits the user through an efficient, intuitive, and personalised experience. On the other hand, the supermarket benefits from real-time data from shoppers, which allows personalising the purchase of each one and finding the needs to subsequently obtain more profit. But on the legal and political side, the processing of personal data is a sensitive issue that could eventually be regulated.

Taking into account the product, price, place, and promotion marketing mix, the team carefully elaborated their approach. The estimated price of FESmarket was set at 3000 €, which offered a competitive advantage over similar products priced between 5000 € and 10 000 €. To effectively reach the target audience, the team opted for online sales through the website, thus saving the costs associated with large shops or resellers. Promotion can have several strategies, for example, advertising. Advertising can be done through communication channels, such as

the Internet, and television. It is important to highlight the unique features and explain the benefits of the smart shopping cart. By promoting the product, will increase the number of customers and supermarkets that want to use the smart shopping cart. This will ultimately result in increased sales.

As for FESmarket, the team's marketing plan included a thorough analysis of the market, with the aim of maximising sales and improving the product's image. Several factors were taken into account, such as political influences and the product's strengths, weaknesses, opportunities, and threats analysis.

Branding plays a crucial role in capturing the attention of the target group and ensuring lasting recall. The name Fast-Efficient-Sustainable (FES) was chosen to convey the essence of the product, an efficient, fast, and sustainable product. In addition, the logo conveys the idea of technology, speed, and modernity.

In terms of marketing strategies, technology fairs are essential for the product, to make itself known at retail trade fairs. However, the team also used traditional methods, such as publishing the logo on the web.

Throughout the implementation of the marketing plan, the team emphasised continuous evaluation, optimisation, and improvement. Following the Plan, Do, Act, Check cycle, the effectiveness of the established marketing principles was regularly evaluated and appropriate measures were taken to ensure optimal results.

At this point, some requirements are extracted that will be essential for the correct development of the product:

- Purchase information, shopping list and living expenses.
- Store the products and keep them refrigerated
- Assisting people with disabilities
- Enable automatic payment
- Have an application
- Intuitive to use
- Innovative and ergonomic design
- Automatic scanning of products
- Sustainable materials
- Minimisation of user effort

2.4 Sustainability

To ensure the sustainability of the FESmarket solution, the team analysed its life cycle and environmental, social, and economic implications.

The environmental sustainability of the smart shopping cart is crucial given the increasing demand for eco-friendly products. Regarding FESmarket, factors like low environmental impact materials and energy-efficient manufacturing processes contribute to a greener product; features such as sensors and optimised routes help customers save time, and energy, and increase satisfaction; energy recovery systems and renewable energy sources translate into higher energy efficiency; recyclable and reusable materials, like recyclable plastics and metals,

result in environmentally friendly disposal; and modular components, which simplify the separation of recyclable parts, further promote the sustainability of the smart shopping cart.

The economic aspects are also important. An intelligent shopping cart should be designed to be cost-efficient in both production and operation. This approach helps reduce the overall costs associated with manufacturing and operating the shopping cart, creating an economically sustainable solution. Integrating business models that focus on long-term profitability can further improve economic sustainability, such as using the shopping cart as an advertising space or collecting data to understand customer behaviour. In addition, the use of sensors together with analytic tools can improve retail efficiency by providing valuable insights to improve the shopping experience and optimise merchandise management, thereby reducing costs and ensuring the economic sustainability of retail.

In the case of social sustainability, the team is committed to ensuring accessibility and inclusiveness for all individuals to benefit from the FESmarket shopping experience. To address any inequities, the team has incorporated voice assistance, support for colour-blind people, and a haptic mechanism into our smart shopping cart, specifically designed to assist visually impaired individuals. By implementing these features, the team aims to reduce barriers and promote equal access for everyone. In the realm of employee relations, FESmarket is committed to upholding fairness and equality. To foster an inclusive work environment, FESmarket will actively pursue a diverse workforce and create a workplace culture where every individual is treated with dignity, respect, and appreciation.

3 Proposed Solution

3.1 Concept

After a process of brainstorming and ideation of possible solutions to the problem initially posed, FESmarket appears. The concept is based on a series of functionalities and products that improve the user experience in the supermarket. The main product is a smart shopping cart that is linked to a mobile application for the user. A product that seeks maximum efficiency, sustainability, design attractiveness, and usability. On the one hand, the shopping cart is composed of cameras capable of scanning the products as they enter the cart. The weight detector system will check the correct relationship between the scanned product and its weight. A thermal insulation zone has been installed to keep the purchased products refrigerated. In addition, to improve accessibility, the product has a side door to introduce heavy products comfortably. Not only this, but it also has a voice assistance system for the visually impaired, and haptic feedback when detecting products. The focal point of the product is the touch screen on the trolley, which allows product-user interaction. It shows all the products in the shopping cart scanned as well as suggestions, discounts, and a real-time map of product locations. The user has an application linked to the shopping cart in order to identify the user profile with the shopping cart by scanning a

quick response (QR) from the shopping cart screen. The user can download their shopping lists, and view purchase history, and discounts. Finally, the system has a wireless charging area for the carts, which is powered by solar panels on the roof of the supermarket.

3.2 Design

For the design of FESmarket we wanted to visually transmit the idea of the product and the values that surround it. For this reason, we have opted for the use of dynamic yet rounded shapes to transmit the ideas of safety, efficiency, and intuitive use. In the trolley, the colours chosen also aim to reflect these ideas and the use of the logo on the trolley itself further links the brand to the product. The same chromatic code is also used in the application interface. The product was modelled in 3D with the computer aided design program SolidEdge and subsequently rendered with Keyshot.

As for the main materials used, aluminium was chosen for the structure due to its lightness and robustness. For the basket Recycled high-density polyethylene from the ocean, for its recyclability, steel wheels, and rubber. The insulation area is made of Extruded Polystyrene Foam (XPS) to maintain the desired low temperature. Diagrams of the main components of the shopping trolley are shown on Figure 2.

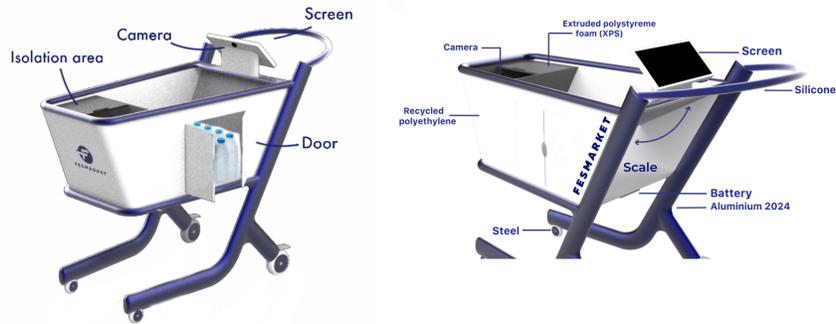


Fig. 2. Illustration of the smart shopping cart and its different parts

Cart The product aims to improve the user experience in supermarkets, making shopping efficient, intuitive, and enjoyable. The process consists of a series of steps that the user must follow. First of all, the customer picks up the shopping cart at the checkout area and scans a QR on the cart screen using the app. Then the shopping list that was in the application will appear and the screen will

indicate the location of the products as well as discounts and suggestions. The user will go to pick up the products, the trolley handle will vibrate to indicate the location of the product and a voice assistant will also indicate it. The product is then placed in the shopping basket and will automatically be recognised by the trolley and added to the shopping cart. The total amount will be charged to the card or account associated with the user’s profile. Finally, when the user has all the products, he/she will place them in bags, leave the trolley in the loading area again, and finally leave.

App In terms of software application, there are two for the product. On the one hand, the one for the shopping cart touch screen, which shows the user the total amount of the products in real time. In addition, it shows product location indications, discounts, product recommendations and more functionalities. The user’s mobile application allows the user to have shopping lists from different supermarkets on the device, purchase history, accumulated points, as well as suggestions generated by algorithms. Figure 3 illustrates the app frameworks 3.



Fig. 3. Application frames

4 Prototype Development

To prototype the product, a simpler version of the final product was built to scale. The main functions of the prototype are similar to the final product, however, the components and user experience are very different from each other. The focus of the prototype is to scan bar codes and refer to the correct products, determine the correct weight belonging to a product, and use the application on the interface.

4.1 Assembly

Cart The prototype’s aesthetic design was deliberately kept simple. A borrowed shopping cart from the student’s union, aeISEP, served as the foundation. The

most important features that needed to be checked were bar code scanning and the determination of the product weight. The following physical components were incorporated into the prototype: (i) Raspberry Pi; (ii) HX711 analog to digital converter; (iii) load sensor; (iv) web camera; (v) monitor, keyboard, and mouse.

Control The prototype works in the following way. The load cell sensor, webcam and monitor, mouse and keyboard are connected to the Raspberry Pi. The monitor, mouse and keyboard are used to control the Raspberry Pi. The webcam is controlled by a developed Python software script that can read bar codes and open a specific file or link if necessary. The load cell sensor is connected to the HX711 which is connected to the Raspberry Pi. The HX711 enables communication between the sensor and Raspberry Pi. A Python script communicates with the load cell which tares the load cell, transmits the gain factor and requests the requested weight. The load cell is calibrated and can determine the weight between 0 and 1 kg. Figure 4 shows a schematic of the connections for the prototype.

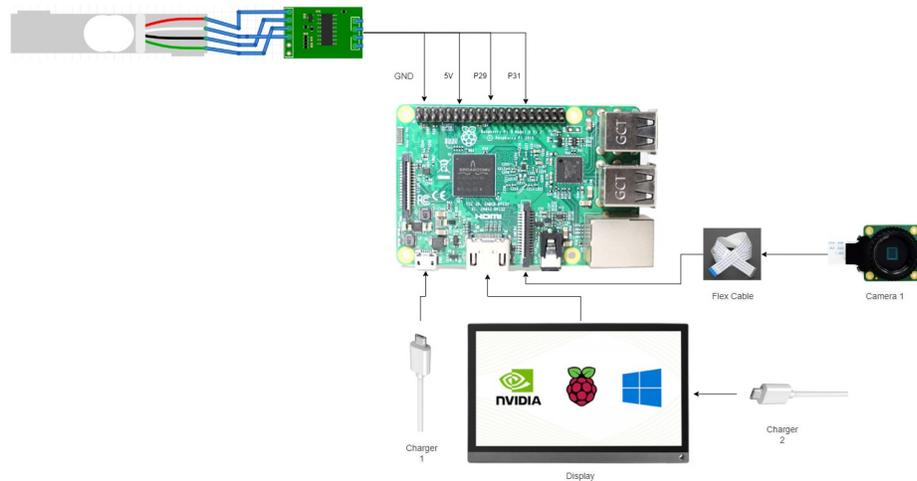


Fig. 4. Prototype circuit diagram

App For the smart shopping cart, an app is being developed for both a tablet and a smartphone. Both apps are written with Angular. The back-end API is written in C#, with the .NET Webapplication. The exact procedure is that the customer creates a shopping list in the mobile app with all the required items at home or on the go. The customer can then transfer the shopping list to the app on the shopping cart tablet in the supermarket using a QR code.

In the app, the customer can first create a customer account or log in to their existing account. Subsequently, the respective articles of the supermarket are listed according to categories and the customer is informed about current offers in the supermarket. The app on the tablet has a similar structure. In the centre is a map of the supermarket, on which the customer is informed about the exact location of the groceries. The app is connected to the cameras so that scanned objects are directly transferred to the app. The weight is determined by the scales and transferred to the app.

4.2 Tests and Results

Cart Testing is a key process for the project, as it allows the feasibility of the project to be assessed. For the FESmarket product, wanted to test both the application and the system for detecting the product in the cart. Unfortunately, in this stage of the project. Not all the testing of the prototype could be finished and will follow in the near future.

Control In order for the load cell in the prototype to work properly. It needs to be calibrated. To do so, you need to know the gauge factor of the load sensor. To obtain the gauge factor you need to have a working, accurate scale as a reference. The load sensor gives an line air output in arbitrary units depending on how much force is applied. The gauge factor is the slope of the linear function of the actual mass as a function of the arbitrary units. The gauge factor is yet to be determined.

The web camera is able to decode barcodes, and open a specific file or url. The web camera scans the barcode frequently. If it has the same barcode 5 times in a row it will open the specific file or uniform resource locator depending what the barcode is.

App

Table 2. Results of the functional tests of the application.

Software					
URL	Method	Result	Size	μ (ms)	σ
Cart					
/api/v1/Cart	GET	OK	1.41 KB	50.8	4.97
/api/v1/Cart	POST	OK	339 B	89.4	38.85
/api/v1/Cart	PUT	OK	458 B	65.2	14.13
/api/v1/Cart	DELETE	OK	458 B	124	21.48
/api/v1/Cart/{id}	GET	OK	499 B	64.6	29.94
/api/v1/Cart/Register	POST	OK	461 B	88.2	44.10
/api/v1/Cart/Unregister	POST	OK	464 B	125.2	127.38
Grocery List					
/api/v1/GroceryList	GET	OK	562 B	102.2	73.18
/api/v1/GroceryList	POST	OK	339 B	88.2	33.81
/api/v1/GroceryList	PUT	OK	338 B	95.4	46.29
/api/v1/GroceryList	DELETE	OK	338 B	105	21.37
/api/v1/GroceryList/{id}	GET	OK	562 B	61.4	31.09
/api/v1/GroceryList/Product	POST	OK	540 B	66.6	21.03
/api/v1/GroceryList/Product	PUT	OK	1.24 KB	69.2	27.40
/api/v1/GroceryList/Product	DELETE	OK	1.06 KB	111.4	6.23
Order					
/api/v1/Order	GET	OK	1.39 KB	84.6	77.41
/api/v1/Order	POST	OK	383 B	123.4	107.58
/api/v1/Order	PUT	OK	369 B	63.6	9.50
/api/v1/Order	DELETE	OK	369 B	123.2	13.37
/api/v1/Order/{id}	GET	OK	371 B	69	33.57
/api/v1/Order/Product	POST	OK	1.17 KB	224.2	164.09
/api/v1/Order/Product	PUT	OK	1.17 KB	70.6	5.50
/api/v1/Order/Product	DELETE	OK	369 B	165.8	114.44
Product					
/api/v1/Product	GET	OK	37.39 KB	109	30.56
/api/v1/Product	POST	OK	440 B	70	17.10
/api/v1/Product	PUT	OK	440 B	67.2	16.75
/api/v1/Product	DELETE	OK	439 B	123.2	14.62
/api/v1/Product/{id}	GET	OK	810 B	67.6	27.75
/api/v1/Product/barcode	GET	OK	810 B	70.2	24.50
Store					
/api/v1/Store	GET	OK	1.36 KB	69.8	41.55
/api/v1/Store	POST	OK	275 B	61.4	17.54
/api/v1/Store	PUT	OK	450 B	82.8	32.84
/api/v1/Store	DELETE	OK	450 B	123	24.20
/api/v1/Store/{id}	GET	OK	450 B	96.4	63.26
User					
/api/v1/User	GET	OK	1.51 KB	68.2	29.25
/api/v1/User	POST	OK	323 B	71.2	27.67
/api/v1/User	PUT	OK	319 B	70.8	9.88
/api/v1/User	DELETE	OK	318 B	138	31.35
/api/v1/User/{id}	GET	OK	318 B	53.6	3.91

5 Conclusion

5.1 Project Outcomes

The project outcomes have successfully addressed the main challenges encountered by customers during grocery shopping, offering a practical solution. The integration of cutting-edge technologies, including cameras, scales, touch screens, and a mobile app, has transformed the shopping experience significantly. By providing features such as product identification, real-time information, and instant discounts, customers can enjoy a more efficient, enjoyable, and intuitive shopping journey. In addition, the FESmarket places great importance on inclusivity by incorporating accessibility tools such as voice assistance and haptic feedback, ensuring that individuals with visual impairments can navigate the store effortlessly and independently. Another noteworthy accomplishment of this project is the emphasis on sustainability. The cart reduces its environmental impact by utilising recyclable and recycled materials as well as solar energy for charging.

The introduction of the smart shopping cart not only enhances the customer experience but also provides supermarkets with several benefits. By offering a superior shopping experience, supermarkets can attract a larger customer base, foster brand loyalty, and ultimately drive economic growth. Furthermore, the smart shopping cart generates a substantial amount of real-time data, which is invaluable for supermarkets to optimise their operations, devise customised marketing campaigns, and make informed business decisions.

Overall, the results of the FESmarket initiative show how it has the potential to change the retail sector. Through its combination of technological innovation, inclusivity, sustainability, and data-driven insights, the smart shopping cart sets the stage for a more seamless and personalised shopping experience, benefiting both customers and supermarkets in equal measure.

5.2 Personal Outcomes

- *“By participating in the European Project Semester, I have gained a lot of knowledge that will definitely help me in the future. On the one hand, it has strengthened my self-confidence, working with people from other countries in a foreign language and with a common goal. I believe that my skills acquired over the years have been very useful and have allowed me to discover something I really enjoy, leading projects. Working with diverse people, from other academic domains and different cultures has enriched me greatly. Working all with the same objective, overcoming obstacles together, and helping each other at all times has made me have a much more global vision of everything, going beyond my area of knowledge.”* – Miquel Orós
- *“Taking part of the European Project semester was an unique experience for me. The fact that you have to work with different people, with different nationalities and academic background represent a challenge but also a perfect way to learn new things.”* – Marian-Daniel Robu

- “During my exchange at ISEP working on the European Project Semester, I have had purely positive experiences. I arrived with high expectations and they have been met. In particular, I liked working with other nationalities. It has taught me skills that I will take with me into the future as an engineer and, on a personal level, it has contributed a lot to my development as a person. This experience has allowed me to develop in communication, cultural intelligence, adaptability and teamwork on a new level.” – Hessel Jacob van Klaveren
- “I have to admit that participation in the European Project Semester has been incredibly rewarding and life-changing. The projects each group worked on went beyond theoretical exercises, presenting real-life issues with tangible consequences. Being able to collaborate with students from different European countries on actual projects has opened up new horizons for me and enhanced my comprehension of various cultures, perspectives, and problem-solving methods. The European Project Semester also gave me the chance to build a network of international contacts and lifelong friendships. Building connections across national boundaries and learning about many cultures, languages, and traditions has been a fascinating experience.” – Dominika Marta Gajda
- “During my European Project Semester, I had the great chance to collaborate on an project with a varied group of international students. Working with people from diverse countries broadened my awareness of different cultures, and ways of thinking. We accomplished the assignment effectively by working together and overcoming obstacles. The information and abilities I obtained on this unforgettable adventure have provided me with priceless instruments for the future. Participating in the European Project Semester has genuinely transformed me into a more versatile, open-minded, and internationally aware person, and I am glad for the lifetime connections I have made along the journey.” – Jelte Van Dyck
- “During my participation in the European Project Semester, I achieved several personal goals and expectations. I was able to gain valuable international experience and enhance my skills by working with students from different countries and cultures. By working together, I have learned to respect different opinions and to resolve conflicts constructively. The EPS has also given me the opportunity to strengthen my project management skills. I have learned to effectively plan, organise and successfully implement projects. Furthermore, my personal development was also enhanced. I was able to improve my communication skills, strengthen my presentation techniques and learn effective time management strategies.” – Tobias Krings

References

1. Arciuolo, T., Abuzneid, A.s.: Simultaneously shop, bag, and checkout (2sbc-cart): A smart cart for expedited supermarket shopping. In: 2019 International Conference on Computational Science and Computational Intelligence (CSCI). pp. 1162–1167 (2019). <https://doi.org/10.1109/CSCI49370.2019.00219>

2. Caper AI: AI-powered Smart Carts & Checkout Systems (2022), <https://www.caper.ai/>, [Accessed in May 2023]
3. Collins English Dictionary : Smart cart definition and meaning: Collins English Dictionary (2023), <https://www.collinsdictionary.com/us/dictionary/english/smart-cart>, [Accessed in May 2023]
4. European Commission: Electromagnetic Compatibility (EMC) Directive (2014), <https://ec.europa.eu/growth/sectors/electrical-engineering/emc-directive/>
5. European Commission: Radio Equipment Directive (RED) (2014), https://ec.europa.eu/growth/sectors/electrical-engineering/red-directive_en
6. European Commission: The Low Voltage Directive (LVD) (2014), <https://ec.europa.eu/growth/sectors/electrical-engineering/lvd-directive/>
7. European Commission: Data protection in the EU (2016), https://commission.europa.eu/law/law-topic/data-protection/data-protection-eu_en
8. European Commission: Consumer Rights Directive (2019), https://commission.europa.eu/law/law-topic/consumer-protection-law/consumer-contract-law/consumer-rights-directive_en
9. Faisal, T., Awawdeh, M., Habte, D., Berhanu, H., Kifle, K., Misghina, L., Bashir, A.: Smart cart with multi-shopping solutions. *International Journal of Interactive Mobile Technologies (iJIM)* **15**(24), pp. 77–93 (Dec 2021). <https://doi.org/10.3991/ijim.v15i24.26397>, <https://online-journals.org/index.php/i-jim/article/view/26397>
10. ISEP : ISEP - Instituto Superior de Engenharia do Porto (2023), <https://www.isep.ipp.pt/>, [Accessed in May 2023]
11. ISO: ISO 9241-210:2019 (2019), <https://www.iso.org/standard/77520.html>, [Accessed in May 2023]
12. Khairnar, P.K., Gawali, D.H.: Innovative shopping cart for smart cities. In: 2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT). pp. 1067–1071 (2017). <https://doi.org/10.1109/RTEICT.2017.8256762>
13. Kumar, A., Gupta, A., Balamurugan, S., Balaji, S., Marimuthu, R.: Smart shopping cart. In: 2017 International Conference on Micro-electronic Devices, Circuits and Systems (ICMDCS). pp. 1–4 (2017). <https://doi.org/10.1109/ICMDCS.2017.8211723>
14. Mekruksavanich, S.: The smart shopping basket based on iot applications. In: 2019 IEEE 10th International Conference on Software Engineering and Service Science (ICSESS). pp. 714–717 (2019). <https://doi.org/10.1109/ICSESS47205.2019.9040750>
15. Mekruksavanich, S.: Supermarket shopping system using rfid as the iot application. In: 2020 Joint International Conference on Digital Arts, Media and Technology with ECTI Northern Section Conference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI DAMT & NCON). pp. 83–86 (2020). <https://doi.org/10.1109/ECTIDAMTNCN48261.2020.9090714>
16. Mohanapriya, D., Anas, R., Nandhini, P., Deepika, N.: Design and implementation of smart basket cart using near field communication. *Indian Journal of Emerging Electronics in Computer Communications* **5**, 778–785 (January 2018)
17. TRACXPOINT: Artificial Intelligence Shopping Cart (2023), <https://tracxpoint.com/>, [Accessed in May 2023]
18. Veeve: Amazon Grocery Cart (2022), <https://www.amazon.com/b?node=21289116011>, [Accessed in May 2023]
19. Veeve: Shopper Engagement Platform for the Physical Store (2023), <https://veeve.io/>, [Accessed in May 2023]

20. Wang, Y.C., Yang, C.C.: 3s-cart: A lightweight, interactive sensor-based cart for smart shopping in supermarkets. *IEEE Sensors Journal* **16**(17), 6774–6781 (2016). <https://doi.org/10.1109/JSEN.2016.2586101>
21. Zhang, J., Liu, Z., Kang, C.: Design and research of intelligent shared shopping cart based on internet+. In: *2022 3rd International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE)*. pp. 246–249 (2022). <https://doi.org/10.1109/ICBAIE56435.2022.9985795>