UiA University of Agder

Master

ENHANCING FOOD PRODUCT INFORMATION LABELS THROUGH AUGMENTED REALITY

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Abstract

Food product labels play a crucial role in conveying information from food producers to consumers. As consumers recognize the significance of label information, the need to access complete information becomes paramount so that they can make the best choices based on their different health goals.

Health considerations vary from person to person; some have restrictions from doctors due to health conditions, some individuals are sensitive to allergenic foods, others prioritize maintaining a stable weight, and some are already overweight, aiming to decrease their weight, while others are slim and wish to increase their weight. Additionally, diverse beliefs and cultural practices influence dietary choices.

Due to this wide range of considerations, information on labels should be sufficient for all individuals, enabling them to make informed decisions when purchasing or consuming food.

This research project aims to address challenges related to the availability, completeness, and findability of information on food product labels. These challenges arise from the limitations of package size, which cannot accommodate all necessary information, and findability issues resulting from attempting to include too much information on small package sizes, leading to information overload. The research seeks to find innovative solutions to improve food product labels and enhance consumers' ability to access complete information for their individual health considerations.

Recognizing the global nature of the issue, data was collected from people located in different locations worldwide to ensure diverse perspectives. Emphasizing user needs, a Human-Centered Design approach was utilized, highlighting challenges arising when information is missing. Integrating this global perspective and Human-Centered Design approach, the research aims to contribute to addressing challenges in food labeling and fostering a universally applicable solution that aligns with consumers' diverse needs.

This work contributes to advancing the application of Augmented Reality (AR) technology in food retail environments. The research advances our understanding of how AR technology can be developed to enhance the availability of information on labels, fostering informed consumer choices.

In this report, I utilized the language model GPT-3.5 (OpenAI, 2023) to generate ideas and arguments, as well as for grammar and spelling corrections. I did not use GPT-3.5 to compose entire paragraphs or chapters. Instead, I employed it solely for generating suggestions that I subsequently evaluated and incorporated into my work.

Keywords:

Availability, Completeness, Findability, Food product labels, Augmented reality, Human-centered design

Contents

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List of abbreviations

2D	Two-Dimensional
3D	Three-Dimensional
AI	Artificial Intelligence
API	Application Programming Interface
App	Application
AR	Augmented Reality
CSS	Cascading Style Sheets
DDR	Double Data Rate
FAO	Food and Agriculture Organization
FDA	Food and Drug Administration
GB	Gigabyte
GHz	Gigahertz
GPT	Generative Pre-trained Transformer
HCD	Human-centred Design
HTML	HyperText Markup Language
ID	Identification
IDE	Integrated Development Environment
MR	Mixed Reality
P	Participant
PC	Personal Computer
PTC	Parametric Technology Corporation
QR code	Quick Response Code
QR reader	Quick Response Code Reader
RAM	Random-Access Memory
ROM	Read-Only Memory
SIKT	Senter for Informasjons- og kommunikasjonsteknologi
SUS	System Usability Scale
SDK	Software Development Kit
TB	Terabyte
TELLS	Transformative Education and Lifelong Learning for Sustainable Growth
UI	User Interface
UXML	Unity Extensible Markup Language
USS	Unity Style Sheet
URL	Uniform Resource Locator
USB	Universal Serial Bus
VR	Virtual Reality
WCAG	Web Content Accessibility Guidelines
WHO	World Health Organization

Chapter 1

Introduction

1.1 Research background and problem statement

Unhealthy diets, recognized as a global health concern by the World Health Organization (WHO), contribute significantly to the premature deaths of 8 million individuals annually[101]. The selection of food, tailored to each individual's health condition, is crucial in addressing this public health issue, considering the diverse health situations people face. To navigate this complexity, consumers must be well informed, having full access to complete and easily accessible information on food product labels, guiding their purchasing and consumption choices.

In response to the escalating health risks linked to unhealthy diets, health organizations such as the Food and Agriculture Organization (FAO)[28] and the Norwegian Food Safety Authority[84] have established guidelines governing food product labeling. These guidelines provide clarity on the essential elements required on each packaged food, including food description, list of ingredients, nutrient facts, allergen information, usage instructions and more[54].

However, these regulatory efforts have encountered challenges, particularly due to the constraints posed by the size of food packages, on which labels should be written. Certain policies have granted exemptions to food product labeling requirements, permitting the omission of specific information for products with small packaging sizes[83]. This exemption presents a unique challenge in food product labeling, potentially resulting in the absence of critical information. This, in turn, affects the availability and completeness of information, further complicating the task for consumers in making informed choices.

On the other side, food producers sometimes attempt to include all important details on small-sized packages. This effort leads to information overload, posing a challenge for consumers trying to find specific information and causing frustration, as well as raising concerns about their ability to make informed and healthy dietary choices.

This research project aims to address the challenges related to the availability, completeness, and findability of information on food product labels. As a solution, the research seeks to explore and implement augmented reality (AR) technology to enhance food labeling. The goal is to use this technology to provide complete and findable information on food product labels, empowering consumers to make informed choices and reducing the burden of diet-related health issues.

1.2 Scope

The scope of this study is to address challenges faced by consumers in utilizing information from food product labels, specifically concentrating on enhancing the availability, completeness and findability of such information.
The project includes a review of relevant research and studies to gain a deeper understanding of these challenges and to identify optimal solution.

The project involves user's need analysis to implement usable solution through the design and development of an Augmented Reality (AR) application, assisting consumers in making informed food choices.

1.3 Research questions

1. How and for what purposes do consumers use food labels ?
2. How can augmented reality be designed and developed for enhancing food product labels ?
3. Can augmented reality effectively enhance food product labels ?

1.4 Objectives

1. Investigate the challenges consumers face when using food product labels to obtain information, including issues related to completeness, availability, and findability
2. Design and develop an application using Augmented Reality (AR) technology to enhance food information labels with the goal of improving the availability, findability, and completeness of information
3. Evaluate the effectiveness of the food label application through user testing.

1.5 Project timeline

In my research project, I employed the Project Timeline tool, a visual representation of tasks arranged chronologically[65], to provide an overview of the entire project from start to finish. This tool played a role in planning, organizing and executing tasks, facilitating time management, allocating resources, monitoring progress and anticipating challenges.

No	TASKS	START DATE	DUE DATE	DAYS
1	Research Background and Problem Statement	14-Aug-23	18-Aug-23	5
2	Scope of the study	21-Aug-23	25-Aug-23	5
3	Research Questions	28-Aug-23	30-Aug-23	3
4	Objectives	31-Aug-23	1-Sep-23	2
5	State-of-the-art	4-Sep-23	29-Sep-23	20
6	Specify context of use	2-Oct-23	6-Oct-23	5
7	Specify the user requirements	9-Oct-23	11-Oct-23	3
8	Application design and development	12-Oct-23	8-Dec-23	42
9	Evaluate the design	13-Nov-23	15-Dec-23	25
10	Findings and Interpretation	18-Dec-23	29-Dec-23	10
11	Conclusion and future work	2-Jan-24	5-Jan-24	4
12	Thesis submission	15-Jan-24	15-Jan-24	1
13	Defense	22-Jan-24	2-Jan-24	1

Table 1.1: Project timeline

Chapter 2

State-of-the-art

This chapter presents the definitions and concepts associated with shopping experiences, product labeling activities, Augmented Reality (AR), barcodes, QR codes, and related works. Through this exploration of the current state-of-the-art and existing literature, my objective is to provide context to my research and align it within the broader domain of food labeling and consumer information availability.This chapter introduces the definitions and concepts associated with shopping experiences, product labeling activities, immersive technologies, Augmented Reality (AR), barcodes, QR codes, and explores related work. Based on the literature review, my objective is to provide context to my research and align it within the broader domain of food labeling and consumer information availability.

2.1 Shopping experience and product labeling

2.1.1 Shopping experience

Shopping experiences encompass the entire process that consumers go through when searching for, evaluating, and purchasing products. There are three critical factors in the customer's shopping experience in the context of innovative technologies: channel choice, value dimensions related to convenience and enjoyment, and social interaction. All these factors are highly intertwined and influence each other [61].

2.1.2 Product labeling

Labelling (Labeling) is the process of assigning a label to a product to make it more recognizable and identifiable by adding products information and the manufacturer[60].

2.1.3 Food labeling

A label consists of valuable verbal information about the products such as the product's manufactured date, producer name, address, ingredients used in products, product's benefits, product expiry date, how & when to use the products, and other necessary information customers seek to know[60]. It is one of the most important and direct means of communicating information to the consumer[27].

The internationally accepted definition of a food label is any tag, brand, mark, pictorial or other descriptive matter, written, printed, stencilled, marked, embossed or impressed on, or attached to, a container of food or food product sale[27].
As such the important information is attached to the product by labeling, it makes customers feel blessed while identifying and making a purchase decision on what they want to buy[60].
FAO promotes Food Label as an effective tool to protect consumer health in terms of food safety and nutrition[27].
The labeling must be correct, provide sufficient information and not mislead consumers[84].

2.1.4 Essential information required for food labeling

The following is a list of essential information required on food product labels, as outlined by The Norwegian Food Safety Authority[53]:

- **The description** of the food must tell what kind of product it is. All foodstuffs must have a name or designation, and in certain cases an additional designation.
- **The list of ingredients** must indicate what the food is made of. The ingredients must be listed in descending order of weight. In the list, the ingredient that has the most should appear first, the second most abundant as number two and so on.
- **Additives, enzymes and flavorings** in foodstuffs must be stated in the list of ingredients. Additives must be indicated with an E-number and/or specific name. The function of the additive must also be stated, for example antioxidant.
- **Substances that can cause allergies or intolerances** must be highlighted in the list of ingredients, for example in bold or italics, so that they are more visible.
- **Quantities of ingredients** must be indicated if an ingredient is highlighted in the labeling by means of text or illustrations. It must state how many percent of this ingredient or category of ingredients is in the product. For example, how much oats are in an oat bread.
- **Net content** , which is how much of the product the package contains, must be stated in weight or volume.
- **The shelf life** must be indicated with "Best before..." or "Last consumption day...".
- **Conditions for storage and use** must be stated in the labeling if necessary.
- **The name or business name and address** of the operator who sells food products in his own name or company name must be stated on the packaging.
- **Country of origin** must be stated in some cases, for example for honey, fresh fruit, fresh meat.
- **Instructions for use** if necessary for the food to be used correctly
- **Alcohol content** must be stated when the alcohol content exceeds 1.2 per cent by volume. The alcohol strength must be indicated with the symbol of percent by vol.
- **The nutrition declaration** provides information about the nutrients in the food

2.1.5 Exceptions to essential information requirements in food labeling

According to Article 16 of the Regulations on Food Information for Consumers by the Norwegian Food Safety Authority, there are exceptions to essential information requirements in food labeling in specific cases[83]:

- For very small packaging with the largest surface being less than 10 cm^2, it is sufficient to include only the designation, allergenic ingredients, net content, and shelf life.
- When the largest surface is less than 25 cm^2, there is no requirement for a nutrition declaration, provided that the packaging is not marked with nutritional or health claims.
- If the product's content is below 5 mg or 5 ml, there are also certain exceptions regarding the information that needs to be included on the label.

Certain foods may be exempted from certain food label requirements, including nutrient declaration and others, based on small packaging, as specified in the guidelines on nutrition by Codex Alimentarius International Food Standards.[28].

2.1.6 Allergen food labeling

Allergen food labeling is a fundamental component of food safety and consumer protection. It encompasses the practice of clearly and accurately identifying the presence of common allergenic ingredients in food products. This labeling is essential to safeguard the health and well-being of individuals with food allergies or intolerances, enabling them to make informed choices and avoid potentially life-threatening reactions. Food businesses need to tell customers if any food they provide contains any of the listed allergens as an ingredient[29]

There are 14 categories of ingredients that must always be stated in the labeling when they are used in a food product. Below you will find examples of foods that contain allergens [82].

- **Cereals containing gluten**: This includes wheat, rye, barley, oats, spelt, korasan wheat and the like. These cereals are often found in foods containing flour, such as croutons, bread and baked goods, cakes, couscous, processed meat and fish products, sauces and soups. The type of grain must be stated in the labelling, but it is up to the manufacturer whether "gluten" is also stated.

- **Shellfish**: This includes crab, lobster, prawns, krill, crayfish and scampi etc. Shellfish are often found in salads. These ingredients can also be found in shellfish and fish dishes, in wok dishes, sauces and the like for use in Asian and Oriental dishes.

- **Eggs**: Eggs are often found in cakes, mayonnaise, soufflés, pasta, pies, some meat products, sauces, desserts and foods that have been brushed with egg.

- **Fish**: Fish is often found in shellfish and fish dishes, liver paste, salad dressings, tapenade, broth and in Worcester sauce.

- **Peanuts**: Peanuts are often found in biscuits, cakes, desserts, chocolates, ice cream, peanut oil, peanut butter, Asian and oriental dishes.

- **Soya**: Soya can be found in tofu, miso, tempeh, soy sauce, soy drinks and soy flour, etc. Soya is also used in some desserts, ice cream, meat and fish products, sauces, soups and vegetarian products.

- **Milk**: You can find milk in butter, cheese, cream, ice cream, desserts, milk powder, yoghurt, pastries, soups and sauces, etc. Some foods are brushed with milk.

- **Nuts**: This includes almonds, hazelnuts, walnuts, cashews, pecans, pistachios, brazil nuts and macadamia nuts. You often find nuts in bread, biscuits, cookies, desserts, ice cream, chocolate, marzipan, nut oils and sauces. Different types of nuts are used in Asian and Oriental dishes. The type of nut must be stated in the labelling.

- **Celery**: This includes stalk celery, as well as the leaves, seeds and root (tuber) of the celery plant. Celery is often found in spices and spice mixtures, salads, some processed meat and fish products, soups, dressings and broth.

- **Mustard**: This includes mustard, mustard powder and mustard seeds. You often find mustard in processed meat products, curries, marinades, salad dressings, sauces and soups.

- **Sesame seeds**: Sesame seeds are often found in bread, vegetarian dishes, sweets, crackers, biscuits, hummus, sesame oil, sesame seeds and tahini (sesame paste).

- **Sulfur dioxide and sulphites**: Sulphites are often used to preserve fruit and vegetables (including tomatoes), and in some meat products, as well as in soft drinks, juices, wine and beer.

- **Lupine**: This includes lupine seeds and lupine flour, and can be found in some types of bread, baked goods, flour, vegetarian products and pasta.

2.2 Barcodes and QR codes

2.2.1 Barcodes

Barcode technology works by assigning a unique number to each product that a business sells. This number is then encoded in black and white areas and represented visually as a barcode. When a product is scanned, the barcode is read by a scanner and the associated data is retrieved from a database [73][2].
Barcode technology is widely used in inventory management and control, as it can speed up the process of both shipping and receiving goods, ensure a more accurate count of what's on hand, and reduce costs[73].

When barcodes are employed in a business process, automation becomes possible, leading to increased productivity and a reduction in human error. Whenever precise identification or tracking is required, barcodes should be the go-to solution[49].
In traditional working environments, employees often have to manually input large amounts of data into a customer database system. This can be a daunting task and is prone to human error. However, by utilizing barcode technology, the need for manually entering customer identification numbers is eliminated, as the data can be swiftly scanned [73].
Barcodes can store a variety of types of data, depending on the specific type of barcode used. Here are some common types of barcodes and the types of information they can store:

- **UPC (Universal Product Code):** This barcode is predominantly used in the retail industry. It has two types - UPC-E, which can encode only six digits, and UPC-A, which encodes twelve digits[19].
- **European Article Number):** Similar to UPC, EAN barcodes are used in the retail industry. They come in two types - EAN-8, which encodes eight digits, and EAN-13, which encodes thirteen digits. EAN-13 is particularly flexible as it can encode large amounts of data within a small space[19].
- **Code 39:** This barcode is utilized in several industries, including defense and automotive. It is alphanumeric and can encode up to 39 characters[19].
- **Code 128:** This barcode uses ASCII characters and is mainly used by the transportation and logistics industries. It can encode a wide variety of information, making it ideal for high information-density applications[19].
- **Codabar:** This barcode is used by many blood banks and shipping companies. It allows for the storage of a maximum of 16 characters[19].
- **ITF-14:** This barcode combines the POS codes and the logistics barcode Code 128. A 14-digit number is required per the symbology's standards[19].

Figure 2.1: Bar code [11]

One of the most common tools for reading barcodes is the handheld barcode scanner[58]. All of the barcode scanners recommended and sold by IDAutomation (publishers of barcode solutions)[38] come equipped with built-in decoders capable of reading various barcode types. Most of these scanners draw power from the PC keyboard or USB port, eliminating the need for an external power supply[102]. When a barcode is scanned, the data is transmitted to the PC as if it were typed using a keyboard[102].

Figure 2.2: Bar code reader [10]

2.2.2 QR codes

A Quick Response code (QR code) is a type of two-dimensional (2D) barcode that can be read using a QR barcode reader or a camera-enabled smartphone with QR reader software [94]. QR codes can store information both vertically and horizontally, which is why they are called 2D barcodes[49]. These codes are popular among mobile phone users because they can store addresses and URLs. With a camera-enabled smartphone, users can scan a QR code, which may be encoded to display text, provide contact data, open a webpage in the smartphone's browser, or even be used for image target recognition using Augmented reality technology[8].

The QR code specification defines data types and services for this information, ensuring that QR code software can accurately interpret the code [66] [41]. The standardization of QR codes is established by various international and national standards, allowing anyone to obtain their specifications without worrying about applicability [66]

QR codes can store various types of information, depending on the encoding method used. They can store data in several formats:

- **Numeric:** This mode is used for storing numbers. The data is encoded in groups of three digits.
- **Alphanumeric:** This mode is used for storing alphanumeric characters. It is more efficient than numeric mode for storing text.
- **Byte/Binary:** This mode is used for storing binary data. It uses 8 bits per character, making it suitable for storing text in various languages and special characters.
- **Kanji:** This mode is used for storing Japanese characters. It uses 13 bits per character, making it efficient for storing Japanese text.

Figure 2.3: QR code [12]

2.2.3 Diffence between barcodes and QR codes

Differences between barcodes and QR codes are outlined below:

1. **Data Capacity:**
   - **Barcodes** have limited data capacity. They typically store numeric data and are commonly used for product identification in retail[80].
   - **QR codes** have a significantly higher data capacity. They can store alphanumeric characters, binary data, and more complex information, making them versatile for various applications beyond simple product identification[80].
2. **Data Formats:**
   - **Barcodes** generally encode numeric data, and the amount of information they can store is limited. They are suitable for basic identification purposes[80].
   - **QR codes** can encode alphanumeric characters, binary data, and various types of information such as URLs, contact information, or Wi-Fi network details. This versatility allows them to convey more complex data[80].
3. **Size and Density:**
   - **Barcodes** require more space to encode the same amount of information compared to QR codes, with limitations in terms of data storage in a limited space[80].
   - **QR codes** can encode more data in a smaller space due to their two-dimensional matrix design, allowing for more information to be stored in a compact code[80].
4. **Scanning Speed and Accuracy:**
   - **Barcodes** are generally quick to scan, and the technology is well-established, with scanning typically done in a linear fashion[90].
   - **QR codes** can be scanned quickly, support faster data retrieval due to their two-dimensional structure, and can be scanned from any angle, providing a more flexible and efficient scanning process[90].
5. **Application Areas:**

- **Barcodes:** Commonly used in retail for product identification, inventory management, and logistics[9].
- **QR Codes:** Widely used in marketing, mobile payments, ticketing, product packaging, and a variety of other applications due to their higher data capacity and versatility[80].

2.3 Augmented reality technology

Augmented reality is a technology that enables users to engage with virtual information superimposed on the physical world. This mediated immersion places digital resources throughout the real world, augmenting users' experiences and interactions. [75].
It blends the virtual world with the real world by overlaying digital information onto our physical environment. Unlike Virtual Reality (VR), which immerses users in a completely computer-generated environment, AR enhances our perception of existing physical reality by adding digital elements to what we see and experience in real-time[96].

Augmented reality allows to add digital information and content to real objects using mobile devices. All you need to do is grab a tablet or smartphone and point at any object to view text, images or videos superimposed on the current view[16].

Augmented reality, with its ability to combine reality and digital information, is being studied and implemented in medicine, marketing, museums, fashion, and numerous other areas [14]

2.3.1 Types of AR technologies

- **Marker-based augmented reality:**Also known as image recognition AR, is a type of AR that requires a trigger photo to activate the AR experience.The user scans the marker using their phone camera, and the digital information appears on top of it[67].

  The cameras continuously scan the input and put a mark for image pattern recognition to create its geometry. When the camera is not focused on a particular spot, the virtual 3D object is not shown properly[5].

  The marker-based AR experience is tied to the marker. This means that the placement of digital elements depends on the location of the marker. In most cases, the experience will display on top of the marker and move along with the marker as it is turned or rotated[3].

  This technology is used in various fields such as education, entertainment, advertising, and industrial design. For instance, in education, it can be used to create interactive textbooks that allow students to visualize complex concepts in 3D . In entertainment, it can be used to create immersive gaming experiences that blend the virtual and real world . In advertising, it can be used to create interactive ads that allow customers to visualize products in 3D . In industrial design, it can be used to create 3D models of products that can be viewed from different angles [3].

- **Marker-less augmented reality:** Is a type of AR that does not rely on a trigger image or marker to activate the AR experience. Instead, marker-less AR uses the surrounding environment as a trigger, scanning real features and placing digital elements accordingly[62][3][46].

  It refers to the software application that does not require any camera to put a mark for image pattern recognition. Marker-less AR places virtual 3D objects in the real-life environment by examining the features present in the real-time data. It relies on the hardware of any smartphone smartphone including the camera, GPS, digital compass, and accelerometer for the AR software to complete the work efficiently. There is no need for an object tracking

system due to the advancement in cameras, sensors, and AI algorithms. It merges the digital data with input from real-time data that are registered to a physical space. Marker-less AR image analysis utilizes the Simultaneous Localisation And Mapping technology that scans the environment and creates appropriate maps to place the virtual 3D objects[5].

Apps that offer such features usually will ask the user to find a flat surface such as a table or floor for placing the AR elements as the objects will not always make sense floating in the air. For computer vision to detect a flat surface, it has to be textured. You will find it challenging or even impossible to use on a white background or on other single color surfaces[62].

- **Location-based augmented reality:** Is also known as marker-less, position based and geo-based augmented reality. In contrast with marker-based AR, it doesn't need special markers to identify the place where a virtual object should appear.
  It primarily relies on GPS, accelerometer, digital compass and other technologies to identify phone's location and position with a high level of accuracy. Modern devices are mostly equipped with these sensors, so the augmented reality is available for every mobile device owner[22].

  It allows developers to attach interactive and useful digital content to geographical points of interest. It is beneficial to travelers to have a clear understanding of the whereabouts of a specific area through virtual 3D objects, videos, texts, links, and audio[5].

  It depends on real-time location systems. These systems are the ones that identify the present location of the users by getting the information from the sensors. Then, they transfer this information to the technology, and the latter can compare the location to the point of interest, getting the best place for the virtual data in the outside world[99].

  When building an augmented reality with geolocation, three main points matter the most:

  - **Sensors**
    The technology accepts the information about the position and motions of the user from the sensors. That's why they are the essential ingredient of the AR apps that use location. The sensors must be placed correctly to connect and send the right signals to the system[99].
  - **Points of interest**
    You can think of points of interest as the virtual layers of the image displayed on the users' screen. Once the system receives the correct information and connects the dots, it must understand what data to show the user[99].
  - **Technique for connecting points**
    The work of the marker-less application depends on how detailed is the information about the users' location. Connecting sensors and points of interest must work as correctly as possible to provide the most efficient picture[99].

  Several industries make use of location-based augmented reality (AR) apps. These industries include:

  - **Tourism**
    Location-based AR is utilized in the tourism industry to offer interactive guides, historical information, and immersive experiences at specific locations and landmarks[99].
  - **Gaming and entertainment**
    Game developers and entertainment companies leverage marker-less AR for creating interactive and engaging experiences, such as location-based games and entertainment content[92].

- **Construction and real estate** In the construction and real estate sectors, location-based AR is used for visualizing architectural designs, providing virtual property tours, and assisting in on-site measurements and planning[99].
- **Education**
  Certain educational subjects, such as geography and history, benefit from location-based AR, allowing students to explore and interact with virtual content tied to specific real-world locations[92].

  These industries are just a few examples of the diverse applications of location-based AR, demonstrating its potential for enhancing user experiences and providing valuable, context-aware content

- **Superimposition-based augmented reality:** Is a type of augmented reality that involves either partial or full replacement of an original view of an object with an augmented view of the same object with an updated augmented view of that object for the human eye[24][5]. Superimposition AR provides multiple views of a target object with the option of showing extra relevant information on that object[5].
  This type of AR is commonly used in the medical field to superimpose an X-ray onto a patient's body.
  It can also be used to enhance a historical tour. For example, to showcase what a statue or structure looked like years ago, visually explaining how it has aged and why that's significant[23].

- **Projection-based augmented reality:**Also known as spatial Augmented Reality or Projection Mapping, is a type of augmented reality that uses projectors to overlay digital content onto physical objects or surfaces in the real world. It involves the projection of computer-generated visuals onto real-world surfaces to create the illusion of interactive and dynamic augmented environments[55].

  The user can freely move around the environment within a specified zone where the fixed projector and a camera for tracking are placed. It is used to create illusions on the depth, position, and orientation of an object by projecting artificial light onto the real flat surfaces. Projection-based AR can be applied for proper guidance to simplify the complex manual tasks in companies or industries. It eliminates the need for computers and screens as the instructions can be placed on a particular task space. [5].

  Projected AR uses projectors to overlay AR content directly over real-life objects using projection mapping techniques[25].
  This allows the uses to view AR content with their naked eyes without needing any external head-mounted AR glasses or handheld AR-enabled devices (smartphones)[25]

  They are two types of AR projection:

  - **Static AR projection:** Static AR projection refers to the use of augmented reality (AR) technology to project static or non-moving virtual content onto the real world. It involves overlaying digital images, videos, or information onto the physical environment in a way that appears to coexist with the real objects.
  - **Dynamic AR projection:**Dynamic AR projection refers to the use of augmented reality (AR) technology to project interactive and moving virtual content onto the real world. Unlike static AR projection, which involves stationary virtual elements, dynamic AR projection adds a layer of interactivity and responsiveness to the augmented experience.

  This type of AR projects virtual content onto a physical surface, such as a wall or table. The virtual content is aligned with the physical surface to create an interactive experience. Projection-based AR is commonly used in advertising, entertainment, and art installations[21].

- **Outlining-based augmented reality:** This type of AR outlines the real-world objects with virtual content. The virtual content is aligned with the edges of the object, creating an augmented version of the real world. Outlining-based AR is commonly used in architecture, interior design, and urban planning. It is also most often spoken about within the car industry, where manufacturers are looking for ways that cars can outline obstacles and help navigate a path to reduce pressure on drivers[21].

  Special cameras are built for human eyes to perform outlining of the specified objects like boundaries and lines to help in certain situations. Outlining AR utilizes object recognition for a better understanding of the current environment[5].

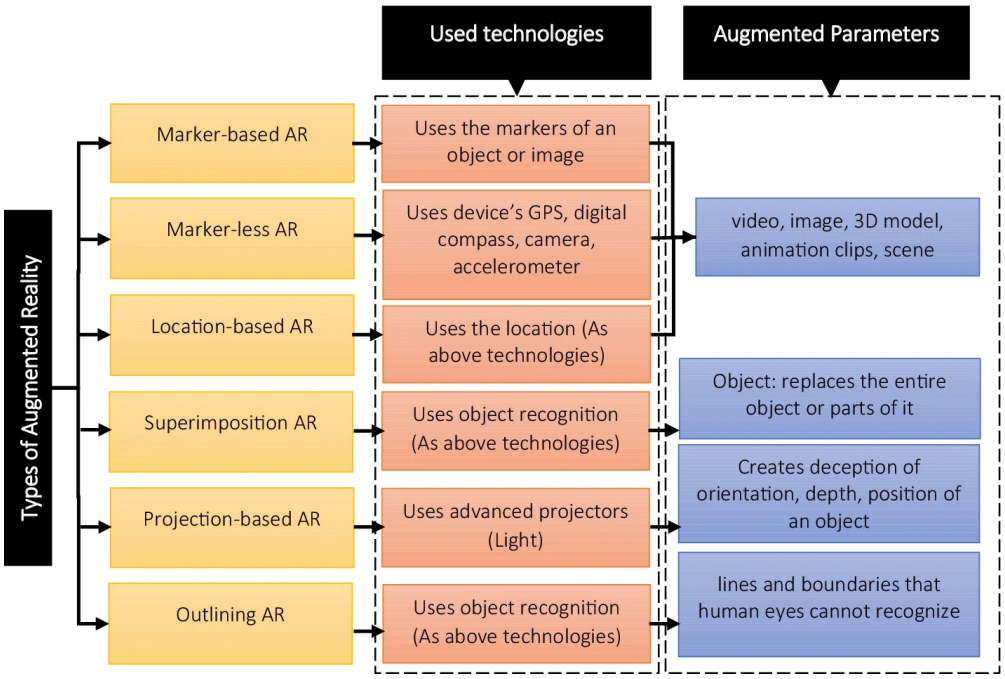

Figure 2.4: Various types of AR technologies used tools and technologies, potential augmented parameters[13]

2.3.2 Augmented reality hardware

AR relies on diverse devices, from smartphones and tablets to dedicated AR glasses, each equipped with displays, cameras and sensors.

AR experiences can be viewed through various display devices, including smartphones, tablets, smart glasses, or dedicated AR headsets. These devices provide the visual output and may include screens, lenses, or projectors to overlay virtual content onto the user's view [26].

Cameras are essential for capturing the real-world view and providing input for the AR system. Most AR devices have built-in cameras or utilize the cameras on smartphones or tablets to capture the user's surroundings and enable interaction with virtual content [26].

AR devices often incorporate a range of sensors to gather data about the user's position, orientation, and movements. These sensors may include gyroscopes, accelerometers, magnetometers, GPS, depth sensors, or environmental sensors. They help to track the user's movements, detect real-world objects, and enable spatial mapping [26]

2.3.3 Augmented reality software

Augmented Reality (AR) software, also known as AR SDKs (Software Development Kits), provide the necessary tools and libraries to develop AR applications. They handle the complex aspects of AR technology such as tracking, mapping, and rendering, allowing developers to focus on creating engaging AR experiences. Here are some of the top AR software tools:

- **Vuforia:** Vuforia is a widely used AR SDK that offers a range of products for developing AR experiences. It supports the creation of both marker-based and markerless AR and has several key features that make it one of the best for object recognition and 3D modeling. Features include Ground Plane, Visual Camera, and VuMarks[64]

- **ARKit:** Developed by Apple, ARKit is a powerful AR SDK for iOS devices. It relies on camera sensor data and additional data (e.g., from a gyroscope and accelerometer) to detect and analyze users' surroundings for augmented reality visualization. ARKit also supports fast motion tracking, face tracking, Quick Look, and various rendering effects[64].

- **Wikitude:** Wikitude is another popular AR SDK that offers a wide range of built-in capabilities, including various rendering features. It provides a full-blown online studio for arranging static augmented reality objects. Developers can use JavaScript API, Native API, Xamarin, Unity3D, Cordova, Titanium for development[44].

- **ARCore:** ARCore is Google's response to Apple's ARKit. It supports developing AR apps for both Android and iOS. ARCore provides three key technologies for 'embedding' virtual content into real environments: motion tracking, environmental recognition, and lighting recognition[44].

- **MaxST:** MaxST AR SDK is a powerful framework for mobile software developers. It is based on five major components: Image Tracker, Instant Tracker, Visual SLAM, Object Tracker, and QR/Barcode Scanne[44].

- **EasyAR:** EasyAR is an Asian solution for creating AR apps. Unlike many other tools, the solution doesn't feature a built-in object manager. Instead, objects are identified by recreating initially predefined 3D models[44].

- **ARToolKit:** ARToolKit is a package of open-source libraries for developing augmented reality apps based on marker recognition. The main principle of ARToolKit's performance is that it processes graphic data received from the mobile camera in the runtime mode guided by the initially known square object markers[44].

Each of these AR software tools has its strengths and weaknesses, and the choice between them depends on the specific requirements of the AR application being developed.

2.3.4 Augmented reality technology in retail

Augmented Reality (AR) technology in the context of retail refers to the innovative use of digital information and computer-generated elements to enhance the shopping experience. AR overlays these virtual elements onto the physical, real-world environment, providing shoppers with an augmented view of their surroundings or product information [68].
Augmented Reality (AR) can plays a significant role in retail by enhancing the overall shopping experience in several ways:

- **Product visualization**:AR enables shoppers to visualize products in their real-world environment before making a purchase. Customers can use AR applications to see how furniture, clothing, cosmetics, or other items will look and fit in their homes or on their bodies. This feature reduces uncertainty and the need for returns, improving customer satisfaction[47].

- **Virtual try-On**: In the fashion and beauty industries, AR allows customers to virtually try on clothing, accessories, makeup, and eye wear. Shoppers can see how items will look on them without physically trying them on, providing a more convenient and hygienic shopping experience[15].
- **Navigation assistance**: Large retail spaces can be overwhelming to navigate. AR apps can help shoppers find specific products by providing real-time, step-by-step navigation guidance through the store. This feature saves time and reduces frustration[52]
- **Product comparison**: AR-based shopping assistants allow customers to compare multiple products side by side. Shoppers can view digital overlays that highlight differences in features, prices, or specifications, aiding in product selection[4].
- **Language translation**: AR apps can provide real-time language translation for international shoppers, helping them read product labels, signs, and instructions in their preferred language[76].

2.4 Blending physical and digital experiences

Blending physical and digital experiences, also known as "phygital," is a term that describes combining digital experiences with physical ones to create synergistic environments where each amplifies the strengths of the other [50].This approach aims to improve customer experiences by seamlessly integrating digital interactions with physical experiences, bridging gaps between channels, and reducing customer friction and frustration[81]

Benefits of blending physical and digital experiences include:

- **Improved Customer Experience:** Phygital experiences create a more personalized, engaging, and seamless customer journey, whether in retail, education, or other sectors[40].
  By combining elements from both realms, businesses can enhance user experiences and provide a more immersive environment[57].
- **Enhanced customer engagement:**Phygital experiences, such as augmented reality demonstrations or interactive digital content, can capture customers' attention and provide contextually relevant information in real-time[50].
  This approach can lead to better customer understanding and more informed purchase decisions[57]
- **Enhanced understanding through phygital:**The application of marker-based AR goes beyond traditional labeling by allowing the overlay of digital content directly onto the physical packaging. This unique feature offers consumers an interactive and tangible understanding of the information presented, contributing to a deeper understanding of the product. The integration of marker-based AR within the 'phygital' concept aligns with promoting informed decision-making and enhancing the overall consumer experience.

2.5 Related work

The nutrition fact information on the label can be transformed into dynamic feedback to make nutrition facts labels easy to use. This study focuses on nutrition facts, applying the FDA's 5-20 rule to determine if a particular nutrient is in a healthy amount and visualizes this feedback using augmented reality technology[42]. Similarly, Prateek et al.[43] utilized Audio Augmented Reality technology to extract textual nutrition fact labels, then translated them into audio format to make it easier for people to choose food products.

M.Carmen et al. [20] took a comprehensive approach by developing an augmented reality application that tracks entire objects, guiding users to the specific area on real packaging where carbohydrate

information is located. This application not only aids in locating relevant details but also assists users in interpreting the information, empowering them to make informed decisions about carbohydrate consumption.

Expanding beyond nutrition, the research by M.Carmen et al. [20] delves into supporting decision-making processes for product features, comparing physical and online items.For beverages, Klaus et al. [30] make a notable contribution by developing a mixed reality system tailored for consumers making choices at beverage vending machines. This system displays the amount of sugar and energy in beverages, providing consumers with valuable insights for informed decision-making.

In a broader context, Abderahman et al. [1] conducted a systematic literature review, identifying food decision-making as a key domain where augmented reality can provide substantial business value. Their findings highlight augmented reality's potential impact on various aspects, including food process efficiencies, marketing, training, and safety.

The influence of augmented reality in decision-making extends beyond the food industry, reaching into the beauty sector. Haidi et al. [34] developed an application utilizing augmented reality technology to increase awareness of halal cosmetic products, providing consumers with the information needed to make informed decisions in the cosmetic product purchasing process.

BAMA, a company based in Norway, sells fresh products from all over the world, reaching thousands of customers throughout Norway. They have created an application that uses a phone camera to scan the QR code on a banana. The application then retrieves a message from a famous player like Martin Odegaard, showing the benefits of eating a banana and stating that it helps him maintain energy during training [9]. This prompts football fans to make a choice, as they know that it helps players gain energy.

2.6 Gap based on the related work

The related works have concentrated on specific aspects of information, such as nutritional facts, carbohydrates, or other targeted features. However, a significant gap persists in developing a solution that provides access to the essential information required for food labeling, despite the limited space on the food product package. This gap underscores the need for an approach that addresses various aspects, as specified in section 2.1.4 of this report.

2.7 Reasons for choosing marker-based augmented Reality for enhancing food product information labels

In this state-of-the-art, the marker-based augmented reality approach was chosen for enhancing food product information labels based on its ability to accommodate the integration of physical and digital realms, offering a transformative and engaging user experience.
The following are the benefits of using Marker-Based Augmented Reality that contributed to the success of this research project:

- **Enhancing user engagement:** One of the primary factors driving the selection of Marker-Based AR is its capacity to provide user engagement. Through visually interactive methods, consumers can access detailed information about food products. Scanning the marker initiates an overlay of digital content on the physical package, fostering a simultaneous blend of both physical and digital information. This integration aligns with the 'phygital' concept, aiming to significantly enhance user engagement.
- **Dynamic viewing based on proximity:** The Marker-based approach allows for viewing adjustment based on the proximity of the user's device to the marker. This dynamic adaptation ensures that users, including those with sight issues, can easily read relevant information

in real-time as they move closer to the package, scanning the barcode or QR code to increase the size of the digital content.
This responsive and dynamic interaction enhances accessibility and the overall user experience, making Marker-Based AR a strategic choice.

Chapter 3

Methodology

This chapter presents the methods and approaches used in my research, including data gathering methods and the human-centered design approach.

3.1 Data gathering methods

Data collection methods are important, because how the information collected is used and what explanations it can generate are determined by the methodology and analytical approach applied by the researcher[36]

3.1.1 Qualitative method

Qualitative research involves collecting and analyzing non-numerical data (e.g., text, video, or audio) to understand concepts, opinions, or experiences. It can be used to gather in-depth insights into a problem or generate new ideas for research[71].

In this method, interviews and observations have been chosen as the data gathering techniques for this study. For interviews, the population comprised of five students, and for observation, the population involved six shoppers in different supermarkets, including Coop Extra[1], REMA 1000[2], and KIWI[3] located in Grimstad.

The choice of the interview population is motivated by the convenience and accessibility of conducting face-to-face interviews with fellow students, facilitating in-depth discussions and a deeper understanding of participants' experiences. Specifically, the focus is on their challenges related to the availability, completeness, and findability of information on food product labels, as well as their opinions on potential solutions using augmented reality technology.

The decision to visit supermarkets and make observations was motivated by the need to understand and explore how and for what purposes users use food labels.

3.1.2 Quantitative method

Quantitative research involves the collection and analysis of numerical data and relies on statistical techniques to draw conclusions[74].
The selected quantitative method for this research project is a survey, which offered the advantage of reaching 5 participants, including administrative staff from the University of Agder and individuals from various geographic locations.

[1] https://www.coop.no/extra
[2] https://www.rema.no/
[3] https://kiwi.no/

Norwegian law stipulates that all researchers dealing with personal data, including any identifying elements such as voice, video, and photos, must complete a notification form before collecting any data[72]. I contacted and informed Sikt, the Norwegian Agency for Shared Services in Education and Research which is a public administrative body under the Ministry of Education and Research[4], to ensure that the intended data processing aligns with Norwegian law and complies with data protection legislation. Having met all requirements, I have obtained approval for data collection.

The notification form can be found in Appendix E.

3.2 Human-centred design approach

The Human-centred Design (HCD) process places the user at the center of the design process, ensuring that the final product meets their needs and preferences, thereby enhancing user satisfaction. With human-centered design, people are involved in the design of products and services right from the start[85].
Human-centred Design concentrates on the product users and where and how they will use the product. This user-centric methodology is guided by a profound understanding of users' needs, preferences, and behaviors, ensuring that the final product aligns with their requirements and enhances user satisfaction.[93].

This approach involves the following activities:

- Understanding and specifying the context of use.
- Specifying the user requirements.
- Producing design solutions to meet these requirements.
- Evaluating the design against the requirements.

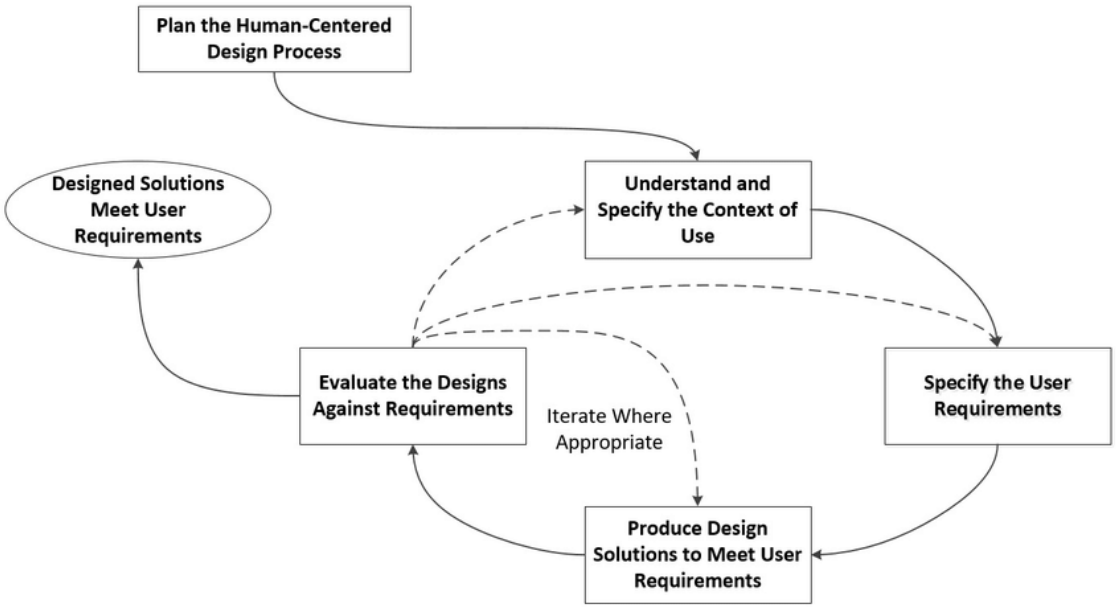

Figure 3.1: The four activities of human-centred design[35]

3.2.1 Specify the context of use

The primary objective of this activity is to gain an understanding of the users and stakeholders, their intended tasks, and the specific environment in which the design will be utilized. The ultimate

[4] https://sikt.no/en/about-sikt

goal is to gather enough data to support the design and development stages [93]. The context of use includes the characteristics of:

- **Users**: The primary users of the AR-enhanced food product label application are consumers of varying age groups and backgrounds.
- **Tasks**: Users will use the application to access information related to food products by scanning QR codes or barcodes in order to have complete information that will guide their choices.
- **Organizational environment**: The organizational environment involves stakeholders like grocery stores, supermarkets, food producers and labeling compliance agencies.
- **Physical environment**: The physical environment for my research project primarily encompasses various settings where food products are purchased and consumed, including physical retail spaces such as grocery stores and supermarkets, where consumers make their purchasing decisions. Additionally, it extends to various locations where consumers interact with food products, such as their homes, kitchens, and dining areas. To facilitate the effective use of the augmented reality (AR) application, these environments should provide sufficient lighting, ensuring that cameras can easily recognize QR codes or barcodes.
- **Technical environment**: The technical environment of my research project revolves around mobile devices and internet connectivity. Users will utilize smartphones or tablets with cameras to scan QR codes or barcodes on food products, enabling access to product information. A stable internet connection ensures seamless access to real-time data retrieval.
- **Social environment**: The social environment of my research project encompasses two types of stakeholders, each with a unique role and impact on the project's development.
  Consumers are the primary end-users of AR-enhanced food labels, and their willingness to engage with the technology is important for the project's success.
  Food product producers, including those responsible for food manufacturing, have a role in providing the necessary food product information for the application's use.

User stories, personas and user senarios

Understanding the needs and expectations of users, User stories, personas and scenarios are tools that empower designers to dive deep into the minds and lives of their potential users, bridging the gap between product creators and end-users[48].
They provide a view of the individuals who will interact with the application, shedding light on their unique goals, needs, and behaviors and offer a roadmap for creating user-centered solutions that not only meet but also exceed user expectations[48].

A user story is a brief narrative that describes a user's experience and usability goals. It generally conforms to the following format: "As a [type of user], I want [some goal] so that [some reason]."[86]

The following are examples of user stories:
"As a health-conscious shopper, I want easy access to the complete information on food product labels so that I can make informed choices"
"As a parent of young children, I want a way to access detailed allergen information on food labels using technology so that I can make food choices that do not negatively affect my kids."
"As a Muslim believer, I want to access ingredient information on food labels using technology so that I can ensure I don't consume foods that go against my beliefs."

Personas provide a detailed description of a fictional user whose characteristics represent a specific user group. They serve as a methodological tool that helps designers approach design based on the perspective of the user rather than (often biased) assumptions.[70]
The following are two personas; others can be found in appendix A

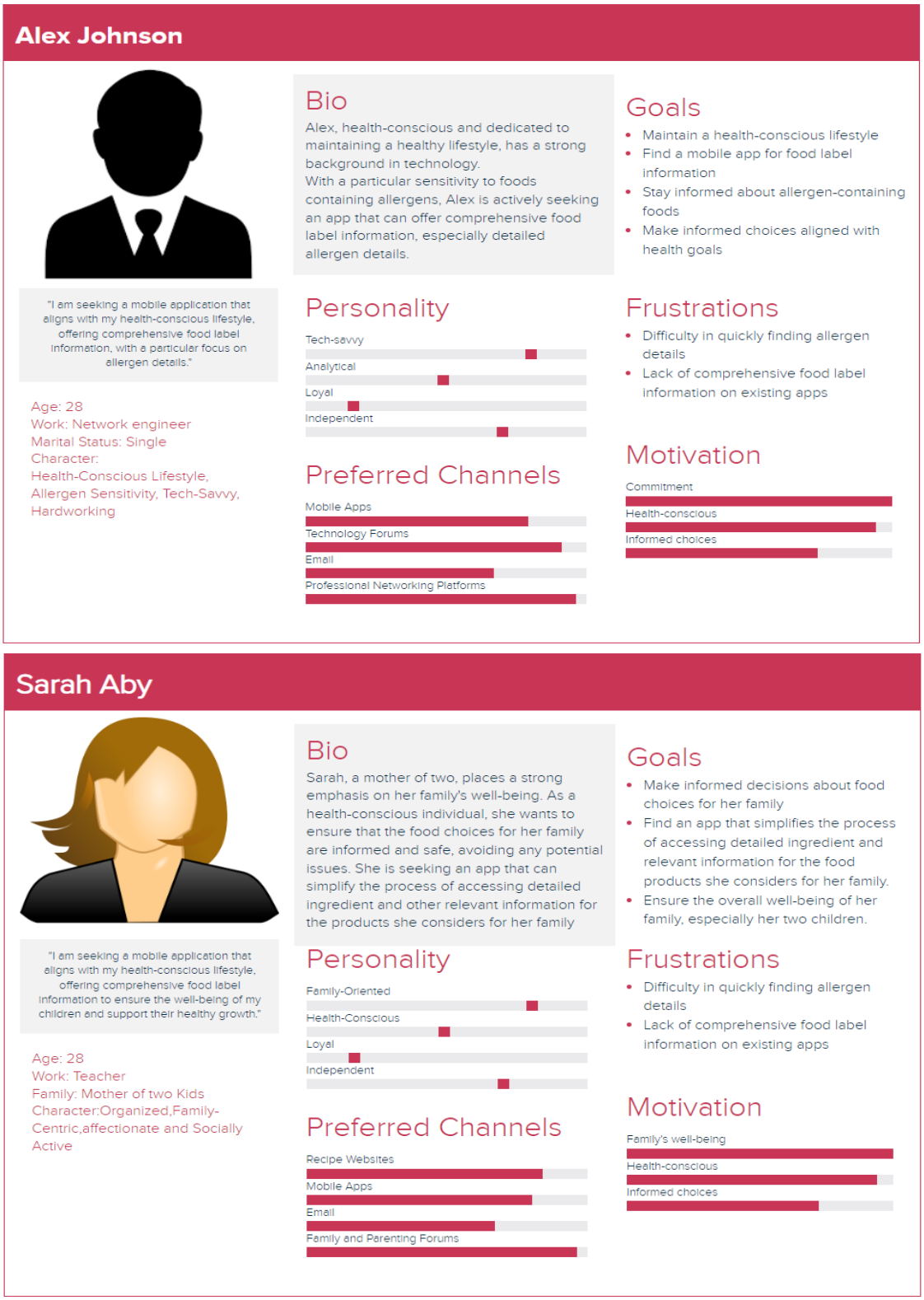

Figure 3.2: Two examples of persona

Scenarios provide a means to situate the user persona and technology within a realistic context of usage. Scenarios are presented as narratives that describe user activity in an informal story format (Carroll, 2000).[70]

The following are senario 1 and senario 2 others can be found in appendix B.

Scenario 1:

Sarah is a busy working mother in her early 30s, and she values making healthy food choices for her family. She's at her local supermarket, shopping for groceries with her two young children. Sarah enters the supermarket and begins her grocery shopping. As she walks through the aisles, she comes across a food product that looks appealing, but she's concerned about its nutritional content, especially since her children have specific dietary needs. She takes out her smartphone and opens the AR-enhanced food label application. Using her phone's camera, she scans the QR code on the product's label. Instantly, a digital overlay appears on her phone's screen, providing detailed information about the product's nutritional content, allergens, and dietary suitability for her family. Sarah is relieved to have quick access to this information, which helps her make an informed decision about whether to add the product to her cart or choose an alternative.

Scenario 2:

David, a busy professional with a strong commitment to fitness, is on his way to the local supermarket after a demanding day at work. As he browses the aisles, he's particular about selecting nutritious snacks that align with his dietary goals. Utilizing his smartphone equipped with the AR-enhanced food label application, David scans a protein bar's QR code. Instantly, the app displays detailed nutritional information, helping him assess if it fits his requirements for a post-workout snack. David appreciates the convenience and accuracy the app provides, enabling him to make health-conscious choices amidst his busy schedule.

3.2.2 Specify the user requirements

In this research project, user requirements were specified using Volere snow cards[95] to identify and categorize them.

Two requirements can be seen in Figure 5.3; others can be found in Appendix C.

Requirement #: 1 **Requirement Type:** 9 **Event:** Scanning QR Code

Description: The system supports the possibility to scan QR code or Barcode

Rationale: To initiate the process of retrieving nutritional information from food product labels

Source: Users' needs specification

Fit Criterion: The system should successfully recognize and process QR codes or Barcode from various food product labels

Customer Satisfaction:4 **Customer Dissatisfaction:**1
Conflict: No conflict

Dependencies: There are no other requirements dependent on this one.

Supporting Materials: A conceptual model diagram in this thesis illustrates how this requirement integrates into the system.

History: Created October 22, 2023

Requirement #: 2 **Requirement Type:**12 **Event:** Accessing information

Description: The AR-enhanced food label application must ensure that all nutritional information is availed to users through readable, hearable, or visible formats, including text and video.

Rationale: To ensure that users can have complete food label information as needed, it must be presented in various formats, such as text and video

Source: Users' need specification

Fit Criterion: The system should provide multiple modes of accessing information, such as text, video, and visual formats, depending on the specific information presented.

Customer Satisfaction:5 **Customer Dissatisfaction:**0
Conflict: No conflict

Dependencies: There are no other requirements dependent on this one.

Supporting Materials: A conceptual model diagram in this thesis illustrates how this requirement integrates into the system.

History: Created October 22, 2023

Figure 3.3: Two requirements

3.2.3 Produce design solution

The achievement of producing a design solution that directly addresses the identified user requirements was realized through the employment of techniques such as use cases, Hierarchical Task Analysis, a conceptual model, and prototyping.

Use case

In this section, I present a visual representation of the fundamental interactions between users and the AR-enhanced food label application. The Use Case Diagram serves as a tool in understanding the system's functionalities and how they align with user activities[31]

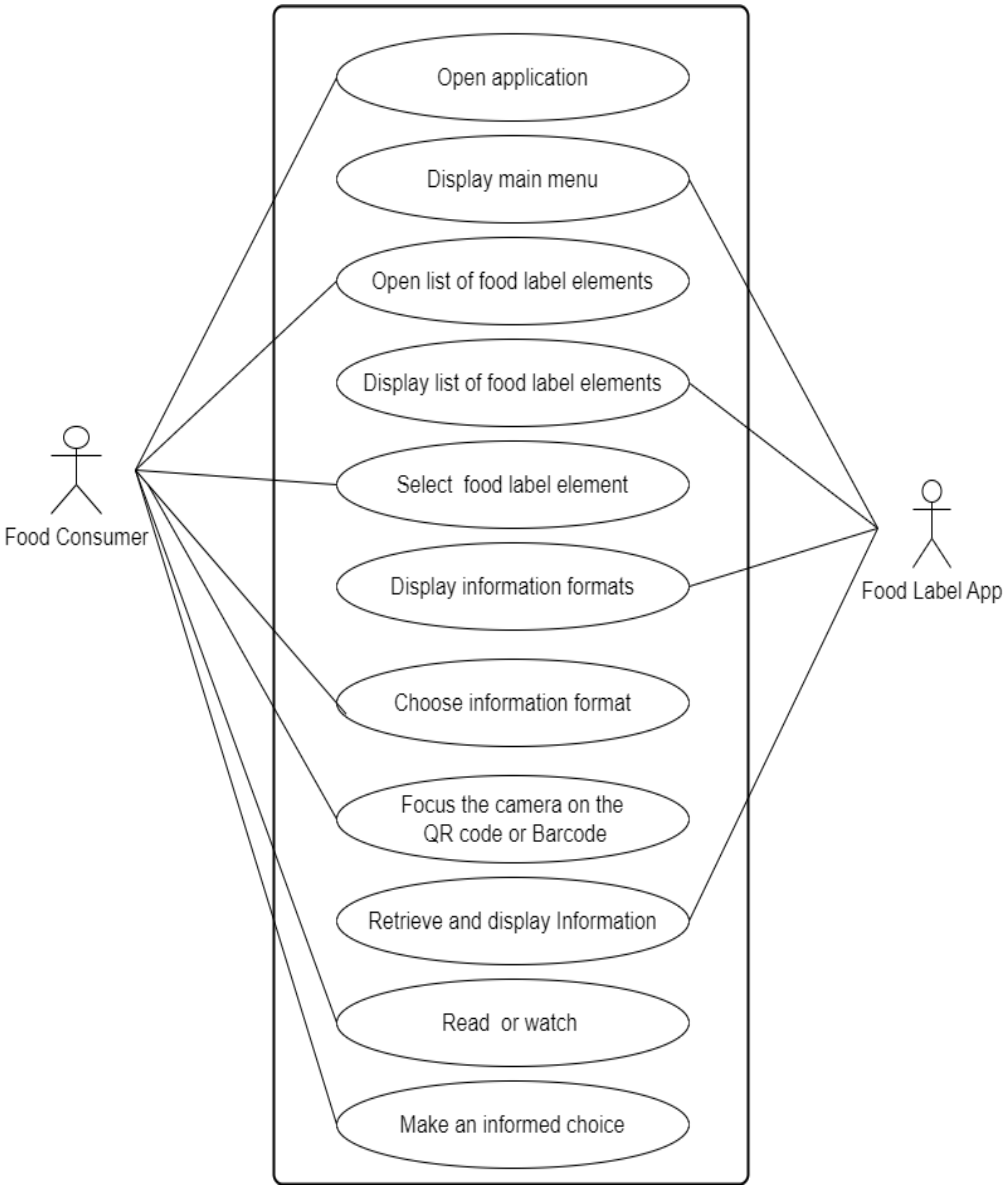

Figure 3.4: Use case diagram

Hierarchical task analysis (HTA)

Hierarchical Task Analysis (HTA) is a systematic method that breaks down complex task into manageable subtasks and create an hierarchical structure that show the step-by-step processes within the application. Through HTA, I gain an understanding of the workflow in using the application[59].

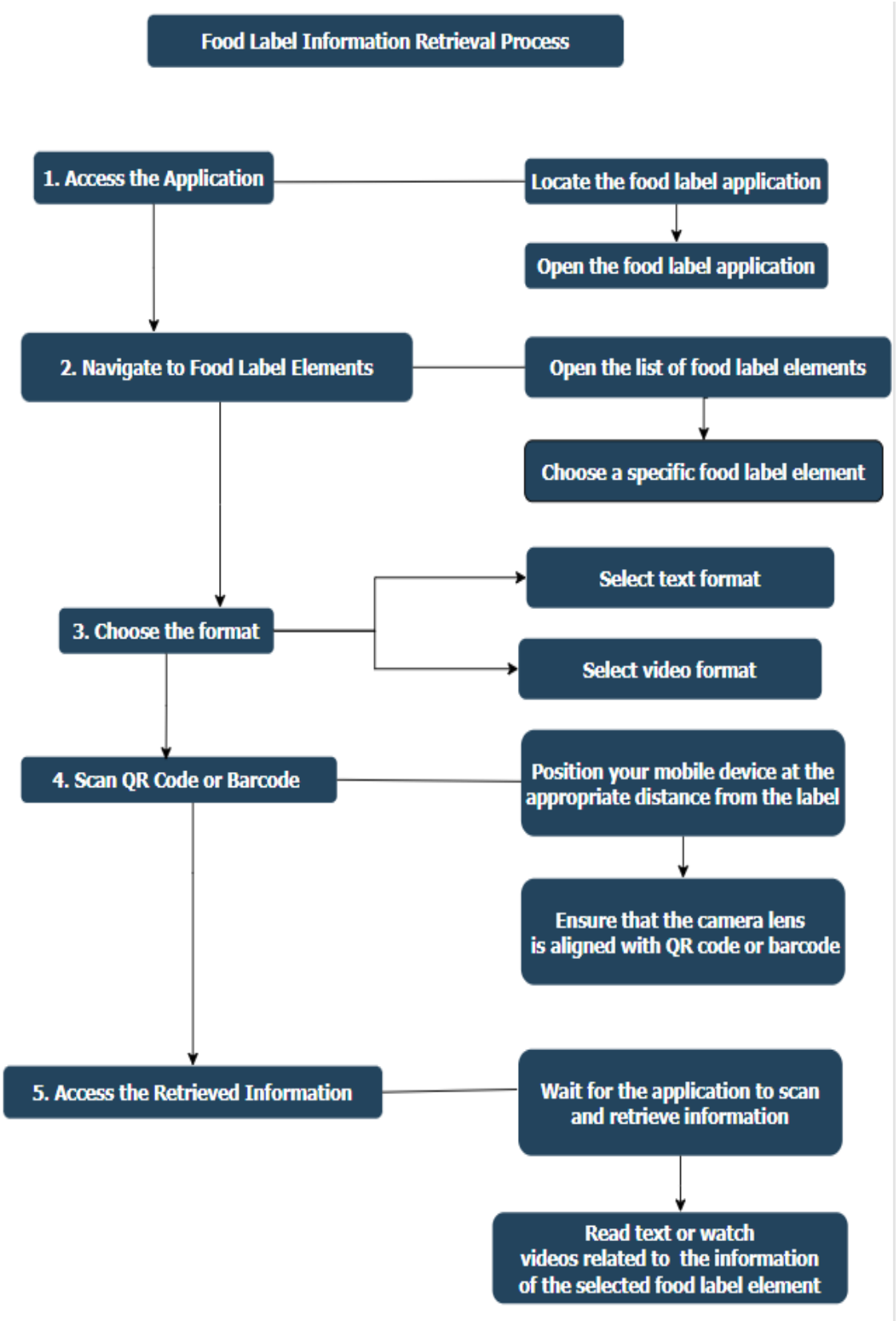

Figure 3.5: Hierarchical Task Analysis (HTA) Diagram

Conceptual model

Producing design solutions to meet user requirements is a critical phase in the design and development process of any product or system[51]This phase involves translating the gathered user requirements into concrete design solutions that address those requirements effectively.
In this project, I have chosen the conceptual model, which is a high-level visual representation of

how the system will operate[45]. It showcases the different stages that users should encounter as they perform actions and how these stages interact with each other[45].

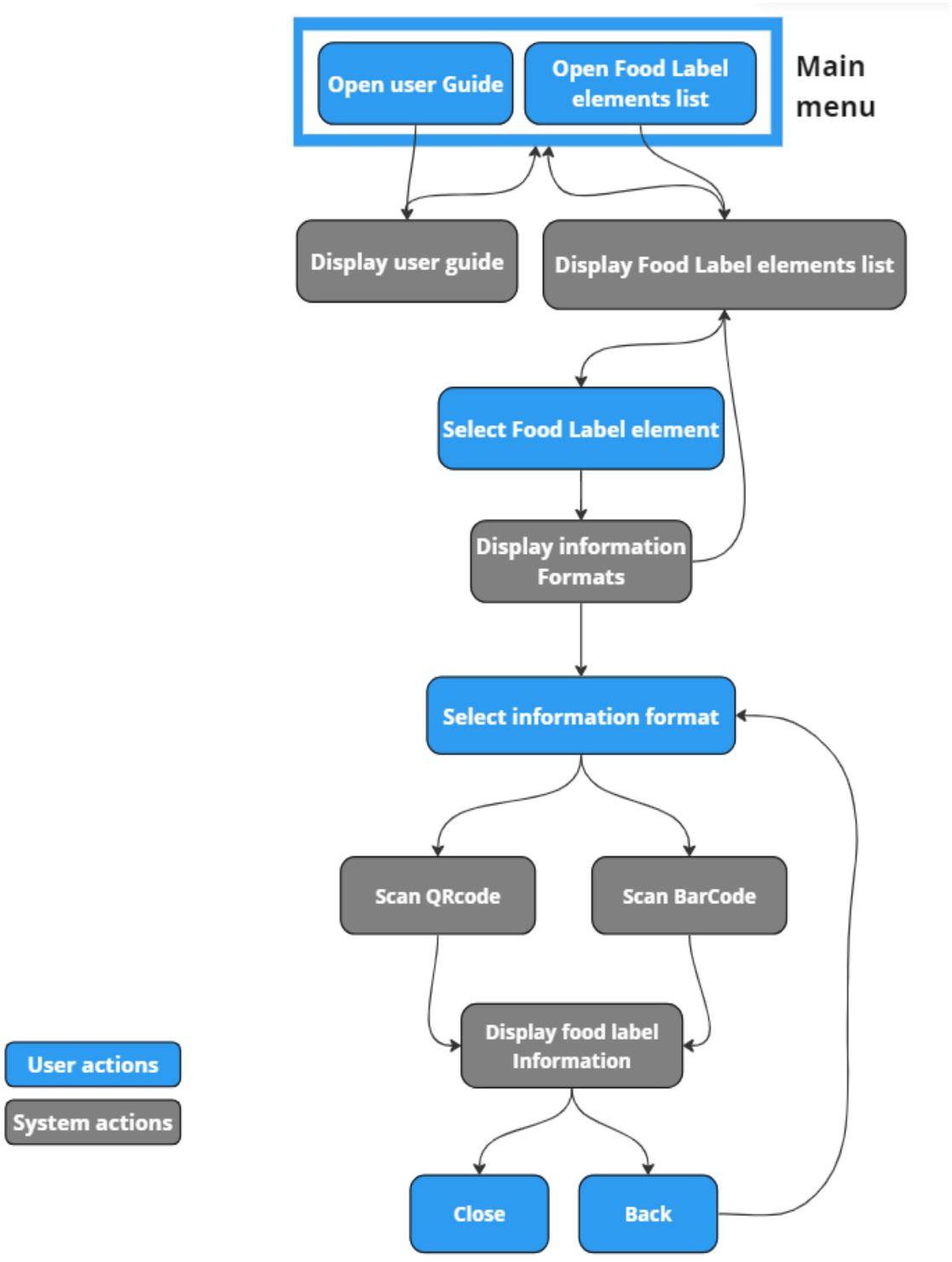

Figure 3.6: Conceptual model

3.2.4 Evaluating the design against the requirements

During the evaluation of the design, the focus was on assessing the user experience and identifying potential challenges that users may encounter. A sample population of 5 individuals was chosen, as it is considered as a reasonable number to obtain feedback on the user experience[33]. The goal was to gather actionable feedback that would guide the iterative refinement of the design, addressing usability issues to meet the specified user requirements.

Low-fidelity prototype testing

A low-fidelity paper prototype was created in the initial design phase.
During low-fidelity prototype testing, participants were engaged with hand-drawn sketches to provide feedback on the overall layout, initial design concepts, and user flow.

During the navigation of the prototype, participants interacted by touching the buttons drawn on paper, representing a click. I promptly introduced another paper representing the next screen, aiming to simulate transitions between screens and observe the experience during usability testing. Each testing session comprised a facilitator (myself) guiding the process, with a participant actively engaged with the prototype.

Participants were informed about the testing process. Goals and expectations were provided without explicit instructions on what to do. This approach allowed participants to navigate the prototype themselves, testing if the application is both easy to use and easily findable. Some changes resulting from user feedback, such as the absence of "go back" and "close" buttons on some screens, were promptly implemented.

The following images showcase the interaction between the participants and the low-fidelity prototype.
Participants have granted permission for the inclusion of these photos in my report.

Figure 3.7: Showcase the interaction between the participants and the low-fidelity prototype

During the low-fidelity prototype testing phase, 1 out of 5 participants provided positive feedback, indicating no concerns with the prototype. However, the remaining participants (4 out of 5) expressed concerns about the absence of an exit button on each screen. They noted that the lack of this navigation element on all app screens caused confusion and limited their ability to navigate through the prototype, especially in exiting the application at any screen or any level of navigation. This finding highlights the significance of incorporating exit buttons uniformly across all screens in the next iterations of the prototype to address the majority of users' concerns and enhance overall usability.

High-fidelity prototype testing

This project developed a high-fidelity prototype as presented in chapter 4.
Before starting high-fidelity prototype testing, I formulated a plan using the usability test plan dashboard[91], a tool that outlines the plan for conducting usability testing, to efficiently guide the testing process and ensure its success.

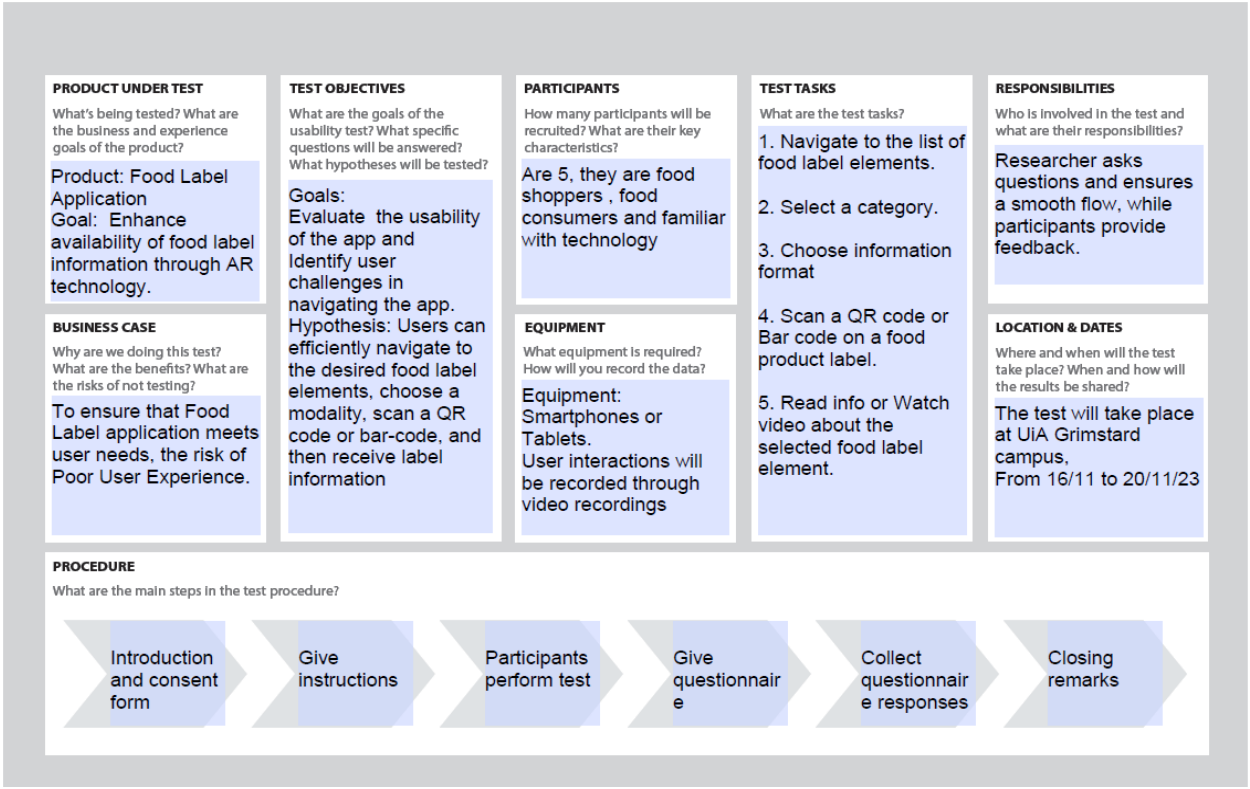

Figure 3.8: Usability test plan dashboard

To gather feedback from users, a System Usability Scale questionnaire was used. The SUS is a simple, ten-item scale that provides an overall perspective on subjective assessments of usability [17].

This scale comprises 10 questions answered using a five-point Likert scale, ranging from strongly disagree to strongly agree. The questionnaire is structured with alternating statements: odd-numbered questions are phrased positively, while even-numbered ones are negative. This design aims to prevent respondents from cheating by consistently selecting the same answer for all questions.[18]

The SUS was employed at the conclusion of the test, after users had spent time interacting with the high-fidelity prototype.

The following is the list of questions used in SUS:

1. I think that I would like to use this app frequently
2. I found the system unnecessarily complex
3. I thought the system was easy to use
4. I think that I would need the support of a technical person to be able to use this system
5. I found the various functions in this system were well integrated
6. I thought there was too much inconsistency in this system
7. I would imagine that most people would learn to use this system very quickly
8. I found the system very cumbersome to use
9. I felt very confident using the system
10. I needed to learn a lot of things before I could get going with this system

The System Usability Scale (SUS) is scored in a multi-step process to obtain a final usability score[18]. Here's a brief description of the scoring procedure:
Score Calculation Steps:

- **Step 1**: Odd Numbers (Positively Phrased)

  Subtract 1 from the response for odd-numbered questions.

- **Step 2**: Even Numbers (Negatively Phrased)

  Subtract the response from 5 for even-numbered questions.

- **Step 3**: Add Converted Scores

  Sum up all the converted scores from Steps 1 and 2. The resulting range is 0-40 (4 multiplied by 10).

- **Step 4**: Convert to 0-100 Range

  To convert the 0-40 range into a 0-100 range, multiply the result from Step 3 by 2.5.

Feedback from users on the System Usability Scale can be found in Appendix D.

Chapter 4

Design & development

This chapter details the design and development process of the food label application prototypes. Describing the prototypes and their components, the presentation covers various aspects, including the software and hardware used during the design and development process, as well as screen interfaces and code samples for both front-end and back-end functionalities.

4.1 Materials and tools

4.1.1 Software

- **Unity** Unity is a game engine developed by Unity Software Inc; an American video game software development company, known for its versatility in creating games and applications [87].

  Unity is not only known for its accessibility but also its flexibility. It is free to use, making it an attractive choice for both independent developers and established studios. Supporting a broad range of project types, Unity is proficient in handling 2D, 3D, augmented reality (AR), and virtual reality (VR) projects [87].

  One of Unity's distinguishing features is its component-based and framework-driven architecture. This approach simplifies the development process by allowing developers to assemble and customize their projects using pre-built components and systems1. This design philosophy not only streamlines development but also enhances code reusability and maintainability[87].

  Unity offers an integrated asset store within its editor, providing developers with a vast repository of downloadable assets, including 3D models, textures, sound effects, scripts, and more2. This asset store greatly expedites development by providing readily available resources for inclusion in projects, saving valuable time and effort [88].

  Additionally, Unity supports the installation of custom packages that contain pre-programmed components. These packages further simplify development by offering reusable, well-tested elements that can be easily integrated into projects [87].

  With its comprehensive feature set, cross-platform support, asset ecosystem, and user-friendly development environment, Unity has established itself as a go-to choice for game and application development across a wide range of industries.

- **Microsoft visual studio**

  Microsoft Visual Studio is an Integrated Development Environment (IDE) known for its efficiency in creating and analyzing code [56]. In the context of augmented reality (AR) development, it serves as a valuable companion tool, especially when used in conjunction with Unity

for scripting in C# [89]. Visual Studio plays a pivotal role in organizing code, identifying errors, and providing helpful code suggestions[56], thus expediting the AR development process. Developers working on AR projects can leverage the robust capabilities of Visual Studio to ensure smooth integration of AR features and enhance the overall development workflow.

- **Vuforia SDK** is a cross-platform Augmented Reality (AR) and Mixed Reality (MR) application development platform, with robust tracking and performance on a variety of hardware (including mobile devices and mixed reality Head Mounted Displays (HMD) such as the Microsoft HoloLens)[79]. This platform is designed to empower developers to craft immersive AR experiences for an array of devices, including smartphones, tablets, and augmented reality glasses.

  Key Features and Capabilities of the Vuforia SDK [97]:

  - **AR tracking**: Vuforia incorporates advanced computer vision technology for precise tracking and recognition of real-world objects, images, and environments. This capability enables AR applications to overlay digital content, such as 3D models, animations, videos, or information, onto physical objects or scenes.
  - **Cross-platform compatibility**: Vuforia supports cross-platform development, providing developers with the flexibility to create AR applications that can seamlessly run on various operating systems, including Android, iOS, and Unity-based applications for different platforms.
  - **Marker-based tracking**: Vuforia is well-known for its marker-based tracking, enabling the recognition of predefined markers, such as images, objects, or QR codes, to trigger AR content. This fundamental feature is crucial for interactive AR experiences.
  - **Model targets**: Vuforia introduces Model Targets, allowing developers to identify and track 3D objects. This feature is particularly valuable for industrial AR applications, product visualization, and maintenance support.
  - **Area targets**: With Area Targets, Vuforia empowers AR applications to recognize and track expansive areas, such as rooms or buildings, facilitating applications in indoor navigation and architectural visualization.
  - **Smart terrain**: Smart Terrain is a dynamic recognition feature that enables real-time identification of physical objects, enhancing the interaction between AR content and the physical environment.
  - **Cloud recognition**: Vuforia supports cloud-based recognition, simplifying the management and updating of target databases remotely. This feature ensures that AR content remains up-to-date and relevant.
  - **Device compatibility**: Vuforia SDK is compatible with a broad spectrum of mobile devices, including smartphones and tablets, and it's optimized for AR glasses like HoloLens and various smart glasses.
  - **Unity integration**: Vuforia seamlessly integrates with Unity, one of the most popular game development engines. This integration streamlines AR development, making it accessible and efficient for Unity developers.
  - **Development resources**: Vuforia provides an array of development tools, including an SDK, a Unity extension, extensive documentation, tutorials, and sample projects, to support developers in creating immersive AR experiences.

    Vuforia SDK has played a pivotal role in the creation of a multitude of AR applications across diverse industries. Its robust tracking capabilities, cross-platform compatibility, and developer-friendly features have solidified its position as a powerful tool for crafting captivating AR experiences[97].

- **UI ToolKit** UI Toolkit is a collection of features, resources, and tools for developing user interfaces (UI) in Unity [77]. It is a retained-mode UI system based on recognized web

technologies that allows to develop custom UI and extensions for the Unity Editor, runtime debugging tools, and runtime UI for games and applications [77].
It is designed to optimize performance across platforms and supports stylesheets, dynamic and contextual event handling, and a data binding system[77]. The core of UI Toolkit is a retained-mode UI system based on recognized web technologies. It supports stylesheets and dynamic and contextual event handling. The UI system includes the following features:

- **Visual tree:** An object graph, made of lightweight nodes, that holds all the elements in a window or panel. It defines every UI you build with the UI Toolkit.
- **Controls:** A library of standard UI controls such as buttons, popups, list views, and color pickers. You can use them as is, customize them, or create your own controls.
- **Data binding system:** A system links properties to the controls that modify their values.
- **Layout engine:** A layout system based on the CSS Flexbox model. It positions elements based on layout and styling properties.
- **Event system:** A system communicates user interactions to elements, such as input, touch and pointer interactions, drag-and-drop operations, and other event types. The system includes a dispatcher, a handler, a synthesizer, and a library of event types.
- **UI renderer:** A rendering system built directly on top of Unity's graphics device layer.
- **Editor UI support:** A set of components to create Editor UI.
- **Runtime UI support:** A set of components to create runtime UI.

Unity recommends using UI Toolkit for new UI development projects [77]

4.1.2 Hardware

The functionality of the food label app has been developed on a PC with the following specifications:
Device name: POSITIVO BGH
Processor: Intel(R) Core(TM) i7-9700 @ 3.00GHz
Memory: 32 GB DDR4 SDRAM
Storage: 1TB
Operating system: Windows 11

Additionally, the app was tested on smartphones running the Android operating system with:
Memory: 6GB
Storage: 128GB
Operating System: Android 10

4.2 Low-fidelity prototype

In the early design phase of my project, a low-fidelity prototype has been chosen as the method for sketching out user interfaces and gathering feedback on fundamental design concepts[69]. This approach allows for quick exploration of ideas and facilitates valuable input from users before proceeding to more detailed design stages.

Figure 4.1: Low-fidelity prototype

A low-fidelity prototype was employed to validate ideas, utilizing paper and cardboard as basic materials. I incorporated a smartphone template to create a familiar context, enhancing the user experience by simulating interaction with a smartphone.

4.3 High-fidelity prototype

A high-fidelity prototype was created and iterated based on usability testing feedback and findings from state-of-the-art, such as incorporating exit buttons uniformly across all screens and refining food label categories.

4.3.1 Icon

Icon is a small image that represents an application on a mobile device. It is usually a square or circle with a unique image or logo that represents the app [39] [32].
The app icon serves as a visual cue for users to identify and locate the app on their device [39]. It also helps to distinguish the app from other apps on the device and can help to create brand recognition [39] [6]
A well-designed app icon can help to attract users to download and use the app [6]. It should be simple, memorable, and convey the purpose and personality of the app [39]

The icon was designed with a fork and spoon, symbolizing eating, and lines representing information, including food details. This signifies that users can find information about what to eat in the application.

Figure 4.2: Icon Image

4.3.2 Splash

A splash screen is the initial graphic that appears when launching a mobile app or computer software, displaying the application's logo or a related visual representation before the main interface fully loads[7].
It is commonly utilized by applications to inform the user that the app is in the process of loading[63].

The splash screen disappears when the application's main screen appears.
The splash screen was created for the following purposes:

- **Loading feedback:** Is employed to inform users that the application is in the process of loading, indicating that the app is initializing and preventing users from perceiving a delay as a problem.

- **Initialization:** Behind the scenes, it provides time for the application to perform necessary initialization tasks before presenting the main menu screen.

Figure 4.3: Splash screen

4.3.3 Main menu

It is a screen that appears when a user opens up an app on a mobile device. It is the primary screen that provides access to the app's main features and functions . The main menu screen typically contains a list of options or buttons that allow the user to navigate to different parts of the app.[37]

The design of the main menu screen is important for creating a positive user experience. It should be easy to navigate and visually appealing. The main menu screen should also be designed to work well on multiple platforms and adapt to different screen sizes and resolutions[37]

The design of the main menu screen was created to provide options and pathways for users to navigate to the list of label elements screen and for opening the user guide content. It includes two buttons: one for navigating to the next screen and another for accessing the user guide.

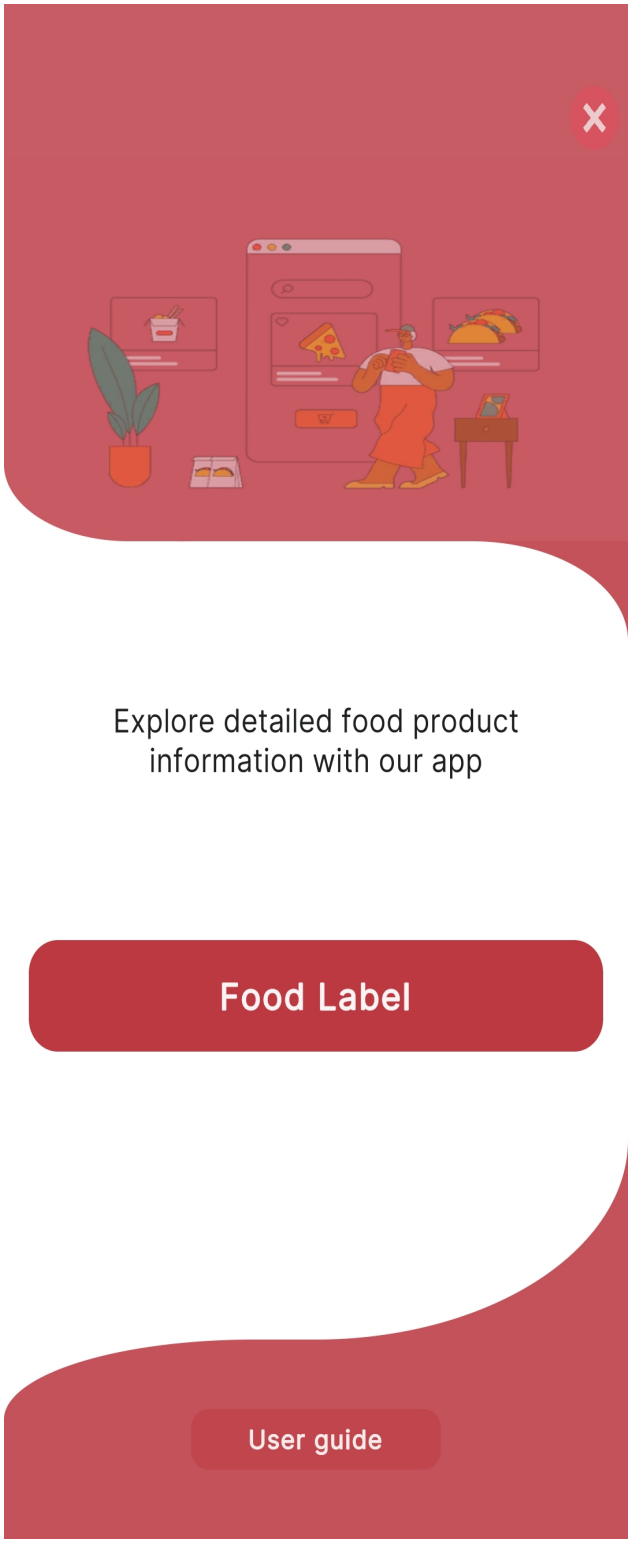

Figure 4.4: Main menu screen

4.3.4 User guide

User guides are designed to help users understand how to use an application or product and can be delivered in various formats[100], help users navigate the app and understand its features and functions.

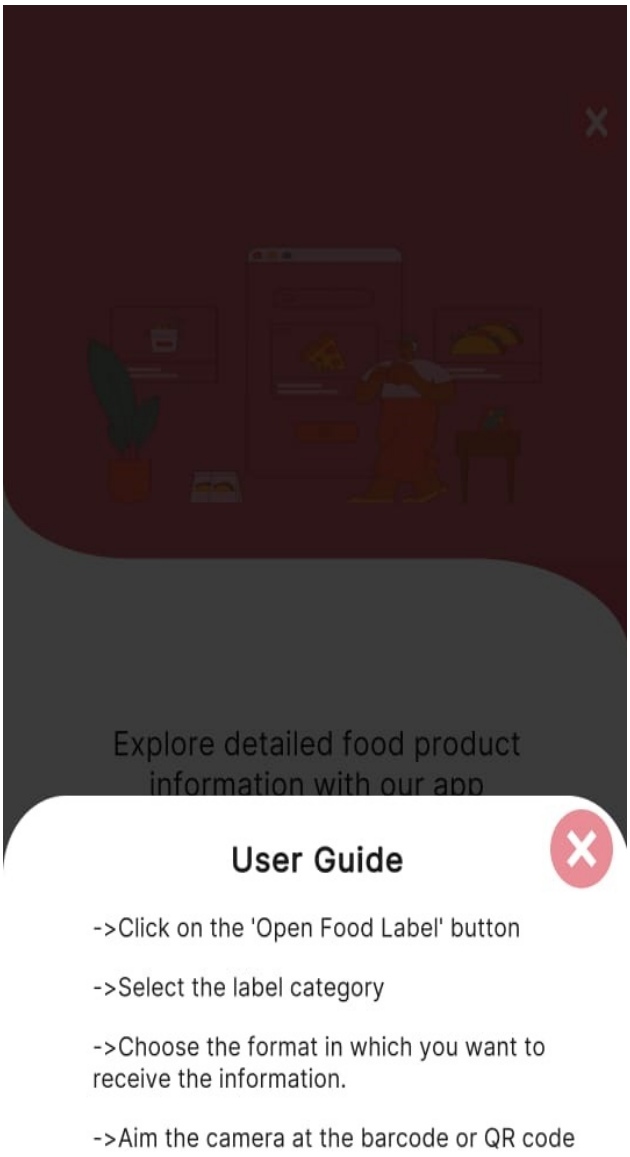

Figure 4.5: User guide Screen

4.3.5 Food label element categories

Reference to a list of essential information required on food product labels[53]; the label elements were categorized into the following categories:

- Ingredients
- Nutrition facts
- Allergen information
- Description
- Guidelines
- Recipe
- Advisory

A screen showing the list of these categories was created so that a user can choose one depending on the information needed for a particular reason.

Figure 4.6: Label elements Screen

4.3.6 Information formats

Information formats refer to the various ways in which information can be presented.
Allowing users to choose between text and video information formats can be beneficial for the following reasons:

- **Accessibility:** Providing both text and video options enhances accessibility. Users with visual or auditory impairments may have a preference for one format over the other. Offering both ensures that a wider range of users can access and understand the content.
- **Flexibility and convenience:** Users may have different preferences based on their context or situation. For example, someone in a quiet environment may prefer reading, while someone on the go might find video content more convenient. Allowing a choice gives users flexibility based on their current circumstances.
- **Content consumption speed:** Users may have different preferences regarding the speed at which they consume information. Some may prefer to quickly scan through written content, while others may appreciate details provided in a video.

- **Bandwidth considerations:** In situations where internet bandwidth is limited, users may prefer text-based content that requires less data for access. Providing a text option ensures a smoother experience for users with restricted bandwidth.
- **Engagement:** Offering a choice can enhance user engagement, as users are more likely to stay engaged with content that aligns with their preferred format.

In this work, the selection of information formats was included based on users' preferences identified during our interviews and surveys.

Figure 4.7: Information format selection Screen

4.3.7 Accessing information

After choosing the preferred format for accessing label information, users can proceed by scanning the QR code or barcode on the food package. This action grants users the flexibility to acquire information through direct reading or video format, as the label details overlay on the food package.

This approach accommodates diverse user preferences, enhancing the user experience. The integration of QR codes and barcode technology ensures a quick retrieval of information without imposing additional tasks on the user.

Figure 4.8: Accessing information on video and text Screens

4.3.8 Front-end development

The development of the front-end utilized UIToolkit, a UI system for Unity built upon well-established web technologies like HTML, CSS, and JavaScript [78][98].
I employed JQuery 2.1.1 for JavaScript, with UXML used as HTML and USS as CSS.

JQuery, a widely adopted JavaScript library, simplifies tasks related to working with HTML documents, managing events, and creating animations. UXML functions as a markup language, defining Unity UI elements, while USS serves as a style sheet language for the visual appearance of Unity UI elements[78].

- **The following is a sample of the UXML codes used in this project:**

```
<ui:UXML xmlns:ui="UnityEngine.UIElements" ...
    xmlns:uie="UnityEditor.UIElements" ...
    xsi="http://www.w3.org/2001/XMLSchema-instance" ...
    engine="UnityEngine.UIElements" editor="UnityEditor.UIElements" ...
    noNamespaceSchemaLocation="../../UIElementsSchema/UIElements.xsd" ...
    editor-extension-mode="False">
```

```
<Style src="project://Assets/Resources/SampleStyle.uss?fileID=74c6" />
<ui:VisualElement style="flex-grow: 0; background-color: rgb(243, ...
    168, 168); width: 100%; height: 100%; flex-direction: column; ...
    align-items: center; justify-content: flex-end; ...
    -unity-background-image-tint-color: rgb(255, 255, 255); opacity: 1;">
    <ui:VisualElement name="ButtonsVE" style="flex-grow: 0; ...
        background-color: rgb(255, 255, 255); width: 100%; height: ...
        100%; color: rgba(15, 17, 16, 0.94); ...
        -unity-background-image-tint-color: rgb(255, 255, 255); ...
        border-top-left-radius: 0; border-top-right-radius: 0; ...
        border-bottom-right-radius: 0; border-bottom-left-radius: 0; ...
        align-items: flex-start; justify-content: space-between; ...
        opacity: 1; align-self: center; flex-direction: column;">
        <ui:VisualElement style="flex-grow: 0; width: 100%; height: ...
            10%; background-color: rgba(196, 82, 90, 0.94); ...
            flex-direction: row; justify-content: flex-end; ...
            align-self: flex-end;">
            <ui:VisualElement name="VisualElement" style="flex-grow: ...
                0; width: 40%; height: 100px; justify-content: ...
                flex-end; align-self: flex-end; margin-right: 20%; ...
                background-image: ...
                url(&apos;project://database/.....;" />
            <ui:Button parse-escape-sequences="true" ...
                display-tooltip-when-elided="true" name="exitbtn" ...
                class="MainMenueExitBtn">
                <ui:VisualElement style="flex-grow: 1; ...
                    background-image: ...
                    url(&apos;project://database/....." />
            </ui:Button>
        </ui:VisualElement>

            <ui:VisualElement style="flex-grow: 0; height: 20%; ...
                width: 100%; background-color: rgb(196, 82, 90); ...
                border-bottom-left-radius: 0; border-top-left-radius: ...
                40%; justify-content: center; align-self: center; ...
                flex-direction: row; align-items: flex-start;">
                <ui:Button parse-escape-sequences="true" ...
                    display-tooltip-when-elided="true" ...
                    name="Button_Open" class="button-blue" ...
                    style="height: 30%; width: 40%; ...
                    border-top-left-radius: 30px; ...
                    border-top-right-radius: 30px; ...
                    border-bottom-right-radius: 30px; ...
                    border-bottom-left-radius: 30px; font-size: 40px; ...
                    white-space: normal; background-color: rgba(179, ...
                    31, 41, 0.29); flex-direction: row; opacity: 0.89; ...
                    align-self: center;">
                    <ui:VisualElement style="flex-grow: 1; ...
                        align-items: stretch; justify-content: center;">
                        <ui:Label tabindex="-1" text="User guide" ...
                            parse-escape-sequences="true" ...
                            display-tooltip-when-elided="true" ...
                            style="white-space: normal; ...
                            justify-content: center;" />
                    </ui:VisualElement>
                </ui:Button>
            </ui:VisualElement>
        </ui:VisualElement>
    </ui:VisualElement>
    <ui:VisualElement name="Container_Bottom" style="flex-grow: 0; ...
        width: 100%; height: 100%; position: absolute; display: flex; ...
        opacity: 1; border-top-left-radius: 30%; ...
        border-top-right-radius: 30%;">
        <ui:VisualElement name="Scrim" class="scrim scrim--fadein" ...
            style="opacity: 0.91;" />
        <ui:VisualElement name="BottomSheet" class="bottomsheet" ...
            style="height: 50%; border-top-left-radius: 10%; ...
```

```
                border-top-right-radius: 10%; background-color: rgb(255, ...
                255, 255); justify-content: center;">
                <ui:Label tabindex="-1" text="User Guide" ...
                    parse-escape-sequences="true" ...
                    display-tooltip-when-elided="true" name="Title" ...
                    class="text--title" style="top: 0; width: 80%; ...
                    justify-content: space-between; align-items: ...
                    flex-start; align-self: center; margin-right: 0; ...
                    white-space: nowrap; -unity-text-align: upper-center; ...
                    flex-direction: row;" />
                <ui:Button parse-escape-sequences="true" ...
                    display-tooltip-when-elided="true" name="Button_Close" ...
                    class="UserGuideExitBtn" />
                <ui:VisualElement style="flex-grow: 1; width: 90%; ...
                    height: auto; align-self: flex-end; justify-content: ...
                    center; margin-top: 3%;">
                    <ui:VisualElement style="flex-grow: 1; width: 100%; ...
                        align-self: center; margin-top: 0; ...
                        justify-content: flex-start;">
                        <ui:Label tabindex="-1" text="- Click on the ...
                            &amp;apos;Open Food Label&amp;apos; button" ...
                            parse-escape-sequences="true" ...
                            display-tooltip-when-elided="true" ...
                            style="white-space: normal; font-size: 39px;" />
                        <ui:Label tabindex="-1" text="- Select the label ...
                            element you want to scan" ...
                            parse-escape-sequences="true" ...
                            display-tooltip-when-elided="true"/>
                    </ui:VisualElement>
                    <ui:VisualElement style="flex-grow: 1; margin-top: ...
                        7%; align-self: center;">
                        <ui:Label tabindex="-1" text="The information ...
                            will be presented in the following ...
                            modalities:" parse-escape-sequences="true" ...
                            display-tooltip-when-elided="true" ...
                            style="white-space: normal; font-size: 39px;" />
                        <ui:VisualElement style="flex-grow: 1; ...
                            align-self: center; width: 90%;">
                            <ui:Label ...
                                tabindex="tooltip-when-elided="true" ...
                                style="white-space: normal; font-size: ...
                                39px; flex-shrink: 1; width: 80%; ...
                                align-self: flex-end;" />

                            <ui:Label tabindex="-1" text="-&gt;Text for ...
                                recommendations" ...
                                parse-escape-sequences="true" ...
                                display-tooltip-when-elided="true" ...
                                style="white-space: normal; font-size: ...
                                39px; flex-shrink: 1; width: 80%; ...
                                align-self: flex-end;" />
                        </ui:VisualElement>
                    </ui:VisualElement>
                </ui:VisualElement>
            </ui:VisualElement>
        </ui:VisualElement>
    </ui:VisualElement>
</ui:UXML>
```

- **The following is a sample of the USS codes used in this project:**

```
.button-blue {
    height: 100%;
    color: rgb(255, 255, 255);
    font-size: 50px;
    background-color: rgba(179, 31, 41, 0.85);
```

```
    border-top-left-radius: 86px;
    border-top-right-radius: 86px;
    border-bottom-right-radius: 86px;
    border-bottom-left-radius: 86px;
    border-top-width: 0;
    border-right-width: 0;
    border-bottom-width: 0;
    border-left-width: 0;
    margin-top: 0;
    margin-right: 0;
    margin-bottom: 0;
    margin-left: 0;
    padding-top: 0;
    padding-right: 0;
    padding-bottom: 0;
    padding-left: 0;
    -unity-font-style: bold;
    transition-duration: 0.5s;
    transition-timing-function: ease-out-elastic;
    width: 100%;
}

.button-blue:hover {
    height: 200px;
    color: rgb(255, 255, 255);
    font-size: 50px;
    background-color: rgb(0, 90, 164);
    border-top-left-radius: 50px;
    border-top-right-radius: 50px;
    border-bottom-right-radius: 50px;
    border-bottom-left-radius: 50px;
    border-top-width: 0;
    border-right-width: 0;
    border-bottom-width: 0;
    border-left-width: 0;
    margin-top: 40px;
    margin-right: 0;
    margin-bottom: 0;
    margin-left: 0;
    padding-top: 0;
    padding-right: 0;
    padding-bottom: 0;
    padding-left: 0;
    -unity-font-style: bold;
    scale: 1.06 1.06;
}

.button-blue:active {
    background-color: rgba(76, 100, 185, 0.95);
    font-size: 50px;
}

.text--title {
    -unity-font-style: bold;
    font-size: 50px;
    -unity-text-align: upper-center;
    -unity-font: url('project://database/.....................);
    margin-top: 60px;
}

.text--paragraph {
    font-size: 50px;
    -unity-text-align: upper-center;
    -unity-font: url('project://database/.....................');
    margin-top: 40px;
    padding-bottom: 40px;
}
```

```
.bottomsheet {
    flex-grow: 0;
    position: absolute;
    width: 100%;
    height: 50%;
    bottom: 0;
    -unity-background-image-tint-color: rgb(255, 255, 255);
    background-color: rgb(255, 255, 255);
    border-top-left-radius: 40px;
    border-top-right-radius: 40px;
    display: flex;
    translate: 0 100%;
    transition-duration: 1s;
    transition-timing-function: ease-in-bounce;
}

.bottomsheet--up {
    translate: 0 0;
}

.scrim {
    flex-grow: 1;
    color: rgba(27, 27, 27, 0.98);
    -unity-text-outline-color: rgba(22, 21, 21, 0.9);
    background-color: rgba(0, 0, 0, 0.84);
    display: flex;
    opacity: 0;
    transition-duration: 0.5s;
}

.scrim--fadein {
    opacity: 1;
}

.MainMenueExitBtn {
    width: 10%;
    height: 50%;
    background-color: rgba(188, 188, 188, 0);
    border-top-width: 0;
    border-right-width: 0;
    border-bottom-width: 0;
    border-left-width: 0;
    opacity: 0.68;
    -unity-text-align: middle-center;
    justify-content: center;
    flex-direction: row;
    align-items: center;
    align-self: flex-end;
}

.MainMenueExitBtn:hover {
    scale: 1.1 1.1;
}

.MainMenueExitBtn:active {
    background-color: rgba(202, 75, 75, 0.33);
    opacity: 0.76;
}
```

4.3.9 Back-end development

A script written in C# was used for back-end development. The following is a sample of the C# code used:

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;
using UnityEngine.UIElements;

public class FromElements : MonoBehaviour
{
    public Button guidanceButton;
    public Button backToMainMenuButton;
    public Button ExitAppButton;

    public Button FactsButton;
    public Button IngredientsButton;
    public Button AllergenButton;
    public Button ClaimsButton;
    public Button InstructionsButton;

    void Start()
    {
        var root = GetComponent<UIDocument>().rootVisualElement;

        guidanceButton = root.Q<Button>("guidanceBtn");
        guidanceButton.clicked += guidanceBtnPressed;

        FactsButton = root.Q<Button>("FactsBtn");
        FactsButton.clicked += FactsBtnPressed;

        IngredientsButton = root.Q<Button>("IngredientsBtn");
        IngredientsButton.clicked += IngredientsBtnPressed;

        AllergenButton = root.Q<Button>("AllergenBtn");
        AllergenButton.clicked += AllergenBtnPressed;

        ClaimsButton = root.Q<Button>("ClaimsBtn");
        ClaimsButton.clicked += ClaimsBtnPressed;

        InstructionsButton = root.Q<Button>("InstructionsBtn");
        InstructionsButton.clicked += InstructionsBtnPressed;

        backToMainMenuButton = root.Q<Button>("backToMainMenuBtn");
        backToMainMenuButton.clicked += backToMainMenuBtnPressed;

        ExitAppButton = root.Q<Button>("ExitAppBtn");
        ExitAppButton.clicked += ExitAppBtnPressed;

    }

    void guidanceBtnPressed()
    {
        SceneManager.LoadScene("GuidanceModScene");
    }
    void FactsBtnPressed()
    {
        SceneManager.LoadScene("NutritionFactModScene");
    }


    void IngredientsBtnPressed()
    {
        SceneManager.LoadScene("IngredientModScene");
```

```
    }
    void AllergenBtnPressed()
    {
        SceneManager.LoadScene("AllergenModScene");
    }
    void ClaimsBtnPressed()
    {
        SceneManager.LoadScene("AdvisoryModScene");
    }
    void InstructionsBtnPressed()
    {
        SceneManager.LoadScene("InstructionModScene");
    }

    void backToMainMenuBtnPressed()
    {
        SceneManager.LoadScene("MainMenu");
    }
    void ExitAppBtnPressed()
    {
        Application.Quit();
        Debug.Log("You have quit the app!!!!!");
    }
}
```

Chapter 5

Findings & discussion

5.1 RQ1 - How and for what purposes do consumers use food labels?

5.1.1 Food label usage and challenges

Adopting a Human-Centered Design approach, this research placed users at the center of the design process, tailoring every aspect to meet their needs and preferences. The research employed a combination of interviews, observations, and surveys to address research question 1.

The findings from interviews reveal that four out of five participants consistently read food labels for various purposes when purchasing or consuming. One out of five participants reads labels only occasionally, particularly when dealing with unfamiliar items.
To gain insights from participants, I initiated discussions about their experiences with food labels, utilizing the following questions:

- Can you provide some insights into your experiences with food product labels?
- How often do you read food labels, and could you share any specific reasons for doing so?
- In your own words, how challenging is it for you to understand the information presented on food labels?

Participant 1, driven by the need for information about allergies, emphasized the need to check labels for potential allergens, saying, "I have extensive experience with food labels. As someone with allergies, I always check labels to ensure there are no potential allergens." Participant 2 indicated variable label-reading frequencies, focusing on unfamiliar items or when the package changed, and said, "I rarely pay attention to familiar food labels unless it's a new product I want to try or when the package has changed." Participant 3 developed a habit of reading labels after an incident with an expired product and said, "I pay attention to food labels, especially when making health-conscious choices, and I particularly focus on the expiration date. This became a habit after an incident where I bought an expired cake some time ago." Participant 4, guided by religious considerations, highlighted the importance of understanding ingredients for adherence to dietary restrictions, saying, "Understanding the ingredients is crucial for me due to religious reasons. As a Muslim, I avoid pork, so my main concern when purchasing food products is ensuring they adhere to my dietary restrictions. Clear labels that explicitly state the contents help me make choices aligned with my religious beliefs." Participant 5, motivated by weight management goals, said, "As you can see, I am starting to gain weight due to the food I eat. Last year, I made the decision to eat foods that I am sure will not have a bad impact on my health. Since then, I started to read labels."

A shared challenge among all participants is the insufficiency of information on food labels, missing essential details for decision-making, and the issue of excessive details, including advertisements on packages, making it difficult to locate the necessary information.

The interviews highlight the participants' dedication to reading labels and the common struggle to find information on labels. This insight supports the need for improved label clarity and content to facilitate informed decision-making.

During the observation phase conducted at Coop Extra[1], REMA 1000[2], and KIWI[3] in Grimstad, it was noted that consumers engage with food labels as part of their decision-making process. People were observed reading labels on food packages before making a purchase decision.
Different shopping behaviors were observed among the shoppers. Some individuals entered the store with a clear idea of what they wanted to buy. For these shoppers, the focus was primarily on essential information such as the expiration date. In contrast, others took 3 to 5 minutes to read and inspect labels thoroughly, examining each side of the packaging. This group seemed to be searching for specific information and, in some cases, struggled to find what they were looking for. Consequently, they either selected a food product after a careful examination or returned it to the shelves.

For understanding the frequency with which people read labels and how easy it is for them to understand them, the survey included the following questions:

- How often do you read food labels?
- On a scale from 1 (very difficult) to 10 (very easy), how easy is it for you to understand food labels?

Survey results indicate a consistent interest in label reading, with 40% of participants (2 out of 5) reporting that they always read labels, while 60% (3 out of 5) reported reading them sometimes. None of the participants claimed to never read labels. However, the ease of understanding labels varies among participants, as reflected in their ratings on a scale from 1 to 10. Specifically, 20% (1 participant) reported their understanding as 1 out of 10, 40% (2 participants) reported it as 2 out of 10, 20% (1 participant) reported it as 6 out of 10, and another 20% (1 participant) reported it as 7 out of 10.

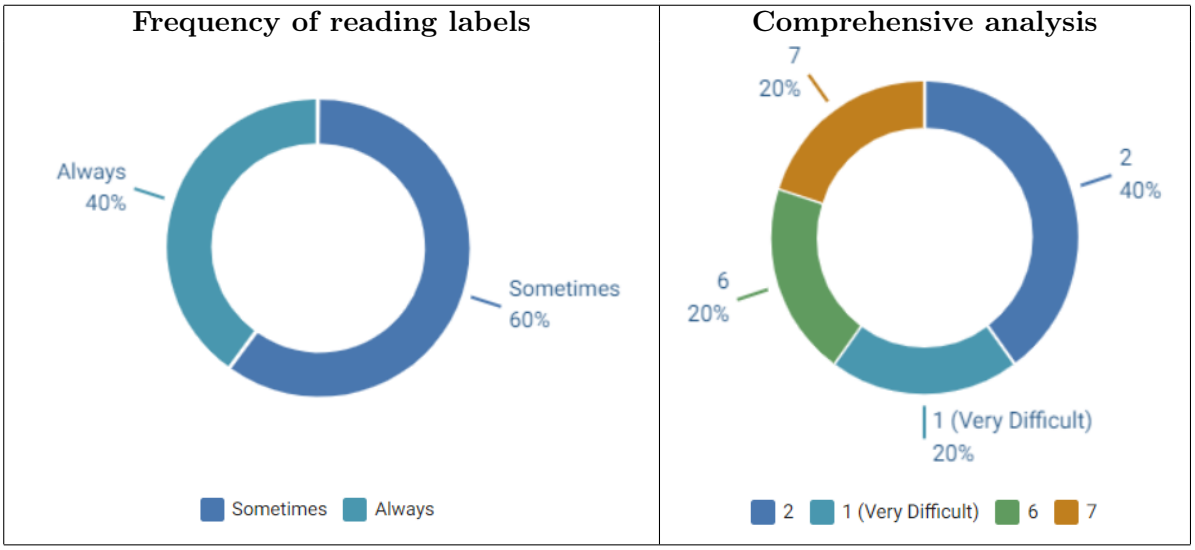

Table 5.1: Survey participants' responses regarding the frequency of reading labels and how easily they are understandable.

These findings suggest that there is a notable level of engagement with food labels among the surveyed participants. While a majority read labels either always or sometimes, there is a diversity in how easily individuals understand the information presented on the labels, as indicated by the varied ratings on the 1 to 10 scale. The insights from interviews, observations, and surveys collectively

[1] https://www.coop.no/extra
[2] https://www.rema.no/
[3] https://kiwi.no/

emphasize the need for enhanced label clarity and content to support informed decision-making.

5.1.2 Impact on decision-making

To comprehend the influence of food label information on decision-making, we investigated participants' perspectives through interviews and surveys. Two pivotal questions guided this exploration:

- To what extent do you believe the information on food product labels influences your choices when purchasing food items?
- Are there specific aspects of the food label that you think have a significant impact on your decision-making?

In response, Participant 1 showcased a preference for comprehensive nutritional information and valued guidance on storage and consumption. However, the most critical factors influencing their choices were allergen information, ingredient lists, and excessive sugar content.

Participant 2 expressed a moderate influence of food labels on their choices, particularly relying on familiarity and its impact on their health. Interestingly, when dealing with unfamiliar products or changes in packaging, the importance of information on labels increased.
This participant stated, "The information on food product labels has a moderate influence on my choices when purchasing food items. I tend to rely more on familiar items, and in such cases, I don't give enough consideration to the labels, as I mentioned earlier. However, when dealing with unfamiliar products or changes in packaging, the information on labels becomes more crucial in influencing my decisions." Ingredient lists emerged as a crucial aspect that significantly influenced their decision-making."
Ingredient lists emerged as a crucial aspect that significantly influenced their decision-making.

Participant 3 emphasized trust in the producers and considered all information provided by them crucial for making an informed decision. This participant stated, "All information that the producer of the food I am considering purchasing wants me to know influences my choices when buying food items, as the decision to consume any food signifies trust in the producer. Thus, any information provided by them is crucial for making an informed decision. The aspects of the food label that significantly impact my decision-making include the expiration date, ingredients, and country of origin." This highlights that complete and available information on food labels is essential for consumers.

Participant 4, adhering to dietary restrictions as a Muslim, highlighted the significant influence of food labels on their decision-making. The absence of clear and easily accessible ingredient lists posed a considerable challenge, impacting their ability to make informed choices aligned with religious beliefs.

Participant 5 faced challenges with missing information on food labels, especially on small packaged foods. The participant shared an experience during a wedding attended, where a cake served in a small package lacked sufficient information for decision-making. The participant explained, "Due to the bad experience I've faced with labels, especially when they are overloaded with text or lack information on small packaged foods, my decision-making is significantly affected. The cake I showed you, I chose not to eat it due to missing information. I brought it here; please take it and see if you can find information yourself. If clear details were available on its package, I would confidently choose to consume it. But as you can see, I have it with me because on that day, I decided to put it in my pocket. It is good you asked me this question while I still have it." The participant concluded by stating that the most critical elements on the food label to be checked are the ingredients, allergy information, and expiration date.

Survey responses further support the significance of food labels in influencing purchasing decisions. On a scale of 1 to 5, participants indicated varying levels of impact, with one participant rating it 5 out of 5, two participants at 4 out of 5, and one participant at 2 out of 5. When asked about the element of the label that most influences their decision, four participants chose "ingredient," while one participant chose "nutrition facts." The findings underscore the diverse impact of food label information on consumer decision-making, emphasizing the pivotal role of clear and accessible food label information, particularly regarding ingredient details, in guiding consumers' choices during food purchases or consumption.

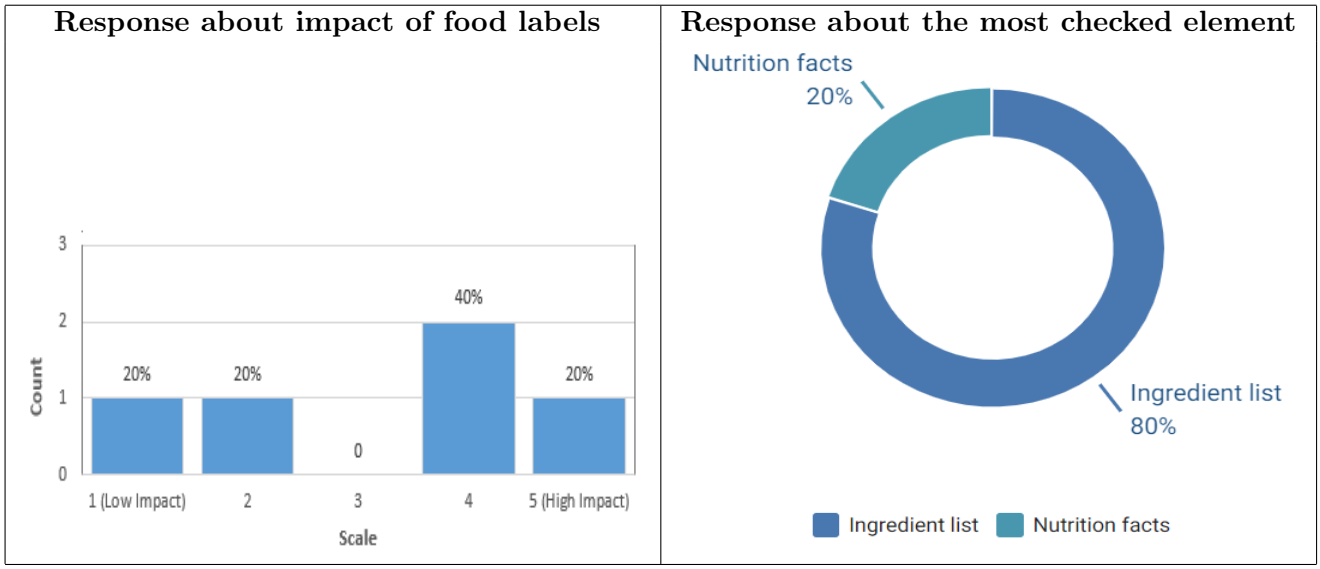

Table 5.2: Participants' responses regarding the impact food labels have on their purchasing decisions and the label element that most influences the decision when purchasing food products

With insights gained from interviews, observations, and surveys, it is evident that users employ food labels for decision-making, enabling consumers to make informed choices for various reasons, including:

- Health condition management
- Dietary preferences
- Dietary restrictions
- Weight management
- Allergen awareness
- Ingredient transparency
- Health consciousness
- Nutritional information

However, the packaging of essential information on food labels poses a significant challenge due to limited space on packages, resulting in incomplete or unavailable information. Balancing the inclusion of necessary information without overloading small packages emerges as a key challenge for manufacturers.

The findings underscore the delicate balance needed to enhance user experiences with food labels. Addressing the constraints of packaging size while ensuring the availability, completeness, and findability of vital information emerges as a key challenge in optimizing user interaction with food labels.

5.2 RQ2 - How can augmented reality be designed and developed for enhancing food product labels ?

The findings from the interviews revealed a positive attitude among all participants (5 out of 5) towards using technology, specifically smartphones, for accessing food label information. Participants expressed interest in the concept of an innovative app that could provide detailed information about the food they consider, recognizing its potential to enhance informed decision-making.
The integration of technology into their food shopping routine was a shared sentiment, with participants believing that such solutions could significantly boost their confidence and efficiency in selecting suitable food products. When asked about their information formatting preferences, one participant opted for the text format, another favored the video format, while three out of five participants expressed a preference for both video and text formats.

Survey responses further supported the interest in utilizing technology, with 4 out of 5 participants expressing a positive attitude, while 1 out of 5 remained uncertain. Regarding the preferred format for accessing food label information, 3 out of 5 participants opted for both text and video, while 2 out of 5 chose the text format.

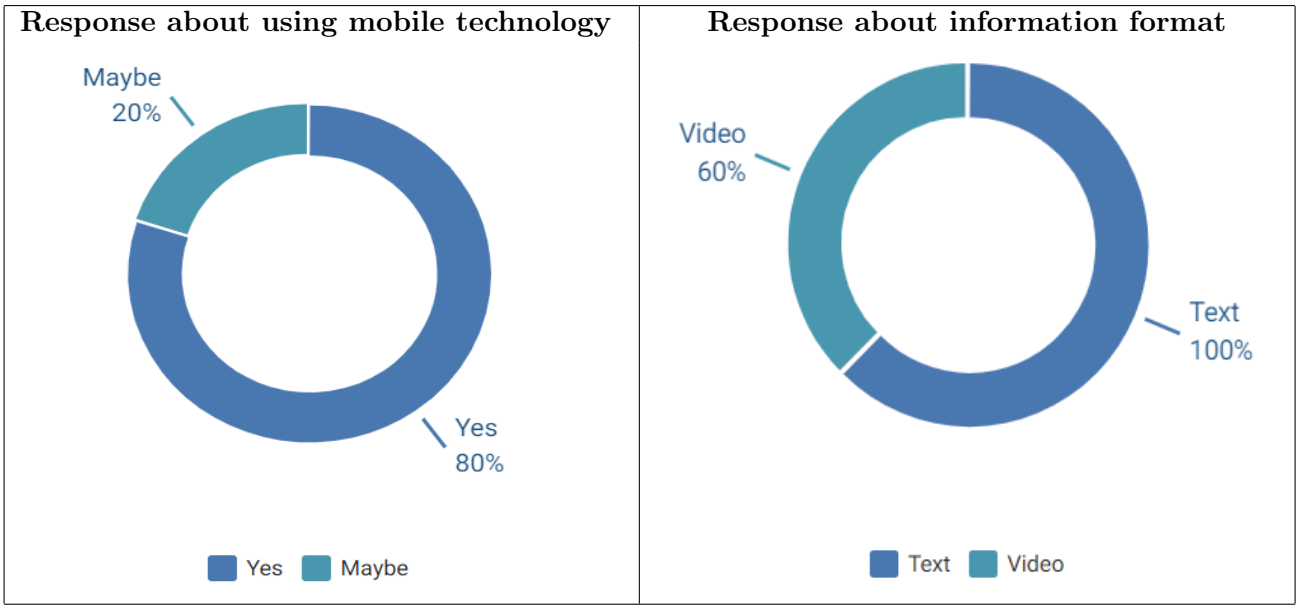

Table 5.3: Participants' responses to the question of whether they are interested in using technology and format they would like to access the food label information

The agreement and enthusiasm expressed by participants in embracing the idea of using smartphones to access food label information in both text and video formats suggest a collective belief in employing augmented reality technology as a valuable tool to tackle existing challenges associated with food labels.
Building on this shared perspective, the integration of Marker-Based Augmented Reality, utilizing QR or BR codes on food labels as markers, emerges as a promising approach to enhance the food decision-making experience for individuals.

To ensure an intuitive and user-friendly experience, UIToolkit, comprising features, resources, and tools for developing user interfaces, was employed. This toolkit includes user guide text and various interface components, such as pictures and buttons. This facilitated consumers in navigating through the interface with clickable buttons for seamless operations.

Recognizing the importance of avoiding information overload in a single location, information was thoughtfully grouped into seven categories. This categorization allows users to select specific cate-

gories and access relevant information, contributing to a more streamlined and effective augmented reality experience for enhancing food product labels.

5.3 RQ3 - Can augmented reality effectively enhance food product labels ?

This research indicates that augmented reality (AR) has the potential to effectively enhance food product labels. The incorporation of AR technology into the field of food labeling has demonstrated its capability to provide interactive, multisensory experiences, serving as a bridge between the physical and digital domains. AR's capacity to dynamically adjust content views based on user's choices contributes to tailoring user experiences, ensuring personalized and interactive engagements with information overlaid on the package.

Furthermore, the specific application of Marker-Based AR surpasses traditional labeling methods by enabling the direct overlay of digital content onto physical packaging. This creates a seamless integration of physical and digital elements, making the information feel like an inherent part of the physical package. This feature empowers consumers with an interactive and understanding of the information presented, fostering a deeper comprehension of the product properties.

The state-of-the-art research accentuates the numerous advantages associated with integrating AR in the enhancement of food product labels. These benefits include improved customer experiences, heightened engagement levels, and a more informed decision-making process.

Moreover, insights from high-fidelity prototype testing further reinforce the usability and functionality of the AR application. The feedback received indicates that the application is well-received and effectively meets users' requirements.

Specifically, the results indicate a usability rate of 85.5%, and a positive experience with the AR-enhanced food product labels, as shown in the findings below:

Participant ID	SUS1	SUS2	SUS3	SUS4	SUS5	SUS6	SUS7	SUS8	SUS9	SUS10	Sum(Positively Phrased - 1)	Sum(5 - Negatively Phrased)	SUM/40	%
P1	5	1	4	1	4	2	4	2	4	1	16	18	34	85
P2	4	2	5	2	4	2	4	1	5	1	17	17	34	85
P3	3	2	4	1	3	1	5	1	5	2	15	18	33	82.5
P4	4	1	5	1	4	2	4	1	4	1	16	19	35	87.5
P5	4	1	5	1	4	1	5	2	4	2	17	18	35	87.5

Table 5.4: SUS finding results

The overall score from all participants is calculated by determining the average percentage as follows:

$$\frac{85 + 85 + 82.5 + 87.5 + 87.5}{5} = \frac{427.5}{5} = 85.5\%$$

The successful integration of AR in providing relevant information, coupled with positive feedback from high-fidelity prototype testing, positions AR as a viable solution for enhancing the overall usability and effectiveness of food product labels

Chapter 6

Conclusion & future work

6.1 Conclusion

In conclusion, this research project aimed to enhance food labeling by understanding the challenges consumers face when accessing food product labels. And proposing a digital technology-supported solution through the utilization of a Human-Centered Design approach, the goal was to ensure that the solution responded effectively to users' needs and requirements. The primary focus was on designing and developing an Augmented Reality (AR) application aimed at improving the availability of information on food labels, employing both text and video formats

Exploring augmented reality technology within the context of food product labels provided an understanding of the current landscape, emphasizing the role AR can play in diverse domains such as retail industry. Through the integration of AR technology, this research aimed to enhance the user experience and facilitate easier access to food label information.

Feedback from participants, gathered through interviews, surveys, and usability testing, strongly supported the idea behind the work. It became evident that there is a significant demand among consumers for accessing information provided by food producers, empowering individuals to make informed choices for themselves and their families.

Acknowledging the project's achievements, it is essential to recognize the constraints imposed by time limitations. Looking ahead, the proposed future work outlines key directions for advancing this research, including expanding the research participants base, involving diverse stakeholders, and exploring advanced technological features.

This research not only illuminates the current state of augmented reality in the context of food labeling but also lays the groundwork for future advancements in technology, usability, and the well-being of humankind.

6.2 Future work

While this research successfully developed a proof-of-concept augmented reality food label application, there are opportunities for improvement, particularly in terms of sample size, stakeholder involvement, and technological advancements. The following areas are identified for future work:

Expansion of participants

The current study faced constraints in both time and sample size. To address this limitation, future work shall allocate sufficient time and focus on significantly increasing the number of study participants. In doing so, it is imperative to involve diverse stakeholders such as food producers, manufacturers, policy makers, and vendors. This expanded representation will contribute to a robust conclusion, especially in light of the global implications of the food labeling issue.

Technological advancements

From a technological perspective, future work will explore advanced features aimed at dynamically fetching information from third-party sources. A proposed mechanism involves establishing API (Application Programming Interface) endpoints provided by food producer entities to expose information about the food products they produce. Upon the user's initiation of the first information request, the application could dynamically retrieve and store the information in its database. Subsequent requests could then be fetched locally, minimizing the need for multiple calls within the app. This approach not only optimizes data retrieval but also ensures real-time synchronization with external data sources, enhancing the overall functionality and user experience.

Accessibility enhancement

Due to time constraints, the accessibility of the application was evaluated through usability testing on mobile devices with different screen sizes. However, for future work, alignment with the Web Content Accessibility Guidelines (WCAG) standards, specifically tailored for mobile applications, is recommended. This strategic alignment ensures a more inclusive experience for individuals with diverse needs and preferences. By adhering to WCAG standards, the augmented reality food label application can better cater to a broader audience, promoting accessibility and usability.

Appendix A

Personas

Name: Allen Aby
Age: 67

- **Background**: Allen is a retiree who enjoys traveling and staying active. She places a strong emphasis on her health and well-being.
- **Characteristics**: Allen is characterized by her adventurous spirit. She is curious about different cultures and is open to trying new things, including diverse cuisines.
- **Skills**: Allen is skilled in using smartphone apps for tracking her fitness and health progress, such as step counters and dietary trackers.
- **Goals and Aspirations:** Allen's primary goals are to stay active, maintain good health during retirement, and explore new cuisines and cultures during her travels.
- **Tasks**: Her tasks include shopping for international foods, considering dietary restrictions, and tracking her daily steps to stay fit.
- **Environment**: Allen lives in a home within a retirement community, travels to various international destinations, and explores diverse local markets during her trips.

Name: Omar
Age: 28

- **Background**: Alex is a fitness enthusiast who follows a strict diet. He pays close attention to the nutritional content of the foods he consumes.
- **Characteristics**: He is a fit and athletic individual with a muscular physique. He is quite social and enjoys sharing his fitness journey on media platforms.
- **Goals and Aspirations**: Alex's goal is to maintain a healthy and balanced diet that supports his fitness goals. He wants to access detailed nutritional information on food labels with ease to make informed dietary choices.
- **Tasks and Environment**: Alex frequently shops for specific foods to fit his dietary requirements. He needs a reliable method to quickly access and analyze the nutritional data of food products.

Name: Eva Robinson
Age: 42

- **Background**: Eva is a nutritionist with a passion for healthy living. She enjoys experimenting with new recipes and ingredients.
- **Characteristics**: Eva is highly knowledgeable about nutrition and dietary needs. She has a strong interest in sustainable food choices and understands the importance of complete food labeling.
- **Skills**: Eva possesses advanced knowledge of nutrition and can interpret complex food labels. She is skilled in providing dietary guidance and recommendations to her clients.
- **Goals and Aspirations**: Eva's goal is to promote healthy eating and sustainable food choices among her clients and the broader community. She aspires to make a positive impact on people's lives through nutrition.

Name: Thompson Aimee
Age: 35

- **Background**: Sarah is a mother of two, a son, and a daughter. She is dedicated to providing her children with a healthy lifestyle and is conscious of the food choices she makes for her family.
- **Characteristics**: Sarah is a caring and health-conscious individual who values sustainability and healthy eating. She enjoys cooking and often prepares homemade meals for her family.
- **Skills**: Sarah is skilled in meal planning, cooking, and understanding nutritional labels.
- **Goals and Aspirations**: Sarah's goal is to ensure her children grow up with healthy eating habits and a strong foundation in nutrition.
- **Tasks and Environment**: Sarah's typical tasks involve grocery shopping, meal preparation, and managing her family's dietary choices. She often shops at local supermarkets.

Name: David Patel
Age: 28

- **Background**: David is a software engineer who lives a busy urban lifestyle. He prioritizes convenience and efficiency in his daily routines.
- **Characteristics**: David is tech-savvy and relies on his smartphone for various tasks. He prefers quick and easy solutions to everyday challenges.
- **Skills**: David is proficient in using smartphone apps and digital tools to streamline his daily tasks. He has excellent digital navigation skills and can adapt to new technology quickly.
- **Goals and Aspirations**: David's goal is to maintain a balanced and efficient lifestyle. He aspires to optimize his daily routines and make informed choices when shopping food product.
- **Tasks and Environment:** David's typical tasks involve managing work-related activities, personal scheduling, and staying connected with friends and colleagues. He often shops at convenience stores.

Appendix B

User senarios

B.1 Scenario 3:

Eva, a health-conscious retiree with a passion for traveling, is on an adventure exploring the markets of a vibrant international destination. She's keen on experiencing new cuisines and cultures while keeping her health in check. Using her smartphone, Eva scans the Barcode on a local food product she's considering. With the AR-enhanced food label application, Eva quickly accesses comprehensive nutritional information, including details on ingredients and dietary restrictions. This empowers her to make informed and healthy choices while indulging in the local cuisine. Eva's ability to use technology and her health-conscious mindset align perfectly with the application's features, enhancing her travel experience.

B.2 Scenario 4:

Alex is a fitness enthusiast in his late 20s who carefully monitors his diet to support his fitness goals. He's at a health food store, looking for the right snacks to fuel his workouts. Alex enters the health food store, determined to find the perfect pre-workout snack. He specifically looks for protein bars and pays close attention to their nutritional content. To aid his decision-making process, he takes out his smartphone, which has the AR-enhanced food label application installed. When he identifies a protein bar he's considering, he scans its Barcode using the application. Unfortunately, after reviewing the initial selection, he decides it doesn't meet his dietary requirements and fitness goals. So, he puts it back on the shelf and selects another protein bar, scanning its QR code with the application. Immediately, his phone's screen displays a digital overlay with detailed nutritional information that aligns with his dietary requirements, leading Alex to make a healthier choice, thanks to the information provided by the AR-enhanced food label.

B.3 Scenario 5:

Allen Aby, a 65-year-old retiree who enjoys traveling and staying active, is planning his next adventure to explore different cuisines and cultures. She wants to ensure she makes the healthiest food choices during her travels while also indulging in local flavors. Allen decides to use an augmented reality (AR) food label application to help her easily access comprehensive nutritional information on international food products she encounters in local markets and stores while traveling. With the AR-enhanced labels, Allen aims to make informed dietary choices that align with her health goals, considering factors like calorie content, allergenic ingredients, and nutritional values. This technology allows her to continue her active lifestyle while staying mindful of her diet during his journeys.

Appendix C

User requirements

Requirement #: 3 **Requirement Type:** 11 **Event:** Interacting with interface

Description: Should be intuitive and user-friendly, requiring minimal training for users.

Rationale: To ensure that users of varying technological familiarity can efficiently navigate the application.

Fit Criterion: At least 82% of users should rate the application as "easy to use" during usability testing

Customer Satisfaction: 4 **Customer Dissatisfaction**:1
Conflict: No conflict

Dependencies: There are no other requirements dependent on this one.

Supporting Materials: A Hierarchical Task Analysis diagram in this thesis illustrates how this requirement integrates into the system.

History: Created October 22, 2023

Requirement #: 4 **Requirement Type:**12 **Event:** Accessing information

Description: The application should provide quick access to nutritional information, with near-instantaneous response times when a QR code is scanned.

Rationale: Quick response times are crucial for user satisfaction and usability

Fit Criterion: At least 95% of scans should yield nutritional information within 2 seconds.

Customer Satisfaction: 3 **Customer Dissatisfaction:** 2

Conflict: No conflict

Dependencies: There are no other requirements dependent on this one.

Supporting Materials: A use case diagram in this thesis illustrates how this requirement integrates into the system.

History: Created October 22, 2023

Appendix D

Feedback from users on the SUS

SYSTEM USABILITY SCALE

Project : ENHANCE FOOD PRODUCT INFORMATION LABELS	**Date:** 20/11/2023
Instruction: For each of the following statements, mark the box that best describes your reactions to this app.	

		Strongly disagree 1	2	3	4	**Strongly agree** 5
1	I think that I would like to use this app frequently.	☐	☐	☐	☐	☑
2	I found this app to be unnecessarily complex.	☑	☐	☐	☐	☐
3	I thought this app was easy to use.	☐	☐	☐	☑	☐
4	I think that I would need assistance to be able to use this app.	☑	☐	☐	☐	☐
5	I found the various functions in this app to be well-integrated.	☐	☐	☐	☑	☐
6	I thought there was too much inconsistency in this app.	☐	☑	☐	☐	☐
7	I would imagine that most people would learn to use this app very quickly.	☐	☐	☐	☑	☐
8	I found this app to be very cumbersome/awkward to use.	☐	☑	☐	☐	☐
9	I felt very confident using this app.	☐	☐	☐	☑	☐
10	I needed to learn a lot of things before I could get going with this app.	☑	☐	☐	☐	☐

SYSTEM USABILITY SCALE

Project : ENHANCE FOOD PRODUCT INFORMATION LABELS	Date: 20/11/2023
Instruction: For each of the following statements, mark the box that best describes your reactions to this app.	

		Strongly disagree 1	2	3	4	Strongly agree 5
1	I think that I would like to use this app frequently.	☐	☐	☐	☑	☐
2	I found this app to be unnecessarily complex.	☐	☑	☐	☐	☐
3	I thought this app was easy to use.	☐	☐	☐	☐	☑
4	I think that I would need assistance to be able to use this app.	☐	☑	☐	☐	☐
5	I found the various functions in this app to be well-integrated.	☐	☐	☐	☑	☐
6	I thought there was too much inconsistency in this app.	☐	☑	☐	☐	☐
7	I would imagine that most people would learn to use this app very quickly.	☐	☐	☐	☑	☐
8	I found this app to be very cumbersome/awkward to use.	☑	☐	☐	☐	☐
9	I felt very confident using this app.	☐	☐	☐	☐	☑
10	I needed to learn a lot of things before I could get going with this app.	☑	☐	☐	☐	☐

SYSTEM USABILITY SCALE

Project : ENHANCE FOOD PRODUCT INFORMATION LABELS	Date: 17/11/2023
Instruction: For each of the following statements, mark the box that best describes your reactions to this app.	

		Strongly disagree 1	2	3	4	Strongly agree 5
1	I think that I would like to use this app frequently.	☐	☐	☑	☐	☐
2	I found this app to be unnecessarily complex.	☐	☑	☐	☐	☐
3	I thought this app was easy to use.	☐	☐	☐	☑	☐
4	I think that I would need assistance to be able to use this app.	☑	☐	☐	☐	☐
5	I found the various functions in this app to be well-integrated.	☐	☐	☑	☐	☐
6	I thought there was too much inconsistency in this app.	☑	☐	☐	☐	☐
7	I would imagine that most people would learn to use this app very quickly.	☐	☐	☐	☐	☑
8	I found this app to be very cumbersome/awkward to use.	☑	☐	☐	☐	☐
9	I felt very confident using this app.	☐	☐	☐	☐	☑
10	I needed to learn a lot of things before I could get going with this app.	☐	☑	☐	☐	☐

SYSTEM USABILITY SCALE

Project : ENHANCE FOOD PRODUCT INFORMATION LABELS	**Date:** 16/11/2023
Instruction: For each of the following statements, mark the box that best describes your reactions to this app.	

		Strongly disagree 1	2	3	4	**Strongly agree** 5
1	I think that I would like to use this app frequently.	☐	☐	☐	☑	☐
2	I found this app to be unnecessarily complex.	☑	☐	☐	☐	☐
3	I thought this app was easy to use.	☐	☐	☐	☐	☑
4	I think that I would need assistance to be able to use this app.	☑	☐	☐	☐	☐
5	I found the various functions in this app to be well-integrated.	☐	☐	☐	☑	☐
6	I thought there was too much inconsistency in this app.	☐	☑	☐	☐	☐
7	I would imagine that most people would learn to use this app very quickly.	☐	☐	☐	☑	☐
8	I found this app to be very cumbersome/awkward to use.	☑	☐	☐	☐	☐
9	I felt very confident using this app.	☐	☐	☐	☑	☐
10	I needed to learn a lot of things before I could get going with this app.	☑	☐	☐	☐	☐

SYSTEM USABILITY SCALE

Project : ENHANCE FOOD PRODUCT INFORMATION LABELS	Date: 16/11/2023
Instruction: For each of the following statements, mark the box that best describes your reactions to this app.	

		Strongly disagree 1	2	3	4	Strongly agree 5
1	I think that I would like to use this app frequently.	☐	☐	☐	☑	☐
2	I found this app to be unnecessarily complex.	☑	☐	☐	☐	☐
3	I thought this app was easy to use.	☐	☐	☐	☐	☑
4	I think that I would need assistance to be able to use this app.	☑	☐	☐	☐	☐
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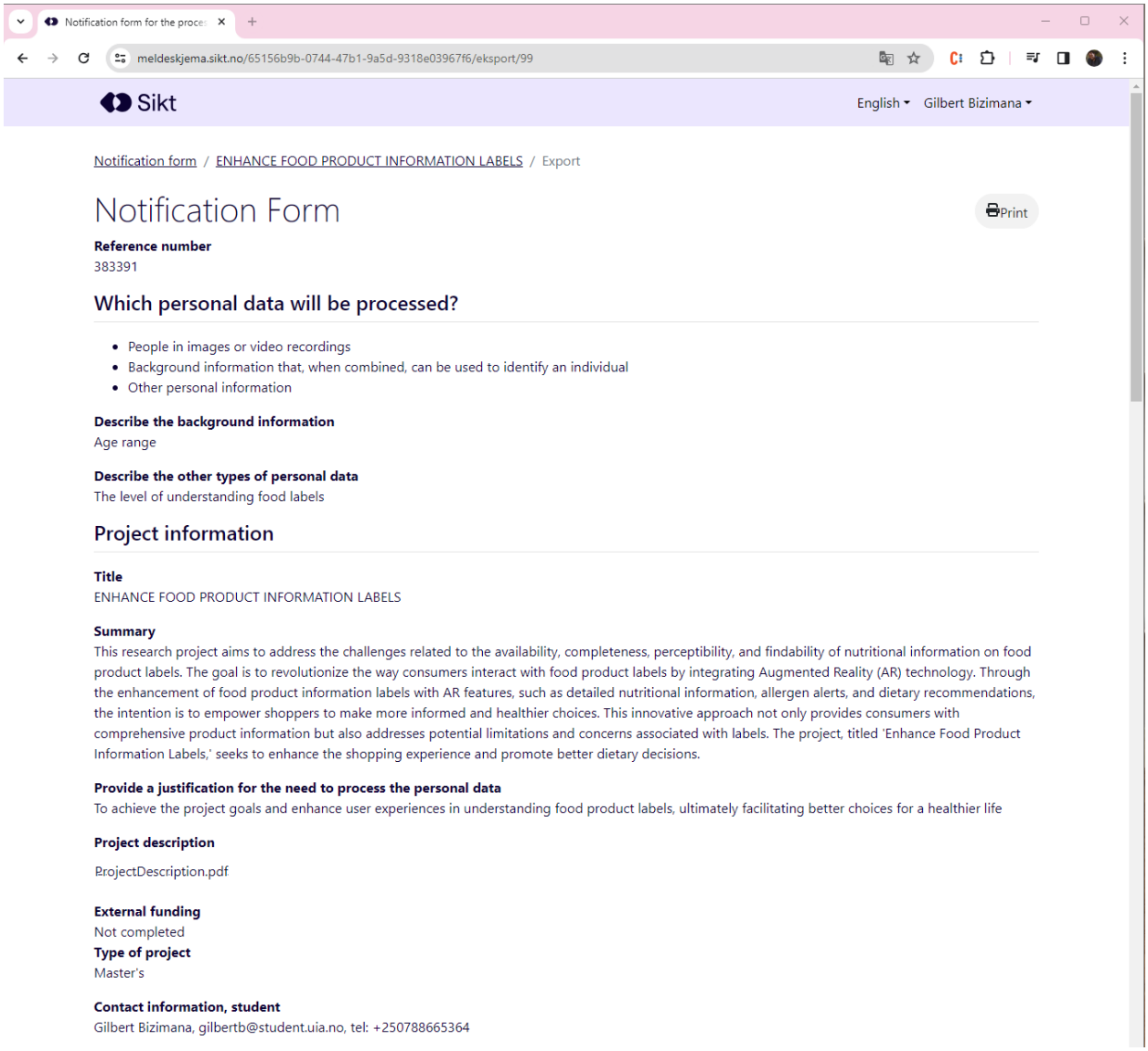
7	I would imagine that most people would learn to use this app very quickly.	☐	☐	☐	☐	☑
8	I found this app to be very cumbersome/awkward to use.	☐	☑	☐	☐	☐
9	I felt very confident using this app.	☐	☐	☐	☑	☐
10	I needed to learn a lot of things before I could get going with this app.	☐	☑	☐	☐	☐

Appendix E

Notification form



Data controller

Institution responsible for the project
University of Agder / Faculty of Technology and Science / Department of Information and Communication Technology

Project leader
Ghislain Maurice Norbert Isabwe, maurice.isabwe@uia.no, tel: +4796208754

Do multiple institutions share responsibility (joint data controllers)?
No

Sample 1

Describe the sample
The first sample consists of administration staff from My university

Describe how you will identify or contact the sample
To select my sample, I will first identify potential participants within my university community, which includes administration staff from my University. Prior to selecting any participants, I will obtain their informed consent, a critical step that involves thoroughly explaining the study's purpose, the nature of their participation, and their rights as participants.

Age group
18 - 70

Which personal data will be processed for sample {{i}}? 1

- People in images or video recordings
- Background information that, when combined, can be used to identify an individual

How is the data relating to sample 1 collected?

Paper-based survey

Attachment

Survey.pdf

Legal basis for processing general personal data
Consent (General Data Protection Regulation art. 6 no. 1 a)

Information for sample 1

Does the sample receive information about the processing of personal data?
Yes

How does the sample receive information about the processing?
Written (on paper or electronically)

Information facilitates

template_for_information_letter_0.docx

Third persons

Does the project collect information about third parties?
No

Documentation

How will consent be documented?
- Electronically (email, e-form, digital signature)
- Manually (on paper)

How can consent be withdrawn?
By simply contacting me and expressing their desire to stop participating at any time

How can data subjects get access to their personal data or have their personal data corrected or deleted?
As we are in the same university, they will directly contact me, either in person or by phone, to request access to their personal data, or to have their personal data corrected or deleted.

Total number of data subjects in the project
1-99

Approvals

Will any of the following approvals or permits be obtained?
Not completed

Security measures

Will the personal data be stored separately from other data?
Yes

Which technical and practical measures will be used to secure the personal data?
- Continuous anonymisation
- Restricted access

Where will the personal data be processed
- Hardware

Who has access to the personal data?
- Student (student project)
- Project leader

Are personal data transferred to a third country?
No

Closure

Project period
01/11/2023 - 30/11/2023

What happens to the data at the end of the project?
Personal data will be anonymised (deleting or rewriting identifiable data)

Which anonymisation measures will be taken?
- Personally identifiable information will be removed, re-written or categorized
- Any sound or video recordings will be deleted
- The identification key will be deleted

Will the data subjects be identifiable in publications?
No

Additional information

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