ODORA SMELL CAMERA

BY

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THESIS

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ABSTRACT

Smell and food have always been important in different cultures and countries. However, we haven't yet developed a method to document and record the food culture. Human society can only describe a recipe through words and images for a long time. And the smell and taste of food, which is the most important part, can not be recorded due to the limitations of existing technologies and the lack of people's interest in smell.

The smell and taste of family meals are so particular for individuals and families. The odor-evoked memories associated with the family member pass from generation to generation, and they are the most valuable memories that accompany one's entire life.

Therefore, I tested and developed a method that combines artificial intelligence vision and olfactory to record the cooking process and then utilize the smell information as a reference for later duplicating the same meals. By applying the latest technology about AI olfactory, the machine can record the smell changes during the cooking process and record the unique smell pattern that reflects the cooking status of the food. And that smell pattern will tell the user how well the food should be cooked through an application on smartphones, tablets, or smart watches while cooking. The name of this product is called Odora Smell Camera.

The smell camera may not be the ultimate way of applying AI nose to the food industry. There is still a lot of work that needs to be done to let my design be a mature product. But I hope this thesis can draw more attention from the public to this young industry full of potential.

To My Family and Professor Suresh Sethi, who inspired me on this path

ACKNOWLEDGMENTS

This thesis has been possible only because of the help and support from many people and friends. I would very much appreciate your assistance, and you will have my gratitude forever.

To my advisor, Professor Suresh Sethi, you are so knowledgeable and patient in guiding me in finding my path and passion. Thanks for your critics and support while discovering an unknown area, which brings me courage. Without you pushing me to be a better researcher, designer, and person, I would never find such an area with so much potential.

To my committee members, Professor Salman Raheel and Dawn M Bohn. Thank you so much for the time you spent on my thesis. I am very grateful for providing your unique perspective in shaping my design and idea.

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CHAPTER 1: INTRODUCTION

Unlike other senses, vision or sounds, for example, the importance of smell did not draw much attention from the researcher and public. One of the possible reasons would be that people use smell much less in everyday life. We got exposed to a world that is much more focused on vision [Marta Zaraska 2017]. Movies, social media, televisions, etc., override the sense of smell in modern life. And compared to the rural area, the urban city is getting deodorized and desensitized [S. Craig Roberts et al. 2020]. Another reason is that the technology of the sense of smell is not as developed as the sense of vision or sound, and the nose and olfactory work remains mysterious. We can not create or record smells or odors as quickly as we create images or take pictures.

However, we can not ignore the power of smell in our daily lives. The study shows that the olfactory may be more important than we thought. Humans will not only communicate only through words or facial and gesture expressions but also through body-based olfactory information [S. Craig Roberts et al. 2020]. The smell also connects tightly with memories. The study has shown that the emotion of nostalgia elicited by odors is more pleasant than memories evoked by other senses [Herz R. S. 2016]. And there are some experiments on how to apply the aroma to unconsciously influence a user's behavior [Judith Amores 2017].

Previous research starts from a broad way of looking into the area of smell. There are plenty of opportunities in the sense of smell. Even though I have explored other ways of utilizing smell-related products to increase work efficiency while studying unconsciously, I found that the association between smell and memories is more exciting and meaningful. The way we record our memories has not changed for an extended period. For decades, the primary method of recording is still images and videos through the sense of vision and sound. Therefore, my research question is how to create memories that combine smell, sight, and sound, to add a new dimension when recording. Thanks to my mother and grandmother's food which reminds me of my childhood. When I tasted my grandmother's food after two years of study in the U.S., the smell and taste of the food brings me back to the time during elementary school. I found that the connection between food, smell, and memories is tight. And in the same time, my grandfather passed away. I realize we have to cherish every minute we spend with our family. And I also recognize that we must record some memories before it is too late. All these experiences lead to my research question, which is to develop a new way of recording the memories of food, taste, and smell memories.

This thesis focuses on the design, development, and prototype of a concept product embedded with vision and olfactory. This design does not replace the traditional cameras and phones but tries to add another dimension to the existing method of recording. It provides a new way to recoding through vision, sound, and smell. Therefore, it carries the capabilities of recording the process of cooking particular food. Everyone cooks differently, which causes the unique flavor of the food. Suppose we could record precisely how the user is cooking, as a reference for duplicating the same flavor. In that case, we can record the taste and flavor of food that connect so tightly with our memories to create family recipes that can pass from generation to generation.

To achieve the purpose of my design, I addressed the following research challenges:

- What technology can support the theory?
- How can a digital nose determine the different phases while cooking?
- How can the user interface help increase the experience of cooking?

The remainder of this thesis includes:

Chapter 2 discusses my inspiration and existing method in a more detailed way.

Chapter 3 shows the process of my exploration to consolidate the solution. It shows the experimental results of an actual cooking process.

Chapter 4 is based on the results of chapter 3. It includes the process of designing a concept design and prototypes.

Chapter 5 discusses the future of the sense of smell in the cooking industry and the limitations of this prototype.

CHAPTER 2: CONTEXT AND RELATED WORK

In this chapter, I discussed the main inspiration for my concept design and how I connected the dots to form my final design. Every dot was essential when I narrowed down my research from a broad area to my final statement.

2.1 Smell and memory

The uniqueness of the sense of smell is derived from the special connection between olfactory bulbs and the brain. Other senses nerves directly connect to the brain's thalamus, the gateway to consciousness. However, the odor information from the nose will proceed straight to the cortical areas to arouse emotions and memories without our awareness [Marta Zaraska 2017]. That is why when sleeping, stimulus from light, sound, and touch will wake you up easier than stimulus from the smell.

Smells can arouse old memories. And the associations of these memories with smell usually happen during the first ten years of one's life. That is when children start to smell the world and associate it with the memories of that moment. And that link between certain smells and specific memories remains tight even though they got exposed to the same odor with other memories multiple times [Herz, 2016]. This is the reason why odor-evoked memories usually bring us back to childhood.

This lays the foundation for utilizing smell or odor to evoke early memories. When we are experiencing important events in our life, recording the smell at that moment along with images and sounds will give us an immersive experience when recalling the memories. Some studies or art have started to use odor to help people memorize and remember things. But the current technology limits the possibility of making such attempts. Recording smell is not as easy as taking a photo or a video, and creating odors are not as easy as drawing or editing pictures. How the brain works and how olfactory nerves receive smell information are mysterious. But as artificial intelligence develops, we are getting close to letting the machine tackle complex smell information and have the sense of artificial olfactory.

2.2 Food and family memories

Odor-evoked memories have been proved to usually happen during the first ten years of one's life. This period that we first experience the world and learn from our parents and siblings, personally speaking, is one of the essential parts of life. Unlike other periods when we have to spend more time on school or work, in the first ten years, we spent more time with family. Therefore, the keyword of this decade is family.

Among all the odor-evoked memories, memories associated with food and flavor always accompany one's life. The family meals may not be the most delicious ones, but it was unique to individuals. No matter how long you have been outside the home, as long as you taste the same meals cooked by your mother or other family members, all the visual and olfactory stimuli will bring you back to the warmest memories. When one grows older or moves to different places, it isn't easy to have the same food flavor as mother's meals. Even if it is the same type of food, everyone cooks differently. How everyone cooks impacts the taste of food. How well the food is cooked depends on the quality of the materials and how much of it is used, influencing the meal's final flavor. It will be almost impossible to let others cook the food with the same taste as your mother did.

All of these lead to my research question:

Can we record the smell and flavor of the food cooked by our parents? Therefore when we miss the taste of our mother's food, we can reproduce it and recall the warm feelings just like looking at an old photo.

Figure 2.1 Meals from my grandmother.

2.3 The existing method of documenting recipes

The most traditional recipes can be from a book or on paper. As technology grows, we now have recipes from applications on websites, phones, and tablets with words and images describing the cooking steps. Other types of recipes contain videos that teach you how to cook right. It includes a more immersive experience while cooking and learning new dishes.

But the recipe form only includes information about what and how to cook. When talking about how well each step should be done, it is hard to describe. An experienced cooker knows when to move to the next step by observing the color and smell of food while cooking. However, suppose the beginner tries to follow or reproduce the flavor from the recipe. In that case, it is not easy for them to practice without experience, and the process would be frustrating.

Most recipes use vague words like "cook for 10 minutes" or "stew 20 minutes" to describe the process. It is okay to follow the instructions because everyone cooks differently and has their cooking habits. But to duplicate the smell and flavor that arouse our emotions and memories, we should find a better way to record the recipes.

Figure 2.2 and Figure 2.3 are examples of such attempts that the followers failed to cook the same looking and flavor of one dish. Some of them are delicious and have a unique flavor, but some might have bad taste because of the mistakes like cooking too long or adding too much salt.

Figure 2.2 Tofu recipe from xiachufang.com.

Figure 2.3 Follower's attempts.

2.4 Inspiration: New method in the food industry

Finding a new method of documenting recipes that benefit the interactive cooking experience becomes my research goal at this point.

A research team developed a new platform that utilizes eight gas sensors and computer vision to monitor the cooking status of a grilled chicken [Fedorov et al., 2021]. Through 8 different types of gas sensors, watch and monitor smoke, alcohol, CO, and other compound changes while grilling chicken. And use the smell graph to feed the algorithm. Along with smell information, they also take a photo of the chicken in different cooking statuses and let the computer learn how the chicken looks during the cooking. Students and researchers are included as taste testers and rate how the chicken tastes. This system can help the kitchen control the quality of food and is a cheap and reliable tool once the database is strong enough to provide precise information about the doneness of the food.

Figure 2.4 A grilled chicken tender.

Another similar study in monitoring cooking status is by Doctor Sen Hsia Hirano. He also uses the e-nose in his experiment to detect food's cooking status. But he focused more on the user experience part. He built up an interactive system to support novice cookers. Based on the smell data collected, the novel system tells the beginner when to move to the next step of cooking to release the anxiety and stress while learning new dishes [Hirano, S. H., 2016].

The two kinds of research and studies above provide me with insights about combining new technology into monitoring cooking phrases with e-nose and giving an interactive interface that teaches and reminds the user of a better cooking experience. Inspired by them, I started my tests on building a system that collaborates computer vision and e-nose to record the cooking process and use the data collected to guide and teach the user to reproduce the unique flavor in their memories.

CHAPTER 3: PROTOTYPE EVALUATION

After discovering existing methods and technologies, I start to build my prototype through AI vision and olfactory and test if my concept works. Without testing to prove its feasibility, the concept design would be weak and not realistic. And it is also through the prototype I gained more insights into designing the product, including how the product's inside structure should be and how the form follows its function.

3.1 AI Vision

There are several open-source artificial intelligence tools on the market. One of them is called the Google AIY Vision kit. This AI vision kit consists of a Raspberry Pi Camera v2, Vision Bonnet, and a Raspberry Pi Zero WH. Because there is detailed instruction online about how to use it and build a machine learning model from zero, I think it is an excellent tool for beginners. Therefore, this is the tool in my prototype.

Figure 3.1 is the inside structure of the Google AIY kit that can run some basic machine learning models.

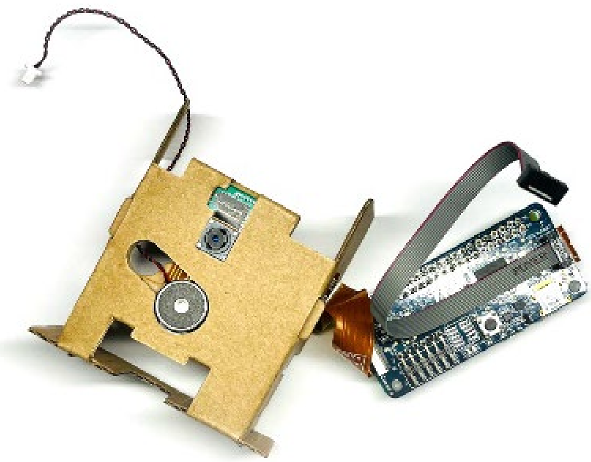

Figure 3.1 Google AIY Vision Kit.

Google AIY Vision kit has many examples of demos pre-installed in their library. One of them is called image classification. By running this demo, the built-in system can detect the type of objects in the camera. It matches the thing to its library and gets a score about the similarity to an object. As shown in Figure 3.2, the object in the camera is detected as a banana.

Figure 3.2 Image classification demo.

My prototype uses it to simulate the actual situation when the machine has a vision and olfactory system built together. Due to my major's limitations, I could not make a machine learning model that could precisely tell what the food is in the camera and what phrases the food is during cooking. This is only for a simple prototype. The main research question of this thesis is to build a concept design that shows the possibility of the product and explores the future scenario and user experience. However, this is necessary to create a complete machine learning model that can see and smell in the future.

3.2 AI Olfactory

Technologies about e-noses are not as powerful as visional tools like screens and cameras. E-noses can not capture smell or odors like how well the cameras take photos. They can only release an odor that is already stored in the container. And smell generators can not release aroma as quickly as screens display images.

There are various gas sensors in the market. They are usually designed for a safety system and can provide a measurement of some gases, such as CO, CO_2, NO_X, SO_2, etc. [Newcastle Safety Servicing 2020; Mirzaei et al. 2018]. These gas sensors can only detect certain odors and can not smell like human beings or other animals.

However, as nanotechnology and machine learning developed, several companies have built machine learning-based device that enables the computer to smell. Aryballe and Smart

Nanotubes are two companies that have already released their products to the market [Aryballe, 2021; Smart Nanotubes - Technology to Digitize Smells, 2022].

I got an early version of Smell Inspector from the Smart Nanotubes as an AI nose for my simple prototype. Smell Inspectors are gas sensing devices based on carbon nanotubes that convert complex smell information into smell patterns. Different smells or odors can create different smell patterns through nanomaterials. And through machine learning and artificial intelligence, computers can memorize new smells patterns and store them in the library. And then recognize what the smell is based on the collected unique information, just like how our brain learns new smells and memories of them [Smart Nanotubes - Technology to Digitize Smells 2022; Panes-Ruiz, L. A. et al. 2018].

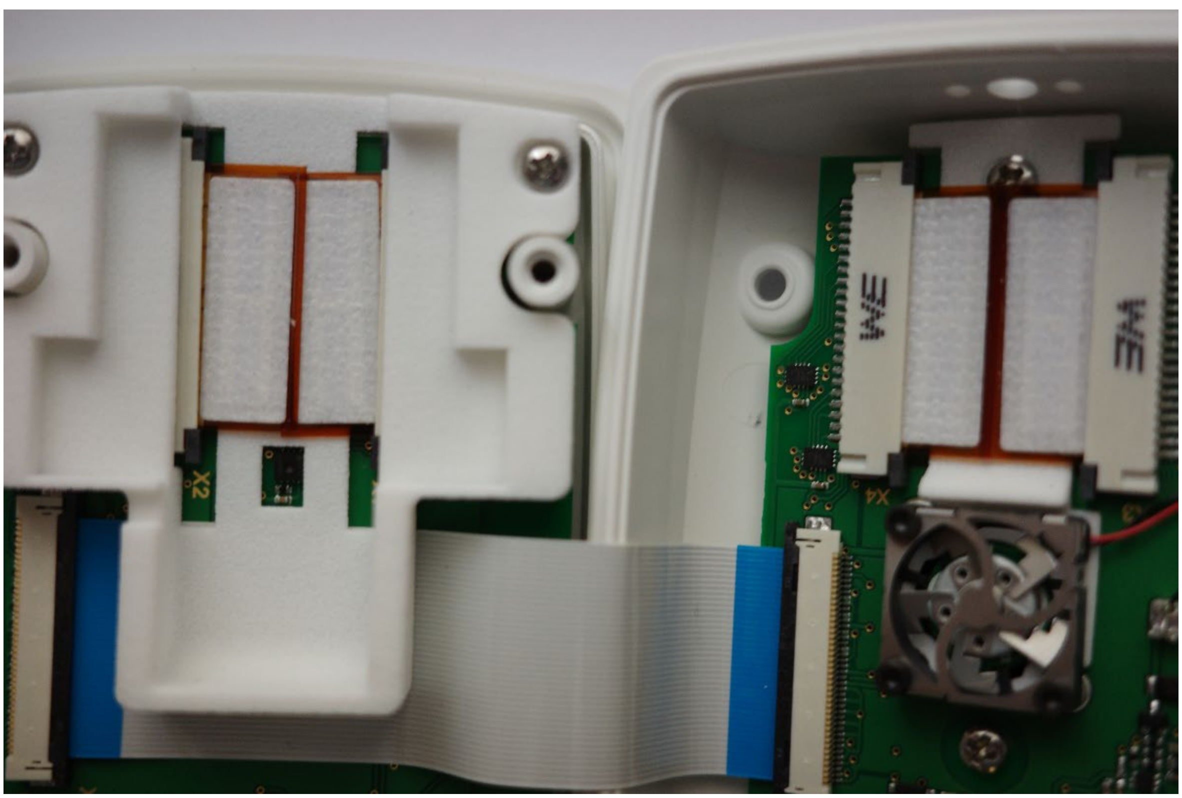

Figure 3.3 Inside the smell inspector.

Inside the smell-inspectors are four smell chips that can sniff odor information and a small fan that breathes air from the front.

I set up my prototype built upon Google AIY Vision kit and Smell Inspector, as Figure 3.3. So, the prototype can see and smell.

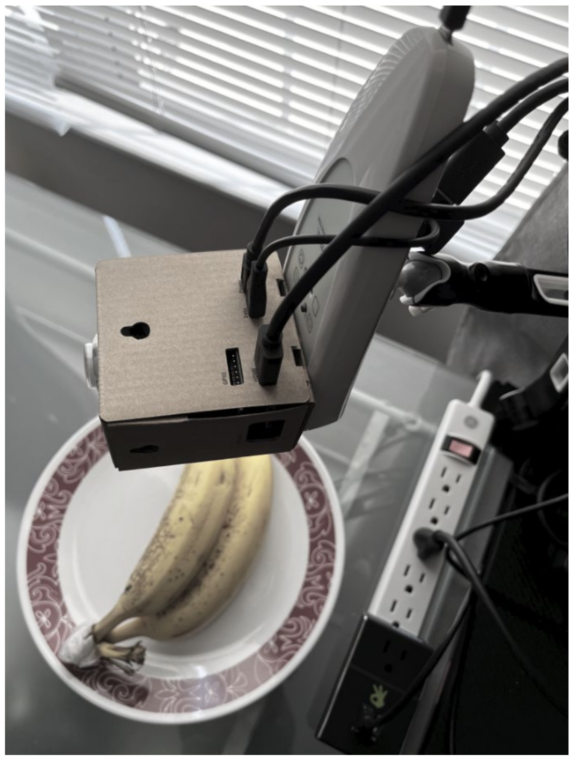

Figure 3.4 Simple prototype with AI vision and olfactory.

I started testing my prototype for simple experiments like smelling and recognizing fruits. The vision kit is connected to a monitor running an object classification model to determine what the object is. And the smell inspector is connected to a PC to detect the odor continuously. The Environment was set up, shown in Figure 3.4. It was training to smell and see a banana.

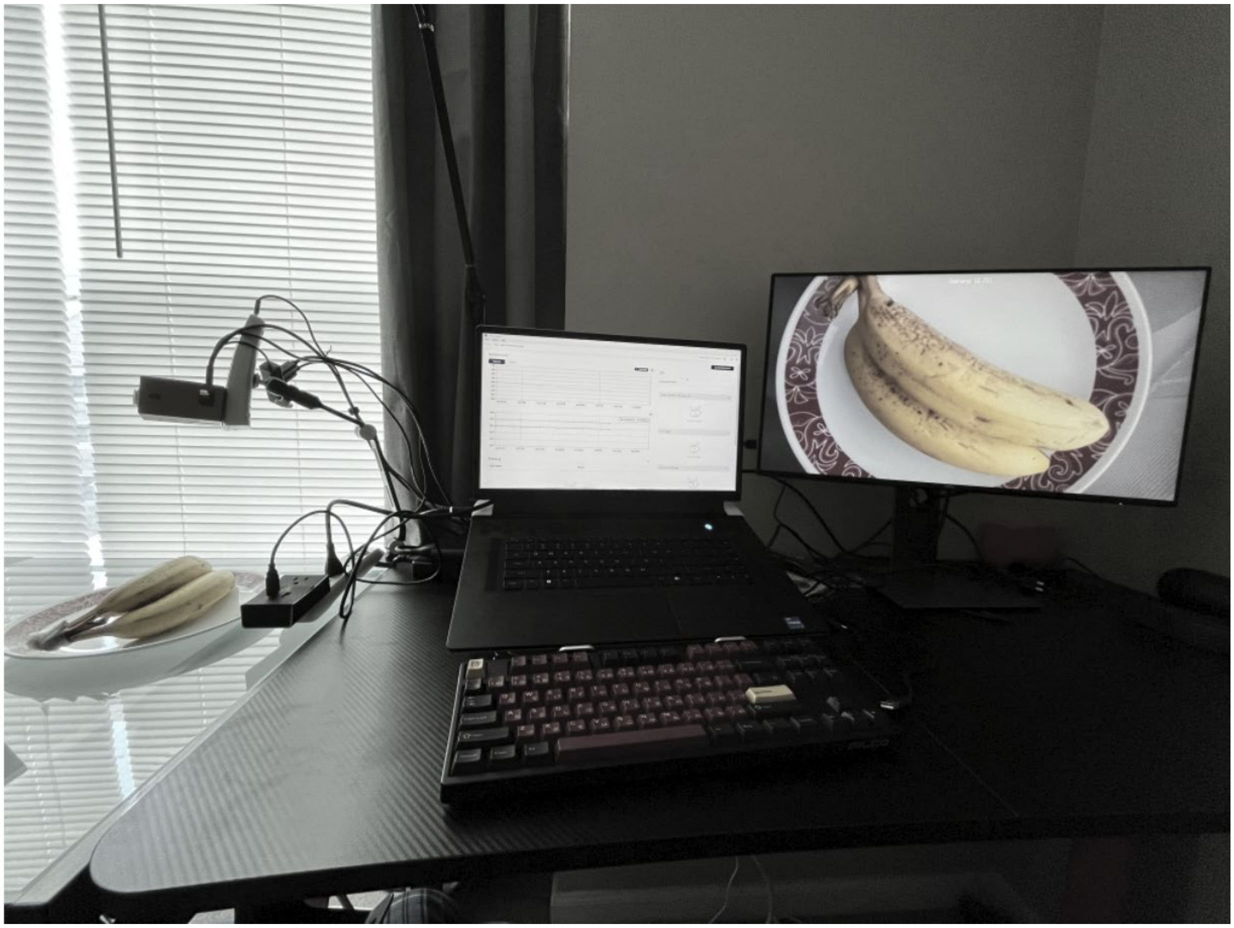

Figure 3.5 Environet set up.

I let my prototype see and smell several fruits like a tomato, an apple, and a banana, as shown in Figures 3.6, 3.7, and 3.8. The graphs on the right side of the figure are their smell patterns. These are the footprints of each unique smell read by the smell nanomaterial chip. After the smell graphs are stored in the library, the next time when machine sniffs the odor with the same smell pattern again, they can recognize it.

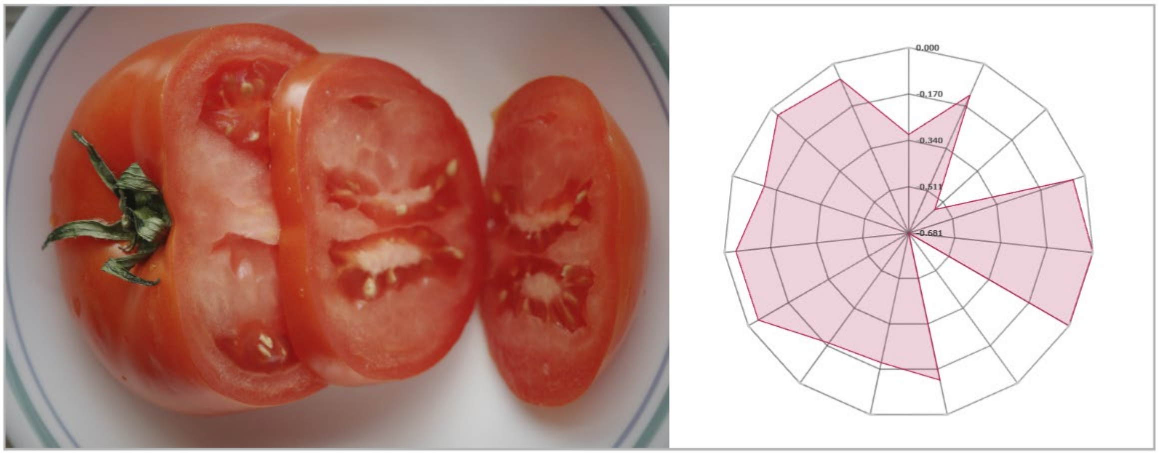

Figure 3.6 Tomato and its smell graph.

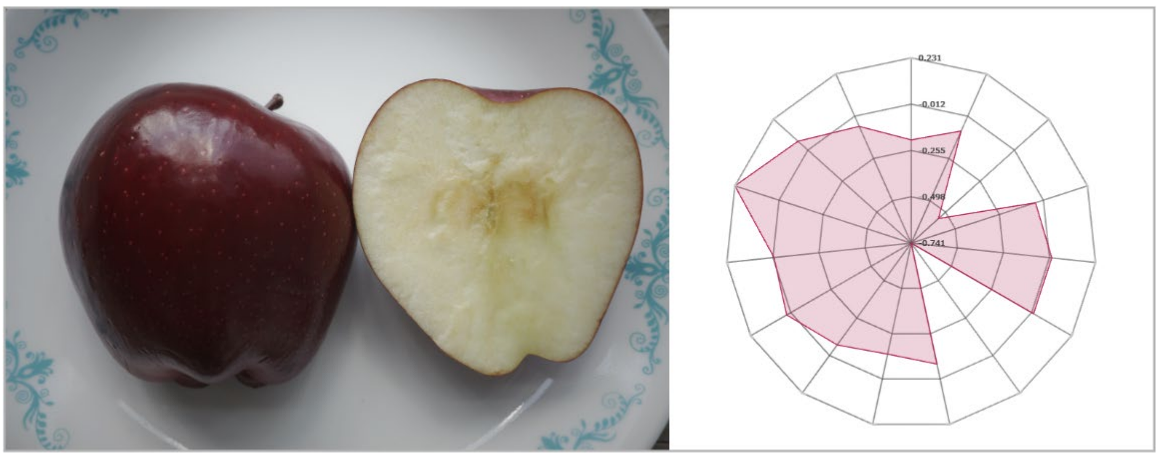

Figure 3.7 Apple and its smell graph.

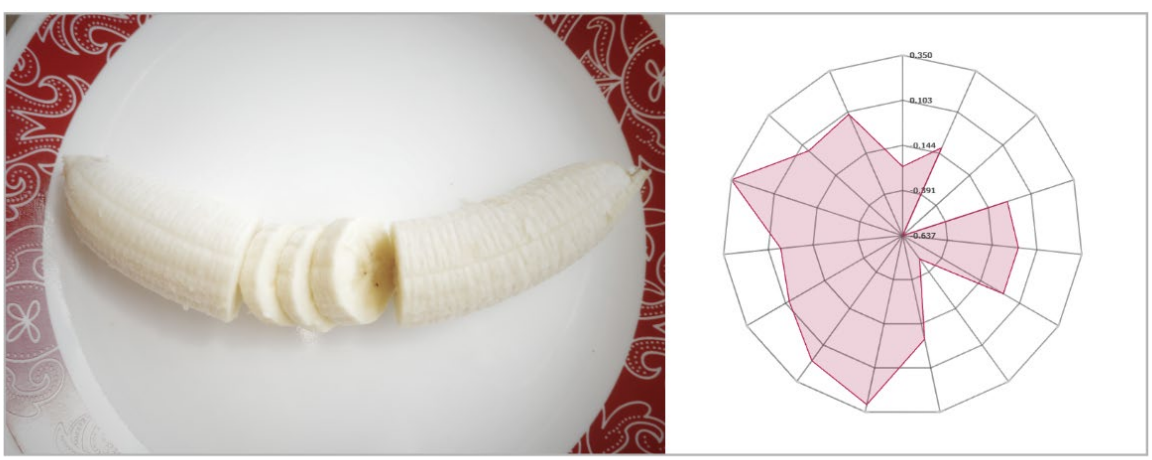

Figure 3.8 Banana and its smell graph.

3.3 Cooking experiments with grilled chicken

Experiments from the last section are only for simple and individual odors. I set up the test in my kitchen to mimic a natural cooking environment full of "noise" (other smells). It has been successful in adding a sense of smell to my prototype. So, I move forward to a more complicated situation, an actual cooking process.

Figure 3.9 My kitchen space.

Ensure that the smell generated during the cooking process keeps flowing to avoid saturation which might lead to failure to read smell information in time. Before I started my test, I turned on the Vent Fan to keep the ventilation. The smell inspector was set above the stove to capture the odors and monitor the temperature and humidity, as shown in Figure 3.11.

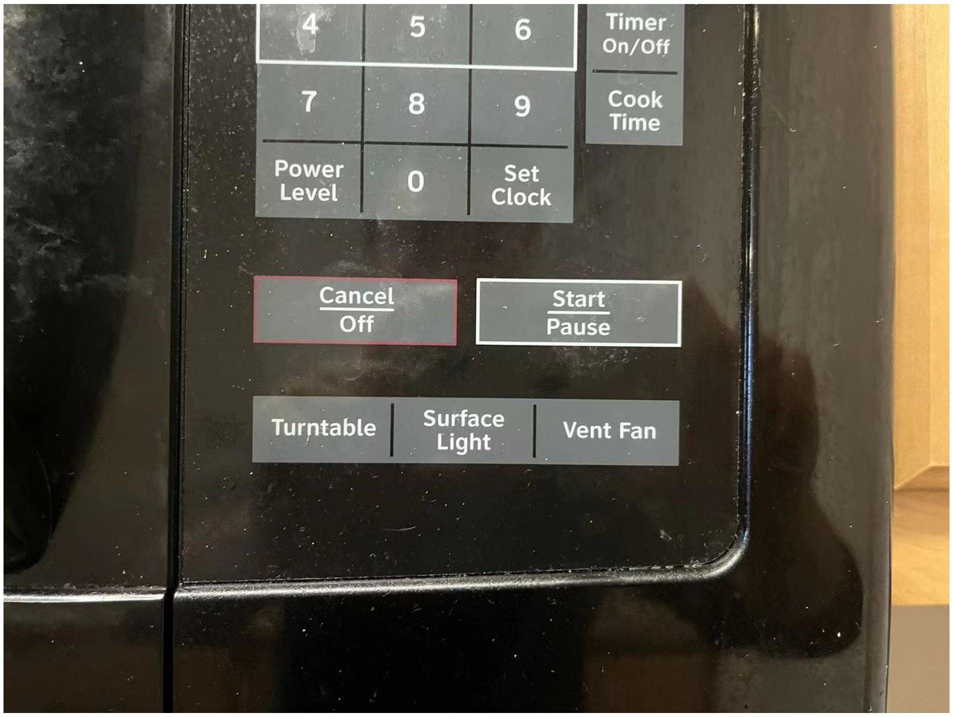

Figure 3.10 Vent Fan.

Figure 3.11 Recording and cooking setup.

The chicken tender was selected as the material for cooking because it is a popular food worldwide. The chicken tender will be grilled with a bit of oil; to keep this experiment simple, Figures 3.12, 3.13, and 3.14 are captured by the camera and show the different statuses of the grilled chicken: fresh, well done, and overcooked. These images are the reference for the computer to learn how it looks in various phases of cooking. The smell information during cooking is discussed in the next section.

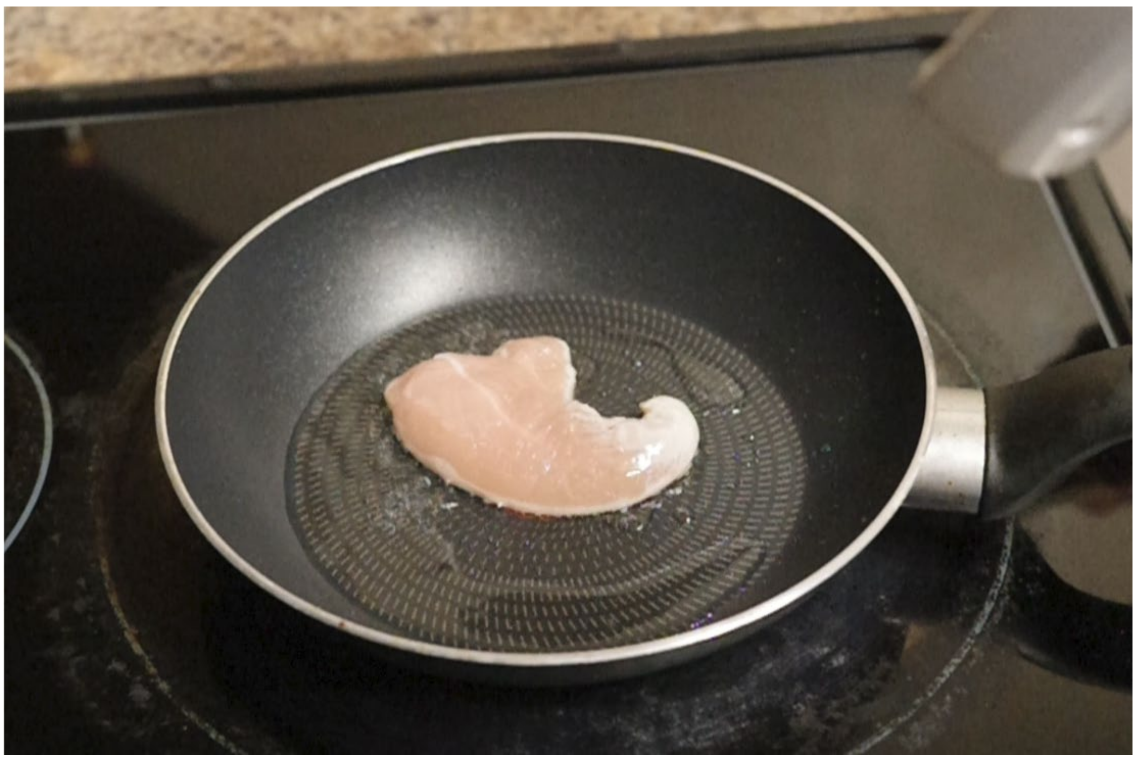

Figure 3.12 Fresh chicken tender.

Figure 3.13 Well done chicken tender.

Figure 3.14 Over-cooked chicken tender, burnt.

3.4 Smell graph and cooking status

The different steps, such as heating, adding oil, adding chicken tender, flipping the chicken, and overcooking the chicken, are marked in Figure 3.15 as events. These events represent that there will be a change of odor around the event. The lower part's smell graph shows the prototype captured smell changes. The smell chip has f1 to f15 different footprints.

As shown in Figure 3.15's smell graph, when starting to cook the chicken, the smell graph arises from 7:13 PM to around 7:18 PM. And 7:18 PM is around the time when the chicken is well cooked. There is a gentle slope at the top of the smell graph around the well-done event, and then it starts to drop because the chicken tender started to be overcooked. Burnt chicken begins to release another kind of smell that decrease the smell graph.

In conclusion, the smell graph reflects the chicken's tender status while cooking, solidifying my concept as a feasible solution for documenting the smell changes during cooking. As long as we can train a model for the computer and let it learn when the food is well cooked and when the user should move to the next step, we can create an interactive and informative recipe embedded with visual and smell information. With odor information embedded recipe, the user can reproduce the same flavor as documented. Or, at least get a score for each step and see which actions may have issues and cause the smell to be different than what was recorded. Through multiple practices, the user will get close to replicating the flavor and aroma cooked by their mother.

We will finally have a method to document our mother's food before it is too late.

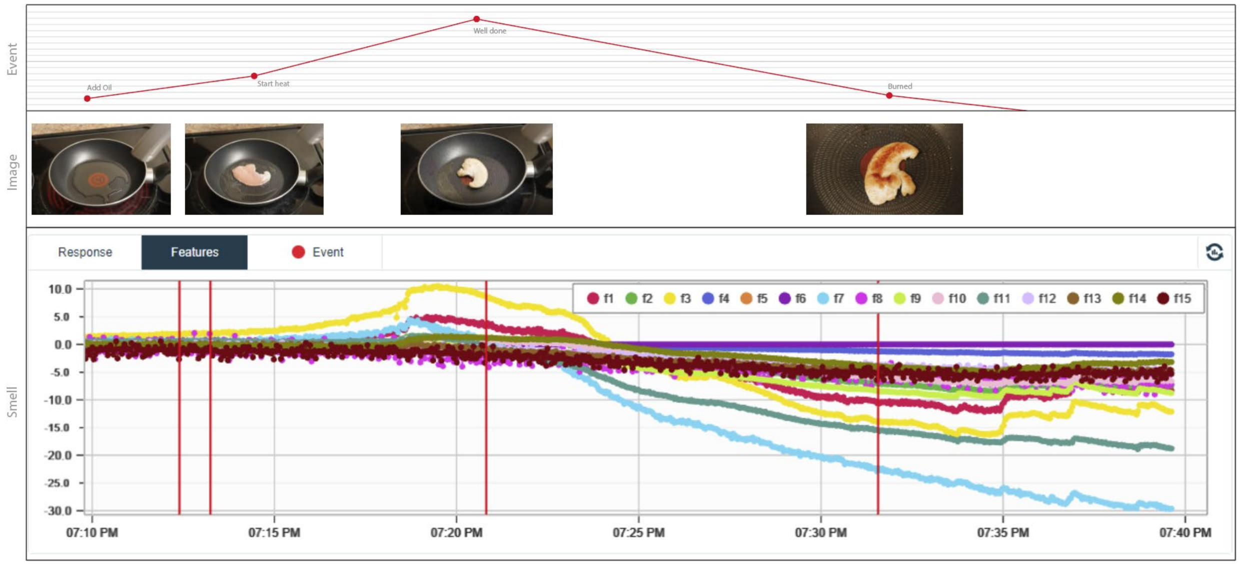

Figure 3.15 Smell graph while cooking.

This is still a simple prototype. Tackling such complicated smell data needs an advanced machine learning model. That is the plan for the future.

CHAPTER 4: DESIGN, ODORA SMELL CAMERA

With the result from Chapter 3, I started the concept design of the Odora Smell Camera. The name Odora comes from the odor era, representing that we can finally add a sense of smell to a machine, and we are stepping into the new era of digital olfactory.

4.1 Internal structure analysis

Thanks to the experiments in Chapter 3, I better understand what product I will design, a camera that can capture smell and images. Taking apart the Google AIY Vision kit and Smell Inspector reveals the inside structure of both devices in Figure 4.1. The most important part of this camera is the structure of the air tunnel. The smell in the air needs to be sniffed in and flow through the nanomaterial-based smell chip and flow out to other directions. Therefore, there should be a small fan that can suck air, and there should be 4 smell chips along the air tunnel.

If for long-term use, smell chips and air tunnels may get contaminated by dust or oil in the air. So, another important point is to keep the inside structure open and to let the user be able to clean the air tunnel.

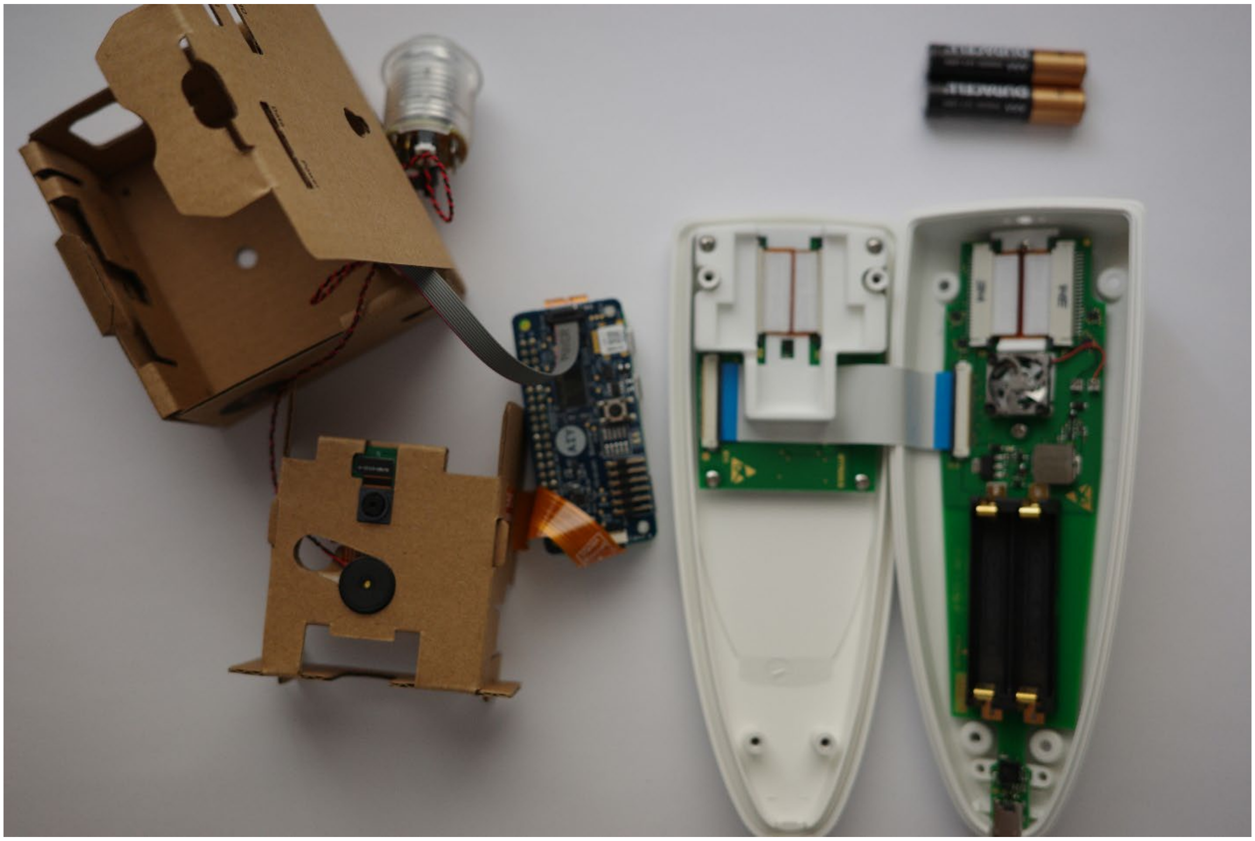

Figure 4.1 Inside of the Google Vision kit and Smell Inspector.

4.2 Form development

The design starts from the overall form iterations. I built some shapes and used a 3D printer to print models for validating the product form. By changing the model's width, thickness, and height, I made several models. One of them was selected as the final dimension. Ergonomic considerations led to the size that is portable and easy to hold by hand.

The features that will influence the appearance of the product are listed below.

Clean: The product should look clean and elegant. It will give an impression that the product is high quality and reliable. The product should also be easy to clean. And any dirt on the product must be obvious, and remind the user to clean the product that might be contaminated during the cooking process.

"Eyes and Nose": The main characteristics of this product are the camera and e-nose. These two features can communicate the ease of use. These symbolic functions and forms should draw the user's attention.

Symmetry: The product's appearance, the iconic camera, and the e-nose must be balanced and symmetric.

Portable: The product is portable and small enough to carry anywhere.

Figure 4.2 shows the iterations of form development.

Figure 4.2 Form development and iterations.

Figure 4.3 is the final concept rendering for Odora Smell Camera. The symbolic logo and name printed on the front face emphasize the meaning of this product, the arrival of the odor era.

The camera is in the middle of the front, and two e-noses are on the camera's side. They work together to see things in the front and smell them.

Figure 4.3 Final design: Odora Smell Camera.

On the back of the Odora Smell Camera is a switch for turning it on and off. That controls the Odora to keep sniffing the smell and filming. On the top part is the shutter-release button. Once pressed down, Odora can capture an image of the smell at that moment. For example, if you are taking a photo of a street, you may also capture the odor of the cookies from the bakery.

Figure 4.4 shows the details of the Odora Smell Camera from the back.

At the center of the back is the magnet. The magnet is used for Odora to attach to its stand. The magnetic connection is a much more reliable method to place Odora on any place that has a small metal sheet. So, it is easy to put on and off. This design is especially suitable in the kitchen area because while cooking, we have to change the place of recording frequently, from a mixer to the stove. Using a screw to fix it like other cameras would make the user experience inefficient and inconvenient.

Figure 4.4 Back of the design.

The magnetic design is also compatible with Magsafe from Apple. It is also compatible with other phones if attached with a metal sheet on the back of other phones. Figure 4.5 demonstrates the example of connecting the Odora Smell Camera to an iPhone.

Odora can connect with phones through Bluetooth. So, you can add a sense of smell to your phones. While taking pictures, you can also record the smell of that moment.

Figure 4.5 Connect to a phone,

Figure 4.6 is a rendering of Odora Smell Camera in a cooking situation. It records the cooking process in the same way as my experiment in Chapter 3. It is in a ventilation area that keeps refreshing the air. Therefore, the Odora can capture the odor changes in time. And it is attached to the stand through the magnets.

Figure 4.6 Odora is recording while cooking.

4.3 Design For Inside Structure

In chapter 3, the structure of the Odora Smell Camera has been defined to have the spaces for a camera, the smell chips, air tunnels, a fan, an entrance, and an exit for the air.

The final design of the inside structure is shown in Figure 4.7. Two smell chips are on each side at the end of the air tunnel. A fan is under the camera and can suck air from the front and blow it out on the side. Therefore, the air and smell flow from the front and exit from the bottom of the camera. The fan is detachable and easy for the user to clean.

Figure 4.7 Detailed view inside the Odora Smell Camera.

The front cover is designed to be removable, providing the convenience of cleaning the outside and inside. I created the front cover as clean as possible to prevent too much dirt from hiding in the gap between different components. There are two entrances to the smell chips and an outlet at the bottom for air to be blown out. A Type-C is on the right side of the camera.

Figure 4.8 Exploded view of Odora Smell Camera.

4.4 User Interface: Cooking Recipes with Smell graph embedded

I designed two applications for Odora.

The first one is called Odora Creator. Odora Creator is the ultimate video and smell editing software for creating fantastic recipes fast. Users can edit any content they capture in Odora Smell Camera, especially creating recipes with smell recorded.

And another software is named Odora Tasty. Odora Tasty is your smart cooking sidekick, offering personalized guidance every step of the way and providing a smell indicator telling you how well every stage should be cooked.

Odora Creator is designed for the content creator and those who want to create their odor-enhanced family recipes. And Odora Tasty is a platform where everyone can share the recipes they made and learn from others' recipes. It is not only a place that utilizes smell for users to cook better but also a place where they can store their valuable memories and food with families.

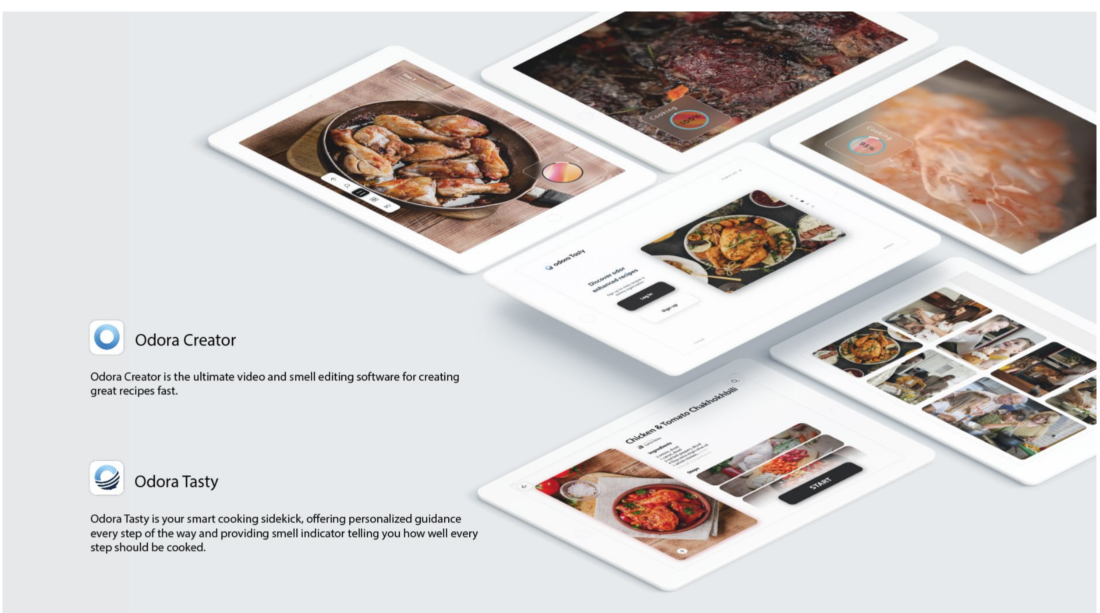

Figure 4.9 Two apps: Odora Creator and Odora Tasty.

That two pieces of software combine the smell information from previous records with the recipes to enhance the cooking experience.

The smell information is converted to gradient colors that keep changing based on the aroma changes. Compared to traditional recipes, smell indicators bring more benefits. It can be used for detecting the freshness of food while preparing food. Whether you are purchasing mear or vegetables in the market or taking food out of the refrigerator, you will get notifications about the freshness of the food and help you make decisions.

While cooking, the smell graph indicates how and how well the food should be cooked. Keep cooking until the smell graph is right to cook the food precisely.

Figure 4.10 shows the smell graph of every step in the recipes.

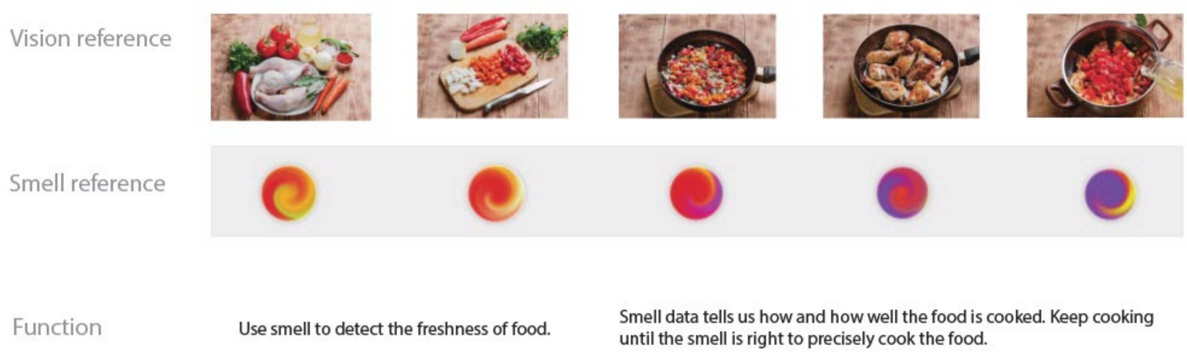

Figure 4.10 Recipes embedded with smell information.

Figure 4.11 is the signup page of the app Odora Tasty. You can change the language at the top right corner. Photos about food in the middle are the hottest recipes of that month, attracting more people to sign up and start cooking.

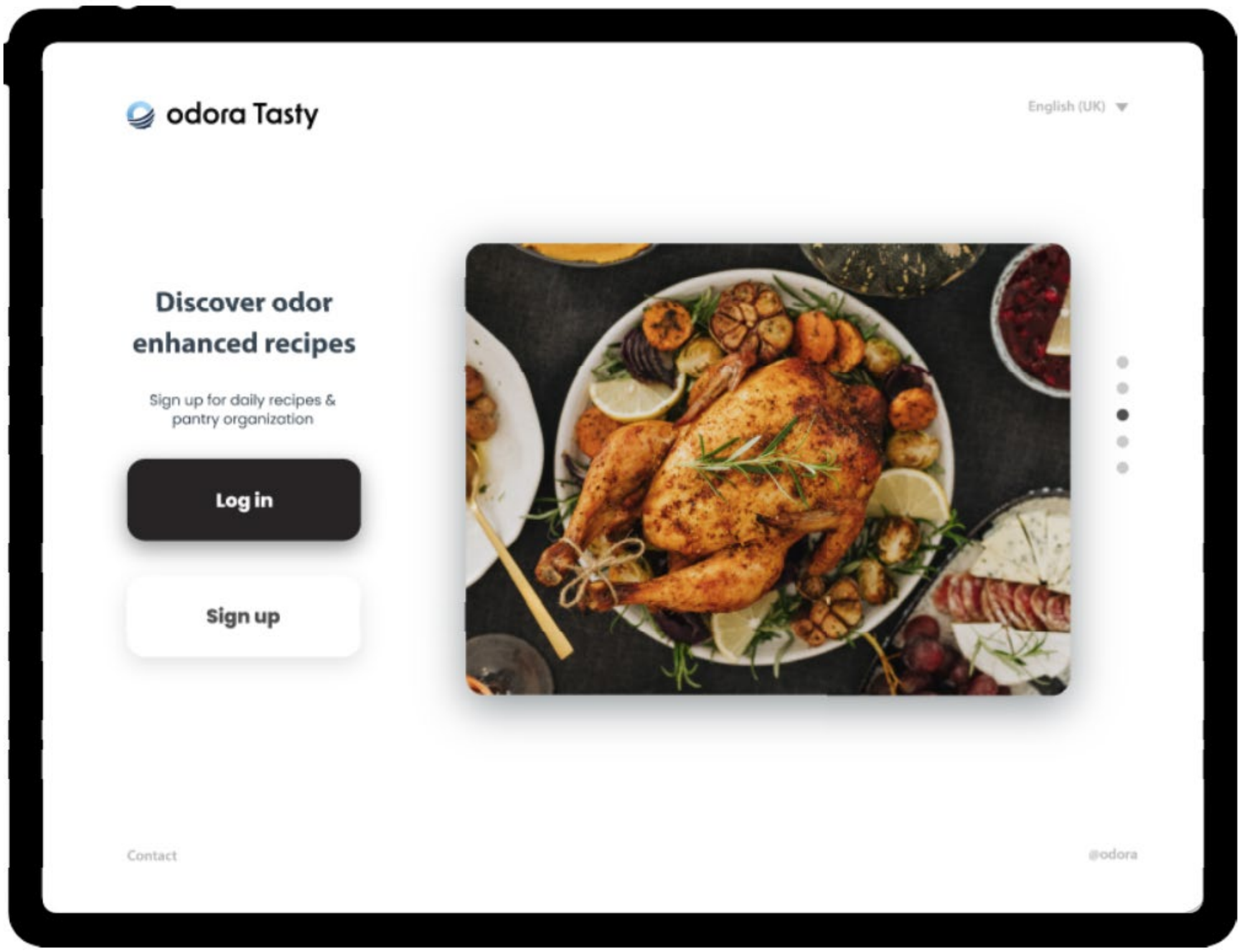

Figure 4.11 Signup page of Odora Tasty

Figure 4.12 are the preview page of one recipe called Chicken & Tomato Chakhokhbili by author Sammi Ricke [Ricke, 2017]. It is not an authentic odor-embedded recipe and is just for demonstrating what the interface looks like.

The page shows details of this meal idea, including the ingredients needed, the preview of the cooking steps, and what it looks like.

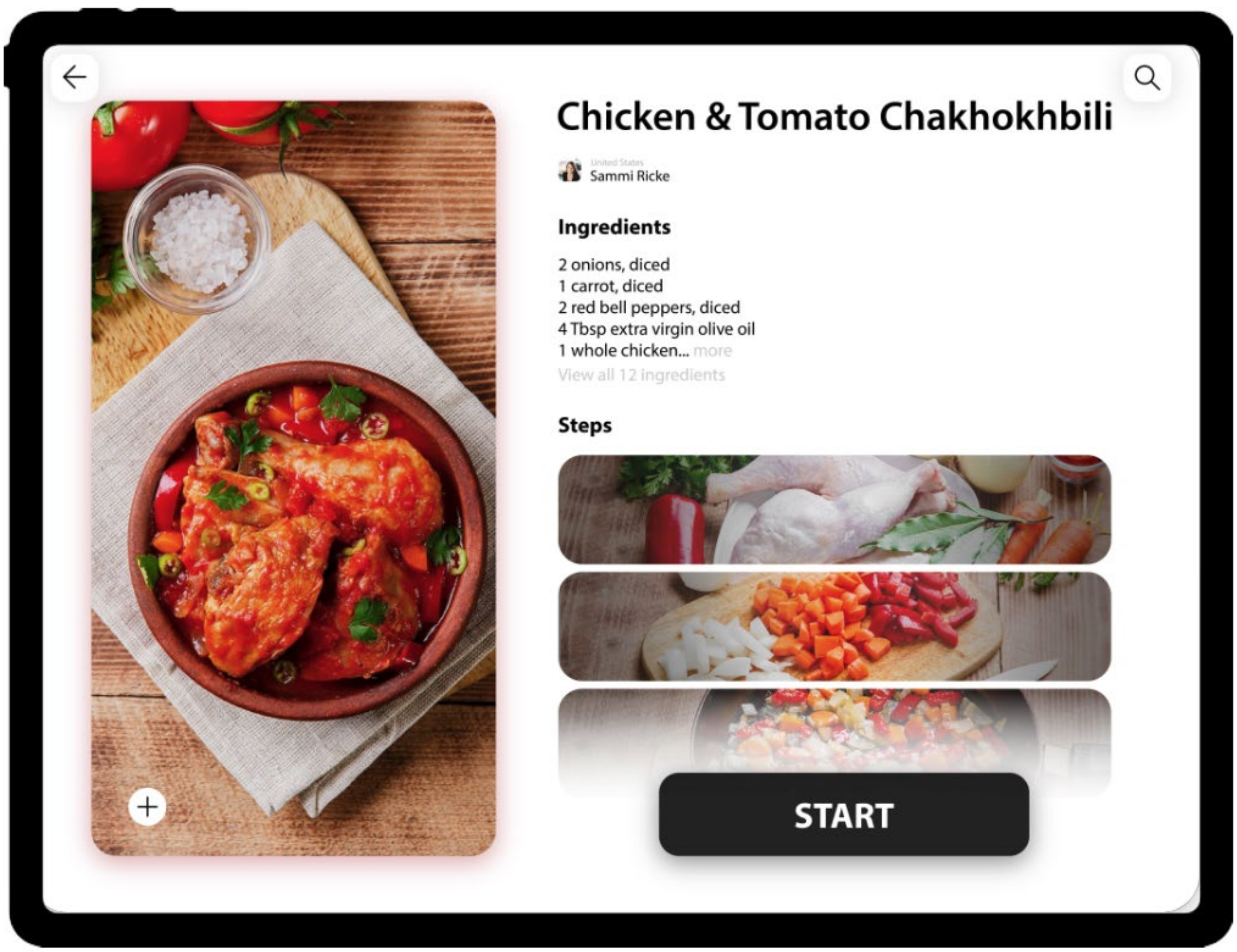

Figure 4.12 Recipe for Chicken & Tomato Chakhokhbili.

Figure 4.13 is the rendering of step 3 from the recipe, Chicken & Tomato Chakhokhbili. It shows what your food should be looked like in step 3. The top left shows the brief instruction for cooking. And the top right is the smell indicator. The smell graph keeps changing, for the smell is changing during cooking. And the black ring outside shows how close you are to this step to be finished.

The concept renderings here are on iPad pro, but the Odora Tasty will release on smartphones and smartwatches to provide a better and more immersive user experience.

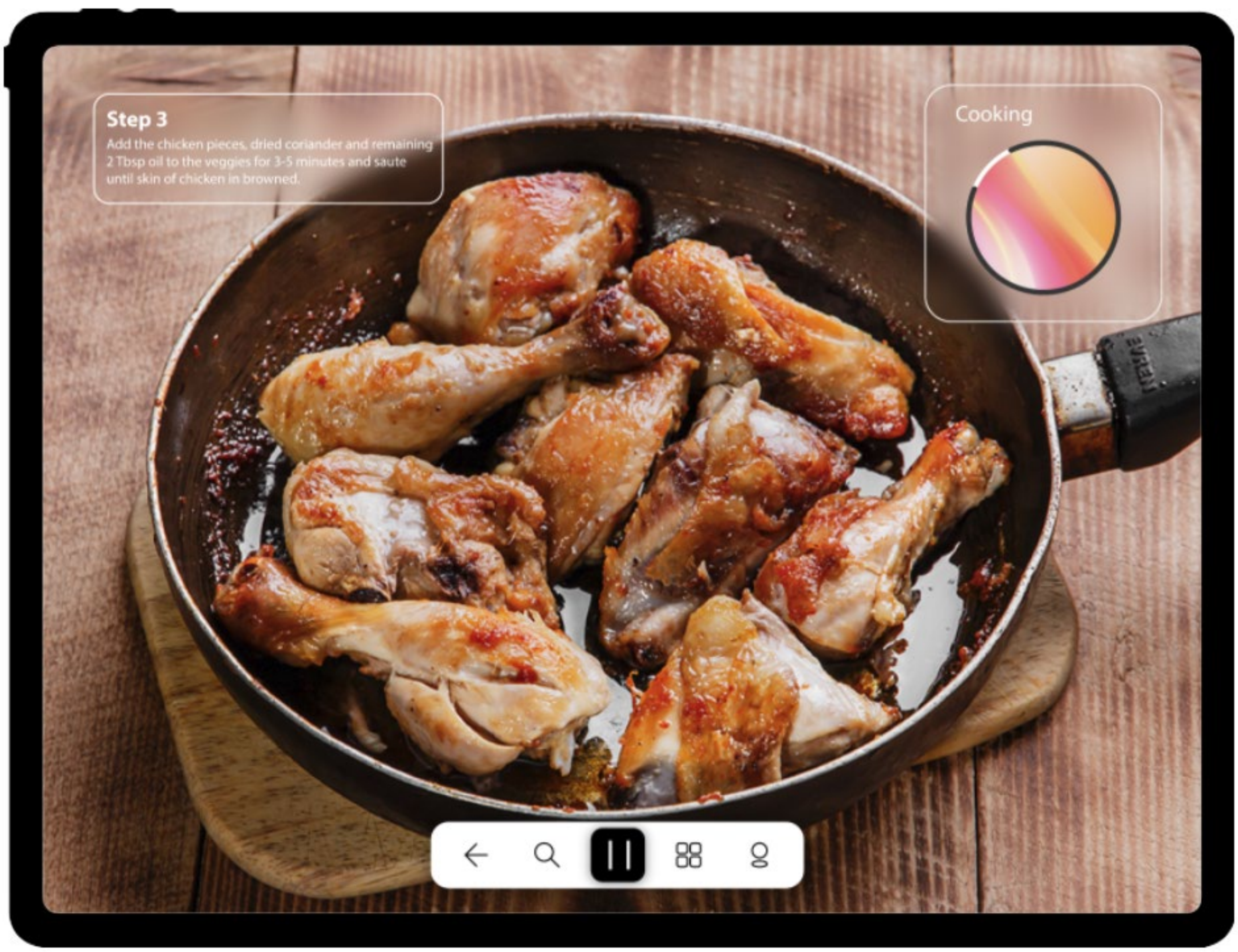

Figure 4.13 User interface while cooking.

Figure 4.14 shows the scenario when cooking. While Odora Smell Camera is sniffing the smell and odors during cooking, it tells the user how close they are to the end of this step and ready to move further.

The whole cooking experience is seamless and intuitive. It provides the future of cooking with the artificial sense of smell.

Figure 4.14 Final concept rendering, learning while cooking.

4.5 Creating Family Recipes Album

The purpose of this product is to capture beautiful memories with family and food. We only had technologies that could capture videos and sound in the past. But memories are richer than we can remember. Recording memories with family members are important and necessary, and recording through multiple senses can give us an immersive experience of the moment we spent with our families.

Odora is here to add one more layer when recording, the layer of smell. The smell and flavor of food can pass from generation to generation. Through Odora, we can create our family recipe album with parents or children to intentionally build great memories.

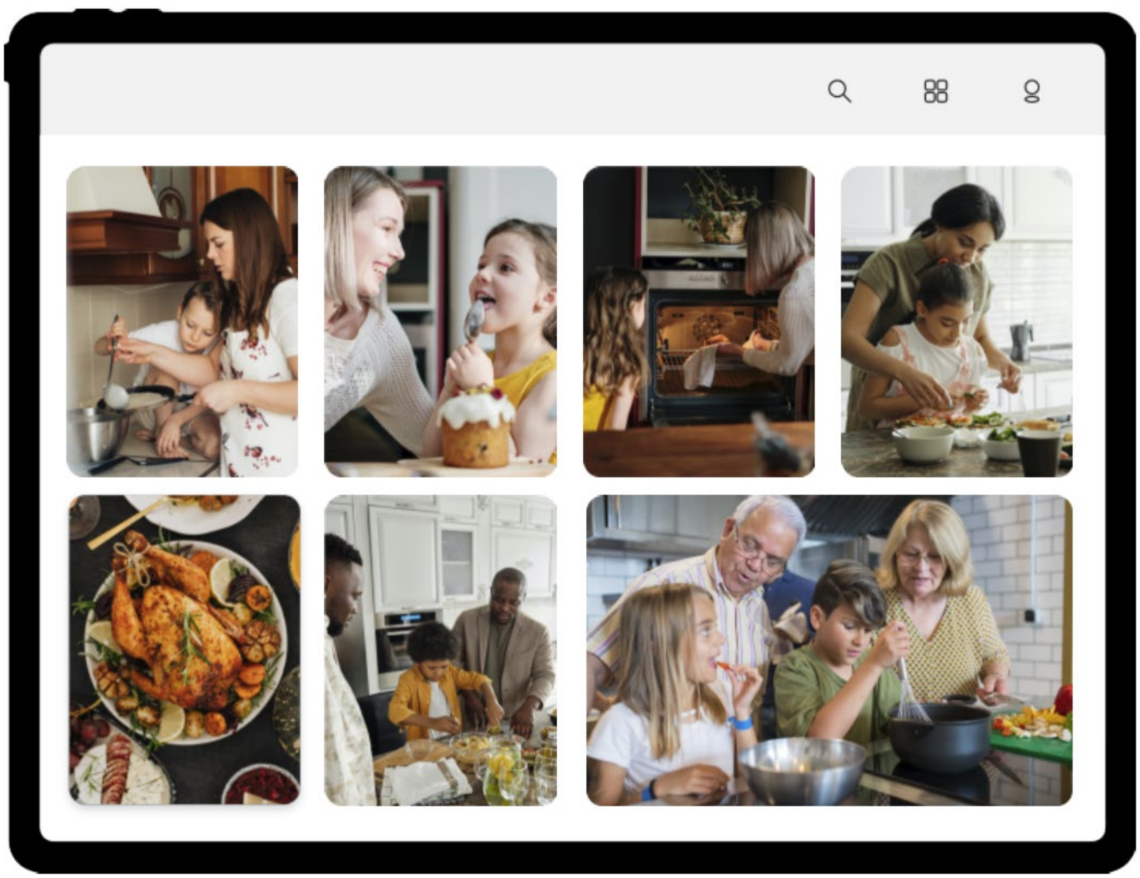

Figure 4.15 Odora, for family memories.

CHAPTER 5: CONCLUSION AND DISCUSSION

Memories of food are an integral part of everyone's life. The aroma of mom's food brings back fond memories of our family. But we don't have a technology that can record that taste. Everyone's food tastes different even though it's the same type of food. How can we reproduce and record the smell and taste in memory? Now nanotechnology and AI allow us to add a sense of smell to machines. So, we can record the smell of mom's cooking process. Use these smells data to know how and to what extent each food is cooked. We can make exactly the flavors we remember with recipes with odor data. This also allows us to share recipes with smell data on the Internet so that other people of different backgrounds and cultures can learn new recipes.

My research and development are not complete. There is a lot of work to be done. The application of artificial intelligence and machine learning in the olfactory area should get the same attention as the visual area. And I have to look at what is happening during cooking and what aroma is released in the different cooking procedures with varying types of food.

As discussed in this thesis, I have built a solid prototype that can prove this concept, which demonstrates a huge potential in this area. My concept design at this moment still needs improvements to polish the user experience. But I hope my study about machine learning in olfactory, memories, and food can draw more attention from other designers and researchers to this area.

And adding a sense of smell to machines will make our life more joyful.

Figure 5.1 Final rendering with a rose.

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