IDC School of Design
अभिकल्प विद्यालय

Design Research Project - II | Integrated Masters | 2020

Assistive Device to Aid the Visually Impaired in Meal Preparation: Roasting

Under the supervision of Dr. Swati Pal
Avyay Ravi Kashyap | 15U130010

Declaration

I declare that this written document represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources.

I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/ source in my submission.

I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Avyay Ravi Kashyap
15U130010
IDC School of Design, IIT Bombay

Approval Sheet

The Design Research Project - II titled "Assistive Device to Aid the Visually Impaired in Meal Preparation: Roasting" by Avyay Ravi Kashyap, Roll Number 15U130010 is approved, in partial fulfilment of the Integrated Master in Design Degree in Interaction at the IDC School of Design, Indian Institute of Technology Bombay.

Guide

Chairperson

Internal

External

Date

Acknowledgements

This project would not have been possible without the valuable inputs and support of many people.

I would like to thank Prof. Swati Pal for her guidance and valuable feedback that helped shape this project.

All the participants, for patiently answering my questions. All the people at NAB Worli and Reay Road for giving me the freedom to interact with all the students and staff at their locations.

All the faculty from IxD for their valuable inputs throughout the course of this project.

Karthik and Kiran for helping me with the prototype.

My batchmates, for entertaining my dry humour and providing much needed company during these testing times.

And my parents for constantly supporting me and allowing me to occasionally make my own dosas.

Abstract

There are over 12 million blind people in India, making India home to nearly a third of the global blind population. Research has indicated lower levels of nutrition in those with visual impairments owing to lowered ability to shop and prepare food for themselves.

Meal preparation is a complex multisensorial task that requires many decisions to be made based on the appearance of the dish. This alienates individuals with vision impairments and makes cooking meals independently inaccessible. Many products that rely on presenting formal cues to guide the individual while performing tasks in the kitchen have been designed, but they do not aid the visually impaired with tasks that involve application of heat. Also, there is a lack of research concerning user behaviour and needs in Indian kitchens.

The aim of this project is to elaborate on the challenges of roasting foods when blind and to design an assistive device that tackles these problems while keeping Indian cooking methods, practices and resources in mind.

Four commonly used cooking techniques involving application of heat were identified. A SWOT analysis was performed to understand the area that required immediate intervention. The technique identified was roasting. The problems identified and discussed were first tackled as discrete units, with the goal to combine them into one assistive device once the challenges faced were mitigated. Mid-way, a change in approach saw the direction of the project change from attempting to solve discrete problems to altering the procedure of roasting foods. Concepts were explored and evaluated based on the parameters of safety, ease of use, familiarity, and costs. The chosen solutions were then designed into a product. Proof of concepts and mock prototypes were built to test the logical validity of the solutions. A concept render of the same is then used to illustrate the usability of this product.

Index

Introduction

Preface

Preparing a meal is a basic activity needed for survival and the ability to be able to perform this activity independently is a skill that everyone should be able to acquire. It is a complex task that involves multiple sensory organs to indicate the state of preparedness of any particular dish. This is especially true when preparing Indian meals, with its complicated gravies, breads, rice, and desserts.

There are many facets that lead to the preparation of a meal; ingredients need to be procured by navigating to a grocer, and locate the ingredients required, arrange the ingredients in their respective places in the kitchen, apply various cooking techniques such as cutting, kneading, stirring, and roasting to prepare the meal, and finally, clean the vessels that were used when preparing the dish. Being able to prepare a meal independently can directly determine the quality of life of an individual [1]. Research has indicated lower levels of nutrition among Visually Impaired Persons (VIPs) owing to the reduced ability to shop and prepare meals independently [2].

A lot of the tasks mentioned above are dependent on sight for their execution. Many decisions are taken on the basis of the appearance of the dish. Loss of sight leads to lowered richness of information available to VIPs to make decisions such as when to proceed to the next step while preparing a gravy, or when to take the food off the pan when roasting. This forces VIPs to substitute the lack of sight by leveraging the heightened sensitivity of their other sensory organs, namely, tactile, olfactory and auditory.

Assistive Devices

Assistive Devices aid visually impaired persons by either augmenting senses or by enhancing sensory perception. There has been extensive work in aiding VIPs by enabling independence in various sectors such as navigation, personal care, financing, time keeping, and healthcare.

But the body of research that deals with assistive technology devices for the visually impaired is slim. Many products exist in the market that have taken ergonomic considerations to make the task of cooking less cumbersome, but very little has been done to inform the user about the state of the meal being prepared. The focus of existing work in this area has primarily been centred around western cooking.

Recent advances in smart home care has led to the widespread use of kitchen appliances with talk-back features and devices with automation. But these are rarely affordable by Indian households and have a history of not working as intended in the Indian context. Also, these appliances rarely take into account fit of device in its environment, current practices and methods used in the Indian kitchen. These devices are also not particularly designed for VIPs, making them cumbersome to use.

Research

Review of Literature

There is a lack of literature directly related to cooking techniques and other related processes of the kitchen, especially so in the Indian context. This prompted investigation of literature that looks at the challenges, strategies, and tools devised to aid the visually impaired in daily living.

As noted by Kostyra et al. [4], there has been considerable amount of work done in the area of identifying needs for visually impaired persons while shopping, going as far as to understand their desires, expectations, and obstacles with product choices and perception of food quality. The study also briefly covered meal preparation, but did so for meals prepared in western homes, which primarily involve usage of breads, cheeses, and meats. Further study on the behaviours and preferences of Indian visually impaired cooks is necessitated to attempt designing solutions for the Indian context.

Sirirungruang et al. [9] describe qualitatively the behaviours of visually impaired shoppers, highlighting behaviours in general and online stores, informational and environmental accessibility problems and strategies such as utilising community (family, friends, salespersons) help to complete the task. This is not too dissimilar to the situation in India.

Kutintara et al. [12] rightly point out that kitchens and utensils are not designed to accommodate people with visual impairments, or any disability. VIPs are required to undergo rehabilitation programs which provide special training in operating the tools required for daily sustenance, taking away their valuable time and forcing them to adapt and look for cues from objects not designed to provide thus, while also reducing the barrier to enter newer task spaces such as cooking.

Many physical products have been designed to provide form based cues to the visually impaired in kitchen tasks involving identifying containers, navigating the kitchen, and certain mechanical tasks such as cutting, peeling and pouring liquids. Kevin Chiam, an industrial designer, develops kitchenware such as knives and cutting boards for a vision imapired professional cook, Christine Ha [13]. Others have suggested smartifying homes to achieve accessibility [14]. Alternate studies have pointed out the possibility of redesigning a kitchen for more universal accessibility [5, 6, 8, 12, 15, 16], but this is rarely feasible in a resource constrained context as is in India. Given the lack of research and a thorough understanding present with regards to Indian visually impaired cooks, an extensive primary research was needed in order to define the needs, and considerations that need to be made for an assistive device.

From the above discussion, the following gaps were identified:

- While there are parts of studies that have focused on meal preparation by VIPs, they have primarily been done with western audiences, whose learnings do not translate to the Indian context.

- Solutions that broadly fall in the food category primarily cater to enabling navigation in organised grocery stores through expensive technical equipment and in some cases, through a massive overhaul of infrastructure, which are resource intensive and hence, not suited for a predominantly resource constrained society. Also, they do not directly address difficulties faced when preparing meals, but rather seek to aid in the background tasks.
- There are a few products in the market that have been designed to allow VIPs to perform tasks in the kitchen without fearing for their safety, but these tasks do not involve dealing with application of heat, as is required by most Indian meals. It becomes even more of a priority to investigate current patterns and understand problems faced by Indian VIP cooks in order to design assistive devices.

Considerations about user safety, enabling independence and accounting for preferences and desires of the VIPs is key to understanding how to design the necessary aids. Thus, the goal of this project is to understand and define the problems plaguing the vision impaired as they prepare a meal, and design an assistive device that enables independence in the kitchen while taking into consideration various aspects of safety, cost, and conformity with everyday objects and tasks.

Methodology

Given the lack of actionable secondary research, an extensive primary research was conducted to gain the necessary insights to develop the assistive device.

Initial understanding of the problem space was obtained through in-person unstructured discussions with individuals with vision impairments at National Association for the Blind (NAB), Worli. Seven individuals were spoken with and the problems they faced, and strategies employed to mitigate the problems when performing tasks in the kitchen were noted.

Insights gained from these discussions made it clear that many activities in the kitchen are mostly tactile and even sighted users rely on vision only as a secondary cue to perform tasks, such as, kneading the dough, cutting vegetables, soaking dals, etc. This however did not hold true for activities involving heat application, and the second round of interviews focused on techniques that involve heat application.

Primary Research

Initial Interviews

The problems noted varied in nature, and not all had to do with the act of preparing a meal. The range of activities varied from measuring quantities, developing proprioception, to filtering and cleaning foods. The problems have been listed in the table [Table.01] under the categories of problems, sensory organs used to substitute sight, and the activity group the problems belong to.

Table.01 *Problems faced by VIPs generated from preliminary interviews*

Problems	**Sensory used**	**Activity type**
Removing stones from rice	-	Cleaning
Cleaning vegetables (ex: cauliflower)	-	Cleaning
Understanding when dal has gone bad	-	Cleaning
Understanding when a dish is finished deep frying	Olfactory, feel (dish rises when finished in some cases)	Cooking
Understanding when chapati is done cooking	Olfactory, Touch, Time	Cooking
Being able to fry more than one at a time	-	Cooking
Straining tea leaves	Touch, sound, proprioception	Filtering
Buttons on many devices are not discernible	Touch from reference	Finding
How to use non-speaking microwaves/mixers	Touch; from reference point (sometimes)	Hearing
Understanding when milk rises	Sound, smell	Levelling
Understanding level of flame	Heat near hand, physical	Measuring
How much atta has been used in chapati	Touch	Measuring
Measuring quantities of spices to put into food	Touch	Measuring
Pouring tea into a cup	Physical/touch	Measuring/levelling
Is the oil hot or not?	Heat feel, sound	Non-tactile feeling
Placing batter into boiling oil	Feel for vessel, touch, heat feel	Placing/Positioning
Where is the surface of the container	Touch (not possible or hurts when hot), proprioception	Proprioception/Positioning

Needs to feel vessel before pouring/putting ingredients in	Touch (not possible or hurts when hot), proprioception	Proprioception/Positioning
Finding the right ingredients if the box is misplaced/two similar boxes	Touch, smell (sometimes)	Searching/Finding
Understanding which masala is being used when preparing a gravy	Olfactory, sometimes touch	Searching/Finding
Understanding when a dish is done cooking before proceeding to next stage	Olfactory, consistency (feel)	Temporal

From the first round of interviews, it became clear that although there are multiple problems faced on a daily basis by VIPs. However, VIPs develop various strategies to overcome many of these problems. For example, pouring water into a cup is a very visual task, and hence quite a challenge to VIPs. VIPs have several strategies to help overcome this problem, from placing their fingertips at the edge of the cup, feeling the change in temperature outside the cup to listening closely to the change in pitch of the sound coming from the cup to gauge the level of water present. These strategies become a part of the user's daily lives, so much so that they can be classified as a behaviour to perform a particular task.

One of the participants said,

"Not everything requires use of eyes while cooking. A lot of it is understood by the feeling."

Before conducting a second round of interviews focusing specifically on the cooking techniques which is mentioned below, I had the opportunity to visit the kitchens of three VIPs. One of them had complete blindness, and two had partial vision. *A sheet with the problems faced and strategies employed during the cooking process has been recorded in the Appendix section.* This, along with speaking to experts in home cooking allowed me to gain a sense for the various techniques typically needed for preparing Indian dishes.

There were four techniques identified that are typically used to prepare staples in Indian homes [10]. These are:

1. Boiling
2. Simmering
3. Roasting
4. Frying

Boiling: Boiling is the process of cooking food in boiling water, or other water based liquids such as milk. This generally results in vegetables becoming soft and tender, and easy to chew. Commonly prepared foods involved stews and rice.

Simmering: Simmering is a process in which foods are cooked in hot liquids just below their boiling temperature. This technique is used to prepare most Indian gravies. It is key to keep track of change in colour and continually stir to ensure even mixing.

Roasting: Roasting is a technique that involves cooking food with dry heat with a small amount of cooking oil applied on the pan to prevent the food from sticking to it. Foods commonly prepared in this method are rotis, dosas, and processed meats.

Frying: Frying is the process of cooking food in oil or any fat. Many foods are prepared using this technique, such as puris, vadas, pakodas, and other western dishes such as french fries, fried chicken etc.

Semi-structured Focused Interviews (Secondary Interview)

The second round of interviews were conducted specifically focusing on the aforementioned four techniques. The interviews were conducted at NAB, Reay Road with five participants of varying years of expertise in the kitchen and varying degrees of blindness. A semi-structured questionnaire was used to keep the conversation on track, but allow for discussion and obtain greater clarity on the problems stated.

The problems and strategies gathered were then analysed to identify gaps and opportunities. A SWOT analysis [11] of the data was done to help identify the tasks that required an intervention, the need to use assistive technologies, possible interventions, and constraints within which the design should work. This has been attached in the following page.

Fig.01: *SWOT Analysis of cooking techniques*

Strengths

Stewing/Simmering

Each step generally has a lot of smells and sounds to aid the VIP in proceeding to the next step

The tolerances in stewing/simmering are quite high, making it less of a need to be precise and on time

Simmering in particular has a large leeway in terms of how the food gets cooked

The end product is a gravy, making mixing of the solid food easier, and less sight dependent

Boiling/Steaming

Doesn't require too much monitoring until the dish starts to boil

There is a considerable tolerance while cooking vegetables/solid food through this method

Many households use pressure cookers as a hack to get around having to keep a constant watch over the state of food while boiling

When water is upto boiling temperatures, the food being cooked boils evenly, reducing the need for ATDs to help VIPs

Roasting

Events leading to roasting are very tactile, making it easy for VIPs to prepare foods

Roasting generally takes place quickly, making is less tasking when compared to many other cooking techniques

Texture, smells and sounds play a part in understanding whether a food is cooked or not

Frying

Preparing foods for frying is generally tactile

There is a distinct smell and texture when an item is done frying

For VIP with low vision, there sometimes is high enough contrast between the cooked and uncooked food to be able to tell difference

Weaknesses

Stewing/Simmering

There are some gravies that require the user to notice a colour change, making it hard for non-sighted users to discern this change

Stirring the gravy to ensure everything mixes might cause spillage (hurt hand) when the levels of the liquids are unknown

Boiling/Steaming

Boiling liquids can jump up and hurt the user

Few tasks require to keep a close watch to prevent over boiling, but these too are temporal

Roasting

It is done on high flame, increasing the chances of burning one's hand

The pan has to be hot before putting the food on it, increasing the chance of burning one's hand

The food cooks quite fast, not allowing much leeway for making mistakes/taking time

Roasting larger objects such as roti/dosa requires flipping the food to cook it. Locating the dish, placing the flat ladle under it, and picking it up and flipping it back onto the same pan is a very hard task to do when neither the dish nor the pan are seen

The flipping has to be done without touching the pan, as the pan is hot

Putting the dish back onto the pan is difficult as the user cannot see the pan

Frying

Oil needs to be upto temperature when cooking

Putting in water based items can cause the oil to jump up

The food cooks quite fast, not allowing much leeway for making mistakes/taking time

Putting in foods in the boiling oil can cause a splash back which can burn hands

The foods need to be flipped to cook properly

Given that there is only a visual cue when the food is done cooking, cooking of the food is done one at a time so as not to overcook or undercook the dishes

Taking the cooked dish out of the vessel without spilling any of the hot oil is also a challenge

Generally VIPs do not attempt frying, mostly deep frying, for fear of burns

Opportunities

Stewing/Simmering

Cognitive load required while remembering what step the user is doing can be reduced through ATD

Safety while mixing or adding ingredients (splashback) can be increased to make this activity more accessible to VIPs

Enhancing the current sensory organs or adding sight through camera vision will improve and aid cooking practices of VIPs

Boiling/Steaming

Safety while handling the foods that are boiling is a necessity

Tasks that require close monitoring can make use of ATDs to reduce cognitive load

Roasting

Ensuring safety of not burning one's hand while roasting will make it more accessible to VIPs

Providing more indicators about the preparedness of the food will ensure properly cooked food

Allowing flipping to be done without wastage and too much effort

Making the process quicker and less cognitively overloading

Frying

Being able to safely put the foods into the vessel will make frying more accessible

Being able to inform VIPs of the state of the oil and splash backs (if any) will make frying a lot safer

Helping VIPs in cooking more than one item at a time will greatly reduce the amount of time they have to spend in front of the vessel and thereby also reduce the risk of burn injuries

Indicating the state of the items being cooked through ATDs will also help understand when to flip or when to remove the item

Threats

Stewing/Simmering

Device malfunctioning/over-reliance on ATD can cause serious injuries

Many changes that occur while preparing gravies are aromatic/dependent on the type of seasoning chosen, making it hard for ATDs to aid in this process

There are many processes that need to take place before stewing, thus not being able to include gravy making as a wholesome activity

Roasting

Safety in roasting can be achieved even without ATDs

Indian households do not use one particular vessel to roast dishes, making standardising a device difficult

Roasting foods involves using both hands, making using an external AD a difficult device to incorporate in the behaviour of the user

Boiling/Steaming

Safety can be achieved even without ATDs, through simpler devices such as gloves

Many devices come with fail-safe safety mechanisms rendering ATDs not relevant

Frying

Unwillingness of VIPs to use ATDs for frying, or rather do frying altogether

Different vessels in different households and lack of scientific methods applied while firing makes it hard to design an ATD for

Using ATDs might make users lax while frying leading to injuries

Different preparations in different households makes it harder to understand when a food is done cooking

Generally VIPs do not attempt frying, mostly deep frying, for fear of burns

Problem Identification

The SWOT analysis brings clarity to a few areas:

- Boiling and Simmering are activities persons with vision impairments are strong in. This is very likely due to the higher tolerances these foods have towards any mistiming on part of the cook. This is contradictory with Roasting and Frying, which are highly dependent on timely executed maneuvers, with much lower tolerances towards mistakes on the cook's part.
- VIPs find Roasting and Frying quite challenging and hence have many weaknesses in these areas, but it is not so with Boiling and Simmering, with the weaknesses coming in the form less likely events such as boiling liquids jumping onto the person's hand, not being able to properly mix the spices in the liquid.
- The weaknesses VIPs face while Roasting and Frying also present a greater number of opportunities to design assistive devices to aid such scenarios, making these techniques more accessible.
- The presence of many threats, coupled with inherent fear of the technique and the various risks it poses, make frying a challenging activity to encourage, as compared to Roasting, with presents a lot more opportunities but not so in threats, making it a more approachable task, one that individuals with vision impairments would be willing to try.

The second round of interviews also shed light on how VIPs and their families approach the various tasks. While VIPs are allowed to make various gravies (simmering) all by themselves, all the participants of the interview stated that none of their family members would readily allow them to prepare dishes that involve roasting on their own. If they are allowed to roast foods, it is done so in the presence of family members. But when it comes to frying dishes, family members do not consider it to be a suitable activity to be performed by the VIPs. They are of the opinion that there are many risks involved and the repercussions, if things were to go wrong, when frying are a lot more grave as compared to other cooking techniques, such as possibly resulting in multiple handicaps. They would much rather avoid making it necessary for the VIPs to cope with multiple handicaps.

In addition, Frying, although a popular technique used to make Indian dishes, is not generally used for making staples. More often than not, it is a technique used to prepare rarer delicacies not consumed on a daily basis by the average Indian family, such as puris and vadas.

Thus, for the purpose of this project, the focus of the intervention will be to do with the technique of **Roasting**.

There are many steps that precede roasting while preparing a meal, such as kneading the dough, or preparing the batter, which are primarily tactile tasks. VIPs have developed several strategies to cope with challenges arising from executing these tasks. Hence, when I refer to roasting as a technique, it will start after the pre-preparation of the food to be roasted, and will not include activities of cleaning that succeed the task of roasting.

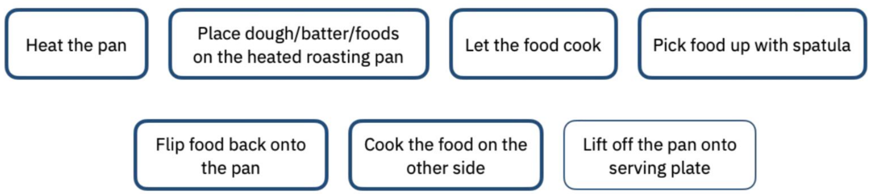
Roasting

This section will look at the task of roasting in greater detail with inputs from my research for the DRS. The behaviours, challenges and strategies employed by visually impaired persons will be discussed here.

Roasting is a technique that involves cooking food with dry heat resulting in caramelisation on the surface of the food. When roasting in a pan, generally a small amount of cooking oil is used to prevent the food from sticking to the pan. Foods commonly prepared in this method are rotis, dosas, and processed meats. For some specific foods, such as dosas and rotis, preparation of the batter/dough is required in order to commence with the roasting. But these are mechanical cooking techniques that do not involve heat application, and will not be discussed in this section.

Method

There are many steps involved in roasting. First, the food has to be placed on the hot pan; second, there might be a need to add a bit of oil/fat around the food to prevent sticking; third, the food has to cook for a while and should be lifted only when brown; fourth, picking of the food for flipping and cooking from the other side; fifth, once cooked sufficiently, picking it up from the hot pan and placing it on a plate to be served. These are the bare minimum steps needed, assuming there is only one item placed on the pan.



Behaviours

Most VIPs are slightly hesitant to try roasting in the beginning, with family members not encouraging this activity either. While VIPs are allowed to partake in the mechanical activities that precede the activity of roasting, there is a general hesitance to perform the task itself. Some VIPs, during the interview, did mention that the initial task of placing the food on the hot pan is not as much of a problem and can be done quite well with a bit of practice, the steps that follow are undoubtedly challenging.

Challenges

The problems associated with roasting foods are numerous. VIPs stated that they had a fear of burning their hands on the hot pan, resulting in them being hesitant to attempt this on a regular basis. This fear exists with family members as well, causing them to prevent the VIPs from performing roasting related tasks. Tasks such as placing the batter/dough/meat on the hot pan are visual in nature and become harder when the pan is heated. While the task of flipping the food in order to let it cook from the other side is not particularly difficult, the tasks that precede this such as placing the spatula underneath the food and lifting it up without folding it upon itself or dropping it that are highly complicated and require greater sensory assistance. Also, some strategies make use of both hands to pick the food off the pan, with one hand being used to hold the food in place while the other uses the spatula to pick it up, and this often comes with the problem of losing orientation and mis-positioning oneself, making the task of flipping back onto the pan even more challenging. *A video of a VIP who kindly agreed to demonstrate the process of roasting a roti is linked here.* Another issue lies in the form of roasting multiple foods at the same time, such as processed meats and cutlets. It becomes hard to keep track of which ones have cooked, which need to be flipped, and flipping them back into the limited area they have on the pan. This forces cooking such items individually which increases the amount of time it takes to prepare a meal. This problem of understanding foods that are cooked versus foods that are under-cooked is a very real problem as the cooked surface faces away from the user, and often gets stuck to the surface of the pan.

Strategies

The participants used multiple techniques in a bid to overcome the barriers imposed. While attempting to place the batter/dough/food on the hot pan, the handle is used as a reference to position the pan and their surroundings. Smell is the primary indicator for how cooked the food is, with time the food has cooked for being a secondary indicator, providing more information with which VIPs can decide when to flip or take the food out of the cooking pan. While preparing rotis,VIPs check the texture to understand if it is tough enough, indicating that it is cooked. When overcooked, there is a distinct charcoal like burnt smell, that arises from the pan. In order to get the food onto the spatula, a secondary aid, such as the rolling pin is used to hold the roasted food in place, while the spatula slips under. This technique, albeit useful, does not guarantee success, and might require multiple tries before the food is lifted off the pan.

A list of problems faced by VIPs when preparing one particular dish (dosa) has been recorded in a stepwise manner. The link to the table can be found in the appendix.

Problems to tackle

While the challenges are many, some of the problems have strategies that help mitigate the difficulties. Understanding when a roasted item is done cooking is informed by temporal aspects associated with the food, and also a distinct smell, unique to every dish. In some cases, as discussed earlier, the texture of the food surface helps inform about its state. This, however, is still a challenge when cooking multiple food items as the process of checking for such ambiguous parameters is tedious and highly error prone. Therefore, problems identified have been categorised as follows:

- Understanding where the centre of the pan is, to allow for placing of the food
- Picking the food up and flipping it back onto the pan
- Being able to do the above tasks with multiple foods

While taking the roasted food out is also an activity that is visual and not easy for VIPs, it is a task that requires considerably less precision as the food can be slid out of the pan. It is for this reason, taking the food out of the pan is not included in the list of problems to tackle.

Design Objectives

The larger objective from this project was to develop an assistive device that would enable independence of individuals with vision impairments in the kitchen while performing the activity of roasting. Based on the problems identified, the objectives were as follows:

- Develop an assistive device that can provide the user with a reference to the layout of the pan
- Develop an assistive device that will aid the user in picking the food off the pan and flipping it back on to ensure it is cooked on both sides while maintaining orientation with respect to their environment
- Perform the above two objectives, but with multiple foods being cooked on the pan

There are some considerations to make when designing for these objectives:

- It is imperative to maintain the safety of the individual performing the above tasks. The objective was to be able to provide as much reliable information as possible to allow the user to make the best decision in tasks that were sight dependent, thus keeping them safe.
- Ease of use was also an extremely important consideration to make. This was to ensure the device would have high adoption rates. It had to be significantly easier to use than roasting food without any device with existing practices.
- Given that this product was being designed keeping Indian staples in mind (roasted staples), familiarity to the Indian cook and their surroundings was key to keeping flat learning curves for any new assistive device.
- And finally, India is a resource constrained country. Keeping costs low is the law of the land. The easiest way to do this is to ensure the design makes use of the available resources at the users' homes.

To summarise, safety, ease of use, familiarity to the user, and keeping costs low are the evaluation criteria chosen in that order to take the explorations forward to come up with the final solution.

The assistive device will include the following:

1. Sensor modules to detect and perform the tasks as necessitated by the user while being able to provide appropriate feedback regarding the preparation of the meal.
2. The basic formal aspects necessary to ensure safety and ease of use, while not being out of the ordinary or obtrusive to perform daily tasks.

Target Audience

The device is primarily targetted at individuals with vision impairments, both partial and complete blindness, who are also relatively inexperienced in the kitchen space (experience < 5), as this would make learning the habit of using a device to cook a lot easier as compared to more experienced cooks who will have to break habits in order to use this device, an undesirable step.

Initial Explorations

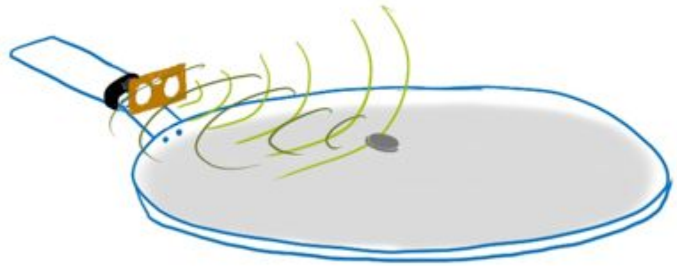
The first approach was to tackle the problems and look at discrete solutions to answer each problem, resulting in many small assistive tools that could help mitigate the problems. But before diving into the initial explorations, it is important to bring clarity to what comprises the problems.

Locating the centre of the pan

Placing the food to be roasted in the centre of the pan is highly dependent on vision, when an individual starts preparing dishes. But even with practice, it requires substantial skill to place the food on the batter in a trackable manner when one cannot depend on sight to locate the food. For VIPs, a major reference to their food, given that they cannot touch the hot pan, is to use other tactile surfaces which help them orient to the pan. This can be the handle of the pan, or the knob of the stove if it is located directly in front of the heat source, or even by using a long non-conducting object of the likes of a rolling pin to touch the pan and keep a reference.

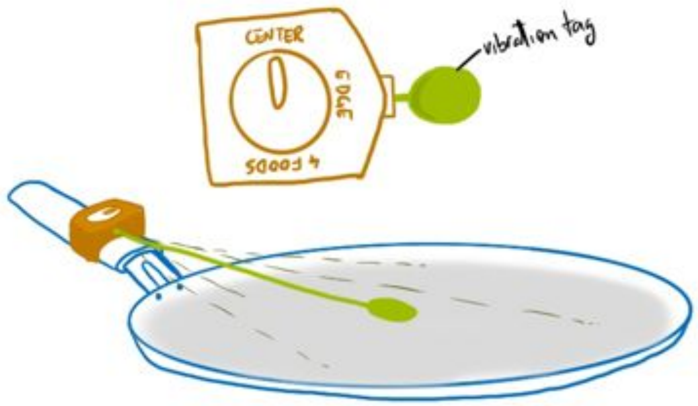
It became obvious that the most important thing in this case was to ensure that a reference point is maintained while providing cues about the location of the centre. One constraint put in place while designing was to use a standard non-stick pan, as the diameter is defined and additional elements such as the presence of a handle, the manner in which it is attached to the pan, and the presence of walls on the side of the pan can act as fall backs and reduce the need for additional steps of components while designing. Also, it is a fairly common utensil found in most Indian households.

1. Using an ultrasound sensor clipped to the handle to provide information regarding location of centre



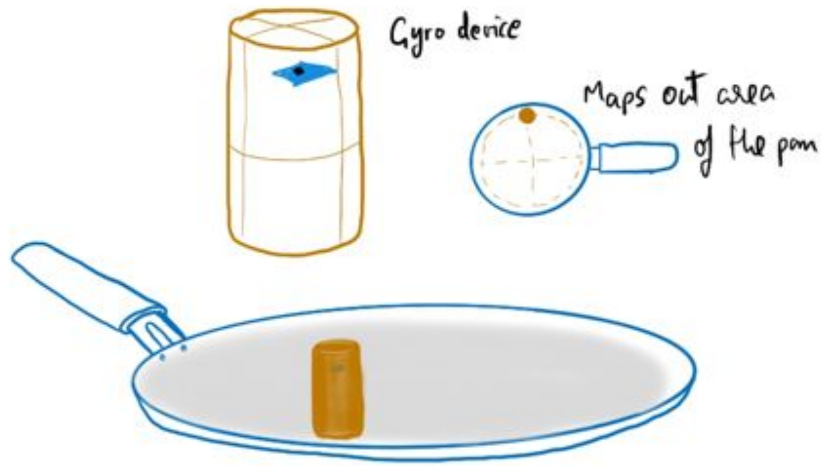
   The ultrasound sensor would be clipped onto the base of the handle, and by measuring distance, would be able to tell when an object was near the sensor. This would be based on a few approximations and dependent on the type of food being prepared. For example, if a dosa is being prepared, approximate dimensions of a ladle will have to be noted to provide an indication when the VIP is near the centre, whereas if a roti is being prepared, approximate size of the dough when flat will have to be taken when providing the same feedback.

2. Using a tag attached to the handle to measure location of centre by calculating distance and angle



A vibro-tactile tag will be attached to a device that is clipped on the handle. Pulling this tag over a hotspot on the pan (centre, edge, etc.) will provide feedback. The user can choose which mode they want to operate in to get the appropriate feedback.

3. Using a gyro based tracking device to map the pan and provide feedback



A non-conducting cylinder with a gyroscope integrated into the device will be used to help the user understand where on the pan their hand is over through haptic feedback provided on the top surface of the device. This device will act as a permanent reference while helping the user map out the pan.

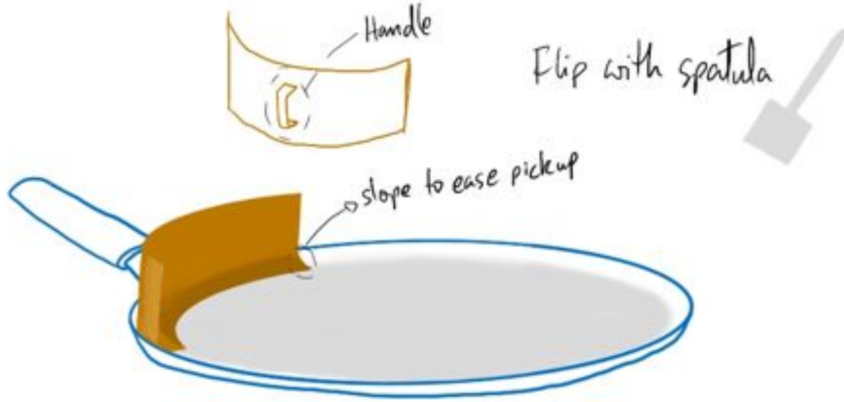
Picking and flipping the food back onto the pan

Picking up roasted food and placing it back onto the pan is a task that requires a considerable amount of skill even with sight. There are many steps involved in this activity, and many checks, some of which are purely visual, that let us know that we can progress onto the next step.

First, it involves understanding if the food is ready to be picked up from the surface of the pan, which can be guessed using temporal assumptions, while also relying on olfactory and in some cases, the change in the tactile textures on the surface of the food. Then, the user has to gently slide the spatula underneath the food, by locating the edge of the food, prodding to see if it done well enough under, while ensuring the food doesn't just move along with the spatula, but rather begins to sit on the spatula. Another check to keep in mind when doing this is to ensure the food doesn't fold upon itself. If all the checks are positive, the user can proceed to the next step, which is lifting the food off the surface of the pan. This is a highly visual task. Keeping the food balanced when one can't come in contact with it is very much dependent on sight. Once the food is lifted off the surface off the pan high enough, all that remains is flipping the food back onto the pan. While this is easy enough, many a times, VIPs use additional tools to make the previous tasks easier, such as using a rolling pin, or a spoon to help grip the food. This makes the VIP lose reference to the pan, and they have to locate the handle to reorient themselves with respect to the utensils. Once this is done, the user would've successfully flipped the food back onto the surface of the pan. There are other issues such as the food folding upon itself when flipped, but these are much rarer than the problems mentioned above.

Given this, an intervention to help maintain orientation, while also providing enough of a leeway to make mistakes when flipping was necessary. There were additional utensils that could be leveraged to provide the necessary tools with which to execute the task. Explorations for this problem chose to utilise these possibilities.

1. A moveable wall to provide reference and increase surface area



The wall would provide an additional surface with which to help pick the food up. With a handle on the other side, the user could manipulate the wall as per their needs.

2. Modified tongs to integrate a spatula

A set of tongs modified with one end mimicking that of a spatula would allow the food to be easily grabbed without losing reference to the pan. But this would not be suitable for all foods and would likely tear through the food when grabbed.

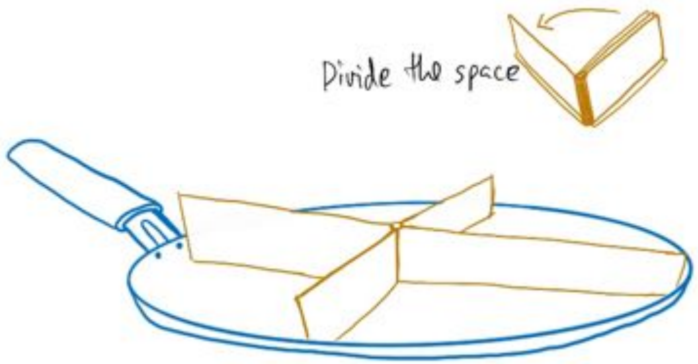
3. Magnetic grabber to aid gripping the food

The magnetic grabber would double up to provide reference to the centre of the pan while also allowing the VIP to grip the food similar to their current practices with a rolling pin.

Roasting multiple foods

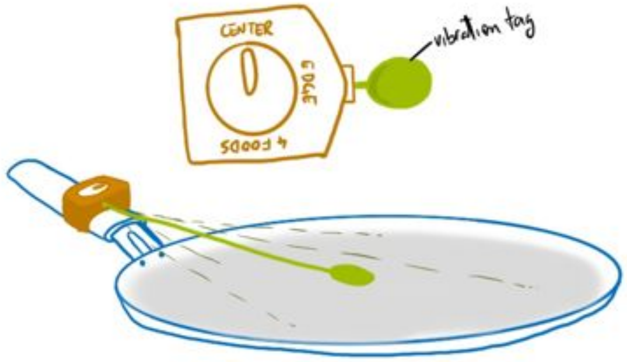
Roasting multiple foods provides an additional challenge to the VIPs. It becomes necessary to keep track of the location of the other foods on the pan surface. Moreover, it is pertinent to keep track of which foods have been flipped, and which ones are yet to be flipped. Also, while flipping, it is important not to disturb or dislocate the other foods being roasted on the pan.

1. Physical dividers that provide modular divisions on the pan



Using fan-like dividers to segregate space on the pan, making it easier to keep track of multiple foods. This would need additional elements to help keep track of multiple parameters like whether it is flipped, and how to orient the user to the rest of the pan.

2. Using tags to indicate location of the food



Similar to locating the centre, a mode will indicate the position of the tag when it hovers over a hotspot predefined by the user.

3. Embedding numerous IR sensors

   IR sensors embedded into the surface of the pan will provide information about whether a food is placed at that particular location or not. The system can keep track of what is being done to inform the user whether they have been successful in their action or not.

Feedback mechanism

Two feedback mechanisms were thought of:
1. Haptic feedback through a vibration motor
2. Auditory feedback through speakers

Based on the environment of the user's and their kitchens, coupled with performing the activity of roasting, audio feedback would result in the VIPs spending more energy trying to listen to the feedback being provided. Also, talkback systems present on devices are not comprehensible to a large section of the population in India, making audio feedback possibly more distracting than the activity itself. It has been mentioned earlier that in order to maintain reference to the utensils, VIPs need to touch a non-harmful surface, be it the handle or the knob on the stove. This provides an opportunity to design vibro-tactile feedback regarding the state of the activity the user is performing. Hence, the feedback mechanism chosen was Haptic feedback through vibration motors.
To give a gist of the above explorations, the problems identified were in doing tasks that were primarily sight dependent. The explorations looked at how these visual cues could be converted to either auditory or haptic cues to overcome the deficit of not being able to rely on sight.

But the explorations done above tackled problems discretely. While they might help with the solving the problems individually, when merged, they make for an unwieldy and inconvenient experience with too many steps and a steep learning curve. Also, the explorations were tackling the problems by trying to replicate the processes followed by sighted users to roast foods. It just so happened that there was a thought that this might not be the best approach. There was an opportunity to redesign the process of roasting by taking into consideration why sighted users do what they do the way they do it. This approach has been described in the section below.

Redefining the Approach

Another look was taken at the tasks we perform when roasting a dish. The question “why do we do this?” was asked for the areas which are problematic to the VIPs.

Locating the centre of the pan

This is a task that is necessary as without it, the food cannot be roasted. The process of relocation as done by VIPs right now, is a fairly imprecise process, but a very convenient one. It involves developing the proprioception senses and with time, as one gains familiarity with the utensils, this becomes less of a hassle. But this process can still be made easier by providing VIPs with cues as to the whereabouts of the centre.

Flipping the food back onto the pan

As sighted users, we flip food back onto the pan as it is the most convenient method to provide heat on both sides. But for VIPs, replicating this method is ridden with difficulties. So, is it really necessary for VIPs to flip the food?

As it turns out, it is not necessary as long as we are able to provide heat from both sides. This eliminates the challenges associated with flipping, making roasting a lot more accessible to the vision impaired.

The challenge now becomes how do we provide heat to both sides of the food.

Roasting multiple foods

The major challenges associated with roasting multiple foods was keeping track of where the foods are and which ones have been flipped. The reason to keep track of where the foods were was to ensure the right foods are flipped and the roasting is even for all foods.

But if heat is provided from the top, then there is no need to keep track of the multiple foods, as all of them will get cooked evenly. Thus, providing heat on both sides eliminates two of the major challenges faced by individuals with vision impairments.

The redefined problems to tackle are as follows:
- Locating the centre of the pan
- How to provide heat from both sides to a food item

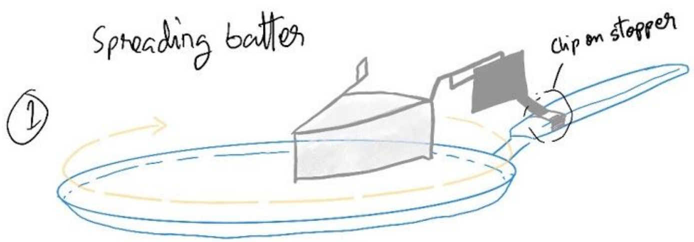
Design Concepts

New concepts were sketched out to tackle the redefined problems.

Placing the food in the centre of the pan

While the problem remained the same, the previous approach was quite disjointed and did not consider the possibility of having more physical solutions. Also, while locating the centre to do the necessary tasks is one approach, another possibility is to have a device that affords lower tolerances by ensuring the food can be placed more comfortably with the device doing the job of placing the food neatly on the pan. Having physicality in the solution provides the opportunity to have a low cost device, while ensuring a flatter learning curve.

1. Dosa Batter spreader



A triangular bottomless bucket which rotates around a pivot would ensure even spreading of the batter in a circular manner with minimal effort from the VIP's side. Once the batter is spread, the device can be taken off, to allow for the cooking of the food.

2. Food slider

Attached to the handle, this device provides a safe surface onto which the food can be propped up against and allowed to slide onto the pan. There can be multiple fixed angles that allow for the food to slide in a predictable manner, reducing the cognitive load of having to gauge the location of the centre of the pan by instead having a larger surface that does the work of placing the object in the centre.

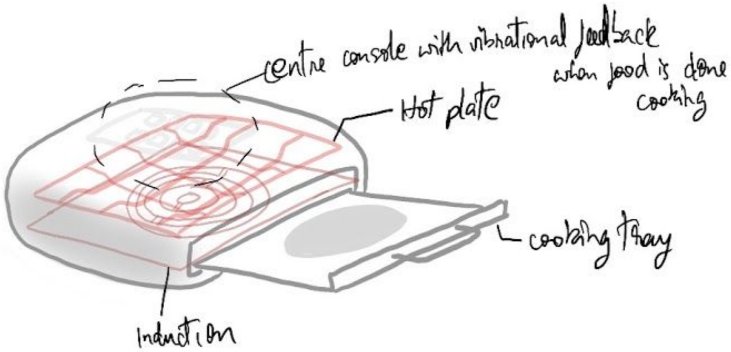
Applying heat on both sides of the food

There were multiple approaches to this problem. The assistive device could be designed keeping in mind existing pans, or could be a device of its own. Both options were explored.

With regards to providing heat on both sides, there again were multiple options; using an induction coil to heat the sides, heating one surface and allowing the heat to transfer when in use, using a cooler to heat one surface, while keeping the other side cool, etc.

Other design considerations taken into account were about handling the safety of the user, ensuring ease of use, ensuring the product is familiar and can fit into the lives of users, and designing frugally to keep costs low.

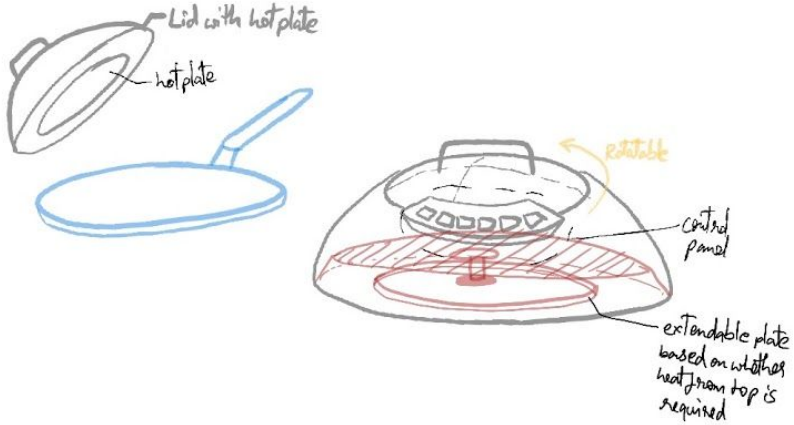
1. Using a separate device to heat both sides



This device imitates a sandwich maker in its application of heat. A pull out tray would be used to place the food to be roasted. When put into the device, the food would be heated from both sides through a hot plate. The control panel present on top of the device would control the heat settings and allow for presets based on the dish being prepared.

This device would make the task of cooking multiple items easier, as well as making it safe for while cooking, due to the outside being non-heat-conductive. The pull-out tray would also make the task of removing the food easy, however, the device would have a steeper learning curve and is likely to be more expensive. Also, as an entirely separate device, it might have lower adoption rates and struggle to fit into users' daily lives and kitchen space.

2. Designing a separate device that works with existing pans



This would be a separate device that works alongside pans present in households. It has a familiar shape of a lid, with a hot plate embedded inside the lid. The control panel on the outside would control settings similar to the previous concept, but with the addition of whether the user wants to use the hot plate or not.

VIPs would already be familiar with a lid, as it is commonly used when preparing dishes like dosas and omelettes. It also provides the safety of keeping the heated parts out of bounds from the users. But as with the previous device, it is an entirely new device designed only to perform the task of roasting, making its learning curve steep and adoption rates possibly low.

3. Designing a solution that fits onto existing pans to make one device

This is a solution that fits onto the existing pans to make a new device for roasting. The concept is designed around the handle, which houses the control console. Through a gear mechanism, when the handle is lifted up, a plate heated through induction closes on the food, thus heating it.

While this allows the food to be cooked from the top, more elements need to be added to ensure safety of the user. Since the additional elements fit onto the pan to make the device, its fit and familiarity will score well with VIPs.

Conclusion

It became clear that the inclusion of an additional heating element that would be powered by electricity and needs to be controlled separately would steepen the learning curve. But the benefits of approaching the problem in this manner outweigh the learning aspect of it.

Safety was the utmost priority with ease of use and familiarity coming in a close second. Given this, I chose to proceed with the second option, the lid with the hotplate. With regards to placing the food on the pan, while an external mechanical solution would tremendously ease the process of placing the food on the pan, it still remains an external solution and integrating it into the workflow of the Lid in a seamless manner still remains a challenge.

Final Solution

The solution to the problem of roasting is tackled by combining the following ideas:

- In order to locate the centre of the pan, two ultrasound sensors will be used along with a vibrational feedback at the handle by providing a 2D map of the location of the centre.

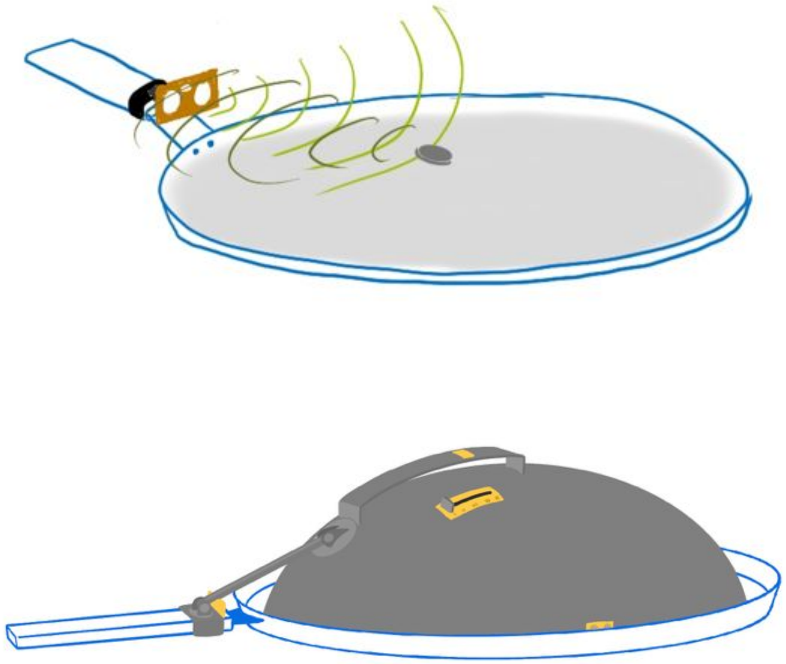


Fig.02 *Concept render of Assistive Lid*

- Heating of the food is done by housing a hotplate inside a lid to be used in conjunction with a common household pan heated from the bottom with a gas stove.

The user controls the heating elements through easily accessible actuators present on the surface of the lid. Accessing the food is enabled by a swivelling hinge mechanism attached to the handle of the pan.

There are many details that need to be defined and refined such as:

- understanding the placement of the control console on the lid for ease of access
- defining the elements on the control console - slider or knob to manipulate heat, shape of button controlling the plate and device
- refining the different haptic feedback that can be provided to be easily distinguishable and intuitive to learn
- placement of the ultrasound sensors to provide location of the centre

Fig.02 shows the basic elements that need to exist on the product based on the ideations, explorations, and analysis of possible solutions.

Working

The lid is a double walled non-conducting plastic surface that houses all the components. The control console is present on the outside, within reach of the VIP, with the electronics and hotplate present inside the lid. The hotplate is heated via thermoelectric coolers, making the surface they come into contact with hot, but turning very cool on the opposite side, making it safe to touch the lid. There is a motor housed in a panel above the hotplate, that controls the movement of the plate (Fig.04).

When the lid is closed, the VIP can take action and choose to place the plate on the food by pressing the “Down” button. This starts to heat the plate, which is controlled by the VIP. Temperature sensors within the lid inform the user when the food is cooked, a vibration motor provides the feedback to the user at the handle. The user can then lift the lid, which automatically causes the hotplate to cut off heat and retract inside. The VIP can then slide the food off the pan onto a serving plate using a spatula.

This process is illustrated in the flow diagram below (Fig.03).

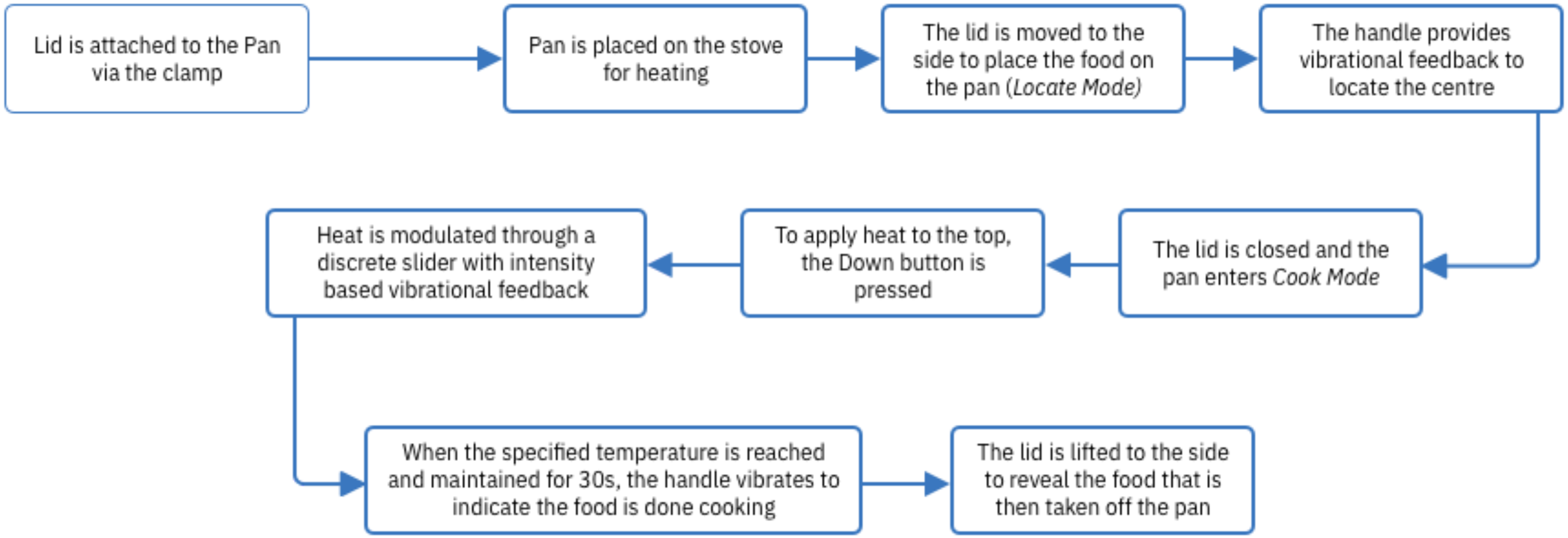


Fig.03 *Flow diagram of the process of using the assistive device*

From an interaction design point of view, there were two major parts that needed to be detailed out. The first was the navigation across the control panel, and the various details involved within the control panel. Second, the feedback being provided for the various steps necessitated when using the device that would feel both intuitive and would flatten the learning curve while using the product.

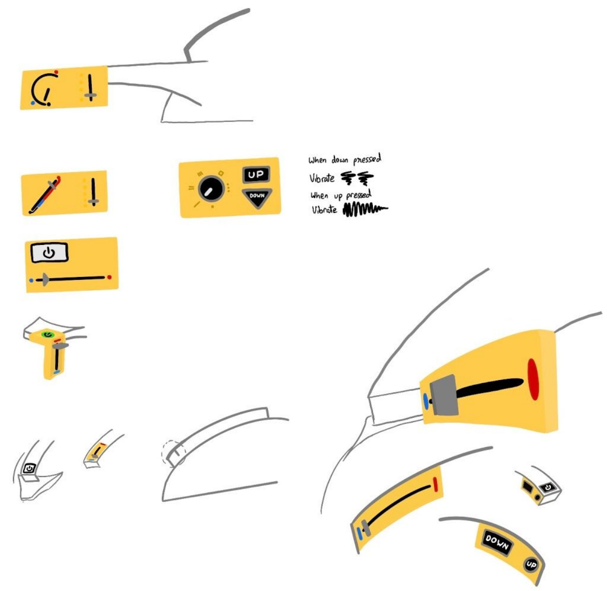
While there are a lot more considerations to be taken from the standpoint of developing a product, such as using the material, formal and tactile aspects to guide a user across the device, lack of expertise in using 3D software to illustrate these aspects coupled with unsurety with regards to taking more industrial design decisions without testing with real users made me shy away from exploring this area in great depth, along with a lack of time given the project deadline.

Control Console

The control console would be the heart of the device. It is the one place from which all the features of the device should be accessed. Defining what functions need to go on the console versus what functions I can trust the user to perform with their rationale keeping in mind that the audience the device is being designed for are individuals with vision impairments was key in ensuring the device would be workable.

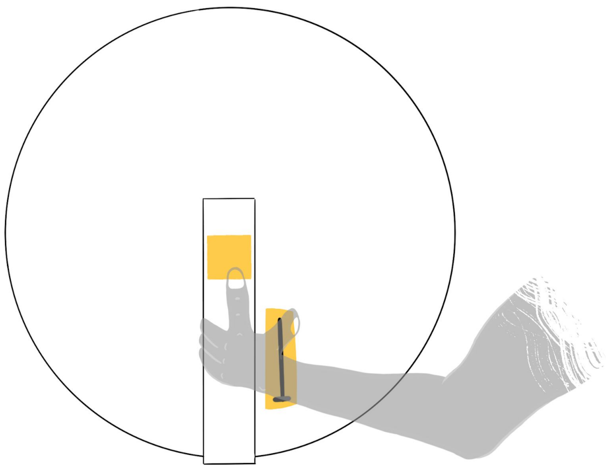
The first question to answer was where should the console be located on the device? There are two places the user would be required to constantly touch, the handle of the pan and the handle of the device. I took the decision to keep the device attached at all points during the roasting process to the pan early on, so this made the handle of the device the primary reference point to the pan and the device. Also, given that haptic feedback regarding the centre of the pan would be given at this contact point, it became obvious to place the control console within the reach of the handle of the device.

With regards to deciding what the action elements on the console should be, a few different layouts and options were tried as seen in the image below.



When placing the actionable elements on the device, there was first the need to define what these elements were. Before these elements can be defined, the user flow of how this device would be used needed to be detailed out. The user flow would help define whether there should be an On/Off button, how the plate would be controlled, how the heat would be controlled, etc. The diagram showing the user flow is attached as Fig.03.

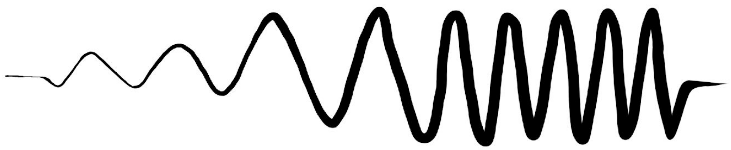
Placing the console near the handle made a few decisions easy. When the hand is on the handle, ideally we would not want the user to remove their hand from the handle, which leaves only the thumb free to access controls. For this reason, a slider was chosen. Also, it made mapping discrete values onto either a horizontal or a vertical surface quite easy to understand. And in order to simplify the use case, the console was designed such that the only decision the user would have to take would be to decide if heat was needed to be applied from the top or not. The down button acts as a switch as well, and this is made possible by deciding to heat the hotplate with a thermoelectric generator, as it takes only a few seconds to get upto temperature. Pressing the down button releases the plate to come in contact with the food, thus heating it from the top when the lid is placed on a pan.



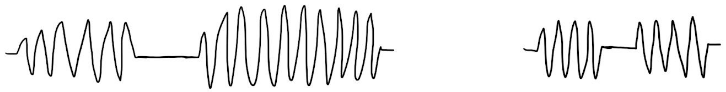
Keeping these factors in mind, the console is split into two parts, with a Down button accessed from the top of the handle by one of the fingers and the heat modulated through a slider present just adjacent to the handle, easily accessed by the thumb. There are tactile elements present on both these elements to keep the user informed about what these elements are responsible for.

Feedback

The feedback needs to be intuitive, and easy to grasp. This is one of the main features keeping the user informed about the status of their device. Two variations of the haptic feedback were used to provide the necessary information; varying the intensity and the duration of the vibration were key in ensuring the feedback remained simple yet loaded with context.



Varying Intensity



Varying duration

While settling what kind of haptic feedback to give users, the first thing to decide was what were the actionable elements that would require feedback.

The Lid has two states. The open state (Locate Mode) when feedback regarding the centre of the pan has to be given to the user. The closed state (Cook Mode), when feedback regarding the amount of heat being applied, whether the plate is down or not, and whether the food is ready or not needs to be given to the user.

There are four places where feedback is to be given. In the open state, since the user is searching for a certain location, a continuous haptic feedback was chosen, with increase in intensity ending with an alarm like buzzing to indicate the arrival in the correct position.

When the lid is closed, there are three actions for which feedback is to be given. Pressing the down button to lower the plate is an act of confirmation. Two vibrations with a gap of 200 microseconds were chosen to represent this action. Modulating the heat through the slider is a continuous activity with discrete locks in between the various heat levels. For this, a continuous haptic feedback with increasing intensity was chosen. When the food is done cooking, the user needs to be alerted to this unmistakably, so as not to overcook the food. Hence, five short high intensity vibrations in short intervals were chosen to provide feedback for this mode.

The idea behind these feedback was to ensure it remains simple enough to comprehend while providing enough information to the user about the status of their device.

Keeping in mind the decisions taken here, the necessary parts to make a prototype were ordered and an attempt was made at building a proof of concept

Costs

While costs are not going to be explicitly discussed, they formed an important factor in deciding which concept to take forward. Various devices that were not explicitly designed for VIPs, but were designed for partial or complete automation were studied, observing things such as materials, heating elements, purpose, and target audience to understand the pricing of the devices. While the expectation is that the device will be a bit more expensive than desirable due to the incorporation of Peltier modules as heating elements, the safety benefits of this design far outweighs what would be a slightly higher pricepoint.

₹2550

₹2700

$999

Dimensions

The dimensions of the device are listed in Fig.04. The sensors are off the shelf parts, which would be considerably smaller, lighter and would pack better. The dimensions are listed for the skeleton that would be necessary to make the device, namely, the lid, the hotplate, and the peltier modules.

The approximate weight of such a setup would be between 400-500gm, which is considerably lesser than the minimum of 750gm for a 28cm non-stick pan.

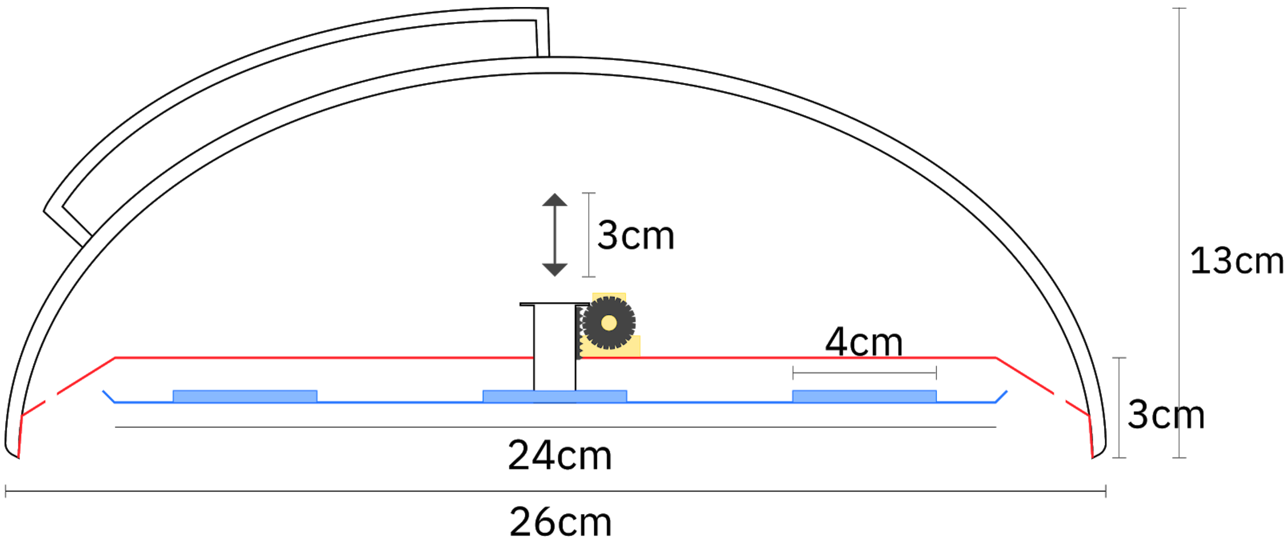


Fig.04 *Dimensions of the assistive device*

Prototype

While the research and the design decisions taken while developing the solution went together hand in hand, a lot of this work was done before the final third of the March. Initial concepts were explored and basic prototypes built before the month of April came by. This, however, was the time the nation went into a lockdown, making the building of a proof of concept more challenging due to delayed availability of parts and lack of domain knowledge on my part with regards to circuit building. There were many challenges in getting the proof of concept to do what I wanted it to do as a result and learning through trial and error was not an option given that materials and sensors were not the easiest to come by. On a side note, I am going to use the words prototype and proof of concept interchangeably in this section as some elements do replicate what would be present on a prototype, while other elements would need greater resources to be able to function as a prototype.

Sensor Prototyping

There are two major components to the prototype. There is the heating element, the hot plate, and there are the sensors and actuators, the ultrasound sensors, temperature sensor, vibrational motor, servo motor and IR sensor. From the list of sensors, I was able to procure the ultrasound sensors (HC-SR04), the temperature sensor (DHT-11), and DC vibration motor. To provide heat to the food being prepared, a thermoelectric generator (SP1848-27145) was attached to a heat sink (stainless steel plate) 19cm in diameter. The heat on the thermoelectric generator (Peltier Module) was controlled through a sliding potentiometer. These elements are visible in Fig.05.

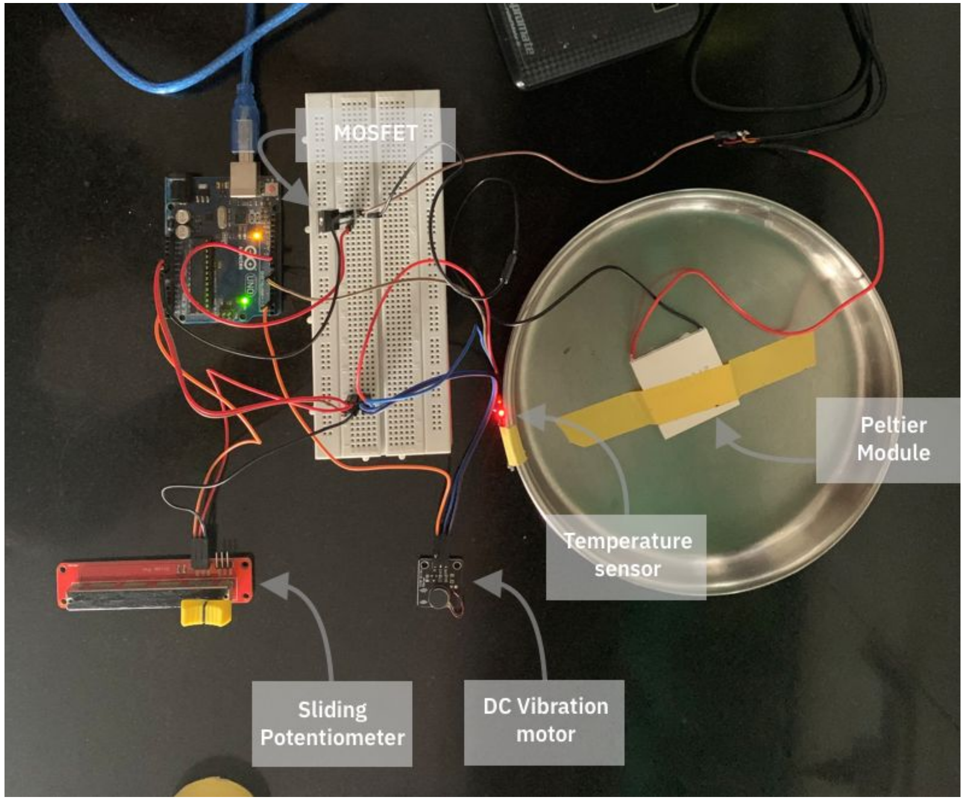


Fig.05 *Connected sensors*

In order to get this PoC running, quite a few considerations had to be taken. The thermoelectric generator uses the peltier effect to generate heat. This means, while one side gets hot from passing electricity, the opposite side gets cold. But since heat generation is an expensive process, energy wise, the current from an arduino would in no manner be able to power the generator. A current upwards of 1A would be required to power the module, and so a separate high power circuit was built to get the generator to work. The other sensors were powered through the arduino itself as they are not power hungry. The connection between the two circuits was made possible through a MOSFET, present on the breadboard in Fig.03. A simple diagram of how the elements were connected is shown in Fig.06.

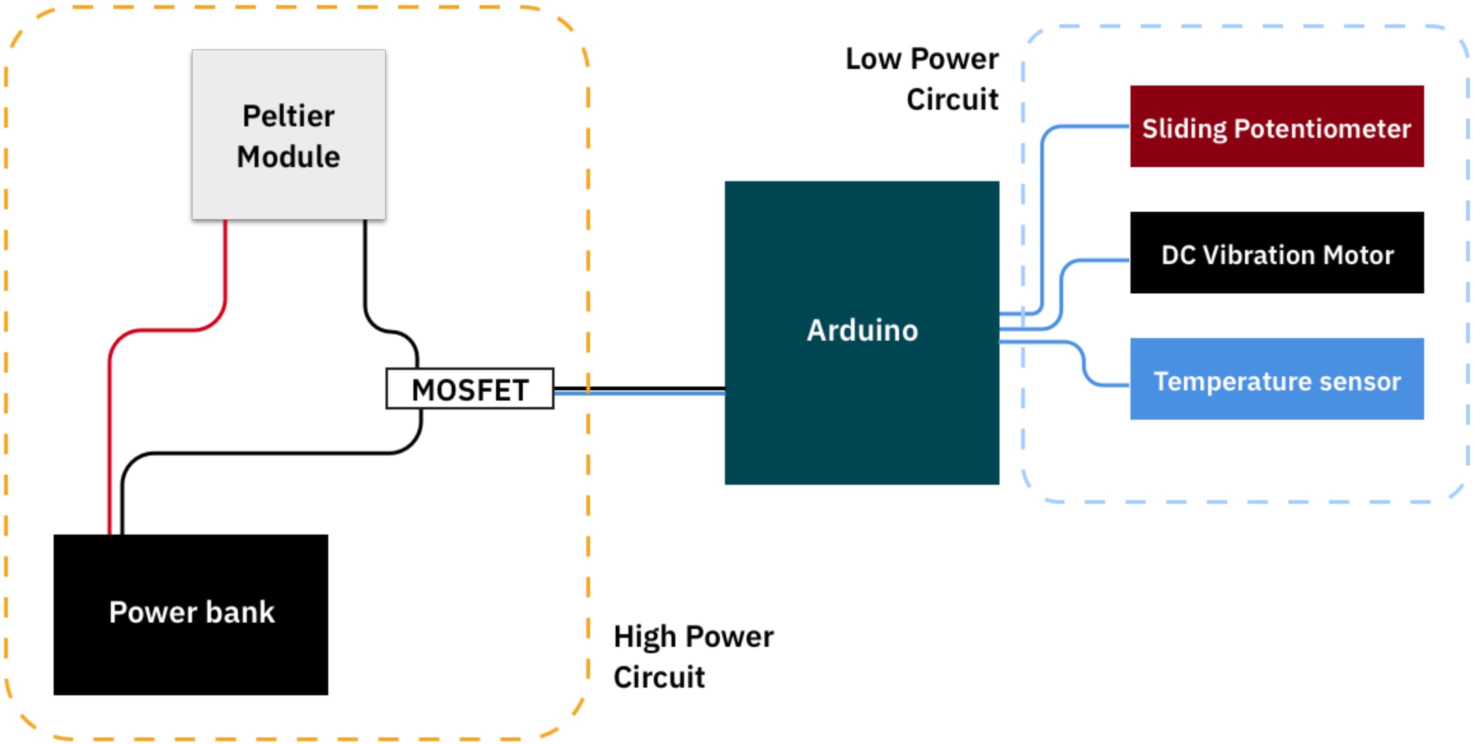


Fig.06 *Simplified map of the connected circuit*

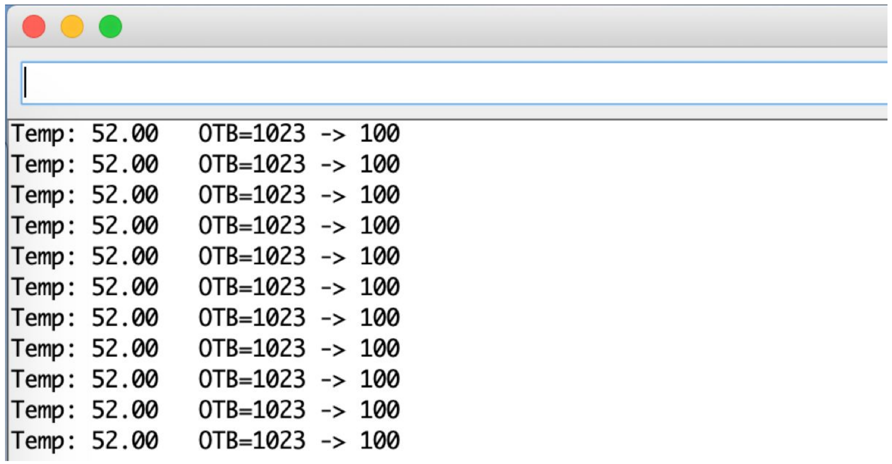
In an ideal scenario, this would have been a no brainer, but many compromises had to be made to get this to work given the work from home situation.

First, given the power consumption of the thermoelectric generator, a separate power source was needed that could also be portable. The ideal solution would've been to incorporate a Li-ion battery present on mobiles, which stores a considerable amount of charge while also being able to output a large amount of current. This, however, was unavailable, so a portable power bank was put in place.

Secondly, I had previously never worked with thermoelectric generators. Hence, I was unable to anticipate the high current consumption of such a device. This lack of experience also led me to order a less powerful thermoelectric generator. Coupled with the low current flow in the circuit, I wasn't able to get the peltier module working to the potential declared in the spec sheet and only got a maximum temperature of 60ºC from the thermoelectric generator being transferred to the centre of the plate. This also meant that the sides of the plate were a relatively cool 40ºC, not nearly enough to cook anything.

This leads me to my third compromise; having to use a smaller plate that initially planned for the prototype. In the assistive device, the intention was to use a plate with a diameter of 24cm. This would have been ideal to cover most sizes of foods while also sticking within the limit of the commonly used 28cm diameter pan found in most households. Given the lack of heat being produced by the thermoelectric generator, a smaller plate with a diameter of 17cm was used instead.

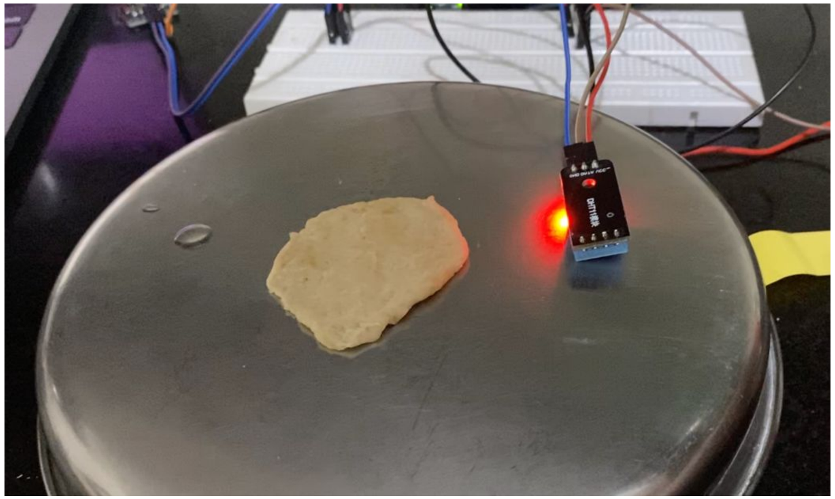
While using multiple peltier modules would theoretically have solved the problem of generating enough heat, the limiting factor in the case of my prototype was the unavailability of enough current flowing through the circuit. Most power banks have an output capacity of only 1A. The one used for the prototype had an output of 2A, but connecting two peltier modules to the same power source would half the amperage making both the modules less powerful and incapable of generating enough heat.



Surface temperature readings from peltier module on high

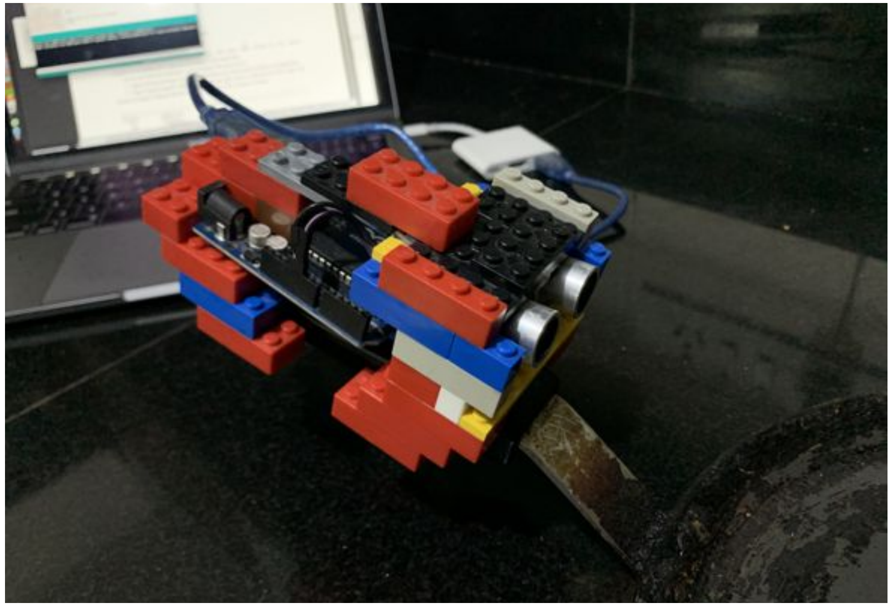
With regards to the low power sensors, from the ones that were procured, the DC Vibration motor functioned only as a digital output. This meant that the unit worked as a switch, with only on and off as possible settings. Intensity of the vibration could not be varied and hence, for the prototype, the feedback given was different from the one designed. Increase in temperature was accompanied by indication at 4 different levels - *off, low, medium* and *high*, with *off* having no vibration at one end of the potentiometer and *high* having three quick vibrations at the other end of the potentiometer. These vibrations indicated a 10ºC incremental increase in heat, from room temperature at *off*, 40ºC at *low,* 50ºC at *medium,* and 60ºC at *high*.

An attempt was made to cook dough using the PoC. The heat sink took about 15 seconds to get up to its maximum temperature of 60ºC. A small flat piece of dough was kept on the steel plate for 70 seconds on each side. While the dough did toughen a little, it was nowhere nearly enough to be *cooked.*



Attempt to cook dough on the hotplate PoC

A proof of concept of the ultrasound sensor was also built and tested for its ability to provide the user with information regarding the centre of the pan. This has a few discrepancies in accurately identifying the centre, with a variance of ±5cm based on whether a hand moves in to place dough or a ladle moves in to pour batter.



Ultrasound sensor enclosed within LEGO on a pan's handle

Physical Prototyping

A physical model of the design was made to check for a few factors regarding usability and fit of the solution in a real life use case. This model was as close to the 1:1 scale as was feasible from the materials available at home. The size of the dome is 22cm across, the closest that was available to the 26cm diameter that is part of the current design.

The primary goal from this prototype was to understand what positions the device should have when opened and what the position of the clamping elements should be when it is closed. Factors influencing the decisions regarding the angles and the position of the lid were the arrangement of the burners on a multiple burner stove, and placement of other cooking vessels. Another factor that needed to be checked was the weight balance of the lid when kept on a pan and the shift in balance when the lid is in the open position. But this part of the prototype was not built due to unavailability of materials that would indicate correctly, the shift in weight and give an accurate representation of the feel of using the product.

The image is attached as Fig.07 showing the position of the lid in the closed and open state. This incorporates a carton as a stand-in for the rod that connects the lid to the handle. The hinge on both ends are replaced by paper folded into a twisted accordion. Cardboard cut-outs for the same did not hold up and provide the same flexibility that would be seen on a proprietary hinge.

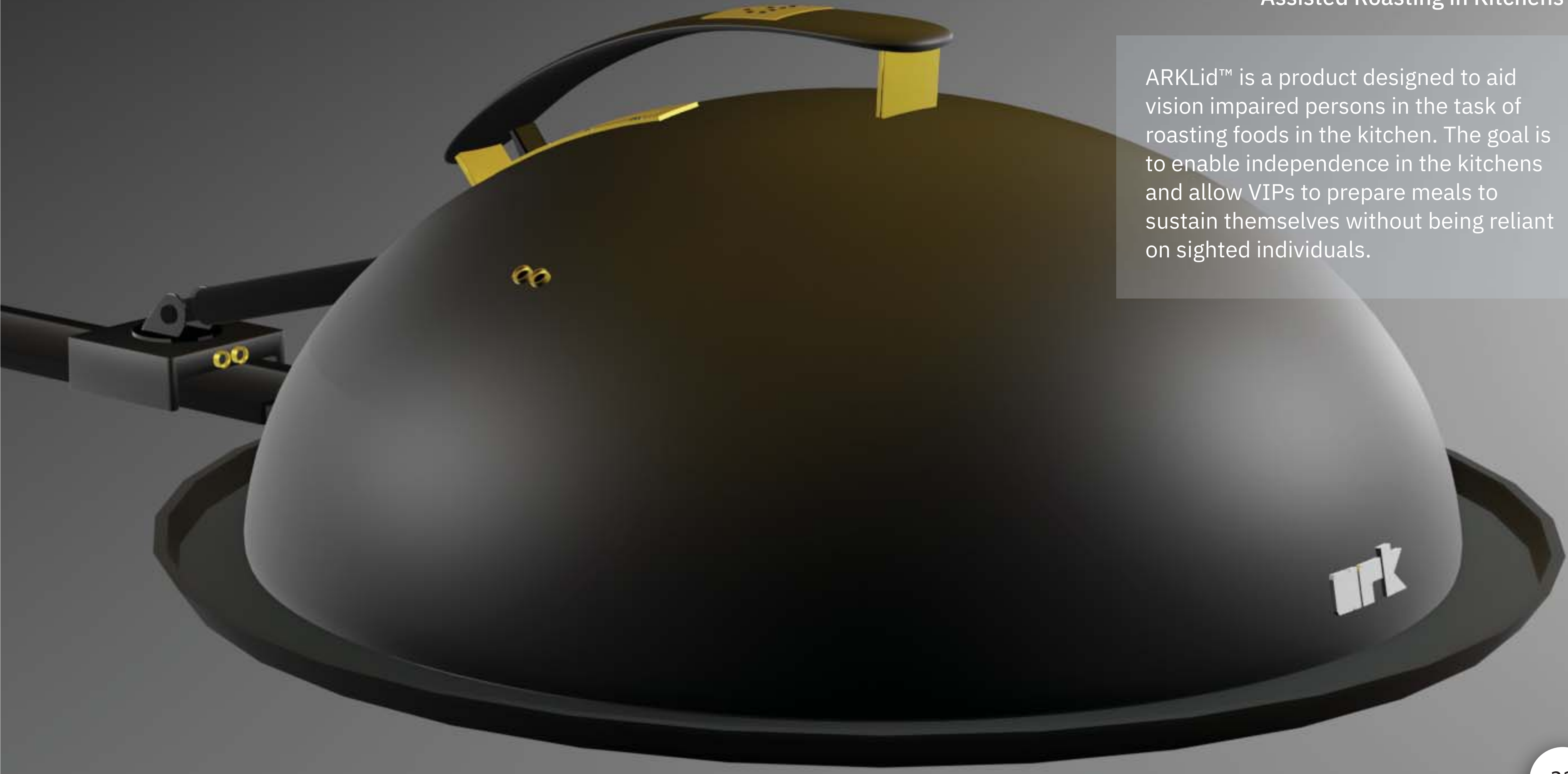
The section below describes the product and its various features that make it accessible for the blind to perform roasting activities. It will also detail the use of the various features and the varying feedback provided for different control settings.

Fig.07 *Lid in Locate Mode and Cook Mode*

ARKLid

Assisted Roasting in Kitchens

ARKLid™ is a product designed to aid vision impaired persons in the task of roasting foods in the kitchen. The goal is to enable independence in the kitchens and allow VIPs to prepare meals to sustain themselves without being reliant on sighted individuals.



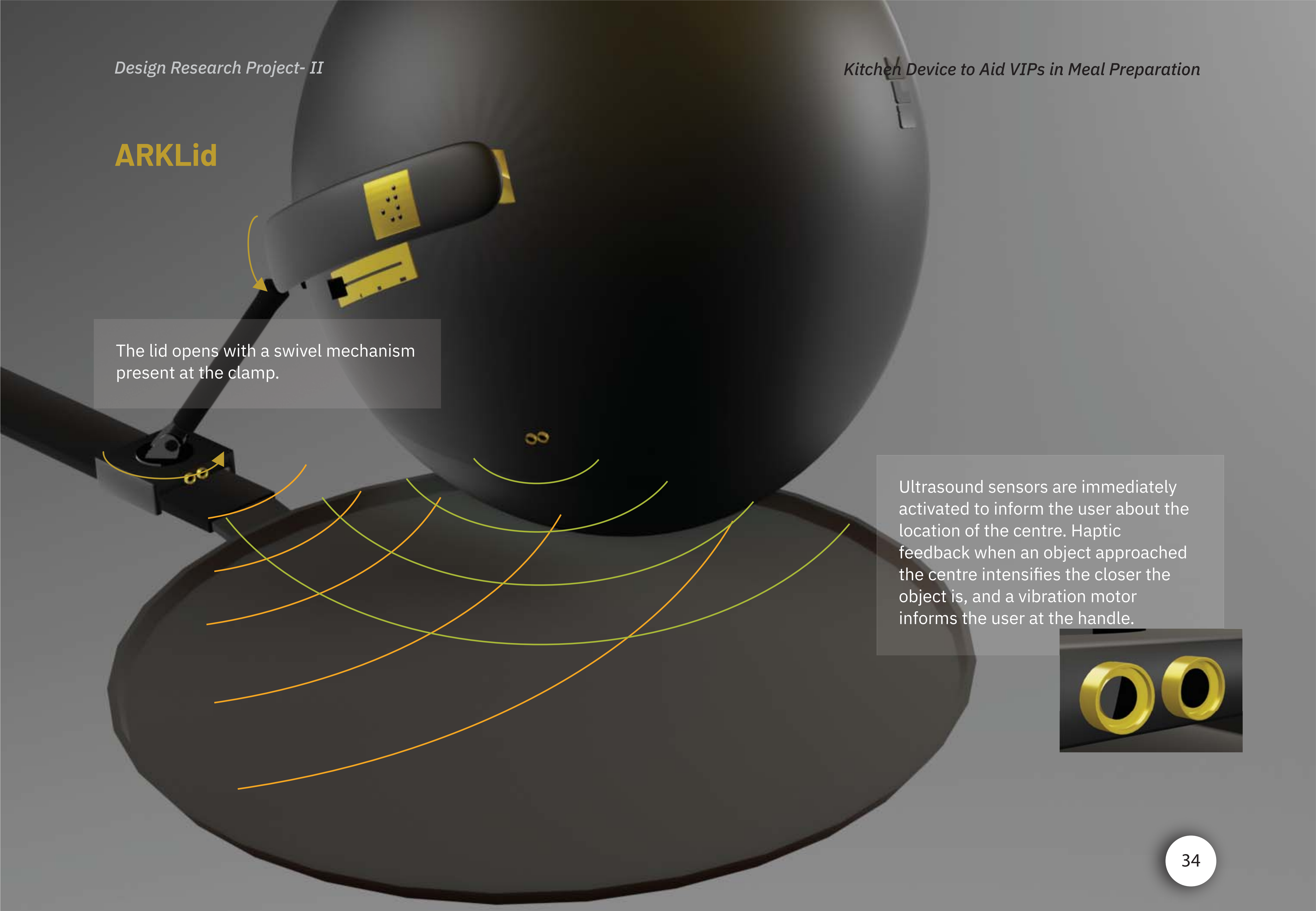
ARKLid

The ARKLid has been designed keeping in mind a 11 inch standard non-stick pan. It will approximately weigh 400-500gm.

The outer cover is made of heat resistant plastic, making it light and safe to touch.

The lid is embedded with sensors and actuators to allow the user full control of the device. Before placing the pan on the stove, the lid is clamped to the pan handle using the clamp.

ARKLid



The lid opens with a swivel mechanism present at the clamp.

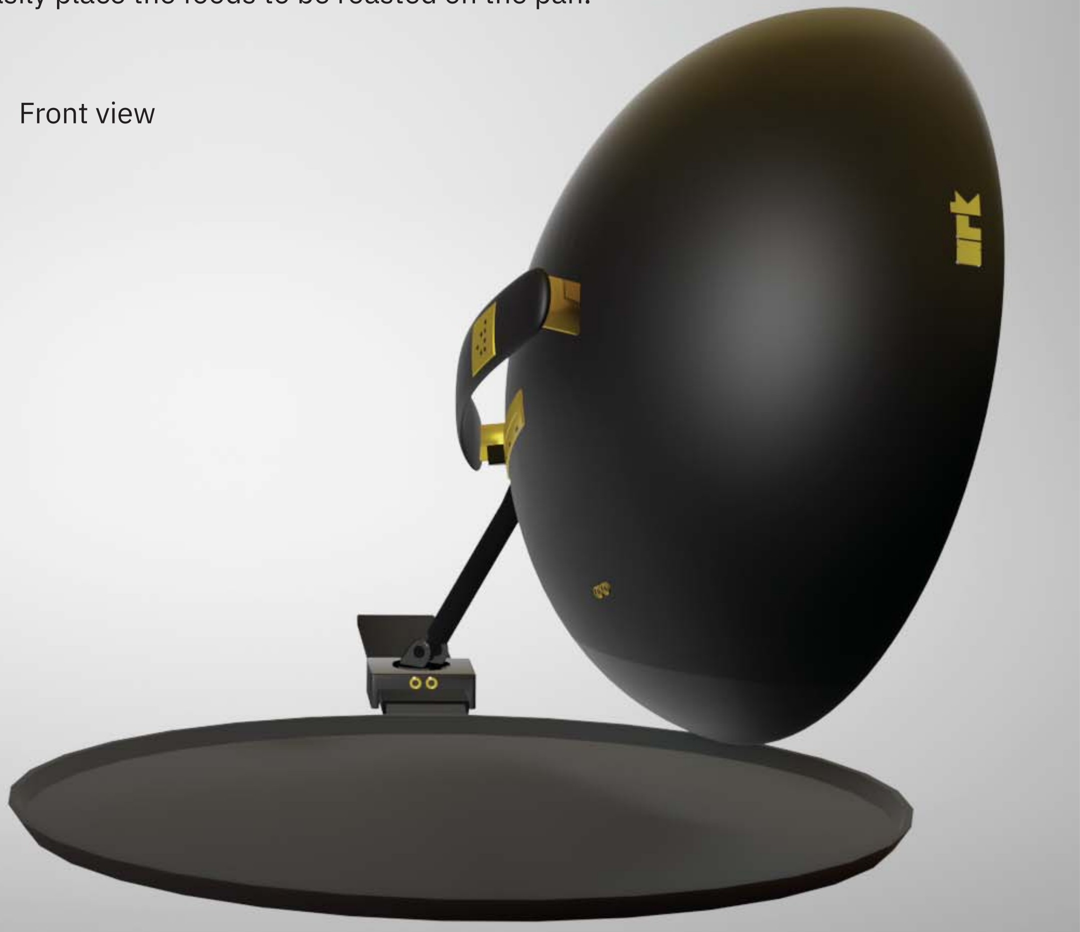
Ultrasound sensors are immediately activated to inform the user about the location of the centre. Haptic feedback when an object approached the centre intensifies the closer the object is, and a vibration motor informs the user at the handle.

ARKLid

The majority of the weight of the device stays within the mass of the pan. Pans of this size weigh around 750gm to 1000g. Nearly 90% of their weight is located within the confines of the pan. While the centre of gravity would increase upwards, the lid will still remain balanced on the pan. Also,the lid moves away from the pan, allowing for access to the pan’s surface when needed. This will allow VIPs to easily place the foods to be roasted on the pan.

Top view

Front view

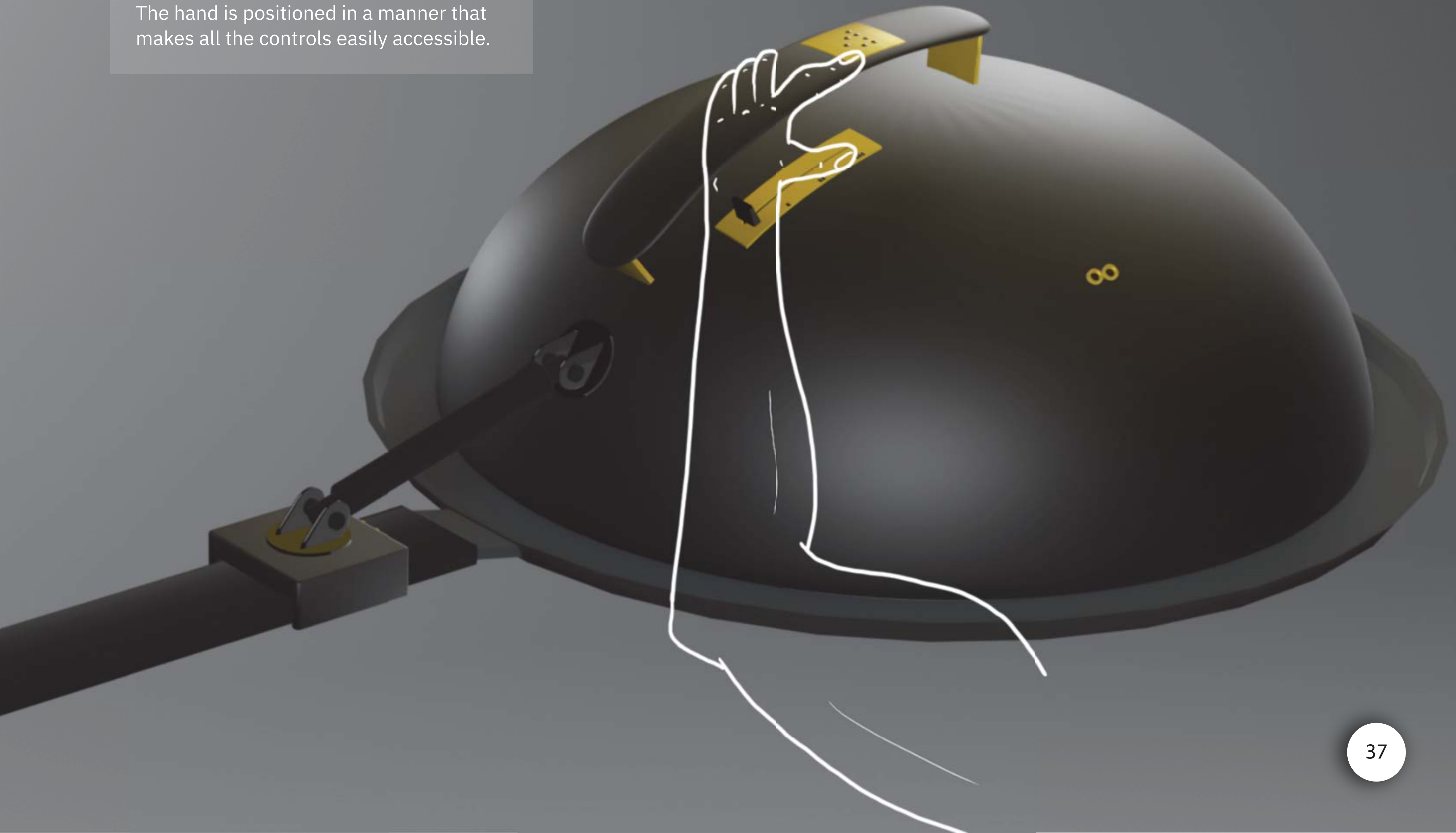


ARKLid

The device is closed to start the cooking of the food to be roasted.

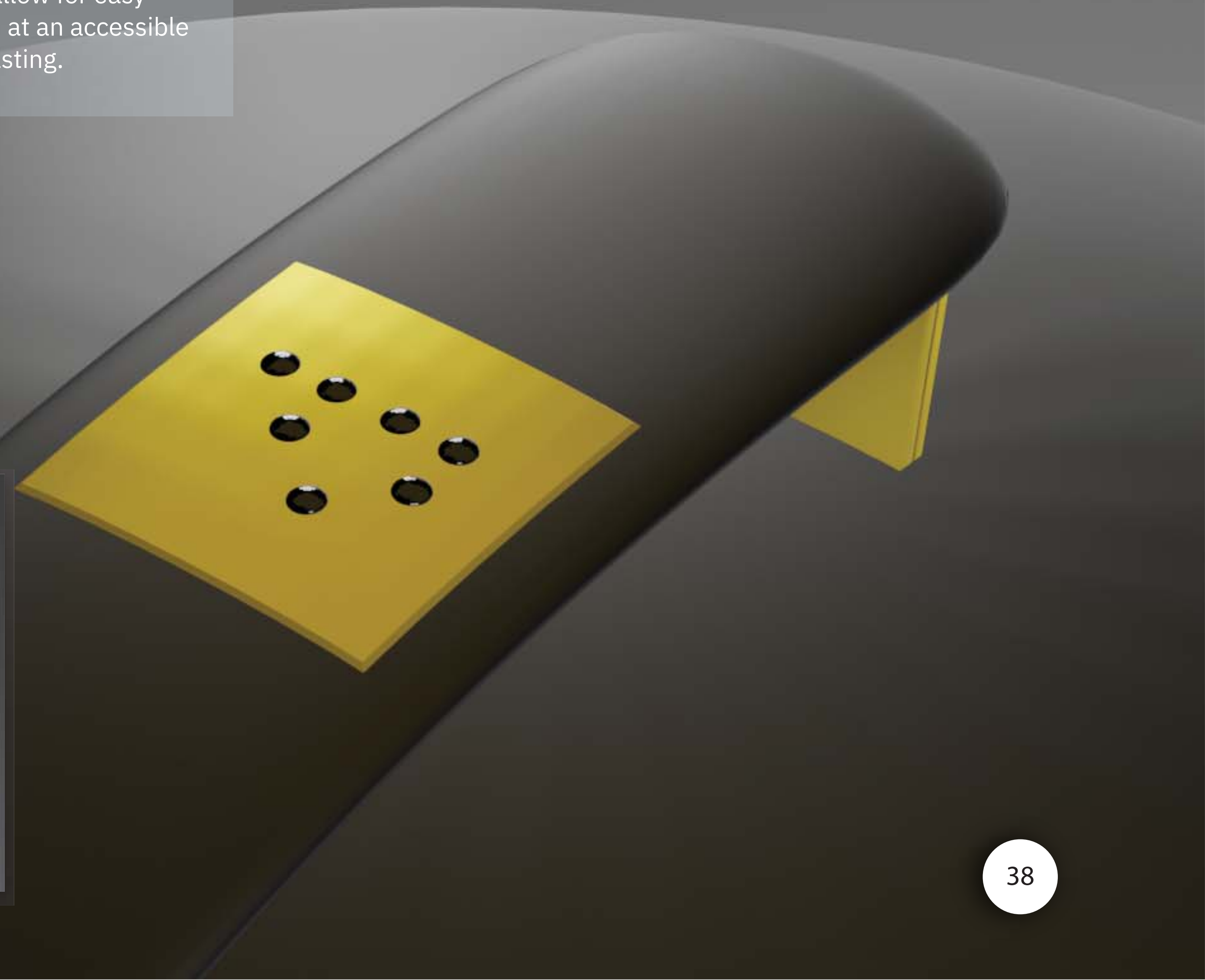
ARKLid

The hand is positioned in a manner that makes all the controls easily accessible.

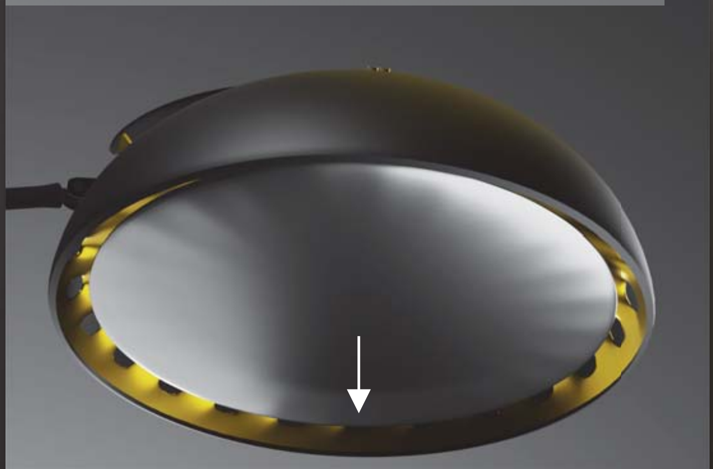


ARKLid

The down button is pressed to start the heating of the food from the top. This releases the plate to sit on top of the food. There is braille inscription in high contrast etched dots to allow for easy identification of the button's purpose. It is located at an accessible position to make it easy to start the process of roasting.



The plate moves down when the down button is pressed through a motor releasing it. Heat is supplied by the thermoelectric generators, allowing the plate to act as a heat sink.

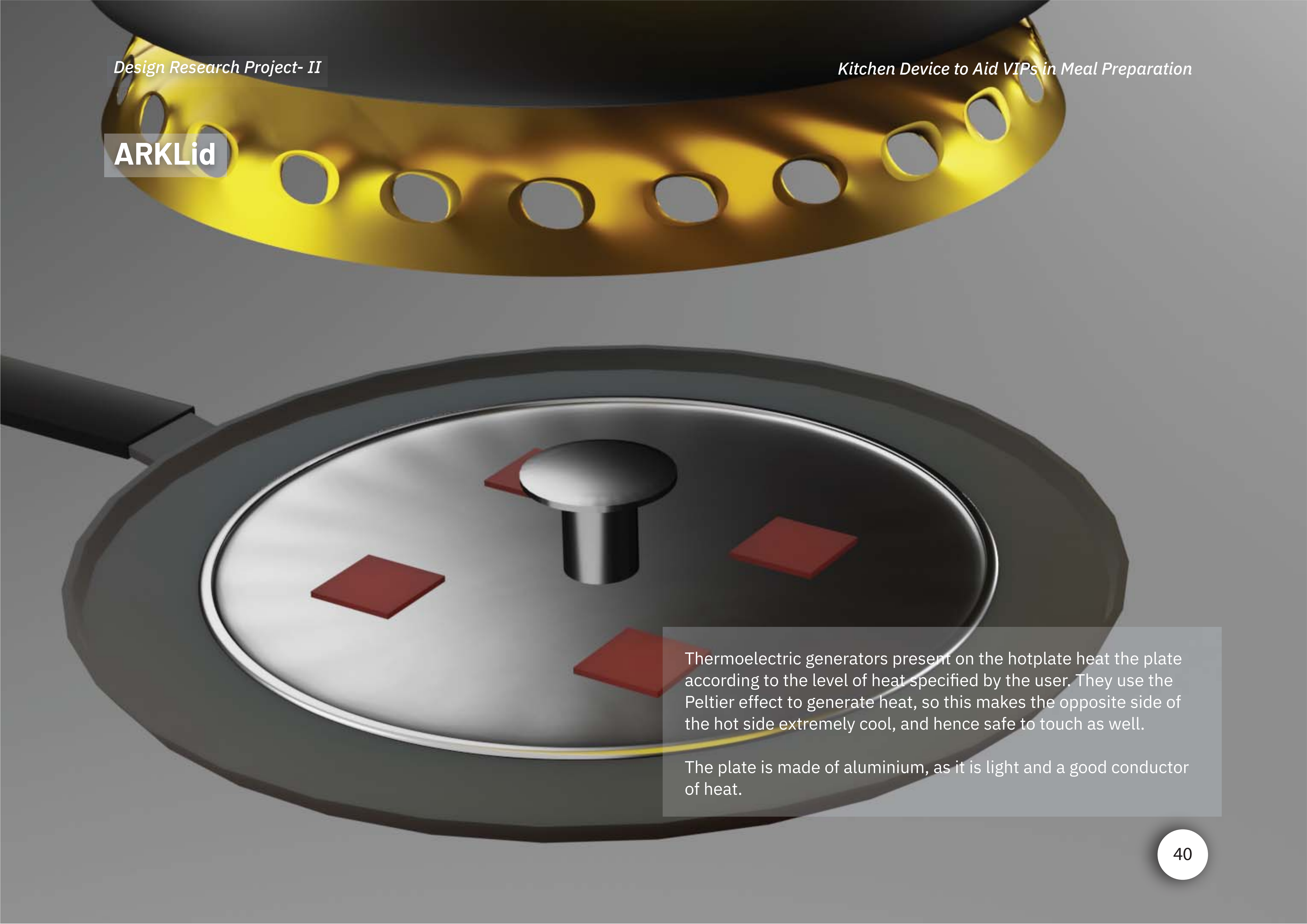


ARKLid

The slider is present right next to the handle, making it easily accessible by the thumb. The values on the slider provide a haptic click as the user moves along the ridge. Tactile elements on the side also provide information about the level of heat being applied through the plate.

The slider is accompanied by a continuous vibrational feedback at the handle, which increases in intensity as the heat applied increases, with indications via short high intensity buzzes for the three heat levels.

ARKLid



Thermoelectric generators present on the hotplate heat the plate according to the level of heat specified by the user. They use the Peltier effect to generate heat, so this makes the opposite side of the hot side extremely cool, and hence safe to touch as well.

The plate is made of aluminium, as it is light and a good conductor of heat.

ARKLid

When the temperature inside the lid reaches 75ºC, haptic feedback is provided at the handle, with four vibrations in quick succession, indicating that it is likely the food is done cooking.

With regular temperature sensors, there wouldn't be more than a 5 second delay between the temperature change and for the sensor to register the change.

ARKLid

The moment the lid is lifted off the pan, the peltier effect is used to cool the plate by applying a reverse current to the thermoelectric generators.

This immediately puts the plate into Locate the centre mode, which provides the VIP with information about where the centre of the pan is to easily locate their food on the pan.

ARKLid

The plate is the only element that comes into contact with the food making it easy to clean and maintain.

The ARKLid can be used with multiple food items like roti, dosa, omellette, cutlets, processed meats, etc.

Limitations

Prototype

Given that this was the first time I was building a circuit with high power sensor modules, I definitely realised how out of depth I was. There were many things that I started to realise after I began building the circuit. The first was in realising the limitations of the peltier modules that I bought. They were the small peltier modules with a relatively lower power output as compared to many of the modules out there. Not knowing the difference between the modules and having not done as much research about these modules as I probably should have given that acquiring parts was always going to be a challenge was an obstacle I was under prepared to deal with.

But knowing what I know having gone through the trials of having to get one module to work, there are a few basic requirements that would be necessary before such a prototype is built again. One, the circuit built should have enough current flowing through it, as current is the limiting factor in getting these modules to work. With the 1A I was able to pass out of a 5V socket, the peltier module was able to attain about 60ºC. The spec sheet of the module says there needs to be a 12V power source to get temperatures of 120ºC. Thus, it should be very much possible to attain such high temperatures and at extremely quick speeds if there is enough current flowing through a circuit.

Also, another observation was the isolation of the heat on the steel plate I used as a heatsink. The steel plate did not act as a very good heat sink, even after using thermal paste, leading me to believe that having better heat sink design would dissipate heat a lot better and make the plate a very good substitute for designing heating elements. This, coupled with using around 4 thermoelectric generators to heat the plate would allow the user to modulate heat as per their wish and allow for extremely quick cooling by reversing the switch, making this concept very safe to use.

ARKLid

There are many factors and additional solutions that would compliment the current solution that were not considered. There were many formal and material based skills that I had picked up over the course of my bachelors that I did put to use, mostly due to the fear of finding myself out of depth.

Also, not having consulted any person with vision impairment about my final solution definitely makes me shy to claim anything about the design and its real world efficacy. There are only theoretical and logical explanations I can give for why this concept should work, with not much real world testing or feedback to back it up.

Evaluation

Given the lockdown and need for maintaining social distancing, along with disruption of delivery services and lack of access to labs to fabricate the necessary parts, evaluation was a tricky subject to broach in this project. Nonetheless, creative people get creative in the best of times and an expert evaluation was conducted.

The ideal experts in this case would be the individuals with vision impairments, but this was not an option given the only form of access was remote access. Professionals who have been involved with VIPs for a long time, who help teach techniques to cope with vision impairments to VIPs and trainers alike were contacted (sighted experts). A video explaining the concept was sent to obtain initial impressions of the device. This video was also sent to parents of VIPs, as they are likely to be some of the most concerned people about the VIP's safety and well being. Four sighted experts and 2 parents were contacted in all. The video was forwarded by some of the sighted experts to other VIPs as well for feedback.

Two sighted experts and four VIPs responded with their feedback. The VIPs were assisted by their caregivers to understand what the product looked like and its functions in addition to the audio description which was a part of the video.

Sighted Experts

The experts noted that the problems the device tackled were real problems that inhibit VIPs from taking it up on a daily basis without supervision. The feedback being provided in terms of vibrational feedback was acknowledged as sufficient and easy to learn. However, different conisistencies of dough/batter would take different times to cook, and an indication for the same is not provided. For this particular project, however, the activities that precede the act of roasting are considered to be standardised (control), thus assuming that these activities will result in foods that offer similar consistency each time it is prepared. A suggestion was made to alter the design to check for the state of food just as one would do when baking.

VIPs

VIPs too acknowledged that the problems being tackled were a major hindrance to the process of roasting. They found comfort in the idea that the tedious task of flipping the food back onto the pan was replaced with applying heat on both sides. However, there were apprehensions about the feedback being provided, with two of the VIPs preferring auditory feedback as it allowed for better multitasking. There were concerns regarding the costs of the device as well, with all VIPs feeling this will be the biggest differentiating factor. Finally, while providing feedback about the centre of the pan was felt to be a step in the right direction, it did not do much in the way of helping spread batter around the pan, a task that requires more assistance.

Conclusions & Discussion

Designing and developing assistive aids for the vision impaired requires a deep understanding of their practices, preferences and problems. The shockingly little information on preparing food using common household utensils, as is preferred by most low and medium income households in India, for the visually impaired necessitated a thorough research into challenges and opportunities afforded in this area.

The solution discussed above is only one of a myriad of directions this project could have taken. The problems identified had to be narrowed down further to a set of smaller problems that hurt the VIP's ability to prepare roasted foods. There could be an argument for a smaller set of interconnected tools that could provide VIPs with the right amount of contextual information to mitigate the problems, as was suggested in the Initial Explorations section.

Another direction one could explore is to look at the end-to-end process of cooking a meal, from gathering the ingredients from shelves, to cleaning them, applying the necessary techniques, and finally, placing on a serving plate to be had. This would bring closer focus to the nuances in each preparation of a dish, while ensuring complexity in understanding how to accommodate user preferences and practices.

The key takeaway from this project was in realising that since so many kitchen tasks can be done through tactile feedback, taking advantage of the VIP's heightened sensitivity was a more appropriate medium to go through as compared to attempting to treat the lack of sight as a deficiency. Observation of the VIPs when preparing meals gave an indication about what the current practices are and what kind of feedback they would expect from a certain task, which helped inform the decisions taken during the design of the feedback.

We acknowledge that the group with which the research was done was a small one, but do feel that the diversity of the experience and backgrounds of the participants is more than sufficient to compensate for the deficit in numbers. Also, while there were many shortcomings with the industrial design aspect of the project, I do believe that there was adequate thought and work put into defining the basic elements to carry forward when refining the product and its details.

Future Directions

As mentioned earlier, this project demonstrates one of many directions for designing assistive products for the vision impaired. Given how little has been done in the area directly associated with cooking, there are a number of opportunities for design. While I chose to focus on roasting as a technique, there are multiple other techniques that are in dire need for assistive interventions. The problems I chose to tackle in roasting were also a small set, barely scratching the surface for possible interventions in the said area.

With regards to the current project, there are many industrial elements, such as materials, form, and manufacturing that were not considered and will undoubtedly go towards the making of a complete product.

Another aspect that strikes me is the ability for multiple population groups to utilise this product. Given the problems ARKLid chose to tackle, there is a use case for the elderly, and for people with frozen shoulder and other arm injuries, who would struggle to perform multiple upper body activities as is required by techniques such as roasting and frying.

Lastly, very little time was given to branding of the product. Marketing would play a huge role in ensuring high adoption rates, and an attractive branding would go a long way in ensuring assistive devices reach the masses they are meant to reach.

Impact of COVID-19

What should have been a fairly normal, and quiet semester, changed very suddenly due to the unprecedented spread of the novel coronavirus. Plans were shredded, deadlines revised and projects took a 180º turn.

In my particular case, there were a few ideas and a general direction that the project was proceeding in before the unexpected pause in March. The initial plan in place was to spend time prototyping different sensors, work with various materials and follow a test-and-reiterate process by collaborating with a few participants with vision impairments.

Having to leave for home in a hurried manner left me very few prototype-able sensors in hand. A lockdown put in place a few days after reaching home meant sensors were hard to come by. Not being able to consult with VIPs for taking design decisions forced me to rethink how I define a particular set of decisions as workable. And this in turn changed how I chose to present my project, going from an approach to define calculable guidelines for preparing Indian foods within which a design would sit to a more concept oriented approach, choosing instead to speak about what could be rather than what should be.

The time away from IDC also allowed for introspection about what I have learnt in my five years and how I could use that knowledge to my benefit to showcase a new idea. While the original plan might've been to create a physical mockup using the plastics and metals in the studios of my department, the lockdown got me to turn towards 3D modelling software, the one kind of software I have always been reluctant to learn.

Another aspect that massively impacted the project was in realising how much I took being able to work with and around my classmates and friends on the campus. This was an important source for both generating ideas and clearing doubts, while time to time providing companionship for venting.

There were many silver linings to the project as well coming out of the situation being as it was for the duration of the project.

The first was in the form of getting a better technical know-how of the working of such high power circuits. It was undoubtedly fun and engaging and in many ways, relieving to be able to work with an arduino after such a long time.

The second was in being forced into taking decisions without complete surety about the decision given that there was absolutely no way to know how the person for whom the product is meant for would react to the product. As a student, we had always relied on doing some form of evaluation of design ideas at various stages before making a few decisions concrete. The pandemic made evaluation not a realistic proposition for two reasons; one, needing to follow social distancing and lockdown guidelines made visiting the homes of others untenable; two, unavailability of parts required to make a product made testing impossible. This made me take many decisions by refining details to a much deeper extent than I normally would have had to for a low fidelity prototype, thus contributing invaluably to my design education.

Overall, while at one point it definitely did seem like the entire project was ruined given the number of changes that were required to be made, spending time thinking about how COVID-19 really impacted my project has made me realise that there were many intangible positives I was oblivious to. The goal when we joined IDC, which was to learn design by partaking in assignments and projects that ultimately seek to teach us the art of decision making in design projects, was undoubtedly made more wholesome through this sudden and dramatic pivot we were put into.

References

1) Ecosse L Lamoureux, Jennifer B Hassell, and Jill E Keeffe. 2004. The determinants of participation in activities of daily living in people with impaired vision. American journal of ophthalmology 137, 2 (2004), 265–270.
2) Nabila Jones and Hannah Bartlett. 2018. The impact of visual impairment on nutritional status: A systematic review. British Journal of Visual Impairment 36, 1 (2018), 17–30.
3) Brady, Erin, et al. "Visual challenges in the everyday lives of blind people." Proceedings of the SIGCHI conference on human factors in computing systems. 2013.
4) Kostyra, Eliza, et al. "Food shopping, sensory determinants of food choice and meal preparation by visually impaired people. Obstacles and expectations in daily food experiences." Appetite 113 (2017): 14-22.
5) Lancioni, Giulio E., et al. “A Verbal-Instruction System to Help a Woman With Intellectual Disability and Blindness Manage Food- and Drink-Preparation Tasks.” Clinical Case Studies, vol. 10, no. 1, Feb. 2011, pp. 79–90, doi:10.1177/1534650110395380.
6) “How to Make Your Kitchen Safer for Visually Impaired Person?”medium.com › how-to-make-your-kitchen-safer-for-visually-impaire...How to Make Your Kitchen Safer for Visually Impaired Person?
7) Jones, Nabila, and Hannah Bartlett. "The impact of visual impairment on nutritional status: A systematic review." British Journal of Visual Impairment 36.1 (2018): 17-30.
8) Ran, Lisa, Sumi Helal, and Steve Moore. "Drishti: an integrated indoor/outdoor blind navigation system and service." Second IEEE Annual Conference on Pervasive Computing and Communications, 2004. Proceedings of the. IEEE, 2004.
9) Sirirungruang, Issavara, and Poramate Boonyuen. "Shoppers with Disabilities: A Study on Experiences, Behaviours and Needs."
10) “The Must Know Indian Cooking Methods For Authentic Taste”. https://spiceitupp.com/indian-cooking-methods-you-need-to-know/
11) Wu, Fong-Gong, Min-Yuan Ma, and Ro-Han Chang. "A new user-centered design approach: A hair washing assistive device design for users with shoulder mobility restriction." Applied Ergonomics 40.5 (2009): 878-886.
12) Benjamas Kutintara,Pornpun Somboon,Virajada Buasri,Metinee Srettananurak,Piyanooch Jedeeyod, Kittikan Pornpratoom, and Veraya Iamcham. 2013. Design and evaluation of a kitchen for persons with visual impairments.
13) Kevin Chiam. [n.d.]. Folks Kitchenware for the Blind. https://kevinchiam.com/folks-kitchenware-for-the-blind.
14) Ying Liu, Jean Bacon, and Roger Wilson-Hinds. 2007. On smart-care services: Studies of visually impaired users in living contexts. In First International Conference on the Digital Society (ICDS’07). IEEE, 32–32.

15) Sandra C Hartje. 2005. Universal design features and product characteristics for kitchens. Housing and Society 32, 2 (2005), 101–118.
16) Mary H Yearns, Patrick E Patterson, and Andrew Bice. 2005. Developing cabinet prototypes for a universal design kitchen. Housing and Society 32, 2 (2005), 81–100.

Appendix

Table containing a breakdown of the problems faced by the VIPs: link.

Table containing detailed breakdown of problems faced when making a dosa: link

Video of an individual with partial vision impairment preparing a roti: link