# Natural User Interface Project

## Cooking with Gesture Interaction

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# Natural User Interfaces

What is a natural user interface? How do we define a natural user interface? There are several definitons of natural user interfaces. As everbody is having a different perception of what natural means to them. In our project we interpreted “natural”  as the interaction in the system, which should be as intuitiv and natural as possible.
So it’s not about creating a natural graphical user interface but more about creating a nearly natural interaction experience for the user.

In a gesture interaction concept the gestures used have to be as logical and intuitiv as possible. We wanted to focus mainly on the interaction with gestures but also considered using voice interaction when expedient.

The next step was to think about in which areas a natural user interface could be beneficial. We wanted to choose a topic where a gesture interaction helps to improve or simplify the overall interaction with a product. We were thinking about areas where gesture interaction is already user partly like mobile phones , tvs or in transportation design.

Also applications for laptops, lightning systems and door systems tried some form of gesture interaction.
We came to the idea that the field of “cooking” could be an interesting one for gesture interaction. These days a lot of cooktops are using touch displays as input devices. Often they do not react properly while cooking and pressing with dirty hands makes that even worse. This is because you either have to press/touch very hard till the cooktop reacts or it reacts to fast.

The usability and user experience is not satisfying. Especially elderly people have problems with pressing the touch buttons. The knob systems work well in case of input mechanism but mostly they give not enough feedback as they only describe the heat in a numeric way from 1 to 9. That is not natural at all. So the input as also the feedback for the whole cooktop interaction system is upgradable in form of usability, affordance and in the natural form of interaction.

Figure 1

Controlling the cooktop with gesture interaction was therefore an idea for our project. The aim for the gestures we wanted to develop was to be as natural or “intuitiv” as possible for the user in his cooking process. Our user group is comprised of people who like to cook and like to try new technologies as well. Of course people are used to common knob systems or touch displays integrated in cooktops and stoves. But only because people are used to some form of interaction it does not mean that it is the most intuitiv form of interaction for using a cooktop.

The description of heat in nine steps is just something we needed to learn as well in “the beginning”. So we wanted to rethink more or less the complete cooking interaction and experience with this device. We wanted to make sure that we address all possible age groups and to especially not exclude the older generation, as we think that they are facing the most difficulties with these touch displays.

Figure 2

# First ideas of NUI’s

In the beginning of our ideation phase we created some sketches of different concepts for a cooktop with gesture recognition.

We were thinking about diverse structures of the cooktop and placed the recognition panel in different positions. As you can see in Figure 3, we thought about placing the gesture control panel on the left side of the cooktop, at the bottom, above the cooktop or in the middle. This are approaches which focus on a direct interaction with the gesture cooktop as the user is forced to perform his gestures in a restricted area.

We deliberated on further interaction possibilities like an indirect gesture control and also took global and local gesture interaction into consideration. We wanted to make the interaction as natural and intuitive as possible for the user, so we also took account of combing these approaches.

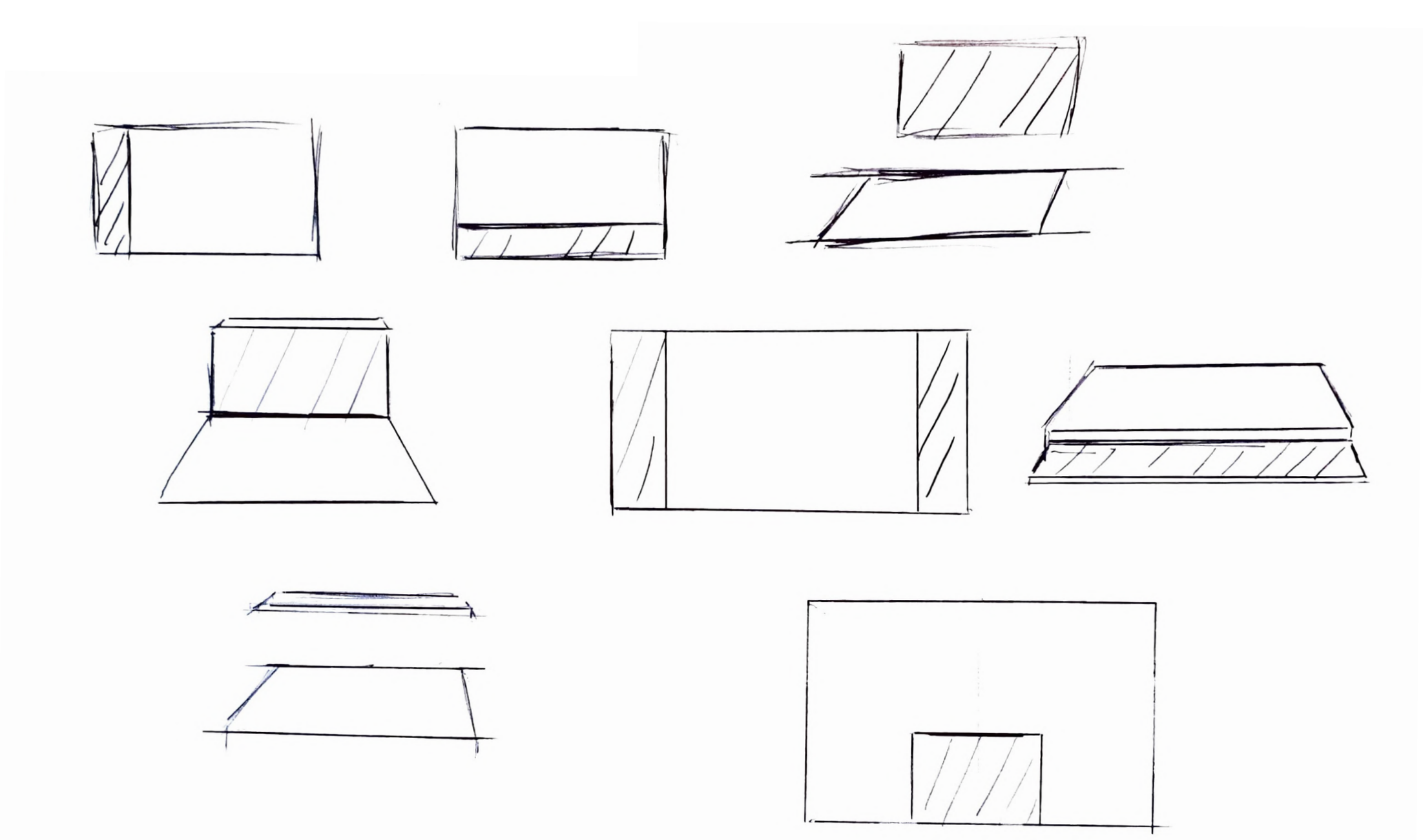

Figure 3: First ideas for placing the control panel

# Human Centered Design

It was very important to include the user in every phase of our project. And not only to test our created concepts , but moreover to get some important insights.
Because of our lacking experience in the area of gesture interaction, it was even more important to understand which type of gestures are accepted by the users and which are rather unacceptable and not intuitiv to use.

So therefore we started at the very beginning by conducting user interviews to find out more in depth about the acceptance of different gestures, especially in the context of cooking.

Within our project, we had several testing iterations where we got good insights and could therefore refine our concept.
We also wanted to include people from different user groups and not only test younger people, but also elderly people.

This way we were able to create a concept which does not exclude any user group. We were able to create a new cooking experience together with the user.

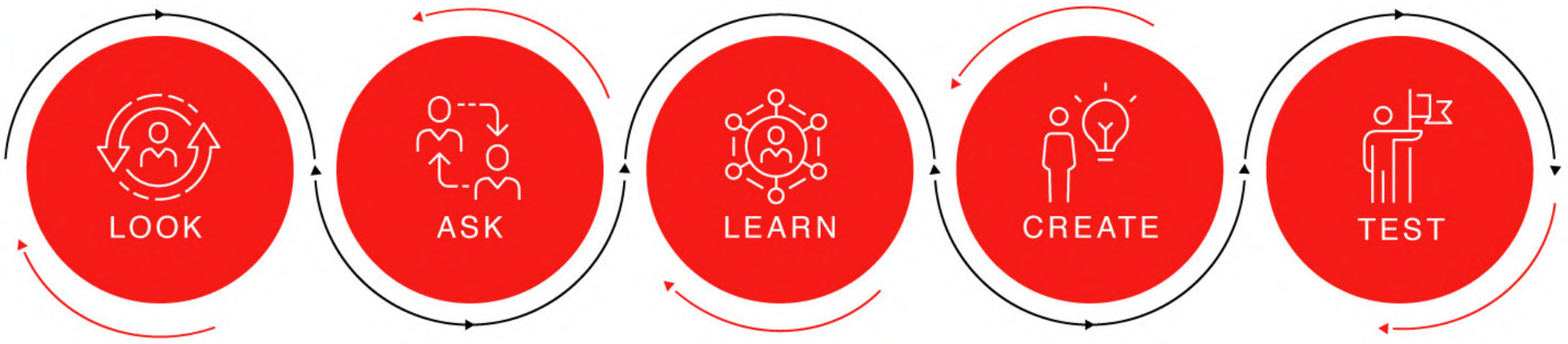


Figure 4: Schematic description of Human Centered Design for our project

# Asking the user

We started to conduct user interviews in order elaborate on different types of gestures used while cooking and their acceptance by the participants.
We let them perform several types of gestures in front of their cooktop like forming a fist or waving over the cooktop and probed on the overall satisfaction and ease of use. We could find out what they think about different types of interaction and if it corresponds to their mental models.

We also had to probe, in which way the gestures should be performed by the user. Should the gestures be executed in a global way or in a local way. Global means giving user the possibility to perform the gesture anywhere on the cooktop and it will be recognized.

A local gesture performance would include restricted areas where the user has to perform the gesture within this defined field in order to control the cooktop.

At the beginning of our interview, we focused on different possibilities for turning the cooktop on.
We had therefore two different ways to perform this task.

One was to do it in a local way on a control panel and to hold out the number of your fingers, which would represent the corresponding cookfield. So there would not be a global turning on in order to control your cooktop but rather turning on your desired cookfield and start the cooking process. But this kind of interaction was not very feasible for the participants in case of usability.

The other way of interacting was to hold out the flat hand over the cooking field. As soon as the system recognizes your flat hand for some seconds, the cooktop would turn on. This gesture was very easy to perform and quite understandable for the participants. So we thought at the beginning to keep it as simple as possible and to not integrate too complex gestures.

## Turn on the stove

| | **Hold out the number of fingers** (local) | **Hold out the hand over the field** (global) |
|---|---|---|
| **Participant 1** (53 years) | Pointing with the fingers is good. Is easy to remember. The fields have to be labeled. | But global is better. I have direct control and can hold my hand over the field. |
| **Participant 2** (52 years) | I don't know how to turn the field on. | Simply holding my hand over it would be best for me. I would make a backup, turn the stove on and then select the field. Otherwise I turn on the plate when I clean, for example. |
| **Participant 3** (21 years) | No, I don't like it. | Global!<br>wipe from left to right plate comes on<br>from right to left: plate goes out. |
| **Participant 4** (25 years) | Yes, showing the finger would be ok. | Just holding the hand is better |
| **Participant 5** (31 years) | how is it with a split plate? | Better. Just hold the hand or swipe from left to right to turn it on. |
| **Participant 6** (22 years) | It's a good idea | I can burn myself when pot on another plate. So I have to move around the pot with boiling water for example |
| **Participant 7** (21 years) | No, its to complicated | What if I move from the bottom to the top? I don't want all fields to start. Maybe holding the hand 2 seconds over the field would be good. |
| **Participant 8** (24 years) | Isn't it easier just to hold the hand over the field ? | Already said that idea before. |
| **Participant 9** (53 years) | It is too complicated. Difficult to shape your fingers. | It is logical, intuitive and good |
| **Participant 10** (29 years) | It's difficult to shape your fingers and not intuitive at all | I like that. However, I would find the gesture better in the local. is also ok in the global. |
| **Participant 11** (25 years) | No, I don't like it. | The gesture is good, but I don't like the global one. One could accidentally trigger gestures on the global. |

Figure 5: Testing results / participants answers

# Asking the User

For regulating the heat we had three different interaction possibilities. All of them could be performed either in a local or in a global way.

One was moving the finger in a circular motion, once over the whole cooktop and the other way would be to perform it over a control panel. But this kind of movement was overall not accepted by the participants. This gesture was somehow an analogy to the interaction with the knobs on a cooktop. They have to be turned in circular way in order to regulate the heat.

Another way of interacting would be moving your hand even globally or over a control area to change the heat. We tested therefore the movement in vertical and in horizontal direction. So moving your hand back and forth or doing it from the bottom (near the cooktop) to the top (away from the cooktop). But moving your hand back and forth was here the most intuitiv way of interacting and changing the heat. This could have been done either globally or in a local way.

After the first interview we got some deeper understanding of what is natural in terms of gesture interaction. We tried to get a tendency whether the user is more likely to use a gobal or local gesture interaction concept. In general we can say that it has been more or less counterbalanced. The younger users tend to prefer the global concept while people from 50 years above prefer the local concept.

Based on the insights from the interview, we refined our overall concept and the defined gestures in order to create a more natural and intuitiv way of interacting with the cooktop.

## Regulate the heat

| | **Moving finger in circular motion** (local and global) | **Move hand up and down** (local and global) | **Move hand back and forth** (local and global) |
|---|---|---|---|
| **Participant 1** (53 years) | You have to keep that in mind, not too many different movements. takes too long and I don't know how far I have to turn. | Move direct over the field | Its better from left to right |
| **Participant 2** (52 years) | Moving local would be good | Hold just one finger and swipe from left to right. not the whole hand | Hold just one finger and swipe from left to right. not the whole hand |
| **Participant 3** (21 years) | Circle over the plate and then the heat comes on. But what if there is a pot on it? Voice control as support | Extra sensor on the side where I can regulate the heat | - |
| **Participant 4** (25 years) | No, I don't like to do that with one finger. Not that precise | it gets hotter down and cooler up. Lift the pot and it will be cooler | Very important for children. A backup -> Face recognition |
| **Participant 5** (31 years) | No, I would move from left to right. | Its ok | - |
| **Participant 6** (22 years) | Yes, i like it | Thats even better. I can move the hand even if pot is on. Not direct over field but next to it. | - |
| **Participant 7** (21 years) | No, I have to twist my finger if I want to regulate from high to low very quick | Its better, but maybe with extra control ? to combine local and global for heat regulation | No, its not that good. |
| **Participant 8** (24 years) | Yes, its easier. | What if pot is on ? | What if pot is on ? |
| **Participant 9** (53 years) | I find it totally strange and it is not a natural movement. it's complicated. not easy to do. | not at all intuitive, no connection to the action | I think it's better, but only in combination with local. Global is not good because the pots are there. |
| **Participant 10** (29 years) | I like the gesture. The output would also be a circle, rotates in the display as feedback | I don't like it at all. | Only ok locally, but the movement is not intuitive. Global is not possible |
| **Participant 11** (25 years) | I find it good. Semicircle, half a disc. | I don't like it. | I think that's good locally, but not globally.<br>I don't like global for security reasons |

Figure 6: Testing results / participants answers

# User Testing

In the first user test we focused on a basic understanding of the cooking interaction process. We tried to elicit the most intuitiv and appropriate gesture. So it was more about building a basic, accepted concept that integrates into the existent activities of cooking. There was no design which was taken into account, only the concepts and gestures were tested.

It was also important for us to find out which gestures were received by which user group and which were not. As this gesture cooktop should appeal to all user groups, it was important to not exclude any age, or groups and to develop a basic concept that would appeal to everyone.

Before we conducted the test, we created an interview guideline, which can be seen on the right side.

By refering to the guideline, we made sure that we all stick to our thought out testing structure and that we receive a uniform result and in depth insights, which we incorporate into our further development.


Figure 7: Our first user testing setup

## Interview guideline

**Short testing description:**

The test should elaborate different gesture approaches for the several cooktop functions. It should give a tendecy for wheter global or local gesture interaction is more accepted by the participants. It should elicit insights which give guidance on how to interact in order to turn the cooktop on and off, regulating the heat, activating the panel etc. The testing should be conducted with the think aloud method and the participants are asked to describe what they are doing and everything that comes into their mind.

**Short introduction:**

Hello, today we want to elaborate some open questions that we have for our project which is natural user interface and we try to develop a concept which helps the user to control the cooktop with gestures. ...

**First part: Global gesture interaction**

1. Turning on the cooktop
    - 1.1 Flat hand gesture
    - 1.2 Waving with flat hand
2. Turning off the cooktop
    - 2.1 Flat hand gesture
    - 2.2 Waving with flat hand
3. Adjust heat
    - 3.1 Circular motion
    - 3.2 Waving with flat hand

**Second part: Direct gesture interaction**

1. Adjust the heat directly on the cooking areas
    - 1.1 Movement over panel in vertical direction
    - 1.2 Moving index finger over panel in vertical direction

        *test both with up to down or down to upper part movement*
2. Selecting a pot
    - 2.1 Placing the pot on the plate
    - 2.2 Selecting pot by placing hand over panel for 4 seconds
3. Deselect pot/ Turn pot off
    - 3.1 Remove pot from panel
    - 3.2 Swipe to left or right gesture
    - 3.3 Moving hand in a vertical direction from the upper panel part to the bottom “shut down”

# Insights

With the user test we got some rich and fruitful insights. We found out that an activating gesture for the different cooking plates is needed to avoid false positives in order to regulate the heat. It was also shown that most users prefer a direct control and a local interaction of the cooktop.

The participants also tend to prefer a vertical movement or a vertical gesture to adjust the heat.

All those insights took us to the decision that 4 control elements could be beneficial in form of interaction as it is easy and intuitive for all age groups.

Adjusting the heat with a circular motion

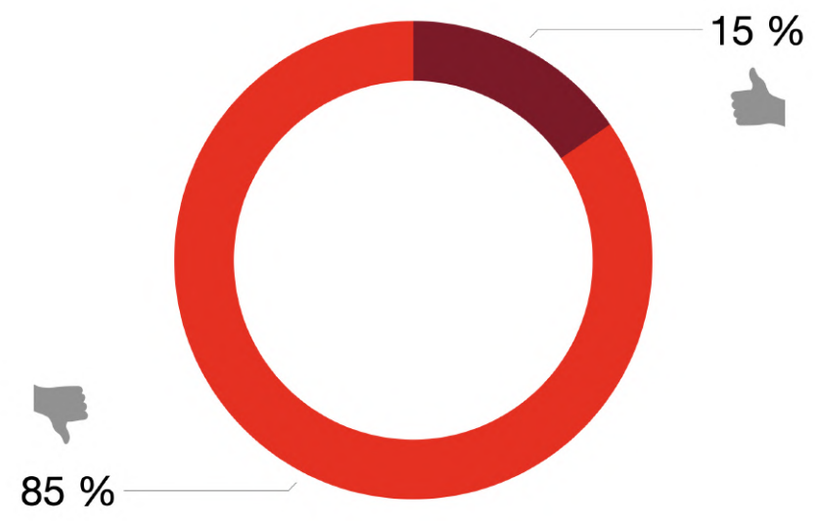


Figure 8

Swipe to right to turn the pot off

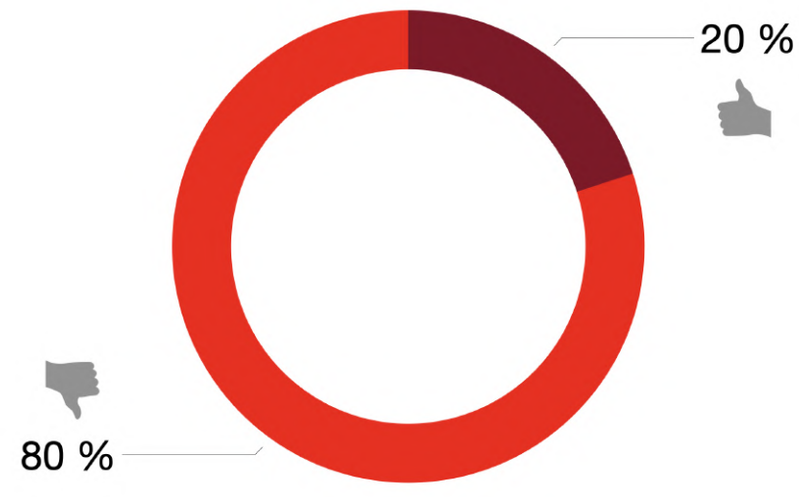


Figure 9

Adjusting the heat with a vertical movement

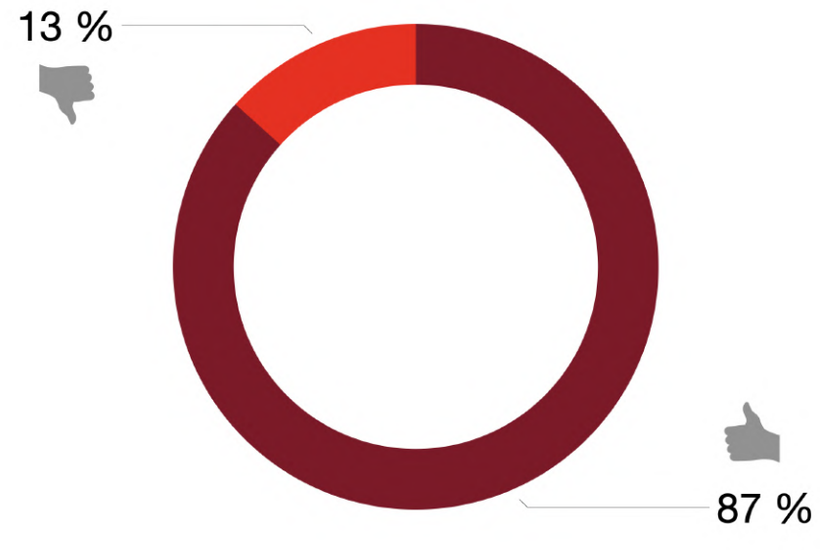


Figure 10

Doing a flat hand gesture to turn the cooktop off


Figure 11

## Insights

- Swipe from left to right to turn on the stove and regulate the heat at the same time -> Increasing the heat will turn the field on
- Some kind of secure -> Face recognition (Shouldn’t turn on if kid is playing there) or just a small button to turn the stove on before gesture recognition will start
- Combining the local and global gesture recognition. Visual, Light and Audio Feedback is very important
- Standby-mode: When removing the pot the field should be turned off and when putting it back again, it should start.
- Don’t define fixed fields. You can put your pot anywhere you like and it will create the heating area.
- For older people, things have to be logical and visible. It has to be intuitive, they should always remember the gesture -> So easy to learn and intuitive, they can learn it quickly again and again. So logical that you don't have to remember it.
- “Local would be more acceptable. I don't think global interaction is good for the general public.”
- „Removing pot for 3 sec while the vegetables do not get burn then this should not close/turn off the heat itself when I want to close then it should reduce or close.“
- „in this case the surface should be cool like new cooktop in market there surface would not get hot, only the pane gets hot“
- „How do we know 4 sec is over or not“
- „Remove pot from panel will not work because then there is a restriction to it that I cannot remove pot even for some seconds, like in a situation when i am afraid my vegetables could burn and i just want to remove the pot for some seconds“
- „Turning on with fingerprint sensor is the best method here for me!“
- „Need to show it visually how the heat is increasing. Some cooktops have numbers and some have a 4 level knob. So I am confused how the heat increases“
- „It is a good idea but with gestures how it recognizes that what amount to heat I need to raise for eg I want to increase it to 6 grade sometimes if my hand goes further more and less than it will be a time consuming process for me“
- „With touch and knob it is easy to adjust heat but moving hand up and down without touch feel I cannot imagine for eg while press on touch screen I know that I am raising level for 2 or 3 grades but gestures measurement is difficult“

# First concept

Turning the cooktop “ON” and “OFF” is done via fingerprint recognition. The user has to put his finger over the scanner to unlock the cooktop and to be able to start cooking. This can also act as a child security lock and also increases the safety when thinking of false negatives or false postives. The cooktop can not accidentally be turned “ON” by performing any gesture over it.

Turning “OFF” your cooktop would than work in the same way. Just holding your finger over the scanner. This kind of interaction also has to give feedback to the user. One would be of course a visual  feedback but also to support it with sound.

We have in total four different control panels, for each cookfield one. In this concept we have thought about giving the user a visual feedback as soon as a pot is placed on the cookfield.
The corresponding control panel gets a red border and displays that the cooktop is in a stand by mode, as you can see in Figure (12). This means that the cooktop is ready for the gesture recognition.

The panel gives also visual feedback as a hand got recognized. To activate the control panel, the user has to hold his hand for 2 seconds over the panel.
The system reacts and shows a bright border around the panel. In addition, the word “ACTIVE” is shown.

In order to adjust the heat, the user has to move the flat hand over the control panel. A flat hand gesture from bottom to top has to be performed in order to increase the heat. In order to decrease the heat, the same gesture has to be performed from the top to bottom.

The current heat level (as shown in Figure 15) is represented by the red area. This provides a visual guideance with marked areas which makes the performance easier and supports the user while regulating the heat.

To turn the cookfield off, the user has to perform a gesture movement to the very bottom of the panel. So the level of the heat is set to 0. The user also gets a feedback that the cookfield is turned “OFF”.

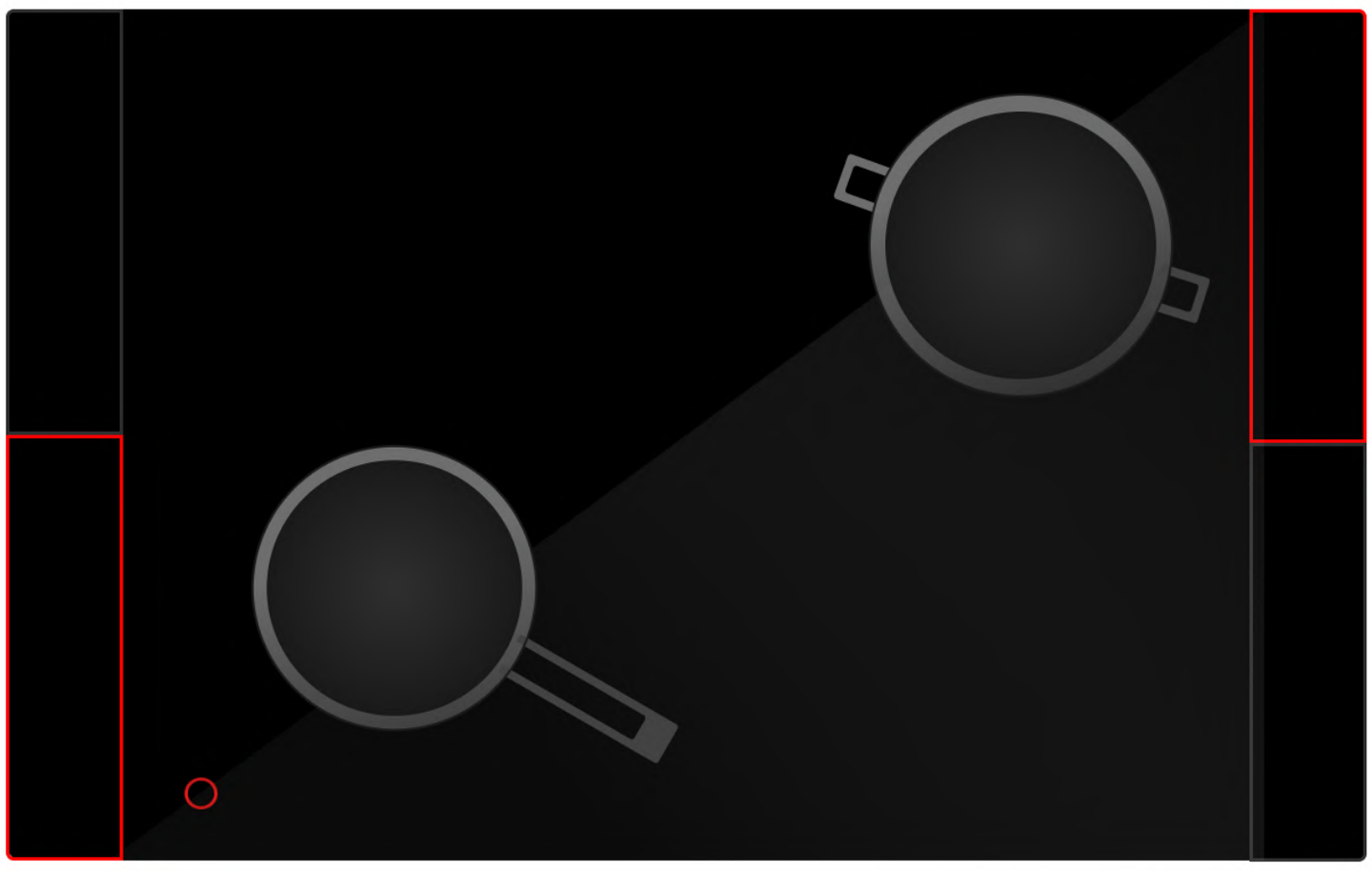

Figure 12: Stand by mode of the cooktop

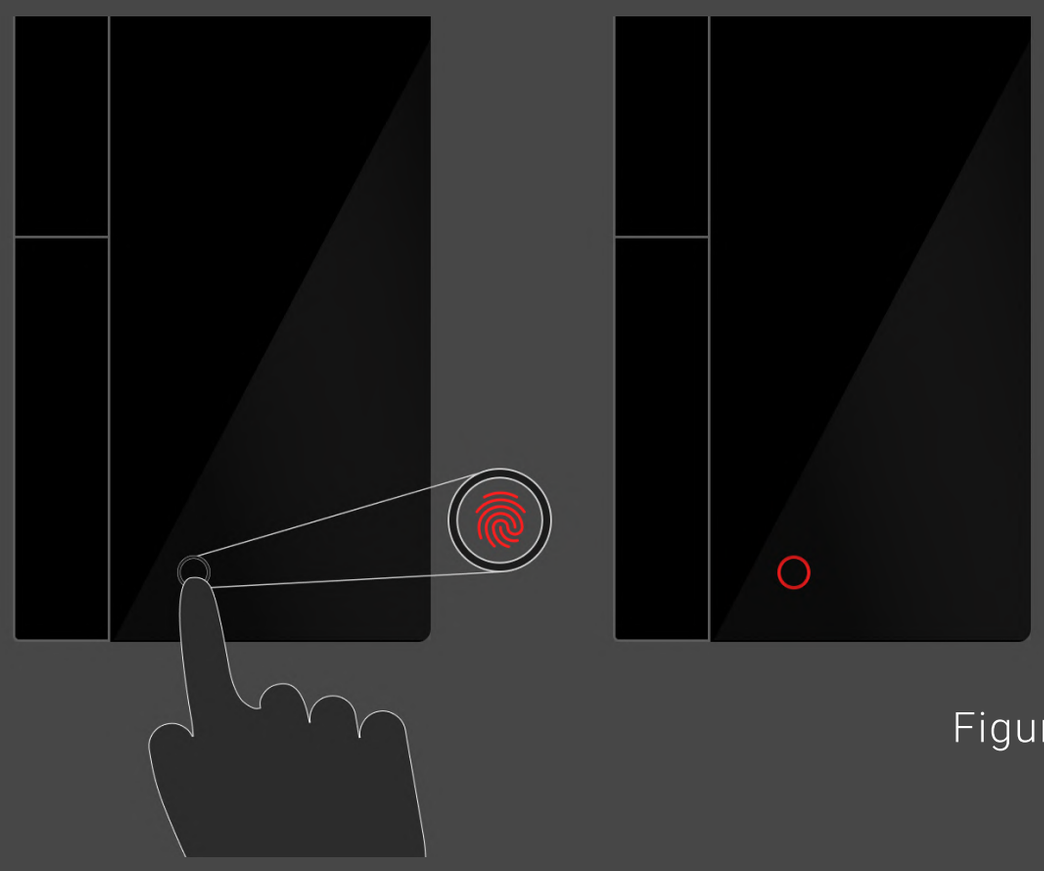

Figure 13

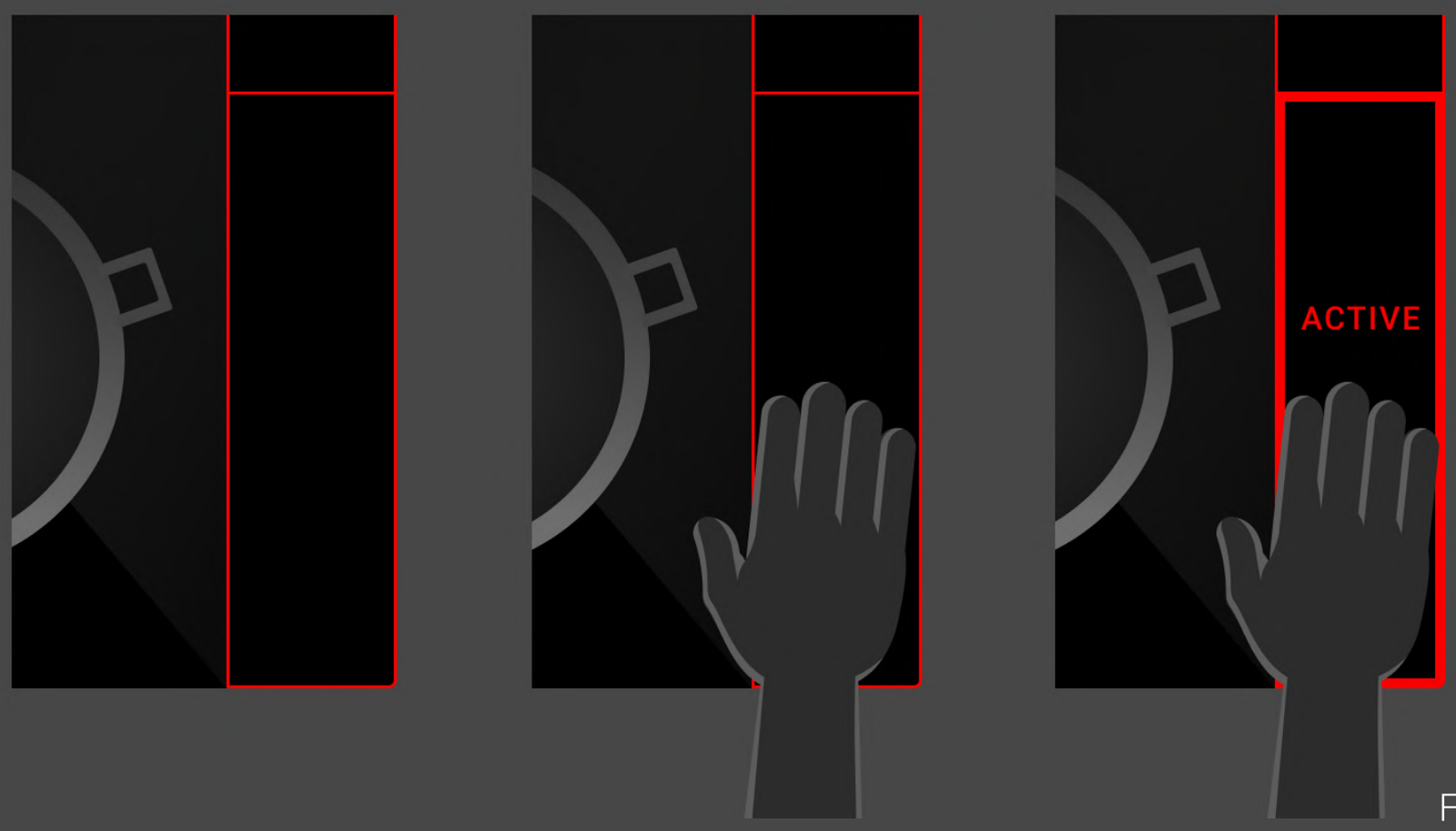


Figure 14

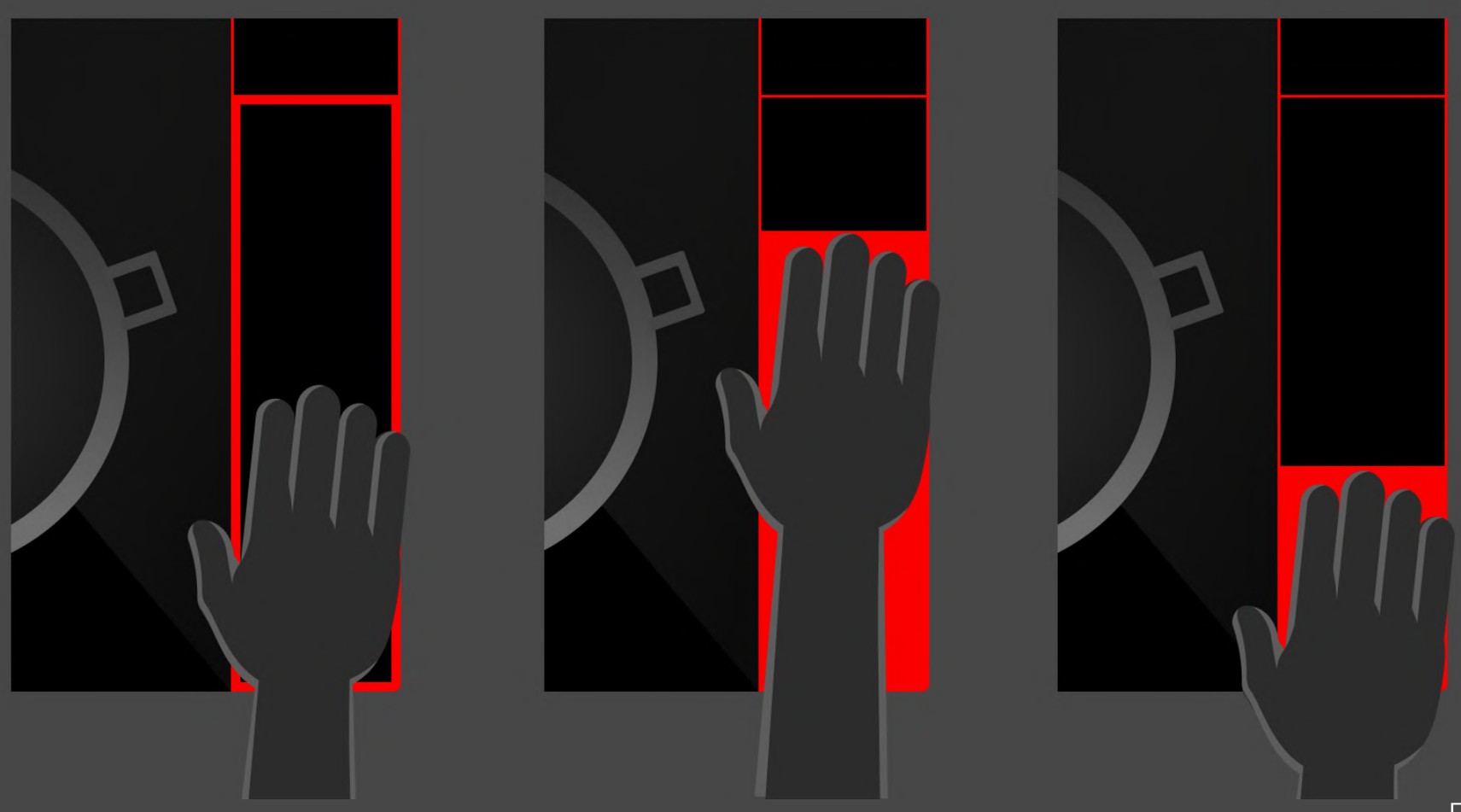

Figure 15

# Refined low-fidelity concept

The first visualisations of our gesture concept helped us to understand the basic structure and concept. In the next step we wanted to refine this concept. We continued by ideating, how the interactions on the panels could work. We thought in different directions in order to find the best and most natural approach.

The refined concept is a cooktop that consists of four gesture interaction panels. Each of the four cooking areas can be controlled with gestures which are performed above the control interaction panel. That enables the user an easy access to a cooking experience based on intuitive gesture interaction. The gestures can be performed with the flat hand.

In our refined prototype, turning the cooktop on and off is possible via speech recognition. A complex on and off gesture is not ideal considering the usabilty (especially for elderly people). So in this case the possible “starting” phrase could be: “Hey Cooktop turn ON” or “Hello Cooktop”. The possible “turning off” phrase could be: “Cooktop OFF” or “BYE cooktop”. We also came across the idea that the speech interaction should be supported with visual and sound feedback.
There could be a starting and turning off sound consisting out of two tones.


Figure 16: Turning ON the cooktop

# Slide concept

Our sliding interaction concept consists of 9 heat levels and guidance boxes. The heat is displayed with numbers from 1 to 9. Another variant could be a panel with 5 heat levels and with wordings for the heat levels. The panel gives visual feedback that the hand got recognized for the gesture performance.

The panel is “fixed” or “locked”  as you can see on the left side in Figure 17. In order to unlock the panel you have to hold your flat hand for 2 seconds over the current level to unlock it. The corresponding field gets ligthend up and the user can regulate the heat.

To increase the heat, a flat hand gesture has to be performed from the bottom part of the panel to the top part.
In order to decrease the heat, the opposit direction has to be used.

After the adjustment of the heat to a specific level, you have to hold your hand again for two seconds over that level. Now the temperature is fixed and as you move your hand from the panel, no false postive happens.

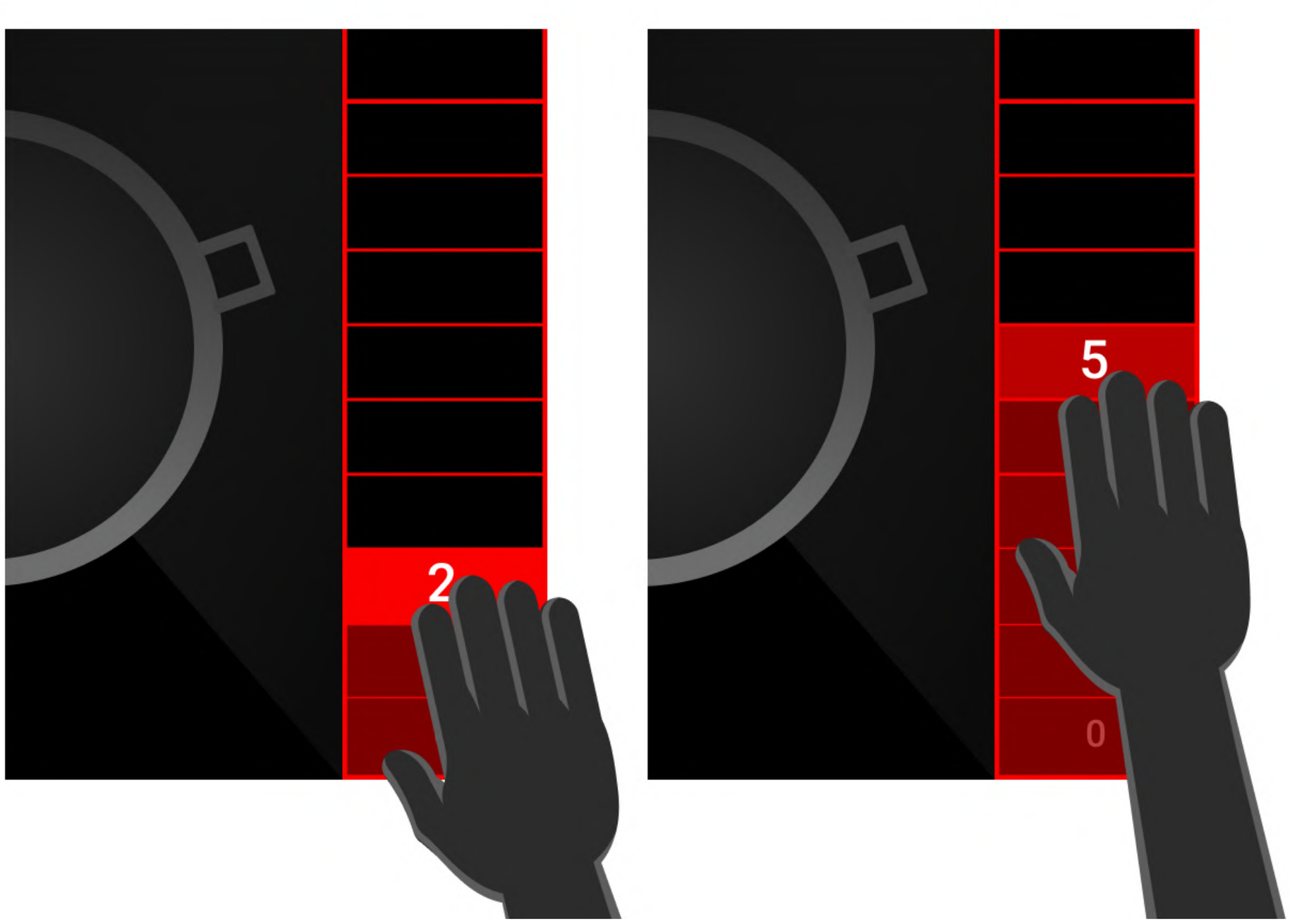


Figure 17: Adjusting the heat level with sliding concept

# Swipe concept

As we have a new form of interacting with a cooktop in form of gesture control, we started to rethink the mechanism of heat adjustment as we have it right now with knobs and touch screens. The numeric description of heat from 1 to 9 evolved out of the adjustment mechanism with a knob, where you had to make it more abstract. Because of that, this concept describes heat in words and not numbers.

The adjustment of the heat is divided into 5 areas/steps.
Also a variant with 9 steps and numbers as the description of the heat level is conceivable.

As you do a swipe gesture to the top, the heat of the panel gets higher. Therefore it doesnt matter where you place your hand on the panel. You do not need any specific starting point for the gesture. Important is only the direction of the swipe gesture.

The 1:1 mapping of the elements on a screen is an interaction that comes from touch screens. As we have a gesture interaction we wanted to question this mechanism as well and ask ourself if we eventually do not need this mapping anymore. The adjustment of the panel would be possible in a new way of interaction with gestures.

In the middle of the panel the level of the heat is displayed. As you do a slide gesture to the top, the heat of the cooking field gets higher.

We also thought about the possibility to fix the heat as otherwise it can cause issues because of false positives. That means we had to think of ways to “lock” the panel for gestures, which should not get detected. For example in the cooking process when you just want to stir something in the pot. The panel should not detect your hand movement as a gesture for adjusting the heat.  So this “fixing” system enables the increasement of the heat without gestures getting detected by accident in order to avoid false positives.

After the adjustment of the heat to a specific level, the user has to hold the flat hand or the index finger over the label for two seconds. Now the temperature is fixed and as the user moves his hand from the panel, no false positive happens.

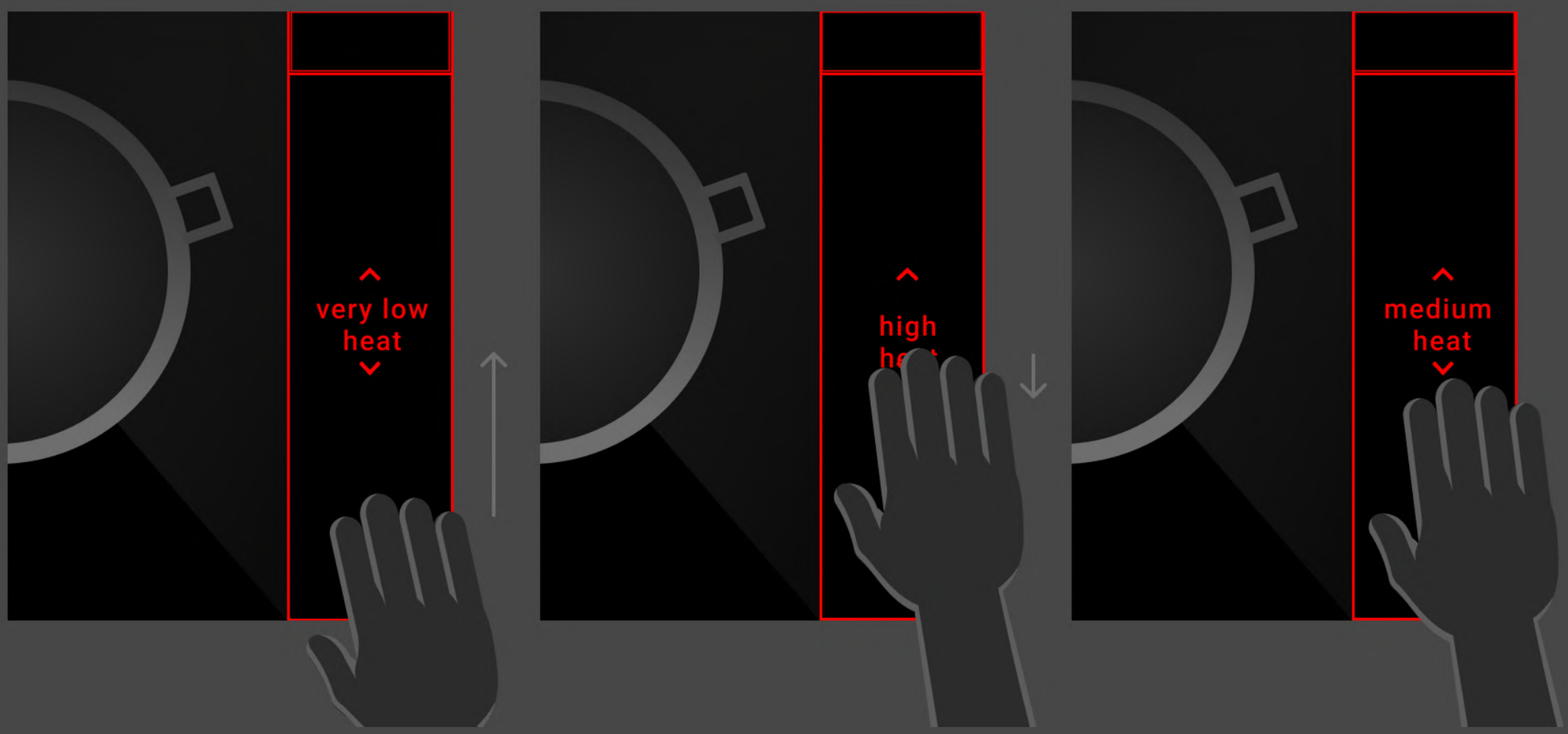


Figure 18

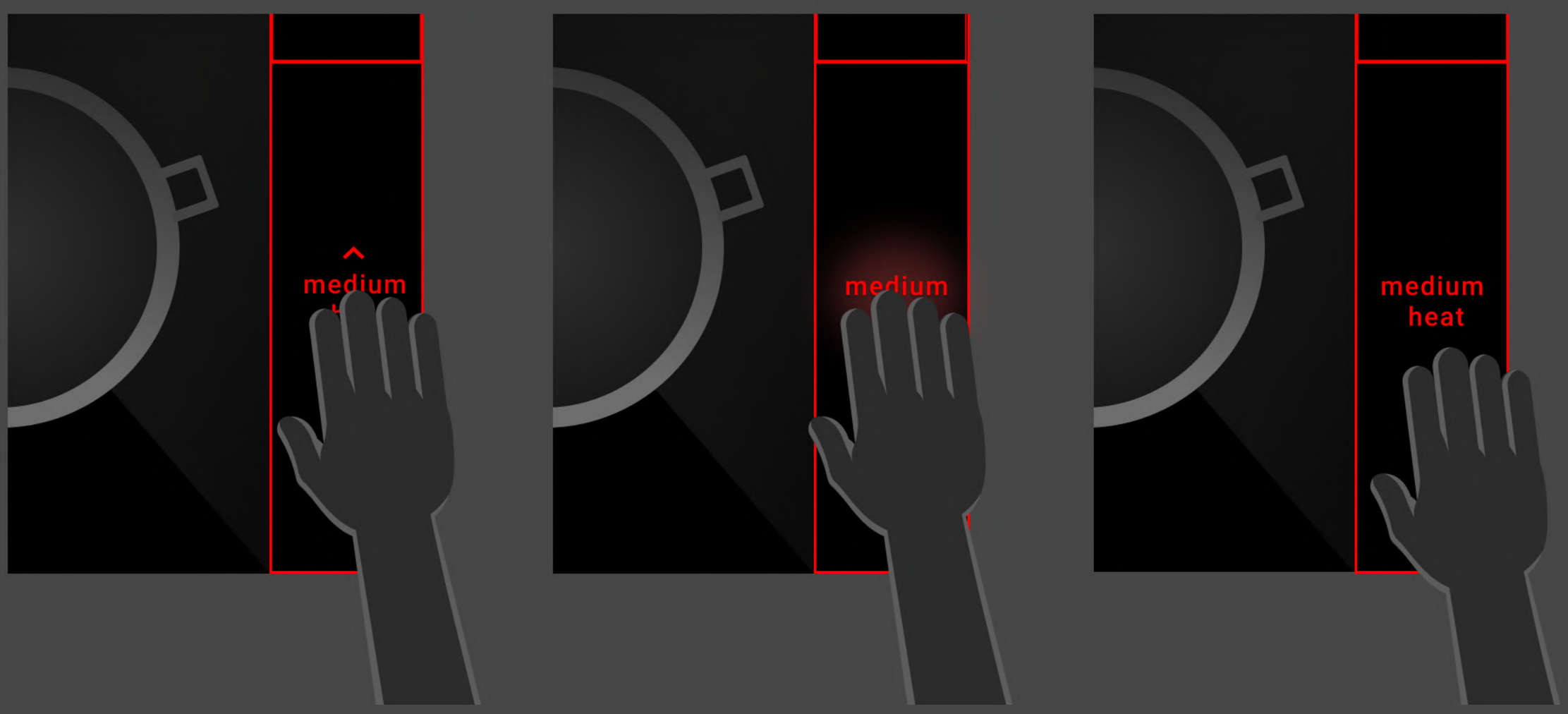


Figure 19

# Programming the high-fidelity prototype

We used the leap motion as the hand tracking tool for our prototypes and programmed the application in JavaFX. For this, we created a scene with the size, the control panel should have later. The application that responded to the hand movements of the participants is shown in this panel.

For the prototype with the swipe interaction, we used leap motion's swipe gesture recognition, which is already integrated. In addition, we have to take into account the direction of movement of the swipe gesture, as the heat increases or decreases depending on the direction.

For the slide prototype, the user's palm position was tracked and, depending on the position, the corresponding heat level was set.

For both prototypes, it was important to implement the panel activation as well as the corresponding feedback in order to make the user understand how the interaction works.

With the second user test, we wanted to test the two concepts “slide” and “swipe” in order to guarantee better usability and a better user experience.
To test both concepts we used the A/B testing approach. To compensate the learning effect, we randomized the order of the concept-test for the participants. With this test we also gathered good insights on the amount of heat levels or the color gradient of the heat in the panel.

```
                    startToLockPanel();
                } else {
                    ResizeHeightTranslation rht = new ResizeHeightTranslation(Duration.millis(30), leapMain.heatLevel, 1000);
                    rht.play();

                    checkIfLevelChanged("Very high");

                    leapMain.heatLevel.setStyle("-fx-background-color: linear-gradient(to top, #FFFF00 , #FF0000)");
                    leapMain.level.setText("Very high");
                    leapMain.level.setOpacity(1);
                    leapMain.arrowDown.setVisible(true);
                    leapMain.arrowUp.setVisible(false);

                    startToLockPanel();
                }
            }
        });
    } // Panel is inactive but hand is recognized
    else {
        Platform.runLater(new Runnable() {
            @Override
            public void run() {
                leapMain.lockstate.setVisible(false);
                leapMain.lockNote.setVisible(false);
                leapMain.vbox.setVisible(true);
                leapMain.progress.setVisible(true);
                leapMain.root.setStyle("-fx-border-color: #DB162F ; -fx-border-width: 5px");

                // Sets the panel to active if the hand is hold for 2 sec
                if (!panelActive) {
                    if (hand.timeVisible() > 2.0) {
                        panelActive = true;
                    }
                    leapMain.progress.setProgress((int) (hand.timeVisible() * 100) / 2);
                }

                if (panelActive) {
                    stateOnActivePanel();

                    leapMain.level.setText("No heat");
                    leapMain.arrowUp.setVisible(true);
                }
            }
        });
    }
} // No Hand Recognized or panel is locked
else {
    if (hands.isEmpty()) {
        panelLocked = false;
    }

    Platform.runLater(new Runnable() {
        @Override
```

Figure 20: Snippet from the code

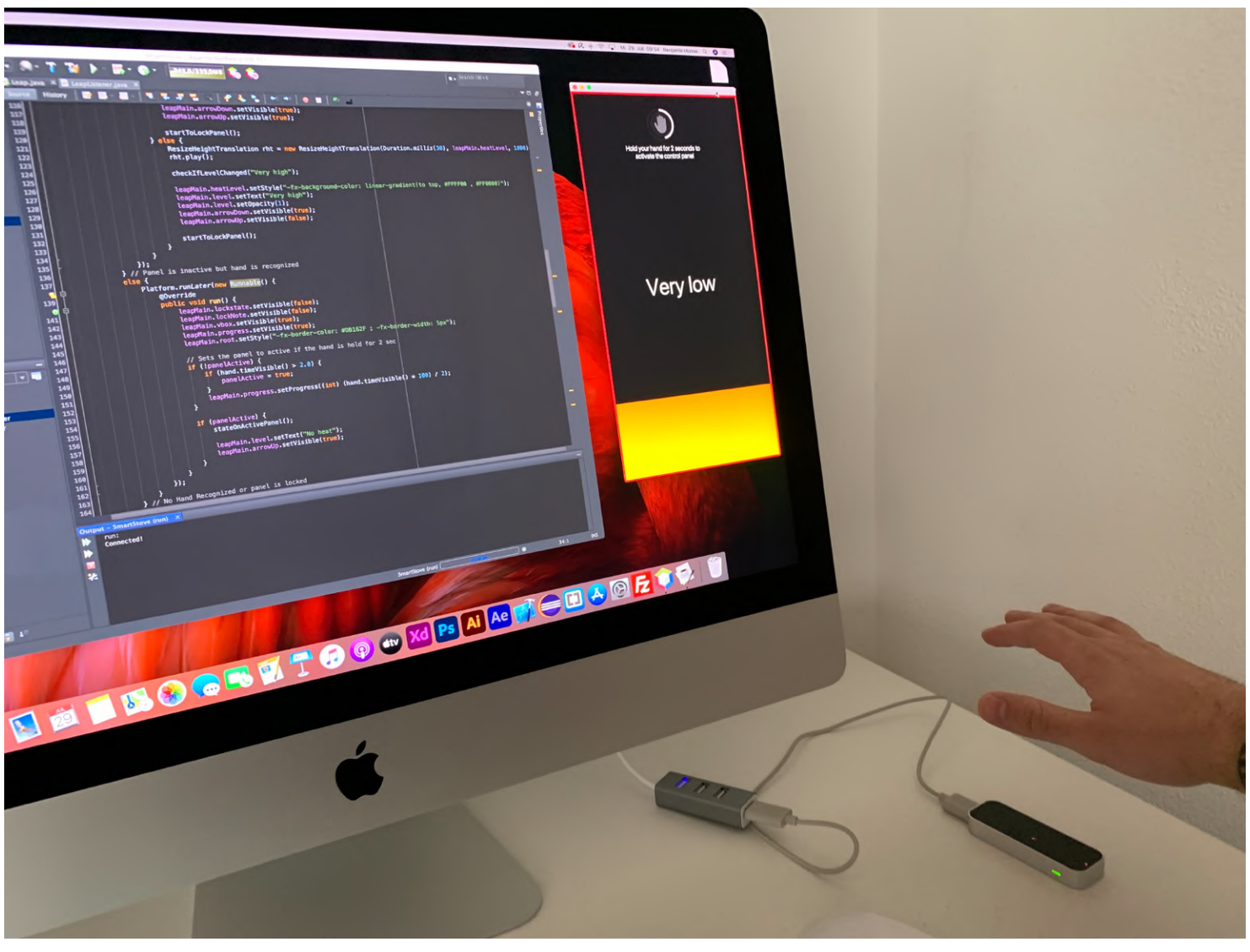


Figure 21: Implementing the slide concept


Figure 22: Implementing the swipe concept

# Second user testing

With the second testing we decided to test two approaches. One was the sliding gesture concept and the other one was a swiping gesture concept with different levels of heat.

In order to find out which approach is more accepted and suitable for the users and which is also better in terms of usability, we carried out a second test.
In order to be able to test the task as realisitc as possible, we programmed a prototype that can be controlled with the leap motion. For this we had different settings that we tested with each participant. (Figure 23 shows the setup and the testing enviroment).

The main focus of this testing was to elaborate which gesture interaction concept is more intuitiv and easier to use. On the one hand we used the slide gesture and on the other hand we tested the swipe gesture.

Another test criteria according to the slide gesture concept was to elaborate if the usage of five heat level is benefical for the user. The idea behind the five levels was to make the heat regulation easier and more comfortable for the user, especially for elderly people. In the user testing that should be probed.

It should be elaborated which heat level concept matches with the mental model of the user. Nowadays people are used to a cooktop with 9 different levels of heat which could give them a feeling of flexibilty. Therefore we also tested the acceptance of the amount of different heat levels. As you can see in the following points:

- 5 steps with wording and slide
- 9 steps with wording and slide
- 5 steps with numbers and slide
- 9 steps with numbers and slide
- 5 steps with wording and swipe
- 5 steps with numbers and swipe

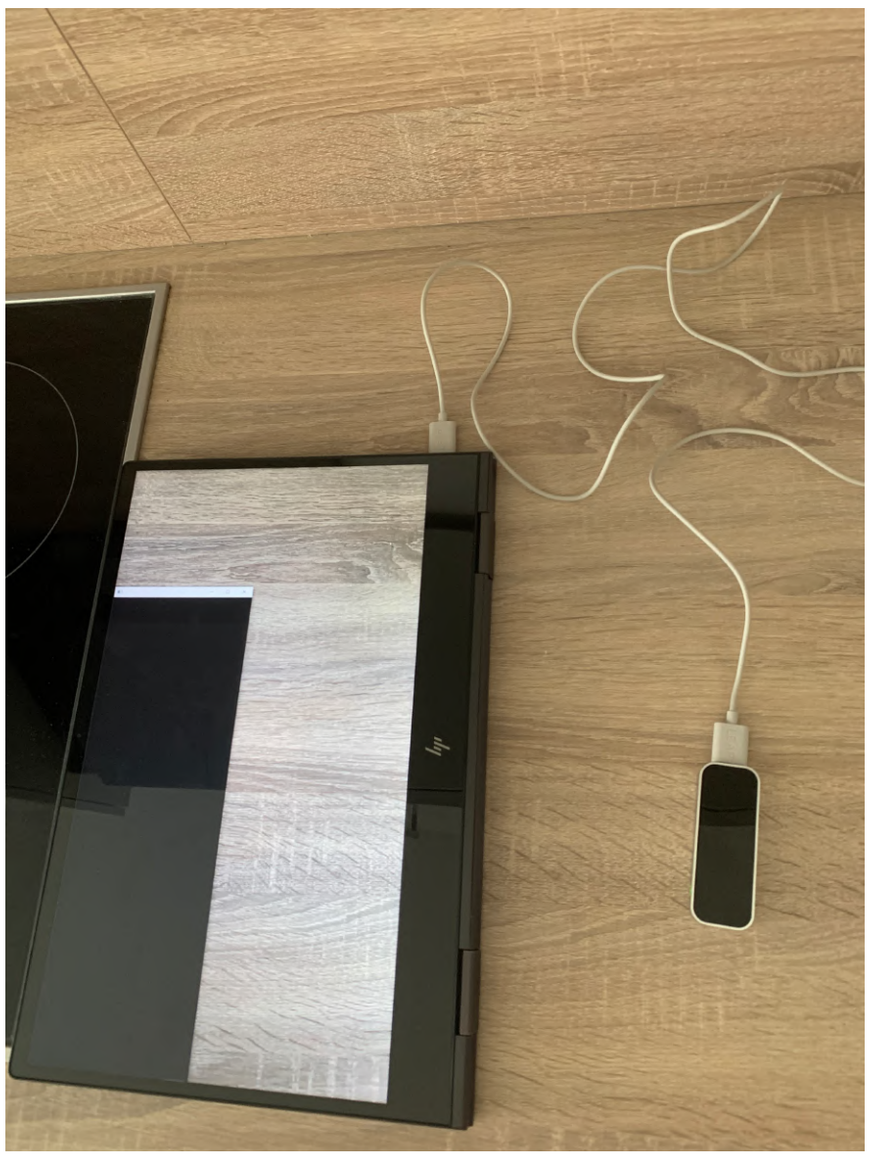

Figure 23: User testing setup

# Regulating heat

First task: Set the level of heat to medium

At the beginning, we tested the regulation of the heat from 0 to medium. Some of the participants were satisfied with using the swipe gesture and could imagine using their cooktop in this way. But there was already a tendency towards the slide gesture, because this interaction was more accurate for most participants and also less prone to errors.

While performing the slide gesture the user always have a reference and knows exactly how far he/she has to move the hand to reach a certain heat level. This approach becomes more efficient for the participants rather than the swipe gesture. (Figure 24)

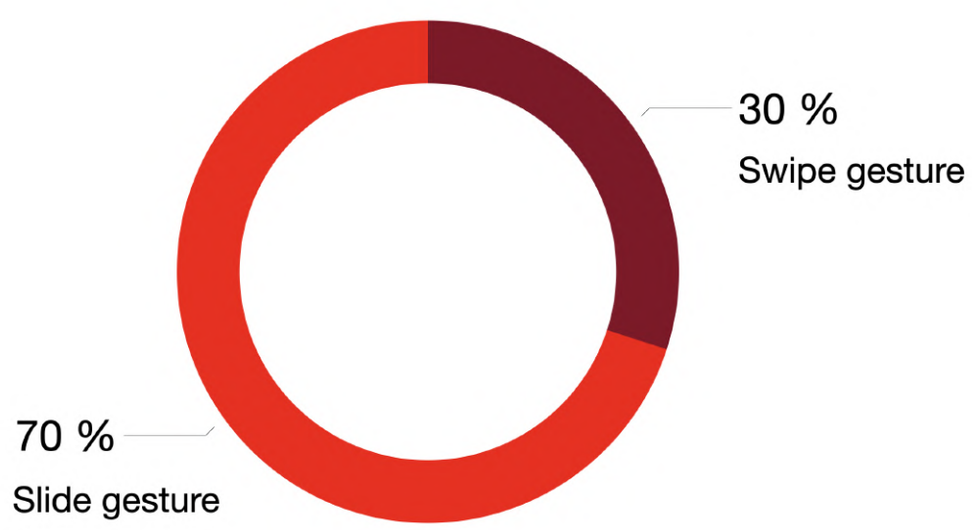


Figure 24: Set the level of heat to medium

Second task: Increase the level of heat from 0 to maximum or decrease the level of heat from maxiumum to 0

After the participants had to switch the heat from 0 to the maxiumum and then from the maximum back to 0, the result was very clear. Almost everyone said that with this interaction, the swipe gesture doesn't work at all, since you have to swipe far too often to put the heat to maximum. (Figure 25)

We already had the idea of taking the velocity and the length of the swipe into account in order to skip several levels and to achieve the maximum with just one swipe. However, this was not very tangible for the users, since they did not know how fast and how long they have to swipe to skip 3 heat levels for example.

The slide gesture was much better received because it was easier to perform, and the user always has a reference and knows exactly how far he has to move his hand to reach a certain heat level.

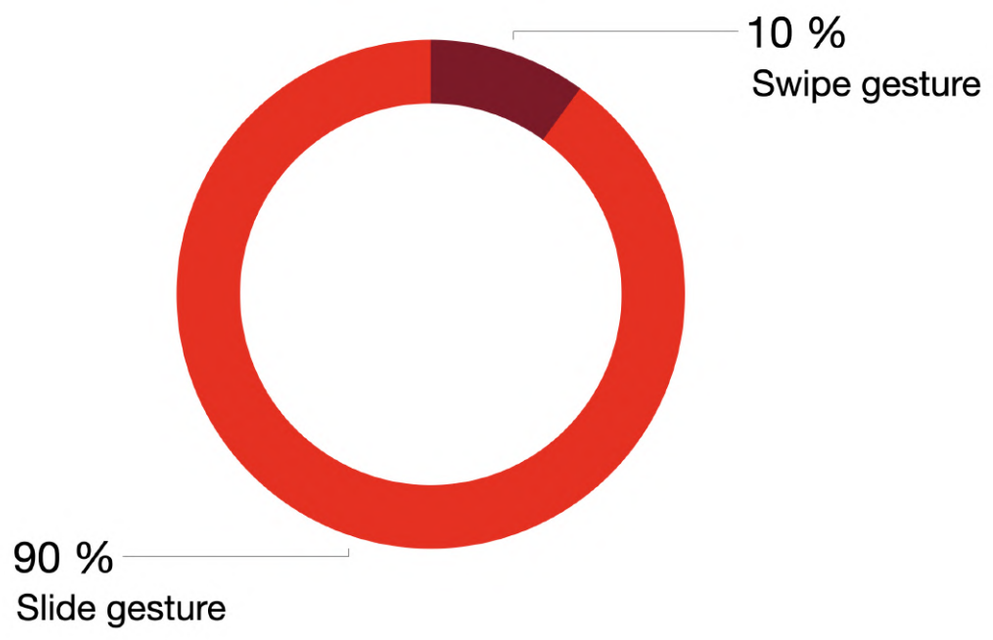


Figure 25: Increase the level of heat from 0 to maximum or decrease the level of heat from maxiumum to 0

# Results out of the second testing

Based on the results of this test we decided to continue with the slide gesture concept as our cooking interaction approach.

Almost all users had a rather neutral opinion on the amount of heat levels. For most of them, the 5 levels were also okay, because in combination with the gesture they are easier to use than 9 levels. This also provides the visual feedback in terms of a red stroke with a gradient color from yellow to red like the steps are increasing or decreasing.

This whole interaction process acts as a one to one mapping, that means the visual feedback on the interface, with its gradient colors, responds on the interface while our hand is moving in a particular direction. We also decided to take a different path for the labeling of the heat. We decided to not describe the heat levels in form of numbers from 1-5, but to use wordings. This wording levels go from “very low” to “very high”. This approach fits better in this context and is not arbitrary adopted from the GUI world, such as the numeric description that we use in our hobs today.

1. Use wordings for heat
2. Use five steps
3. Sliding gesture for heat adjustment

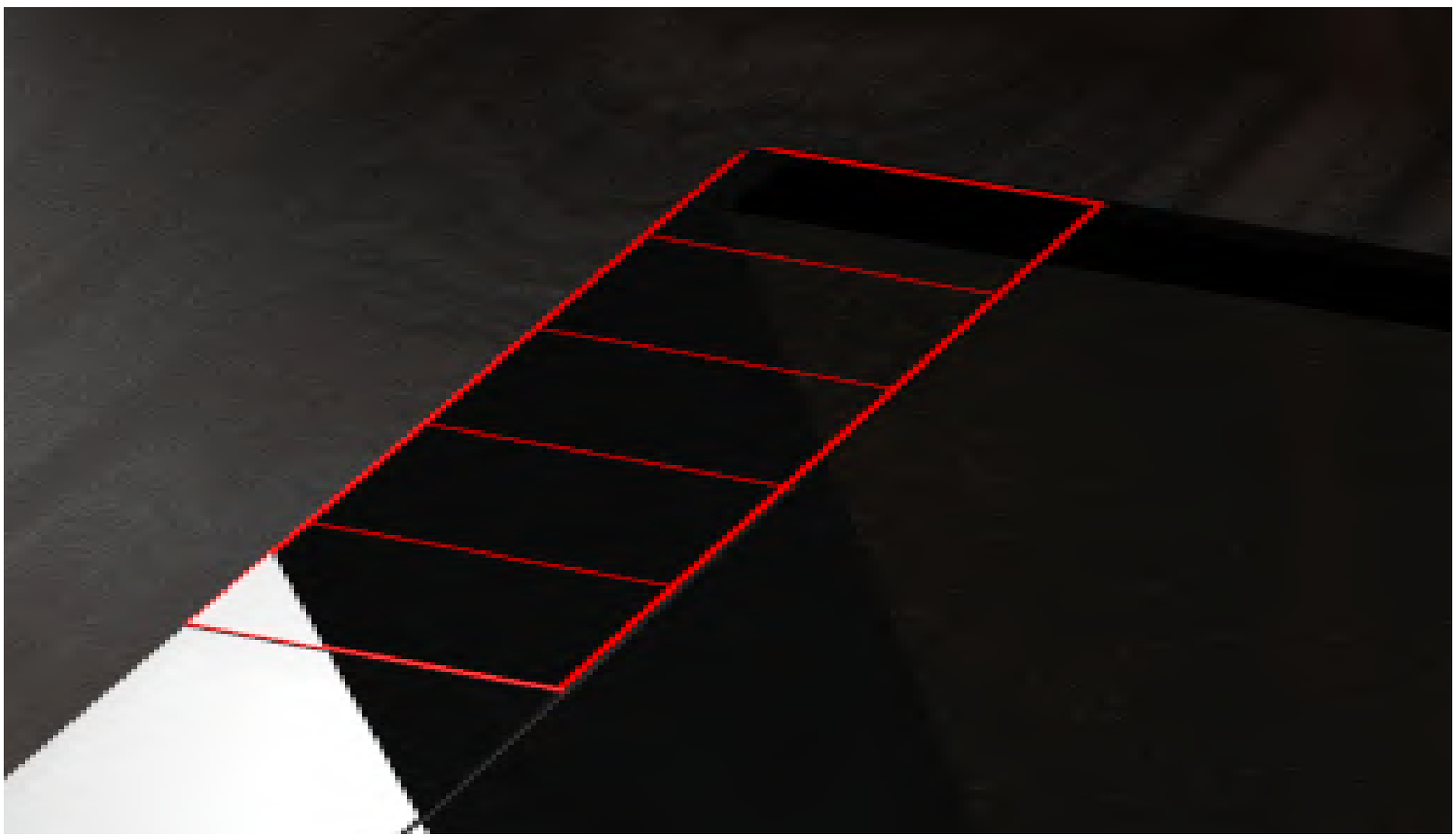

Figure 26: Resulting interface appereance after second user testing

# Usability test

Based on the insights from the A/B testing, we developed our high-fidelity prototype. All details were taken into account and the prototype was completely worked out, how it should look and work later. Therefore we implemented and also animated transitions, which react based on the users interaction.

To test our high-fidelity prototype again, we finally carried out a usability test with 9 participants. This was also used to test which configuration of the heat level works best for the user and whether the feedback supports the general interaction with the cooktop as good as possible.

In addition, attention was paid to the smaller details such as the length of the activation gesture or the speed at which the system regulates the heat upwards. We were able to generate important insights that we implemented in our final high-fidelity prototype.

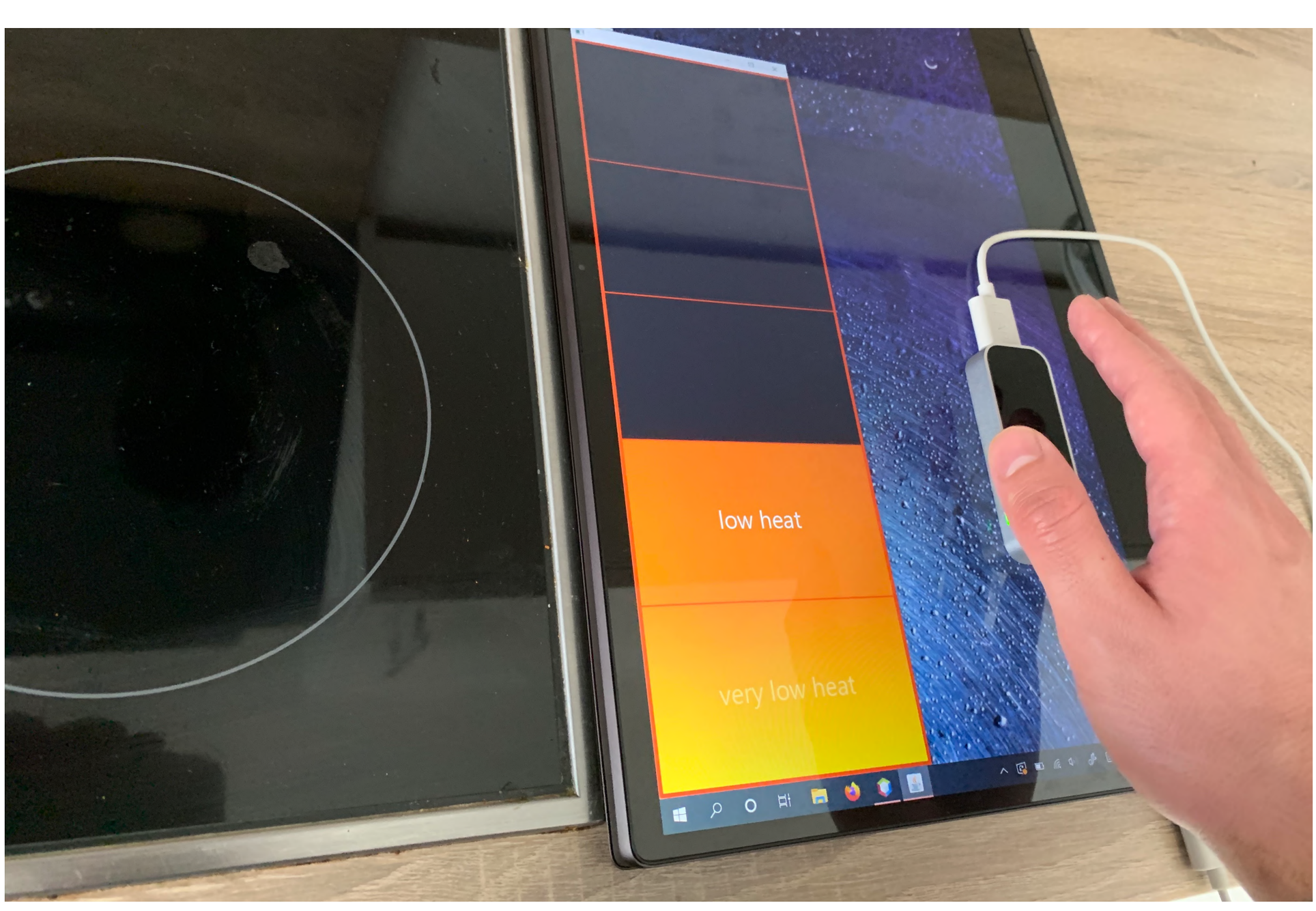


Figure 27: User performing gesture on leap motion

# Final concept

Based on all the insights we got from the user testings and interviews we created our final high fidelity prototype.

In order to demonstrate how the final product will look like, we created visual renderings of the whole cooktop. This shows the basic structure clearly and can imagine quite good how it works.

Our smart cooktop consists of 4 control panels. Each cooking field therefore has its own control panel to enable a more direct type of interaction and to make it easier and more intuitive for all user groups.

The control panel also serves as a visual output source to give the user feedback on the current status and on his overall interaction.

The individual interaction options are explained in more detail on the following pages.

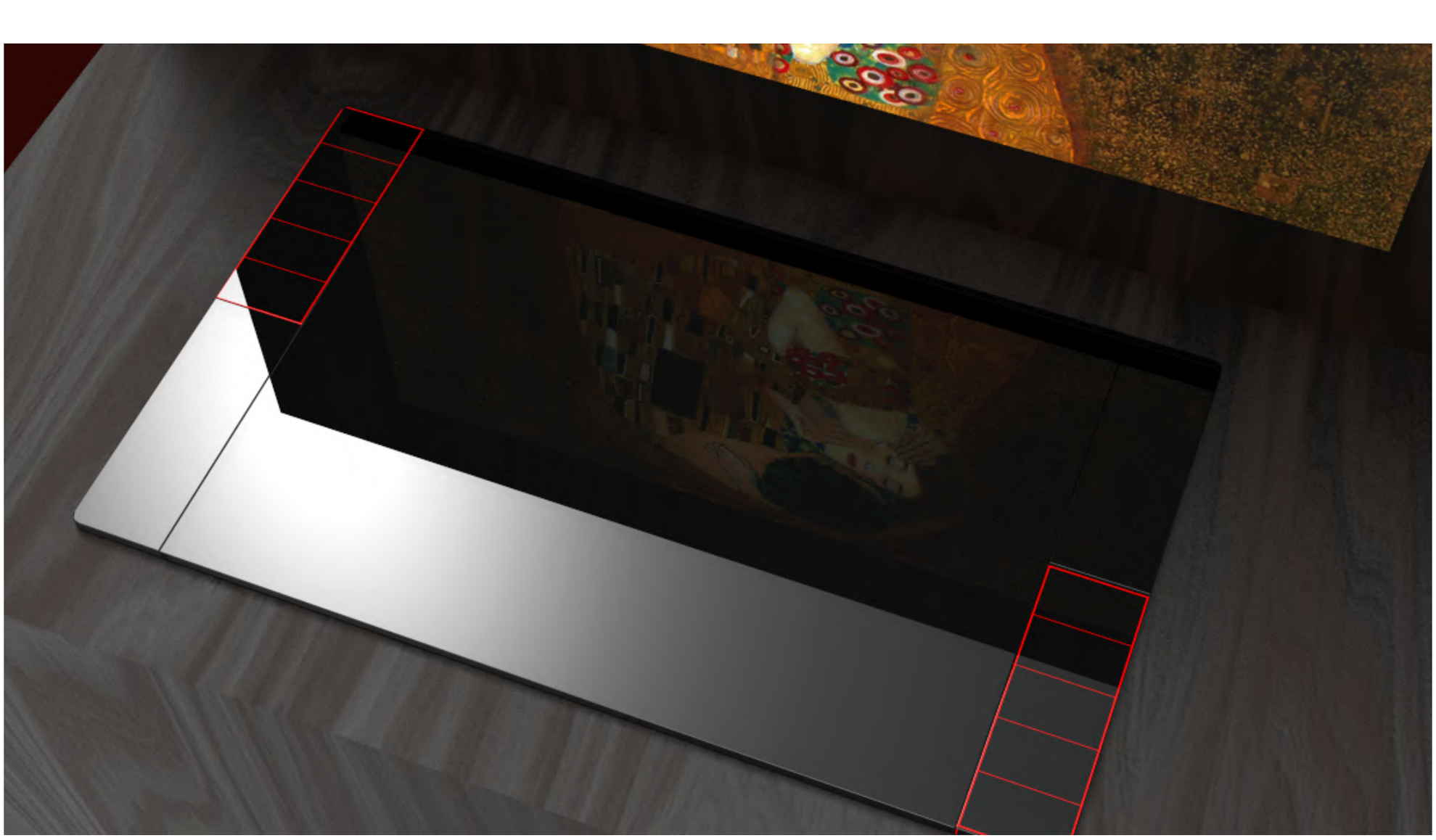

Figure 28: Final concept interfaces of gesture interaction panels

# Turn on the cooktop

We decided to use voice control to switch on the entire cooktop. To do this, the user must say the command "Hey cooktop, turn on". He then receives acoustic feedback in form of sound and the entire cooktop is outlined by a red light to make clear that the cooktop is now active. It can also be switched off the same way.

The voice control ensures that the cooktop does not switch on accidentally as this could lead to fatal problems. In addition, only the language of people who are registered are recognized to ensure that children do not have access to it.

We deliberately chose voice control rather than a gesture because it is safer and it does not force the user to learn a complex gesture in order to turn the cooktop on. It would otherwise make the interaction more difficult and thus make the user experience worser. In addition, switching on must be as intuitive as possible and should not require the user to remember a complex gesture.

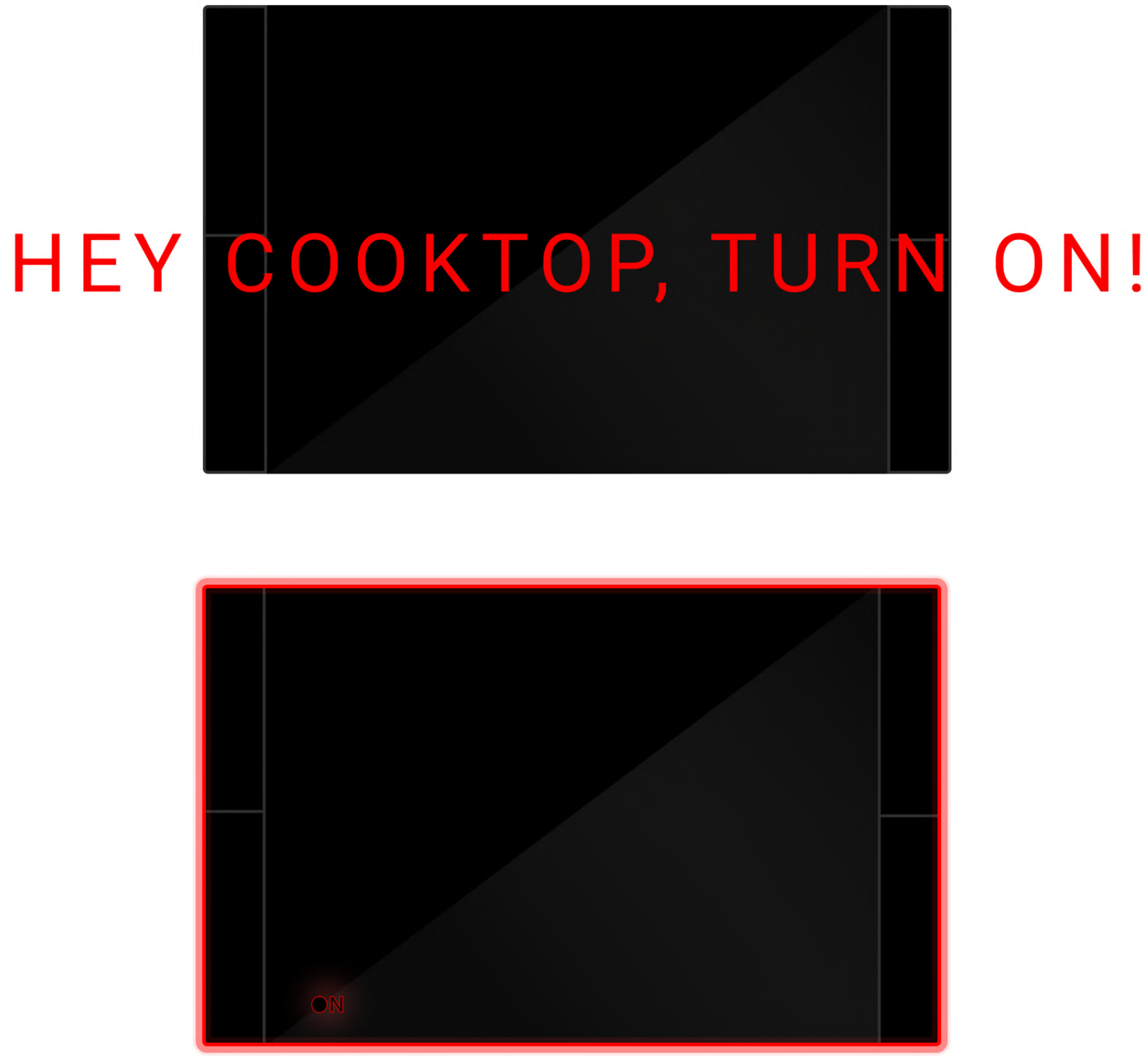


Figure 29: Visual feedback when cocktop turns ON

# Activating and unlocking the panel

During the cooking process, the user moves frequently and performs a variety of gestures over the cooktop. Therefore it must be ensured that an unconscious gesture is not accidentally recognized as an action and thus triggers a false positive.

On the other hand, gestures that are too complicated and complex should not be used for the interaction, as this makes it more difficult to use.

For this reason, we had to make sure that the user's movements are not recognized as a gesture if they don’t intend to interact with the cooktop. This way we integrated an activation gesture of the control panel.

In order to regulate the heat, the user has to hold his flat hand for 2 seconds over the panel. This is supported by a circle indicator, so the user can see the progress of time. After activation, the control panel receives an illuminated red frame to signal that it is now active and the heat of the selected field can be regulated.

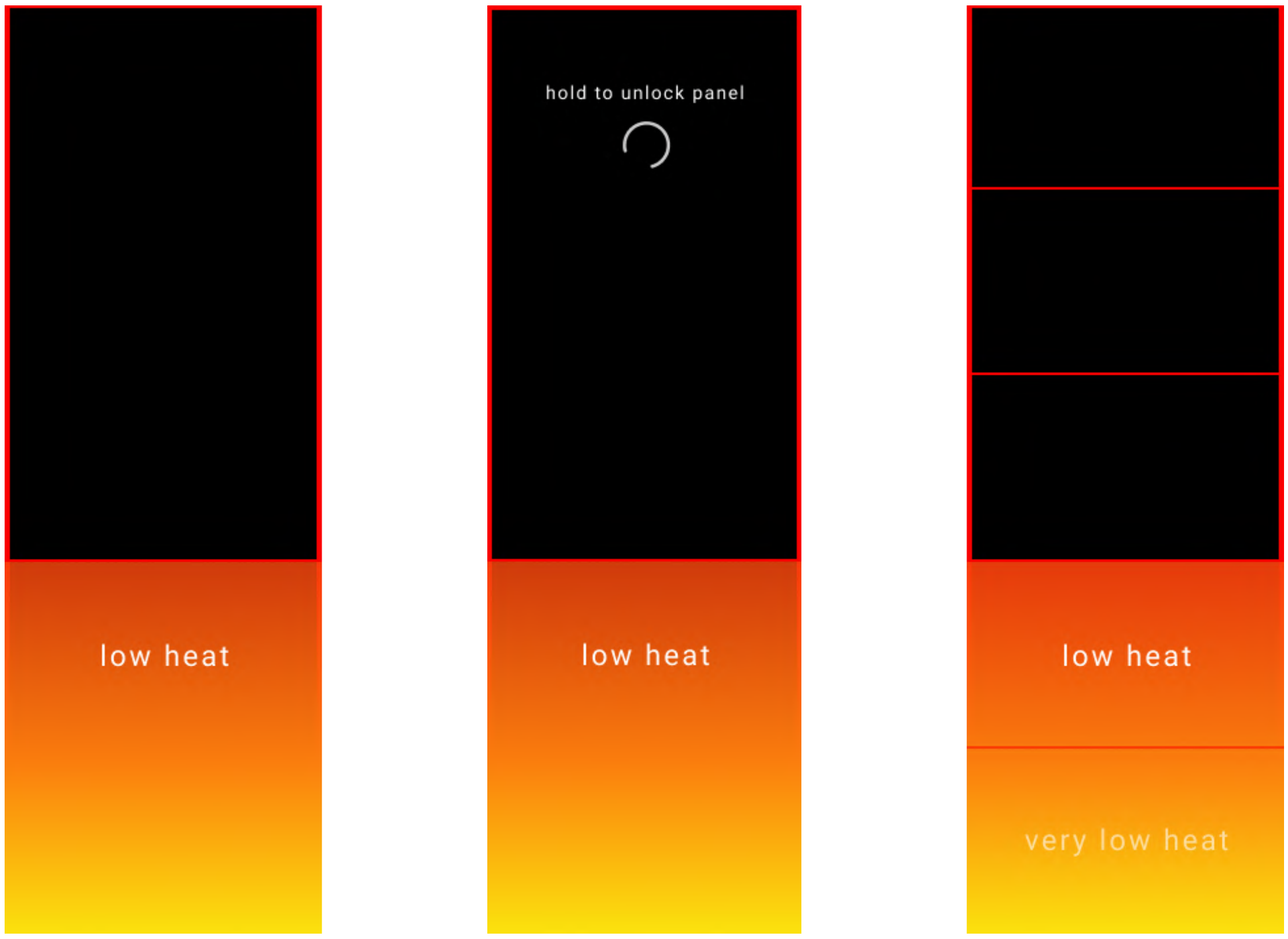


Figure 30: Activating and unlocking the panel to raise or reduce the heat

# Adjusting heat

The control panel is divided into five areas, which stand for the respective heat levels. There are a total of five different levels of heat, which are shown in the figure below.

The individual heat levels are represented on the one hand by a label, and on the other hand by a gradient which shows the highest heat in a dark red and the lowest in yellow.
We deliberately chose wording for the label and not the representation of heat with numbers. In order to regulate the heat, the users hand is mapped almost 1:1.

We defined certain areas for the individual levels in which the user's hand must be placed in order to set the heat level. The user thus moves his hand in a horizontal direction over the control panel. Moving from the bottom to the top increases the heat and the opposite movement reduces the heat.

Due to the position detection of the hand, the user is not bound to certain gestures and can also quickly move his hand to the height of a certain level and quickly reach and activate it.

To switch the cookfield off, the user can slide to the bottom to adjust “no heat”.

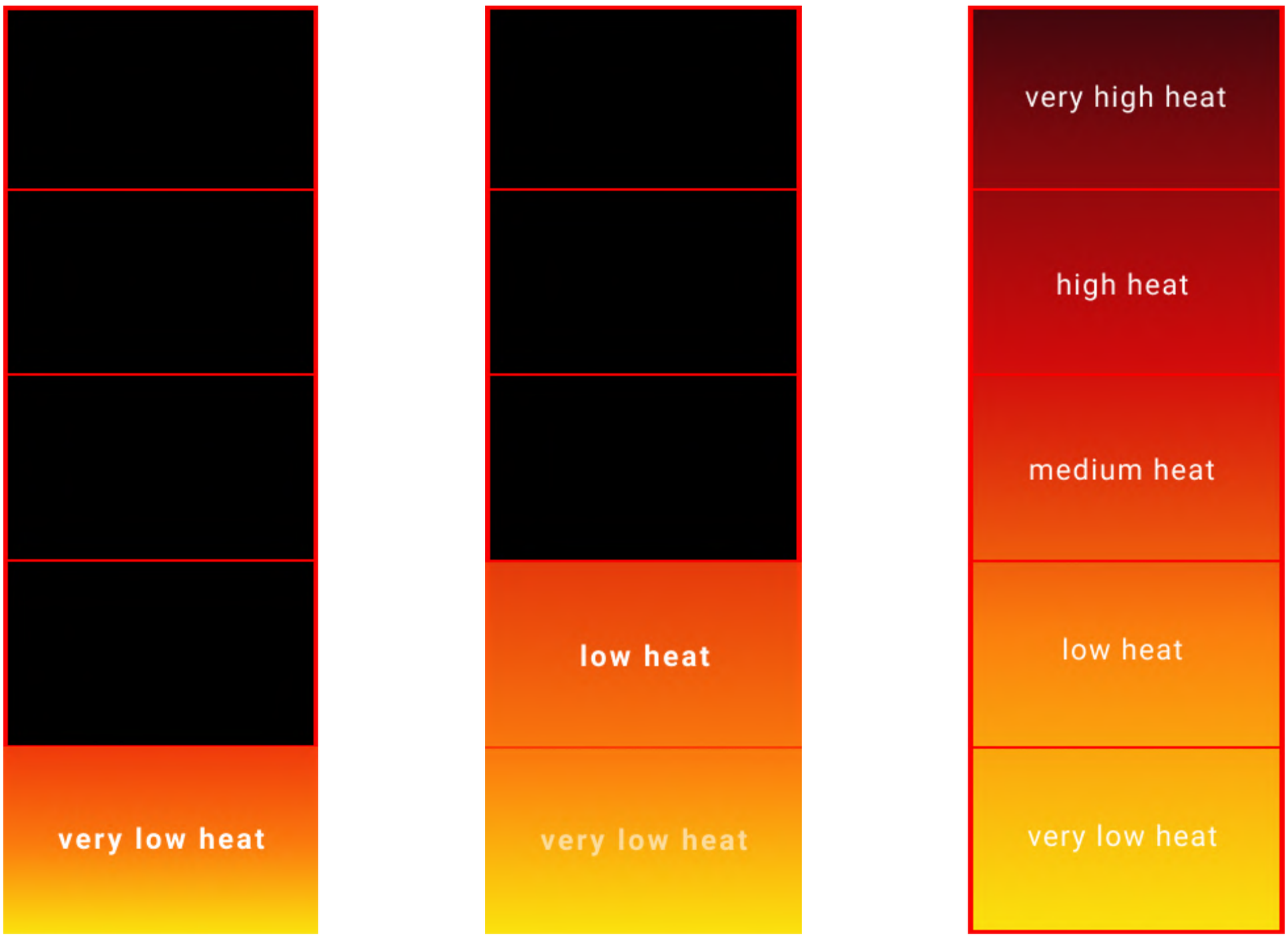


Figure 31: Adjusting the heat with slide gesture and visual feedback

# Fixing heat

After the heat has been regulated, the system must ensure when the hand is pulled away, the heat is not accidentally changed without the user noticing it. Therefore false positives have to be prevented.

For this reason there is the option to fix the level of heat. In order to fix the heat, the user has to hold his hand again for 2 seconds over the control panel. It is the same procedure like unlocking the panel. It is just an inverted interaction and the user is able to use the same gesture.

Fixing the level is also supported here by visual feedback, as one is used to from the unlocking interaction.


Figure 32: Fixing the heat to desired level by holding the hand for 2 sec

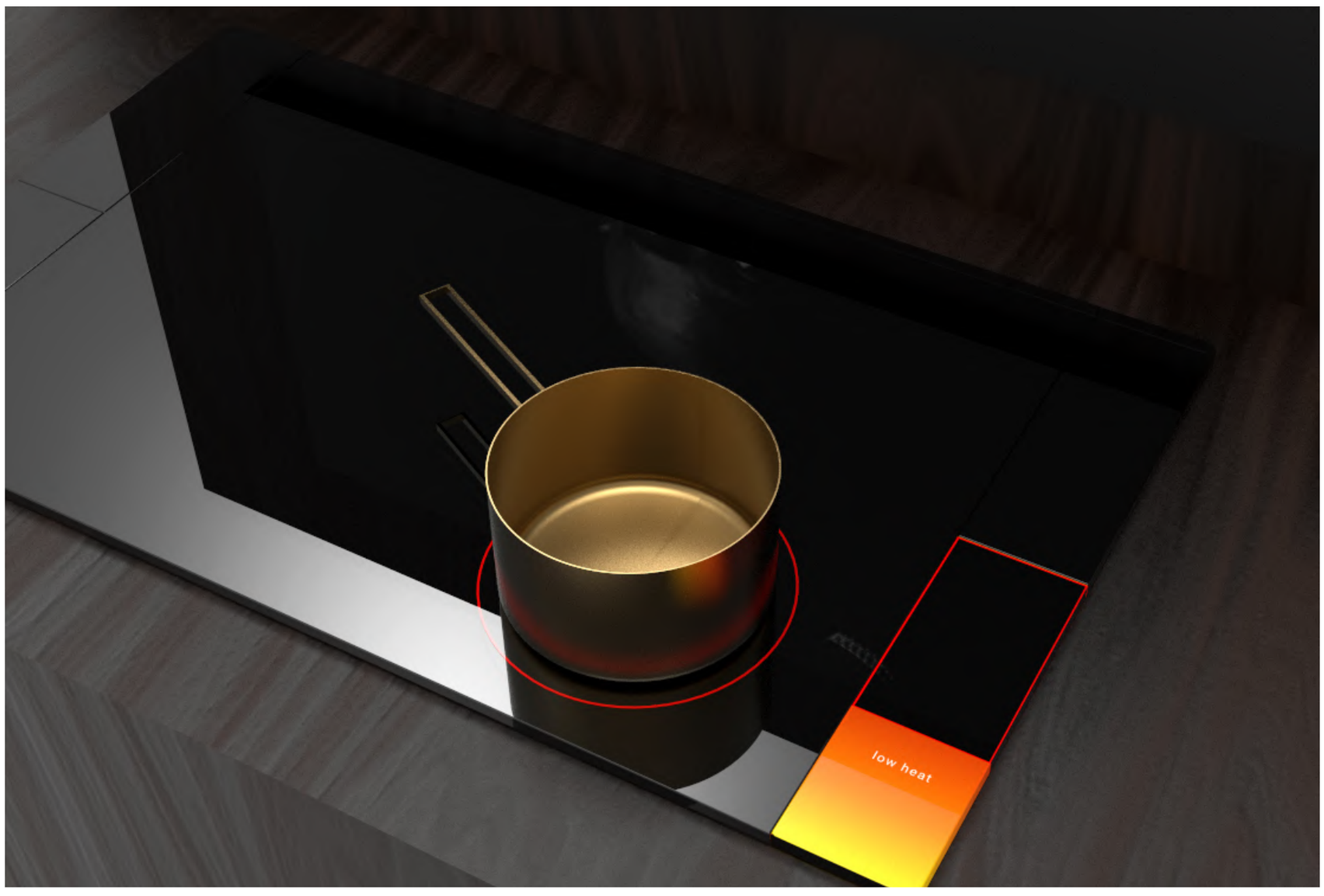


Figure 33: Visual rendering of the smart cooktop

# Conclusion

Our aim in our natural user interface project was to improve the interaction with the cooktop with the help of natural interaction elements. In the end we used basically two differnt gestures for interacting with the cooktop. A slide gesture and a hold gesture. Sliding to adjust heat, holding to unlock and lock the panel.

We wanted to keep it as easy as possible to make that complex new interaction with gestures graspable for the user. We also included voice interaction for turning on and off the cooktop. This enables the user a completely hands free interaction with the device.

The gestures appear logic, memorable and easy to the user as we found out with our user testings.

The human centered design appproach with the different testings helped us to collect different insights like, the mental models of the user, if the gestures are logic, feasibly and intuitiv and also the acceptance of the overall gesture thematic.

All in one cooking with gesture interaction is an improvement compared to the current touch interaction. You have four adjusment panels to make the cooking process as flexible and efficient as possible.

Also elderly people are included as the GUI consists out of 5 heat levels which are easy to adjust by sliding. The User interface is readable and the color gradient supports the ease of understanding and perceiption of the adjusted heat.


Figure 34: Visual rendering of the cooktop

# Table of figures



*All other pictures are created by ourselves*