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# Elicitation study for a Smart Weather Station

*Application with a Leap Motion Controller*


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# Abstract

More and more devices are being developed that allow applications to be controlled using gestures, as this has a number of advantages. However, defining the exact gestures for each command and application is not an easy task. In fact, the 3D dimension of gestures and their great diversity open up a wide range of possibilities and make them more difficult for people to learn. This thesis analyses which gestures would be the most intuitive for users, in order to have gestures that are as user-friendly as possible. The application chosen is that of a smart weather station, with fifteen associated instructions. These commands will mainly control functions that are specific to this application. The analysis will be carried out in relation to a possible real-life application using the Leap Motion Controller, an infrared camera capable of detecting hand gestures.

In order to obtain the most intuitive gestures, an elicitation study is carried out as follows. In a preparatory phase, the fifteen instructions are identified and linked to referents (descriptions of the action and its result). Twenty-five participants are asked to perform a gesture for each instruction, which is recorded by the Leap Motion Controller. Each participant also gives a score out of seven to rate how well their gesture matches the referent. These gestures are then classified into forty categories, allowing general trends to be identified. For each instruction, the most frequent or two most frequent gestures are also identified.

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# Chapter 1

# Introduction

## 1.1 Context

Machines and applications are nowadays omnipresent in our lives. A lot of these devices are now controlled by touch screens, as this is for example the case for smartphones, tablets or smart watches. New ways of controlling applications however are arising, such as smart gloves (Bhaskaran et al. 2016), smart rings (Gheran et al. 2018, June), or smart armbands like the *Myo Armband* (Eadicicco 2016, January). In this thesis, an analysis will be made, based on a camera capable of recognizing hand gestures as a way to control different applications. The camera model used is the Leap Motion Controller: a small infrared camera, capable of recognizing hands at a distance of approximately 30 cm. This device will be used in the context of a Smart Weather Station, in which it is possible to consult the temperature of the room, or its humidity level for example.

## 1.2 Problem

As more applications for gesture-based control emerge and alternative devices are developed, there is a need to choose the best gestures for each application. Finding the right gestures can be complex: there is a huge variety and a balance needs to be struck between something that is easy to remember, easy to perform and meaningful to as many people as possible. For example, for a smart weather station, finding the optimal gesture to display the $CO_2$ level can be challenging. In addition, each device has its own limitations as well as its advantages that should be exploited. In the case of the Leap Motion Controller, gestures should only involve the user's hands, as it cannot recognize any other part of the body. Shaking your head, for example, will not be recognized.

## 1.3 Motivation

Being able to control applications solely with gestures presents a great deal of benefits for several media. When used with virtual reality devices for example, it can reduce the simulator sickness. It is also very useful for an easy and effective visual feedback when used in augmented reality. Gesture control can present some interesting advantages in a lot of different domains as well. In healthcare, where sterility is a key issue, it can allow surgeons to control certain application without having to touch anything (Rise and Alsos 2020). Another example is the use of gesture-based interaction to control basic car functions, with as objective to be less distracted while driving. In the context of a smart weather station, having a gesture controlled application can be a practical way of accessing data more quickly, without having to search through the menus. In addition, if people are already familiar with these gesture-based commands for basic applications, they will be better able to handle more important applications and limit mistakes that could have serious consequences.

Gesture control can also have some drawbacks. Firstly, devices need to be able to recognize the different gestures correctly. The limitations can be at a hardware level: a gesture-recognizing camera needs to have enough background contrast to allow users to control applications in darker environments, for example. On a software level, recognizing the correct gesture can be difficult, as the execution of the gesture can vary from person to person. As touch screen controls have been around for some time now, humans can also have trouble adapting to a new sort of interaction (Attwenger 2017, June). Finally, 3D gestures can be more difficult to learn than their 2D counterparts, as the addition of a new dimension increases the diversity of gestures. The last two drawbacks can and must be reduced by choosing intuitive and easy gestures.

Overall, depending on the application, the use of gesture based control can be very beneficial and choosing the right gestures can significantly limit some important drawbacks.

## 1.4 Objectives

The aim of this thesis is twofold. The first objective will be to identify the best gestures for controlling a smart weather station. Fifteen commands have been defined, specific to this application. An analysis will be carried out to determine which gestures humans would naturally use to represent these commands. The aim is to discover which gestures would be the most intuitive for each of these commands, but also to analyze these gestures in order to draw some useful conclusions for other applications.

A second objective is also to measure each one of these gestures using the Leap Motion Controller. This data can then in the future be used by the QuantumLeap framework to recognize the command modeled by the gesture, as well as map the gestures to functions of the smart weather station (Sluÿters et al. 2022).

## 1.5 Approach

In order to find the most intuitive gestures, an elicitation study will be conducted. Twenty-five participants will be asked to invent a gesture they deem fit for a particular command. The thinking time will be measured and after each gesture the participants will be asked to rate its goodness of fit on a scale from one to seven. The participant's gestures will also be recorded using the Leap Motion Controller and the QuantumLeap framework (Sluÿters et al. 2022).

Each of the gestures of the participants will then be classified into different categories of similar gestures. During this categorization, the intention behind the gesture will prevail over the gesture itself. This categorization will provide an overview of the participants' gestures, and will make it possible to determine which gestures would be the most intuitive for each instruction. Each category of gesture will also be classified according to its nature, form and range of motion, in order to analyze the trends in the different gestures. An analysis can be carried out as such, putting into perspective the different ways of inventing gestures.

## 1.6 Contributions

We distinguish two different types of contributions for this thesis. First, the most frequent (or the two most frequent) gestures are identified and characterized for fifteen instructions of a smart weather station. A broader analysis of the types of gestures created by the participants is also carried out and discussed.

The second type of contribution is the data collection of the Leap Motion Controller recordings. For each of the twenty-five participants, every single gesture was recorded and can be used as a basis for further analysis and AI training.

## 1.7 Roadmap

The structure of the thesis will be as follows. There will first be a description of important background information. In this chapter, the smart weather station as well as the concrete application will further be described, and an extensive description of the Leap motion controller and how it works will be provided. The term elicitation study will also be defined.

The third chapter details the methodology, explaining the approach before, during and after the experiment. In this first section, the criteria for the selection of the commands are defined. The next section explains the procedure of the experiment, and the last section describes the choices for categorizing the gestures.

The results are then presented in Chapter 4. This will include the socio-demographic background of the participants as well as the categories of gestures and their classification in terms of type, range of motion and form. The most frequent gestures for each instruction are also detailed, as well as the agreement rate and agreement score (measures of how much the participants agree on the gestures for a particular instruction) for each instruction. Finally, the average goodness of fit and the thinking time for each instruction are displayed.

Chapter 5 will contain a detailed analysis of the gestures and their characterization. Finally, we will conclude with a brief overview of the thesis, its advantages and disadvantages, threats to validity and possible future work.

# Chapter 2

# Background Material

## 2.1 Application: Intelligent Weather Station

For the purposes of this thesis, the context chosen was that of a smart weather station. All of the commands were based on an app provided by *Netatmo* and their *Smart Home Weather Stations*.

### 2.1.1 Netatmo

Founded in 2011, *Netatmo* is a French company manufacturing smart home solutions. *Netatmo* has since integrated the *Legrand Group* and has even won twenty awards. They consider their product as innovative, inspiring and elegantly designed. Their products include Smart Thermostats, Smart Indoor and Outdoor Cameras and Smart Door Lock and Keys. The first product they launched however, is their Smart Home Weather Station, which will be used in the context of this thesis (*Our work* n.d., *Netatmo* 2024, March).

### 2.1.2 Netatmo's Smart Weather Station

*Netatmo*'s Smart Weather Station allows users to monitor several weather parameters inside and outside their home in real-time. It comes with two stations: the indoor station and the outdoor station. The first set of sensors measures the inside temperature, humidity, noise, CO2 and pressure. The outdoor station records the outside temperature and humidity.

All of the data is available on an app the company developed. This allows the clients to access this information wherever they are, as long as they have an internet connection. Another feature of the application is the ability to consult previous measurements. As such, users can consult graphs showing the evolution of the various meteorological variables. They also include a seven day weather forecast for the particular area the captors measure. This forecast includes a great number of variables, such as the temperature, the wind direction, how much rain they predict, etc. Finally, the last feature that will be discussed is the *Netatmo Weathermap*. *Netatmo* allows its clients to consult the weather data from all its community. One can this way consult the weather measured by any other exterior station in the world (*Netatmo Weathermap* n.d.).

The app's home page is shown as well as some displays of the different features are available on figure 2.1.

## 2.2 Leap Motion Controller

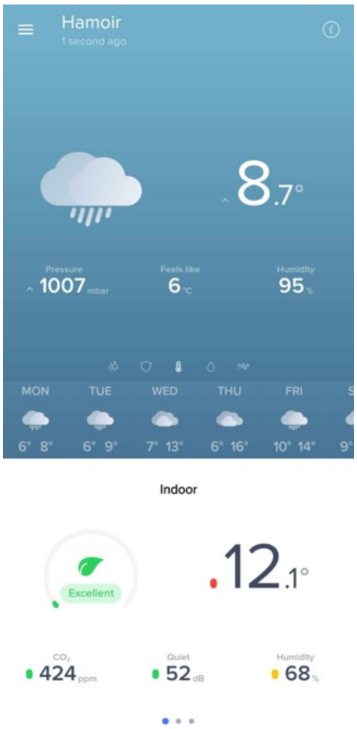
The device that will be used during this thesis to record the hand gestures is the Leap Motion Controller.

### 2.2.1 Description of the Leap Motion Controller

The Leap Motion Controller is a product originally sold by the *Leap Motion* company. It has now been bought by *Ultrahaptics*, creating this way the company *Ultraleap*. This hand tracking camera is already being used for several virtual reality applications. In particular, *Ultraleap* advertises the use of the Leap Motion Controller for enhanced learning, by emphasizing the benefits of practicing practical skills in a safe environment (*Leap Motion* 2024, March).

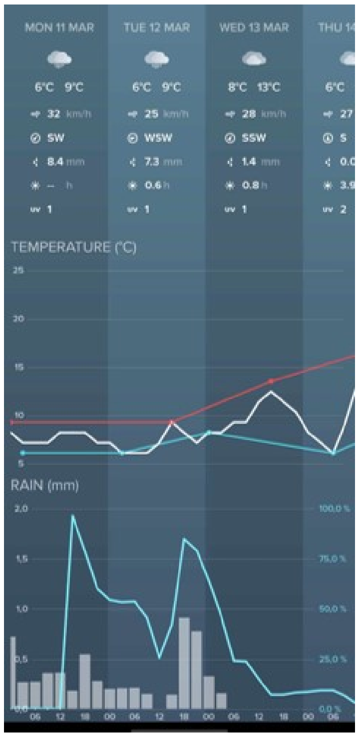
Two cameras with infrared LEDs are mounted on the Leap Motion Controller. The lenses are large enough to recognize hands in a wide area, allowing the user to make large movements. The hand tracking software then processes the images and reconstructs a 3D view of the user's hands and fingers, (*How Hand Tracking Works | Ultraleap* n.d.).

Because the software only reconstructs the hands, movements involving other parts of the body are not recognized. For example, movements in which a person's hands touch their ear or shake their head are not recognized. These movements were therefore not allowed during the study.

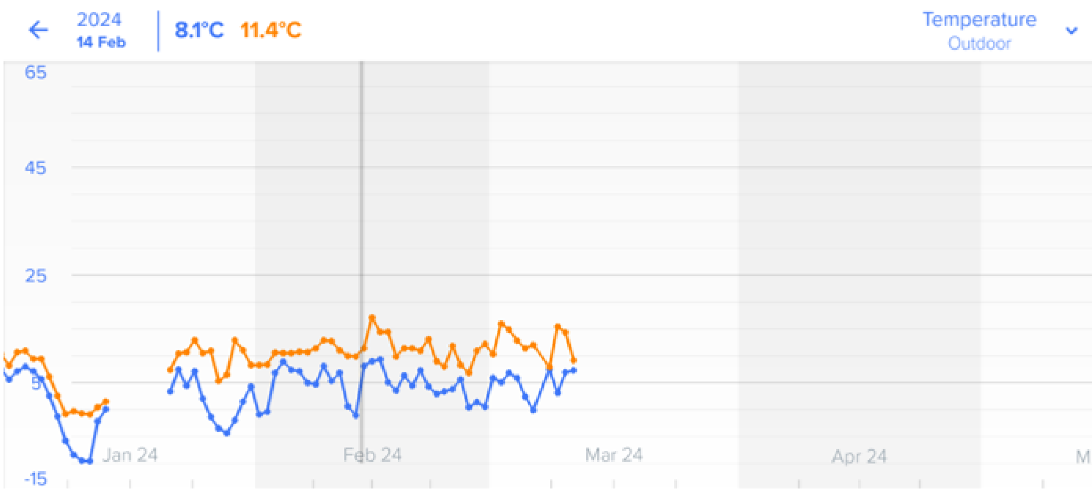



(a) Home page


(b) Weathermap




(c) Seven days forecast




(d) Evolution of the Outdoor Temperature

Figure 2.1: Different screen displays of the *Netatmo Weather App*

## 2.3 Elicitation studies: definition, benefits and limits

An elicitation study can be defined as a study which gathers input from end users by asking them to propose their own gestures for specific predefined functions, using referents, with the aim of reaching a common agreement. Invented by Wobbrock et al (Jacob O Wobbrock et al. n.d.) in 2005, these types of studies have grown in popularity, and in 2024, 267 of such studies have been identified by Villarreal-Narvaez et al. 2024.

Benefits abound: information is spontaneous (in the right context), there are no side effects, and it's easy and cheap to conduct. However, *legacy bias*, the influence of using existing technologies on the invented gesture, can affect the results. This method can also lack creativity (Villarreal-Narvaez et al. 2024).

# Chapter 3

# Method

## 3.1 Preparation

### 3.1.1 Choosing the commands

The first step was to identify the instructions that would be asked of the participants. After a number of iterations, a total of fifteen instructions were selected. The aim here was to select commands that were closely related and specific to the *Netatmo Weather App*. These final instructions can be divided into different categories. First, there are five commands that display a specific meteorological variable: temperature, pressure, humidity, $CO_2$ level and noise. The second category uses the same variables, but displays their evolution over time. A third category of commands controls the *Netatmo Weathermap*: zoom in, zoom out and move the map around. Two additional instructions were chosen: *displaying a seven days forecast* and *changing the theme (light <> dark)*.

The instructions are written with a touch screen application in mind, such as *swipe left to access the temperature*. Instead, a command stating *display temperature* is used. Another example are the instructions *display the menu* and *dismiss the menu*, which were not included because one of the many benefits of gesture control is to limit the use of a menu. Finally, commands that were too complicated, either because they were meteorological terms that people were not familiar with, or because they were a combination of too many terms, were also discarded or merged. This was for example the case for the command *display dew point* for the first case. For the second case, the commands *display indoor temperature* and *display outdoor temperature*, and *display indoor humidity* and *display outdoor humidity* were merged to two commands displaying the temperature and humidity.

There were two reasons for this decision which was taken after a test experiment. Firstly, to prevent the experiment from being too long and thus the quality from withering towards the end of the experiment, and secondly, because it was too difficult for the test participant to come up with specific gestures, who eventually gave up.

The final set of instructions is the following:

1. Display Temperature
2. Display Pressure
3. Display Humidity
4. Display $CO_2$ level
5. Display Noise
6. Display 7 days forecast
7. Show the evolution of Temperature
8. Show the evolution of $CO_2$ level
9. Show the evolution of Noise
10. Show the evolution of Pressure
11. Show the evolution of Humidity
12. Change theme (Light <> Dark)
13. Zoom out to navigate to another weather meter
14. Zoom in to navigate to another weather meter
15. Move the map around to navigate to another weather meter

In the rest of this thesis, the instructions 1-5 will sometimes be referred to as *display the variable X*, and instructions 7-12 as *show the evolution of variable X* to represent any of these instructions.

### 3.1.2 Referents

In order to give all the participants the same unbiased information, a referent was made for each command. A referent is an explanation of the instruction that all participants can refer to and allows the command to have an unequivocal meaning. Each referent consists of a title defining the instruction, and two screens displaying the application view respectively before and after the command. An example of such referent is available on figure 3.1, and all referents can be found in Appendix 1. In the rest of this thesis, the instructions will sometimes be referred to as referents.

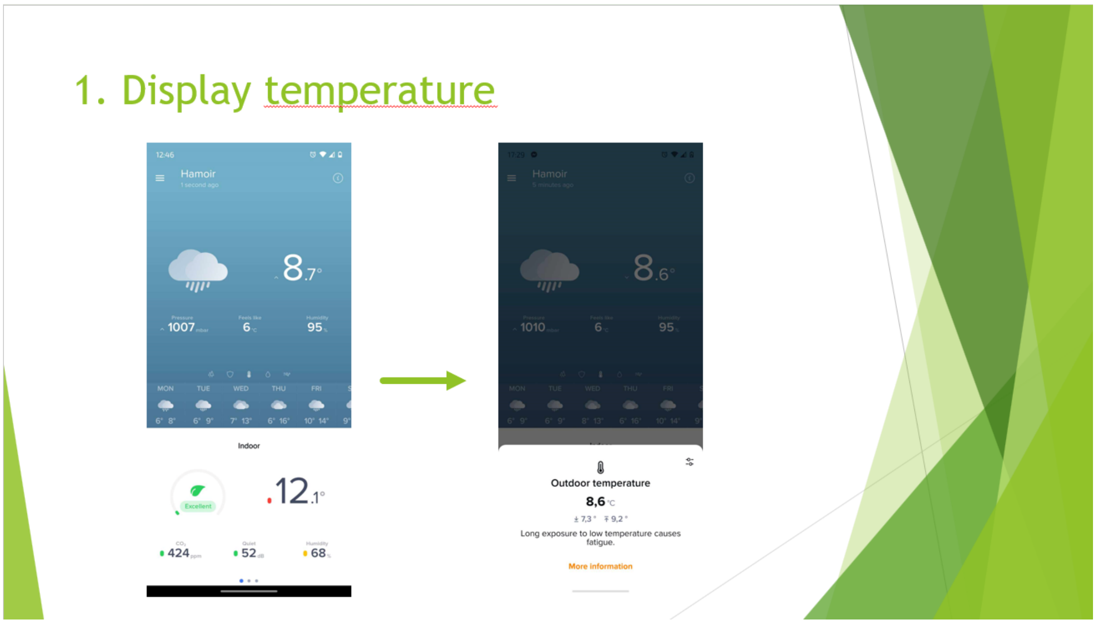



Figure 3.1: Referent for the first command: *display temperature*

### 3.1.3 Test Participant

As previously mentioned, the experiment was conducted a first time with a test participant to ensure the quality of the procedure. This allowed the instructions and the procedure itself to be refined. It also gave the experimenter the opportunity to go through the whole procedure once and eliminate as much non-objective behaviour as possible.

## 3.2 The experiment

### 3.2.1 Forms and Preliminary Information

Each participant is first asked to complete a short form. This form includes demographic data such as gender, age, activity domain as well as data regarding frequency of use of technological objects. Participants are asked to rate their frequency of computer, phone, tablet, console and kinect use on a scale of one to seven.

The context is then explained to the participants, as follows. They are introduced to the possibility of gesture recognition and its more intensive use in the future, explaining that the aim of this thesis is to find out which gestures would be the most intuitive for certain commands within a given application. They are then explained the background to the smart weather station, and to the *Netatmo* company. It is made sure they understood the various functions implemented in the application, so that they will have as few doubts as possible when discovering the referents. The difference between the categories of *display variable X* and *show the evolution of the variable X* is also explained in this context.

The participants are then immediately explained how to use the Leap Motion Controller, so as not to give them time to think about potential gestures, in order not to skew the experiment. They are told what it is, how it works and then given a few minutes to test the device freely.

Finally, the procedure is explained, emphasizing that the presence of a timer does not limit their thinking time and that they have as much time as they need. When they have no more questions, the experiment can begin.

### 3.2.2 Procedure

The same procedure is applied to each command. The referent of the command is first shown to the participant. A timer measures the time taken to think of a gesture. When the participant knows which gesture they are going to make, they signal it to the experimenter, who stops the timer. The participant then records the gesture on the Leap Motion Controller while being filmed by the experimenter. Once the gesture is correctly recorded, the participant rates its *goodness of fit* (how well the proposed gesture fits the referent) on a scale of one to seven. The participant can then move on to the next command.

### 3.2.3 Evaluation

At the end of the experience, the participants are asked to fill out a last survey. in this form, participant can rate the usability, design and productivity of the Leap Motion Controller, marking the end of the experiment. At last, to eliminate as many external stimuli as possible, the order of referents is randomized after each participant.

## 3.3 After the experiment

After all the experiences had been completed, a classification of the different gestures had to be made. A total of 371[1] gestures were classified into 40 categories. The categorization was based more on the intention behind the gestures than on their appearance. This means that two similar gestures with completely different meanings can be classified in two different categories. Similarly, two different gestures with the same intention can be placed in the same category.

For example, the gesture of putting a hand flat down towards the table, has been used in two contexts: *display pressure* and *change theme (light <> dark)*. The first one has been classified as *imitation of pressure*, and the second one as *idea of covering something*. However, tingling fingers representing rain and a drop imitation, though different in gesture

[1] Unfortunately, four gestures (all from different participants and different instructions) were lost due to technical problems.

outlook, have been classified into the same category: *imitating rain*.

Another classification decision was to discard the parts of the gestures that made no contribution. For example, one participant consistently added a gesture to represent the word *'show'* in the instructions. As a result, they had three gestures for the instructions *show the evolution of variable X*, instead of two like most of the other participants. It was decided to include only the other two gestures in the classification.

Finally, a last choice has been made regarding the categorization. As explained in the first section, there are five commands for displaying a meteorological variable and five commands for displaying its evolution. What the participants very often did was to set up a system in which they invented a gesture for the meteorological variable, another for the concept of a graph or an evolution, which they then put together for each *show the evolution of variable X* command. A new category was therefore created each time to distinguish between commands for displaying the variable and those describing its evolution. Thus, if two participants had the same gesture for a variable, but implemented the idea of the graph differently, their gestures were originally classified in different categories. This resulted in a very large number of categories. It was eventually decided to differentiate only when the variable was different, but to group together gestures with different implementations for the graph concept (provided it was indeed the same concept behind it). In fact, these gestures were not very different and all had the same idea behind them. This meant that the number of categories could be significantly reduced without compromising quality.

# Chapter 4

# Results

## 4.1 Participants

A total of 8 women and 17 men took part in the experiment. 22 of them are students, all in a wide variety of domains of activity. These include healthcare, engineering, IT, economics, psychology... The age range lies between 16 and 53, with an average of 25. Although the majority were right-handed (20 people), there were also four left-handers and 1 ambidextrous person. This is more or less in line with the world average, as there are around 10% left-handed people and 1% ambidextrous (de Kovel et al. 2019).

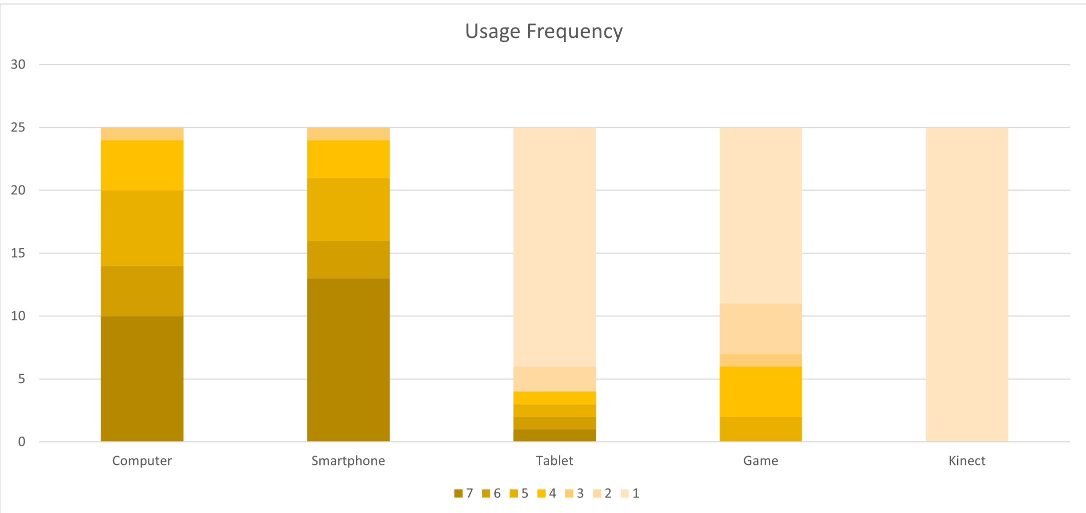



Figure 4.1: Participant's Usage Frequency for different devices

The frequency with which participants use the different devices varies greatly. The smartphone, for example, is widely used, with as many as 13 people using it very frequently (7 on the scale). The computer is also used very often, whereas the tablet and the game consoles are used less frequently. Finally, no one uses a Kinect.

## 4.2 Categories

The gestures have been categorized into forty categories. These categories are the following:

1. Rising hand/finger
2. Drawing in the air to represent a letter/number/figure
3. The static use of hands to represent a letter/number
4. Spread
5. Imitation of pressure
6. Fist
7. Static hand to represent a bubble or a circle
8. Mimic rain/drops/waves
9. Hand lying flat
10. "Ok" sign
11. Mime smoke or escaping air
12. Movement of hand going from fist to extended hand
13. Snap Fingers/Clap
14. Hands moving away (with the idea of displaying something)
15. Concept of a graph or evolution
16. Concept of a graph or evolution and a drawing in the air to represent a letter/number/figure
17. Concept of a graph or evolution and the static use of hands to represent a letter/number
18. Concept of a graph or evolution and static hands to represent a bubble or a circle
19. Concept of a graph or evolution and rising hand/finger
20. Concept of a graph or evolution and Imitation of pressure by : 1) hand moving towards the other hand (both hands facing each other), 2) hand/index descending
21. Concept of a graph or evolution and Opposite movement of pinching
22. Concept of a graph or evolution and Fist
23. Concept of a graph or evolution and Mimic rain/drops/waves or pretend to touch water
24. Concept of a graph or evolution and a Hand lying flat
25. Concept of a graph or evolution and an "Ok" sign
26. Concept of a graph or evolution and a Mime smoke or escaping air
27. Concept of a graph or evolution and a Movement of hand going from fist to extended hand
28. Concept of a graph or evolution and a Snap of Fingers/Clap
29. Lateral Hand Movement
30. (Two fingers of) Two hands moving apart
31. Sun/light mime then moon/sleep mime

32. Movement of hand going from fist to extended hand then back to a fist
33. Idea of covering something (by putting the hand flat against something)
34. Pinch
35. Arm movement with static hand
36. Hands coming together
37. Push against imaginary wall
38. Tapping a button/pulling on an imaginary thread (idea of activating a button)
39. Wrist rotation
40. Concept of a graph or evolution and a wrist rotation

A broader description of these categories can be found in Annex 2 and 3.

### 4.2.1 Taxonomy of the Gestures

#### 4.2.1.1 Nature

We can further analyze the categories of gestures by classifying them according to different criteria: their nature, their range of motion and their form.

The first criterion, a gesture's nature, can be divided into four types: symbolic, physical, metaphoric and abstract. A *symbolic* gesture is a gesture that visually depicts a common accepted symbol. This can be for example the *"ok"* sign for the meaning *"accept"*. A *physical* gesture interacts directly with the object, such as for example using an index to move a map. A *metaphoric* gesture links a gesture to a certain metaphor, as for example pressing an invisible button to turn the light on. Finally, gestures to which no specific meaning or reason seem to be attached are classified as *abstract* (Jacob O Wobbrock et al. n.d.).

For our application, 20% of gestures were symbolic, 28% metaphoric, 23% physical and 29% abstract. A more detailed distribution of the gesture's nature can be found on the graph 4.2. For the gestures involving the *Concept of a graph or evolution* and another variable, the nature of the variable was chosen, as it was deemed more specific to the instruction.

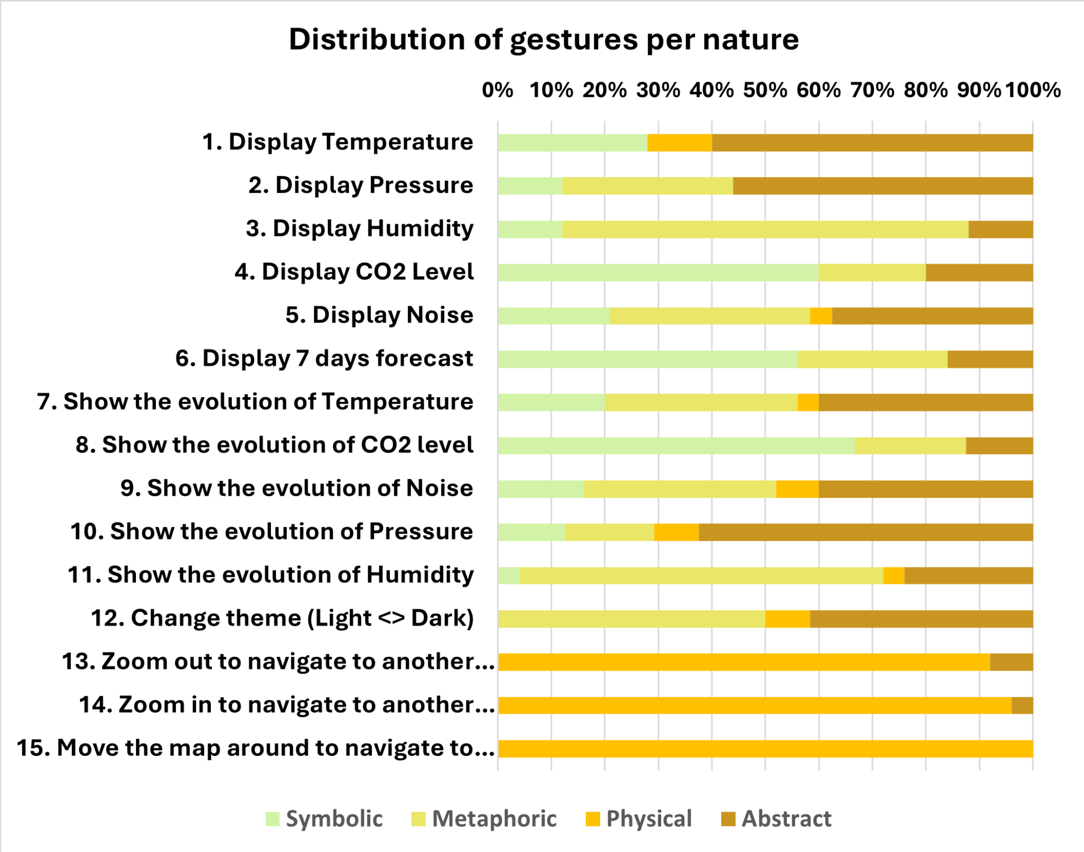



Figure 4.2: Distribution of the gesture's nature for each instruction

#### 4.2.1.2 Range of Motion

Gestures can also be classified according to their range of motion. The Range of Motion relates the distance between the position of the human body producing the gesture and the location of the gesture (Nyamabu and Vanderdonckt 2018). Possible values are as follows:

1. Close intimate (0cm-15cm)
2. Intimate (15cm-45cm)
3. Personal (45cm-1.2m)
4. Social (1.2m-3.6m)
5. Public (3.6m+)
6. Remote

Due to the context involving the Leap Motion Controller, all of the participant's movements were in an Intimate Range of Motion.

#### 4.2.1.3 Form

Each category of gesture has been characterized by its form. Four types of forms can be identified (Nyamabu and Vanderdonckt 2018, Jacob O Wobbrock et al. n.d.):

- **Stroke**: when the gesture only consists of taps and flicks
- **Static**: when the gesture is performed in only one location
- **Static with motion**: when the gesture is performed with a static pose while the rest is moving
- **Dynamic**: when the gesture does capture any change or motion

The form distribution for each instruction is shown in Figure 4.3. The absence of *stroke*-type gestures is immediately noticeable. However, the three other forms were all present in the vast majority of instructions. There is a general trend towards dynamic gestures, which make up a large percentage of many instructions.

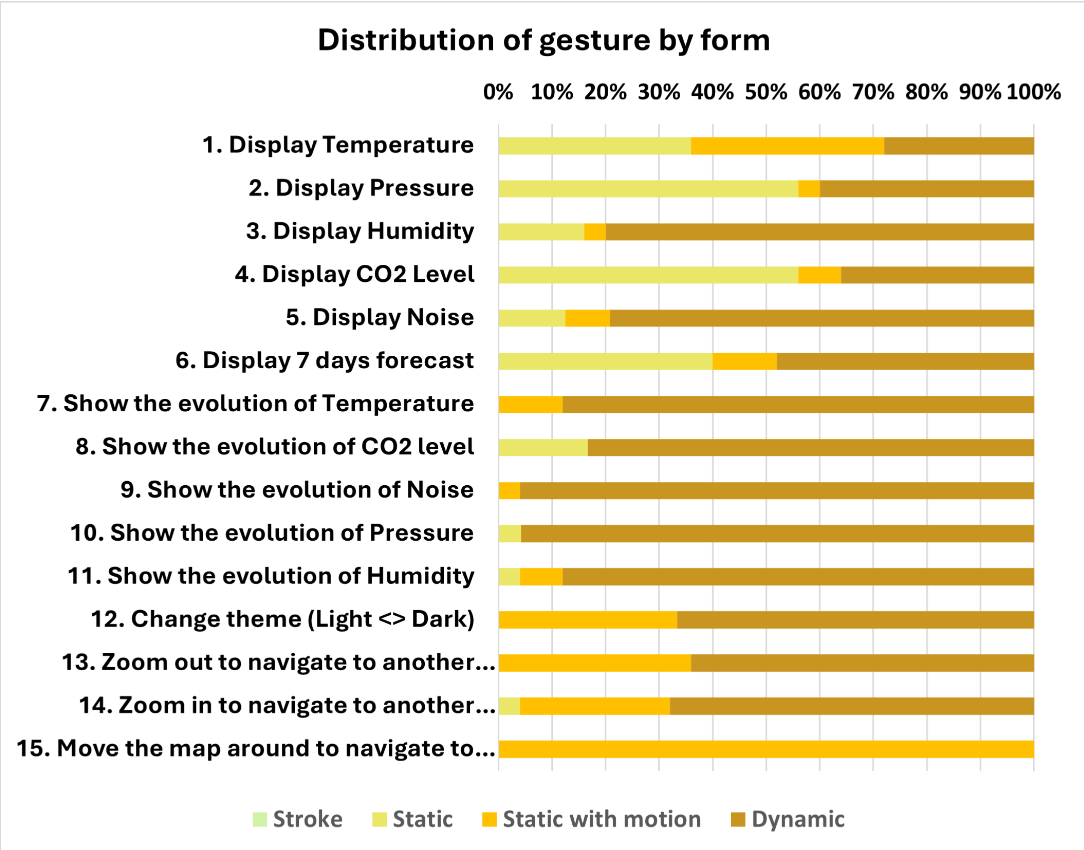



Figure 4.3: Distribution of the gesture by form for each instruction

## 4.3 Most frequently used gestures per instruction

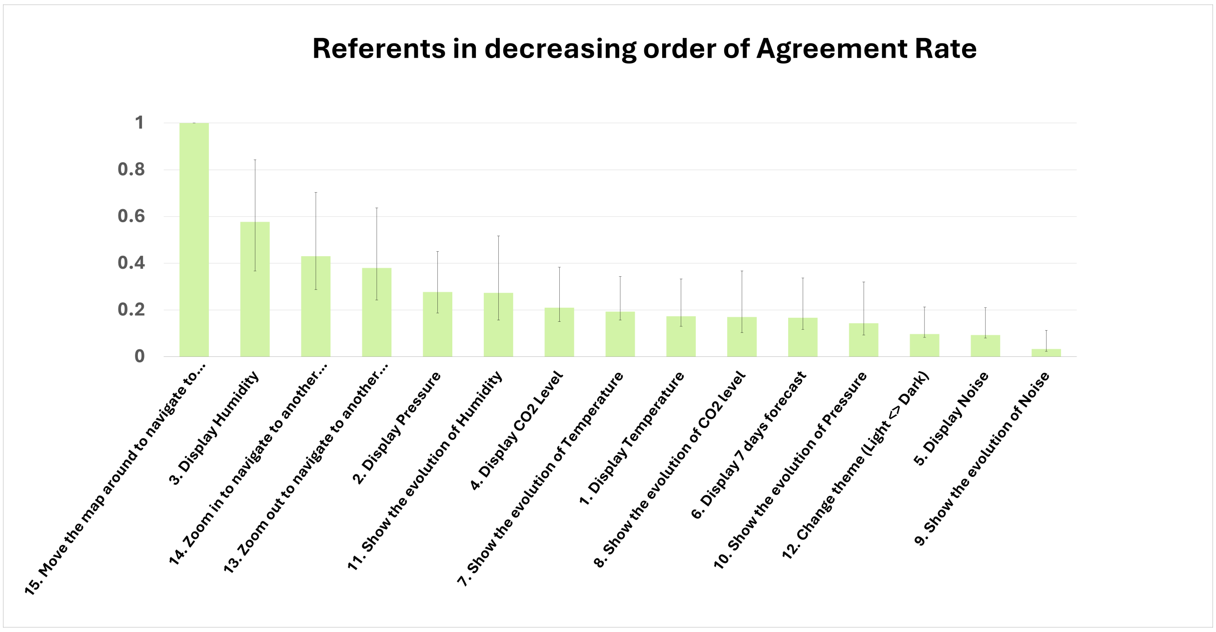
Once all the gestures have been categorised, the most intuitive gestures according to our participants can be defined for each instruction. The table 4.1 shows all the most frequent gestures for each instruction, with the number of participants who made this gesture for the given instruction in brackets. A gesture is considered to be frequent if it was imagined by at least five people for that particular instruction.

| **Referent** | **Category** |
|---|---|
| 1. Display Temperature | Rising hand/finger *(9)* |
| 2. Display Pressure | Fist *(11)*<br>Imitation of pressure *(8)* |
| 3. Display Humidity | Mimic rain/drops/waves *(19)* |
| 4. Display $CO_2$ Level | The static use of hands to represent a letter/number *(10)* |
| 5. Display Noise | Movement of hand going from fist to extended hand *(6)* |
| 6. Display 7 days forecast | The static use of hands to represent a letter/number *(9)*<br>Hands moving away (with the idea of displaying something) *(5)* |
| 7. Show the evolution of Temperature | Concept of a graph or evolution *(9)* |
| 8. Show the evolution of $CO_2$ level | Concept of a graph or evolution and the static use of hands to represent a letter/number *(10)* |
| 9. Show the evolution of Noise | *no agreement* |
| 10. Show the evolution of Pressure | Concept of a graph or evolution and Fist *(9)* |
| 11. Show the evolution of Humidity | Concept of a graph or evolution and Mimic rain/drops/waves or pretend to touch water *(13)* |
| 12. Change theme (Light <> Dark) | Movement of hand going from fist to extended hand then back to a fist *(6)* |
| 13. Zoom out to navigate to another weather meter | Pinch *(15)* |
| 14. Zoom in to navigate to another weather meter | Spread *(16)* |
| 15. Move the map around to navigate to another weather meter | Arm movement with static hand *(25)* |

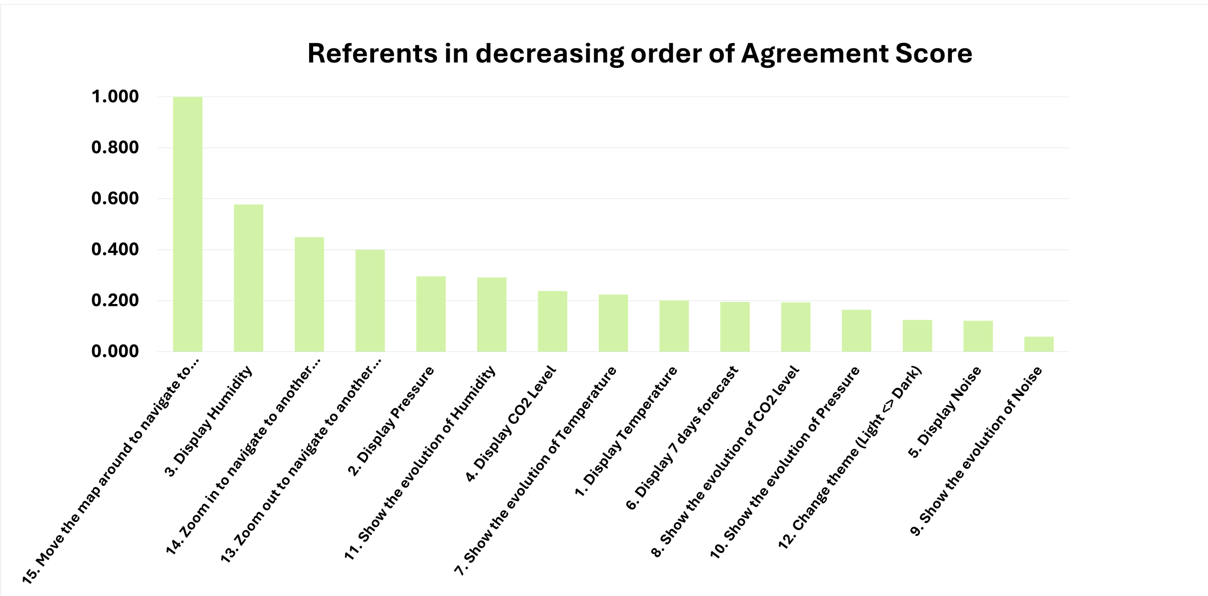
Table 4.1: Most frequent gestures for each instruction

## 4.4 Agreement Rate and Agreement Score

To quantify the extent to which participants agree on the gestures, two metrics were defined: the Agreement Rate and the Agreement Score. The first one was computed using AGATe (*AGATe Tool* n.d.), and can be calculated for each instruction as follows




(a) Agreement Rates




(b) Agreement Scores

Figure 4.4: The Agreement Rates and Agreement Scores for each referent, in decreasing order

(adapted from Vatavu and Jacob O. Wobbrock 2022):

$$AR = \frac{\sum_i \sum_{j \neq i} [p_i = p_j]}{N * (N-1)}$$

where $N$ represents the number of participants and $p_i$ (with $1 \leq i \leq N$) the proposal of the $i^{th}$ participant.

The second metric is the Agreement Score, defined as

$$AS = \sum_{P_i \subseteq P} \left( \frac{|P_i|}{|P|} \right)^2$$

where |P| represents the cardinality of the set of proposals for each command, and $|P_i|$ the cardinality of the $i^{th}$ subgroup of proposals that are in agreement (Vatavu and Jacob O. Wobbrock 2022).

The results, as shown on Figure 4.4, are very disparate, with agreement rates ranging from *0.059* to *1*, and agreement scores from *0.033* to *1*. Both graphs have (as expected) the same profile.

An Agreement Score is considered low if it is below *0.1*, medium between *0.1* and *0.3*, high between *0.3* and *0.5* and very high above *0.5*. In this case, we have only one instruction with a low Agreement Score, a majority of instructions with a medium score and two each for high and very high Agreement Scores.

## 4.5 Analysis of the Goodness of Fit and the Thinking Time

The values of the other experimental data, Goodness of Fit and Thinking time, are shown in Figure 4.5. Goodness of fit remains fairly constant for the first 12 instructions, with an average of 4.3, and even increases to an average of 6.2 for the last three instructions. Thinking times are more variable, but a similar trend can be observed: the values for the last three instructions differ greatly from the rest. Here the average thinking time for the first twelve instructions is 14.0 and for the last three instructions it is 6.7.

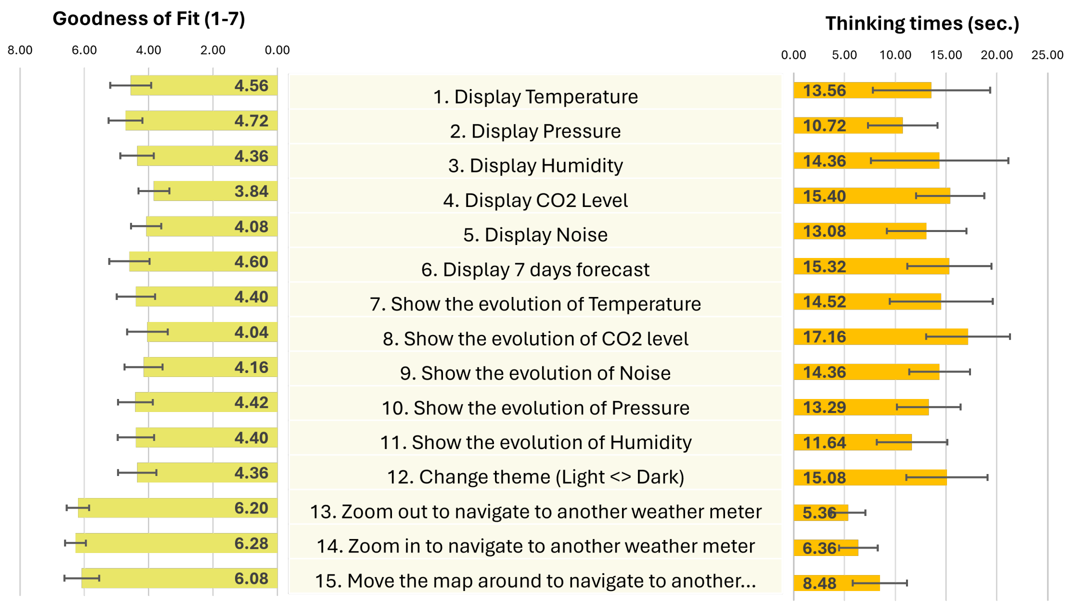



Figure 4.5: The mean Goodness of Fit and Thinking Time for each instruction

# Chapter 5

# Analysis

## 5.1 Participants

As the majority of the participants were students and quite young, it is no surprise that the usage frequency for computers and smartphones are so high. The effects of the high smartphone use are directly visible on some instructions and this is especially the case for the instructions controlling the *Netatmo Weathermap*. Indeed, to zoom in and out, a large proportion of participants opted for pinching and spreading gestures, imitating the gestures they would make on a touch screen. This is a perfect example of the effect of the legacy bias mentioned in Chapter 2.

## 5.2 Choice of categories

The number of categories chosen, forty, is quite large. Jacob O. Wobbrock et al. 2009's study for example, only has 27 categories, but has overall less intricate commands. Having fewer categories for this application would result in too widely differing gestures being grouped together in the same category. A large number of very different gestures are already in the same categories, but have the same idea behind them. For example, a gesture mimicking a slope and a gesture in which the profile of a graph is drawn have been classified together in category 15: Concept of a graph or evolution.

There are two reasons why so many different categories have been defined. The first is the large number of different abstract gestures. This is because the application itself is abstract, as weather variables, for example, are not something you can touch, and for some participants hard to visualize. So when participants use abstract gestures, they are often not at all the same, and therefore difficult to group together. A certain amount of flexibility was nevertheless allowed in the categorization when the abstract gestures presented the same type of profile.

The second reason is the choice of the referents themselves. The interdependence between the commands *display variable X* and *show the evolution of variable X* was explained in Chapter 3. For the categorisation of the gestures of the *show the evolution of variable X* commands, the categories that differ in the expression of the graph concept were placed in the same category, but this only resulted in a partial reduction of the categories. A new category was still created for each different expression of the variable. In addition, this dependency between commands limited the number of similar gestures between different participants for different categories. And participants who didn't implement this system where two gestures were combined often found themselves making abstract gestures which, as mentioned above, were rarely similar to others.

## 5.3 Gesture's Taxonomy

As far as the form of the gestures is concerned, it is immediately noticeable that many of the gestures are dynamic, especially in instructions 7 to 11. This is due to the many adaptations of the *Concept of graph or evolution* gestures, with another gesture specifying the variable. As the *Concept of graph or evolution* gesture is dynamic, so are all its derivatives. Only gestures without this idea could thus be static.

As for the form of the gestures for the *display variable X* instructions, they are varied. Since these instructions do not represent a manipulative action, they can be static. When there is a notion of progression, as it is the case for a volume button for example, static gestures are not appropriate. Here however, this is not a problem and they therefore make up a relatively large proportion of the gestures. However, due to the relatively abstract nature of some of the commands, participants relied on concepts that were easier to visualize, such as rain for humidity. These visual concepts tend to be dynamic because they are more complex to show. Finally, for the same reason, there are no stroke-type gestures, as they are not usually used to represent commands that are too specific.

The nature of the gestures observed varies greatly from one instruction to another. For the first twelve instructions there are almost no physical gestures, whereas for the last three there are almost only these. This is logical, given the different temporal nature of the instructions. The actions resulting from the first twelve gestures have a single immediate effect. Zooming in, on the other hand, can be done gradually, as can zooming out and moving the map. Physical gestures express this progressive nature of the instructions precisely because they interact directly with the object in question.

Some instructions have a lot of metaphoric gestures, as the participants came up with a lot of mimes. This is for example the case for the instruction *display humidity*. The most symbolic categories often include gestures of category 3 (*the static use of the hands to represent a letter or number*). Comprising no fewer than 28 gestures, this is the largest category.

## 5.4 Agreement

### 5.4.1 Profile

Agreement rates are quite high on average. This can be explained by several factors. Firstly: the choice of categorization. On average the participants had the same idea, even if the execution of the gesture was not exactly the same. This was the case for *display humidity* and *display pressure*, for example. For the instructions controlling the *Netatmo Weathermap*, the high level of agreement is largely explained by the existence of a technology that is already very familiar to the participants. As they were all more or less in the same age group, most of them imitated the gestures they already made on their smartphones or tablets, for example.

The low scores for noise instructions are due to the limitations of the Leap Motion Controller. In fact, most participants' first idea was to make a gesture related to their ears. When choosing an alternative, participants sometimes tried to create a similar gesture, but this often resulted in very specific gestures that were very different from each other.

For the *Change Theme (Dark <> Light)* instruction, the low score was due to the fact that only one gesture was required for two commands. Some of the participants only gave one command, but most of them actually gave two. Classifying two commands as one therefore resulted in a large number of categories, because if participants had the same gesture for the first command, for example, this was not always the case for the second.

### 5.4.2 Relation with Goodness of Fit

On Figure 5.1, the relation between the Goodness of Fit and the Agreement Score is shown. One might expect the two curves to follow each other closely. This is more or less the case here, with a few exceptions. The first concerns instruction 3, *display humidity.* In fact, most of the participants had the same idea, to mimic rain or drops, but as this deviated from the original concept, they weren't convinced by their gesture. There is a similar spike for instruction 11, *show the evolution of humidity.*

The opposite occurred for instructions 13 and 14, *zoom out to navigate to another weather meter* and *zoom in to navigate to another weather meter* respectively. Everyone thought their gesture was very well adapted, but the agreement score was not as high. The reason for this is that there were often two kinds of gesture for these instructions: those who spread and pinched, and then those who moved their hands apart and together to represent each instruction respectively.

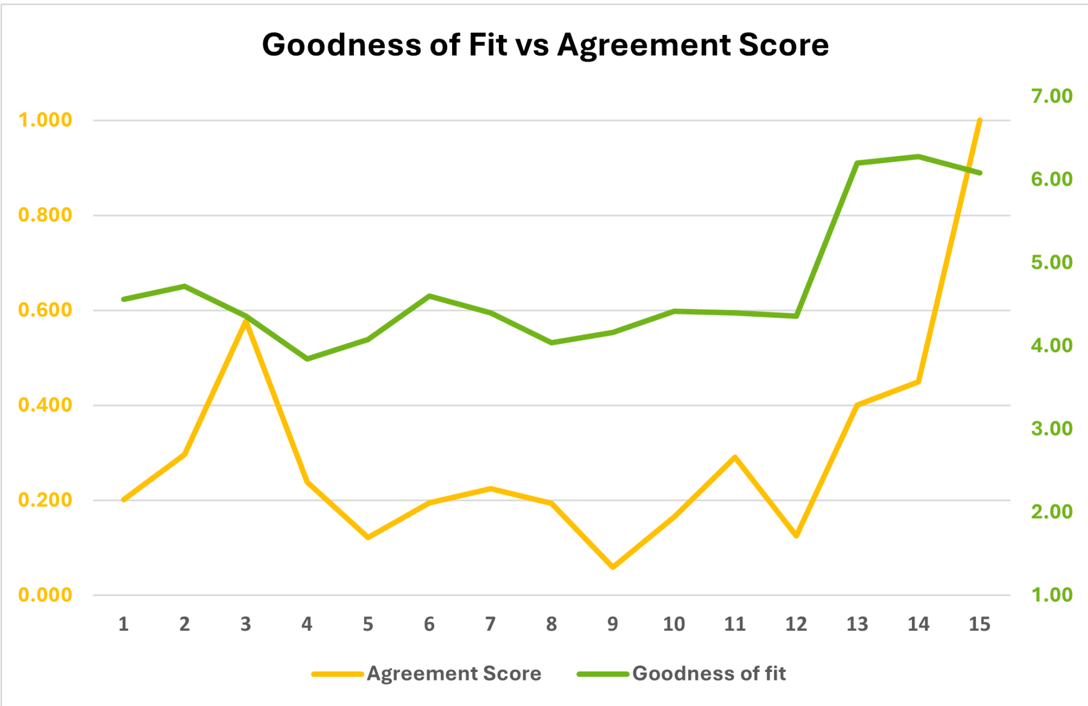



Figure 5.1: Relation between the Goodness of fit and the Agreement Score

# Chapter 6

# Conclusion

## 6.1 Review

Using gestures to control applications has proven to be very useful in many areas, such as health care or for increasing the car safety. In the case of a weather application for example, this could be a convenient way to access data more quickly without having to search through menus. Before implementing such a technology, it is necessary to identify the best gesture commands for each of the instructions. An elicitation study was thus conducted to obtain the most intuitive gestures, leading to more user-friendly gestures. During this elicitation study, the gestures of the participants have been recorded using the Leap Motion Controller.

A total of fifteen instructions have been chosen to represent this particular application. An experiment has been conducted in which participants had to invent a gesture for each instruction and referents were made to illustrate them in an unbiased way. In total, 25 people have participated to this experiment, generating 371 gestures. These gestures were classified into forty categories, each characterized by their nature, range of motion and form. The most frequent gestures, as well as the corresponding Agreement Rate and Agreement Score for each instruction were also identified.

The results showed a bias induced by the lack of diversity in the age of the participants. Participants tended to use similar gestures as on the devices they use regularly. The relatively high number of categories has also been justified: the abstract gestures of the different participants were rarely similar, and a dependency of the gestures prevented different participants to have the same gestures for different instructions.

The gestures were varied in both form and nature. As these were not commands that were performed very regularly, none of the gestures consisted of a simple stroke. While the gestures were largely static for the first, relatively simple instructions, they tended to be more dynamic for the more complex instructions. In terms of the nature of the gestures, we observed that participants intuitively tried to give meaning to their gestures and avoided using abstract gestures. Physical gestures were preferred for instructions that required gradualness.

For the most part, the proposed gestures achieved a medium level of agreement. Some gestures, especially physical ones, even achieved high or very high scores. This was also related to the participants' perception of their goodness of fit. Despite the relative correlation, some exceptions were explained.

## 6.2 Benefits and limits

### 6.2.1 Benefits

The spontaneous nature of an elicitation study made it possible to find a series of intuitive gestures. With the exception of the instruction *show the evolution of the noise*, an agreement could be found for each of the instructions. A practical implementation is now easier, as a mental association was uncovered for almost every instruction. For example, instructions related to humidity would be best controlled by gestures related to rain. Some instructions, such as gestures about pressure, even have multiple associations. One can therefore choose the gesture that best suits the application. In the case of this application and the Leap Motion Controller, for example, a fist gesture would be the most appropriate because no other instruction uses a similar gesture and because it is easy to recognize.

A logic was also found between the gesture, making it easier for future users to remember. This is illustrated by the instructions *show the evolution of variable $X$*, where a gesture representing a graph is followed by the gesture specific to the variable.

Finally, this type of study can easily be carried out in other parts of the world where the mental association may be different. It is cheap and relatively quick. Gestures can be adapted according to culture or language. For example, a *"C"* gesture for $CO_2$ may be inappropriate if the word does not begin with a $C$ in a particular language.

### 6.2.2 Limits

As previously mentioned, a major drawback of elicitation studies is the influence of previous technologies in the creation of new commands. This was particularly evident in the last three instructions, where the majority of participants mimed the same gestures as on their existing devices. This can be a problem as the gesture may not be optimal. In fact, for zooming in and out, using the same gestures as on a touch screen can be problematic as they are very similar. On a touchscreen, touching the screen allows the system to know which of the commands it is responding to, but in the air the difference is much smaller, sometimes even non-existent.

The lack of creativity was another disadvantage of elicitation studies. Even if some of the participants have creative ideas, there is very little chance that they will be the same as others. These gestures will therefore never have a very high agreement score. One way to remedy this would be for the experimenter to make a note of the creative ideas that they find user-friendly. During validation, these gestures could be included to see if, on average, users prefer them to more mainstream gestures.

## 6.3 Threats of Validity

The first observation relates to languages. It was not anticipated that the participants would not always have sufficient knowledge of English. However the referents were all designed in English. The experimenter therefore had to translate all the instructions verbally, which could slightly bias the expertise, depending on the tone of voice. The experimenter might also be tempted to use gestures to accompany his explanations, thus distorting the whole procedure.

The randomization of the instructions also caused confusion among the participants. Some were under the impression that they already had a particular instruction, e.g. *display the temperature*, whereas what they had before was *show the evolution of temperature*. Moreover, when they first came across a referent illustrating the *show the evolution of variable X* instruction, they generally did not realize that they had to adapt it for each variable (even though they had been told this at the beginning of the procedure). This led sometimes to poorer results than if the procedure had not been randomized. Randomization remains important because participants are still influenced by the referents they have seen before. However, it might have been better to keep the gestures of the same category together and to let the gestures of the category *display the variable X* precede those of the category *show the evolution of the variable X*.

It is also important to note that although the referents are intended to be the same unbiased basis for each participant, they still illustrate the actions. They may introduce bias due to the reference screens. For example, for the instruction *display humidity*, there was a droplet icon, which may have led some participants to draw one.

## 6.4 Future Work

### 6.4.1 Short-Term

Firstly, the experiment could be extended to other age groups. For example, it would be very interesting to interview older people in order to limit the legacy bias associated with touchscreen devices. Of course, there would still be a bias, but it would probably be induced by different technologies than those used by young people.

The gestures defined for each category could also be validated. A simple way of doing this would be to first ask another independent person to classify all the gestures, in order to compare the two categorizations. A second way would be to check whether other people would be able to recognize the gestures. This could be done by using a questionnaire in which people have to associate the gestures with the commands. It would also be necessary to analyze the simplicity of the proposed gestures, for example by timing the learning process. Finally, it should be checked that the gestures are distinct enough for the technology (in this case, the Leap Motion Controller). Some technologies have more difficulty recognizing certain types of gesture, and before implementing them for an application, it is important to make sure that the proposed gestures do not pose any problems in this respect.

In the same spirit of continuity, the data from the Leap Motion Controller could be analyzed and trained specifically on the gestures that the participants agreed on the most. This specific data could then be analyzed to test its gesture recognition rate across a range of different users. This would allow the usability of the device to be tested in a real-world application.

### 6.4.2 Medium-Term

In a medium-term perspective, two types of future work could be envisaged. First, the number of elicitation studies in all types of applications could be increased. This would make it possible to identify general trends, regardless of the application. Eventually, this could lead to concrete guidelines for developers of these technologies.

It would also be possible to actually develop a gesture-controlled weather station, or at least make it possible for Netatmo users to experience this, whether using a Leap Motion controller or some other technology.

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# Appendices

# Appendix A

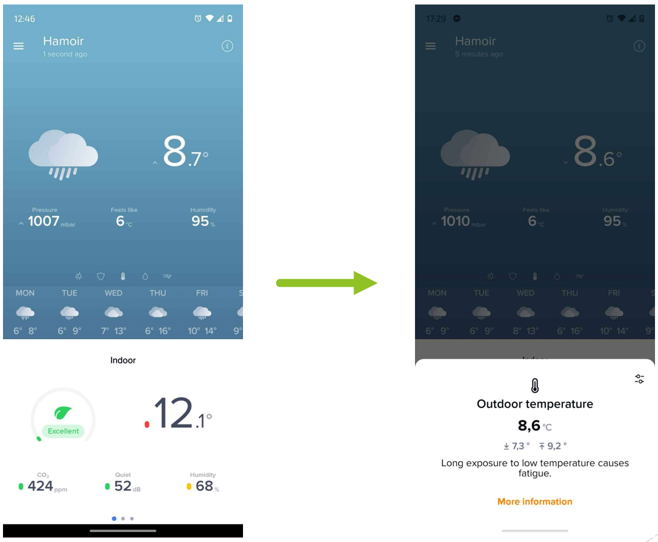
# Annexes

## A.1 Annex 1: Referents

# Gestures Netatmo

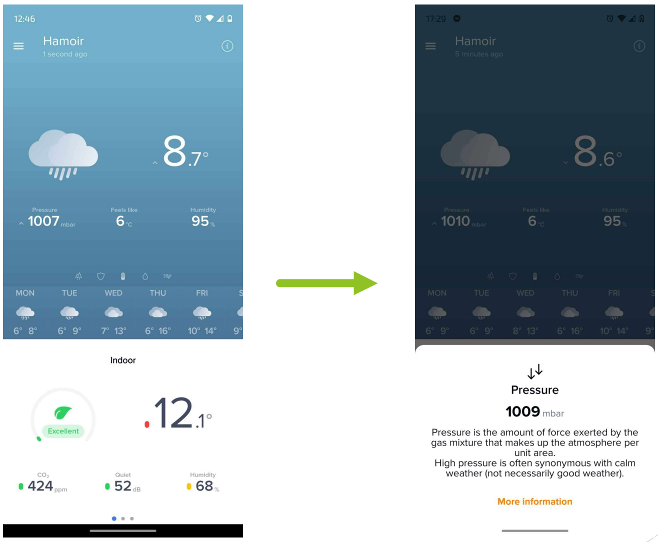
1

## 1. Display temperature



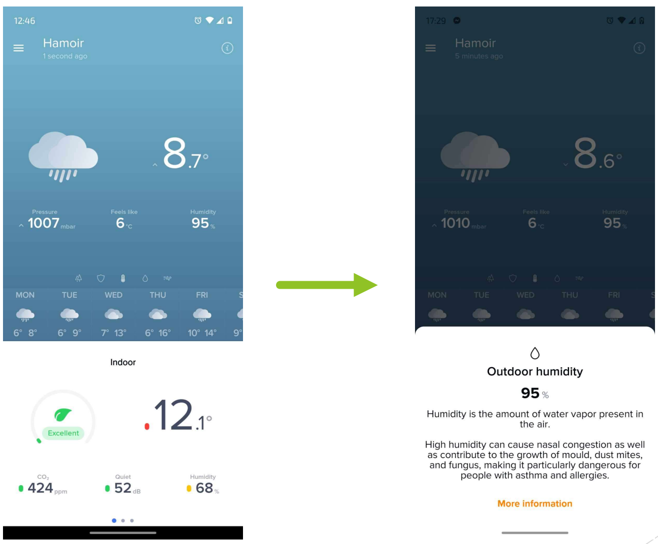

2

## 2. Display Pressure



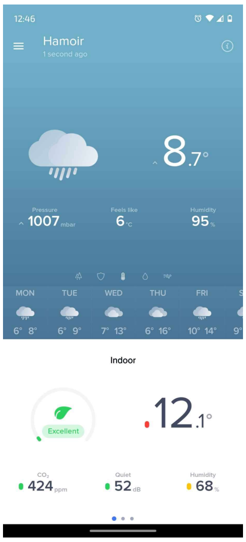

3

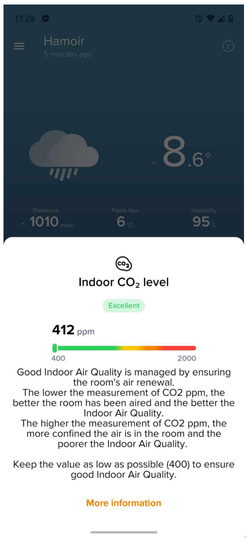
## 3. Display humidity




4

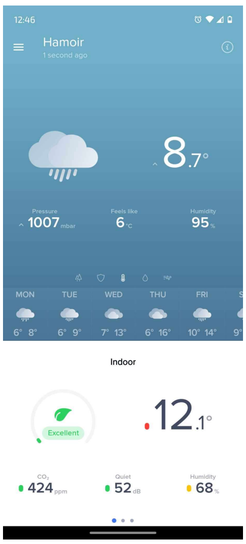
# 4. Display CO2 level

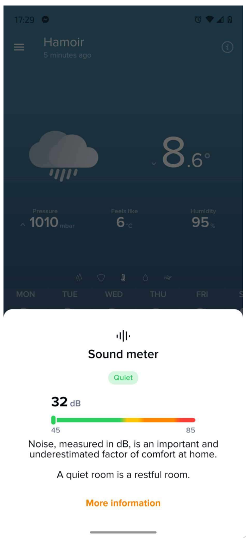



5

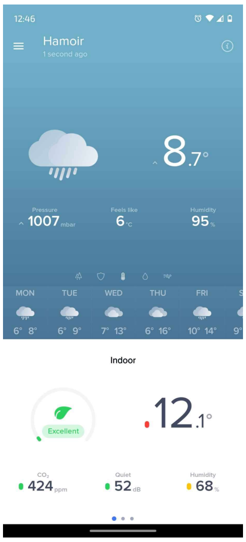
# 5. Display Noise

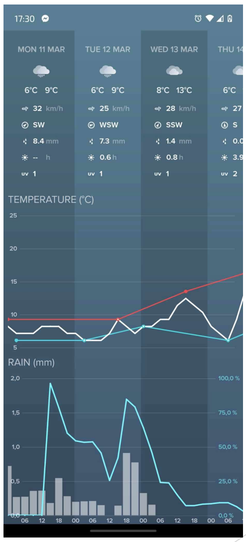



6

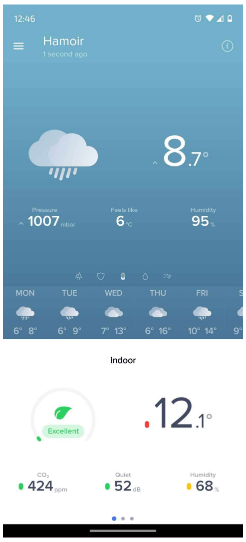
# 6. Display 7 days forecast




7

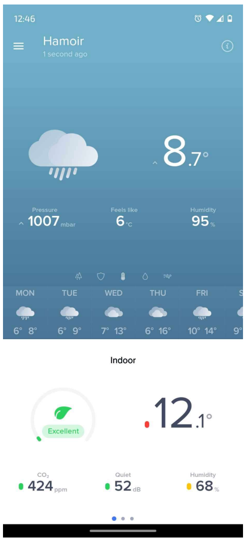
# 7. Show the evolution of Temperature





8

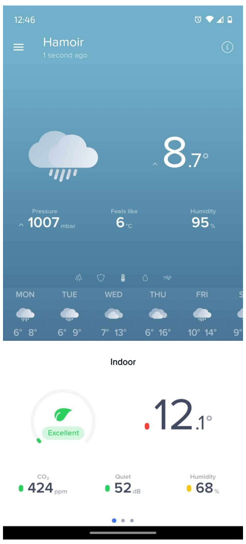
# 8. Show the evolution of CO2 level





9

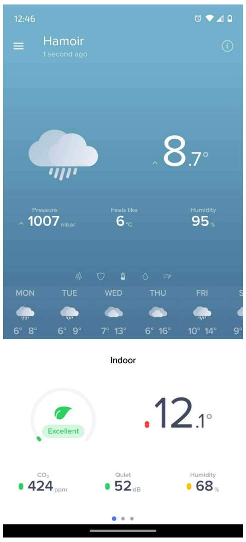
# 9. Show the evolution of Noise

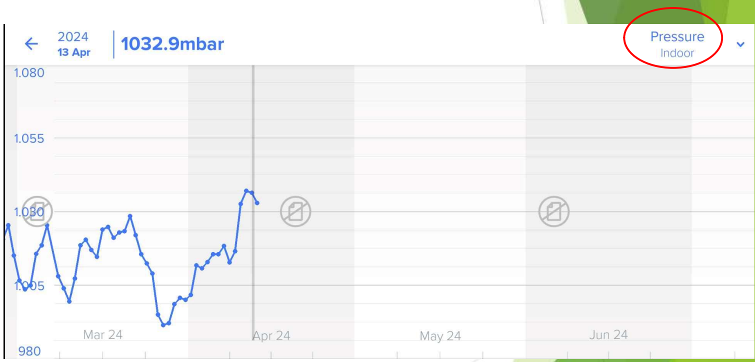




10

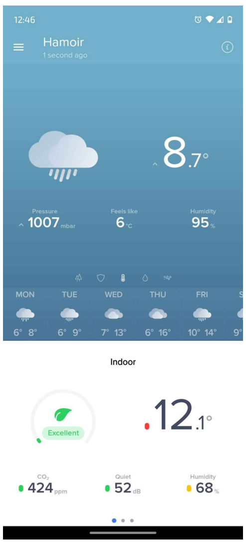
## 10. Show the evolution of Pressure

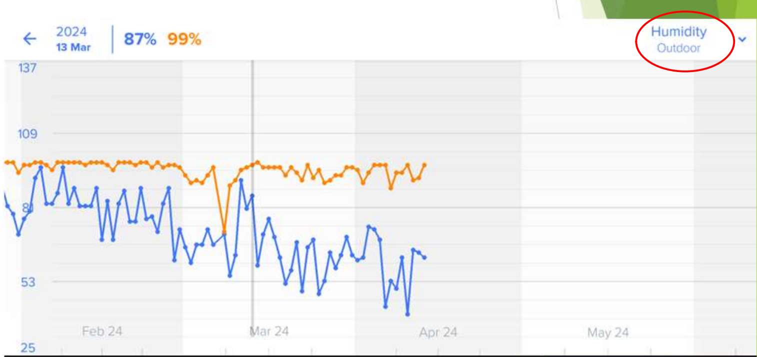



11

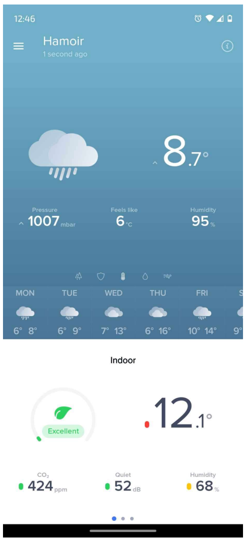
## 11. Show the evolution of Humidity

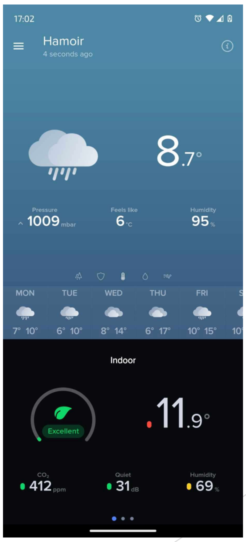



12

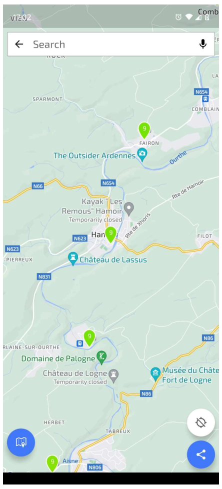
## 12. Change theme (Light <-> Dark)




13

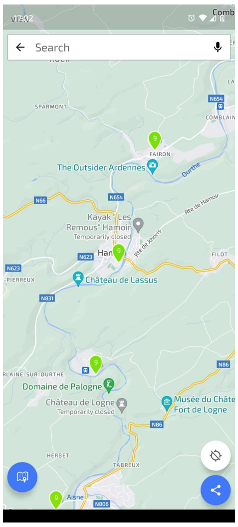
## 13. Zoom out to navigate to another weather meter





14

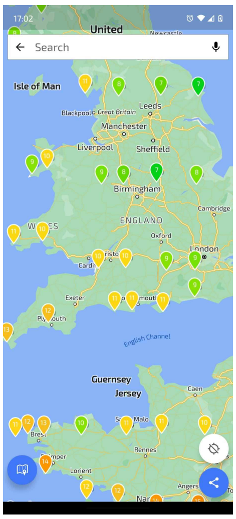
## 14. Zoom in to navigate to another weather meter





15

## 15. Move the map around to navigate to another weather meter





16

## A.2 Annex 2: Description of the categories

| N | Category | Description |
|---|---|---|
| 1 | Rising hand/finger | All gestures in which one (or both) hands are raised, regardless of their position (flat hand, index finger, hand with palm up, etc.). |
| 2 | Drawing in the air to represent a letter/number/figure | The gestures for which the participants draw in the air: it could be a figure (*"cloud"*), a word (*"$CO_2$"*), or a number (*"7"*). |
| 3 | The static use of hands to represent a letter/number | Gestures where the hands are used to show a letter (*"C"*), or a number ("7"). For a number this often translates to showing the same number of fingers. |
| 4 | Spread | A spread movement, with the thumb and index, or with the thumb and with the four other fingers. |
| 5 | Imitation of pressure | This is done by: 1) one hand moving towards the other hand (both hands facing each other), 2) one hand/index descending towards the table |
| 6 | Fist | One or two fists. |
| 7 | Static hand to represent a bubble or a circle | This is often done with two hands. |
| 8 | Mimic rain/drops/waves or pretend to touch water | This includes all gestures that imitate water, whether it's rain, a drop or waves. |
| 9 | Hand lying flat | Hand can be facing up or down |
| 10 | "Ok" sign | It was here never used to signify "accept". |
| 11 | Mime smoke or escaping air | This gesture is done by miming the air escaping a person's mouth, or by miming surrounding gasses |
| 12 | Movement of hand going from fist to extended hand | *Blossom* |
| 13 | Snap Fingers/Clap | |
| 14 | Hands moving away (with the idea of displaying something) | The hands were facing the computer or the table |

| N | Category | Description |
|---|---|---|
| 15 | Concept of a graph or evolution | Miming a slope, drawing the profile of a graph or making a swinging motion with their hands and wrists. |
| 16 | Concept of a graph or evolution and a drawing in the air to represent a letter/number/figure | Can be done simultaneously or one after the other |
| 17 | Concept of a graph or evolution and the static use of hands to represent a letter/number | Can be done simultaneously or one after the other |
| 18 | Concept of a graph or evolution and static hands to represent a bubble or a circle | Can be done simultaneously or one after the other |
| 19 | Concept of a graph or evolution and rising hand/finger | Can be done simultaneously or one after the other |
| 20 | Concept of a graph or evolution and Imitation of pressure by : 1) hand moving towards the other hand (both hands facing each other), 2) hand/index descending | Can be done simultaneously or one after the other |
| 21 | Concept of a graph or evolution and spread | Can be done simultaneously or one after the other |
| 22 | Concept of a graph or evolution and Fist | Can be done simultaneously or one after the other |
| 23 | Concept of a graph or evolution and Mimic rain/drops/waves or pretend to touch water | Can be done simultaneously or one after the other |
| 24 | Concept of a graph or evolution and a Hand lying flat | Can be done simultaneously or one after the other |
| 25 | Concept of a graph or evolution and an "Ok" sign | Can be done simultaneously or one after the other |
| 26 | Concept of a graph or evolution and a Mime smoke or escaping air | Can be done simultaneously or one after the other |

| N | Category | Description |
|---|---|---|
| 27 | Concept of a graph or evolution and a Movement of hand going from fist to extended hand | Can be done simultaneously or one after the other |
| 28 | Concept of a graph or evolution and a Snap of Fingers/Clap | Can be done simultaneously or one after the other |
| 29 | Lateral Hand Movement | Parallel to the table |
| 30 | (two fingers of) two hands moving apart | Unlike category 14, hands were facing each other |
| 31 | sun/light mime then moon/sleep mime | |
| 32 | Movement of hand going from fist to extended hand then back to a fist | Like category 12, but with the reverse gesture added after |
| 33 | Idea of covering something | By covering the table with one or two hands |
| 34 | Pinch | Often with the thumb and the index, but sometimes with the thumb and two fingers, or with the thumb and the four other fingers |
| 35 | Arm movement with static hand | Manipulation sign, where an index or the entire hand moves along with the map on the screen (used exclusively for the instruction 20) |
| 36 | Hands coming together | Reverse of category 30 |
| 37 | Push against imaginary wall | Often the imaginary wall is parallel to the laptop |
| 38 | Tapping a button/pulling on an imaginary thread (idea of activating a button) | Pulling an imaginary thread hanging from the ceiling |
| 39 | Wrist rotation | The same gesture one would do to simulate a vortex for example |
| 40 | Concept of a graph or evolution and a Wrist rotation | Can be done simultaneously or one after the other |

## A.3 Annex 3: Taxonomy of the categories

| Cat. | Name | Nat. | Form | Freq. |
|---|---|---|---|---|
| 1 | Rising hand/finger | A | M | 22 |
| 2 | Drawing in the air to represent a letter/number/figure | S | D | 14 |
| 3 | The static use of hands to represent a letter/number | S | T | 28 |
| 4 | Spread | P | D | 21 |
| 5 | Imitation of pressure by : 1) hand moving towards the other hand (both hands facing each other), 2) hand/index descending | M | D | 14 |
| 6 | Fist | A | T | 13 |
| 7 | Static hand to represent a bubble or a circle | S | T | 6 |
| 8 | Mimic rain/drops/waves or pretend to touch water | M | D | 20 |
| 9 | Hand lying flat | A | T | 8 |
| 10 | "Ok" sign | A | T | 6 |
| 11 | Mime smoke or escaping air | M | D | 5 |
| 12 | Movement of hand going from fist to extended hand | M | D | 7 |
| 13 | Snap Fingers/Clap | A | D | 9 |
| 14 | Hands moving away (with the idea of displaying something) | M | D | 6 |
| 15 | Concept of a graph or evolution | M | D | 19 |
| 16 | Concept of a graph or evolution and a drawing in the air to represent a letter/number/figure | S | D | 5 |
| 17 | Concept of a graph or evolution and the static use of hands to represent a letter/number | S | D | 21 |
| 18 | Concept of a graph or evolution and static hands to represent a bubble or a circle | S | D | 2 |
| 19 | Concept of a graph or evolution and rising hand/finger | A | D | 5 |

| | | | | |
|---|---|---|---|---|
| 20 | Concept of a graph or evolution and Imitation of pressure by : 1) hand moving towards the other hand (both hands facing each other), 2) hand/index descending | M | D | 2 |
| 21 | Concept of a graph or evolution and spread | A | D | 3 |
| 22 | Concept of a graph or evolution and Fist | A | D | 10 |
| 23 | Concept of a graph or evolution and Mimic rain/drops/waves or pretend to touch water | M | D | 13 |
| 24 | Concept of a graph or evolution and a Hand lying flat | A | D | 10 |
| 25 | Concept of a graph or evolution and an "Ok" sign | A | D | 2 |
| 26 | Concept of a graph or evolution and a Mime smoke or escaping air | M | D | 4 |
| 27 | Concept of a graph or evolution and a Movement of hand going from fist to extended hand | M | D | 3 |
| 28 | Concept of a graph or evolution and a Snap of Fingers/Clap | A | D | 2 |
| 29 | Lateral Hand Movement | A | M | 4 |
| 30 | (two fingers of) two hands moving apart | P | M | 9 |
| 31 | sun/light mime then moon/sleep mime | M | D | 2 |
| 32 | Movement of hand going from fist to extended hand then back to a fist | M | D | 6 |
| 33 | Idea of covering something (by putting the hand flat against something) | M | M | 3 |
| 34 | Pinch | P | D | 16 |
| 35 | Arm movement with static hand | P | M | 25 |
| 36 | Hands coming together | P | M | 6 |
| 37 | Push against imaginary wall | A | M | 4 |
| 38 | Tapping a button/pulling on an imaginary thread (idea of activating a button) | P | D | 7 |
| 39 | Wrist rotation | A | D | 7 |
| 40 | Concept of a graph or evolution and a Wrist rotation | A | D | 2 |

## A.4 Annex 4: Table of the gestures from each participant for each instruction

| Referent | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Display Temperature | 9 | 2 | 39 | 1 | 9 | 9 | 38 | 1 | 2 | 10 | 4 | 3 | 4 | 1 | 1 | 2 | 1 | 1 | 3 | 1 | 3 | 1 | 1 | 3 | 9 |
| 2. Display Pressure | 9 | 5 | 6 | 5 | 5 | 7 | 5 | 1 | 5 | 6 | 6 | 3 | 6 | 13 | 6 | 2 | 6 | 5 | 6 | 6 | 6 | 5 | 5 | 6 | 6 |
| 3. Display Humidity | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 37 | 8 | 8 | 8 | 3 | 9 | 8 | 8 | 2 | 8 | 8 | 8 | 8 | 10 | 8 | 7 | 8 | 8 |
| 4. Display $CO_2$ Level | 2 | 6 | 10 | 3 | 3 | 1 | 3 | 10 | 11 | 3 | 1 | 3 | 2 | 11 | 11 | 2 | 3 | 3 | 3 | 11 | 11 | 3 | 7 | 2 | 3 |
| 5. Display Noise | 2 | 12 | 13 | 12 | 9 | 1 | 10 | 37 | 12 | 5 | 4 | 3 | 12 | 13 | 2 | 2 | 12 | 39 | 39 | 5 | 3 | 12 | 13 | 39 | 5 |
| 6. Display 7 days forecast | 2 | 14 | 14 | 14 | 3 | 15 | 17 | 29 | 14 | 3 | 1 | 3 | 2 | 3 | 17 | 3 | 3 | 14 | 3 | 15 | 3 | 1 | 39 | 7 | 3 |
| 7. Show the evolution of Temperature | 24 | 15 | 15 | 24 | 24 | 1 | 15 | 38 | 17 | 17 | 15 | 15 | 1 | 15 | 19 | 15 | 19 | 19 | 17 | 15 | 17 | 15 | 19 | 17 | 1 |
| 8. Show the evolution of $CO_2$ level | 16 | 22 | 7 | 17 | 17 | 7 | 17 | 10 |  | 17 | 19 | 17 | 3 | 15 | 26 | 16 | 15 | 17 | 17 | 15 | 26 | 17 | 18 | 17 | 17 |
| 9. Show the evolution of Noise | 16 | 4 | 28 | 24 | 39 | 1 | 25 | 38 | 26 | 20 | 21 | 17 | 12 | 15 | 26 | 16 | 27 | 40 | 40 | 15 | 17 | 27 | 21 | 27 | 24 |
| 10. Show the evolution of Pressure | 24 | 24 | 22 | 24 | 5 | 18 |  | 38 | 38 | 22 | 22 | 17 | 6 | 13 | 22 | 16 | 22 | 20 | 22 | 5 | 22 | 5 | 28 | 22 | 22 |
| 11. Show the evolution of Humidity | 23 | 23 | 30 | 25 | 23 | 8 | 23 | 1 | 23 | 23 | 23 | 17 | 9 | 15 | 23 | 15 | 23 | 24 | 23 | 15 | 23 | 23 | 21 | 23 | 24 |
| 12. Change theme (Light <> Dark) | 31 | 39 |  | 13 | 13 | 1 | 13 | 13 | 29 | 14 | 38 | 37 | 29 | 29 | 31 | 32 | 38 | 33 | 32 | 33 | 32 | 33 | 32 | 32 | 32 |
| 13. Zoom out to navigate to another weather meter | 37 | 34 | 30 | 34 | 36 | 34 | 34 | 34 | 34 | 34 | 34 | 36 | 34 | 34 | 34 | 4 | 34 | 34 | 30 | 34 | 1 | 36 | 34 | 30 | 30 |
| 14. Zoom in to navigate to another weather meter | 30 | 4 | 34 | 4 | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 30 | 4 | 4 | 4 | 4 | 4 | 4 | 36 | 4 | 9 | 30 | 4 | 36 | 36 |
| 15. Move the map around to navigate to another weather meter | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |

## Resume

More and more devices are being developed that allow applications to be controlled using gestures. However, defining the precise gestures for each command and application is not an easy task. In fact, the 3D dimension of the gestures make them more difficult for people to learn. This thesis analyses which gestures would be the most intuitive for users, in order to have gestures that are as user-friendly as possible. The application chosen is that of an intelligent weather station, with around fifteen associated commands. The analysis will be carried out in relation to an application using the Leap Motion Controller, an infrared camera capable of detecting hand gestures. In order to obtain the most intuitive gestures, an elicitation study will be carried out. For each instruction, the two most frequent gestures are described and an analysis will be carried out to characterize the gestures.

De plus en plus d'appareils sont développés pour permettre le contrôle d'applications à l'aide de gestes. Cependant, définir des gestes précis pour chaque commande et chaque application n'est pas une tâche aisée. En effet, la dimension 3D des gestes rend leur apprentissage plus difficile. Cette thèse analyse quels gestes seraient les plus intuitifs pour les utilisateurs, afin d'avoir des gestes les plus accessibles possibles. L'application choisie est celle d'une station météo intelligente, avec une quinzaine de commandes associées. L'analyse sera effectuée par rapport à une application utilisant le Leap Motion Controller, une caméra infrarouge capable de détecter les gestes de la main. Afin d'obtenir les gestes les plus intuitifs, une étude d'élicitation sera réalisée. Pour chaque instruction, les deux gestes les plus fréquents sont décrits et une analyse est effectuée pour caractériser ces gestes.



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