# DataSphere

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Abstract. This project aimed to develop a data visualization application controlled by only using gestures. This is accompanied with the goal of establishing a more explorative interaction with data visualization when compared to the data navigation using regular pointing devices. To make the interaction with an interface based on gestures possible, the Leap Motion[5] has been implemented in the application named the DataSphere showing data about earthquakes that have appeared in the last century. This visualization is as follows navigated by using gestures that we have specified and implemented. Based on the results of user evaluations, we have come to the conclusion that the interaction that we have developed did not meet our goal when it comes to improving the explorative experience of users compared to the experience of using the regular pointing devices.

## 1 Introduction

The use of the computer mouse has become a conventional way to interact with the computer since the invention of this pointing device. However, during this time, some alternatives like the touchscreen have been developed. The touchscreen has quickly grown as a very common way of interacting with devices, but the other alternatives that are already widely available at the market are less often used to control devices. This is also the case with the Leap Motion[5], since it is not common to see the usage of it in everyday life in contrary to the touchscreen.
Often, the computer mouse or touchscreen are also used to interact with data visualization. One type of data visualization is a mapping of global information on a map of the earth. The map can be zoomed in and out by scrolling with the pointing device or using a specific gesture on a touchscreen to get a closer look. With the mouse or with your finger moving over the touchscreen, the viewer can be moved over the map by dragging the mapping. In this research we want to find out if we could improve the experience of looking at this type of data visualization by using the less conventional Leap Motion instead of the regular pointing methods. This research goal will get accompanied by the following main question: *Can we establish a more explorative interaction with datasets compared to the visualization of data that is navigated using regular pointing devices?*

In this paper, the development and evaluation of the data visualization controlled by the Leap Motion will be discussed.

## 2 A Not So Explorative Exploration through Data

### 2.1 The Problem

By using regular pointing devices, the interaction between device and user is done indirectly. Because of the indirect way in which the user navigates data visualization, the user misses the more direct and explorative feeling of interacting with data.

### 2.2 The User Group

The Leap Motion is generally not known to be a way of interacting with a device, which makes it interesting to develop a data visualization controlled with the Leap Motion that is meant for a varied audience. The visualization can be interacted with in museums by all the visitors. The majority of the visitors would know about the usage of the computer mouse or the touchscreen which will cause the users of the developed data visualization to compare the Leap Motion control with the conventional pointing methods they are used to. The visitors can experience an explorative feeling during the usage of the Leap Motion. Meaning that the user feels like exploring the data using an immersive way of interacting with the data, because only gestures are needed for controlling the visualization.

## 3 Gesture your Way through Data

### 3.1 The Solution

To overcome the possible lack of exploration and direct feel of interacting with data, the Leap Motion will be implemented in our data visualization. The Leap Motion establishes a very different interaction when compared to the regular pointing methods, since it will capture the gestures of the user. The user does not need to physically move something else or touch a screen to interact with an interface. The hands of the user will be followed by the Leap Motion and the user only has to give the right gestures to control the interface. The interface will be in this case a mapping of global data on the earth. In this way, we want to offer the users a true exploration through data about our world with our developed application called the DataSphere.

### 3.2 The Application

The interface of the data visualization application shows a three-dimensional sphere that represents Planet Earth. On this sphere, data about the globe are visualized from a dataset. We focused on a dataset of earthquakes around the world that is shown on the globe. As follows, rotation of and zooming in on the globe can be performed by the

gestures of the users. Not only the position and the scale of the globe can be manipulated by the user, it is also possible to move through time showing the earthquakes that happened in a specific period of time. The interface, functionalities and the processing of the gestures captured by the Leap Motion will be implemented by using TouchDesigner[4], a visual development platform for creating interactive systems.

### 3.3 The Gestures

All the interactions with the data visualization can be performed by using the specified gestures. We chose to separate data manipulation and navigation by ascribing these to the left and right hand respectively. By separating the two different kinds of tasks we wanted to prevent possible confusion of the user during interaction.
By holding the palm of the right hand open and horizontally while moving in the x- and z-axes (Fig. 1), the user can rotate the globe. When the user moves the right hand with open palm in the y-axis, the user zooms in or out. By using the 'grab' gesture with the right hand, the user holds the globe at its last position. If the 'grab' gesture is used again, the user releases the globe from the held position, giving the user the ability to move the globe again.
The data manipulation is assigned to the left hand. The timeline of the earthquake dataset can be navigated through by the 'pinch' gesture. The user has to move the pinching left hand in the y-axis to manipulate the time.

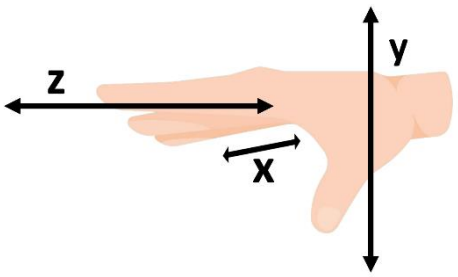


**Figure 1.** The orientation of the axes relative to the hand (https://www.freepik.com/free-photos-vectors/hand). Moving in the x-axis means that the hand is moved sideways. Moving the hand upward and downward can also be considered as moving in the y-axis. When moving in the z-axis, it can also be said that it is moving backward and forward.

### 3.4 The Interface and Visualization

The interface is kept as minimalistic as possible to avoid too many distractions from the data visualization itself. The instructions will be shown at the right of the screen to avoid that the user will forget the gestures which can happen easily, since many users will not have used the Leap Motion before and are hereby still uneasy with the usage of gestures. At the left side of the interface, the timeline and the legend of the data are shown. The earthquakes will be visualized in the shape of a circle from which the center represents the epicenter and the diameter shows the magnitude of the earthquake. The magnitude is also stated in the circle of the earthquakes.

### 3.5 Usability Requirements

The goal is to give the users an explorative experience and a feeling of having more direct control of the visualization when navigating through the data. Therefore, this

research will focus mainly on the attitude of the user towards the developed application. This means that the user should pick up the use of the gestures without thinking too much which adds the learnability as a usability requirement to consider. The user should enjoy controlling the data visualization and feel like they explore data. To avoid any annoyance of the user during the use of the application, the efficiency is also an important usability requirement, since errors made by the user should be avoided.

# 4 Results and Evaluation

## 4.1 The User Evaluations

The attitude of the user towards the data visualization application is the most important usability requirement in this research, which caused us to use mainly a questionnaire to measure the satisfaction of the users. The users were also able to give us detailed feedback after the user evaluation, which helped us to work on improvements. All the user evaluations have been performed by offering the users the application and giving them the same tasks. In this way we could get a clear insight of how the user handled the interaction with the interface. The questionnaire, that has been given to the user afterwards, contained questions about the learnability of the gestures, the response of the interface on the gestures of the user and how the user would rate the way of controlling the data visualization. All the questions, the answers, feedback and the tasks that the users had to perform are found in the documents about the user evaluations[1,2,3]. We performed three user evaluations. After every user evaluation, the prototype has been improved or altered based on the results of the evaluation.

## 4.2 User Evaluation 1

The first evaluation has been performed on the prototype (Fig. 2). The prototype shows the earthquakes dataset. The rotation and zooming in and out were already implemented completely. Also, the gesture to move through the timeline has been implemented. The instructions in the interface were not present yet, so this has been solved by using a piece of paper with the necessary instructions that the user could read at the beginning of the evaluation. The results of all the given questions can be found in Table. 1 and Fig. 5. Based on the results, the attitude towards the application is rather divided. A high rating is given to the learnability of the gestures (Table 1.7) and the majority of the users found the data visualization to be explorative (Table 1.9). However, there are still some problems to solve when it comes to accuracy of the more detailed and complex gestures, like the ‘pinch’ gesture that is used for navigating through the timeline (Table 1.3). Also, the rating of how the application responded when users move their hands away from the sensor of the Leap Motion has been rated relatively poorly (Table 1.6). The globe will go back to its standard position and rotates at a constant speed. This does not allow users to focus on data on certain locations without holding their hand above the sensor which is not acceptable as it should be used as a data visualization application. As seen in Fig. 5 every user had some errors consisting of unintended actions. Based on the more detailed feedback that was given by the test users, there are

some disagreements about how the globe would rotate and be zoomed in and out. Some users liked to have inverted control with the gestures, while others like the noninverted way of controlling the movements of the globe. With inverted control we mean that for example, when the user wants to rotate the globe to the right, it is expected that the hand would have to move to the left. Also, the way in which the orientation of the timeline was set and how the gesture of moving the time had been instantiated confused the users. This is where affordance showed its importance, since the timeline was orientated vertically, but the gesture had to be made horizontally. Based on the observations and the feedback[1] the users gave, this difference confused them while using the timeline, trying to direct the movement of the gesture upwards instead of sideways, because that was how the timeline was orientated. This confusion can be solved by changing the direction in which the 'pinch' gesture has to be moved.

### 4.3 User Evaluation 2

The second user evaluation has been performed on the prototype seen in Fig. 3. The same questions have been asked with some extra questions added about the clarity of the instructions in the interface and the visualization of the earthquakes. We wanted to improve the way in which users can look at data more carefully, since the previous prototype did not allow the user to look at data without holding their hand above the sensor of the Leap Motion. The grab gesture has thus been added to the interaction allowing the user to hold the globe in a specific position. In order to solve the inaccuracy of the navigation through the timeline, the pinch gesture has been changed. Instead of moving the pinching left hand sideways, this hand must be moved backward and forward. This was expected to be more intuitive, since it meets the affordance of the shown timeline on the screen. However, the users that tested this version of the application still were not satisfied with the movement. During the evaluation, suggestions were given that the pinched hand needs to be moved upward and downward. Regarding the improvements of the previous tested prototype, instructions have been added to the interface as seen in Fig. 3. The instructions were stated by using simple illustrations of the hand with arrows that indicate the direction in which the movements must be made. Based on the suggestions[2] that some users made and the ratings by some users (Table 2.8), the instructions were unclear. This has been caused mainly because the users interpreted the instructional illustrations of the hands to be seen from above instead of from behind. This caused incorrect movements of the hands of the users. We suspected that this also caused the higher percentage of unintended actions by the user (Fig. 6) and the lower ratings of the use of all the gestures and the learnability of these gestures (Table 2.1-2) when compared with the results of the first user evaluation (Table 1.1-2). The rotation and zooming in and out were difficult to learn as seen in the feedback in the second user evaluation document[2], because of the mentioned confusing instructions. Improvements have been done on the visualization of the earthquakes. To avoid inaccuracy of the navigation through time that has been noted by the users based on the rating (Table 1.10), every step in the timeline of the tested prototype now represents five years, instead of one year. So, the earthquakes are shown of the five years that are selected from the timeline. To distinguish between the different years, the circles of the earthquakes get the colour of the year in which the earthquake took place. The colour of every year also changes every step in the timeline resulting in different sets of colours

that represent the years. The years and the assigned colours are shown in the legend of the data in the down left corner (Fig. 3). Based on comments[2] from this user evaluation, the magnitudes of the earthquakes needed to be visualized clearer and the colours of the circles have not been received well (Table 2.14). Based on the ratings that were given by the users, the explorative experience is still present when using the application having the highest average rating of the results (Table 2.10). However, the use of both hands for different tasks has been received very poorly (Table 2.5) when compared to the rating in the first evaluation (Table 1.5). The unclear instructions could also have caused this overall negative attitude of the users towards the DataSphere.

### 4.4 User Evaluation 3

The prototype shown in Fig. 4 is tested in the third user evaluation. Improvements have been made on the prototype. Now, the user has to move its left pinching hand upward and downward to move the timeline which has been suggested by users in the second evaluation[2]. Also, because of the unclarity of the directions of the arrows that were shown in the instructions of the prototype in Fig. 3, we replaced the arrows by animating the instructions. The illustrations have been improved too by drawing the hands from above which is expected to give a much clearer understanding about the movements of the gestures. The animated instruction of the timeline navigation is placed above the timeline so it would be clear to the user that the shown gesture has to be used for changing the time. The instructions indeed received a higher rating (Table 3.8) complying with our expectations. The colours of the circles of the earthquakes did not seem to be approved during the previous user evaluation (Table 2.14). We expected to solve this problem by using one set of colours that represents the different years in the selected time period. Thus, we removed the random generation of colour sets and added a fixed colour scheme. The users wanted to have more detail in the data visualization, however, the colours have been rated better (Table 3.14) than during the previous user evaluation (Table 2.14). By grouping multiple years per step in the timeline and by having changed the direction of the 'pinch' gesture to navigate through time, the rating of the accuracy and the response of controlling the timeline is higher (Table 3.11 and Table 3.3) when compared to the first prototype evaluation (Table 1.10 and Table 1.3). Another result that stood out is the amount of unintended actions of users that is decreased (Fig. 7) compared to the quantity of unintended actions during the previous evaluations (Fig. 5, Fig. 6). Unfortunately, the explorative aspect of the DataSphere has been lacking looking at the rating (Table 3.10). This rating is much lower than in the first user evaluation which is also the case for the rating of the control by gestures compared to regular pointing devices. It is difficult to say if this is caused by the subjectivity of the users or because of some specific changes we have made in the application.

## 5 Conclusion and Discussion

### 5.1 Conclusion

To give the user a more explorative way to interact with a data visualization, the DataSphere has been developed. The explorative aspect of the DataSphere is not clearly present based on the overall results of the user evaluations and thus, the interaction with the data has not been considered to be more explorative compared to using the more conventional pointing devices.

### 5.2 Discussion

There are problems to overcome when it comes to the robustness of the gesture processing. The gestures are not accurately captured yet when it comes to the more complex gestures, like the 'pinch' and 'grab' gestures for manipulating the data. The gestures and movements must be made precisely which causes a lot of unintended actions of the user, naturally affecting the experience with the data visualization. Also, we noticed that the amount of light in the room in which the Leap Motion is used, influences the sensitivity and accuracy of capturing the gestures. Not only the gesture processing of the Leap Motion caused trouble to find a way in which users could interact with the interface without errors. It is also difficult to find the most intuitive gestures for users to use the application. With the term intuition, we mean that users have their own perception of what they can expect from the gestures that are used to interact with the application. For example, that some users find it more fitting to move their hand upward to zoom in, while the other users think that the view is in this way zoomed out. Users have experienced this during our user evaluation as can be seen in the comments in the third user evaluation document[3]. We believe that the difficulty of developing more intuitive interaction with gestures is caused mainly because using gestures to control interfaces is not conventional. If it would have been used more often in applications a set of standards would have been already grown. Standards help giving users the same perceptions about the actions that are performed when specific actions are made during interaction. As you can see in the usage of the computer mouse from which it is for example generally known to users that clicking the right mouse button will give you additional options in an interface. If a set of standards would exist for gestures, it could have helped acquiring more intuitive interaction by complying to some standards. The kind of data visualization we focused on also requires much more complex and extensive data manipulation and navigation, which we did not manage to implement. This is mainly because the amount of gestures can be quickly too overwhelming for the user to learn and use which already could be noticed during the evaluations of the DataSphere. Also, more gestures would also mean that more specific gestures would have to be made to establish interaction which then can cause the application to be more error prone. This also means that more instructions must be given to the user in the form of more animations which will have a negative effect on keeping the interface of the data visualization clear. In regular data visualization a lot of tools and filter options are shown in the interface, but these buttons can be kept much smaller in contrary to the instructional animations of the hands. If the same number of functionalities would be preserved in the data visualization application with the Leap Motion the only option is to remove the instructions from the interface to keep the visualization clear, which causes problems for the usability of the application. It is preferred that the user can rely on recognizability, instead of having to remember all the gestures. We also did not manage to create a good data visualization of the earthquakes since we needed to find

a way to minimize the number of steps in the timeline. We initially wanted to show just one year per step, but this negatively affected the accuracy of the control of the timeline. By grouping the years, the data is difficult to analyze. Looking back, it would have been a better choice to find another kind of dataset, since the data about the earthquakes turned out to be less suitable for the limited functionalities we were able to add to the application in the time we could spend on the project. The satisfaction of the users has been measured during the user evaluations. We noticed that most of the results of the ratings of every user in all the evaluations are divided which makes it difficult to find evident conclusions. We needed much more users to get more reliable information about the average satisfaction which we could not achieve due to time constraints. Also, the user evaluations have different numbers of users which means that the comparisons of results of the evaluations cannot be done very accurately. If we would have more time, we could have also made the same data visualization, but then controlled with the touchscreen which improves the ability to compare the different kinds of controls of the application.

## 6 Future Work

We experienced that the development of our data visualization controlled by gestures is at this moment difficult, since we observed that a lot of users showed some discomfort when using the Leap Motion and that they have different perceptions about the outcomes of the gestures even when accompanied by instructions. At this moment, the use of the touchscreen would have been more suitable for the data visualization we wanted to create. Developments are needed that will cause the Leap Motion to gain more publicity so that more users get familiar to using only gestures for interactions with systems. The resulting standards that will be formed would eventually help create data visualizations that users can navigate and manipulate in the explorative and direct way that we had wanted to accomplish during this project.

## References


1. Ricchiuti, M., Zwart, R.: User Evaluation 1 Document
2. Ricchiuti, M., Zwart, R.: User Evaluation 2 Document
3. Ricchiuti, M., Zwart, R.: User Evaluation 3 Document
4. TouchDesigner by DERIVATIVE, https://derivative.ca/
5. LeapMotion by Ultraleap, https://www.leapmotion.com/

# Appendix

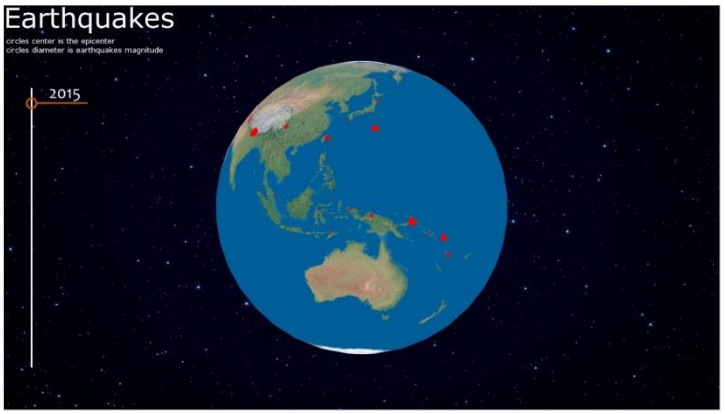


**Figure 2.** The interface of the prototype used in the first evaluation.

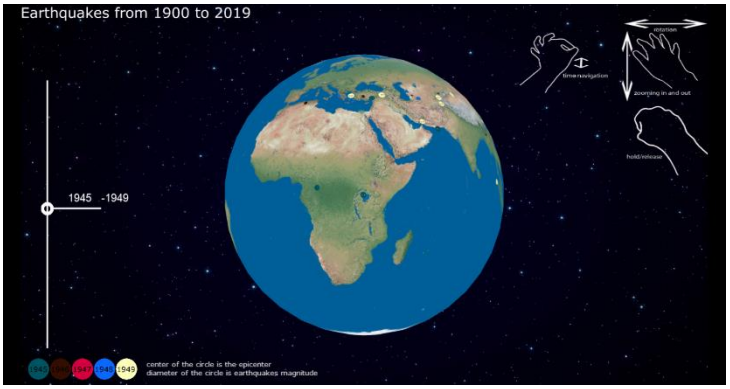


**Figure 3.** The interface of the prototype used in the second evaluation. Instructions have been added to the interface, as well as a legend of the visualization of the earthquakes. The steps of the timeline have been modified from one year to five years. With the added grab gesture, the user can hold the globe in its current position, so that the user can focus on a specific location.

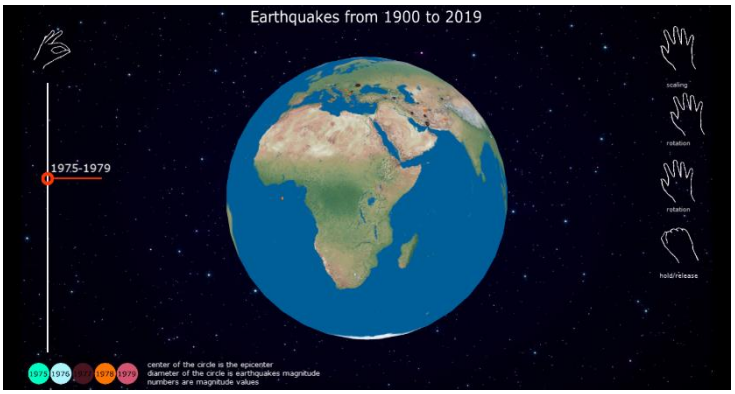


**Figure 4.** The interface of the prototype used in the third evaluation. The instructions have been replaced by instructional animations of the hands. The colour scheme of the visualization has been improved as stated in the paper.

| | USER EVALUATION 1 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Questions | Rating looking at the number of people (percentage of total of users) | | | | | Average Rating |
| | | 1 bad | 2 | 3 | 4 | 5 good | |
| 1 | How would you rate the use of gestures to zoom in and out on the sphere? | 0 (0%) | 1 (14.3%) | **2 (28.6%)** | **2 (28.6%)** | **2 (28.6%)** | **4.3** |
| 2 | How would you rate the use of gestures to rotate the sphere? | 0 (0%) | 1 (14.3%) | **3 (42.9%)** | 2 (28.6%) | 1 (14.3%) | **4.0** |
| 3 | How would you rate the response of your gestures of the left hand? | 1 (14.3%) | **4 (57.1%)** | 1 (14.3%) | 1 (14.3%) | 0 (0%) | **2.7** |
| 4 | How would you rate the response of your gestures of the right hand? | 0 (0%) | 1 (16.7%) | 1 (16.7%) | **3 (50%)** | 1 (16.7%) | **3.7** |
| 5 | How would you rate the use of your right and left hands for different tasks? | 0 (0%) | **2 (28.6%)** | **2 (28.6%)** | 1 (14.3%) | **2 (28.6%)** | **4.0** |
| 6 | How do you rate the response of the application if you move your hands away from the Leap Motion? | 2 (28.6%) | 1 (14.3%) | **4 (57.1%)** | 0 (0%) | 0 (0%) | **2.7** |
| 7 | How easy was it for you to learn the gestures to control the interface? | 0 (0%) | 1 (14.3%) | 0 (0%) | **4 (57.1%)** | 2 (28.6%) | **4.7** |
| 8 | How would you rate this control by gestures when compared to regular pointing devices? | 0 (0%) | **2 (28.6%)** | **2 (28.6%)** | **2 (28.6%)** | 1 (14.3%) | **3.8** |
| 9 | How explorative did this data navigation with gestures feel? | 0 (0%) | 0 (0%) | 1 (14.3%) | **4 (57.1%)** | 2 (28.6%) | **4.8** |
| 10 | How do you rate the accuracy (control) of the timeline? | 2 (28.6%) | **3 (42.9%)** | 1 (14.3%) | 1 (14.3%) | 0 (0%) | **2.5** |

**Table 1.** The results of the first user evaluation. The ratings of the most relevant questions are shown. Every part is rated from 1 to 5, with 1 being the worst rating and 5 being the best rating. The number of persons that have rated the score is notated for every rating and after that the percentage of how many users of the users in total have given this rating. The score that is given the most is stated in bold. Also, the average rating is calculated for every question.

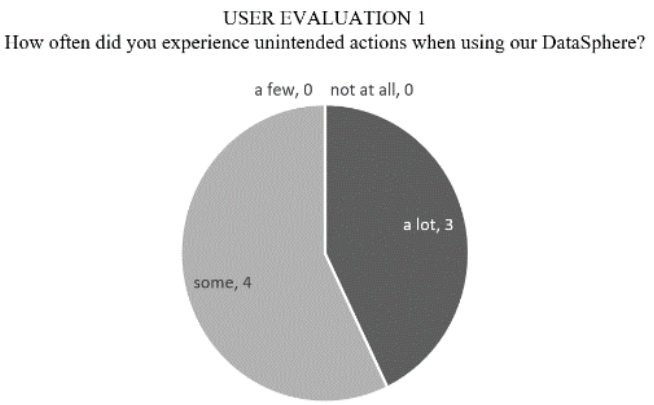


**Figure 5.** This pie chart shows the proportion of users that experienced a specific amount of unintended actions during the usage of the DataSphere in user evaluation 1.

| | USER EVALUATION 2 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Questions | Rating looking at the number of people (percentage of total of users) | | | | | Average Rating |
| | | 1 bad | 2 | 3 | 4 | 5 good | |
| 1 | How would you rate the use of gestures to zoom in and out on the sphere? | 0 (0%) | **2 (50%)** | **2 (50%)** | 0 (0%) | 0 (0%) | **2.5** |
| 2 | How would you rate the use of gestures to rotate the sphere? | **1 (25%)** | **1 (25%)** | **1 (25%)** | **1 (25%)** | 0 (0%) | **2.5** |
| 3 | How would you rate the response of your gestures of the left hand? | 0 (0%) | **2 (50%)** | 1 (25%) | 0 (0%) | 1 (25%) | **3.0** |
| 4 | How would you rate the response of your gestures of the right hand? | 0 (0%) | 0 (0%) | **2 (50%)** | 1 (25%) | 1 (25%) | **3.8** |
| 5 | How would you rate the use of your right and left hands for different tasks? | **2 (50%)** | 1 (25%) | 1 (25%) | 0 (0%) | 0 (0%) | **1.8** |
| 6 | How do you rate the response of the application if you move your hands away from the Leap Motion? | 0 (0%) | **2 (50%)** | **2 (50%)** | 0 (0%) | 0 (0%) | **2.5** |
| 7 | How easy was it for you to learn the gestures to control the interface? | 0 (0%) | **2 (50%)** | 1 (25%) | 0 (0%) | 1 (25%) | **3.0** |
| 8 | How clear were the given instructions? | 0 (0%) | **2 (50%)** | 1 (25%) | 0 (0%) | 1 (25%) | **3.0** |
| 9 | How would you rate this control by gestures when compared to regular pointing devices? | 0 (0%) | **2 (50%)** | 1 (25%) | 0 (0%) | 1 (25%) | **3.0** |
| 10 | How explorative did this data navigation with gestures feel? | 0 (0%) | 0 (0%) | 1 (25%) | 1 (25%) | 1 (25%) | **4.0** |
| 11 | How do you rate the accuracy (control) of the timeline? | 0 (0%) | **2 (50%)** | **2 (50%)** | 0 (0%) | 0 (0%) | **2.5** |
| 12 | Is the visualization of the data clear and understandable? | 0 (0%) | **2 (50%)** | **2 (50%)** | 0 (0%) | 0 (0%) | **2.5** |
| 13 | How would you rate the earthquakes visualization? (circles/magnitude) | 0 (0%) | **2 (50%)** | **2 (50%)** | 0 (0%) | 0 (0%) | **2.5** |
| 14 | How would you rate the scale and colours of the visualization? | 0 (0%) | **3 (75%)** | 1 (25%) | 0 (0%) | 0 (0%) | **2.3** |

**Table 2.** The results of the second user evaluation. The ratings of the most relevant questions are shown. Every part is rated from 1 to 5, with 1 being the worst rating and 5 being the best rating. The number of persons that have rated the score is notated for every rating and after that the percentage of how many users of the users in total have given this rating. The score that is given the most is stated in bold. Also, the average rating is calculated for every question.

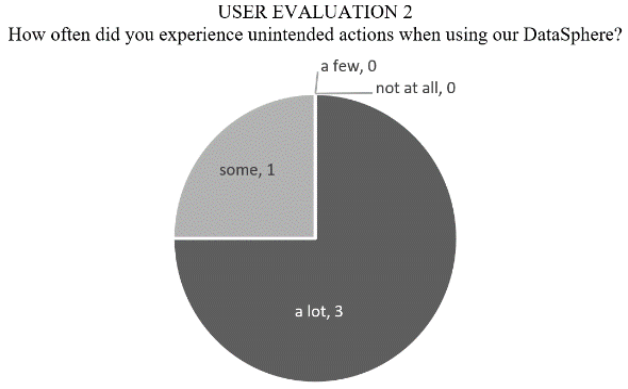


**Figure 6.** This pie chart shows the proportion of users that experienced a specific amount of unintended actions during the usage of the DataSphere in user evaluation 2.

| | USER EVALUATION 3 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Questions | Rating looking at the number of people (percentage of total of users) | | | | | Average Rating |
| | | 1 bad | 2 | 3 | 4 | 5 good | |
| 1 | How would you rate the use of gestures to zoom in and out on the sphere? | 0 (0%) | 1 (25%) | 0 (0%) | **3 (75%)** | 0 (0%) | **3.5** |
| 2 | How would you rate the use of gestures to rotate the sphere? | 0 (0%) | 1 (25%) | 0 (0%) | **2 (50%)** | 1 (25%) | **3.8** |
| 3 | How would you rate the response of your gestures of the left hand? | 0 (0%) | 1 (25%) | 1 (25%) | **2 (50%)** | 0 (0%) | **3.3** |
| 4 | How would you rate the response of your gestures of the right hand? | 0 (0%) | 0 (0%) | 0 (0%) | **4 (100%)** | 0 (0%) | **4.0** |
| 5 | How would you rate the use of your right and left hands for different tasks? | 1 (25%) | 0 (0%) | **2 (50%)** | 0 (0%) | 1 (25%) | **3.0** |
| 6 | How do you rate the response of the application if you move your hands away from the Leap Motion? | 0 (0%) | 0 (0%) | **3 (75%)** | 1 (25%) | 0 (0%) | **3.3** |
| 7 | How easy was it for you to learn the gestures to control the interface? | 0 (0%) | 1 (25%) | **2 (50%)** | 1 (25%) | 0 (0%) | **3.0** |
| 8 | How clear were the given instructions? | 0 (0%) | 0 (0%) | 1 (25%) | **2 (50%)** | 1 (25%) | **4.0** |
| 9 | How would you rate this control by gestures when compared to regular pointing devices? | 0 (0%) | 1 (25%) | **2 (50%)** | 0 (0%) | 1 (25%) | **3.3** |
| 10 | How explorative did this data navigation with gestures feel? | 1 (25%) | 1 (25%) | 0 (0%) | **2 (50%)** | 0 (0%) | **2.8** |
| 11 | How do you rate the accuracy (control) of the timeline? | 0 (0%) | 0 (0%) | **2 (50%)** | **2 (50%)** | 0 (0%) | **3.5** |
| 12 | Is the visualization of the data clear and understandable? | 0 (0%) | 0 (0%) | **4 (100%)** | 0 (0%) | 0 (0%) | **3.0** |
| 13 | How would you rate the earthquakes visualization? (circles/magnitude) | 0 (0%) | 1 (25%) | **2 (50%)** | 0 (0%) | 1 (25%) | **3.3** |
| 14 | How would you rate the scale and colours of the visualization? | 0 (0%) | 0 (0%) | **2 (50%)** | **2 (50%)** | 0 (0%) | **3.5** |

**Table 3.** The results of the third user evaluation. The ratings of the most relevant questions are shown. Every part is rated from 1 to 5, with 1 being the worst rating and 5 being the best rating. The number of persons that have rated the score is notated for every rating and after that the percentage of how many users of the users in total have given this rating. The score that is given the most is stated in bold. Also, the average rating is calculated for every question.

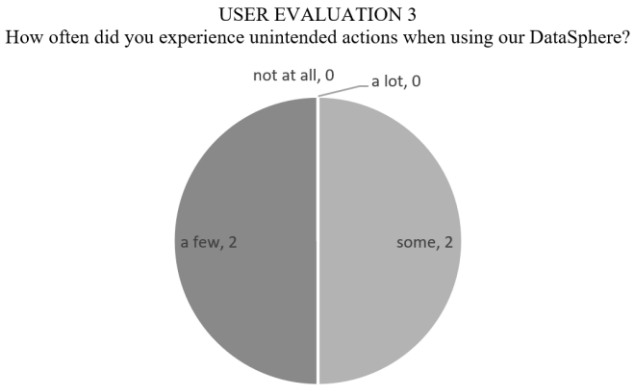


**Figure 7.** This pie chart shows the proportion of users that experienced a specific amount of unintended actions during the usage of the DataSphere in user evaluation 3.