Welcome, and thank you for participating in our study. By taking part in this study, you will be helping us measure several visualization methods. The study includes three parts: (1) training (which we are doing now), (2) the experiment, and (3) an interview for your comments. During the training session, correct answers will be displayed on the screen. Please feel free to ask any questions. When the formal experiment starts, no answer feedback will be provided and we won't be able to answer any questions.

Introduction

You will see three vector field visualization methods. A vector has magnitude and orientation in 3D. In this study, vector magnitude is represented using the digit (A) and the power (B) terms in the scientific notation as shown on the screen.

$$Vector\ magnitude = A \times 10^{B}$$

For example, 320 can be written in the form: 3.2×10^2 and it can be depicted using the first method shown on the screen.

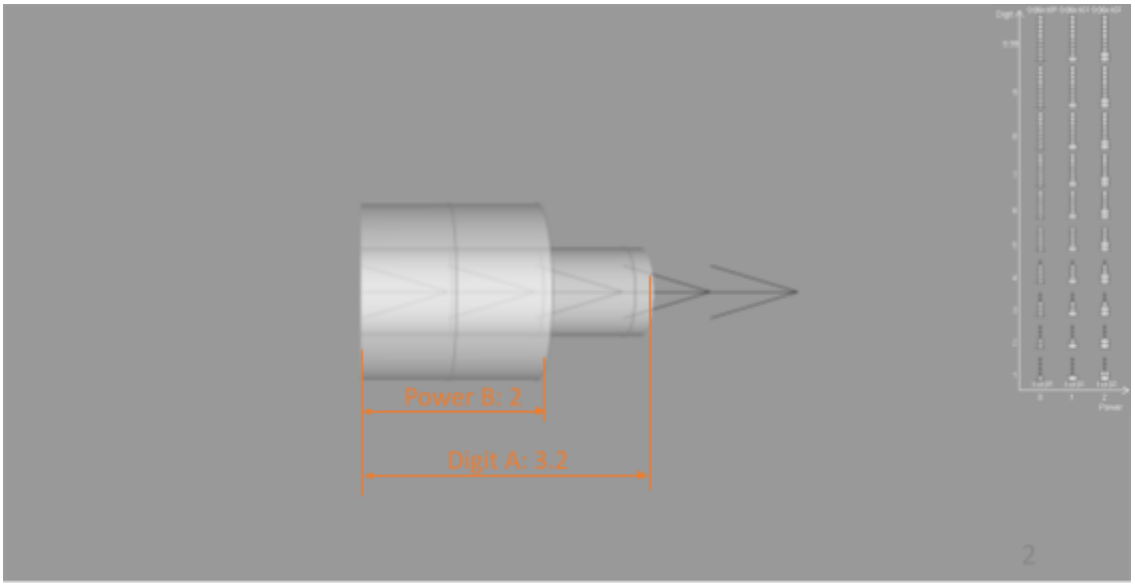


Figure 1. One example of method 1: $320 = 3.2 \times 10^2$, where the digit A is 3.2 and the power B is 2.

Three Visualization Methods

Method 1: Length-Length

This first method uses two co-centric cylinders to represent A and B accordingly: the length of the inner cylinder (radius = 0.5) represents the digit A, and the length of the outer cylinder (radius = 1) shows the power B. For example, here we show 320 as this glyph.

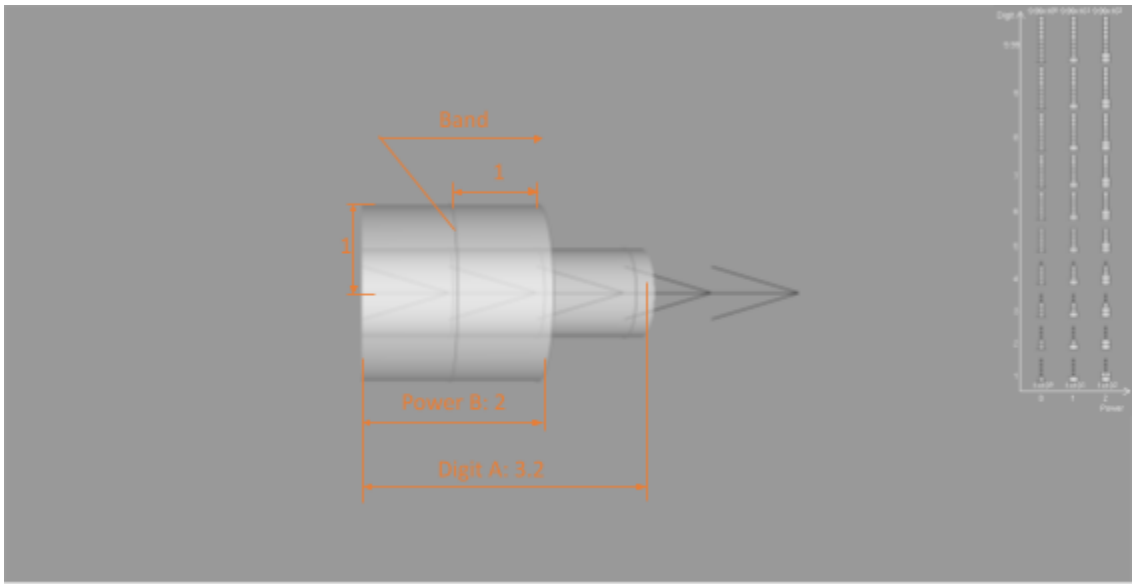


Figure 2. One example of method 1: 320 = 3.2 x 10^2, where the digit A is 3.2 and the power B is 2.

To help you see the A (here 3.2) and B (2), we draw bands around each cylinder, and the distance between two adjacent bands is 1 unit. Now you can see the length of the outer cylinder (B, the power term) is 2 and the length of the inner one is 3.2. Sometimes, the inner cylinder is shorter than the outer one, for example for a number like 3.5 x 10^6.

Also, a fishbone-like mark inside a cylinder uses the same scale as the band for your scale reference and that the distance between two adjacent fishbone is 1.

As you can tell, here A, the digit term A, is a real number with a range of [1, 10), and B, the power term B, is an integer. A legend showing the length scale of A and the B is displayed in the upper-right corner of the screen. The horizontal axis represents the power B, and the vertical one shows the digit A. The horizontal axis shows the possible power categories in the vector field, here 7 in this example.

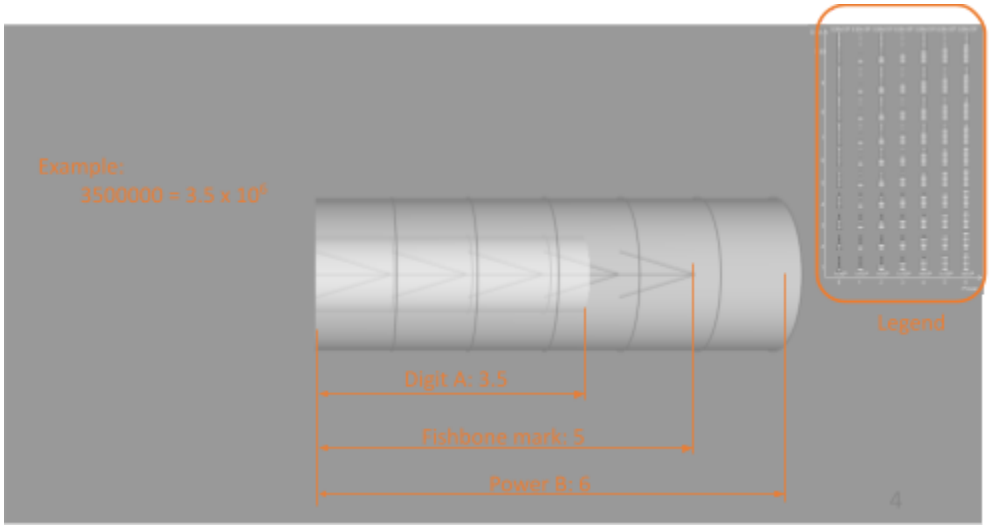
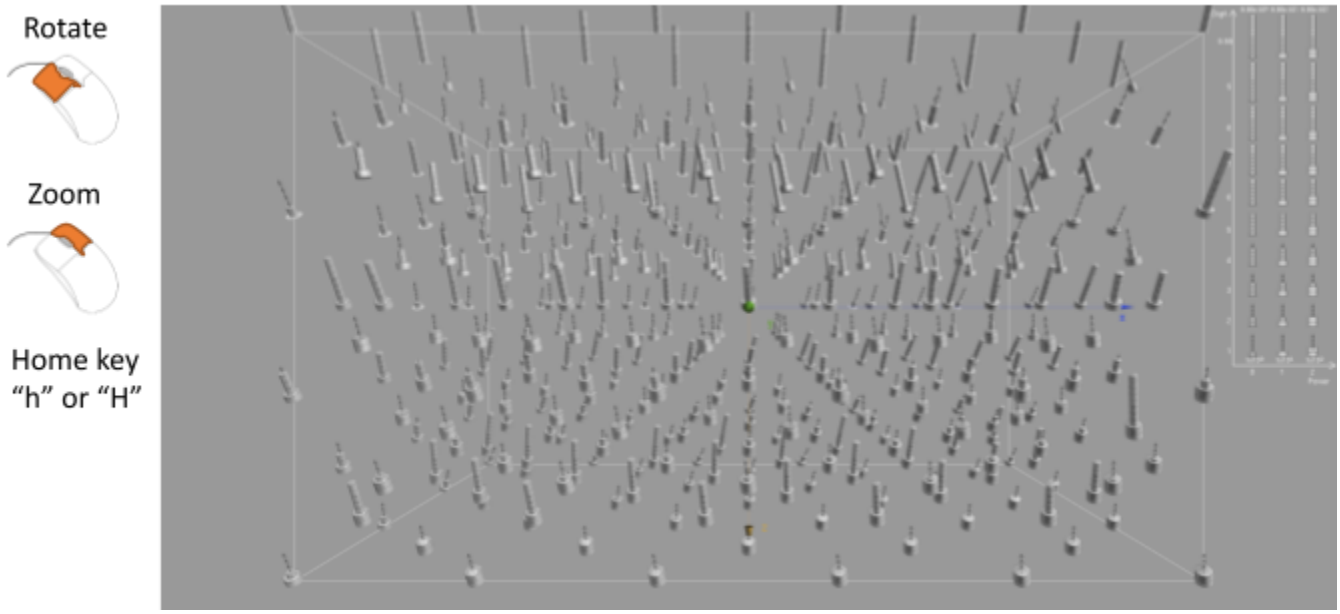


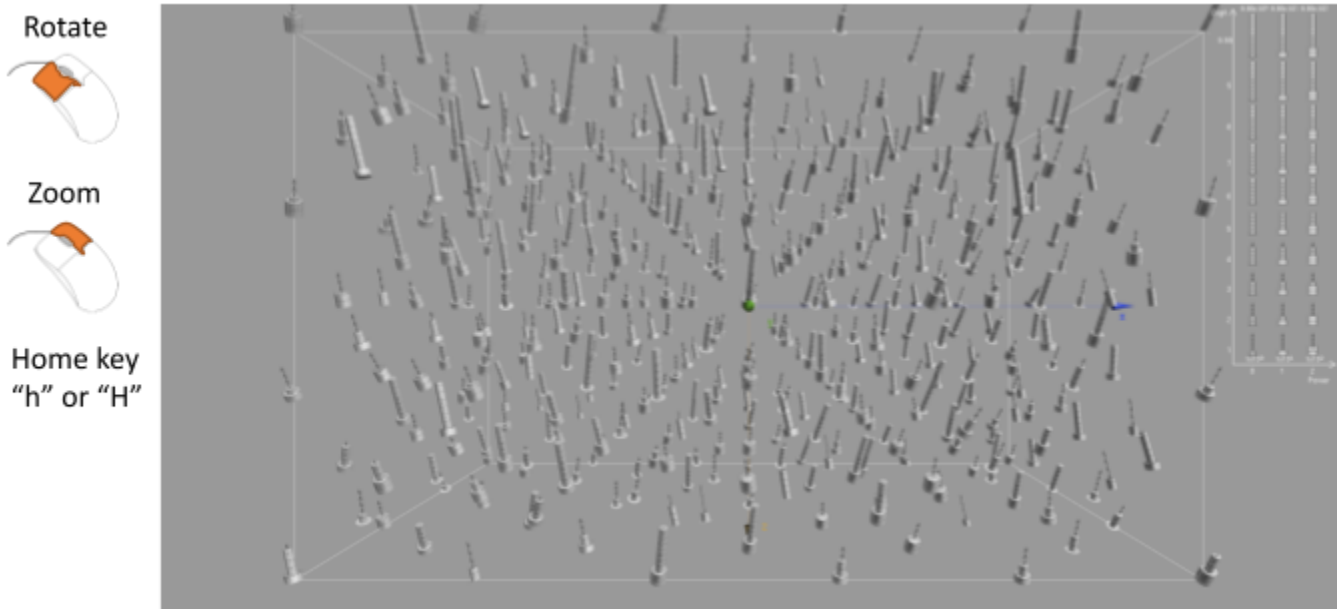
Figure 3. One example of method 1: 3500000= 3.5 x 10^6, where the digit A is 3.5 and the power B is 6.

Now, a vector field consists of many individual vectors. This interface is interactive and you can rotate the data by holding and dragging your left mouse button and zoom in and out using the right button. Your middle button is reserved to answer questions.

In the structured condition, all vectors belonging to the same power will be close to each other. In the random condition, different powers are distributed randomly.



(a) An example of a structured vector field



(b) An example of a random vector field

Figure 4. Structured and random vector fields using method 1.

Method 2: Color-Length

Here shows the second visualization method. Compared to method 1 you just saw, the method uses color to show power B. As you can see from the legend, the yellow color represents power of 2, as a result, this vector represents 320 (3.2×10^2).

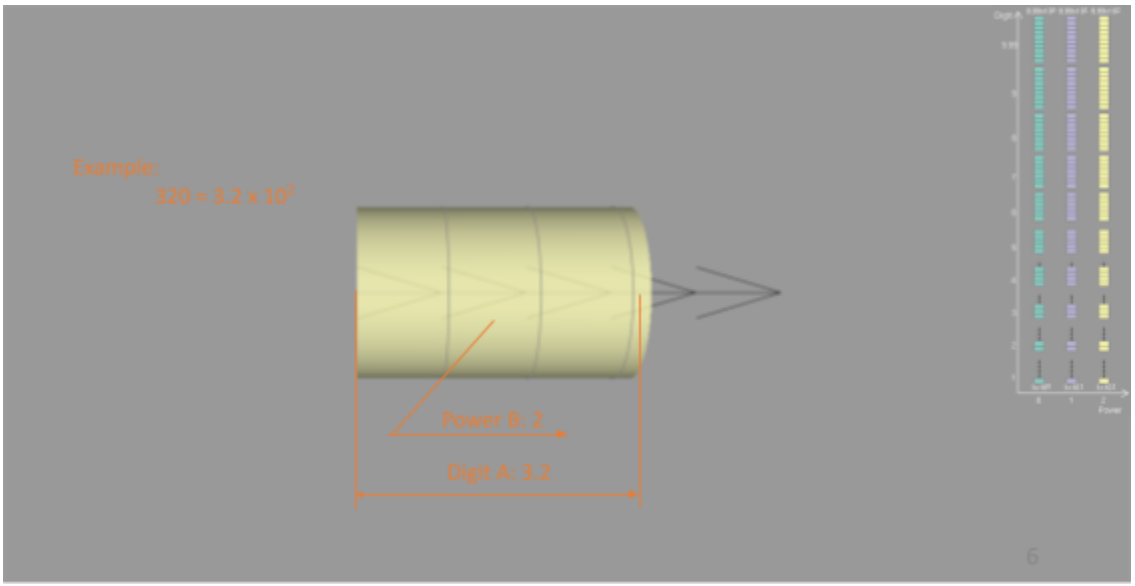
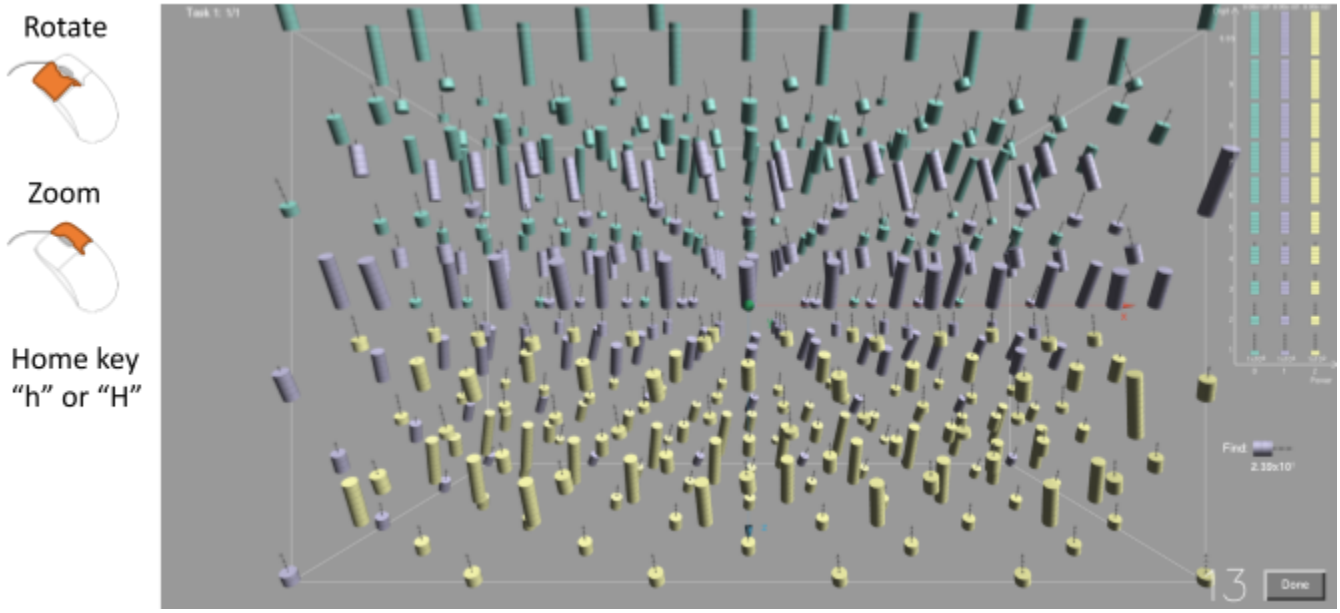


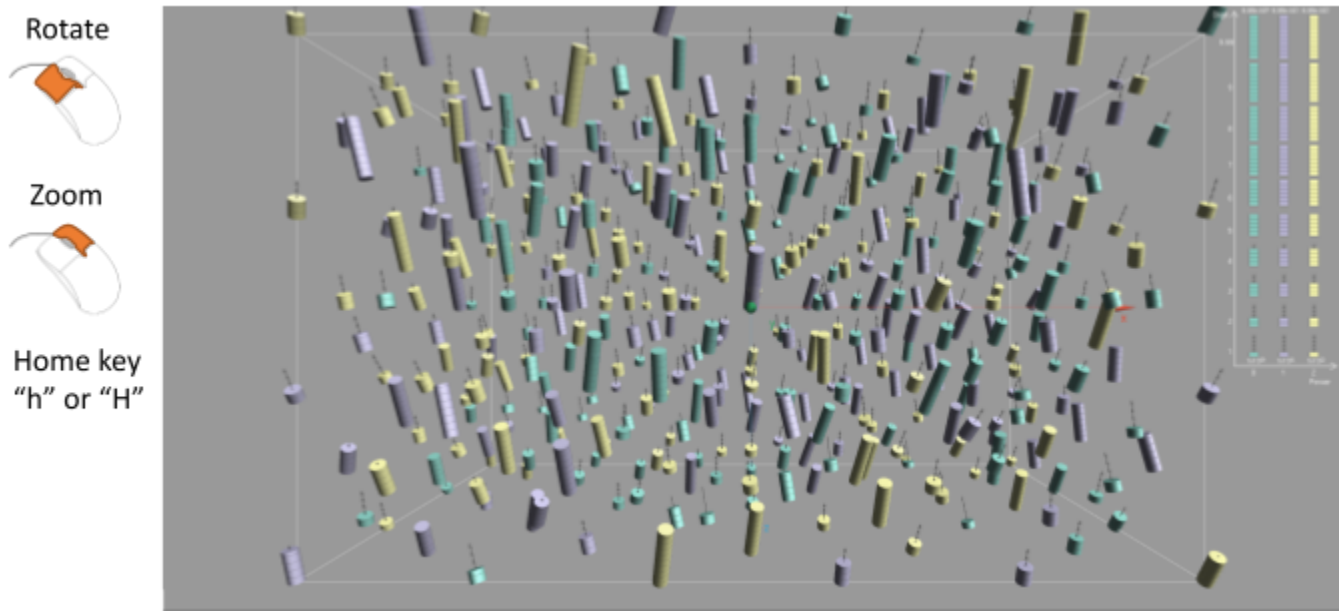
Figure 5. One example of method 2: $320 = 3.2 \times 10^2$, where the digit is 3.2 and the power is 2.

Again, you can see them displayed as a field. In the structured condition, all vectors belonging to the same power will be close to each other.

In the random condition, different powers are distributed randomly.



(a) An example of a structured vector field



(b) An example of a random vector field

Figure 6. Structured and random vector fields using method 2

Method 3: Texture-Length

Now, let’s look at Method 3. Here, power is replaced by texture instead. The 2D legend shows the texture segments in different powers, and the texture on a cylinder is generated by repeating those texture segments. The amount of black in white represents the power. When the number of power category is 4 (power = [0, 1, 2, 3]), we can see that white represent 0 and near black represent 3, and the proportion of black linearly increase for 1 and 2.

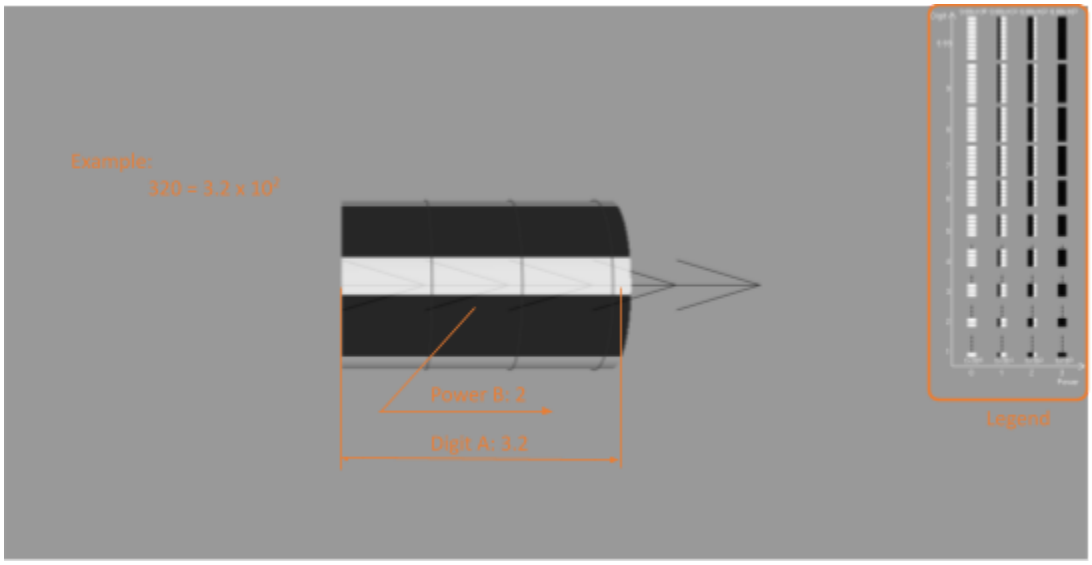
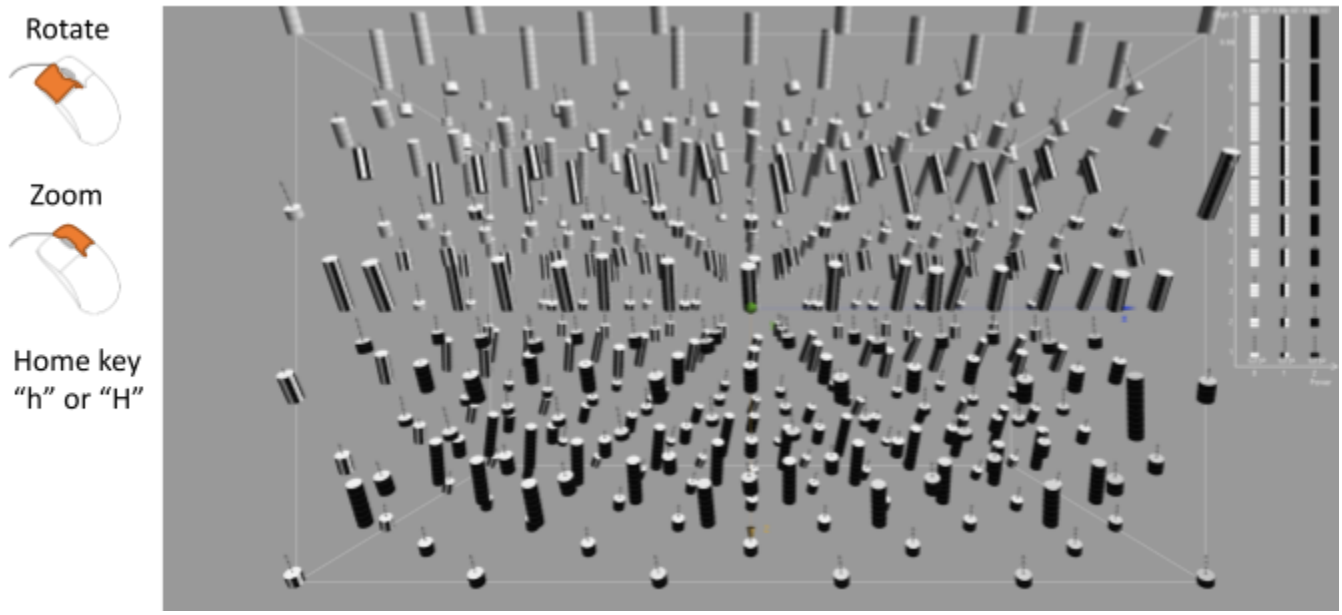


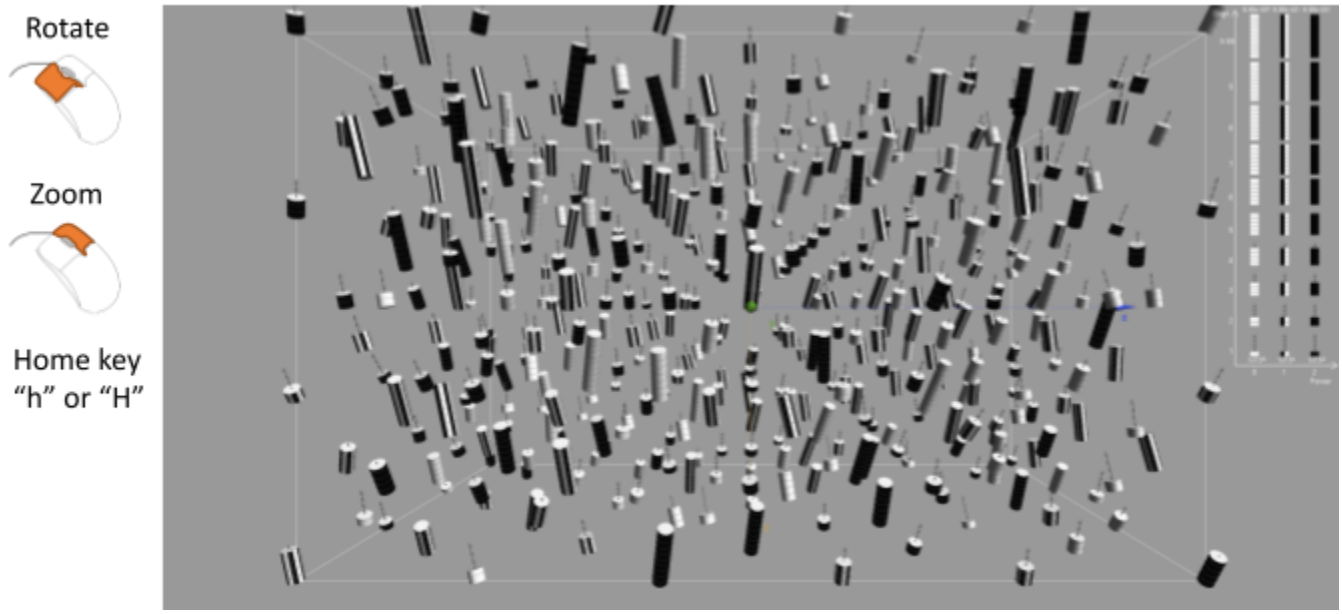
Figure 7. One example of method 3.2: 300 = 3.2 x 10^2, where the digit is 3.2 and the power is 2.

Here are a few more examples.

Again, showing many vectors using the structured texture-length approach will give us a vector field as shown on the left screen. We also show you an example of a random field using this approach.



(a) An example of a structured vector field



(b) An example of a random vector field

Figure 8. Structured and random vector fields using method 3

Tasks

Now, let’s look at the three tasks you will be working on today.

Task 1: quickly within 20 seconds, find the vector with the magnitude of X (X will be provided in each task).

Your goal is to find the vector which has the magnitude of X. In this example, we ask you to find the vector with magnitude of 23.9 (or 2.39×10^{1}). There is only one correct answer. The key for each sub-task will be shown on the middle-right side of the screen under the digit-power legend display. You can use any strategies to help you locate the vector and please be as accurate as you can.

Use middle-mouse button to select your answer. You can change your answer before timeout or by clicking the “Done” button to go to the next task (or during the training, click the “Next” button after seeing the feedback). A

timer is next to the “Done” button. Just a reminder, you can rotate the data with left-mouse dragging and zoom with right-mouse button.

Next task will be automatically loaded if timeout.

During the training session, feedback will be provided. For each task, the correct vector will be marked by two blue triangles on each end of the vector.

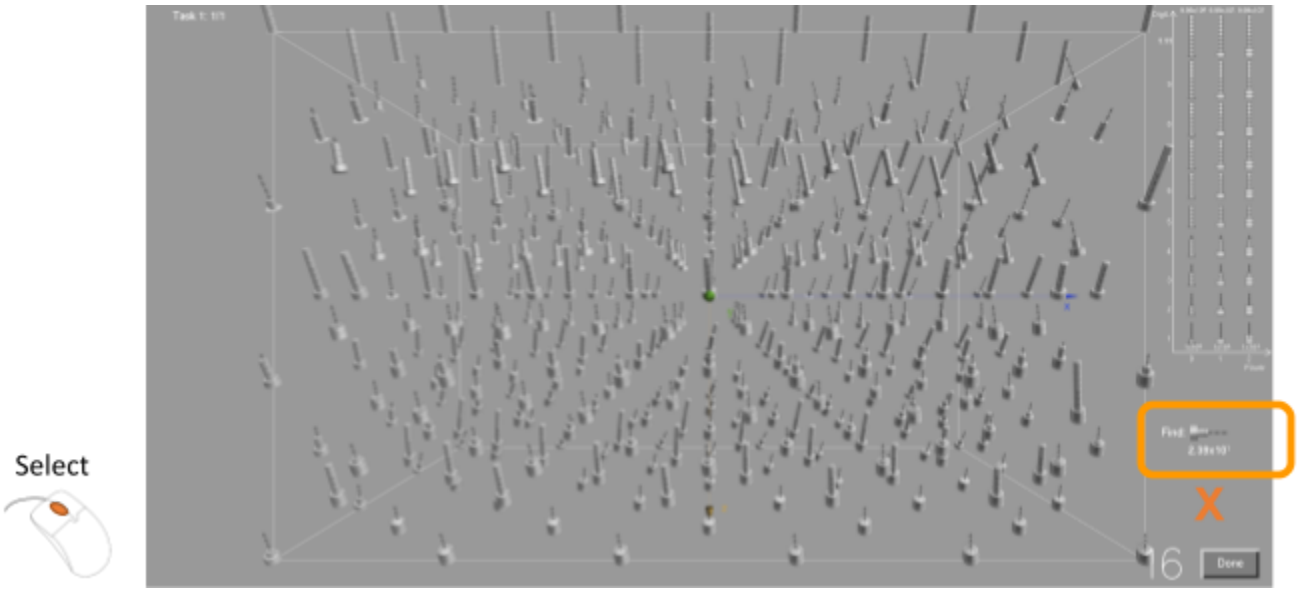


Figure 9. An example of task 1.

Task 2: quickly within 20 seconds, which vector has the maximum magnitude when power is X **(X will be provided in each task)?**

During the second task, your goal will be to find the vector with the maximum magnitude among the vectors with power X, where X is an integer. In this example, the X is 2.

To answer this question, click your answer vector using the middle mouse button, and the selected vector will be highlighted by two red triangles.

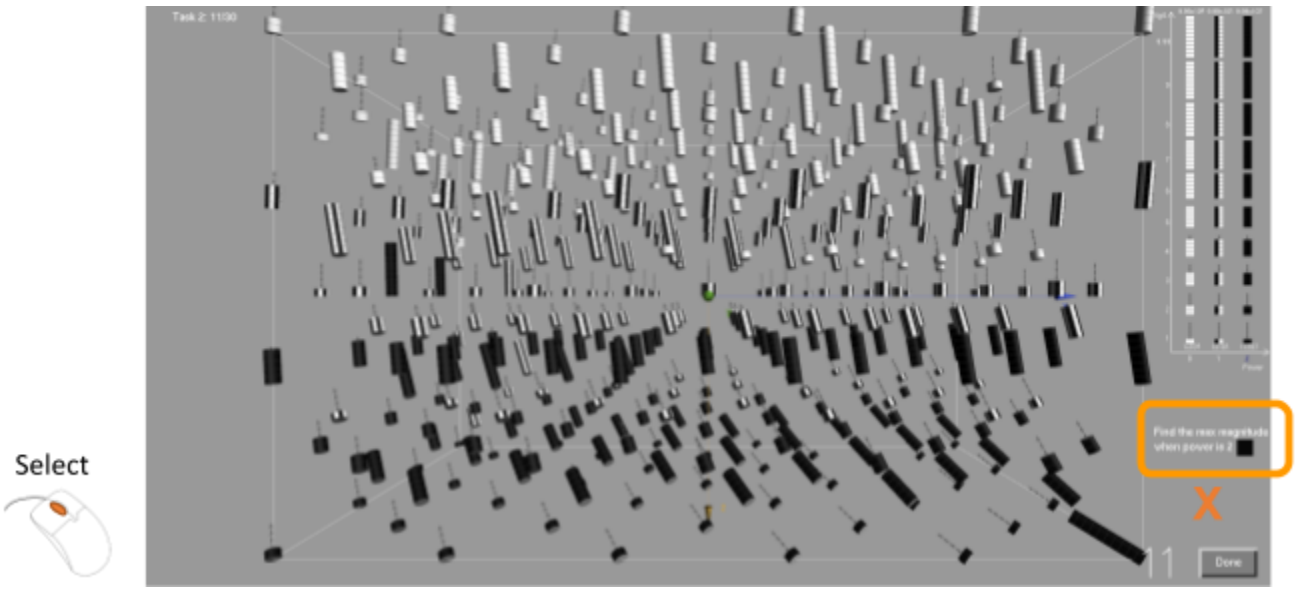


Figure 10. An example of task 2.

Task 3: quickly within 1 second, estimate the total number of different powers in the vector field.

In the third task, your goal is to estimate the total number of different powers in the vector field. The vector field will be shown on the screen for 1 second. The answer is between 3 and 7 inclusive ([3, 7]).

To answer this question, please click a button with the left mouse button. In this example, the key is 3, because there are three colors to show the powers.

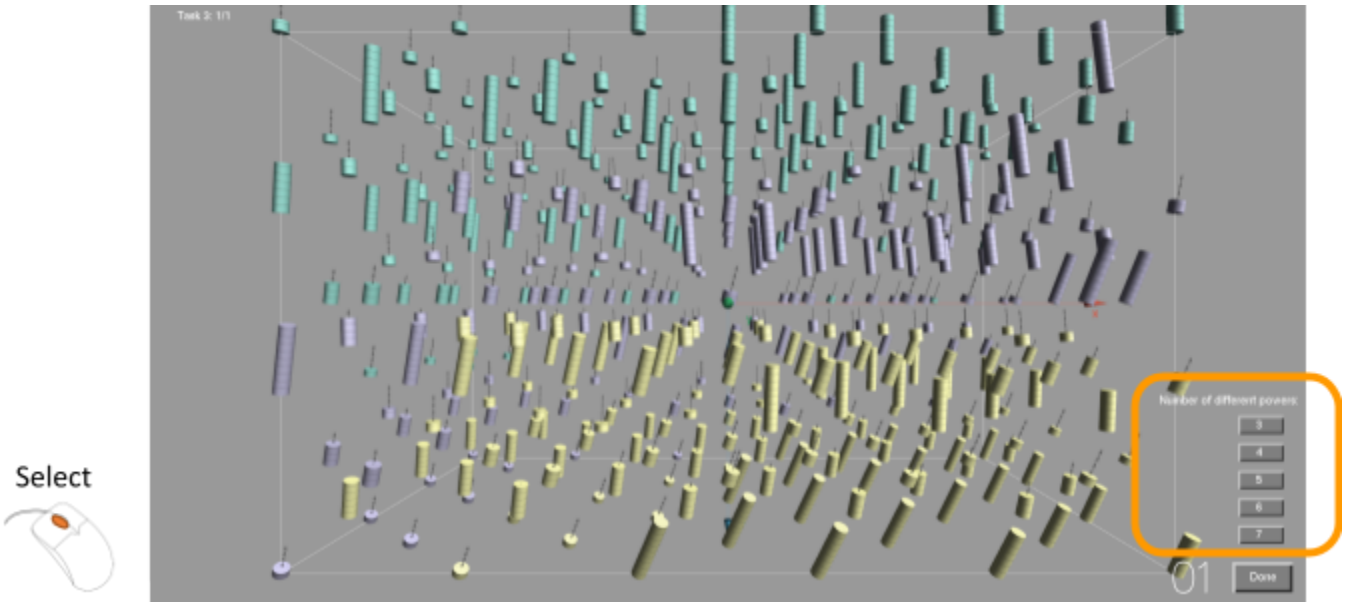


Figure 11. An example of task 3.

Now let's practice with real tasks. You will be asked about your confidence levels using the visualization method. There will be an optional 1-minute break before advancing to the next task. Please feel free to ask questions during this training section. Please feel free to refer back to this presentation or the print out during the training. During the formal study, you won't have access to these documents.

Please complete each task as accurately and as quickly as you can. Accuracy is more important than speed.