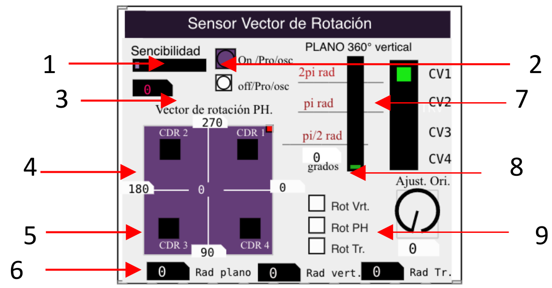
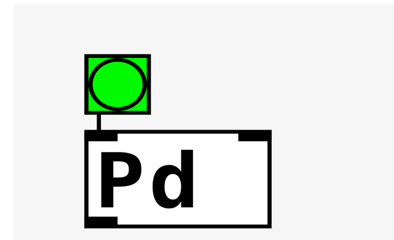
Patch Pure DAta

ROTATION VECTOR (M. VECROT) AND (M. VECROT 3D) MODULE

Diseño y desarrollo de sistemas MMHCI híbridos con bioseñales y un DMI de smartphones, para obras bio-interactivas mixtas y performáticas

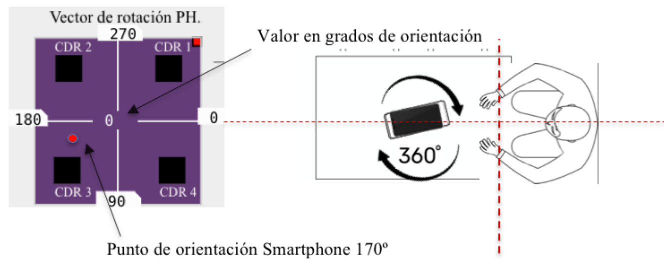
Pure Data Patches for the PhD Thesis: Juan Pablo posada Alvarez





Patch Pure DAta

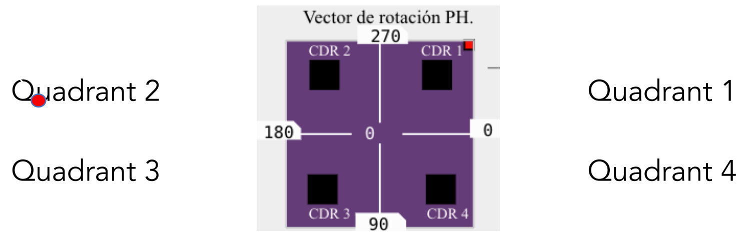
1. **Filter window adjustment** (moving average): Reduced values in this parameter allow an uninterrupted flow of the signal with noise, while high values contribute to stability in data variation by decreasing the noise level. It is recommended that this parameter be adjusted according to the tests performed with each device in combination with the Processing app.
2. **On/Pro/OSC:** Activating the "On/Pro/OSC" button allows you to send the rotation vector sensor value data to the Processing application. In addition, it is possible to send this data to any software that supports receiving data by OSC. The addresses and labels for receiving the data are as follows: "rotationX" for the x-axis, "rotationY" for the y-axis, "rotationZ" for the z-axis. The default port for data transmission is 8070.
3. **Off/Pro/OSC:** Enabling the "Off/Pro/OSC" button allows you to restrict the data passage of rotation vector sensor values to the Processing application.
4. **PH Rotation Vector:** This Cartesian plane represents the orientation of the Smartphone device in a single horizontal plane in real time. By default, the axis of rotation that represents this plane is around the Z axis. When you place the Smartphone and Display upwards on a table and rotate it on its axis, you can see the dot – red – indicating the specific orientation of the device and the quadrant in which it is located, as shown in the image.



Smartphone display in 170° orientation in CDR 3

Instead of using cardinal points, the quadrants (CDR) are numbered from 1 to 4, allowing the performer to locate himself without depending on a geomagnetic reference of the north pole. When the smartphone is rotated clockwise, the degrees advance from 0° to 90°, from 91° to 180°, and so on up to 360°. It is important to bear in mind that, when crossing the limits of 360° and 0° degrees, the values make a complete leap. To avoid this inconvenience, values above 358° degrees and those below 2° degrees have been limited. Also, it is recommended not to continue spinning beyond these limits in any way, as it would cause an interruption in values.

5. **(CDR) Quadrant:** This box provides a visual representation of the quadrant in which the Smartphone is oriented. In addition, it indicates the opening of the event gate by displaying the activation of a cross inside, as shown in the image. Each quadrant covers a range of 90° degrees. which allows independent control and interaction of each one. This independence is achieved by activating gates arranged at the module outputs, enabling precise and dynamic control of the device's orientation.



Visualization in CDR 2 with gate activation in PD

6. **Data Output:** The three values associated with the data output allow visualization of the scaled values in radians for each of the three axes of the rotation vector sensor. The user can use these values to generate any type of interaction. For data outputs to be activated, each axis in the section with ROT labels must be activated.
7. **360° vertical flat rotation vector:** This vertical bar represents, in real time, the plane of the vertical rotation vector. By default, this rotation is defined around the X-axis of the device. The initial position for sensor calibration is set when the smartphone is in a horizontal position, with the display facing upwards, either held in the hand or resting on a flat surface. At this reference position, the display will oscillate around the value of π radians (180°), as shown in image (a). An example of this vertical tilt movement and its corresponding visual representation is presented in image (b).

a) b)

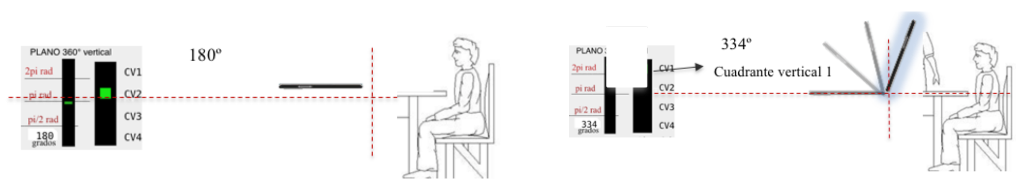
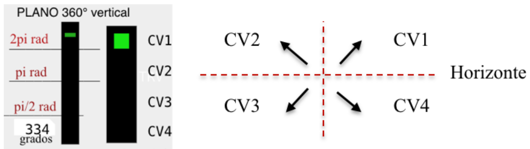


Figure **Error! No text of specified style in document.**.1 180° calibration position on CV 2 and tilt on CV1

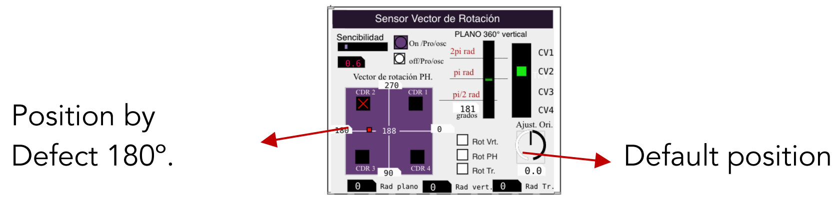
8. **Vertical Quadrant Display:** To visualize this vertical rotation plane, a vertical graphic bar was implemented. This design choice was made due to the limitations of the graphical user interface in Pure Data (PD), which does not support the rendering of objects with three-dimensional perspective. Adjacent to this bar is the vertical quadrant (CV) display. As in the horizontal plane, the vertical rotation range has been divided into four segments or quadrants: two above the horizon and two below. Each of the black lines on this display delimits the key positions of the smartphone: vertical/horizontal and with the screen (display) facing up or down, resulting in the four segments mentioned. This representation is illustrated in the image.



Visualization of the rotation vector in vertical plane

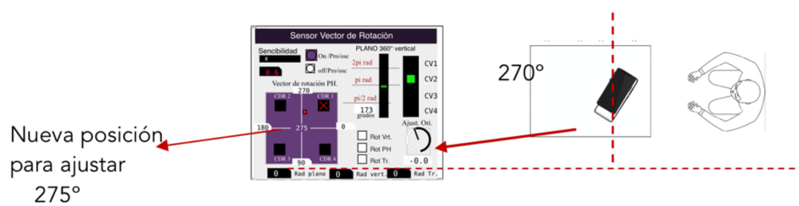
It is important to note that the representation of the rotation position is made with the Smartphone oriented towards the north pole, which is clarified in the Processing application and is essential to understand both the movement and its representation in PD. If the smartphone is not oriented towards the magnetic north pole, the vertical measurement values will be altered and the range from 0 to 360° will be reduced.

9. **Aajuste ori:** The module has been designed with the ability to adjust the rotation vector data in the horizontal plane to suit the user's specific conditions, dispensing with the orientation reference of the north geomagnetic pole. By default, this knob is set to 0 and the position indicator is set to 180°, as shown in the image

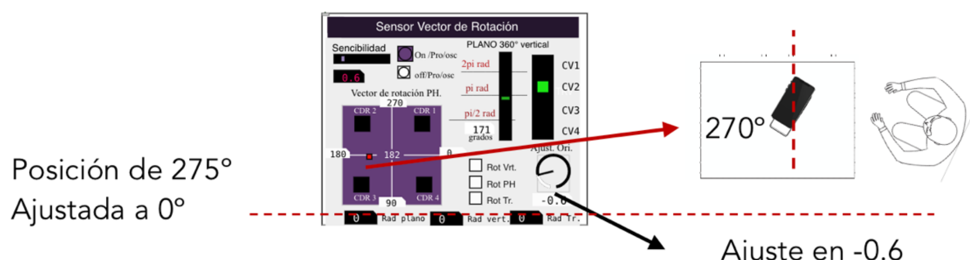


Default position: rotation vector orientation (north pole)

When the performer is not oriented towards the north pole, it is possible to adjust the modulus so that, in any position, the quadrants have the same distribution as if it were oriented to the north pole. The calibration procedure is carried out as follows: the performer must place himself with the Smartphone in the new horizontal position, as can be seen in Figure 4.27, this new position corresponds to 275° in quadrant 3. To make this position the new reference, the values of the horizontal adjustment knob are set to -0.6, making the 275° reference 0° or 180°, as illustrated in Figure 4.28.



Reference Settings in the Horizontal Plane of the Rotation Vector



New PH position in Rotation Vector set to 0º.

A simple method of adjustment involves turning the knob until it aligns with 0°. However, it is important to note that this adjustment to the new position must allow for a full turn to access all four quadrants. Otherwise, if the setting to 0° does not allow a full rotation of the smartphone in the horizontal plane, another value can be selected that allows rotation without limitations.

10. **Rot (PH, Vtr, Tr):** Each checkbox enables rotation vector data on each axis to be available on each module output, while also allowing submission to the Processing application for calibration and adjustment. The labels "Rot vrt" correspond to the vertical plane, "rot PH" to the horizontal plane, and "rot Tr" to the transverse plane.

3D Quadrants and Transverse Rotation: The incorporation of the Main module in Pure Data focuses on the collection of vector rotation sensor data and the identification of features relevant to IM interaction modes. However, in addition to the main module that contains algorithms to determine the position of the Smartphone in the quadrants of the vertical and horizontal axes, a secondary module was designed. This secondary module combines the data from the quadrants in the horizontal and vertical plane to obtain orientation in a three-dimensional space of the Smartphone. To achieve this, an algorithm has been implemented that divides the 3D plane into 8 quadrants and activates a binary gate corresponding to each quadrant. Each of these allows interaction to be generated based on the specific orientation of the device in three-dimensional space. The segmentation scheme in the child module is illustrated in Figure 4.29, thus providing a visual representation of this process and the visualization of the activation of each quadrant.

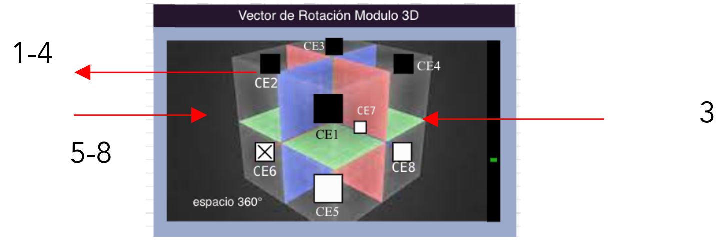


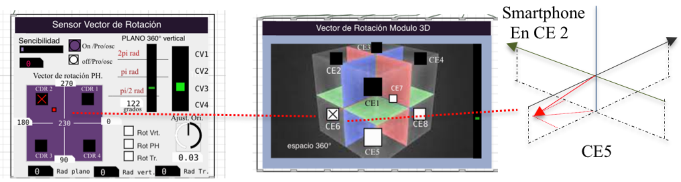
Figure **Error! No text of specified style in document.**.2 Visual interface of the 3D Rotation Vector module in Pure Data

This module must be connected to the main module for proper operation in the corresponding Inlet and Outlets in Pure data.

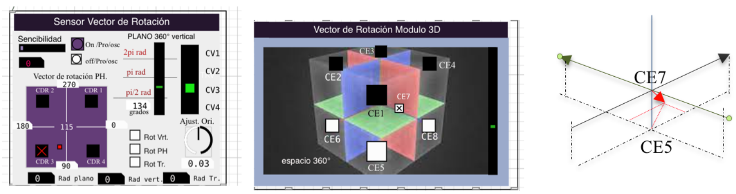
1. **CE (1-4):** These black boxes make it easy to see the activation of each spatial quadrant located above the horizon when the Smartphone is oriented in quadrants 1 to 4.
2. **CE (5-8):** These white boxes make it easy to see the activation of each spatial quadrant located below the horizon when the Smartphone is oriented in quadrants 5 to 8. It is important to note that quadrant 7 cannot be represented spatially at the exact point of the module.

3. **Vertical Flat Rotation Vector:** This vertical bar, as in the main module, represents the plane of the vertical rotation vector in real time. This helps to see the location and division between the planes above and below the horizon. Additionally, it is important to note that the default orientation of the device is aligned with the north geomagnetic pole. In this sense, the visual layout of the module is simply referential; the fundamental thing is to understand the assignment of each spatial quadrant (SC) and in what position it is activated by means of the Smartphone. In images 4.30 a and b, an example is presented illustrating two positions of the Smartphone and their respective activation quadrants. This underscores the importance of the initial orientation of the device and how this relates to the activation of the spatial quadrants:

a) Smartphone in CE2 main and secondary module view



b) Smartphone in CE7 main and secondary module view



Examples of 3D Rotation Vector Positions and Quadrants in PD

It is also important to mention that for MMHIC interaction systems, it is essential to note that rotation vector data such as accelerometer data on smartphones, can suffer a lot of noise, especially in low-gamma ones. This noise factor, inherent in measurement devices, can affect the accuracy of the data captured and, therefore, the interpretation of the user's gestures and movements, and this will be reflected when the 3D location gates are activated.

- **Inlet:** Input for OSC module.
- **Outlets 1, 2 and 3:** Output of radian values (0, 6.28) of the three axes of the rotation vector (Vrt, PH, Tr). In order for the output to send values it must be enabled in the module (Rot) boxes on PD.

- **Outlet 4-5-6-7:** Output bit value (1.0) for detection of CR1, CR2, CR3, CR4 quadrants for the horizontal plane. Likewise, these 3 outputs connect to the secondary module of 3D Quadrants to Inlets 1, 2 and 3.
- **Outlet 8-9-10-11:** Binary output (1.0) for detection of CV1, CV2, CV3, CV4 quadrants for the vertical plane. Likewise, these 3 outputs connect to the secondary module of 3D Quadrants to Inlets 4, 5 and 6.

The module is connected as follows:

- **Inlet:** These entrances connect the outlets of the main module 4, 5, 6 and 7.

Inlet 5 -6 -7-8: These inlets connect the outlets of the main module 8, 9, 10 and 11