# Exercise 2

## Group 04 members:

- Abdelkader Temer
- Josue Enrique
- Ouassim Milous
- Younes Hebik

**To run the Simulink modules for exercise 2, first you have to load the EMG data to the workspace by running the matlab script (exo2.m).**

## Q2. The cardinal directions targets:

To achieve movement in the four cardinal directions, we processed the four muscle signals and implemented a multiplexer to encode the information into the VRSink block. This was done by combining the signals from the left and right sides of each muscle through subtraction. Each muscle group thus controls movement along a specific axis:

- If the right biceps signal is stronger than the left biceps, the cursor moves in the positive x-direction; otherwise, it moves in the negative x-direction.
- A similar approach is applied to the trapezius muscles for movement along the y-axis.

The multiplexer inputs are:

1. The processed muscle signal responsible for x-axis movement.
2. The processed muscle signal responsible for y-axis movement.
3. A constant value representing movement (or lack thereof) in the z-axis direction.

By carefully adjusting thresholds and fine-tuning the gain, we ensured that the maximum signal intensity maps effectively to the target positions, allowing the cursor to reach all four cardinal directions.

## Q3. Diagonal Targets:

To enable efficient movement toward the four diagonal targets, we designed specific muscle activation patterns tailored for diagonal cursor control. By carefully setting thresholds and combining muscle activations, we ensured smooth diagonal movements.

We achieved this by integrating signals from two muscles for each diagonal direction. For example, when one muscle signal triggered movement in the +Y (North) direction and another in the +X (East) direction, the cursor moved at a 45-degree angle toward the Northeast (NE).

Building upon our implementation of the cardinal directions—where signals independently controlled X and Y movements—we linearly combined these signals (using addition and subtraction) to produce a resultant signal incorporating both x and y components. This method ensured precise diagonal movement since the combination of equal-intensity vectors along both axes naturally results in a 45-degree trajectory.

The processed signals were then passed through a multiplexer (MUX) to the VRSource block. To maintain accurate diagonal movement, we carefully adjusted the gains and thresholds to ensure that the two combined signals had equal magnitudes.

## Q4. Moving in Eight Directions:

To enable movement in all eight directions, we combined both cardinal and diagonal movements. This was achieved by applying a time shift to the signals using a step function, ensuring that the cursor first moves along the four cardinal directions before transitioning to the diagonal ones.

We explored different strategies for assigning muscle signals to movement control:

- One approach involved assigning the biceps signals to control vertical (Up/Down) movement instead of horizontal (Right/Left), while the trapezius muscles handled the horizontal movement.
- Another possible approach was to let the right biceps control positive x-direction movement while the trapezius managed negative x-direction movement. However, this method introduced challenges in signal combination and tuning. Differences in signal magnitudes could prevent an exact 45-degree diagonal trajectory, and variations in peak signal timing could cause asynchronous movement.

By fine-tuning signal processing and threshold adjustments, we ensured smoother transitions between the cardinal and diagonal directions for more precise eight-directional control.

## Q5. Alternative Implementation Approaches:

To achieve eight-directional cursor movement without relying on signal shifting, we explored methods to generate additional signal samples and control inputs. This allowed for more precise movement control. Possible approaches include:

- **Using the derivative:** By computing the velocity of each muscle signal, we obtain both positive and negative directional components, effectively doubling the available control signals.
- **Applying a double-threshold technique:** Each muscle signal is split into two distinct signals by setting two different thresholds, providing finer control over movement initiation and intensity.
- **Implementing a MATLAB function block:** This block concatenates the outputs of the MUX controlling cardinal direction movement with the MUX managing diagonal movement, ensuring smooth transitions and accurate control.

These methods offer an alternative way to achieve precise eight-directional control while maintaining signal consistency and responsiveness.