S 1.1 HMIs for disabled persons

1) Intent detection VS somatosensory feedback

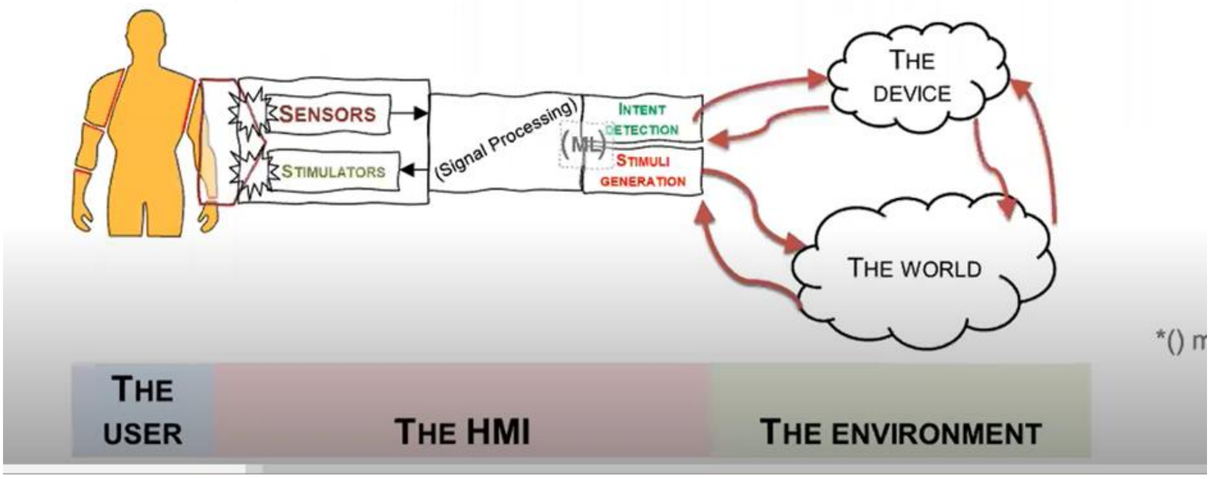
Intent detection: the feed-forward path

- detecting signals out of the participant‘s body
- converting them into control commands for your robot

Somatosensory feedback

- detecting signals from the environment and the robot
- converting them into bodily stimuli for your participant

2) Illustration (or similar)



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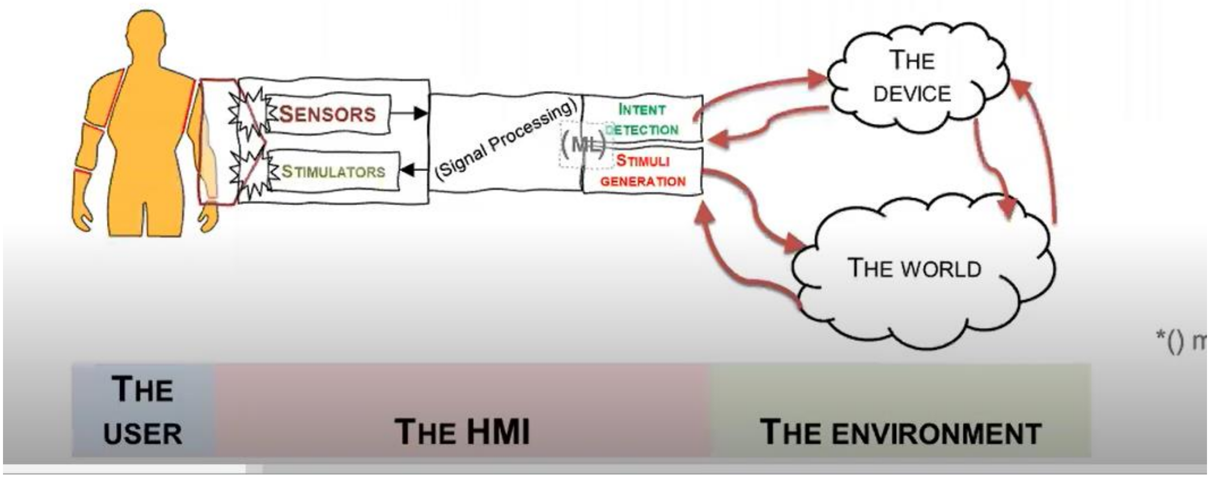


S 1.1 HMIs for disabled

3) Examples:

Sensors: e.g. Electromyography (EMG), Ultrasound, Force Myography

Stimulators: e.g. Tactile Pulses/Vibration, Force Feedback

E 2.1 Ground Truth Problem

State an example problem regarding the ground truth data acquisition for amputees. Propose a solution.

E 2.2 Offline VS Online Intent Detection

State the problem of offline vs. online intent detection. Compare it to a machine learning model that classifies CT scans from tumors into maligne and benigne. Give a reason, why offline intent detection does not work as well for e.g. human subjects with amputation.

S 2.2 Ground Truth Problem

- We cannot know if the person is performing the correct movement / providing the correct label as the limb is missing!
- They have no sensori-motor feedback any longer (proprioception)

Solution ideas:

1) "Think about performing the correct movement"
   - In case of congenitial amputation X
2) "Do the same movement with both sides"
   - Does not work for bilateral (both sides) amputation X
3) "Just produce signals patterns, which you can distinctly repeat"
4) Start with some signals and update model incrementally

S 2.3 Offline VS Online Detection

- Classically, you would first get huge amounts of data, then train and test your model (offline). Then your model would have a specific accuracy etc to classify maligne tumors.
- The difference: Your CT scans don't change, depending if they were correctly classified. The human user does! So we need a system that adapts to the user, but need to keep in mind that the user also adapts to the system **(Coadaptation)** and though his/her brain plasticity changes his/her biosignals. So in a way you have to models adapting to each other, which only works if the first model is "adaptable" => can incrememtally learn (online)
- Offline detection ignores the users interaction with the system!

Eigenvalues & Eigenvectors (basic)

Intuition (2D transformations)

What does a matrix $A \in \mathbb{R}^{n\times n}$ generally do to a vector $v \in \mathbb{R}^n$?

$$Ax = y$$

$\Rightarrow$ **Rotation** and **Scaling**

Examples:

$A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ (no transformation), $B = \begin{bmatrix} 2 & 0 \\ 0 & 4 \end{bmatrix}$ (scaling), $C = \begin{bmatrix} 0 & -1 \\ 0 & 1 \end{bmatrix}$ (90° rotation clockwise)

$A_\varphi = \begin{pmatrix} \cos\varphi & -\sin\varphi \\ \sin\varphi & \cos\varphi \end{pmatrix}$ (general rotation matrix)

What are Eigenvectors and Eigenvalues of a Matrix $A \in \mathbb{R}^{d\times d}$**?**

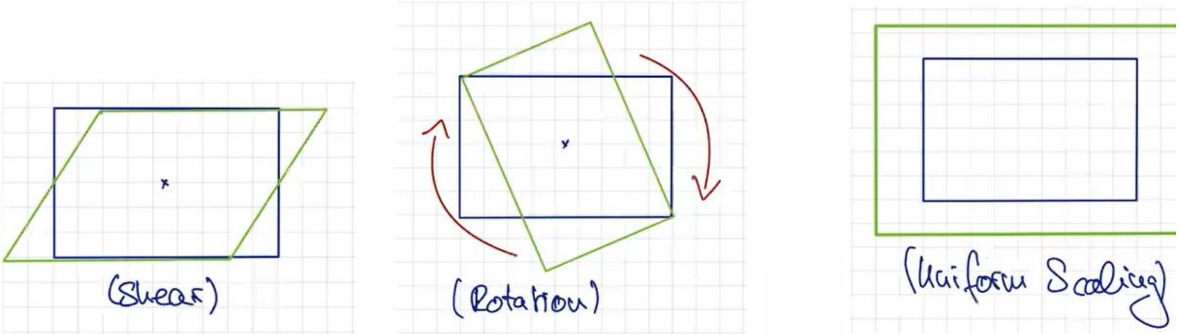
Let A be a $n \times n$-Matrix. $\lambda \in \mathbb{C}$ is an eigenvalue of A if there is a vector $x \in \mathbb{C}^n \setminus \{o\}$

$$A\boldsymbol{x} = \lambda \boldsymbol{x}.$$

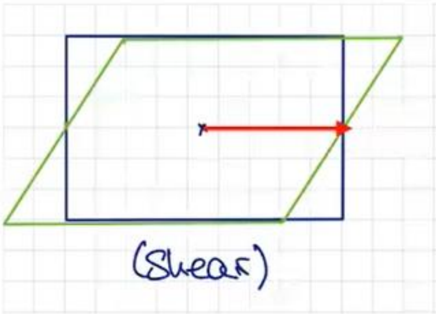
$\boldsymbol{x}$ is then called eigenvector of A.

E 2.4 Eigenvalues & Eigenvectors - Intuition

Sketch or describe the Eigenvector and –value for the matrix performing this geometric transformation.

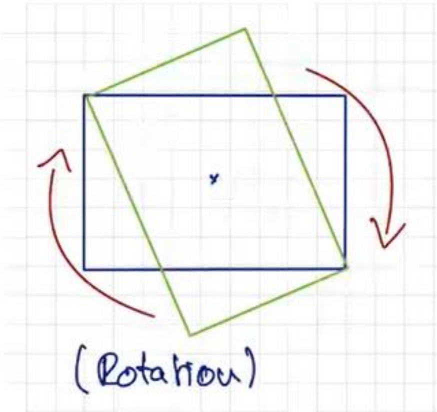


S 2.4 Eigenvalues & Eigenvectors - Intuition

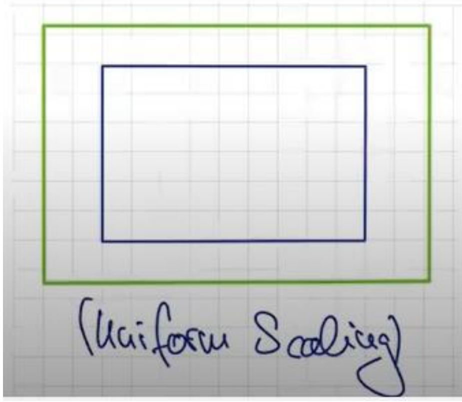


$\boldsymbol{x}$ is any vector with $x_2 = 0$

λ for these vectors is 1



for $\varphi \neq b\pi$, with $b \in \mathbb{Z}$, no eigenvalue or -vector



All vectors are eigenvectors.

λ is scaling coefficent