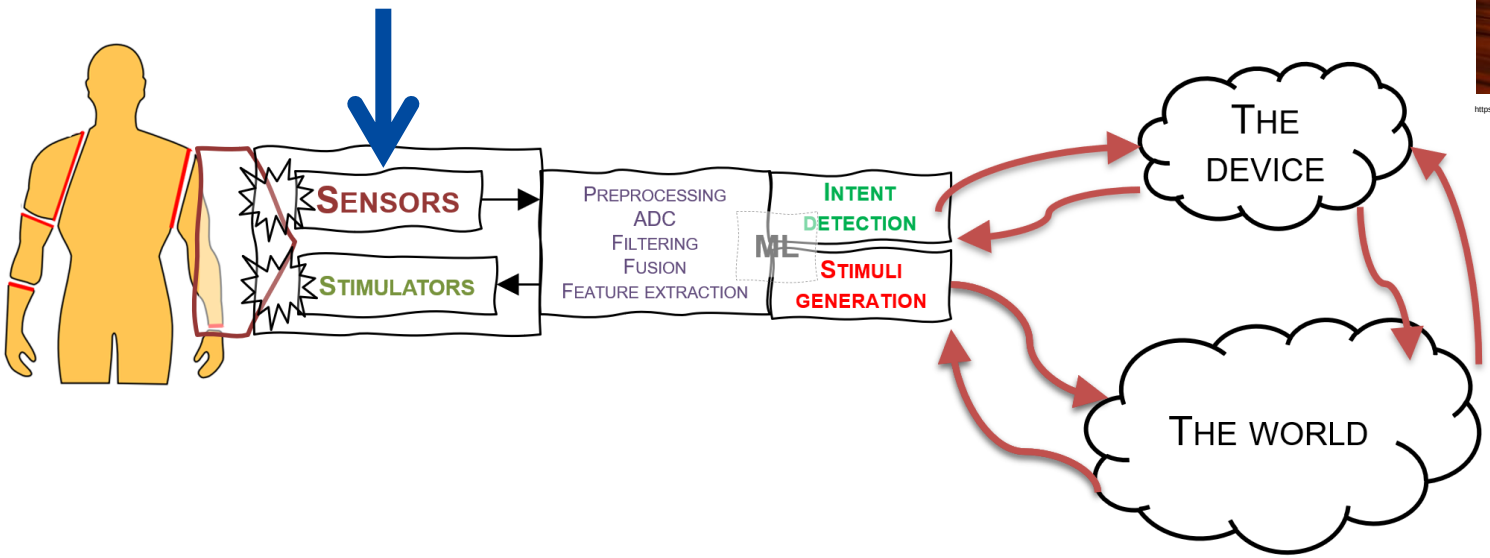
Closing the loop

Closing the loop



https://www.pexels.com/photo/woman-with-a-prosthetic-hand-holding-a-paper-coffee-cup-5386178/

Sensors

What kind of sensors would be helpful to grab a paper cup of coffee with a prosthesis and drink the coffee?

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Sensors

What kind of sensors would be helpful to grab a paper cup of coffee with a prosthesis and drink the coffee?

- Pressure
- Force
- Temperature
- EMG
- FMG
- …

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Sensors

What kind of sensors would be helpful to grab a paper cup of coffee with a prosthesis and drink the coffee?

How could an IMU be beneficial in this scenario?

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Sensors

What kind of sensors would be helpful to grab a paper cup of coffee with a prosthesis and drink the coffee?

How could an IMU be beneficial in this scenario?

The IMU could be used to determine the orientation of the prosthesis holding the coffee and this could be used to adapt the orientation of the prosthetic hand if it is moved to overcome spilling.

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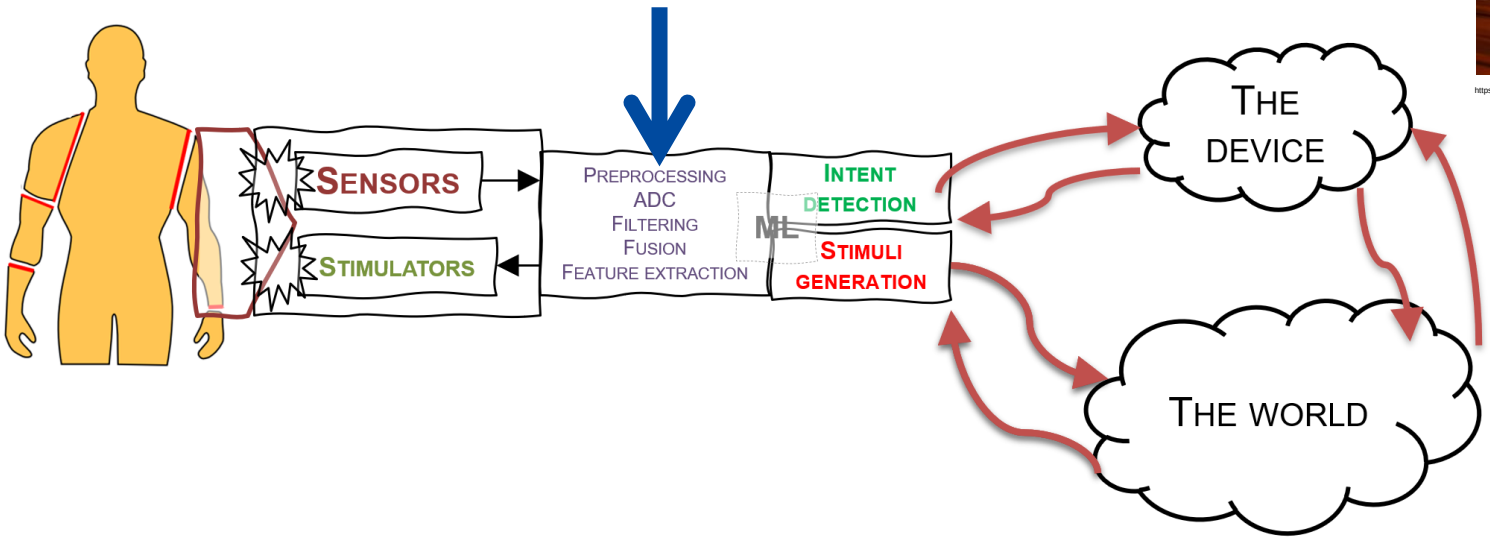
Closing the loop



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Preprocessing

The recorded EMG signal has a broad range of frequencies. However, the most interesting range for intent detection is 50-150Hz. What filter would you apply to preprocess your signal?

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Preprocessing

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A band-pass filter for the range of [50Hz, 150Hz]
A common choice for EMG signal processing is the Butterworth filter due to its flat frequency response in the passband.

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Feature Extraction

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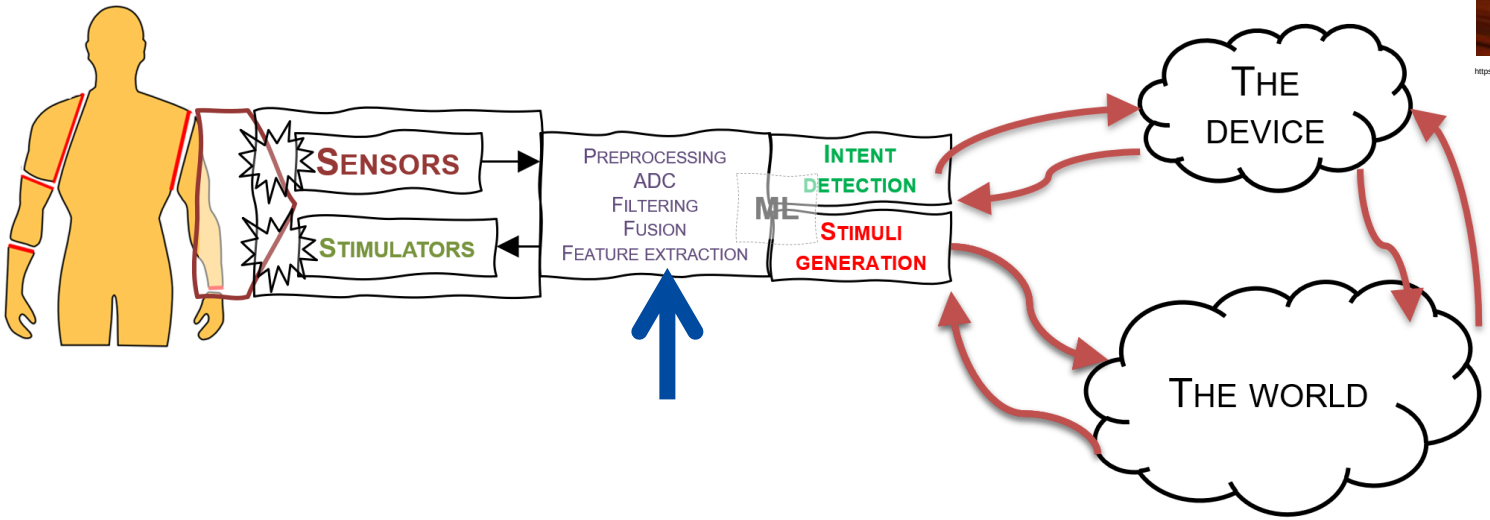

Feature Extraction

- The more a muscle is contracted, the higher is the amplitude of the EMG
- The more a muscle is contracted, the more force is applied

If you know that the paper cup starts to deform at a force with magnitude ||F||, what would be reasonable features of your EMG signal for the grasping the paper cup?

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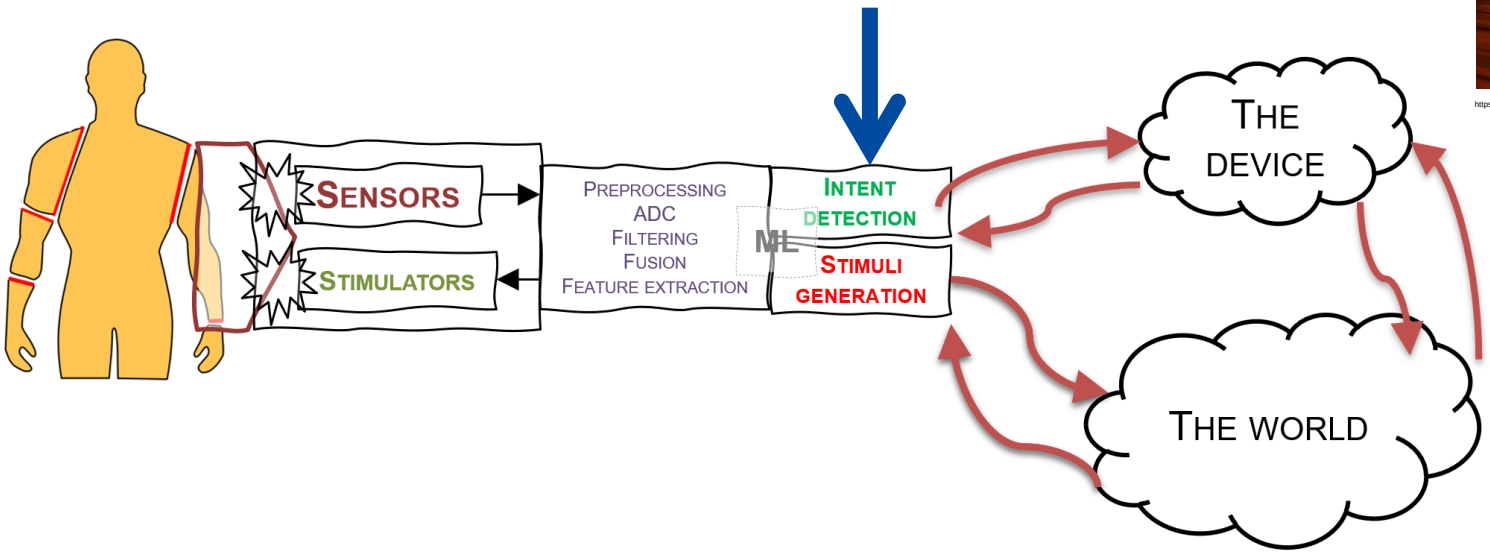
If you know that the paper cup starts to deform at a force with magnitude ||F||, what would be reasonable features of your EMG signal to detect that someone wants to grasp the paper cup?

- Amplitude of the EMG
- Continuous EMG signal over a specific threshold -
  Ensures that the muscle activity stays above a certain level for a sustained period, which is crucial for stable and controlled actions, such as holding a paper cup without deforming it.
- …

Feature Extraction



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Intent detection

Based on the features you selected. How could you determine the intent of a person and decide if someone wants to grasp the paper cup or not?

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Intent detection

Based on the features you selected. How could you determine the intent of a person and decide if someone wants to grasp the paper cup or not?

- If the amplitude of the EMG if over an specific threshold a
- If the amplitude of the EMG is below a specific threshold b (in case someone wants
- Continuous EMG signal (95% of the values) in the threshold range [a,b] over more than 2s

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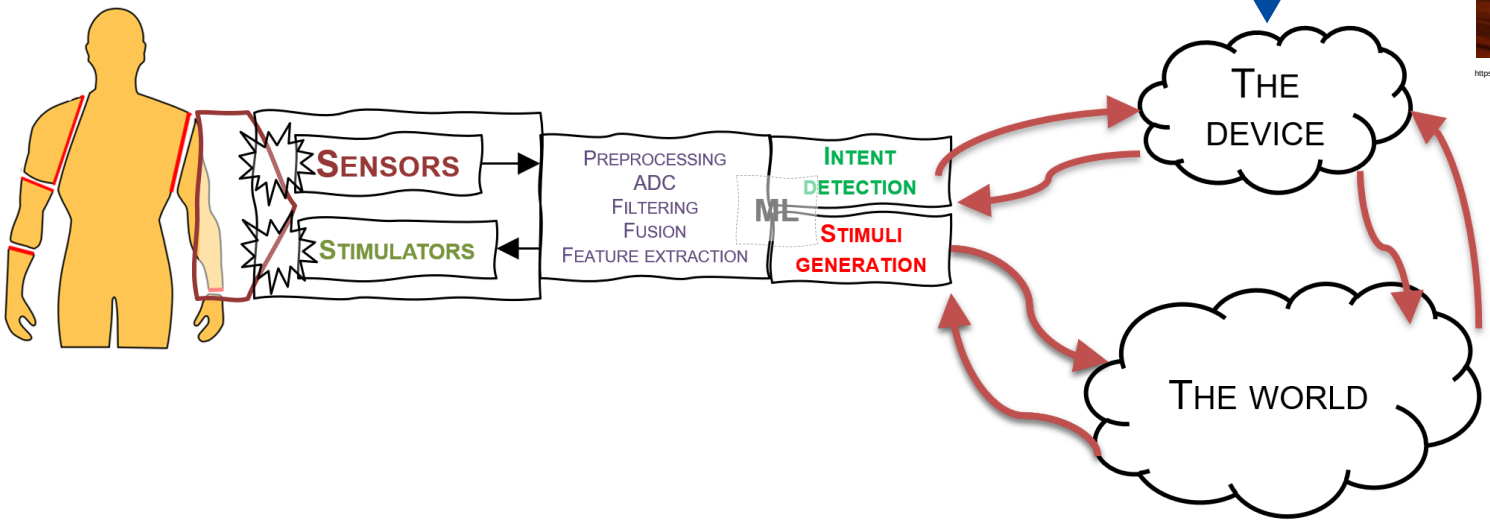

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Device

The processed sensor data show that the user's intent is to grasp the coffee cup. Image that the prosthesis uses an IMU to track its orientation and you know that the paper coffee cup is standing on a table.

How could you use shared autonomy to grasp the paper cup using the IMU as input?

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The human moves the hand to the paper cup and the hand. Once it is grasped, the prosthesis autonomously tries to keep it at a reasonable orientation to overcome spilling.

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Name 2 representation of rotations do you know apart from quaternions! What are their drawback ins contrast to quaternions?

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- Euler angles: might lead to singularities
- Rotation matrix: higher computation effort

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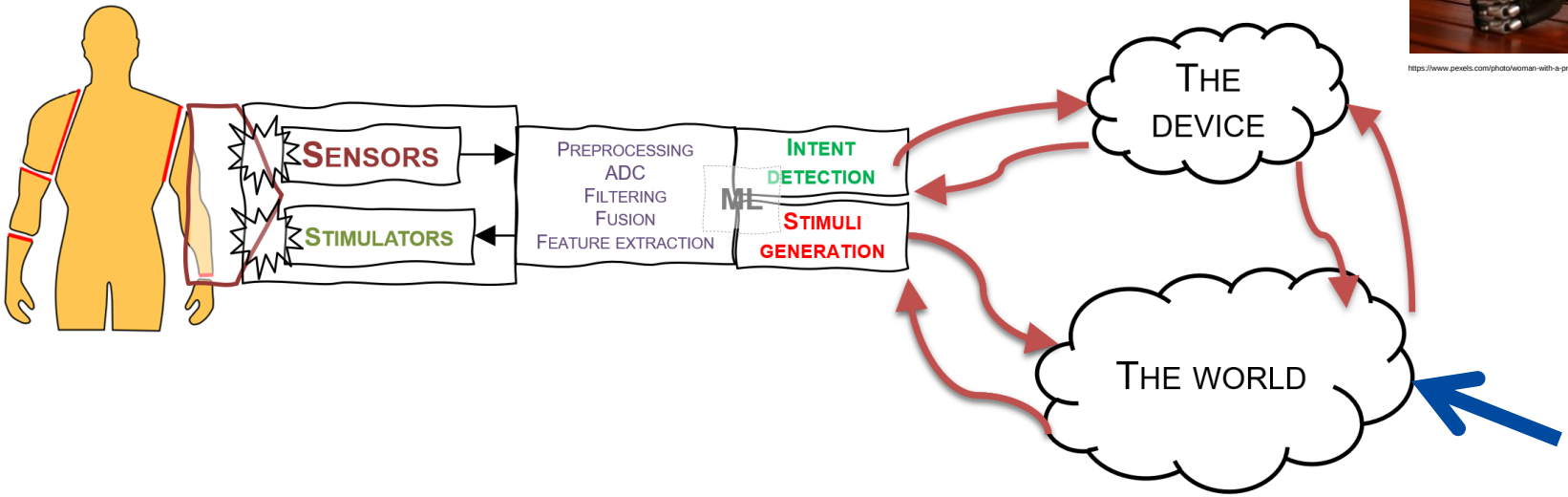

What sensors could you use to overcome potential damage to the prosthesis? Name 2 and explain why!

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What sensors could you use to overcome potential damage to the prosthesis? Name 2 and explain why!

- Temperature sensor: the material might deform if the temperature is too high
- Force sensor: to check if the force applied to the paper cup does not deform it too much. If some coffee might be spilled on the prosthesis, it might harm the device.

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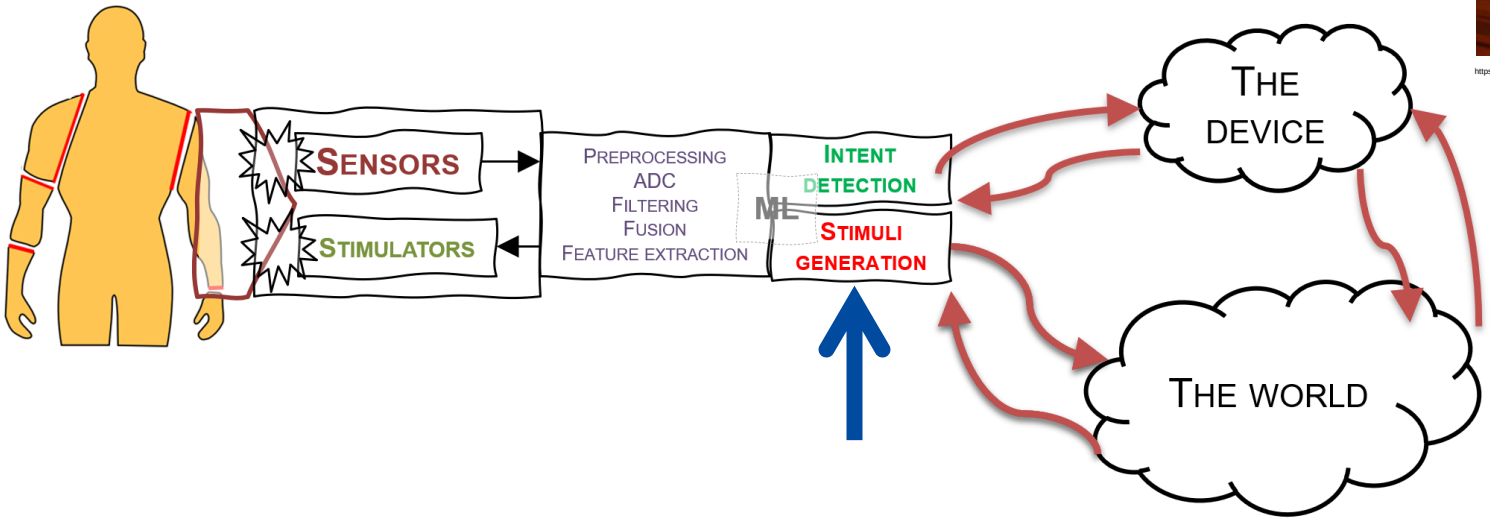

World

The paper coffee cup is grasped with a force of $\|F_{int}\|$.

What stimuli are generated due to this action? Name 2 of them!

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World

The paper coffee cup is grasped with a force of $\|F_{int}\|$.

What stimuli might be generated due to this action?
Name 2 of them and how you could measure them!

- Pressure on the prosthetic hand, with a pressure sensor at the fingers
- Deformation of the paper cup, with a camera

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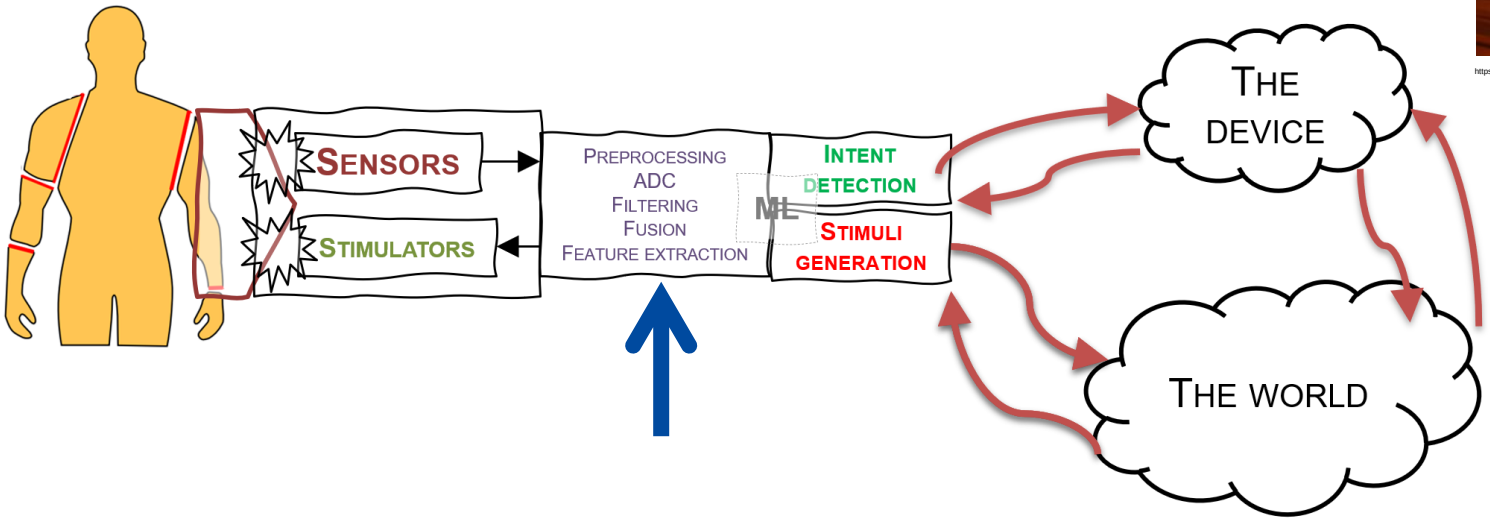

Data Processing

Imagine the prosthesis has a temperature sensor included together with a program which informs the user if whatever the prosthesis holds is very hot, hot, lukewarm, cold, or very cold. How could you preprocess the data from the temperature sensor?

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You could use subsampling and define the threshold if you e. g. measure more than 75°C it belongs to bin 4. It is a 3 in the interval]75°C, 50°C]. And so on…

classify temperature readings into predefined bins or categories based on thresholds

preprocessing involves transforming and categorizing continuous temperature readings into discrete categories

Feature Extraction

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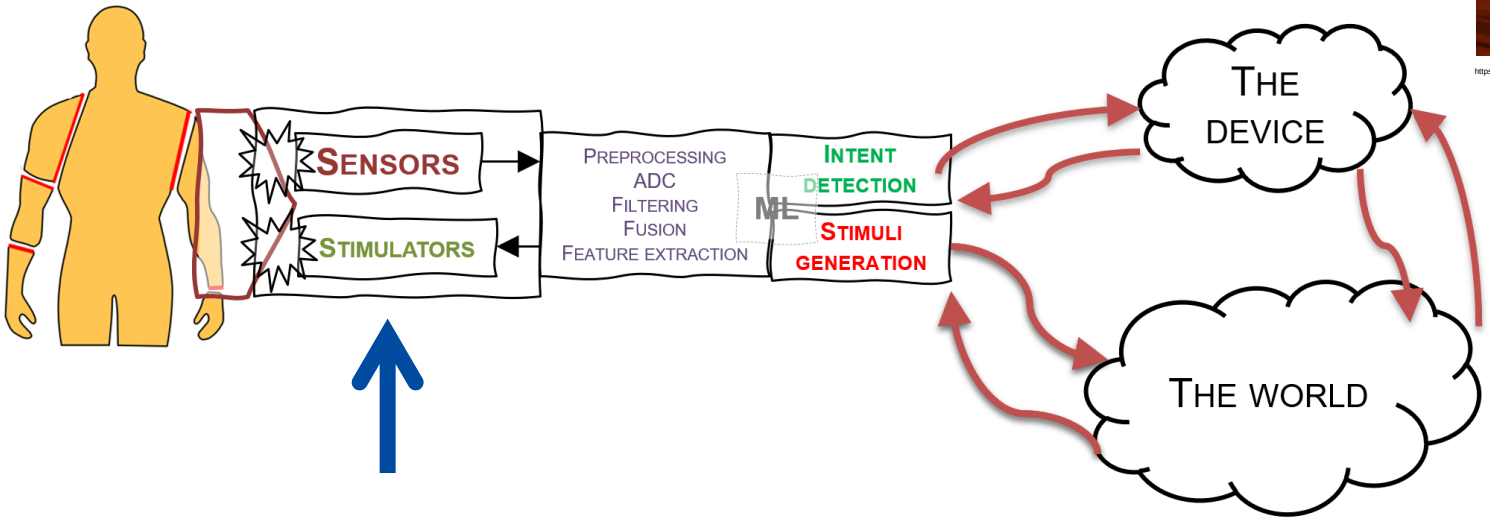

Feedback

Imagine the prosthesis has a temperature sensor included together with a program which informs the user if whatever the prosthesis holds is very hot, hot, lukewarm, cold, or very cold. How would you feed back that information?

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You could add some LED at the prosthesis which adapts its color depending on the temperature of the object which is grasped.
Or triggering auditory alerts