NTNU
Norwegian University of Science and Technology

Physical Computing Workshop: Day 3

Embedded Sensors and Actuators

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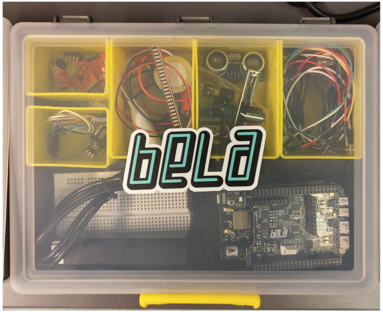
The MCT4045 Bela Kit



- Kit designed by Stefano Fasciani for the course MCT4045 (scheduled in the 3rd semester of MCT).
- Technical details and datasheet of all parts included in the MCT Hardware Kit are available at:
  `https://uio.instructure.com/courses/22318/files/503966/download?wrap=1`

Warm-up Activity
How would I map from . . . to . . . ?

Pick one component from the MCT Bela hardware kit and explain it to the class in terms of:

- Characteristics of the component
- Potential mapping to an interactive music system e.g. what audio/music parameter would you modify/control?

Learning Outcomes

By the end of the session, you will be able to...

— Identify the basic differences between sensors and actuators.

— Get a sense of the main parts when designing an interactive system.

— Be exposed to real-world projects based on physical computing.

— Discern the differences between digital and analog sensors and actuators.

— Be able to normalize sensor data.

— Explore mappings from sensor data to sound.

— Demonstrate a custom-made musical instrument in a performance setting.

Physical Computing: Sensors and Actuators

Physical Computing

- Physical computing involves the communication between our physical world and the digital world of computers.
- The way this is made possible is through the process of transduction, which is the conversion of one form of energy to another.
- The use of microcontrollers can provide vast opportunities to develop reactive and interactive sound projects beyond using a computer keyboard, mouse, screen and speakers.
- The types of inputs and outputs that are available to use to make transduction possible and how to process the data.

Nazemi, M. (2019). Sonic Interaction With Physical Computing. Foundations in Sound Design for Embedded Media: A Multidisciplinary Approach. [1]

Input

- Inputs can be sensors, switches, levers or sliders.
- Sensors: There are two broad categories of sensors, digital (number of states, usually 2) or analog (continuous range of states).
- The use of microcontrollers can provide vast opportunities to develop reactive and interactive sound projects beyond using a computer keyboard, mouse, screen and speakers.
- There is a range of sensors available: *sensing pressure* (e.g. force resistive sensor (FSR)), *sensing the environment* (e.g. temperature, photoresistors), *sensing movement/distance* (e.g. accelerometer, gyroscope), *sensing body* (e.g., muscle Sensor (EMG), brain waves (EEG)).

Nazemi, M. (2019). Sonic Interaction With Physical Computing. Foundations in Sound Design for Embedded Media: A Multidisciplinary Approach. [1]

Output

- The output is the mechanism that provides feedback to the user using movements like actuators and motors, light, video or sound.

Nazemi, M. (2019). Sonic Interaction With Physical Computing. Foundations in Sound Design for Embedded Media: A Multidisciplinary Approach. [1]

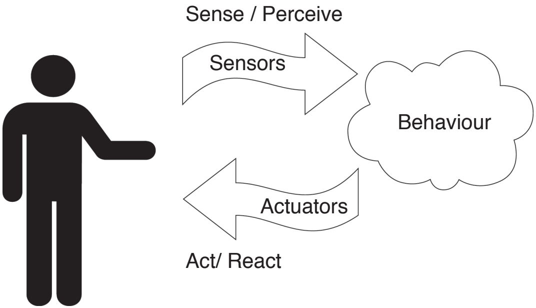
Processing

— It requires a computer to take the information from the input, make some decisions based on changes that may occur in real time and output feedback to either the user or another computer.

— We need to use software to make sense of the incoming data from the input and convert that data into meaningful information to be sent out as an output for the user or as a message to another computer.

Nazemi, M. (2019). Sonic Interaction With Physical Computing. Foundations in Sound Design for Embedded Media: A Multidisciplinary Approach. [1]

Diagram of an Interactive System



Banzi, M. (2009). Getting Started with Arduino. O?Reilly Media/Make. [2]

When Designing your Interactive System...

Input / Sensors	Behaviour	Output / Actuators

Examples of Projects

Project 1: Embodied Interactions

Project: `https://www.audiocommons.org/2018/05/18/tei-2018.html`

Sophie Skach, Anna Xambo, Luca Turchet, Ariane Stolfi, Rebecca Stewart, Mathieu Barthet (2018). Embodied Interactions with E-Textiles and the Internet of Sounds for Performing Arts Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction [3]

Project 2: Stillness under Tension

Performance: "Stillness under Tension" (UiO-NTNU muscle band)
The MCT Opening Ceremony (August 2018)

Martin, C. P., Jensenius, A. R., and Torresen, J. (2018). Composing an ensemble standstill work for Myo and Bela. In Proceedings of the International Conference on New Interfaces for Musical Expression (pp. 196-197). Virginia Tech. [4]

Bela examples & Workflow

Analog vs. Digital

— See code day 3

Normalization of Sensor Data

Normalization by scaling between 0 and 1 (feature scaling) is a common calculation to facilitate relations with other domains e.g. mappings to sound. The formula for normalization is:

$x_{new} = \dfrac{x - x_{min}}{x_{max} - x_{min}}$ where x_{new} is the normalized value, x_{min} and x_{max} are the minimum and maximum values within a range.

— Typically you can create a function so that when you call the function you get as a result the normalized value: x_{new} = *normalize(x, x_max, x_min)*