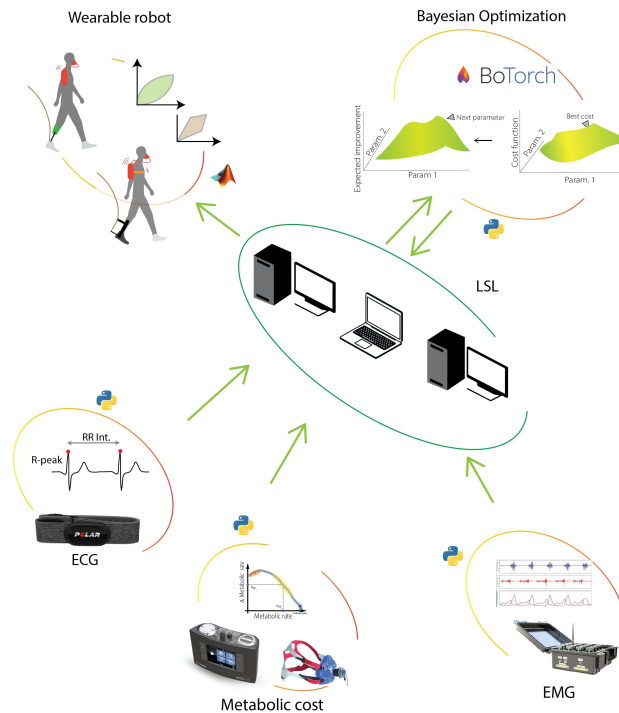


# HIL Toolkit: Acquisition, estimation and optimization of human in the loop experiments

Toolkit for human in the loop optimization

## Human In Loop optimization Toolkit



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## Requirements for the toolkit

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### General requirements

- Python 3.10 or higher.
- Labstreaminglayer - install [here](#).
- pylsl - install by running `pip install pylsl`.

### Metabolic cost.

- Cosmed or other metabolic cart device.
- Setup metabolic cost acquisition code.

### ECG

- Polar H10
- Bluetooth capable laptop for ECG.

### Foot pressure.

- Pressure SDK.

## Installation

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Complete python HIL toolkit install using pip in main directory.

```
pip install -e .
```

## HIL optimization.

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- First setup the device as mentioned in the device setup section.
- Setup the optimization problem in the `config/<optimization>.yaml` file. An example of the optimization problem is provided in the `config/ECG_config.yaml` file.
- Setup optimization using HIL toolkit. Example of this is provided in the `scripts/ECG_optimization.py` file.
- Run the optimization script. `python scripts/ECG_optimization.py`

## Device setup

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### Cost acquisition

## Custom sensor setup

- Since the most physiological sensors are not open source, we have to use provided an acquisition script for the sensors.
- Example of this script is provided in the `scripts/cost_acq.py` folder.
- This script will help setup the cost acquisition device and send the data to the optimization pc.

## ECG device setup

For setting up the new polar H10 ( ECG sensor )

- Please turn on the computer bluetooth connection.
- Run the following script to find all the available POLAR sensor scripts `python scripts/search_polar.py`. This script will search for polar sensors in the bluetooth range and save the BLE information in the `config/polar.yml` file. And return success or failure.
- Run the script to collect data from the polar and send it. `python scripts/collect_polar.py`

## Exoskeleton/prosthesis

### Initial setup

Follow these steps to the setup the exoskeleton device.

- Connect the device to the network or use a ethernet cable to connect the device to the computer.
- Check the IP address of the device. The IP address can be found in the control panel of the device or use command window, type `ipconfig` or `ifconfig` and find the IP address of the device.
- Check if the device is connected using `ping <IP address of the device>`. If the device is connected it will return the response from the device.
- Create a server in the optimization pc for testing the communication.
- If control system is in matlab/simulink use the matlab script provided here to test the communication. `comms/communication_test.m`
- If control system is in python use the python script provided here to test the communication. `comms/communication_test.py`
- If the communication is successful, the device is ready to be used for the optimization.

### Adding Exoskeleton/prosthesis in optimization

- Add the device the following lines in the `config/<optimization>.yml`

```
Exoskeleton:  
  port: 5555  
  ip: "192.168.0.10"
```

## Cost Estimation

**Warning** The estimation is not fully tested. Please use with caution.

## Metabolic cost estimation.

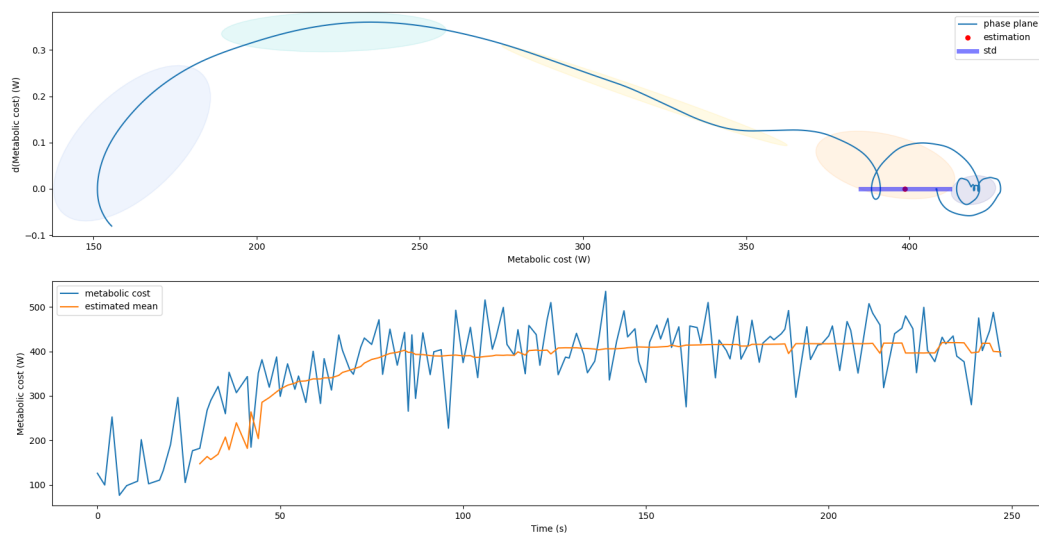
Please refer the following paper for the details of the estimation.

### Reference

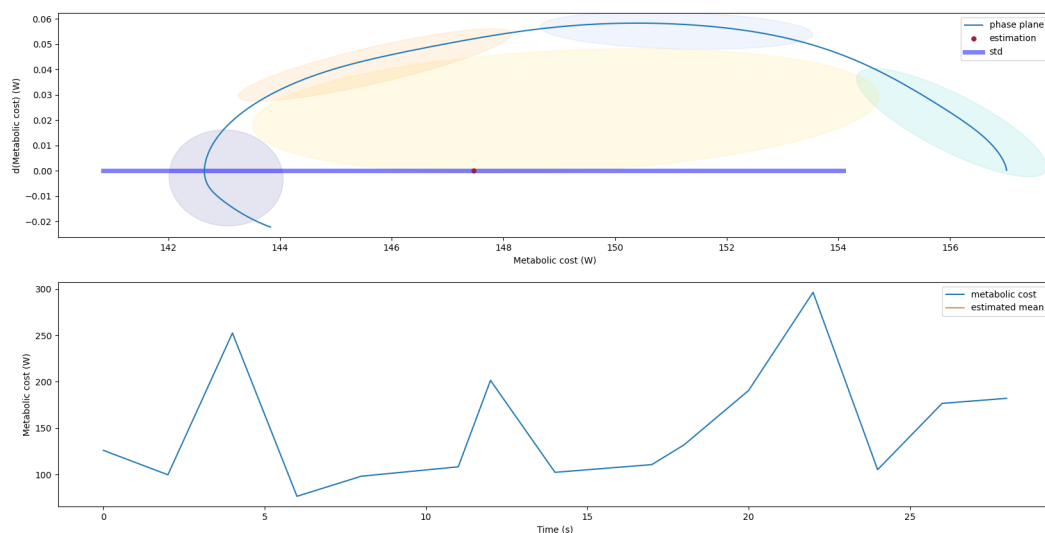
Kantharaju, Prakyath, and Myunghee Kim. "Phase-Plane Based Model-Free Estimation of Steady-State Metabolic Cost." IEEE Access 10 (2022): 97642-97650.

Estimation in scripts for offline.

- Run the following script to estimate the metabolic cost. `python scripts/estimate_metabolic_cost.py`
- This script will estimate the estimate the metabolic cost data in the provided in the `data/met_data.npy`.
- The scrip will generate the estimation and the also video as shown in the following figure.



- It will also make a video of the estimation and the actual data. The video will be saved in the `scripts/Results/videos/` folder.



## Estimation in notebooks.

- Run the following notebook . [notebooks/preprocessing\\_cosmed.ipynb](#) to convert the raw data to the metabolic cost data.
- To perform the estimation run the following notebook. [notebooks/estimation\\_cosmed.ipynb](#)