# On stability assessment using the WalkIT smart rollator

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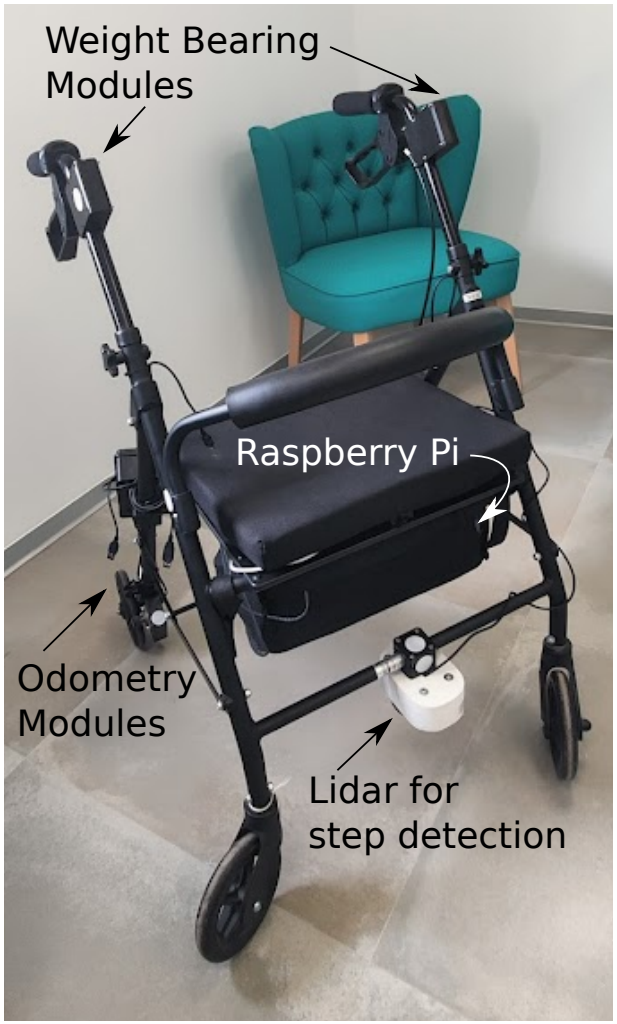
# An ageing population

- New approach: prevention and monitoring.
- Key metric: Stability.
- Manual assessment: Tinetti Mobility Test.
- Automatic assessment: automatic adquisition of spatiotemporal gait parameters, such as walking speed, stride-to-stride variability or person's center of mass.

Monitoring through mobility assistive devices.

# The WalkIT architecture



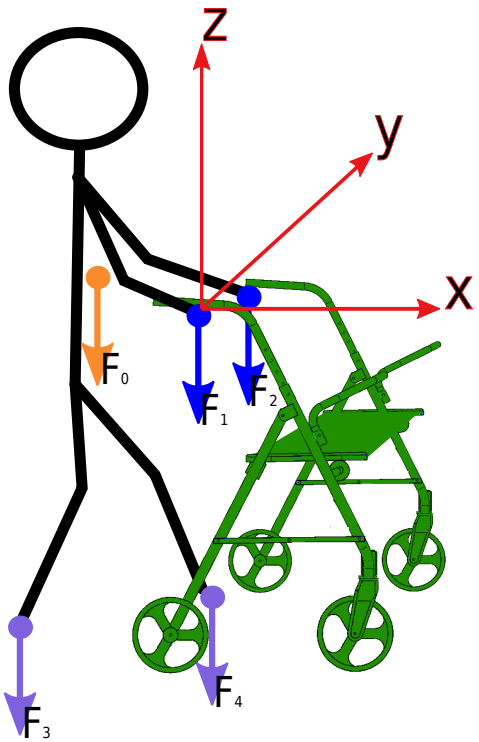

## Traditional smart rollators:

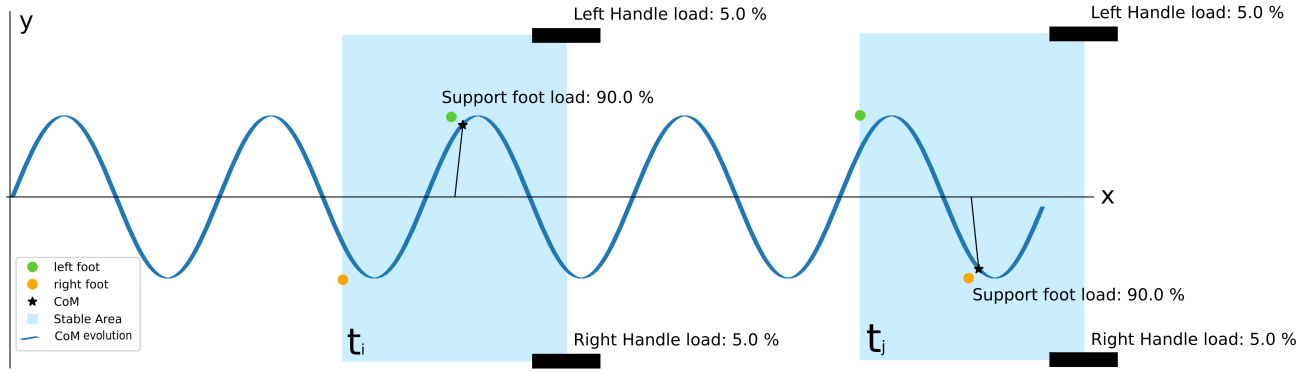
- custom made: blackboxes difficult to replicate and customize.
- change barrier: users are reluctant to use any device but the one they are used to.

## WalkIT: Open Source modular architecture.

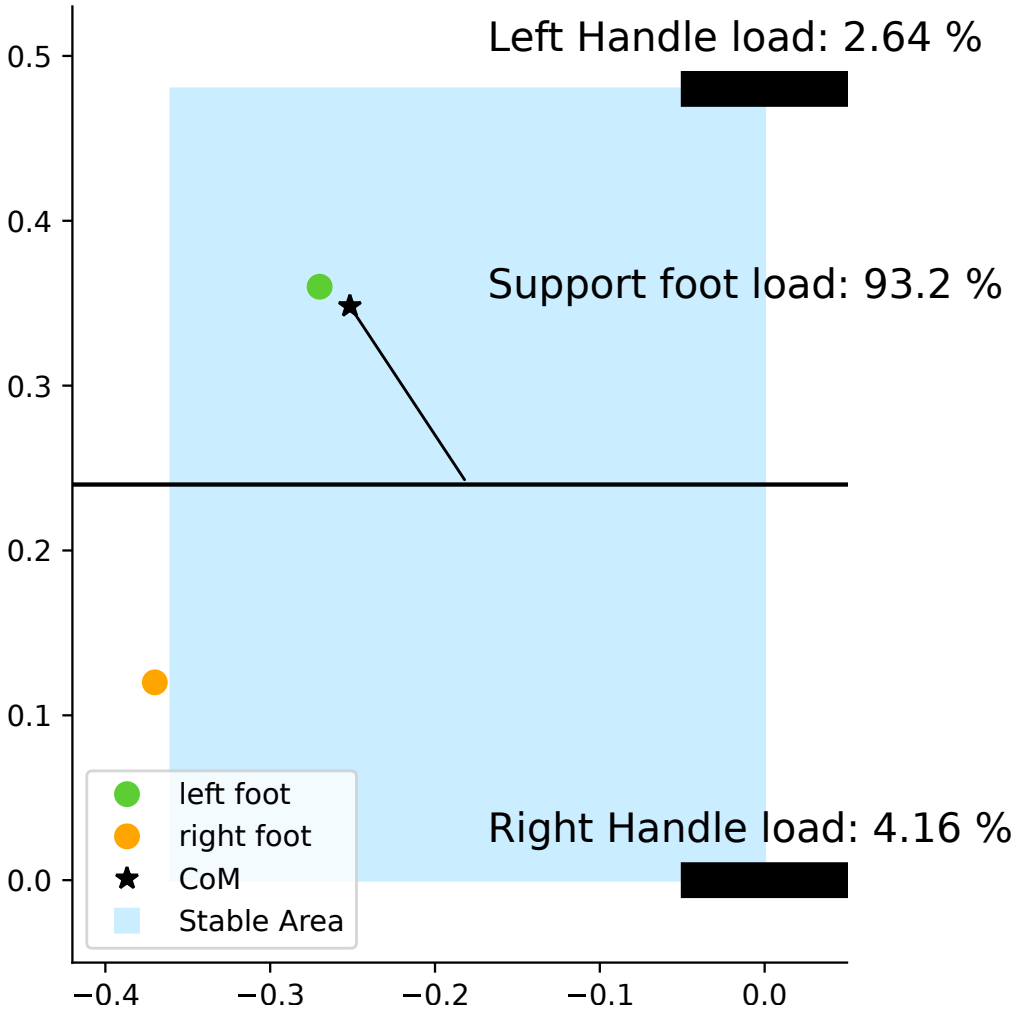
- based on using off-the-shelf components.
- can turn most commercial rollators into a smart device.

# Center of Mass (CoM)

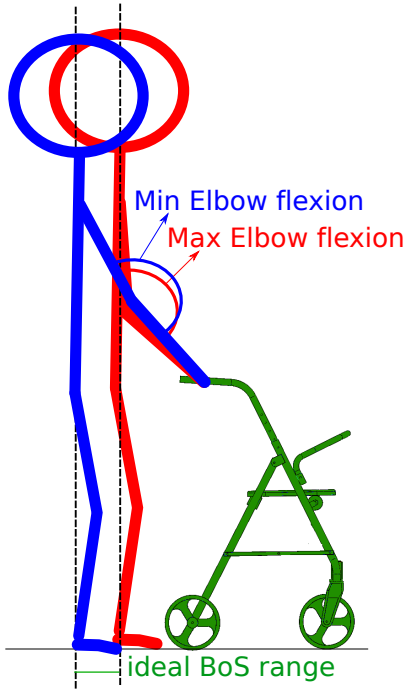


# Base of Support (BoS) I



# Base of Support (BoS) II




BoS x-axis limits in rollators:

- correct handlebar height[a].
- appropriate distance from the frame.
- elbow is naturally flexed at a 15-to-30-degree angle.

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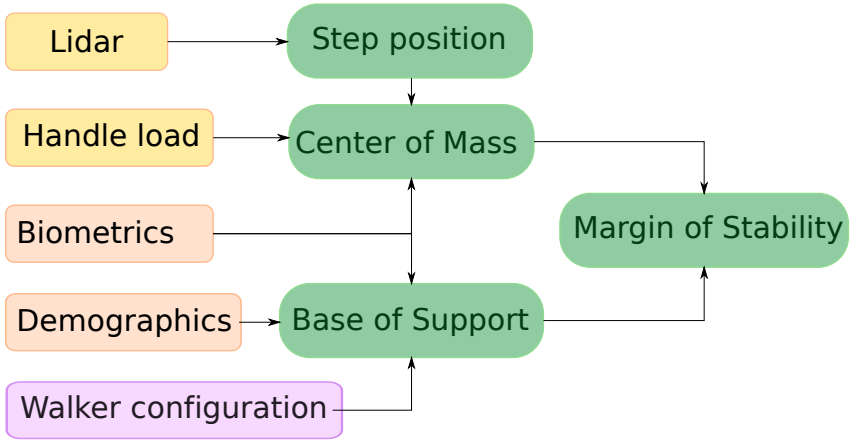
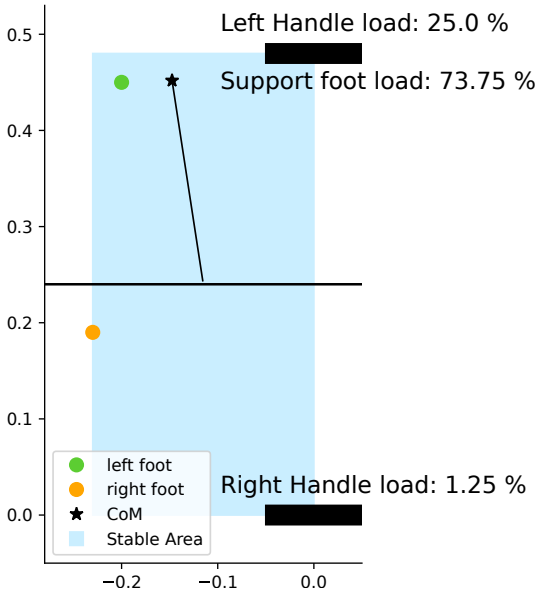
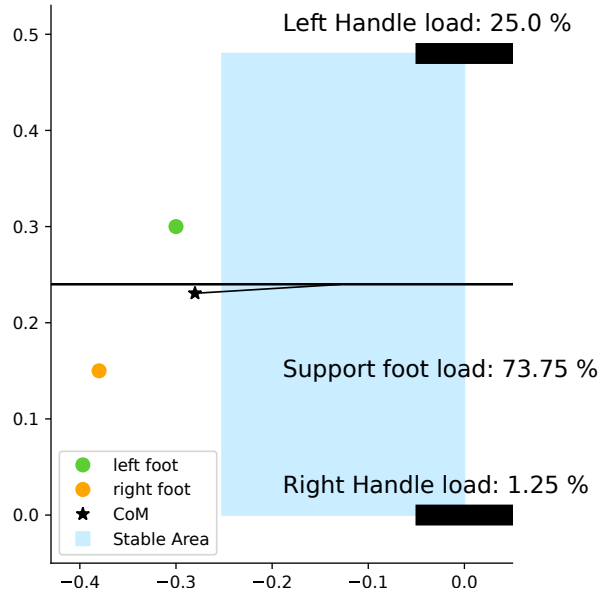
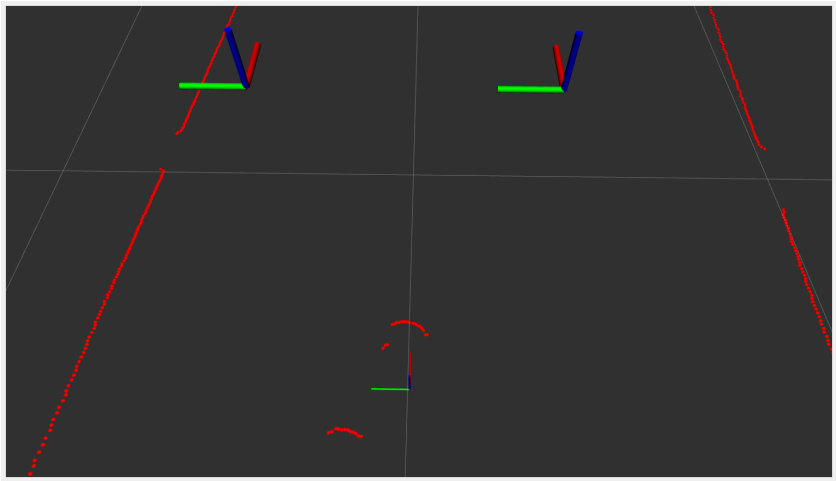
[a] handlebar height $=$ user height $*0.45 + 0.087$

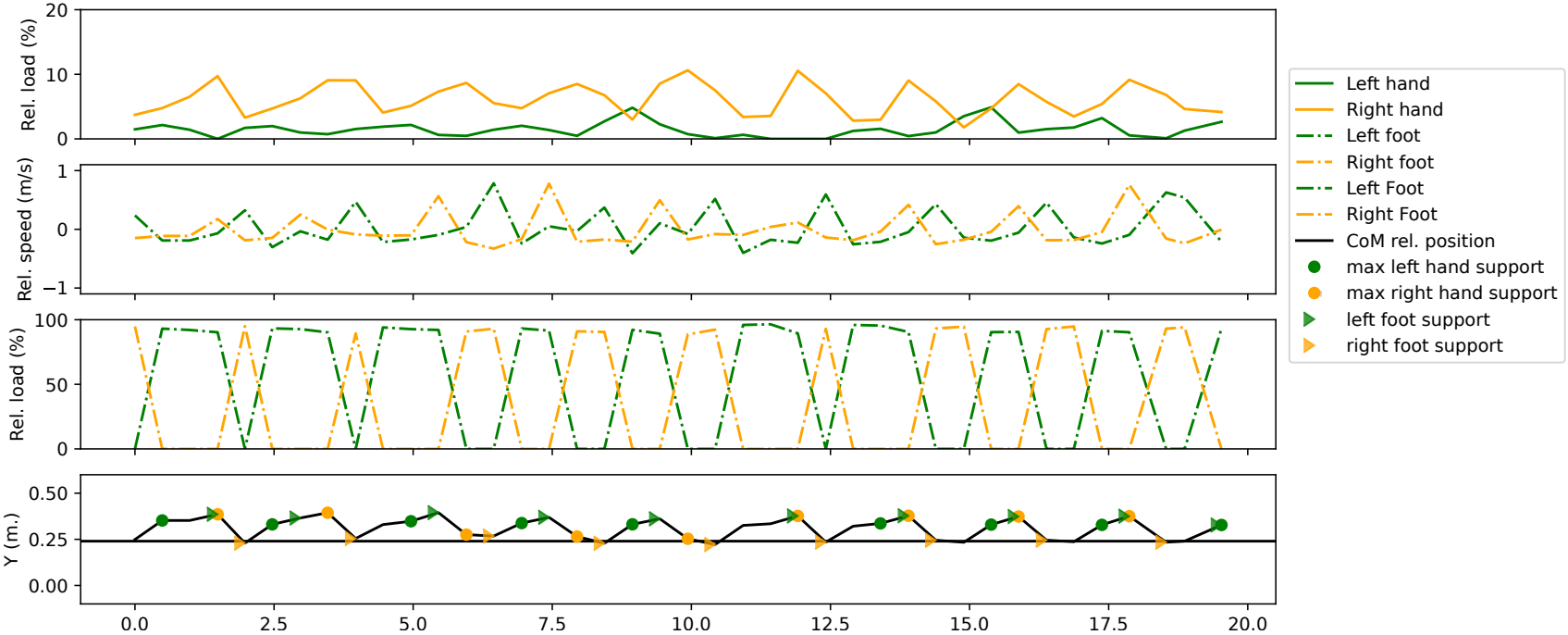
# Margin of Stability (MoS)






Rel. load (%)
Rel. speed (m/s)
Rel. load (%)
Y (m.)
Left hand
Right hand
Left foot
Right foot
Left Foot
Right Foot
CoM rel. position
max left hand support
max right hand support
left foot support
right foot support
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0

- experiments took place at *Macrosad Arroyo de la Miel* nursing home.
- volunteers had to follow a corridor, perform a U-Turn at the end and return to their departure point.

| | Age | Gender | Height | Weight | Medical condition |
|---|---|---|---|---|---|
| A | 43 | Male | 1.74 | 94 | No previous conditions, nor experience using rollators |
| B | 38 | Male | 1.84 | 110 | Recovered from severe leg polytrauma. |
| C | 82 | Female | 1.55 | 61 | Several chronic conditions such as hypertension, polyarthritis, generalized arthrosis, and polyarthralgia. |

- Dataset contained CoM over time and sensor data used to obtain it.
- 75% of the dataset was used to train our models and the remaining 25% to evaluate them.
- Three different regression models were used with each user indepently to predict next CoM sample over time: Linear Regression (LR), Support Vector Regression (SVR) and Regression Trees (RT).

| Patient | Patient A | | | Patient B | | | Patient C | | |
|---|---|---|---|---|---|---|---|---|---|
| Estimator | LR | SVR | RT | LR | SVR | RT | LR | SVR | RT |
| Mean error | 0.14 | 0.06 | 0.07 | 0.17 | 0.06 | 0.09 | 0.09 | 0.09 | 0.11 |
| Std. dev | 0.11 | 0.05 | 0.07 | 0.08 | 0.05 | 0.08 | 0.07 | 0.05 | 0.09 |

# How accurate is this predicted CoM? Back to MoS.

| | Data CoM inside BoS | Data CoM outside BoS |
|---|---|---|
| Predicted CoM inside BoS | True Positive | False Positive |
| Predicted CoM outside BoS | False Negative | True Negative |

| Patient | Patient A | | | Patient B | | | Patient C | | |
|---|---|---|---|---|---|---|---|---|---|
| Estimator | LR | SVR | RT | LR | SVR | RT | LR | SVR | RT |
| TP | 1496 | 1532 | 1567 | 465 | 526 | 522 | 238 | 200 | 237 |
| TN | 6 | 27 | 84 | 1 | 1 | 14 | 0 | 11 | 18 |
| FP | 97 | 76 | 19 | 17 | 17 | 4 | 26 | 15 | 8 |
| FN | 84 | 48 | 13 | 61 | 0 | 4 | 3 | 41 | 4 |
| Precision | 93.91 | 95.27 | 98.8 | 96.47 | 96.87 | 99.24 | 90.15 | 93.02 | 96.73 |
| Recall | 94.68 | 96.96 | 99.18 | 88.4 | 100.0 | 99.24 | 98.76 | 82.99 | 98.34 |
| F-Score | 94.3 | 96.11 | 98.99 | 92.26 | 98.41 | 99.24 | 94.26 | 87.72 | 97.53 |

# Conclusions

- A novel stability assessment method for smart rollator users has been presented.
  - Tested by three volunteers with different tipology.
  - Based on the prediction of the projection of each user's CoM onto their BoS.
  - Three different prediction techniques have been used: Lineal Regression, Support Vector Regression and Regression Trees.

# Future work

- Extending tests to a significant number of volunteers for further validation.
- Study specific user assessment, not just in terms of height, weight, and sex, but specifically considering their gait traits.
- Introduce warnings about risk fall situations.
- Study the impact of selective braking in the smart rollator.

Thanks for your attention.
Questions?

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