Prédiction du risque de chute via l’estimation des caractéristiques de la marche à l’aide de capteurs embarqués

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Introduction
Falls

**Why measure gait?**

**How to measure?**

**What to measure?**

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**Falls**

- **Common**
  - 1/4 of people over 65 fall at least once a year
  - (Alexander, Rivara, & Wolf, 1992)

- **Costly**
  - Cost of fall related care
  - $30,000,000,000
  - (Burns, Stevens, & Lee, 2016)

- **Harmful**
  - 1 in 5 falls in older adults results in major injuries
  - (Sterling, O'Connor, & Bonadies, 2001)
  - Each year at least 300,000 older people have hip fractures
  - (Boslaugh, 2016)

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**Vicious Cycle**

- Fall
- Increased risk of falling
- Fear of falling
- Reduced activity
- Decreased muscle strength
Why measure gait?

How to measure?

What to measure?

Visual assessments

Subjective
Patients tend to outperform or underperform
Just a glimpse of what happens in real life
Laboratory assessments

Why measure gait?

- Expensive
- Complex
- Time consuming
- Not available for everyone
- Not real life
Use IMU found in everyday embedded devices to assess gait
Why measure gait?

How to measure?

What to measure?

In 2017, **59%** of adults **65–69 years old**, **49%** of adults **70–74 years old**, and **31%** of adults **75–79 years old** are smartphone owners.

Go beyond counting steps: Mobility Measures
Gait Variability: Stride time variability

Neuromotor noise is increased, which in its turn results in a greater variability.

Non-linear measures: Lyapunov Exponent.

Reflects the ability to recover from small perturbation.

Local dynamic stability and variability of gait are associated with fall history in elderly subjects

Marcel J.P. Toebes 4, Marco J.M. Hoogemans 4, Regula Furrer 4, Joost Dekker 5, Jaap H. van Dieën 4,4

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RESEARCH ARTICLE

Local dynamic stability during gait for predicting falls in elderly people: A one-year prospective study

Lucia Biziove 1,1, Zdenek Svozoba 1,1, Miroslav Janura 1,1, Maria Cristina Bisio 1,1, Nicolas Vuillerme 1,1,1,1

Differentiating fall-prone and healthy adults using local dynamic stability

Thurmon E. Lockhart 7 and Jian Liu
Locomotion Research Laboratory, Department of Industrial and Systems Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA
Smartphone sensor Quality?

Heel Strike detection error of around 7 ms

Stride times derived from the smartphone app and a reference device were highly correlated with an error of around 17 ms

Sensor Quality is not the issue

Find a method to process the data and be robust against real life activities
What is real life?

Holding your smartphone the **way you like to hold it**, **doing whatever you like**, **wherever you like**.

It is complex!

- Different user behavior
- Different walking environments
- Different activities
Controlled environment test
Find a robust way to process the smartphone Accelerometer and Gyroscope signal for frequent phone positions to detect steps and calculate stride time variability.

Objective

Iphone 6s

Found on the Appstore

Sampling frequency:
100Hz

10 participants average Age~28 years

Detect peaks.

3 speeds: Comfortable- Low- High and asymmetrical mode
Preliminary Findings

Hand is a more complex: **Motion mode** of the hand affects the signal
Strength of swing affects the signal

To treat mis-detected steps we apply statistical filtering

- Remove abnormal strides more than 1.5 sec and less than 0.8 sec
- Remove strides more than 3 SD away from the mean

Susi et al. 2013
Findings

Detection of steps is really important:
Must improve
Measurements in Elderly and Young
Objective: Calculate **gait variability** and **nonlinear measure**: Lyapunov exponent on elderly and young adults.

We developed an android app for hospital physiotherapist to measure phone IMU signals.

**Objective**
6 old non-fallers
6 young

**Hospital**
6MWT

**Walk back and forth**

Estimate Lyapunov exponent

Estimate Standard deviation of stride time

6 young
Expect 10 young

6 old non-fallers
Expect 30 elderly with fallers

Enguerren Houdry
Findings: Gait variability

Average: $34 \pm 13$ ms

Average: $29 \pm 8$ ms

(Hausdorff et al., 1997)
What is the Lyapunov exponent?

- Estimates a system’s local dynamic stability.
- Reflects the ability to recover from small perturbation
- The higher it is, the worse the system’s resistance to local perturbations

Machine learning and improved hand step detection
8 subjects walking on treadmill 3 different speeds for 210 secs and recording 360 steps per speed per subject.

Total number of steps in database: $3 \times 360 \times 8 = 8640$ examples

Find a way to associate $X$ and $Y$ using a model
Histogram based Gradient boosting

- Only treadmill walking
- No irregular activities
- Sensor placed in hand (wrist placement can be different)
- Only on young adults

Sensitivity: 98%
Specificity: 96%
Conclusions and Future work
Conclusions

We were able to measure stride time variability with a good precision for different phone handling positions.

Created a phone IMU recording app and were able to record 6MWT at Hospital and extract data.

Promising results from machine learning for step detection.
Future work

Enlarge dataset to include many cases for machine learning model

- Different walking environments
- Different activities
- Add population

Use online databases
Medipole experiment data
Future work

Include more elderly population and follow up phases.

We want to get to ambulatory assessments

Compare calculated features with history of falls

FOLLOW UP

Compare calculated features with upcoming falls
Thank you for listening
Laboratoire de Biomécanique et Mécanique des Chocs (LBMC UMR_T 9406, UCBL-Univ Eiffel), Lyon

ou pour la version anglaise

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