NOKIA Bell Labs

Gait Analytics as an Indicator of Health

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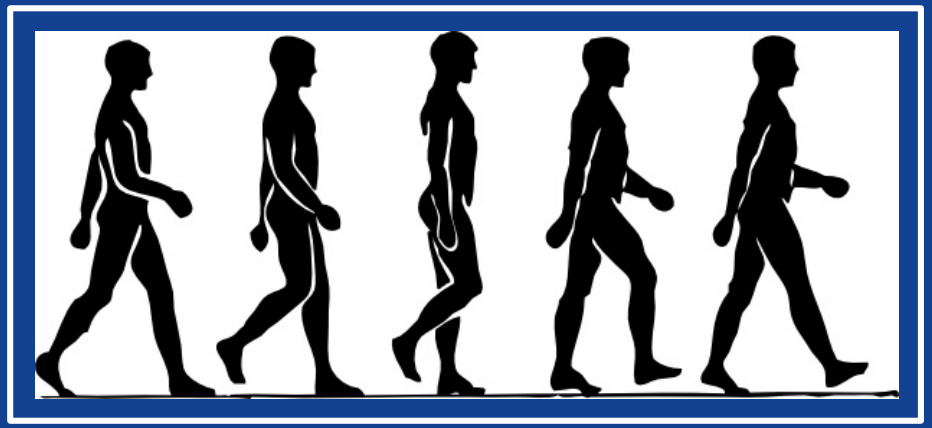

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Problem Statement

This project originated with the request for a non-invasive system to prevent falls of clients at elder drop-in centers in Singapore.

This application gave the opportunity to aim toward two relatively novel contributions:

1. **Prevent** falls before they happen. Most gait systems only detect falls.
2. Analyze over time, using **gait trend analytics**. Most gait systems perform one-time analysis.

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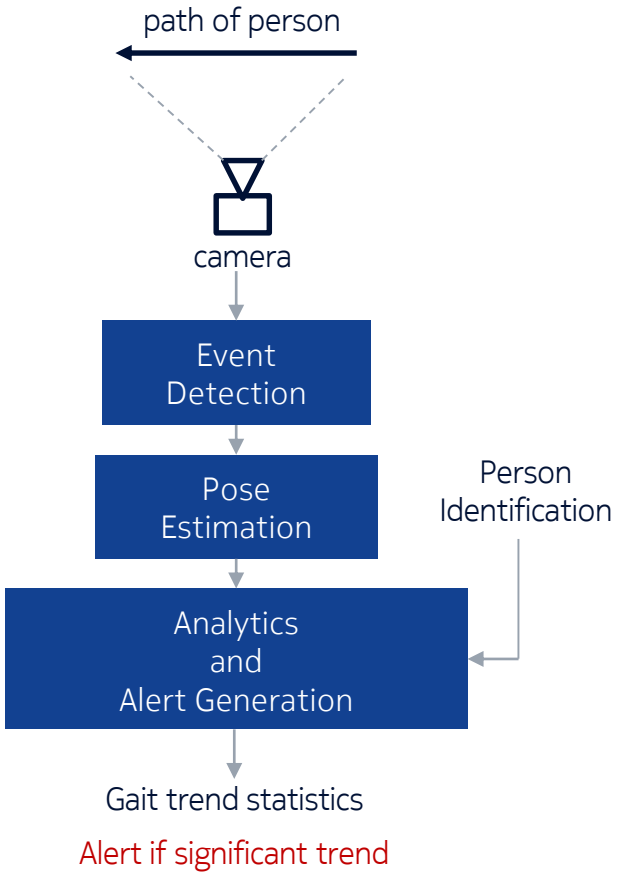
Architecture

System

The system has 3 modules:

1. **Event Detection –** Detect person walking across camera view by motion “tripwires”.
2. **Pose Estimation –** “Skeletal features” are extracted using the OpenPose tool.
3. **Trend Analytics –** gait features are examined over time. A non-zero trend of gait features may indicate a health change.



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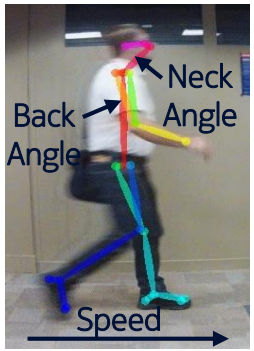
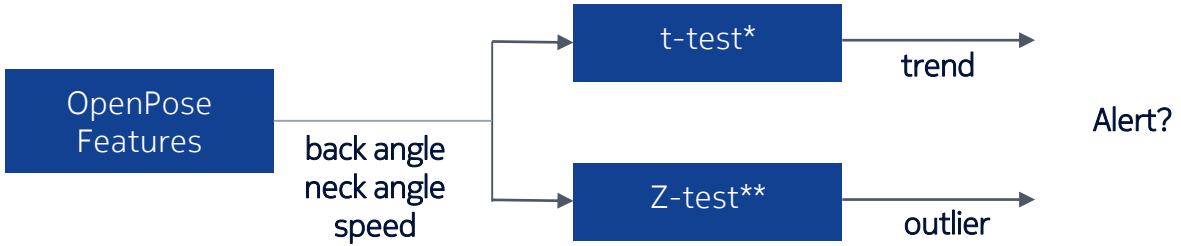
Module 3 – Gait Trend Analytics

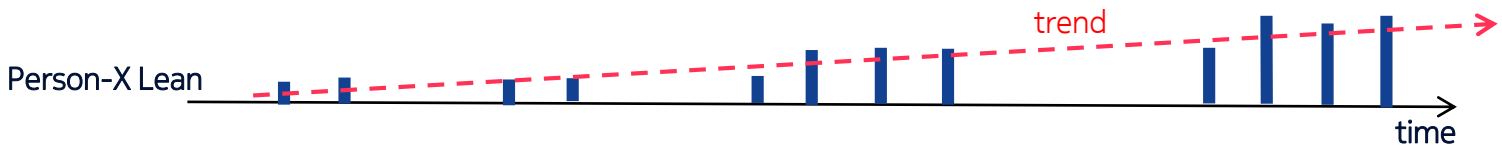
Trend Measurement and Alerting

Although we use standard statistical tests, our contribution is using gait trend analysis to **prevent** rather than just **detect**.

t-score: $t_o \sim slope / \sigma$, Z-test: $z(n) = | s_n - E(s) | / \sigma$







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Experiments

We really want to measure if falls are prevented. We do every experiment except that:

- Experiment 1 – Most consistent feature
- Experiment 2 – Trend for healthy population
- Experiment 3 – Outliers for healthy population
- Experiment 4 – Analytically-added trend
- Experiment 5 – Physically-added trend
- Experiment 6 – “Nudge”-added trend

Experiment Parameters:

– 3937 gait events, 50 labeled persons, two 3-month periods, 5 to 318 events per person

– 30 fps video capture, OpenPose confidence threshold > 0.2

– Chose OpenPose above-threshold frame closest to middle of walk to measure features

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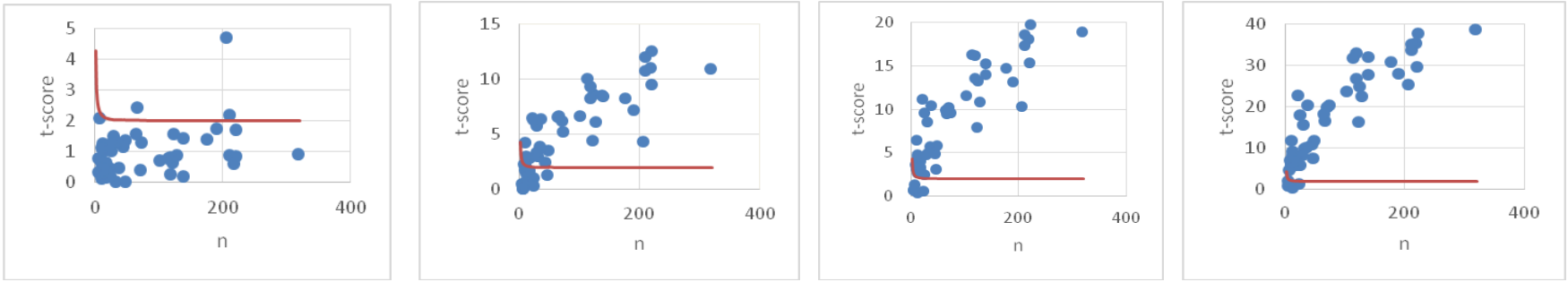
Experiments

Experiment 4 – Analytically-added trend.

Added 3, 5, and 10 degrees to angle features, and reduced speed by 10%, all in total, over the course of 1 month to healthy population data (3937 gait samples, 50 people).

“null hypothesis” **+ 3°** **+ 5°** **+ 10°**



Observation – Above n=50 gait events for +3°, and n=30 for +5° and +10°, all trends are significant at 95% confidence

Conclusion – System measures trending back-angle feature with easily measured statistical significance.

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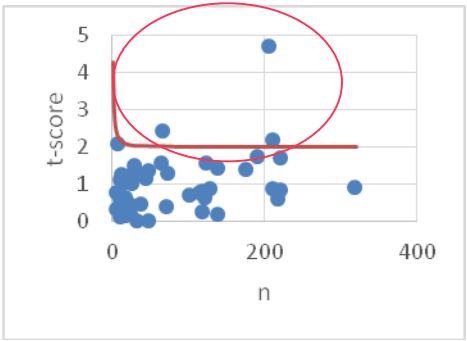
Experiments

Experiment 6 – “Nudge”-added trend.

In our “null hypothesis test”, some samples contradicted this hypothesis. These people were purposefully attempting to improve their gait. This gave us an idea for a “nudge experiment.



Feedback:

Experiment:

- 3400 events, 35 people, 3 months.
- People walk with 2-4° “better” (more upright) gait when given positive feedback.

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Other Applications

Elder Care →

- **Degenerative disease monitoring -** e.g., Parkinson's
- **Physiotherapy, Health Club** – measure progress or general gait/posture health
- **Exercise Assist** – next Peloton (network exercise bike) feature?
- **Worker Safety** – continuous, noninvasive health monitoring for worker safety, quantitative measure of "don't operate heavy machinery if …"
- **Workplace Safety** – monitor all workers to maintain and design safer workplaces

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