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# Automatically detecting health changes using transfer times of older adults

Greet Baldewijns[1,2,3*], Stijn Luca[1,2], Bart Vanrumste[1,2,3] and Tom Croonenborghs[1,4,5]

**Abstract**

**Background:** As gait speed and transfer times are considered to be an important measure of functional ability in older adults, several systems are currently being researched to measure this parameter in the home environment of older adults. The data resulting from these systems however still needs to be reviewed by healthcare workers which is a time consuming process.

**Methods:** This paper presents a system that employs statistical process control techniques (SPC) to automatically detect both positive and negative trends in transfer times. Several SPC techniques, Tabular CUSUM, Standardized CUSUM and EWMA, were evaluated. The best performing method was further optimized for the desired application. After this, it was validated on both simulated data and real-life data.

**Results:** The best performing method was the Exponentially Weighted Moving Average control chart with the use of rational subgroups and a reinitialization after three alarm days. The results from the simulated data showed that all positive and negative trends are detected within 14 days after the start of the trend. On average, only one false alarm is triggered every five weeks. The results from the real-life dataset confirm those of the simulated dataset.

**Conclusions:** The system presented in this paper is able to detect both positive and negative trends in the transfer times of older adults, therefore automatically triggering an alarm when gradual changes in gait function occur.

**Keywords:** Assisted living; Gerontechnology; Change detection algorithms; Statistical Process Control; Log Logistic distributions; Gait speed

## Content

Text and results for this section, as per the individual journal's instructions for authors.

## Section title

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*Sub-sub-sub heading for section* Text for this sub-sub-sub-heading ... In this section we examine the growth rate of the mean of $Z_0$, $Z_1$ and $Z_2$. In addition, we examine a common modeling assumption and note the importance of considering the tails of the extinction time $T_x$ in studies of escape dynamics. We will first consider the expected resistant population at $vT_x$ for some $v > 0$, (and temporarily assume $\alpha = 0$)

$$E\big[Z_1(vT_x)\big] = E\left[\mu T_x \int_0^{v\wedge 1} Z_0(uT_x)\exp\big(\lambda_1 T_x(v-u)\big)\,du\right].$$

If we assume that sensitive cells follow a deterministic decay $Z_0(t) = xe^{\lambda_0 t}$ and approximate their extinction time as $T_x \approx -\frac{1}{\lambda_0}\log x$, then we can heuristically esti-

*Correspondence: greet.baldewijns@kuleuven.be
[1]KU Leuven Technology Campus Geel, AdvISe, Belgium, Kleinhoefstraat 4, Geel, Belgium
Full list of author information is available at the end of the article
[†]Equal contributor

mate the expected value as

$$\begin{aligned} E\big[Z_1(vT_x)\big] &= \frac{\mu}{r}\log x \int_0^{v\wedge 1} x^{1-u}x^{(\lambda_1/r)(v-u)}\,du \\ &= \frac{\mu}{r}x^{1-\lambda_1/\lambda_0 v}\log x \int_0^{v\wedge 1} x^{-u(1+\lambda_1/r)}\,du \\ &= \frac{\mu}{\lambda_1-\lambda_0}x^{1+\lambda_1/rv}\left(1-\exp\left[-(v\wedge 1)\left(1+\frac{\lambda_1}{r}\right)\log x\right]\right) \end{aligned} \quad (1)$$

Thus we observe that this expected value is finite for all $v > 0$ (also see [1, 2, 3, 4, 5]).

**Competing interests**
The authors declare that they have no competing interests.

**Author's contributions**
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**Author details**
[1]KU Leuven Technology Campus Geel, AdvISe, Belgium, Kleinhoefstraat 4, Geel, Belgium. [2]KU Leuven, ESAT-STADIUS, Belgium. [3]iMinds Medical Information Technology department, Belgium. [4]KU Leuven, Department of Computer Science, DTAI, Belgium. [5]Program in Translational NeuroPsychiatric Genomics, Brigham and Women's Hospital, Harvard Medical School, Broad Institute of Massachusetts Institute of Technology and Harvard, Cambridge, MA.

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**Figures**

**Figure 1 Sample figure title.** A short description of the figure content should go here.

**Figure 2 Sample figure title.** Figure legend text.

**Tables**

**Table 1** Sample table title. This is where the description of the table should go.

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