Visual Data Exploration for Balance Quantification During Exergaming

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Introduction

Unintentional injuries are among the ten leading causes of death in older adults and falls cause 60% of these deaths.
Exergames, digital games controlled by body movements, have been proposed as a way to improve balance among older adults.

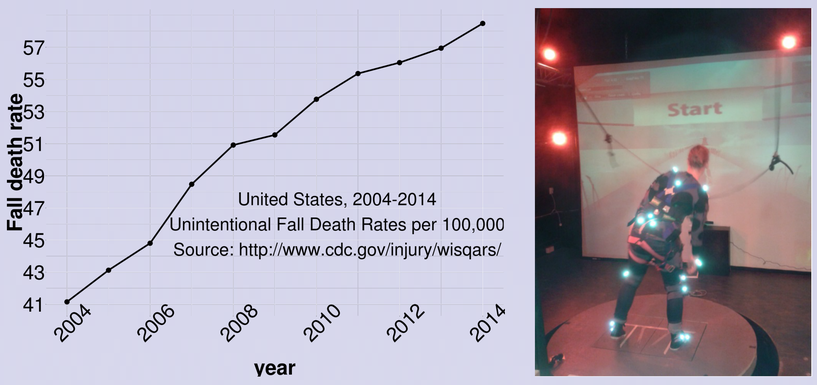

Figure 1: LEFT: *Unintentional fall death rates (adults $65+$).* RIGHT: *An ice-skating exergame proposed as a way to improve balance.*

The main goal of this study is to conduct an exploratory multidimensional data analysis, using visualization techniques, to establish measures that can be used to quantify balance ability in real-time during exergaming.

Methods

Fourty healthy participants, twenty older and twenty younger adults, played a custom-made ice-skating exergame ten times according to five different instructions. Thus, during game-play $40 \times 10 = 400$ trajectories of the center of pressure (CoP) were derived from force plate recordings.

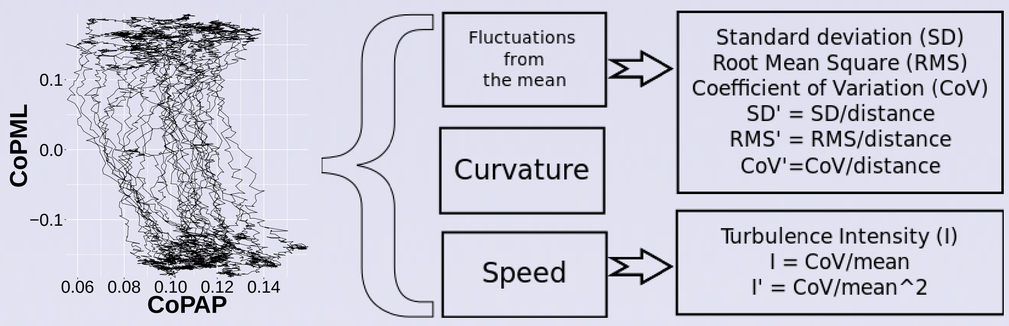

Figure 2: LEFT: *An example of a CoP tajectory.* RIGHT: *Features extracted from the CoP trajectories.*

In general it is known that younger adults (younger than 60 years) have better balance than older adults. Thus, here we consider measures to be suitable for quantifying balance if they show age-related differences.

Results

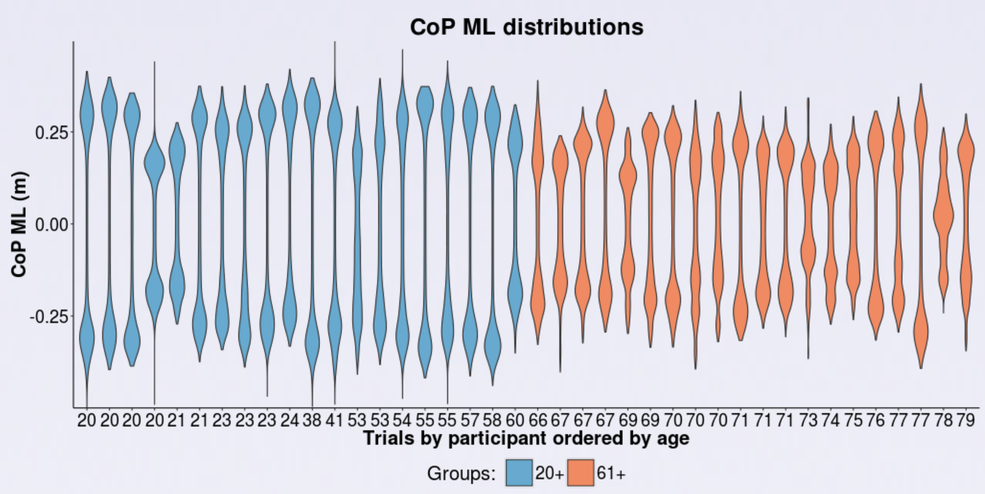

Figure 3: *Violin plots representing CoP lateral transitions between feet.*

In Fig. 3 distances between bumps suggest that younger participants may have larger base of support (BoS), during game-play, than older participants. The thickness of the distributions of valleys between bumps indicates faster CoP transitions among younger than older participants.

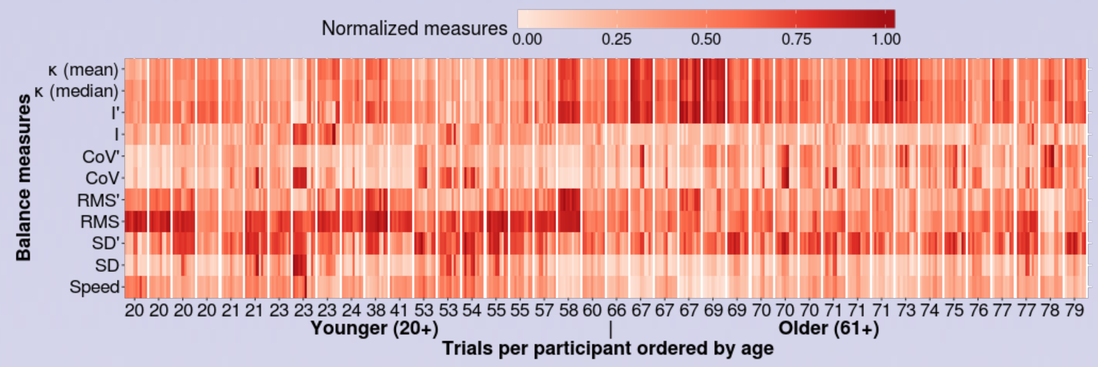

Figure 4: *Visualization of feature median values per trial and participant as a heatmap.*

In Fig. 4, κ and I' values are clearly lower for younger than for older participants. In contrast, RMS values are higher for younger than for older participants. Speed values show slightly higher values for younger than for older participants but not as clearly as for other measures.

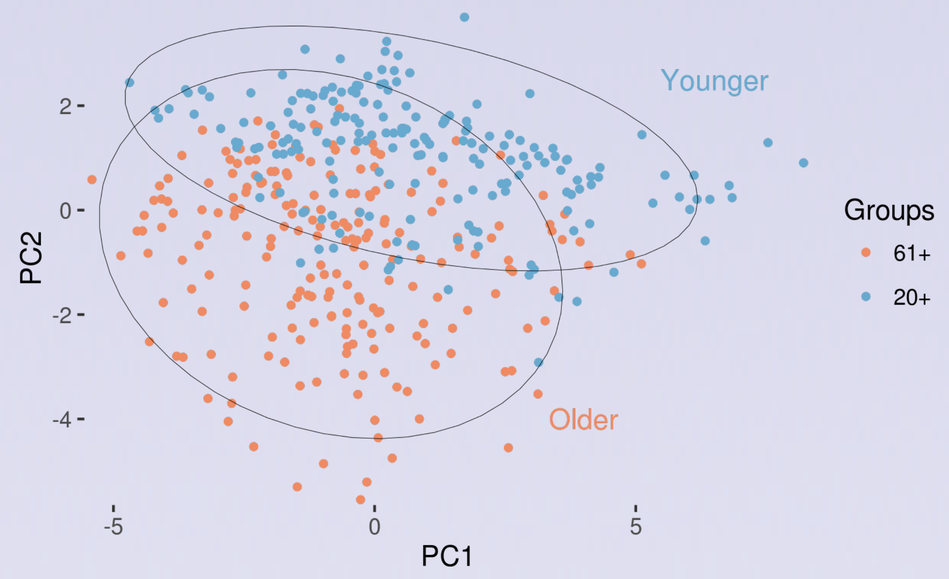

Figure 5: *Projection of the feature median values on the first two principal components PC1 and PC2.*

In Fig. 5, the first two principal components (PC) account for more than 79% of the variance. The contributions of κ, I', RMS, and speed on the two first PCs confirm the observations in Fig. 4 because of strong correlation values between them.

Conclusions

Here we have shown an example of how visualization can be used as a way to explore multivariate data of balance quantification. The properties of the used visualizations can reveal clusters, patterns and relationships hidden in the data. Moreover, the creation of such visualizations are straightforward because they are commonly implemented in standard software for statistical analysis.

The most promising measures are RMS, I', κ and speed, as they show the largest differences between groups and provide additional information on the quality of the movements. One of the main drawbacks of this study is that force plates are not common devices used at home. Therefore, the next step in our research is to apply the techniques presented here to data recorded from devices more commonly used at home such as Kinect.

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