A PIEZOELECTRIC SMART TEXTILE SOCK FOR GAIT ANALYSIS
A FEASIBILITY STUDY

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Introduction

Gait analysis focusing on mobility parameters such as **cadence, stance and swing time**, and joint angles of hip, knee and ankle, has become a common tool in sports and rehabilitation medicine. Traditionally, gait analysis has been confined to the laboratory as it makes use of the combined inputs from treadmill, force plates, accelerometers and (3D) video systems.

Recent developments in materials science have produced **textile based sensors** that can be integrated in regular clothing which opens up for **ambulatory monitoring outside the lab** on a 24-7 basis. In this study an **instrumented sock** has been used to **record timing of ground contact of the heel and toe**.

Aim

The aim of this study was to investigate the **feasibility of extracting gait information** from signals recorded by a **smartphone** from a newly developed **piezoelectric fibrous sensor** integrated in the heel and toe of a **smart textile sock**.

Method

Five subjects followed a protocol for treadmill walking and running at **pre-defined and self-chosen speeds** using the **three foot-strike types; heel-, mid- and toe-strike**, resulting in a database with well-defined walking/running sequences. A **software system for gait analysis was developed** focusing on **timing of heel and toe contact to the ground** and foot-strike type identification.

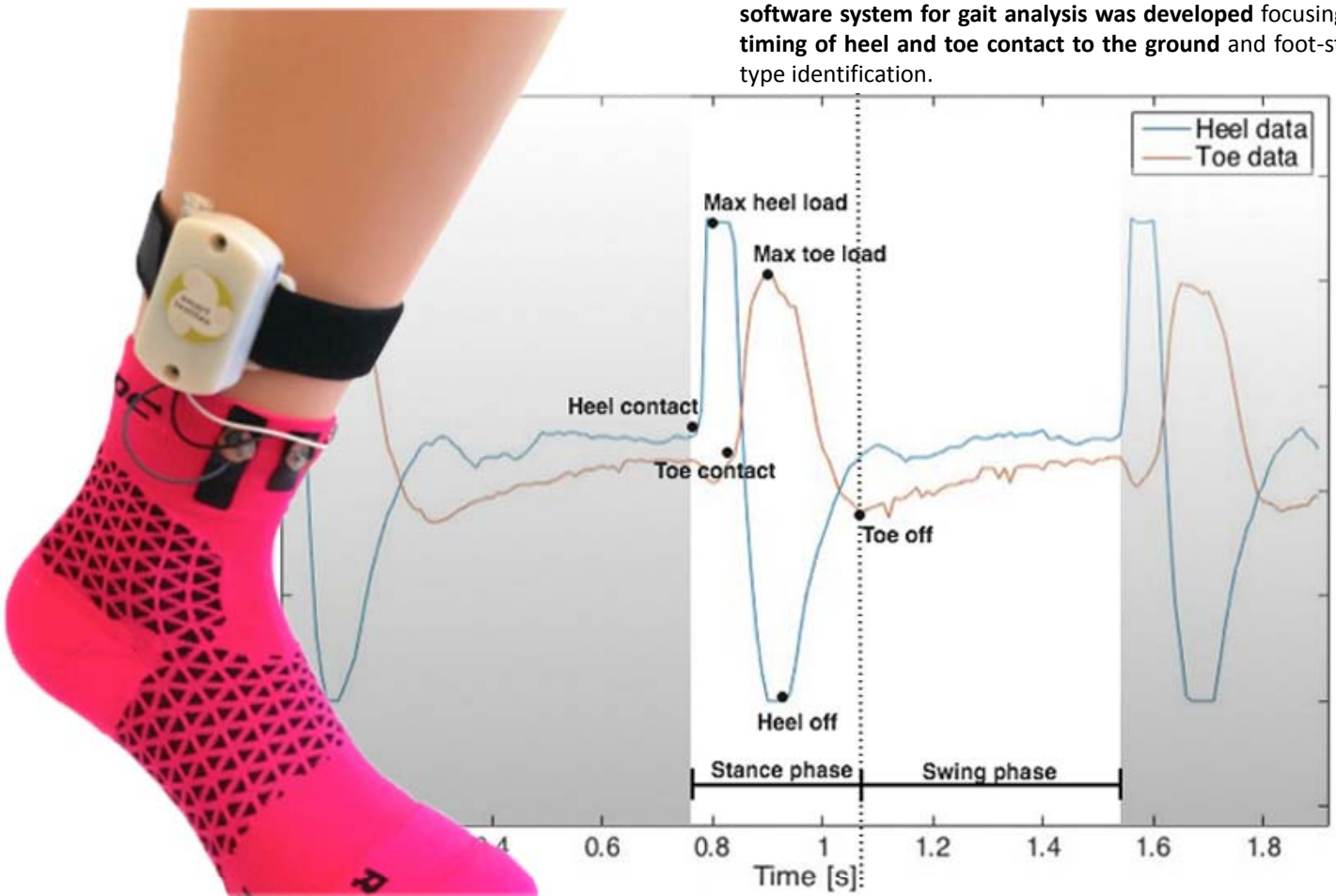

Figure 1. Illustration of the complete system. The sock is instrumented with piezoelectric fibers in heel and to and connected to a Bluetooth unit sending to a smartphone. The graph shows a short sequence of the signals collected during a run. Distinct events of the step cycle is identified (marked) defining the step profile. Step profiles are then isolated and analyzed separately in order to be classified as either heel-, mid- or toe-strike.

Results

An **artificial neural network** was defined based on a subset of the recorded signals. The network **classifies steps of heel-, mid- and toe-strike type** with a hit rate of 97 % on the test data set, and steps of only heel and toe-strike type with a hit rate of 98.7 % on the testing data.

From the isolated segments (figure 1) **information about cadence, stance and swing time could be extracted** and found to be **reliable estimates of these gait parameters** when compared to the walking/running sequences of the protocol.

Conclusion

This study **demonstrates the feasibility** to use the newly developed piezoelectric textile sensor for **direct measurement of gait related parameters and foot-strike identification**.

Further development of the textile sensor is needed to overcome the signal fade off within 5–20 minutes, which currently limits the smart textile sock's general applicability.

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