STEP RATE MONITOR FOR GAIT ANALYSIS

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Abstract

With an increase in the popularity of running, an increase in the occurrence of running related injuries is also apparent[1]. Excessive knee joint loading has been recognized as one of the most common factor when predicting the occurrence of injury[2]. A common outcome for altering joint loads during running is with an increased step rate (number of steps per minute). By achieving a reduction in joint loading, an injured runner may be enabled to continue running without aggravating symptoms, while receiving care for their injuries. Thus, it is important to monitor step rate during a running analysis. Fabrication of the device has resulted in a prototype that successfully calculates step rate in real time, while providing visual feedback to the clinician.

Motivation

- 56% of recreational runners will sustain a running related injury each year[3]
- Excessive joint loading is a common risk factor[4,5]
- Modifying applied load may be one injury prevention strategy
- Manipulating a runner's step rate can be used to achieve a reduction in applied loads
- Currently, there are no devices that calculate step rate

- **Aim**: To create a device that will identify a runner's step rate while on a treadmill with minimal setup time for use in a clinical setting.

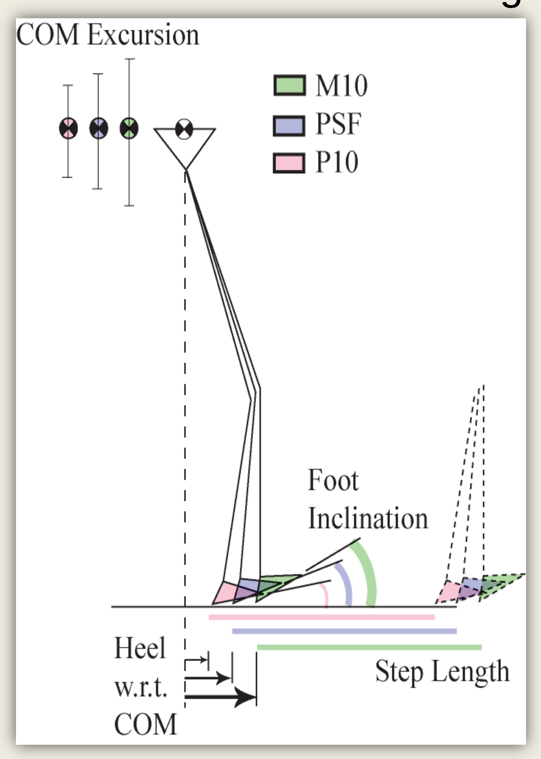

Figure 1 (left). Kinematic changes that occur due to a modification of step rate, a comparison between preferred stride frequency (PSF) and 10% above (P10) and 10% below (M10) PFS. With an increase in step rate a decrease in stride length, foot inclination angle, center of mass (COM) vertical excursion, and the distance from heel to COM at initial contact will be observed.

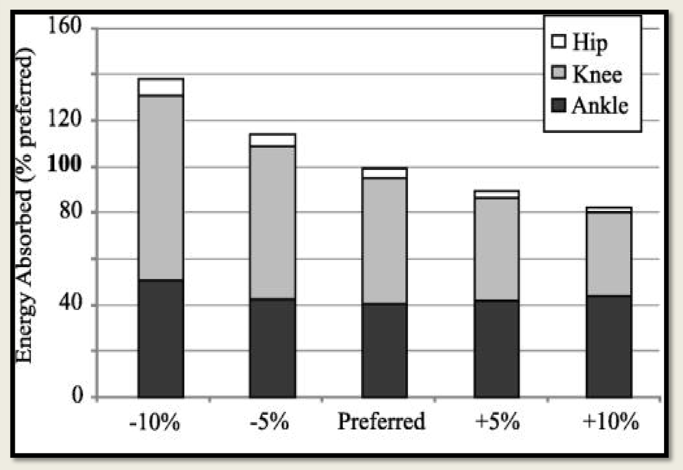

Figure 2 (right). Changes in energy absorbed as step rate is modified. An increase in step rate will result in a decrease in energy absorbed.

Design Specifications

- Uniaxial accelerometer (PCB Piezotronics, model U353B16)
- Attachment method: 4 neodymium magnets
- Placement: Front, center on support beam below treadmill belt
- DAQ System: Module CA-1000, MatLab DAQ Toolbox

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Final Design

Signal Filtering

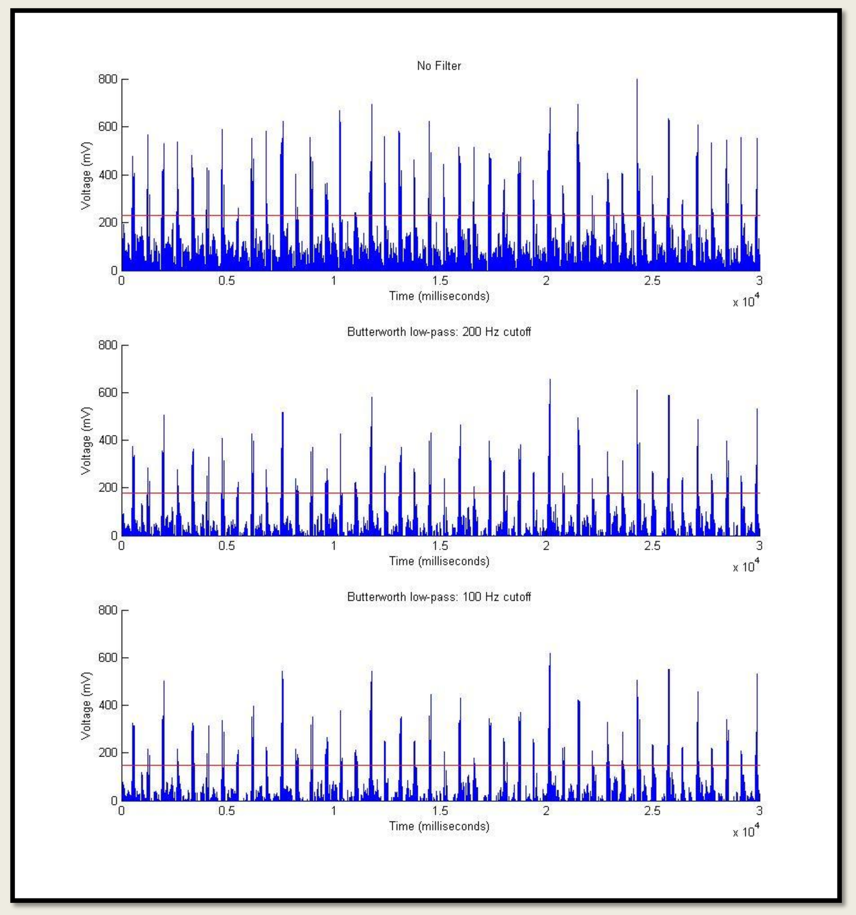

Figure 3 (above). Plots displaying the effects of filtering (a) raw data with a (b) low-pass Butterworth filter with a 200 Hz cutoff frequency and a (c) 100 Hz cutoff frequency.

Data Processing

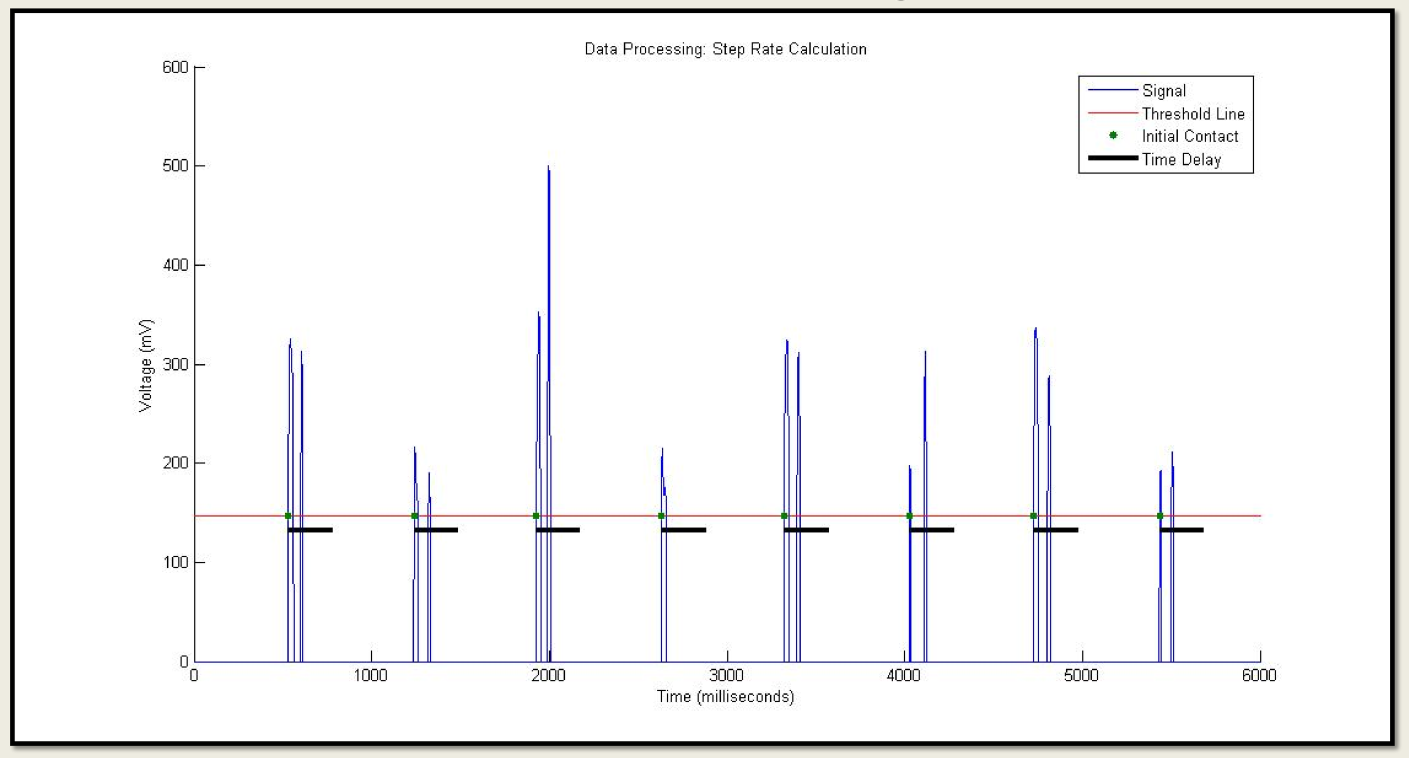

Figure 4 (above). Graphical representation of the key values to calculate step rate. A calibration period is used to identify key parameters such as threshold and the time delay. Data is then filtered and all values below the threshold are set to zero. Every time the signal crosses the threshold, a step is counted and the time delay begins to ensure that multiple vibrations are not counted for a single step.

User Interface

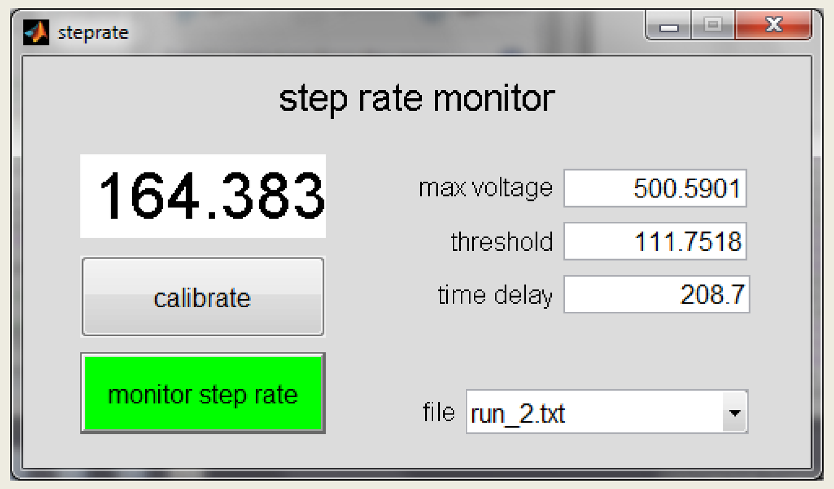

Figure 5 (above). User interface that is displayed to indicate the runner's step rate.

Attachment

Figure 6 (above). Method of attachment. Aluminum angle bracket is used to position accelerometer in the correct orientation. Neodymium magnets are used to secure to treadmill.

Cost Analysis

Item	Price
Accelerometer (1)	$275
Magnets (4)	$8.00
MatLab (1)	$500
Signal Conditioner (1)	$495
Total Cost	$1,278

Table 1 (above). Total cost of materials in single prototype: $1,278. These calculations assume the facility will have a access to a computer and a data acquisition system.

Testing

Placement of the Accelerometer on the Treadmill

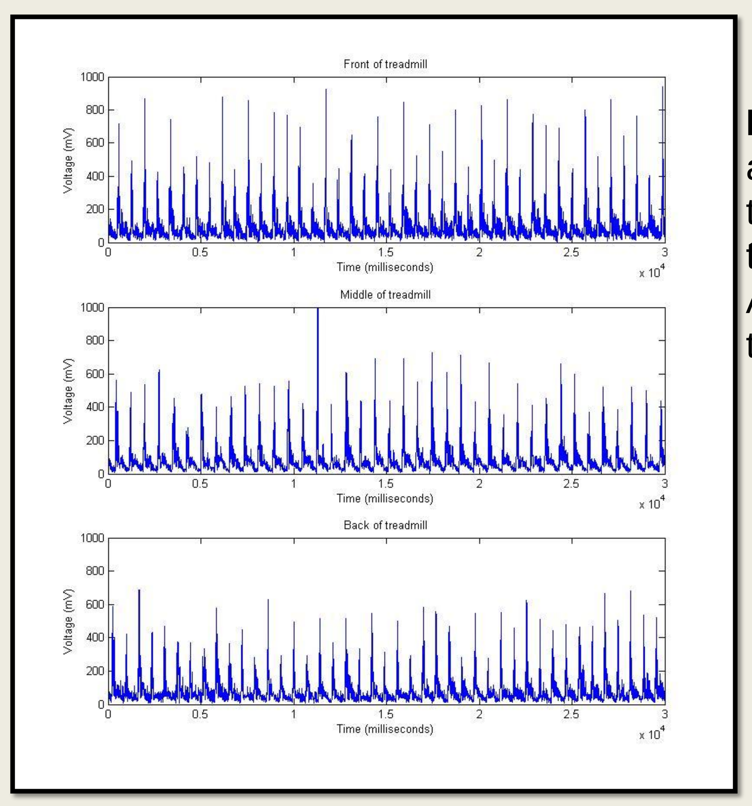

Figure 7 (left). Acquired signal from attachment of the accelerometer on the front, middle, and back of the treadmill's middle support beam. Attachment on the front resulted in the best signal.

Different Speeds with the Same Step Rate

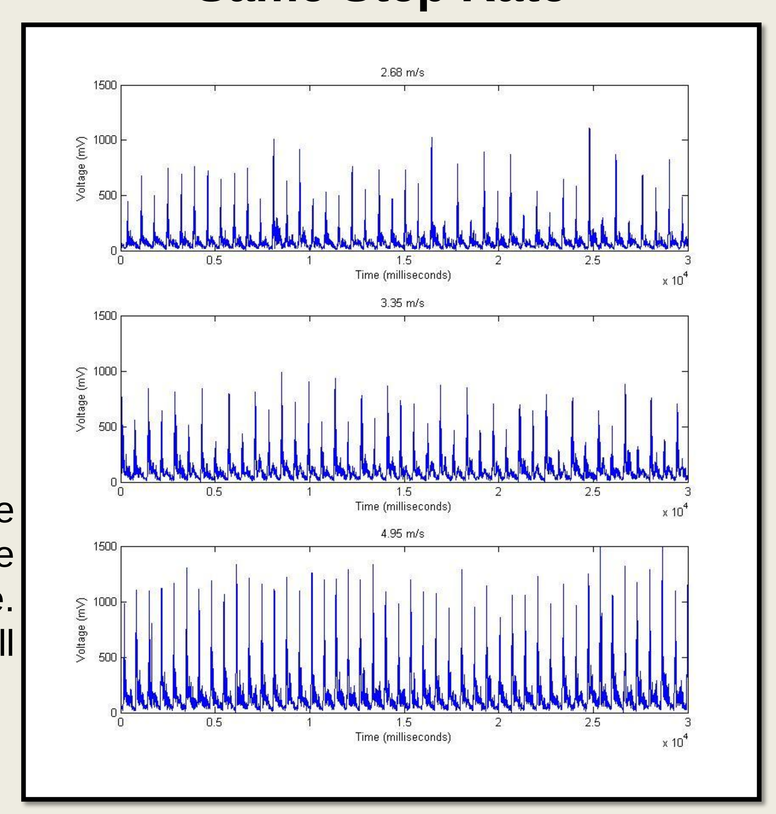

Figure 8 (right). Comparison of the signal at different speeds, while maintaining a constant step rate. Relevant signal was acquired at all speeds.

Design Criteria

- Compatible with the clinical treadmill created by Standard Industries
- Must not compromise the infrastructure of the treadmill
- Must not interfere with the runner on the treadmill
- Accurately identify step rate of an individual
- Feedback of runner's step rate updated frequently
- Identified step rate must be displayed in real time

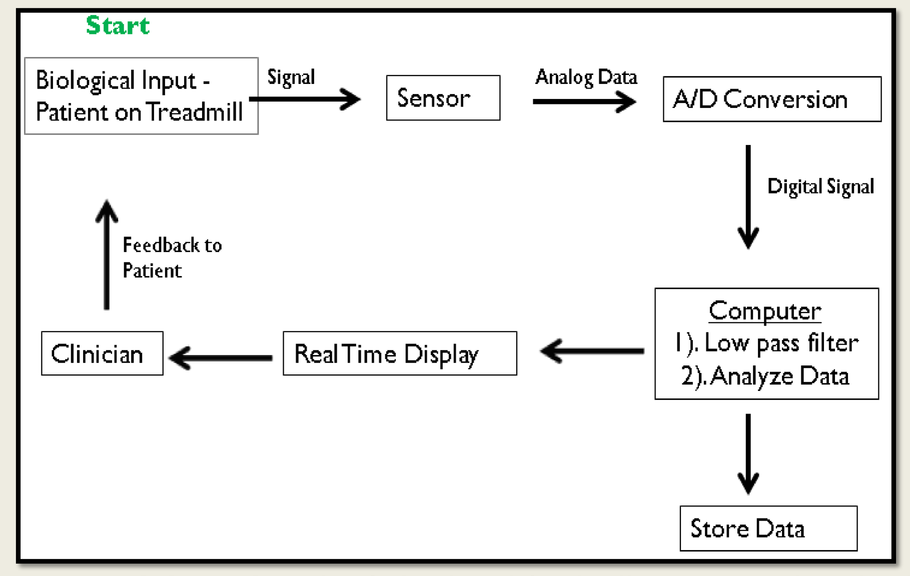

Figure 10 (above). Final design block diagram. The design needs to collect analog data, convert it to digital, and manipulate it to determine the step rate.

Future Work

Real-time Data Processing

- Properly collect accelerometer signal with DAQ system using a MatLab toolbox

Improve Signal Filtering

- Reduce noise while retaining biologically relevant data
- Increase magnitude of relevant data to improve signal to noise ratio

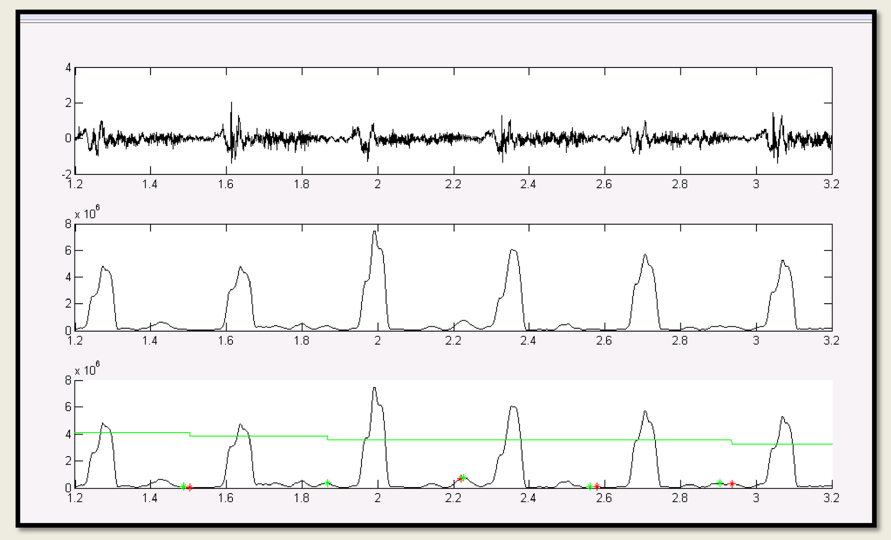

Figure 10 (left). Graph of future filtering procedures on signal.

Device Interface with Runner

- Provide visual relevant feedback for runner in the form of a speedometer
- Displaying a "green zone"

Further Testing

- Device accuracy with diverse body types and running styles
- Device use on different clinical treadmills

References

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