A Versatile Networked Sensing System as Add-On System for Augmenting Sports Devices

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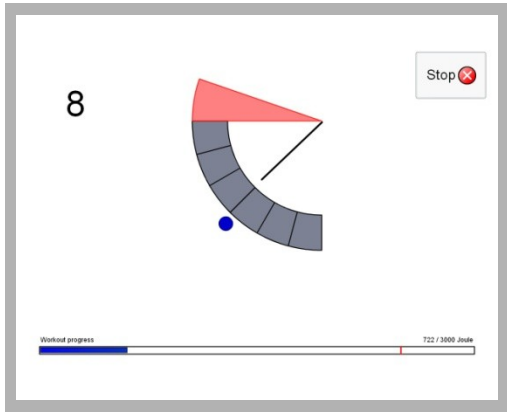
Augmentation of Workout Machines

More effective workout with visual Feedback

Synchronous Workout Machine

Sensor device for measuring the lever angle with an acceleration sensor

Leg extension / flexion exercise



Visual Feedback during exercise

Development Process

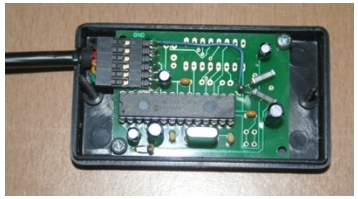
Redesign of the sensor device to meet the hardware requirements

Phase I:

Prototype I

- Rapid Prototyping on the Particle Platform
- algorithm development to transform acceleration into Joule
- Data transmission by RF
- limitation to only a few devices because of small RF bandwith
- feasibility analysis

Phase II:

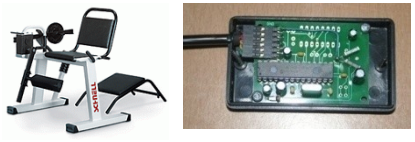


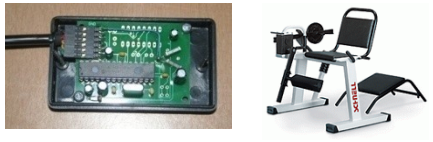
Prototype II

- PIC 18F2550 and ADXL203
- improving of performance and reliability
- optimizing sensor accuracy min. 1°
- optimizing and increasing sampling rate > 50 Hz
- wired data transmission to get small jitter <= 1ms
- high measurement resolution

Synchronous Workout System Architecture

Prototype II (sensor device redesign)





FTDI Converter

Sensor & communication augmented sports equipment

Serial-to-USB

Serial-to-USB

Sensor & communication augmented sports equipment

Server

...

Server

Run time exercise visualization and feedback tool

TCP/IP

TCP/IP

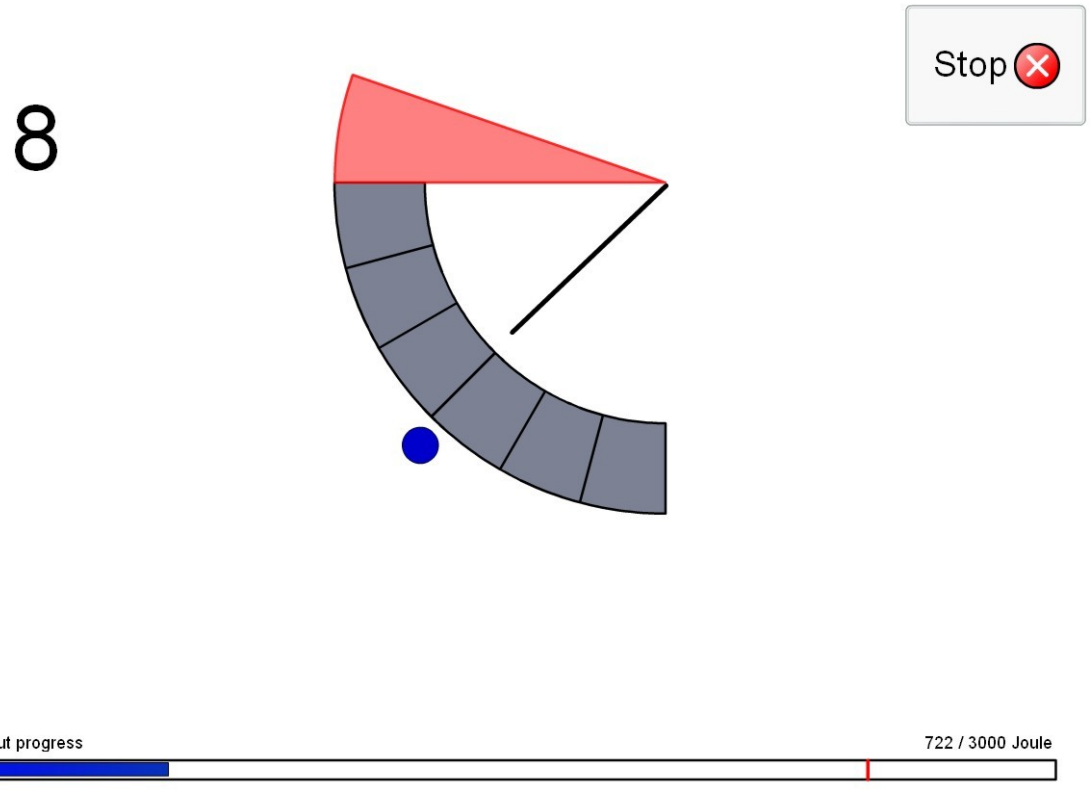
Run time exercise visualization and feedback tool

Data exchange by a simple XML Protocol

Flash GUI

Flash GUI

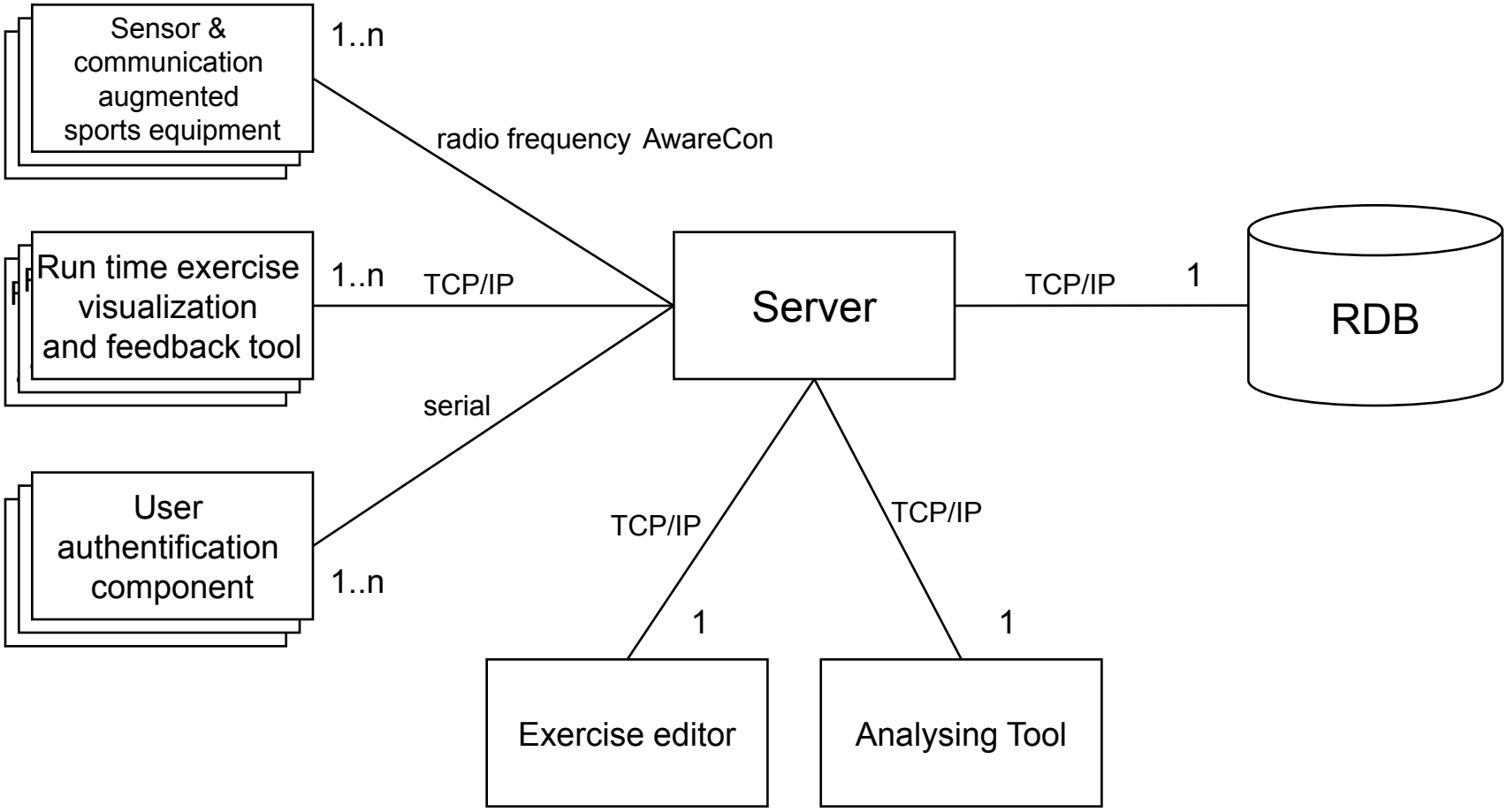
Joule, not repetitions!



Thank You!

Synchronous Workout System Architecture

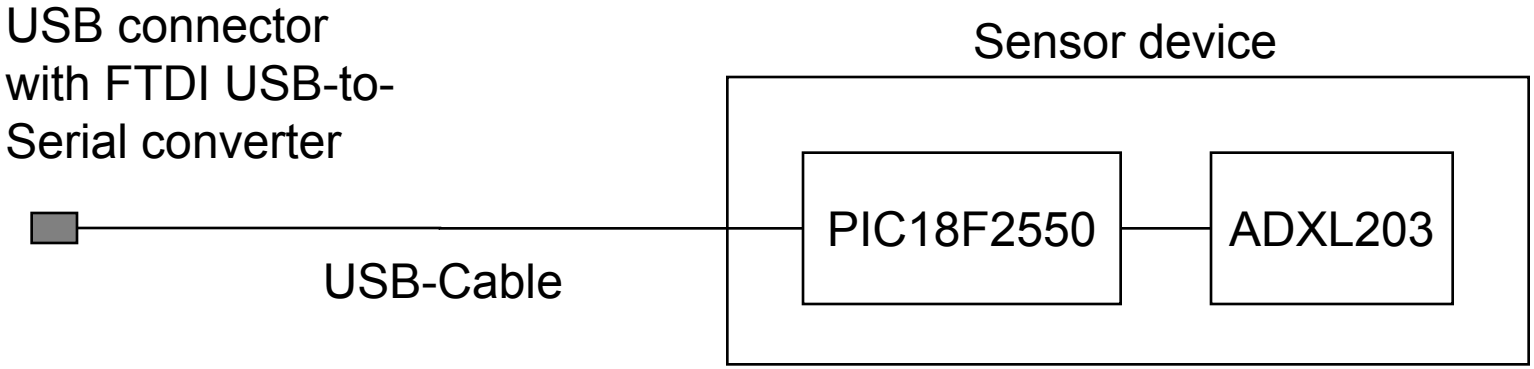
Prototype I (vertical functional prototype)

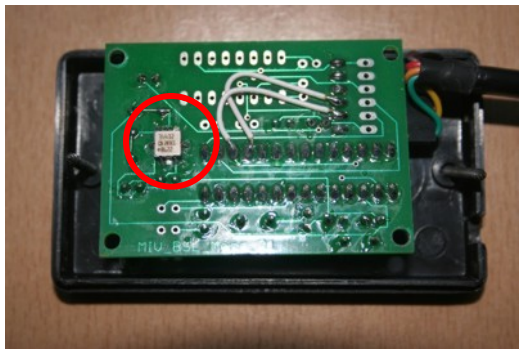


Backup

Sensor Device Architecture

Optimized for high accuracy and small structural shape



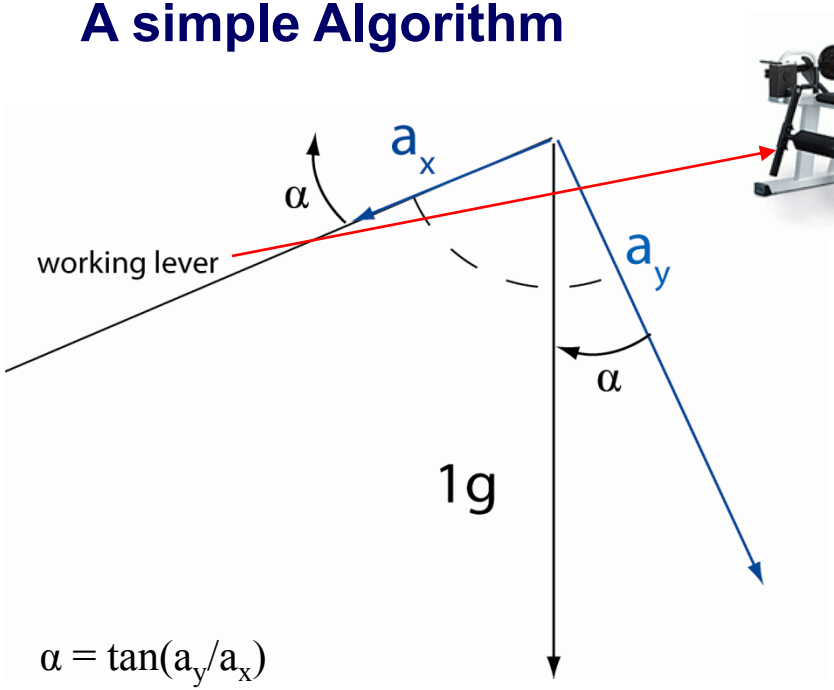


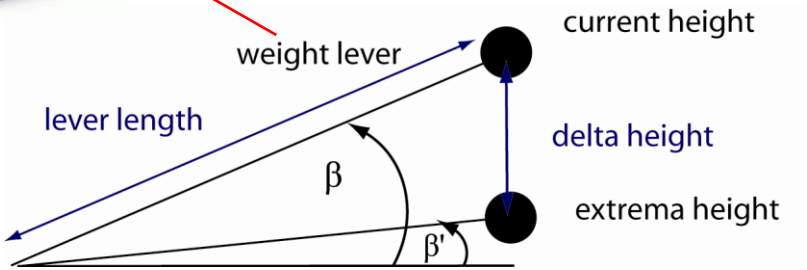
ADXL203

PIC 18f2550

Converting Acceleration into Joule

Counting Joule, not repetitions, for measuring workout success
A simple Algorithm





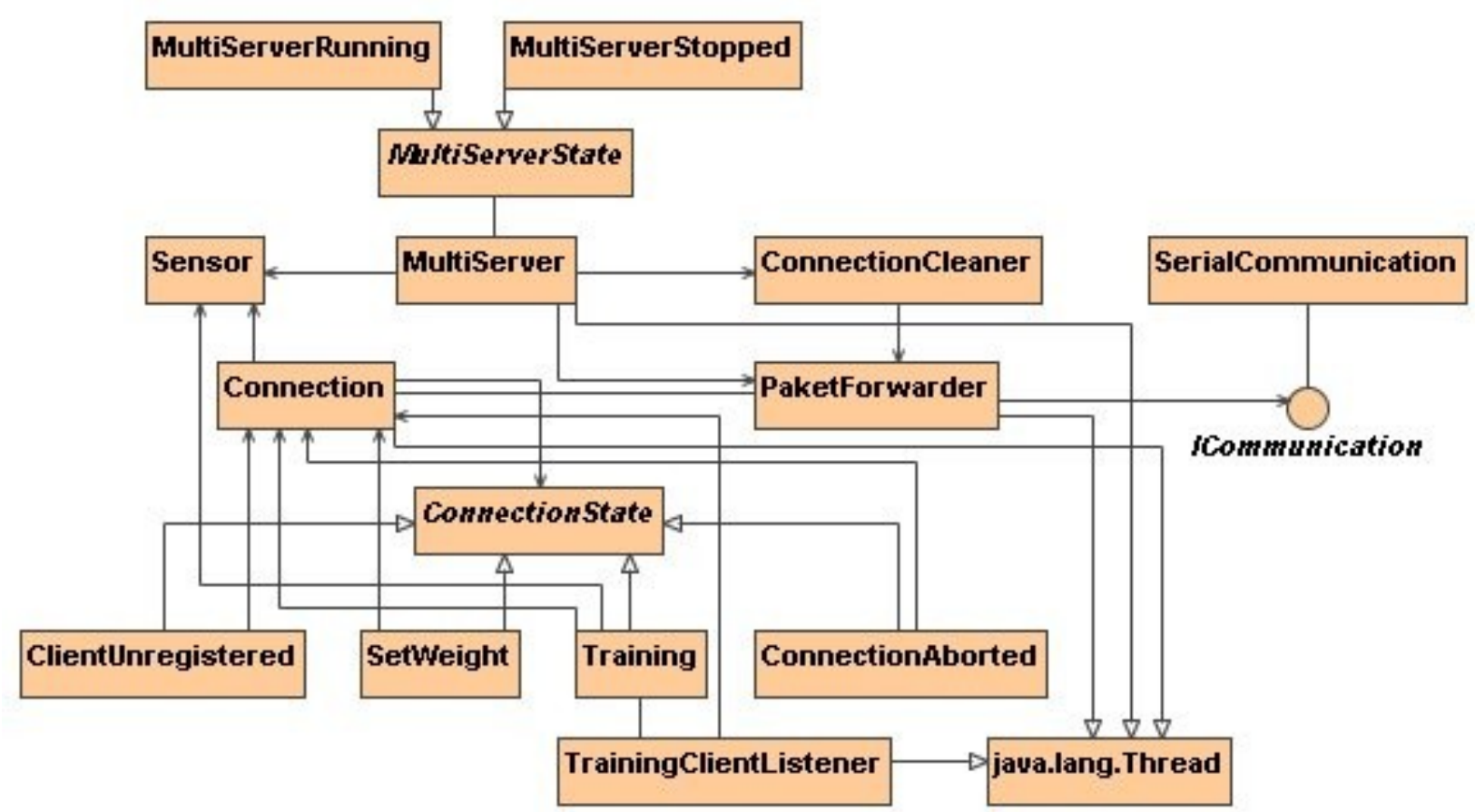
$\alpha = \tan(a_y/a_x)$

$\beta = f(\alpha)$
f: transmission function

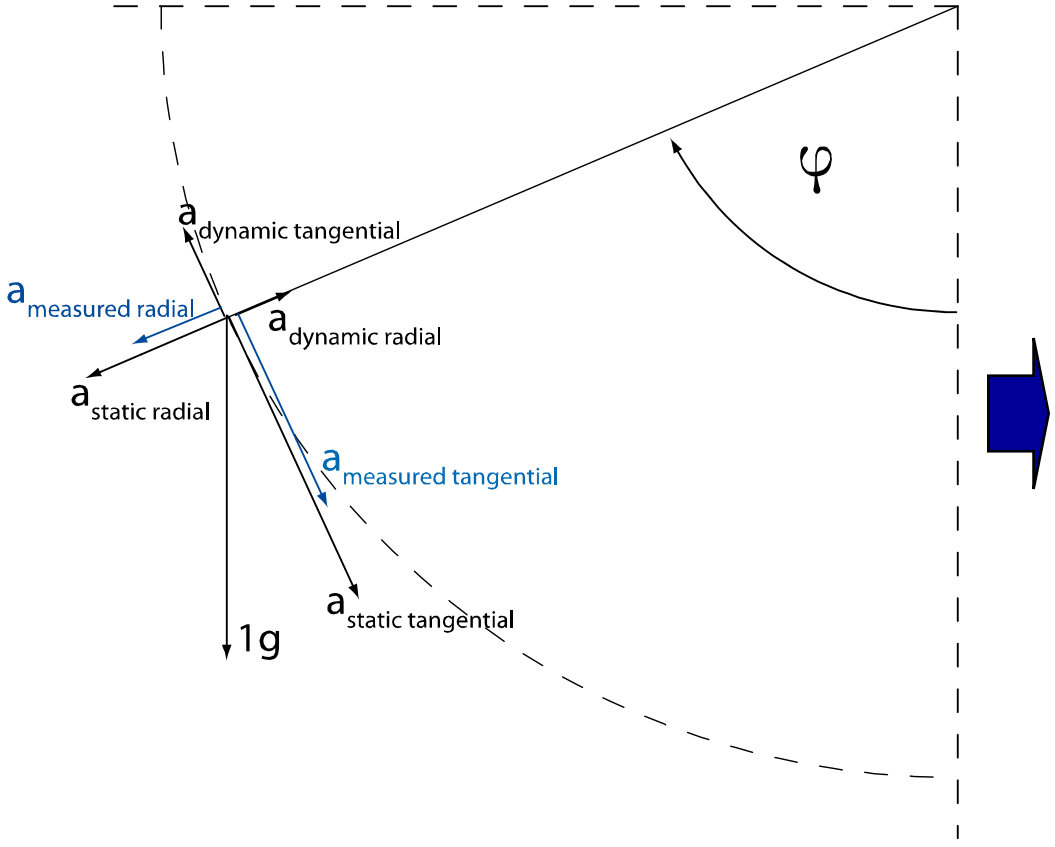
currentHeight = leverLength * $\sin(\beta)^{-1}$
extremaHeight = leverLength * $\sin(\beta')^{-1}$
deltaHeight = abs(extremaHeight – currentHeight)
work = weight * 9,81 * deltaHeight
power = work / (currentTime – extremaTime)

Software Architecture

State Pattern avoids inconsistent program states



Partitioning of the acceleration vectors



Mounting the sensor at the axis to zero out the dynamic acceleration

Comparison of Acceleration Sensors

ADXL203 is much more accurate

Backup