Departamento de Engenharia Eletrotecnica e de Computadores

VBT Device

Internet of Things

Assigment 1

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1 Introduction

Velocity-based training (VBT) is an emerging methodology in the field of sports and physical exercise, prioritizing the speed of movement execution over the traditional emphasis on lifting heavy loads. This approach has been progressively recognized by the scientific and sports community due to its effectiveness in personalizing training programs, optimizing athletic performance, and minimizing the risk of injuries. By monitoring the speed of execution, VBT allows for more precise prescription and adjustment of training, grounded on scientific bases, to maximize the development of strength and power.

Within this methodology, we present our project: the development of a velocity-based training device, designed to integrate the advantages of VBT into training contexts, this small device, equipped with sensors, is capable of measuring the speed and power of movement in real-time, providing immediate feedback that enables the continuous adaptation of training parameters, such as reps, load among others.

2 Goals

Before specifying the project's goals, let's pay attention to a practical case of VBT application. Let's assume we have an athlete who does two sets of an exercise, it could be Deadlift, deadlift is a weightlifting exercise targeting multiple muscles, involving lifting a loaded barbell off the ground to hip level, one of the sets is more controlled, and the other is more explosive. A good coach can identify this, but by how much is one more explosive than the other, or for example, why was one of them slower? Should the athlete change the load? Or is the athlete training to become more explosive and intends to keep a history and record of this explosion in order to know their progress?

Other example is, in lifting, performing more repetitions within a set leads to increased fatigue, if we monitor velocity, we're able to quantify this fatigue through a reduction in speed from your strongest or initial lift in the set, to your final repetitions, where fatigue sets in and velocity decreases. Typically, individuals encounter a point of failure in many exercises due to a significant drop in velocity during a set, and utilizing this concept of velocity loss as a measure of fatigue can be instrumental across various aspects of our training, specifically, it's beneficial for adjusting our workout volume to minimize fatigue, crucial for athletes in-season to maintain their freshness for optimal performance in competitions.

With this, we present the primary goal of this project: design and prototype a wearable VBT device that utilizes sensors to capture useful kinematic data during gym training exercises. This data will be processed and analysed to provide real-time feedback on various VBT metrics and insights to enhance training effectiveness, such as:

- Movement Velocity: Measure the speed of barbell movement during the exercises.
- Power Output: Calculate the rate of work performed, providing insights into force and speed combined.
- Stability: Analyze movement symmetry and identify potential imbalances that could lead to injuries.
- Rep Counter: Automatically count the number of repetitions performed for each set.
- Bar path: Track the trajectory of the barbell throughout the exercise, providing feedback on proper lifting technique.

The system should be able to process the IMU(Inertial measurement unit) sensor data properly, efficiently and accurately, to extract the key VBT metrics.
The second goal of this project is to create a user-friendly mobile application that:

- Wirelessly connect with the VBT device board(Zolertia Re-mote) via Bluetooth Low Energy(BLE).
- Receive, Process and Display real-time VBT data on the key metrics.

- Empowers users to dynamically adjust training parameters throughout their workout: This includes the ability to select exercise types and weight loads.
- Track progress over time through historical data visualization.
- Provide personalised insights.

The last goal of this project is to integrate a cloud platform like AWS to enhance functionality by facilitating community building and progress sharing among athletes and coaches. Users should be able to share training data and compare progress. Additionally, the cloud will enable advanced data visualization and analysis, generating personalised graphs and trends of user metrics over time, providing deeper insights into individual progress and informing data-driven training decisions.

By achieving these goals, this project strives to offer a comprehensive VBT solution that goes beyond basic data collection. It aims to provide meaningful, actionable insights for athletes and coaches, allowing them to optimize training, enhance performance, and reduce injury risk, ultimately leading to a safer and more effective training experience.

3 Approach and Work Plans

Here is a detailed approach that we developed to ensure a good execution of our project:

- Phase 1: Design and Projecting - Project Beginning (2 weeks):
    1. Sensor Integration: Study and Test the IMU 6-axis sensor.
    2. Software Development: Planning, developing a detailed software development plan, outlining functionalities, algorithms, and necessary math basics.
    3. Mobile App Planning: Define and Design the core functionalities of the mobile app.
- Phase 2: Development and Integration (8 weeks):
    1. Software Development: Begin development of software modules for data acquisition, processing, and communication.
    2. Device Assembly: Design a preliminary device housing using Fusion 360 software.
    3. Device Assembly: Prototyping - 3D print a first-pass prototype of the device housing.
    4. Mobile App Development: Implement the mobile app integration, if possible using low-code tools.
    5. Software Development: Finalize core functionalities of the software including data processing algorithms and communication protocols.
    6. Device Assembly and Software Integration: Run a first test of the core modules before starting the testing phase.
    7. App and Cloud Integration and Testing.
- Phase 3: Testing and Evaluation
    1. Functional Testing: Conduct comprehensive testing of data acquisition, processing, transmission, and overall device functionality.
    2. Validation Testing: Develop and implement testing procedures to compare device output with established standards.
    3. User testing: Perform and evaluate tests on athletes.
    4. Analyze Collected Data.
    5. Improvements or Corrections.

4 List of Materials

- Acquisition Board: Zolertia Re-mote
- Sensor: Grove - 6-Axis Accelerometer&Gyroscope
- Mobile App (Low code if possible)
- Cloud: AWS

5 Expected outcomes

Overall, this project's anticipated outcomes are not simply the creation of individual components but the development of a comprehensive and validated VBT ecosystem. This ecosystem will provide athletes and coaches with valuable tools and data-driven insights to optimize training, enhance performance, and potentially reduce injury risk.

Additionally, the project aims to contribute to the advancement of VBT research by offering valuable data and insights into the potential of this methodology.

Main Outcomes:

- Development of a functional VBT device prototype: This prototype will effectively capture and transmit kinematic data (movement information) during training exercises.
- Creation of a user-friendly mobile application: The application will display real-time feedback on key VBT metrics, including movement velocity, power output, and movement symmetry. This information will be presented clearly and intuitively for athletes and coaches to understand and utilize.