**Project Plan: Identifying Fatigue Indicators Through Player Movement Patterns in Competitive Squash**

**How to Approach the Problem**

**Objective**: To identify fatigue indicators in squash players by analyzing their movement patterns over the course of a match using player tracking data.

**1. Key Steps in the Process**

**Step 1: Define Fatigue Indicators**

* **What to look for**:
  + Decreased speed (average movement speed reduces over time).
  + Inconsistent recovery to the “T” position (slower or less frequent).
  + Reduced court coverage (smaller movement range).
  + Longer reaction times to ball movements.
  + Irregularity in stride lengths or movement patterns.

**Step 2: Data Collection**

* **Video data**: Gather videos from competitive squash matches. Prioritize long rallies or full matches for a gradual fatigue effect.
* **Player tracking**: Use tools like MediaPipe, OpenCV, or DeepLabCut to extract player movement trajectories from the video.
* **Ball tracking**: To identify rally timings and correlate movement with ball location.

**Step 3: Data Preprocessing**

* Normalize player coordinates to a standard squash court layout.
* Segment the match into rallies for analysis (e.g., based on ball tracking or manual annotation).
* Smooth noisy data (e.g., apply a moving average filter).

**Step 4: Feature Extraction**

* Calculate metrics such as:
  + Average speed and acceleration per rally.
  + Time spent in different court zones.
  + Recovery time to the “T” after shots.
  + Reaction time to ball movement.
  + Rally length vs. player performance over time.

**Step 5: Fatigue Analysis**

* **Trend Analysis**:
  + Plot metrics (e.g., speed, recovery time) over time to identify fatigue patterns.
* **Statistical Analysis**:
  + Use regression or clustering techniques to detect patterns correlating with fatigue.
* **Comparative Study**:
  + Compare metrics between early and late match segments or across different rallies.

**Step 6: Validation**

* Compare identified fatigue patterns with expert observations or physiological data if available (e.g., heart rate, match commentary).

**2. Outline for the Paper**

**Title Page**

* **Title**: Identifying Fatigue Indicators Through Player Movement Patterns in Competitive Squash
* **Author**: Dhruv Panchal
* **Date**: Submission date
* **Affiliation**: Princeton Day School

**Abstract**

* Summarize the motivation, methodology, and key findings in 150-200 words.
* Highlight the novelty of using movement data to infer fatigue in squash.

**Introduction**

* **Background**:
  + Importance of fatigue management in squash.
  + Challenges of identifying fatigue in real-time.
* **Motivation**:
  + Lack of automated tools for detecting fatigue.
* **Objective**:
  + Analyze movement data to derive fatigue indicators in squash players.
* **Scope**:
  + Focus on player movement without integrating physiological data.

**Related Work**

* Review:
  + Existing methods for tracking fatigue in sports (e.g., tennis, basketball).
  + Movement analysis techniques in sports analytics.
  + Squash-specific studies (if any).
* Identify gaps in the current literature that your research addresses.

**Methodology**

**1. Data Collection**

* **Source of data**: Describe video sources and match selection criteria.
* **Tracking tools**: Explain the software used for player and ball tracking.
* **Preprocessing**:
  + Normalizing court layout.
  + Rally segmentation.

**2. Feature Extraction**

* **Metrics to analyze**:
  + Movement speed and acceleration.
  + Recovery time to the “T”.
  + Reaction time to ball movement.
  + Court coverage area.

**3. Analysis Techniques**

* Statistical methods (e.g., t-tests, regressions).
* Clustering or machine learning to classify fatigue states.
* Trend analysis across match segments or rallies.

**Results**

* **Quantitative Findings**:
  + Graphs showing changes in metrics (e.g., speed, recovery time) over time.
  + Statistical comparisons between match segments.
* **Visualizations**:
  + Heatmaps of player court coverage.
  + Line plots of speed vs. time.
* **Insights**:
  + Correlations between movement patterns and observed fatigue.

**Discussion**

* Interpret the results:
  + What do the identified patterns reveal about fatigue?
  + How reliable are these indicators for inferring fatigue?
* Discuss limitations:
  + Potential noise in tracking data.
  + Absence of physiological validation.
* Suggest future directions:
  + Integrating biometric data (e.g., heart rate, oxygen levels).
  + Real-time fatigue detection systems.

**Conclusion**

* Summarize:
  + The problem, methodology, and key findings.
  + Practical implications (e.g., for coaching or injury prevention).
* Highlight the potential for further research in automated sports analytics.

**References**

* Cite all relevant sources from sports analytics, fatigue analysis, and squash-related studies.

**Appendices**

* Include:
  + Raw or sample data (player tracking coordinates).
  + Algorithms or formulas used.
  + Additional graphs or tables.

**Tasks to Complete**

**Data Tasks**

1. Gather competitive squash videos (multiple players and matches).
2. Extract player and ball tracking data.
3. Preprocess and normalize movement data