## **Project Proposal – Intelligent System for Exercise Classification and Evaluation**

**Project Repository:**<https://github.com/Nicolas-CM/PoseTrack_AI_ADN.git>

**MMFit Dataset – Official Website and Repository:**[https://mmfit.github.io](https://mmfit.github.io/)<https://github.com/KDMStromback/mm-fit>

### **1. Introduction and General Objective**

This project aims to develop an intelligent system capable of classifying physical exercises and evaluating whether they are being performed correctly, using real-time pose analysis.

The system will be developed **iteratively**, with continuous adjustments based on data understanding, model performance, and feasibility. Eventually, the system will focus on **three selected exercises**, chosen according to performance, clarity of metrics, and relevance in physiotherapy and fitness contexts.

### **2. Main Research Question**

**How can we develop an intelligent system that accurately classifies physical exercises and determines whether they are being performed correctly, using real-time pose estimation?**

**Subquestions:**

* What joint-based metrics (e.g., angles of knees, hips, wrists) are most relevant for evaluating exercise correctness?
* How can the system provide real-time feedback on posture during exercises?
* How can this system be applied in physiotherapy and fitness to monitor users' progress?

### **3. Problem Type**

This is a **supervised classification problem** within the domain of artificial intelligence applied to computer vision, focusing on:

* **Human activity recognition** (HAR) from video and sensor data.
* **Pose-based movement analysis** for form evaluation.
* **Multi-modal signal processing** (video + wearable sensors).

### **4. Methodology (CRISP-DM Framework)**

We follow the CRISP-DM (Cross-Industry Standard Process for Data Mining) methodology, adapted to an experimental and evolving project scope:

#### **1. Business Understanding**

* Purpose: Analyze and assess exercise performance in real time to provide corrective feedback.
* Potential applications: personalized training, rehabilitation, home physiotherapy.

#### **2. Data Understanding**

* **MMFit Dataset** ([GitHub](https://github.com/KDMStromback/mm-fit), [Web](https://mmfit.github.io/))  
   Includes labeled videos and synchronized sensor data for 10 physical exercises.

#### **3. Data Preparation**

* Pose extraction using MediaPipe (2D) and MMFit-provided data (3D).
* Feature engineering: joint angles, trunk inclination, joint velocity.
* Data normalization, segmentation, and augmentation if needed.

#### **4. Modeling**

* Initial classifiers: SVM, Random Forest, XGBoost.
* Hyperparameter tuning and cross-validation to improve generalization.

#### **5. Evaluation**

* Standard metrics: Accuracy, Recall, F1-Score.
* Pose-specific metrics: joint angle error, trunk alignment deviation.

#### **6. Deployment**

* Development of a real-time interface with pose visualization and corrective feedback.

### **5. Dataset: MMFit**

#### **Exercise Types (only 3 will be selected for final system):**

* Squats, Lunges, Bicep Curls, Sit-ups, Push-ups, Tricep Extensions, Dumbbell Rows, Jumping Jacks, Dumbbell Shoulder Press, Lateral Shoulder Raises.

#### **Modalities and Sensors:**

* **Pose Data**:  
  + 2D: 18 keypoints (COCO format)
  + 3D: 17 keypoints (Human3.6M format)
* **Sensors**:  
  + Accelerometers, gyroscopes, magnetometers, heart rate monitors
  + RGB and Depth Cameras

#### **Labels:**

* Activity class
* Repetition count
* Execution quality (correct/incorrect)
* Start/end of each set

### **6. Evaluation Metrics**

* **Accuracy**: Correctly classified exercise instances over total.
* **Recall**: Model’s ability to detect correct execution.
* **F1-Score**: Balance between precision and recall.
* **Inference time**: Speed of real-time classification.

**Pose-specific metrics**:

* Joint angle error: Difference between measured vs ideal angles (e.g., 90° in a squat).
* Trunk inclination: Based on the relative position of head, shoulders, and hips.
* Symmetry metrics: Comparison between left and right limbs.

### **7. Data Expansion Strategies**

If more data is needed to improve performance or generalization, we may:

* **Capture additional videos** from volunteers performing exercises at different speeds and viewpoints.
* **Generate synthetic movements** using simulation tools or pose generators.
* **Use annotation tools** such as LabelStudio or CVAT to label new data.
* **Collaborate with fitness professionals or physiotherapists** to gather real-world data.

### **8. Ethical Considerations**

* **Informed consent**: Required for all participants whose movements are recorded.
* **Privacy & data protection**: Videos and personal data will be anonymized and securely stored.
* **Inclusivity**: The system should avoid bias and be adaptable to users of different body types, ages, and abilities.

### **9. Next Steps**

* Complete exploratory data analysis.
* Train initial models and evaluate performance on a subset of exercises.
* Begin development of the real-time interface.
* Iterate on the system design based on feedback and results.
* Select 3 final exercises to focus on for deployment.