Methodology

**Hardware:**

1. **Raspberry Pi Pico**:
   * Central processing unit for the system in both papers.
   * No changes or additional hardware.
2. **MPU-6050 Sensor**:
   * Six-axis motion sensor with a gyroscope and accelerometer to capture posture data. This is the same in both papers.
3. **Neoprene Velcro Shoulder Strap**:
   * Used to securely mount the MPU-6050 sensor on the acromion process and T5 vertebra in both papers. No changes in the description.

4.Complementary filter:

-The complementary filter effectively combines the low-frequency stability of the accelerometer (which measures tilt based on gravity but is susceptible to noise from linear movements) with the high-frequency responsiveness of the gyroscope (which tracks rotation but drifts over time). This fusion helps to maintain a more reliable and stable estimate of tilt angles, reducing noise and drift.

-The complementary filter operates efficiently in real-time, making it suitable for continuous monitoring of posture. It applies a weighted combination of the accelerometer and gyroscope data to track changes in orientation, ensuring the system provides accurate and responsive feedback for posture corrections.

**Software:**

1. **Platform**:  
   Both papers explore the same platforms:
   * **Spyder**: An open-source Python IDE for code development and data analysis.
   * **Google Colab**: A cloud-based platform for training models on larger datasets
2. **Programming Language**:
   * **Python**: Used in both papers for machine learning and data analysis.
3. **Libraries**:
   * **Scikit-learn**: For machine learning algorithms and model evaluation.
   * **Pandas**: For data manipulation and analysis.
   * **Matplotlib**: For visualizing data.

4.Bluetooth module:

 **Wireless Data Transmission**: A Bluetooth module enables real-time, wireless communication between the posture monitoring system and external devices like smartphones, tablets, or computers. This eliminates the need for physical connections, allowing users to receive posture feedback or data on a mobile app, increasing convenience and usability.

 **Low Power Consumption**: Bluetooth modules, especially **Bluetooth Low Energy (BLE)**, consume minimal power, making them ideal for wearable posture monitors. This extends the device’s battery life, enabling longer periods of posture monitoring without frequent recharging, which is essential for continuous usage.

Feature extraction and selection

DATASET COLLECTION:

**. Sensor Placement and Initialization:**

* **IMU Sensor on Acromion**: Place one IMU sensor on the subject’s acromion (shoulder tip) to capture shoulder movement and posture.
* **IMU Sensor on Cervical Region**: Place the second IMU sensor at the cervical position (upper spine/neck area) to track neck and upper back alignment.
* Ensure proper calibration of the sensors to accurately capture accelerometer (for tilt and position) and gyroscope (for rotation) data.

**2. Data Collection Setup:**

* Use the **Bluetooth module** to wirelessly transmit the IMU data to a central device (e.g., smartphone or computer) where the dataset will be stored.
* Define the **sampling rate** for data collection (e.g., 100 Hz) to ensure consistency in time intervals across samples.

**3. Recording Posture States:**

* Collect data in **various postures**:
  + **Neutral (correct)** posture (standing or sitting upright).
  + **Hunching** (forward rounding of shoulders and neck).
* **Slouching** (leaning back with rounded lower back).
* Iruct the subjects to maintain each posture for a fixed period (e.g., 30 seconds per posture) while the system records data from both IMUs.

**4. Feature Extraction:**

* **Accelerometer Data**: Collect acceleration values along the X, Y, and Z axes from both IMUs to measure tilt angles and shifts in posture.
* **Gyroscope Data**: Capture rotational velocity along the X, Y, and Z axes from both sensors to track movement and rotation of the upper body.
* Use a **complementary filter** to fuse the accelerometer and gyroscope data for more accurate and stable orientation estimation (to reduce noise and drift).

**5. Posture Classification Labels:**

* Each recorded segment of data must be labeled with the corresponding posture state (e.g., "neutral," "hunching," "slouching").
* Labeling can be done either manually during the collection process or automatically if specific time intervals are predefined for each posture.

**6. Multi-Sensor Data Synchronization:**

* Ensure **synchronized data** collection from both IMUs to capture relative movements between the shoulder (acromion) and neck (cervical).
* This step is essential for detecting complex postures like hunching or slouching where both regions might move together or independently.

**7. Data Storage:**

* Store the collected data in a structured format (e.g., CSV, JSON), with each entry containing:
  + Timestamp.
  + Accelerometer and gyroscope data from both IMUs.
  + Filtered tilt angles from the complementary filter.
  + Posture label (neutral, hunching, slouching).
* Additionally, store metadata such as subject ID, trial number, and environmental conditions.

**8. Bluetooth Transmission Efficiency:**

* Ensure efficient Bluetooth communication to minimize data loss during real-time transmission and guarantee reliable data collection without interruptions.

**.9. Multiple Trials:**

* Collect data from multiple subjects and across different trials to ensure the dataset has enough **variability** in posture and movements for robust model training.
* Include data for **dynamic movements** (e.g., transition between sitting, standing, or walking) to improve the posture classification model's generalizability.