CHILLGUY: AI REVOLUTION IN LOGISTICS

Problem Description:

In logistics and supply chain management, fragile and high-value shipments such as pharmaceuticals, electronics, and perishable goods are vulnerable to instability during transit. Sudden tilts, vibrations, and shocks can lead to damaged goods, financial losses, and inefficiencies in delivery. Traditional monitoring systems rely on reactive approaches, only identifying issues after damage has occurred.

There is a need for a real-time, AI-driven solution that can predict and detect movement instability, allowing logistics providers to take proactive measures to prevent damage.

Solution Description and Research methodology:

To address the issue of shipment instability, **ChillGuy** leverages **sensor data analytics and machine learning** to detect and predict movement anomalies in real time. The system utilizes data from **accelerometers, gyroscopes, and magnetometers** to assess motion stability. By analyzing variations in acceleration and angular velocity, ChillGuy identifies potential risks such as excessive tilting, vibrations, or sudden shocks.

The research methodology involved the following steps:

1. **Data Collection** – Sensor data was recorded using **SensorTile.Box Pro**, capturing **X, Y, Z axis readings** from accelerometers, gyroscopes, and magnetometers.

2. **Feature Engineering** – Magnitude values were computed for acceleration and angular velocity, and **rolling variance** was calculated to detect sudden fluctuations.
3. **Threshold-Based Analysis** – Empirical thresholds were set to classify stability levels based on motion variations.
4. **Machine Learning Model Selection** – Multiple ML models were tested to classify movement stability based on sensor data trends.
5. **Model Training & Testing** – The dataset was split into training and testing sets, with models trained to differentiate between stable and unstable conditions.
6. **Evaluation & Optimization** – The best-performing models were selected based on test accuracy, and hyperparameter tuning was conducted to enhance predictive performance.

Machine Learning Models Used

1. **Random Forest Classifier**
    - Captures complex patterns in motion fluctuations.
    - Handles non-linearity in sensor readings effectively.
2. **Logistic Regression**
    - Provides an interpretable model for binary classification (stable vs. unstable).
    - Helps in understanding feature importance in predicting instability.

The combination of **sensor data processing, statistical variance analysis, and machine learning classification** ensures **real-time detection of shipment instability**, allowing logistics providers to take preventive actions before damage occurs.

How STAIoTCraft Helped in Executing the Project Efficiently:

STAIoTCraft played a crucial role in streamlining the development of **ChillGuy** by providing a **seamless environment for sensor data acquisition and real-time deployment.**

SensorTile.Box Pro Integration – Enabled precise motion data collection from accelerometers, gyroscopes, and magnetometers without requiring complex hardware configurations.

Data Visualization & Processing – Provided built-in **graphing tools and analysis utilities** to inspect sensor readings, aiding in feature selection and anomaly detection.

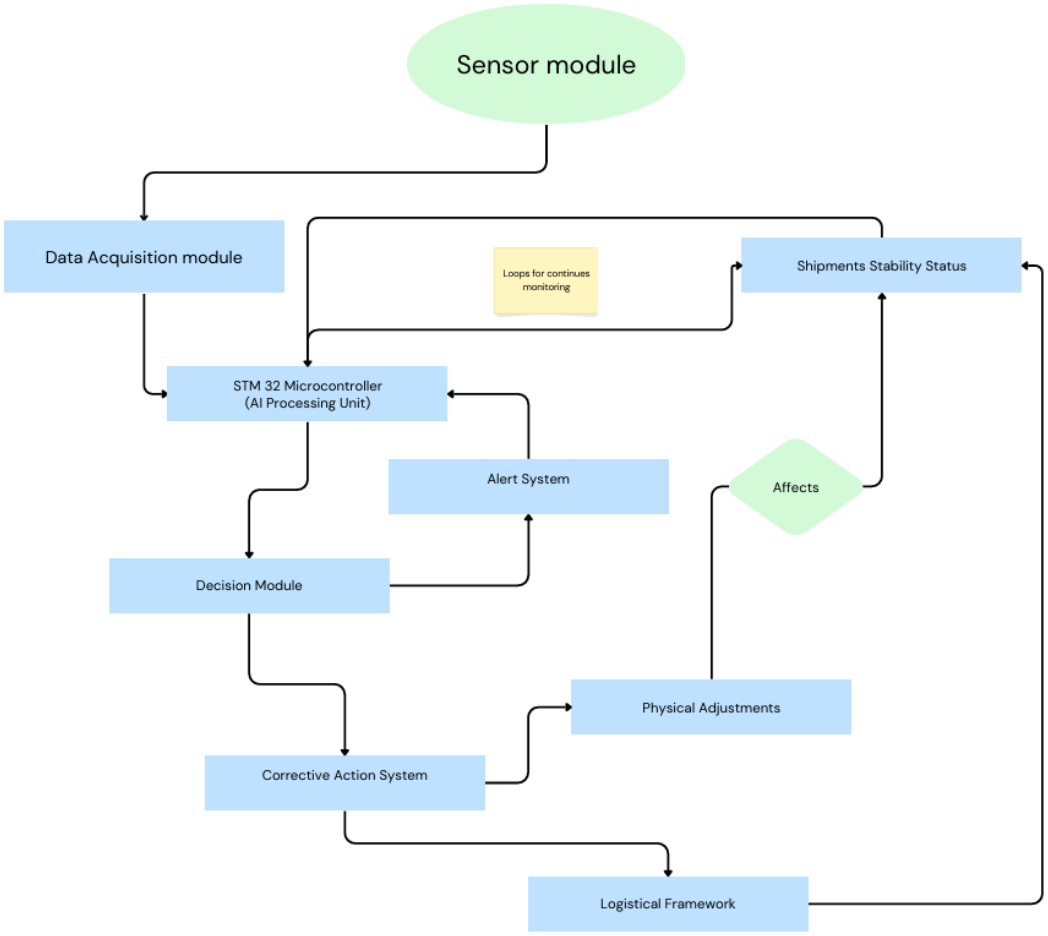
Detailed Solution Description:

ChillGuy is an AI-driven shipment monitoring system that **analyzes motion stability** using real-time sensor data from **accelerometers, gyroscopes, and magnetometers**. It detects **sudden jerks, excessive tilting, and strong vibrations** during transit, ensuring the safety of fragile and high-value shipments.

System Workflow

1. **Data Collection**
    - **SensorTile.Box Pro** captures motion data (X, Y, Z values) from **accelerometer, gyroscope, and magnetometer** at regular intervals.
    - Data is stored in CSV format for training and testing ML models.
2. **Data Processing & Feature Engineering**
    - Compute **acceleration magnitude**: Acc=sqrt(X2+Y2+Z2)
    - Compute **angular velocity magnitude**: Gyro=sqrt(Gx2+Gy2+Gz2)
    - Compute **magnetic field strength magnitude**: Mag= sqrt(Mx2+My2+Mz2)
    - Calculate **rolling variance** to detect sudden fluctuations.

3. **Machine Learning Model Training** 🤖
    - **ML Algorithms Used**:
        - **Random Forest Classifier** – Captures non-linear patterns in motion fluctuations.
        - **Logistic Regression** – Provides an interpretable model for stability classification.
    - Model is trained using **labeled sensor data** (Stable = 0, Unstable = 1).
    - Data is **standardized** to improve accuracy.
4. **Real-Time Monitoring & Alert System**
    - The trained model classifies incoming sensor data into **Stable or Unstable** states.
    - If **rolling variance exceeds thresholds** (Acceleration > 50 mg, Angular Velocity > 20 dps, Magnetometer > 50 mGa), an **alert is triggered**.
5. **Deployment & Integration**
    - The AI model is **deployed on embedded systems** to allow real-time monitoring.
    - Alerts are **sent to logistics teams** for corrective actions when excessive instability is detected.


Sensor module
Data Acquisition module
Loops for continues monitoring
Shipments Stability Status
STM 32 Microcontroller (AI Processing Unit)
Alert System
Affects
Decision Module
Physical Adjustments
Corrective Action System
Logistical Framework