**Roadmap to Gait Biometrics in Security(BIOMETRIC)**

**Core Areas to Study**

**(a) Mathematical & Theoretical Foundations**

* **Linear Algebra** → matrix transformations, eigenvalues (for PCA, feature extraction)
* **Probability & Statistics** → Gaussian distributions, hypothesis testing
* **Signal & Image Processing** → Fourier transforms, filtering, feature extraction
* **Optimization** → gradient descent, convex optimization

**(b) Computer Vision & Machine Learning**

* Image preprocessing (OpenCV, scikit-image)
* Feature extraction (GEI – Gait Energy Image, silhouettes, skeleton-based features)
* Deep learning (CNNs, RNNs, Transformers)
* Human pose estimation (OpenPose, MediaPipe)

**(c) Biometrics & Security Concepts**

* Biometric recognition pipelines (enrollment, verification, identification)
* Performance metrics (FAR, FRR, ROC curve, EER)
* Privacy and security concerns (spoofing, adversarial attacks)

**Tools and Frameworks**

**Programming Languages**

* **Python** (main language for research + ML prototyping)

**Libraries & Frameworks**

* **Computer Vision:**
  + OpenCV (image/video processing)
  + scikit-image
  + MediaPipe / OpenPose (skeleton-based gait recognition)
* **Machine Learning & Deep Learning:**
  + TensorFlow / Keras
  + PyTorch (most research papers use this)
  + scikit-learn (traditional ML)
* **Data Handling & Visualization:**
  + NumPy, pandas
  + Matplotlib, seaborn

**Datasets for Research**

* **CASIA Gait Dataset** (most cited, large-scale)
* **OU-ISIR Gait Database** (many variants, good for deep learning)
* **USF HumanID Gait Dataset**
* **TUM Gait Dataset**

**Research Directions**

1. **Feature Extraction Approaches**
   * Model-free (silhouette-based, GEI, Gait Flow Image)
   * Model-based (skeleton, joint angles, motion dynamics)
2. **Deep Learning for Gait**
   * CNNs for silhouette-based recognition
   * GaitSet, GaitPart, GaitGL (state-of-the-art networks for gait recognition)
   * Transformers for spatio-temporal gait sequence modeling
3. **Cross-Condition Gait Recognition**
   * Handling clothing changes, carrying objects, view angle variations
4. **Security Integration**
   * Multi-biometric systems (gait + face + iris)
   * Privacy-preserving gait recognition (differential privacy, homomorphic encryption)
   * Anti-spoofing techniques

**Practical Setup**

* Install **Python + PyTorch + OpenCV**
* Start with **CASIA dataset** → preprocess silhouettes → try simple CNN-based classification
* Explore **pose-based approaches with OpenPose**
* Reproduce a **recent research paper** (like GaitSet or GaitGL) to gain research insight
* Extend → add your novel idea (e.g., robust to clothing changes, edge-device optimization, secure storage of gait templates)