**TensorFlow:**

* It is used across in many tasks, it has a particular focus on training of deep neural networks.
* It is math library based on dataflow.

**MatPlotLib:**

* It is plotting library for the python and when it is extended in numerical mathematics which is numpy.
* It gives an object-oriented API which is used for embedding plots into app with the help of general-purpose GUI.

**Pandas:**

* It is mainly used for data manipulation and analysis.
* In general, it provide data structures and operations to manipulate numerical tables and time series.

**Keras:**

* It offers Python interface for artificial neural networks.
* It also acts as an interface for the TensorFlow Library.

STOPPING POINTS

**SURF:**

* **Detects keypoints** in the signature based on regions of high contrast (e.g., where strokes intersect or curve).
* **Generates descriptors** (numerical representations) that capture the uniqueness of a signature.
* **Fast processing** due to its use of an integral image, making it suitable for real-time applications.

**SIFT:**

* SIFT (Scale-Invariant Feature Transform) extracts detailed, scale-invariant keypoints that remain consistent under different sizes, angles, and distortions.
* Extracts highly distinctive keypoints, making it robust against forgeries.
* Works on multi-scale features, meaning it can detect patterns regardless of size variations.
* More accurate but computationally heavier compared to SURF.

**CNN:**

**Receives signature images as input** (preprocessed and feature-extracted versions).  
**Automatically learns patterns** in handwriting, strokes, curves, and pressure variations.  
**Classifies signatures** into **genuine or forged** based on learned features.  
**Enhances accuracy** by reducing human effort in manual feature engineering.

### **🔹 How CNN Works in Signature Fraud Detection?**

1. **Input Layer:**

* Takes the **grayscale** or **feature-extracted image** from SURF & SIFT.
* Converts it into a matrix of pixel values.

**2. Convolutional Layers:**

* Applies **filters (kernels)** to extract patterns such as strokes, curves, and edges.
* Identifies **signature characteristics** unique to an individual.

**3. Pooling Layers:**

* Reduces image size while preserving key features (**Max Pooling** is commonly used).
* Helps CNN focus on essential parts of the signature.

4. **Fully Connected Layer (Dense Layer):**

* Flattens extracted features into a **one-dimensional vector**.
* Passes the features to a **classification layer**.

5. **Output Layer:**

* Uses **Softmax** or **Sigmoid Activation** to predict whether a **signature is genuine or forged**.