

## Android App for Handwriting Analysis Using Deep Learning

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**DOI:** <http://doi.org/10.5281/zenodo.3564162>

### Abstract

*In this project, we aim to develop an android app to predict if a person is an extrovert or introvert by analyzing their handwriting in an offline manner using deep learning. Graphology is the analysis of physical characteristics and patterns of handwriting which has many applications in the field of employment profiling, marital compatibility, graphotherapy, psychological analysis, medical diagnosis, etc. Graphology is an effective tool used in employment profiling. According to an article published in 1988 in The Wall Street Journal around 80% of the fastest growing companies in Western Europe used handwriting analysis as part of their HR procedures hiring full time graphology experts. Model training is done on Google colab and the model is then compressed using Tensorflow Lite to run on a mobile device. This can reduce human effort and handwriting analysis can be done without the supervision of a graphologist.*

**Keywords:** Deep learning, google colab, object detection classifier, tensorflow, tensorflow lite, transfer learning

### INTRODUCTION

Graphology is an art of reading the patterns and physical characteristics of a handwriting claiming to identify the writer, indicate the psychological state at the time of writing and evaluate personality characteristics of an individual. In this project we predict if the handwriting of a person shows extroversion or introversion using object detection classifiers by deep learning. Graphology generally considered as pseudoscience has wide application in the field of employment profiling,

marital compatibility, psychological analysis, graphotherapy, medical diagnosis etc. handwriting is termed as brain writing as our neuromuscular movement associated with our brain pattern and occurs unconsciously while writing. Whether, it be with their foot or hand every person has a distinct style of writing. These patterns are under the control of the muscles which in turn are in control of the brain and the pen or pencil is just an equipment.

The prime features used by the

graphologists are the size of handwriting upper and lower loops crossing over t's pressure and irregularity. The personality traits predicted in this project are extroversion and introversion. An extrovert is an outgoing and gregarious person who is primarily concerned with physical and social environment. They gain energy from outside world. Whereas an introvert is a person characterized by concerned with their own thoughts and feeling. They become energized spending quiet time alone. The handwriting of extrovert is characterized with large handwriting. They have a garlanded baseline, ornated handwriting and strokes with a right slant. While, the handwriting of an introvert is small with fewer or no garlanded baseline with quieter strokes and upright or back handed slant [1]. This project uses transfer learning method in deep learning by retraining a model to learn the patterns and characteristics of the handwriting. It then uses object detection classifiers to predict the percentage of extroversion or introversion.

## Software

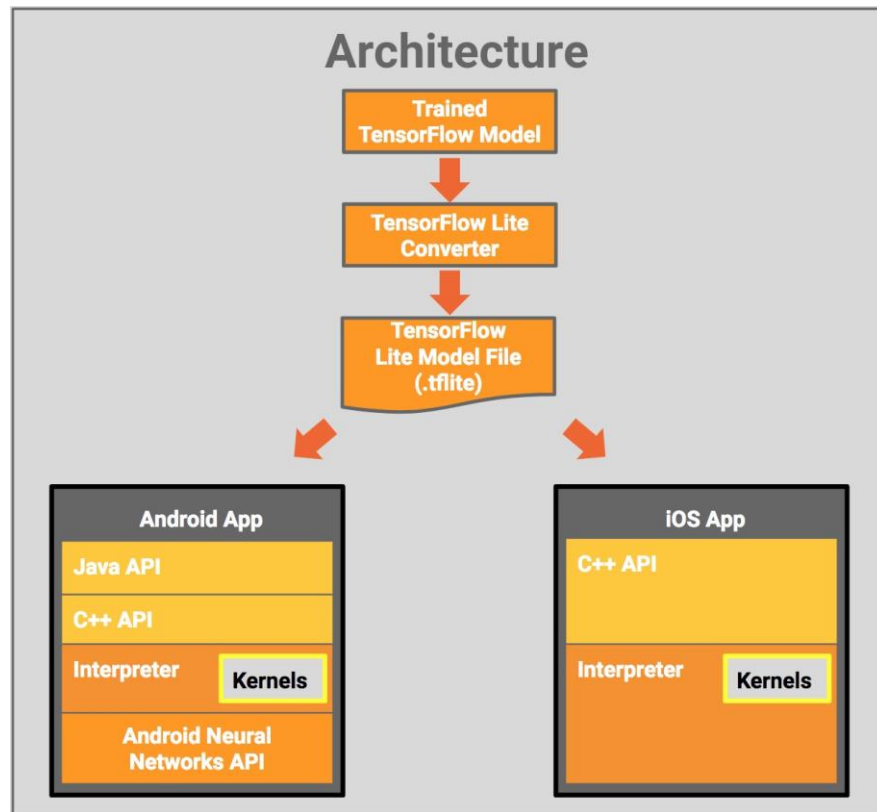
### *TensorFlow*

TensorFlow (TF) is Google's free and open source software library for data flow and differential programming. It is a multipurpose machine framework and can be used anywhere from training huge model across clusters in the cloud to

running models locally on an embedded or mobile device. It provides stable Python and C Application Program Interface (APIs); and without API backward compatibility guarantee: C++, JAVA, Go, JAVA Script and Swift (earlier release). It is used for applying deep learning to various Google products such as Google search Gmail, Speech recognition, Google photos, etc. It is also used for on device computer vision model to do optical character recognition to enable real time translation and has many other applications.

### *TensorFlow Lite*

TensorFlow Lite is the next generation of TensorFlow mobile which promises better performance to leverage hardware acceleration on supported device. It is TensorFlow's light weight solution for mobile and embedded devices; enables on-device machine learning interface with small binary size and low latency. TensorFlow Lite supports both iOS and Android platforms. It also supports hardware acceleration with Android Neural Network API. The first step involves conversion of trained TensorFlow model to TensorFlow Lite file format (.tflite) using the TensorFlow Lite converter. This converted model is used in the Application. The main components for deploying model are Java API, C++ API, and Interpreter as per Fig. 1.

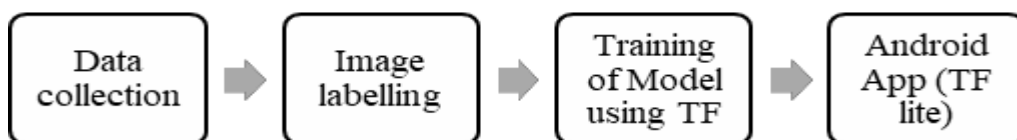


**Figure 1:** Block diagram of Tensor Flow Lite architecture.

### Implementation

This project uses transfer learning method in deep learning by retraining a model to learn the patterns and characteristics of the handwriting. Deep learning is a subfield of machine learning which is concerned with algorithms inspired by the structure and function of the brain called Artificial Neural Networks (ANN). While

machine learning uses algorithms to analyze the data, learn from that data and make informed decisions based on what it has learned, deep learning structures algorithms in the layers to create an ANN that can make intelligent decisions on its own. The implementation process of the project is shown in Fig. 2.



**Figure 2:** Block diagram of implementation.

### Data Collection and Labelling

Myer Briggs Type Indicator (MBTI) is a sixteen personality type introspective self-report questionnaire with purpose of indicating differing psychological

preferences in how people perceive the world around them and make decisions [2]. It classifies human personality into sixteen types as shown in Fig. 3.

# What's Your Personality Type?

Use the questions on the outside of the chart to determine the four letters of your Myers-Briggs type. For each pair of letters, choose the side that seems most natural to you, even if you don't agree with every description.

<p><b>1. Are you outwardly or inwardly focused? If you:</b></p> <ul style="list-style-type: none"> <li>• Could be described as talkative, outgoing</li> <li>• Like to be in a fast-paced environment</li> <li>• Tend to work out ideas with others, think out loud</li> <li>• Enjoy being the center of attention</li> </ul> <p>then you prefer <b>E</b> Extraversion</p>	<p><b>2. How do you prefer to take in information? If you:</b></p> <ul style="list-style-type: none"> <li>• Focus on the reality of how things are</li> <li>• Pay attention to concrete facts and details</li> <li>• Prefer ideas that have practical applications</li> <li>• Like to describe things in a specific, literal way</li> </ul> <p>then you prefer <b>S</b> Sensing</p>	<p><b>3. How do you prefer to make decisions? If you:</b></p> <ul style="list-style-type: none"> <li>• Make decisions in an impersonal way, using logical reasoning</li> <li>• Value justice, fairness</li> <li>• Enjoy finding the flaws in an argument</li> <li>• Could be described as reasonable, level-headed</li> </ul> <p>then you prefer <b>T</b> Thinking</p>	<p><b>4. How do you prefer to live your outer life? If you:</b></p> <ul style="list-style-type: none"> <li>• Prefer to have matters settled</li> <li>• Think rules and deadlines should be respected</li> <li>• Prefer to have detailed, step-by-step instructions</li> <li>• Make plans, want to know what you're getting into</li> </ul> <p>then you prefer <b>J</b> Judging</p>
<p><b>ISTJ</b> Responsible, sincere, analytical, reserved, realistic, systematic. Hardworking and trustworthy with sound practical judgment.</p>	<p><b>ESTP</b> Outgoing, realistic, action-oriented, curious, versatile, spontaneous. Pragmatic problem solvers and skilled negotiators.</p>	<p><b>INTJ</b> Innovative, independent, strategic, logical, reserved, insightful. Driven by their own original ideas to achieve improvements.</p>	<p><b>ENTP</b> Inventive, enthusiastic, strategic, enterprising, inquisitive, versatile. Enjoy new ideas and challenges, value inspiration.</p>
<p><b>ISFJ</b> Warm, considerate, gentle, responsible, pragmatic, thorough. Devoted caretakers who enjoy being helpful to others.</p>	<p><b>ESFP</b> Playful, enthusiastic, friendly, spontaneous, tactful, flexible. Have strong common sense, enjoy helping people in tangible ways.</p>	<p><b>INFJ</b> Idealistic, organized, insightful, dependable, compassionate, gentle. Seek harmony and cooperation, enjoy intellectual stimulation.</p>	<p><b>ENFP</b> Enthusiastic, creative, spontaneous, optimistic, supportive, playful. Value inspiration, enjoy starting new projects, see potential in others.</p>
<p><b>ISTP</b> Action-oriented, logical, analytical, spontaneous, reserved, independent. Enjoy adventure, skilled at understanding how mechanical things work.</p>	<p><b>ESTJ</b> Efficient, outgoing, analytical, systematic, dependable, realistic. Like to run the show and get things done in an orderly fashion.</p>	<p><b>INTP</b> Intellectual, logical, precise, reserved, flexible, imaginative. Original thinkers who enjoy speculation and creative problem solving.</p>	<p><b>ENTJ</b> Strategic, logical, efficient, outgoing, ambitious, independent. Effective organizers of people and long-range planners.</p>
<p>then you prefer <b>I</b> Introversion</p>	<p>then you prefer <b>N</b> Intuition</p>	<p>then you prefer <b>F</b> Feeling</p>	<p>then you prefer <b>P</b> Perceiving</p>

Figure 3: MBTI sixteen personality types.

The data collected are handwriting samples labelled with corresponding personality type. This is done through an online MBTI test. The data collected is divided into training and testing data as 80% and 20% respectively. This is then uploaded into Google drive for training of model using google colabrotary.

### ***Training of Model using TensorFlow***

Transfer learning is a deep learning technique where a model trained on one task is re-purposed on a second related task. It focuses on storing knowledge gained while solving one problem and apply it to a different but related problem. This reduces the vast compute and time resources required to develop an ANN. Pre-trained model approach choses an available model trained on a dataset with general features. The model pre-trained in this project is MobileNet which is an architecture suitable for mobile and embedded based vision applications where there is lack of computer power. It is pre-trained to detection the objects in a room. In re- training the model to extract the features from the input handwriting dataset only the last nodes of the hidden layer is re-trained.

### ***Android App Development using TensorFlow Lite***

TensorFlow Lite converts frozen graph into a TF Lite file using TensorFlow Optimizing Converter Tool (TOCO). In a frozen graph the variables from the latest checkpoint file are combined with the graph and turned into constants, this is an important in the process of using TF Lite.

The process is called freezing because every variable converted into a constants with a value from the constants read from a particular checkpoint. Graph Def. file a doc.pb (binary format) or doc.pbtxt (text format) file is the heart of the modal data. It contains the description of the graph in a way it can read by another program. Checkpoint file contains serialized variables from a TensorFlow graph. It doesn't contain the graph structure, just the state of the variables at a particular iteration of the learning. It is usable to tell the variable values at different points in the learning process. After TF Lite optimizes the model using tflite\_convert an Android application is developed using Android Studio. This application takes an image of the handwriting as input and displays the probability out of one on whether the handwriting belongs to an extrovert or introvert. The application can be installed on any Android phones and is run easily.

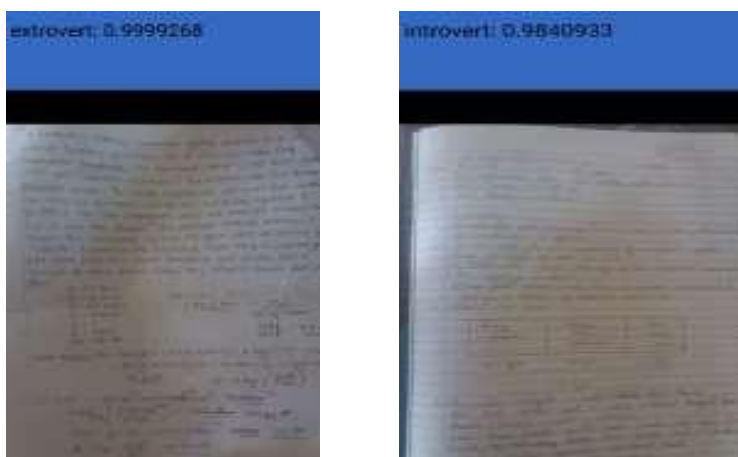
### **RESULTS**

TensorFlow is an efficient software for handwriting analysis. The use of one kind of training sample can help in isolating and detecting letters from an image but having different training and testing sets of handwriting samples from people with previously determined personality types can lead to more accurate results that is to say with more data more accuracy can be attained. While training the model and testing it an accuracy of 45% was only reached. A Convolution Neural Network (CNN) is used in MobileNet model implemented in this paper. Even though this is an efficient model



for mobile vision application, handwriting features extraction can be done more

effectively by other neural networks. The results are shown in Fig. 4.



**Figure 4:** Result showing extrovert and introvert handwriting.

With graphology able to detect various personality traits, this project can be expanded to predict other personality types such as intuitive or sensing feeling or thinking perceiving or judging in MBTI. It can also be applied to various other applications of graphology such as disease detection, criminology etc.

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