# Sensorflow: Learning Language Through Motion

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## Abstract

Learning the grammar and syntax of a new language has always proven to be challenging for most students taking courses through a traditional classroom setting or by autodidacticism. This has usually lead to the scholars feeling a sense of boredom in class and put their attention on other subjects whether it relates to school or a personal matter. In the case with scholars practicing autodidacticism, they can only rely on dictionaries, books that go through examples and rules in order to construct sentences in the language being learned, or software that repeatedly regurgitate the same sentences. Some of the ways that teachers have attempted to mitigate the problem is to incorporate activities that engage the students to think about the lessons being taught and create new experiences to take after class using games or hypothetical real-life situations. But, as new technological advancements are being made and the world is getting saturated with smart devices like cell phones, tablets, computers, and other devices that are connected to the World Wide Web, these devices aren't being taken full advantage in aiding scholars specifically with learning a language. Recently, a new discovery was made with machines having the ability to classify images with the same certainty as people called machine learning. This idea nowadays has been used successfully to classify images of different objects, create sentences that a human being would say, and predict whether a person is more likely to have cancer along with more applications that are difficult and taxing to humans. If we implement the same algorithm machine learning utilizes to classify images (Convolutional Neural Networks) on an alphabet, we can possibly append a physical component in the student's curriculum that would engage them in acquiring new knowledge applicable in real-life situations using the language being taught.

## 1. INTRODUCTION

There are many different ways to teach a language to a scholar, but with the advancements in today's technology, we haven't taken advantage of innovative ways to integrate learning using these resources. Scholars have different environments in where they learn languages; whether that's residing in a classroom with a professor educating them about the different grammatical and syntactic properties or through their own time reading a textbook self-informing themselves about distinct ways to aggregate words into a complete sentence. But these methods are difficult to keep their interest as there is minimal to no connections to real-life examples where the scholar can make the association with the material learned about the language and the outside world **[3, 4]**. Research done by Nuffield Languages Inquiry has revealed that nine out of ten students in high school choose not to continue their studies with foreign language after the age of sixteen **[1, 2]**. In order to mitigate the problem, games have been used as a middleman between the student and the knowledge learned in order to let the students create new experiences with hypothetical situations created in the game **[3]**. This has been used with game theory **[5]** to enhance the learning of a language for students, but I believe we can make it even better with technology. Using our devices like our smartphones or small IoT (Internet of Things) gadgets with education could also enhance learning in both a classroom setting or with autodidacts **[6]**. There is research being performed with having a machine "learn" by using different mathematical functions and data to learn and improve its knowledge without having a person explicitly write a computer program to make decisions on a particular problem **[7, 8]**. Machine learning has opened a new realm of aids for people to focus on more specific problems and allowing the program to verify or perform arduous processes while being confident in the solution given by the computer. This paper will focus on how we can use models offered in machine learning in order to identify and aid learning the alphabet of any language while engaging the students in hopes to create new experiences that they will retain in their future.

## 2. METHODOLOGY

### 2.1 Definition of Terms

There are a few key elements that are defined as:

1. Machine Learning – "The concept of a computer simulating learning by automating knowledge acquisition and refinement. This view can be demonstrated by a simple model of intelligent processing where the learning system accepts environmental observations which incorporates them into a knowledge base, thus allowing the computer to facilitate some performance task" **[9, 11]**
2. Convolutional Neural Network – A type of neural network that has many neurons (inputs) and biases that are learnable in order to solve either a classification or regression problem. Each neuron takes the weighted sum of the inputs and is passed through an activation function–logistic function (sigmoid or tanh) to see what the model's response is given the original data (input). This is iterated multiple times in order to reduce the error to give an output which is reliable for some application (usually classification or regression problems) **[8]**

3. Game Theory – “Provides models of situation in which each chosen action can give us in different cases, different results with a known probability” **[4]**
4. Internet of Things – “IoT represents a system which consists of things in the real world with sensors attached to or combined to these things, connected to the Internet via a wired or wireless network structure.” **[13]**

## 2.2 Methodology

The overall goal of the project is to successfully use machine learning to correctly classify and aid students who are learning a language through a mobile application. The scholar will be able to use an IoT device (mobile phone in this case; future development would include making the device more natural for writing, like using sensors inside a pencil or something similar) to write a specific letter of any alphabet, and the application would give back feedback on improving line strokes, or visual appearance of the letter in an interactive way. This will potentially help the student compose structured sentences in a different language along with creating new experiences that they will be able to apply in a real-life situation. The long-term goal will split into smaller goals that are as follow:

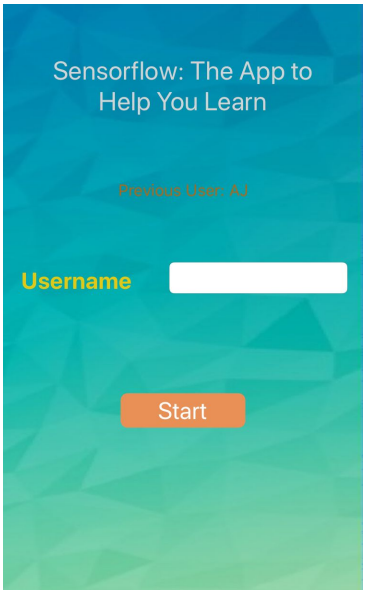
1. Create a huge amount of data for the machine learning model to train on (at least 1,000 examples per letter).
2. Graph the data generated and find correlations for a subset of an alphabet to format the data in a way which it can be trained through a Convolutional Neural Network.
3. Pre-process the data in a format that is acceptable for the Neural Network.
4. Develop a program that will use a Convolutional Neural Networks and train on the data.
5. Analyze the results given and identify any issues with the data or program.
6. Train the data until it gives back a confidence level that is acceptable for us.(around 90-95%)
7. Test it on new data to verify the level of certainty (how reliable the program is classifying different letters of an alphabet).
8. Collect the results.
9. Discuss how we can use the results to aid the user on accurately writing a letter of the alphabet being learned.
10. Implement the input discussed previously.
11. Create a rough user interface for the application
12. Test the software and identifying any possible optimization for future work.
13. Collect the results.
14. Report the results via a document and discuss about the future work of this research.

The alphabet that will be used is a dummy alphabet created by us that can be easily changed into a real alphabet of any language. Our alphabet will be a proof of concept into demonstrating that a

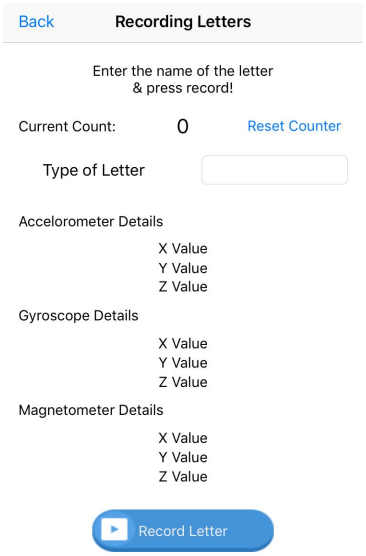
Convolutional Neural Network can train and classify a letter of any alphabet. The specific method for testing the hypothesis is the Experimental Computer Science method where there is some creation of software to identify concepts that will assist solutions to a problem with the construction of a system in which the software can be tested for validity **[10]**. We will be using an experimental methodology where we will test it with students in order to dictate any changes that need to be made for a better experience with the application. This is an ongoing project that will mainly focus on collecting data and allowing the machine learning model to predict letters in order to aid the learning process of the scholar. This would be possible by using a Convolutional Neural Network and the activation layer in order to find common patterns with similar letters **[8]**. Just like the neural networks looks at the different layers of colors in pictures (RGB), it will use different axes on a sensor (x,y, and z) to find what patterns the model can find with similar letters. All of the data will be generated using an Internet of Things device--a smartphone--and record the data into a database where the model can extract and download it to train. As the machine learning algorithm trains more, or tries to predict what the letter is by using what it knows from previous data and then verifying it with the actual label it was given, it will use mathematical optimization algorithms like a Least Squared Mean Error to reduce the error and try different weights in order to find the features of each particular letter. By finding the smallest error of each letter, it will allow to generalize the data to predict letters made from other people that the machine learning hasn't seen, but still predict with a high accuracy depending on the Least Squared Mean Error function.

## 3. Current Progress/Results

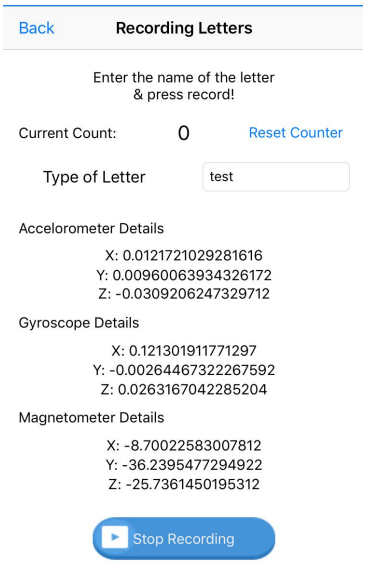
During the process of creating the skeleton to gathering enough data for a Machine Learning model to learn, we used the most popular mobile platforms (iOS and Android) to create application for both of them in order to create real-world data that are examples of what a "letter of an alphabet" would look like.



In the picture above, this is the main menu where a user can be defined and this is used to discern who is submitting the data and allowing the program to pick up on patterns or gestures that pertain to the specific user. The name is preserved and if the application is turned off, it saves the previous user so they can pick it up after they decide to submit more data.




In the picture above, this shows the main interface in submitting data. There are sections that describe the different sensors that it's storing into a remote database and the x,y and z values of each sensor. This value is changed 65 times in a second in order to get the most coherent data without sacrificing too much on battery power. We will determine later in the analysis stage if we can lower this number and still achieve a very high level of certainty from the Machine Learning model.



In the picture above, it's an instance where the values are being changing into what the x, y, and z values are of each sensor. We can see that it's being very precise and taking as many decimals as possible for the sole reason of being as close to the real data as possible. The button on the bottom will stop gathering the process of recording data or after 10 seconds if the user is taking a very long time recording. We couldn't let it run until the user desired to stop it because of the fact of the program crashing for recording data. This would cause an error from the application and create a plethora of other problems that could be avoided by setting an upper limit to recording a single sensor data.

All of these are just examples of where the project is at currently. We are very close to being in the analysis part of the project where we can see the program learn and have an application which will be able to tell apart different letters that the user creates with their smartphones.

## 4. Conclusion

The end to the project is not near yet, as we still have the analysis part of it where we can set apart the precursor to formatting the data into the Machine Learning models for image prediction. In this case, we aren't sending pictures as the data, but sensors with an X, Y, and Z axes which will apply the same concepts of a Convolutional Neural Network and let it learn what a "letter" looks like. We are currently in the analysis part and soon, in the testing phase where we can start to test the application with real-world users and learn on what we can improve on to successfully identify different letters of any alphabet. Once we get to the testing, we plan to look at the data that is available and look at the differences and similarities between other letters in order to find if it's viable to use Convolutional Neural Networks for optical character recognition. Some future projects that could stem out of this project is testing different machine learning models like a Recurrent Neural Network where the network remembers what is saw previously and stores it into "memory" in order to more accurately predict letters or use a different optimization algorithm like Adam or Stochastic Gradient Descent which use the same concept of trying to minimize the error of the model predicting a set of letters, but using exponential decay in order to have a more stable learning process where the model converges the error to the minimal error for a particular letter.

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