COMP 437/537 Final Project Submission Form

Intelligent Binary Finger Counting System

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Project Description:

Numbers and counting is a hard subject to many children, teenagers and even adults. Those people usually rely on their hands for calculating. However, they can only calculate up to 10 using their both hands which is not sufficient to solve mathematical questions or to deal with life problems that requires mathematical calculations. Binary fingers counting could solve the problem and allow accounting to more than 10. Binary fingers system is similar the computer binary system in which it specifies a binary number for each finger of one or both the hands. Each finger represents a power of two number. By combining the fingers, one can represent any number from 0 to 31 using one hand and from 0 to 1023 using the two hands. Figure 1 shows the number represented by each finger ($2^0 - 2^9$).

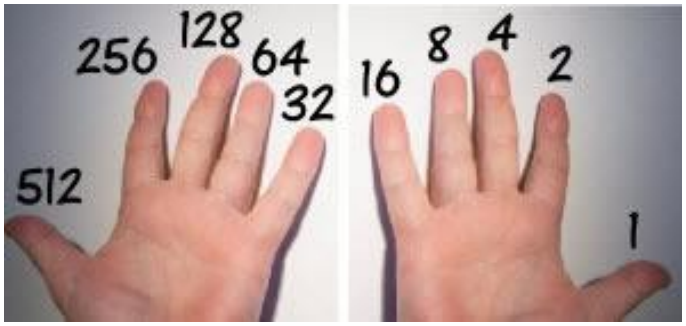

Figure 1: Binary Fingers System

For example, if we need to represent number 7, we need to combine the thumb, the index and the middle fingers of the right hand as in figure 2.

Figure 2: Number 7 using Binary Finger System

In this project, I am proposing an application that teaches teanagerrs or adults Binary Fingers System in an interactive manager. The application contains the necessary information about this counting system, and most-importantly it provides interactive exercises as shown in figure 3.

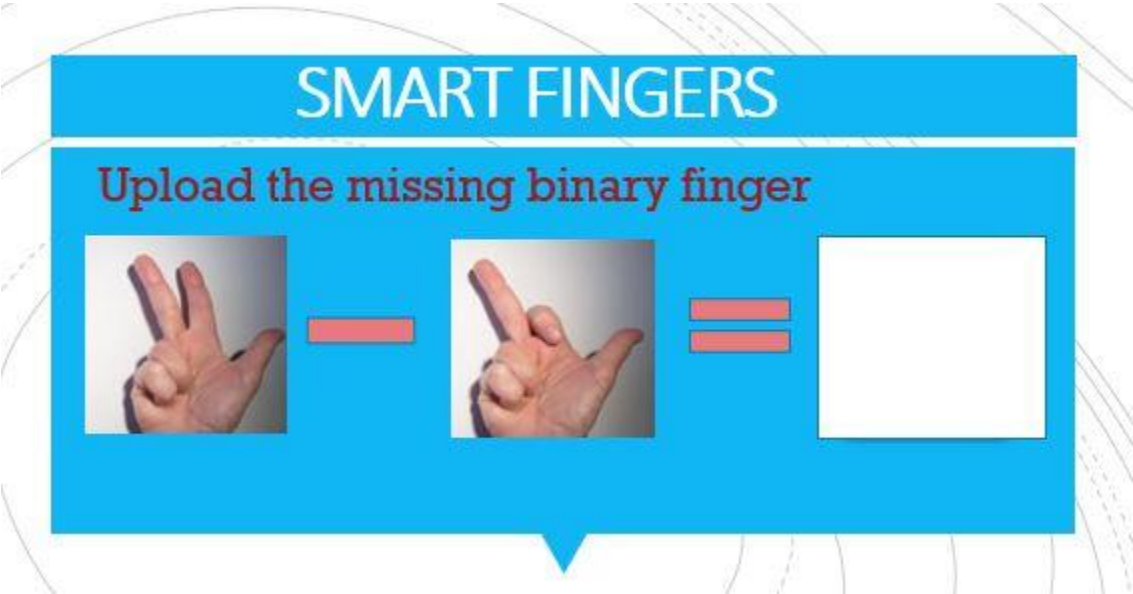

Figure 3: Binary Finger System Sample Exercise

They are calculation questions based on the binary finger system in which the user responds by a binary number hand image, so the system evaluate the response using machine learning(Number recognizer). We can claim that this project provides a better way of learning through interactivity.

Technical Aspects:

In my project, I needed to use machine learning to implement hand number recognizer system and user friendly interface connected to it. For the machine learning part, I used ICVL [1] dataset to train cnn to estimate hand poses, so I can build hand gesture recognizer using the estimated hand poses. However, I didn't find enough information or resources on how recognize the numbers after estimating the pose. The paper that I was following to build the model didn't have enough details to build the number recognizer and the authors hasn't publish their code yet. So I had to change the model. The model that is working currently is CNN model with two convolutional layers and one fully connected layer as it is clear in figure 4.

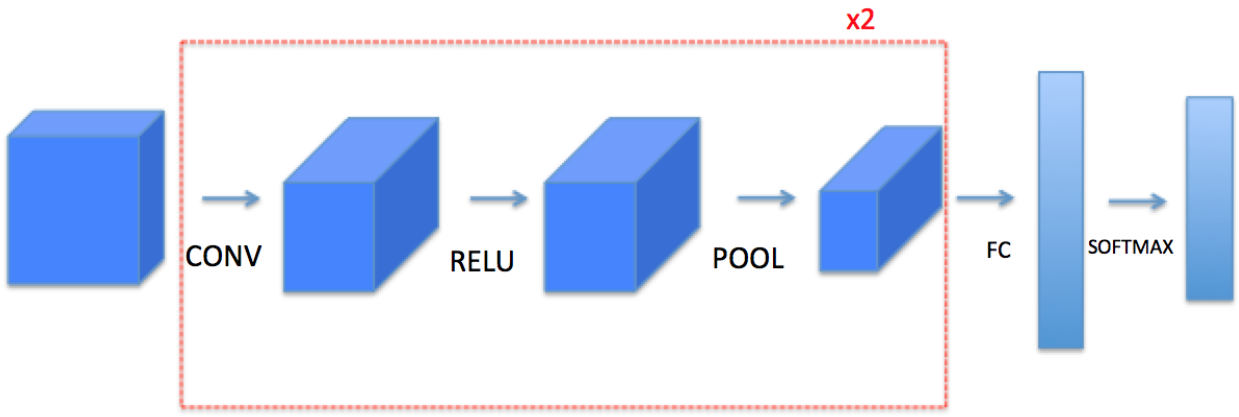

Figure 4: Number Recognizer Model

I trained the model on SIGNS [2]dataset ,which has 1080 different hand numbers images, to classify hand gesture to the appropriate number class [0,1,2,3,4,5]. Figure 5 shows some samples of the dataset.

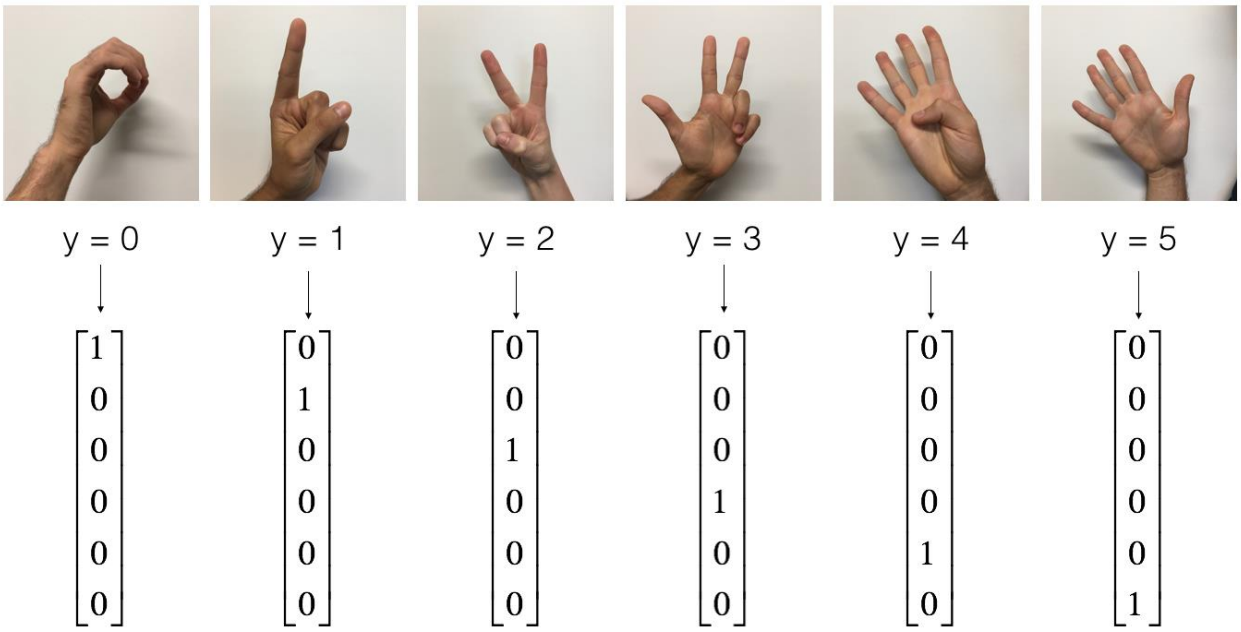

Figure 5: SIGNS dataset

In fact, the model is working with high accuracy to classify the number represented by the hand gesture. Yet, due to the lack of binary finger system numbers unique poses images, the model couldn't classify all binary finger system poses. However, number system classifier is sufficient

to present the user interactivity with the application ,and evaluate user acceptance and satisfaction.

For the user interface, I developed a website that introduces Binary Finger System to the users and explain the logic behind the system. Moreover, interactive binary finger exercises is provided in the website. For the first version, in order to test how the model works and the connectivity between the two parts of the system, the user had to upload the hand gesture image to solve the exercises. As a second version, the system should record the hand gesture through the device camera and give immediate result. Figure 6 shows a snapshot of the system's interface.

Figure 6: Binary Finger User Interface

Novelties:

The uniqueness of Binary Finger System is its real time and natural interactivity. Users can use their gestures to respond to the system's queries instead of the traditional way of input interactivity. The need for such hand gestures interactivity is increased in binary finger counting compared to other counting techniques. In other words, users should learn how to form the number gesture or pose on their hands and the system should evaluate the pose accordingly.

Technologies Used:

To complete the machine learning part of the project, I used Python 2.7[3] with Tensorflow[4] package and many other packages such as: Numpy, Pip, Scipy, Matplotlib and Math. I used Linux ubuntu distribution[5] as an operating system as it is easier to download and configure system files in Linux. The user interface of the system was developed using HTML, CSS and Javascript languages. Linking the two parts was tricky, I used PHP language to link and pass the needed parameters from python scripts to the website. To test php scripts, I used Apache HTTP Server [6].

One of the important necessities to complete the project was to understand machine learning concepts such as: regression, classification and dealing with datasets. Python programing and web development skills were also necessary. Moreover, understanding target users' needs and requirements was an essential factor to develop the user interface.

The main technical limitation I faced in the project is the lack of Binary finger poses data. The available datasets and models targets control hand poses or normal number poses. This limitation makes it difficult to build an accurate binary finger system recognizer that classify all 1023 hand number poses.

Evaluation Conducted:

- Objective Evaluations

  To evaluate the system, each feature was tested. The most critical part was the machine learning part specifically hand gesture recognition feature. To evaluate hand gesture recognition, the model was tested on 120 samples of the SIGNS datasets. The accuracy of the model on the training set was 94% and 78 on the testing set. Figure 7 shows the plot of the cost function after completing the training.

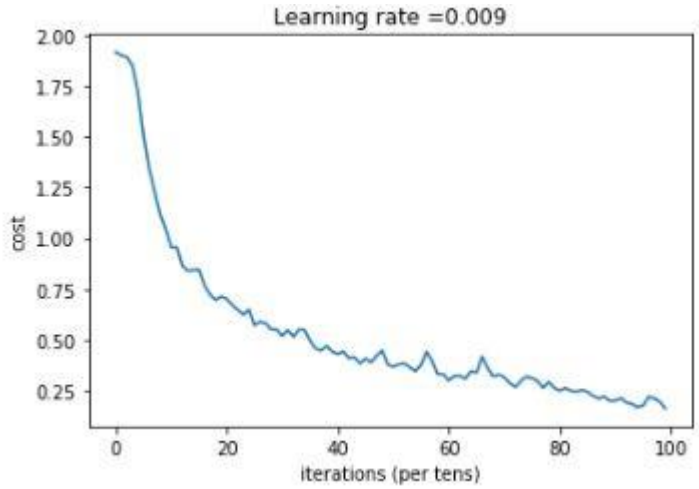

Figure 7: Hand Gesture Classifier Cost Function

- Subjective Evaluation

  In order to easily evaluate the user satisfaction while using the system, a feedback survey was created at the end of the website. Users can evaluate the system and give their suggestions by answering the survey questions. Figure 8 shows the user satisfaction survey of Binary Finger Application.

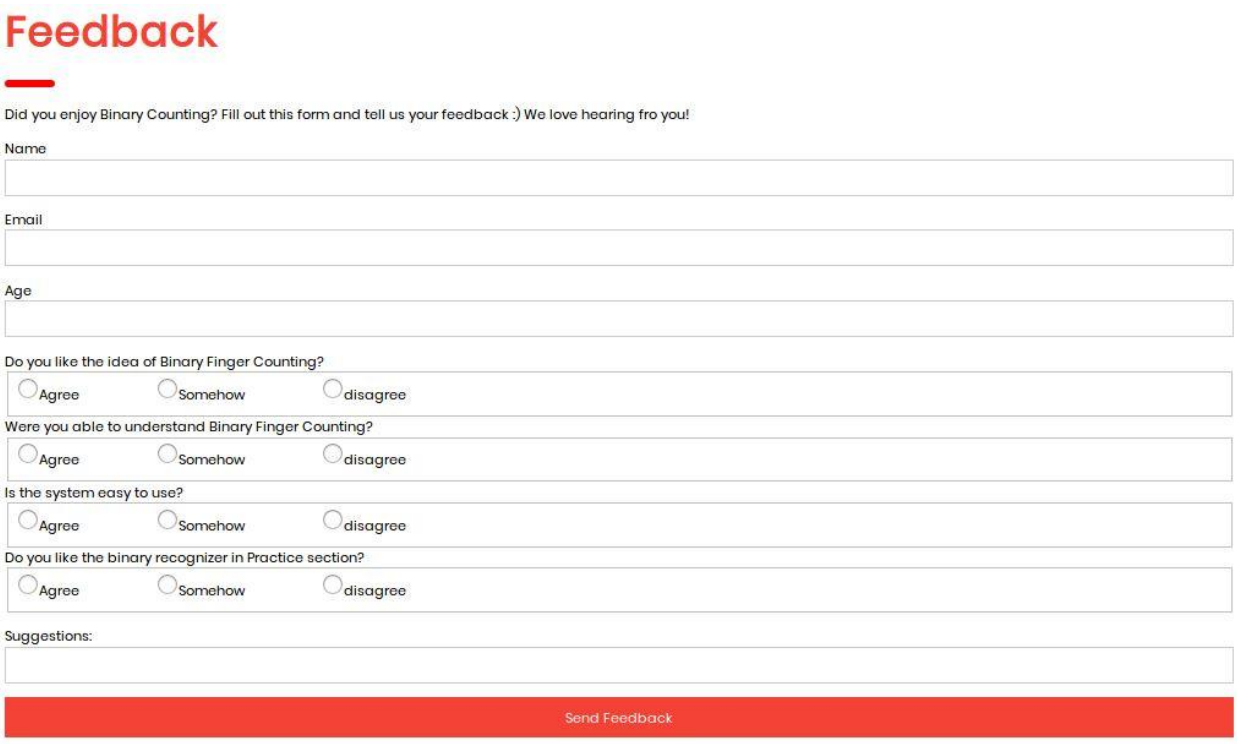

Figure 8: User Satisfaction Survey

I did the subjective evaluation with five potential users around the age of 20. In general, users were excited and positive about the system and its idea. Table 1 shows the results of this evaluation.

Table 1: User Satisfaction Evaluation Results

	Do u like the idea of Binary Finger Counting?	**Is Binary Finger Counting understandable?**	**Is the system easy to use?**	**Do you like the binary recognizer?**
Agree	4	2	3	1
Somewho	1	2	2	2
Disagree	0	1	0	2

Related Works:

[1] Otberdout, N., Ballihi, L., \& Aboutajdine, D. (2017). Hand pose estimation based on deep learning depth map for hand gesture recognition. 2017 Intelligent Systems and Computer Vision (ISCV) doi:10.1109/isacv.2017.8054904

[2] K. (2018, February 13). Kulbear/deep-learning-coursera. Retrieved from https://github.com/Kulbear/deep-learning-coursera

[3] Python 2.7.0 Release. (n.d.). Retrieved from https://www.python.org/download/releases/2.7/

[4] TensorFlow. (n.d.). Retrieved from https://www.tensorflow.org/

[5] C. (n.d.). What's new in Ubuntu 18.04 LTS and OpenStack Queens. Retrieved from https://www.ubuntu.com/

[6] Group, D. (n.d.). Apache HTTP Server¶. Retrieved from https://httpd.apache.org/

[7]W3.CSS Templates. (n.d.). Retrieved from https://www.w3schools.com/w3css/w3css_templates.asp