Sketch Recognition Final Project

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ABSTRACT

This project is a grading system for the Chinese high school education, I aim to make this system useable in many different subjects and in many different scenarios. Since the project is too big to be done in a semester for Sketch Recognition class's final presentation, I divided the project into several stages and several segments, I will address what I have done, my plan and expected difficulties for each segment.

KEYWORDS

Interdisciplinary Research, Sketch Recognition, Fuzzy Mathletics, Convolutional Neural Network

1 Chinese Poem Grading system

The project was inspired by Taele's Chinese character learning system, I thought it would be fantastic to have a system that not just focus on one character but recognize a paragraph of characters and grade them individually, in the end produce a grade for evaluation.

1.1 Current Grading System

The current grading system is completely done manually, sometimes a scanning machine is involved to make it easier for the teachers to grade on computers, but the judgement on if each character is written correctly is completely done by teachers. This process is time consuming and produce a lot of errors, from my experience and some interviews, students often have to argue with teachers to get points back for incorrectly graded poems, an automated system can help with this situation.


初中语文名句默写专题
2018 年
【安徽】
1. 默写古诗文中的名句。(10 分)
(1) 补写出下列名句中的上句或下句。
①所以动心忍性，________________。 (《孟子》)
②水何澹澹，________________。 (《曹操〈观沧海〉》)
③至于夏水襄陵，________________。 (郦道元《三峡》)
④________________，恨别鸟惊心。 (杜甫《春望》)
⑤________________，巴山夜雨涨秋池。 (李商隐〈夜雨寄北〉)
⑥________________，身世浮沉雨打萍。 (文天祥〈过零丁洋〉)
(2) 根据提示写出相应的名句。
①《渔家傲・秋思》中，范仲淹借酒抒发思乡之情的句子是 "________________。"
②《送东阳马生序》中，宋濂面对衣着华丽的"同舍生"的态度是 "________________。"
1. (10 分)
(1) ①曾益其所不能 ②山岛竦峙 ③沿溯阻绝 ④感时花溅泪 ⑤君问归期未有期 ⑥山河破碎风飘絮 (共 6 分。每句 1 分，有漏字、添字、错别字的，该句不得分)
(2) ①浊酒一杯家万里 ②略无慕艳意 (共 4 分。每句 2 分，有漏字、添字、错别字的，该句不得分)
【天津】
12. 请将下面诗文语句补充完整。(8 分)
(1) 几处早莺争暖树，________________。 (白居易《钱塘湖春行》)
(2) 落红不是无情物，________________。 (龚自珍《己亥杂诗》)
(3) ________________？留取丹心照汗青。 (文天祥《过零丁洋》)
(4) 山重水复疑无路，________________。 (陆游《游山西村》)
(5) ________________，西北望，射天狼。 (苏轼《江城子・密州出猎》)

The picture on the right is a typical "write poem from memory" exercise. Students will write down the write sentence from a poem from the provided hints.

1.2 Design of the System

1.2.1 Input. There can be several input systems that make sense for this system: pen/stylus/hand input directly onto the computer screen can be used while students practice at home using this system, but for a testing scenario, realistically speaking scanning is more reliable and professional. Although scanning cannot record the sequence of the strokes but in a "writing poem from memory" exercise, sequence of stroke is not important thus is irrelevant to the grade.

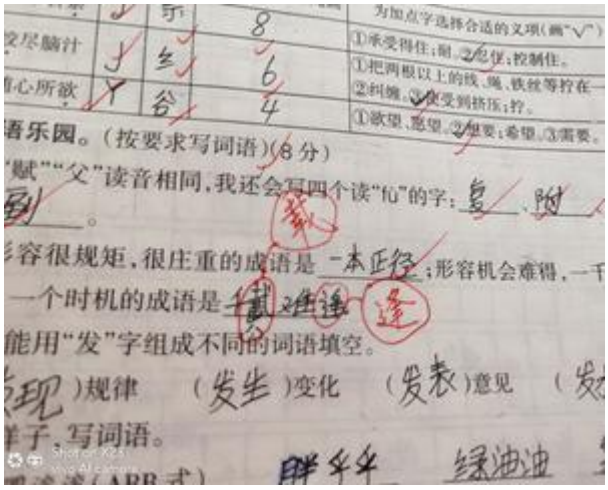
1.2.2 Grading. The grading part of the system can be very complicated since students' handwritings are not "perfect" and lots of Chinese characters are very similar (some examples are shown below)

Now these problems are tricky because of 2 reasons: Some characters in a poem (especially the complicated and/or often used characters) are valued during the grading process by teachers, other characters that are rarely or never used are allowed to be slightly off.

I have had some trivial discussion with some Chinese teachers in The High School Affiliated to Renmin University of China, I will utilize my winter vacation to have more conversations with varies experts in the Chinese education system and get some feedbacks.

1.2.3 Output. The output of a traditional grading is numerical, it tells the students which character is wrong and student would have to check what the correct character. I would like to improve this feedback system by explaining where did the student make the mistake, what type of mistake was it (wrongly written or

homophone) An example of wrongly written mistake is shown below.



An example of homophone mistake is attached below.

Additionally, in the case of homophone mistake, we can output the meaning of both characters which helps the student to learn characters by meaning instead of rote learning.

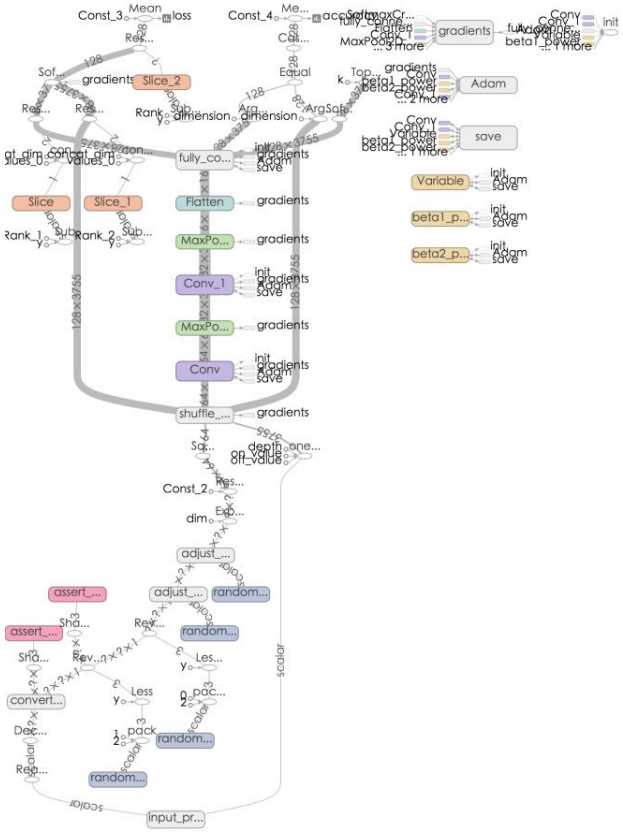
1.3 Previous work & TensorFlow

The best and "easiest" way for Chinese character recognition seems to be Convolutional Recurrent Neural Network, I am able to write a working code using my previous work on CNN and the tutorial on how to use TensorFlow, but this is very pre-made, I was simply following the instruction while making minor modifications, in the future I would like to develop a simpler code while maintain the high accuracy, but CNN has become the architecture of choice for complex vision recognition problems for several years, I do not know if I can develop a system without CNN.

TensorFlow is the second machine learning framework that Google created and used to design, build, and train deep learning models. You can use the TensorFlow library due to numerical computations, which in itself doesn't seem all too special, but these computations are done with data flow graphs. In these graphs, nodes represent mathematical operations, while the edges represent the data, which usually are multidimensional data arrays or tensors, that are communicated between these edges. In this system, the design is as follow:

1. Convolutional layer 1, 3 × 3 32 filters, same filling, activation function using Relu
2. Filters with a maximum pooling layer of 1, 2 × 2, with a step size of 2
3. Convolutional layer 2, 3 × 3 64 filters, the same filling, activation function using Relu
4. Filter with maximum pooling layer 2, 2 × 2, step size is 2
5. Convolutional layer 3, 3 × 3 128 filters, the same filling, activation function using Relu
6. Filter with maximum pooling layer 2, 2 × 2, step size is 2
7. The logit layer: because there are 3755 different Chinese characters in our training set, so the number of neurons in this layer is 3755. Because it is the logit layer, we will use softmax to calculate the probability. The layer does not need to activate the function.

The flow looks like this:



Although this is the "code" part of the project, I feel like addressing more on my future plans, since this is my first semester learning sketch recognition, my ability is limited, which is why I wish to write down my plan based on what I think sketch recognition is capable of, and develop this plan into my thesis.

1.4 Problems

Several problems were brought up to this system and I am sure more will come up after more interview and during development. I will address some that are impactful and immediate to the starting stage of the project.

First of all, Chinese education system does not heavily depend on online systems, we do not have a sophisticated system like

Blackboard in the U.S., it would be a challenge to introduce the learning part of the system to students and parents.

Second, the grading system input will most likely be scanning, and this might raise issues like poor quality of image, it would be difficult to specify a type of scanning machine or a system of paper used for exams.

Third problem is that my skill's limitation, my code can only recognize simple single characters with a fairly high accuracy, but to recognize a sequence of characters, I need to learn more to develop my own recognizer. I have researched on previous work, there are projects that utilize Convolutional Recurrent Neural Network for image-based character recognition. I am not sure if CNN is considered sketch recognition since it is image based instead of sketch based, but the nature of reality does not allow us to implement a sketch-based system. I would love to have more discussion with professor Hammond and the Sketch Recognition Lab members.

Finally, is subjective vs objective view of a character that is not perfectly written. The education system trusts teachers to make the correct subjective decision on whether a character is correct. But how would our system get approved by authorities to be capable to make the objective decision, where to draw the line of correct and incorrect to convince them it would make the right decision?

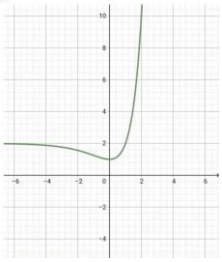
With these problems brought up during discussion, a math teacher brought up a mathematical problem that is hard to grade because of the same reason which I will introduce in the following segment.

2 Mathematical Problem Grading ystem

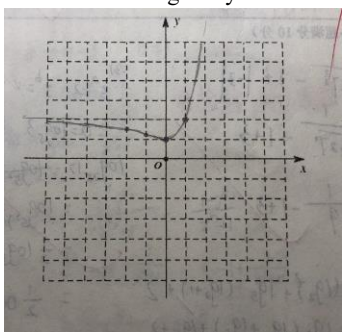
A math teacher brought up this problem that he made for his student while discussing the Chinese poem grading system:

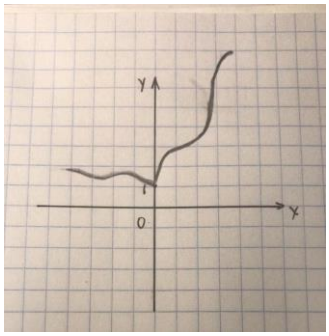
Draw the function $f(x)=4^x-2^{x+1}+2$

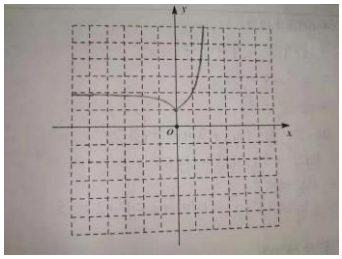
The function should look like this:

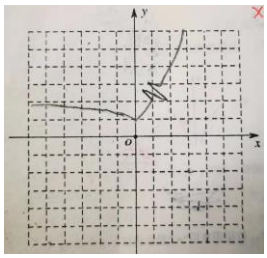


Student's drawings vary a lot:









Grading this problem is extremely subjective, a numerical grading scale (0 to 5) instead of binary (wrong or right) makes it even harder to grade objectively.

2.1 Design of the System

2.1.1 Input. The input has to be scanning already drawn graph, which brings up the previously mentioned issue again, only this time the problem at hand is not so time consuming, so the question is can scanning and grading produce a more subjective result than manually grading.

2.1.2 Grading. The grading process is not only complicated for this problem but also dynamic. Each question's grading criteria can be different and with each different function, the focused attribute of the function changes. Using the problem we have as an example, the teacher will grade it by looking at asymptote, some particular points that the function goes through and the increase/decrease of the function. If some of these key factors are clearly wrong then it should be graded as 0, however if only 1 or 2 are wrong and the rest are perfect, we have to develop a grading scheme. This scheme although is subjective, but with the reinforcement of sketch recognition can be more objective.

2.1.2 Output. The feedback student get is usually a circle of where the function is wrongly drawn or no feedback at all. With this system we wish to precisely provide students with what is wrong with their drawing and how to improve it (what important attribute they forgot so they will not make the same mistake again)

2.2 Fuzzy Mathematics

Fuzzy mathematics, also known as Frisian mathematics. After 1965, a general term for mathematical fields such as fuzzy topology and fuzzy measure theory developed on the basis of fuzzy sets and fuzzy logic. It is a mathematical tool for studying many indistinct and even ambiguous problems in the real world. It has a wide range of applications in pattern recognition and artificial intelligence.

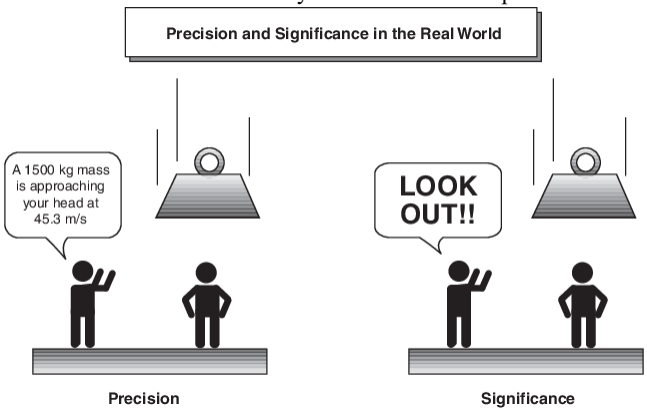
While calculating the variables, you need to consider a two-value situation. For example, the store needs to predict whether there will be rain the next day to decide how many umbrellas to prepare for sales. However, it is impossible to predict a constant that is rarely prepared without rain. Prepare a lot. Of course, there is a premise that the prediction cannot be 100% accurate.

Although the final result to solve this problem is definitely a binary discrete: that is, to prepare "some" umbrellas. However, the normal probability-based approach is to calculate the probability of rain, and then find the minimum number of umbrellas that meet the demand in the confidence interval to obtain this intermediate value.

The orthodox probability method is relatively complete and mature, and the theoretical basis is also very perfect. The disadvantage is that there are more processes and the process is more complicated. The actual effect on solving the problem is not obvious, that is, it is more focused on theoretical perfection.

Fuzzy mathematics can carry forward the obvious advantages suitable for application here, directly define the ambiguity of rain (although the meaning must be similar to the probability of rain), and then directly substitute it into the calculation. The original two-value judgment is reduced to the interpolation algebra (here It should be explained that the original judgment function can be written as an algebraic formula. The interpolation here is actually to change the Boolean variable whether it is raining to an interpolation function.)

I wish to touch on this in this system and have a deeper discussion.



2.3 Problem and Inspiration

The problem of this grading system is also what gave me inspiration to the next segment. The problem is that if we wish to solve this kind of problems, the system cannot be static, there has to be a way to dynamically give the machine instructions to a different problem.

3 Dynamic Grading System

This system becomes very generic, this is an ideal system similar to the Turing machine, with an easily reprogrammable machine in the middle, which means we can easily reprogram it to grade many different types of problems, input is by scanning or stylus and output is a fleshed out report for the student to improve upon.

3.1 Design of the System

The aim for this system is to be extremely versatile, so every part of the system will be described ideally here, this does not mean the final system will be as versatile as it is described here.

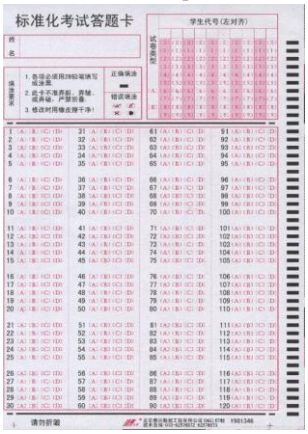
3.1.1 Input. For the input to be versatile we would like to include all possible ways of inputs: stylus, scanning, even 3D tracking. The aim is to make this system used in as many subjects/areas in education as possible, this includes science, literature and athletically subjects.

3.1.2 Grading. Grading part of this system would be programmable and easy to use to user groups like middle/high school teachers. Ideally teachers would input some trivial weights (on each grading criteria) to indicate what is the problem mainly testing the student, resulting in a feedback that is objective but is subject to teacher's preferences.

3.1.3 Output. Feedback of this system should be informative, to each type of problem that is solvable by the system should have a template that produce meaningful advice to students and help them improve.

3.3 Ultimate Goal and Philosophy

The goal of this project is to help the education system automate the process of grading. Over the years, grading of multiple-choice problems are taken over by Optical Mark Readers, these readers take in a piece of paper like the one shown below, machine will handle the grading. Utilizing sketch recognition, I aim to automate the process of grading objective questions as much as possible.



Through interviews with teachers and my personal TA experiences, every question is designed to test students upon a single or an area of knowledge, mistake made outside that area are sometimes ignored because that isn't the aim of the class. But this is way of grading is not completely objective, a completely objective way of grading will count every single mistake as an error. Although the grading process is should always be objective but there will inevitably be subjective issues.

I think it is an interesting discussion on where we draw the line that a grading criterion is too subjective, this also involves fuzzy mathematic as mentioned above.

4 Conclusion

This project is ambitious, I only had time to get a very "theoretically hard" but "implantation wise easy" coed to work for final presentation, I used previously learned CNN knowledge and self-learned TensorFlow to understand this CRNN way of recognizing Chinese characters which is very fruitful. But I dedicate this paper to explain my plan for the future and for my thesis, I spent a lot of time discussing these technical and theoretical issues with my high school teachers and other peers, I have learned a lot during this process and wish to learn more.

ACKNOWLEDGMENTS

I would like to thank the amazing Chinese community on zhihu.com which provides me a lot of help while setting up my TensorFlow CNN recognizer.

I would also like to thank teachers and professors that gave me many opportunities to tutor younger students and gave me insight on the education world, you ignited my passion for education and I will try my best to give back to education and hopefully improve it. Last but certainly not the least I would like to thank professor Hammond for a lot of things. Thank you for the introduction to Sketch Recognition, I see a lot of potential in this field and would love to learn more from you and all the lab members. Thank you for being my advisor, I will need a lot of advising in the future, I am looking forward to it.
If anyone have any advice on this project please do not hesitate to email me, I would love to discuss this with you further.

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