UCLouvain
École de statistique, biostatistique
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FACULTE DES SCIENCES

LINFO2275: Data mining and decision making

~ Project 2 Report ~

Gesture Recognition

Group 13 :

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Academic year : **2021-2022**

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Introduction

Amid the recent development of machine learning algorithm, the hand gesture recognition has gained an rapid interest. Thus, in this project, we will develop a sketch recognition system identifying the category of a sequence, and implementing/testing it with Python. The sequence consists on a three-dimensional tracking of the position vector $r(t) = [x(t), y(t), z(t)]^T$ of the hand that is recorded as a sequence of the three coordinates in function of the time t. Thus, the user is executing a sketch or a symbol with his hand, which is recorded and recognized by the system. Sketches and symbols are rapidly executed freehand drawings (Huang et al., 2019). Here, the sketches are drawings of the numbers from 0 to 9 (10 classes or categories). In order to train the recognition system, a publicly available gestures data set, gathered by and described in (Huang et al., 2019), is used. Ten users participated and were each asked to sketch ten times the numbers {0,1,2,3,4,5,6,7,8,9} (called domain 1 data in Huang et al., 2019). We therefore have ten repetitions of these ten numbers by ten users, that is, 1000 sequences in total.

To solve this, we will proceed in two steps. The first step is to implemente a baseline technic in python to categorise the sketches. And in the second step, we will compare the accuracy of our implementation with *the gesture-based system for next generation.*

1 Baseline implementation

Our baseline implementation with be based on the dynamic time warping algorithm, which will give us the alignment path and cost of two sketches. In our case, we will compare the alignment cost of a specified sketch with all other available sketches and choose the one with the smaller cost. That one with the smaller alignment cost with the specified sketch, will be our recognized category of the specified sketch.

To do so, We will first produce a vector quantization on the dataset which is some kind of *preprocessing of the data*. The main goal of this preprocessing of the data is to get an array structure for the data, in order to compute the dynamic time warping algorithm on the array structure obtained.

1.1 Vector quantization of the data

In order to perform dynamic time warping algorithm on the data, we will transform each set of the sketch into an array. Each array will be of length *the number of points of the concerned sketch*, and each element of the array is the *3D coordinate* (x, y, z) of each point of the concerned sketch. For instance, the sketch 1 of user 1 for the category of 1 will be transform to an array of length 127 where the first element of the array is the list $[0.042075, 0.036799, 0.258380]$. And then, the sketch will be represente by : $[\,[0.042075, 0.036799, 0.258380], \ldots]$

1.2 Dynamic time warping framework and analysis

In this subsection, we will implement the baseline technique : *the dynamic time warping algorithm.* The main objective is to quantify the similarity between two sketch. So we will first compute the similarity between a given sketch of user i and all other sketches of all j users. Then we will retain the sketch most similar to the given sketch. The most similar sketch is the sketch with the minimum alignment cost from the dynamic time warping algorithm.

1.2.1 Overview of the method

Once the algorithm has been compute in python (see the python file attached), the goal here is to perform a dynamic time warping on a specified set of sketch and get the lower alignment cost. The corresponding sketch to the one with the minimum cost aligned with the specified one will be the category predicted by our model. In the table below are resume some of the recognized pattern for specific pattern.

Table 1: Recognized pattern for 10 sketch of each of the 10 users

input pattern	1	2	3	4	5	6	7	8	9	10
user 1	7	2	3	4	5	10	10	8	2	10
user 2	7	8	3	8	5	6	8	7	3	10
user 3	1	2	3	4	5	6	7	4	9	1
user 4	1	2	8	4	5	9	7	8	9	8
user 5	5	3	3	9	5	7	7	8	9	10
user 6	4	3	2	6	5	6	7	8	9	10
user 7	4	3	2	8	8	10	6	8	9	10
user 8	7	2	3	4	8	6	7	8	9	10
user 9	7	3	3	4	5	10	7	8	2	4
user 10	9	9	9	5	5	10	10	8	5	8

1.2.2 Accuracy of the methods

With the output of the algorithm, we can compute the accuracy of the model. Below, are the accuracy plot of our baseline implementation for all users.

Table 2: Accuracy of the implementated dynamic time warping algorithm

User	1	2	3	4	5	6	7	8	9	10
Accuracy	20%	40%	60%	50%	80%	40%	60%	80%	60%	60%

The model accuracy is represented in the graph below

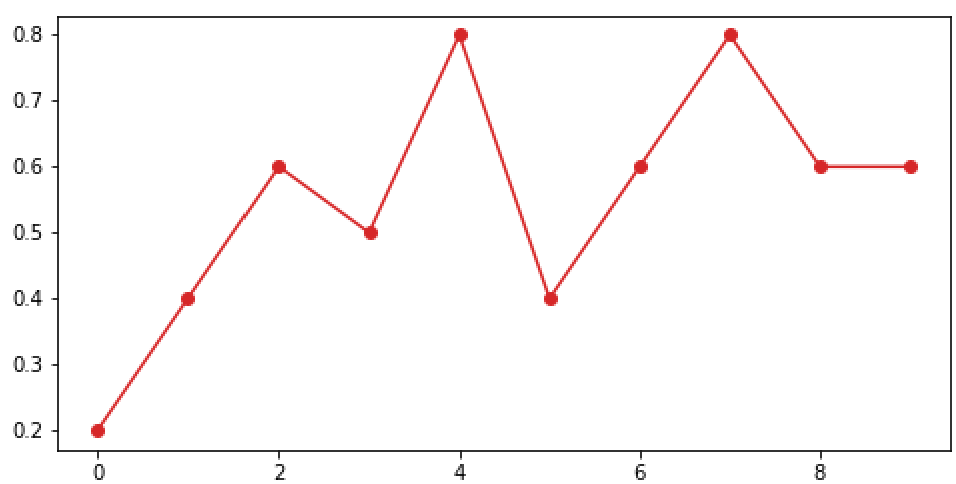

Figure 1: Accuracy of the baseline implementation

2 Comparison with Gesture-based system for next generation

In this section, we will compare the baseline implementation with the *Gesture-based system for next generation*[1].

[1]Huang J, Jaiswal P, Rai R (2019). Gesture-based system for next generation natural and intuitive interfaces. Artificial Intelligence for Engineering Design, Analysis and Manufacturing 33, 54–68. https://doi.org/10.1017/S0890060418000045

In this implementation, the preprocessing of the data in different from the one we have implemented. Thus, we obtain different accuracy. Recall that in the gesture-based system, the sketch recognition is based on set of geometrical and statistical features. And then the final recognition is based on Support Vector Machine classifer. According to Huang(& all) article, the implementation of this method give the following accuracy :

Table 3: accuracy of the Domain01 based on gesture-based system

	Cross-validation accurancy	Test Accuracy
Domain01	99.43%	99.00%

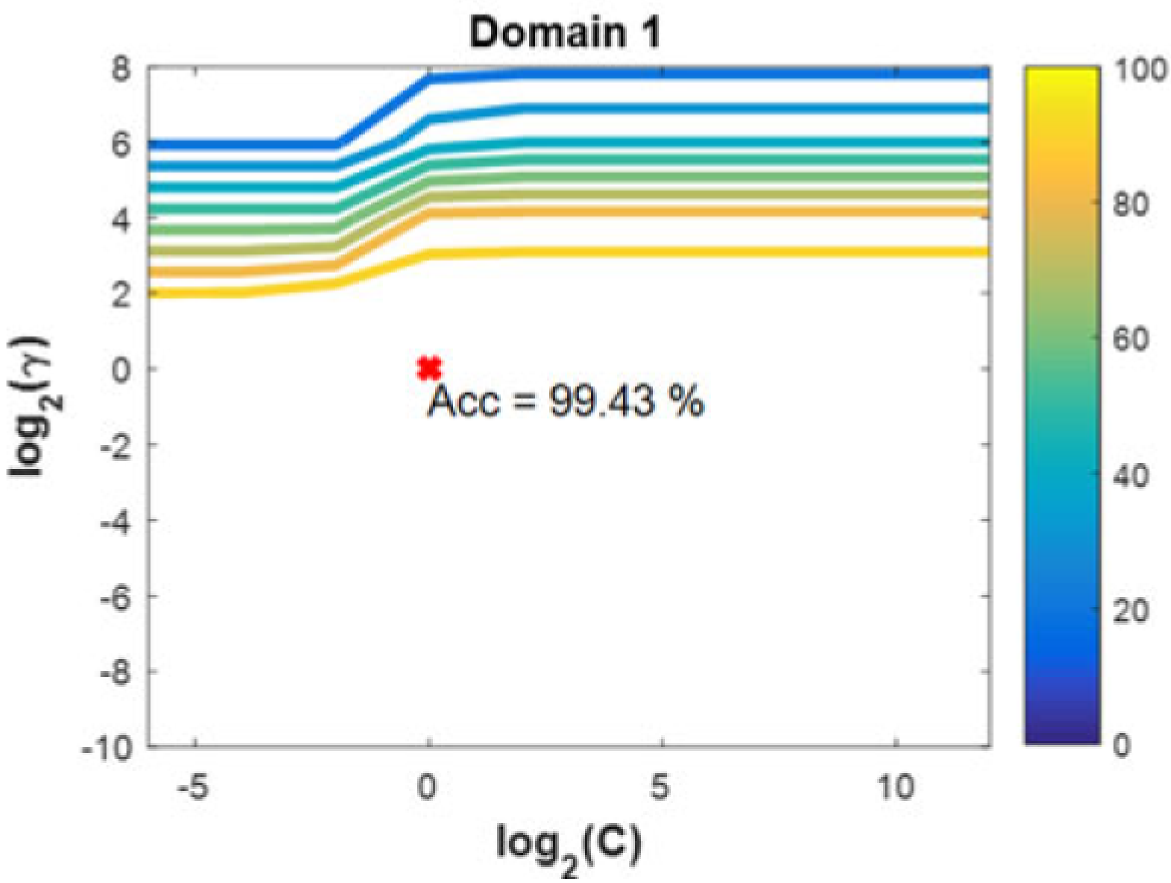

Figure 2: Cross-Validation accuracy of Gesture-based system

Overall, notice that the accuracy of our model is less than the accuracy of the model used for the *Gesture-based system* and also, our baseline implementation is time consuming (13mn in average to recognized a given pattern).

Conclusion

Sum up, in this project, we have implemented a dynamic time warping algorithm in the case of gesture recognition. And after, we compare the accuracy of our basline implementation with the *Gesture-based system* developped by Huang J, Jaiswal P, Rai R. Indeed, our baseline technique present less accuracy than the accuracy of the technique proposed by the *Gesture-based system*, but the dynamic time warping remain a valid method to dig into gesture recognition.