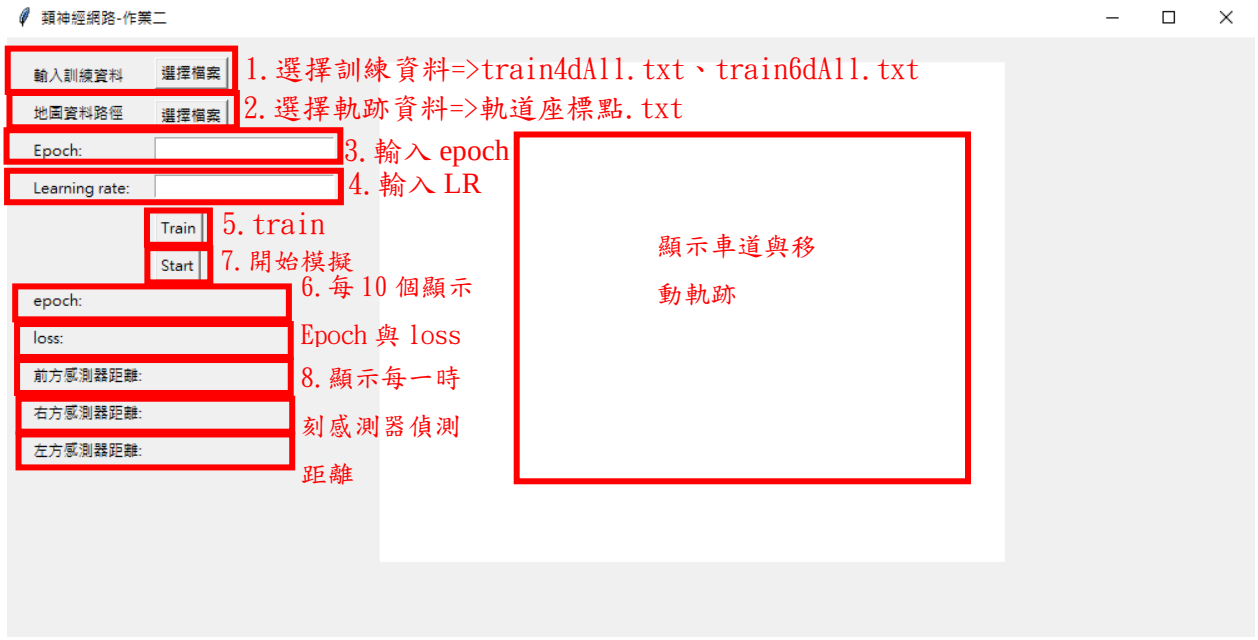
# 類神經網路作業二報告

## (1) 程式介面與操作說明

詳細操作可以看 111522101_HW2.mkv，需要把軌跡圖清空在選一次地圖資料路徑就好。




## (2) 程式碼說明

本次作業使用四個 class 和一個 main 當作主要架構，class 部份分別是 Dataprocessor 、Kmeans、model、simulator，以下會分別進行講解

### ➢ Main.py

main.py 主要是負責介面的設計與 class 的調動，GUI 主要是使用 tkinter 進行撰寫，在 button 的部分分別會調用 get_file_url() 取得訓練檔案資料與 draw_track 繪製路徑圖

```
96   window = tk.Tk()
97
98   f = Figure(figsize=(5, 4), dpi=100)
99   plot_view = tk.Frame(window)
100  plot_view.place(x=300,y=20)
101  canvas = FigureCanvasTkAgg(f, plot_view)
102  canvas.get_tk_widget().pack(side=tk.RIGHT, expand=1)
103
104  window.geometry("1000x500+200+300")
105
106  window.title('類神經網路-作業二')
107  #選擇檔案
108  file_name = tk.StringVar()   # 設定 text 為文字變數
109  file_name.set('')            # 設定 text 的內容
110
111  route_name = tk.StringVar()   # 設定 text 為文字變數
112  route_name.set('')            # 設定 text 的內容
113
114  tk.Label(window, text='輸入訓練資料').place(x = 20,y = 20)
115
116  tk.Button(window, text='選擇檔案',command= lambda: get_file_url(file_name)).place(x = 120,y = 16)
117
118  tk.Label(window, text='地圖資料路徑').place(x = 20,y = 50)
```

Train_model()會取得學習率與 epoch 次數進行 model 的訓練

print_result()會使用調用模擬程式開始進行感測器的計算與路徑的繪製

```
148     #開始訓練資料
149     tk.Button(window, text='Train',command= lambda: train_model(
150             int(interation.get()),
151             float(learning_rate.get()),
152             window,
153             epoch,
154             loss
155     )).place(x = 120,y = 140)
156 
157     front_distance = tk.StringVar()
158     front_distance.set('')
159     tk.Label(window, text='前方感測器距離:').place(x = 20,y = 260)
160     tk.Label(window, textvariable=front_distance).place(x=120, y=260)
161 
162     right_distance = tk.StringVar()
163     right_distance.set('')
164     tk.Label(window, text='右方感測器距離:').place(x = 20,y = 290)
165     tk.Label(window, textvariable=right_distance).place(x=120, y=290)
166 
167     left_distance = tk.StringVar()
168     left_distance.set('')
169     tk.Label(window, text='左方感測器距離:').place(x = 20,y = 320)
170     tk.Label(window, textvariable=left_distance).place(x=120, y=320)
171 
172 
173     tk.Button(window, text='Start', command= lambda: print_result(window,canvas,front_distance,right_distance,left_distance)).place(x = 120,y = 170)
```

```
52  def train_model(epochs,learning_rate,window,epoch,loss):
53      global rbfModel,feature_len,y_train
54      dataprocessor = Dataprocessor()
55      x_train,y_train = dataprocessor.splitFile(file_url)
56      feature_len = len(x_train[0])
57      kmeans = KMeans(x_train,len(x_train[0]))
58      m,sigma = kmeans.process()
59      print(m,sigma)
60  
61      rbfModel = Model(epochs,learning_rate,m,sigma,len(x_train[0]))
62      rbfModel.train(x_train,y_train,window,epoch,loss)
63  
64  def print_result(window,canvas,front_distance,right_distance,left_distance):
65      simu = Simulator(0,0,90)
66      four_dimension,six_dimension = simu.start(window,canvas,f_plot,feature_len,rbfModel,front_distance,right_distance,left_distance)
67      if feature_len == 3:
68          save_4d_result(four_dimension)
69      else:
70          save_6d_result(six_dimension)
71  
72  def save_4d_result(four_dimension):
73      file = open("track4D.txt", "w")
74      for i in range(len(four_dimension)):
75          towrite = ' '.join(str(item) for item in four_dimension[i])
76          file.write(f"{towrite}\n")
77      file.close
78  
79  def save_6d_result(six_dimension):
80      file = open("track6D.txt", "w")
81      for i in range(len(six_dimension)):
82          towrite = ' '.join(str(item) for item in six_dimension[i])
83          file.write(f"{towrite}\n")
84      file.close
```

使用 Dataprocessor 呼叫將資料分成 input 與 label

使用 Kmeans 挑出 rbfn 的初始值 m 跟 sigma

將資料丟進 RBFN model 進行訓練

將訓練好的 model 與 GUI 所需設定的物件放入 simulator，並取得路徑與方向盤資訊

看維度繪製檔案

## ➢ Dataprocessor

將資料分成 input 跟 label，會根據輸入的維度不同做不同處理，並且會將 label 使用 min max scaler 正規化，以便後續 model 訓練。

```python
class Dataprocessor:
    def __init__(self):
        self.x_train = []
        self.y_train = []

    def splitFile(self,dataset_url):
        with open(dataset_url,'r',encoding='utf-8') as f:
            for data in f.readlines():
                data = data.split(' ')
                if(len(data) == 4):
                    self.x_train.append([float(data[0]),float(data[1]),float(data[2])])
                    self.y_train.append(float(data[3]))
                else:
                    self.x_train.append([float(data[0]),float(data[1]),float(data[2]),float(data[3]),float(data[4])])
                    self.y_train.append(float(data[5]))

            self.x_train = np.array(self.x_train)
            self.y_train = np.array(self.y_train)
            self.y_train = (self.y_train - np.amin(self.y_train)) / (np.amax(self.y_train) - np.amin(self.y_train))
        f.close()

        return self.x_train,self.y_train
```

Min max scaler

讀檔與將資料從 string 轉成 float

```python
    def readfile(url):
        read = open(url)
        file = read.readlines()
        read.close()
        return file

    def text_to_numlist(dataset):
        """load text dataset to numeracial list dataset

        Args:
            dataset (string): txt or other file

        Returns:
            dataset: float_list
        """
        dataset = [list(map(float,data)) for data in dataset]
        return dataset
```

- Kmeans

```
class KMeans:
    def __init__(self,x_train,K):
        self.x_train = x_train
        self.K = K

    def euclidean(self,data,center):
        differ = data - center
        return np.linalg.norm(differ,axis=1)

    def process(self):
        center_pos = random.sample(range(0,len(self.x_train)),self.K)
        center = self.x_train[center_pos] # data[center_pos] have K
        sigma = np.zeros(len(self.x_train[0]))

        for _ in range(100):
            arg = np.zeros(len(self.x_train))
            #算每個點的距離並給定是哪一群
            for i in range(len(self.x_train)):
                arg[i] = np.argmin([self.euclidean(self.x_train[i],center)])

            #下一次的center更新
            for c_pos in range(self.K):
                center[c_pos] =  np.mean(self.x_train[arg == c_pos],axis=0)

        for c_pos in range(self.K):
            sigma[c_pos] = np.sum(self.euclidean(self.x_train[arg == c_pos],center[c_pos])) / len(self.x_train[arg == c_pos])

        return center,sigma
```

隨機挑三個點當中心點，並且初始化 Center 與 sigma

中心點更新，一開始將資料屬於哪個群先記錄在 arg，再把根據 arg 把群體內的點做 mean

算 sigma

- Model

```
def train(self,x_train,y_train,window,epoch_setter,loss_setter):
    for i in range(1,self.epochs + 1):
        loss_sum = 0
        for data,label in zip(x_train,y_train):
            #正向傳遞
            active,self.F = self.predict(data)

            loss_sum += ((label - self.F) ** 2) / 2
            #倒傳遞更新參數
            new_w = self.w + (self.learning_rate  * (label - self.F) * active)

            preprocess_m = self.learning_rate *(label - self.F) * self.w * active * (1 / (self.sigma ** 2))
            data_sub_m = data - self.m
            new_m = self.m + np.array([preprocess_m[i] * data_sub_m[i] for i in range(len(preprocess_m))])

            new_sigma = self.sigma + (self.learning_rate  * (label - self.F) * self.w * active * (1 / (self.sigma ** 3)) * (self.euclidean(dat
            new_theta = self.theta + (self.learning_rate  * (label - self.F))

            self.w = new_w
            self.m = new_m
            self.sigma = new_sigma
            self.theta = new_theta

        if i % 10 == 0:
            print("epoch:",i)
            print(loss_sum)
            print("sum(loss_sum) / len(loss_sum)",loss_sum / len(x_train))
            print("------")
            epoch_setter.set(str(i))
            loss_setter.set(str(loss_sum / len(x_train)))
            window.update()
```

Forward

Back probagation

每 10 次 epoch 會印一次 loss 在 GUI 上

## ➢ Simulator

```python
class Simulator:
    def __init__(self,car_x,car_y,phi) -> None:
        self.car_y = car_y
        self.phi = phi
        self.b = 3
        self.coordination = np.array([
            [-6,-3],[-6,22],[18,22],[18,50],[30,50],[30,10],[6,10],[6,-3],[-6,-3]
        ])

    def rotate(self,theta):
        theta = np.radians(theta)
        c, s = np.cos(theta), np.sin(theta)
        new_point_x = (c * 100) - (s * self.car_y)
        new_point_y = (s * 100) + (c * self.car_y)
        return np.array([new_point_x,new_point_y])
```

使用旋轉矩陣，將點定在車的右邊 100，然後用 phi 將車子面相對的位置

```python
    def get_intersection(self,sensor):
        p1,p2 = Point(self.car_x,self.car_y), Point(sensor[0],sensor[1])
        l1 = Segment(p1, p2)
        min_distance = float('inf')
        for i in range(1,len(self.coordination)):

            p3, p4 = Point(self.coordination[i - 1][0], self.coordination[i - 1][1]),\
                Point(self.coordination[i][0], self.coordination[i][1])

            l2 = Segment(p3, p4)

            # Point2D
            intersection = l1.intersection(l2)
            #如果有相交
            if intersection != []:
                intersection = intersection[0].evalf()
                distance = p1.distance(intersection)
                min_distance = min(min_distance,distance)

        return min_distance
```

取得車與自定義的右邊 100 遠的線使用旋轉矩陣轉成感測器的方向形成的線段與車道邊界相交的點與車位置的距離，挑最短的回傳

```python
def start(self,window,canvas,f_plot,feature_len,rbfModel,front_distance,right_distance,left_distance):
    # [前,右,左]
    four_dimension,six_dimension = [],[]
    while(self.car_y + 3 < 37):

        #前方感測器
        front_sensor_vec = self.rotate(self.phi)
        front_sensor_dis = self.get_intersection(front_sensor_vec)

        #右方感測器
        right_sensor_vec = self.rotate(self.phi - 45)
        right_sensor_dis = self.get_intersection(right_sensor_vec)

        #左方感測器
        left_sensor_vec = self.rotate(self.phi + 45)
        left_sensor_dis = self.get_intersection(left_sensor_vec)
```

取得各個感測器抓到與車道的最短距離

```python
        if(feature_len == 3):
            _,F = rbfModel.predict(np.array([float(front_sensor_dis),float(right_sensor_dis),float(left_sensor_dis)]))
        if(feature_len == 5):
            _,F = rbfModel.predict(np.array([float(self.car_x),float(self.car_y),float(front_sensor_dis),float(right_sensor_dis),float(left_sensor_dis)]))
        F = F * 80 - 40
```

將感測器抓到的資料丟到 model 進行預測，並將得到的結果正規化回來

```python
        self.update(F)
        print(self.car_x,self.car_y,self.phi)

        #更新前右左距離
        front_distance.set(str(front_sensor_dis))
        right_distance.set(str(right_sensor_dis))
        left_distance.set(str(left_sensor_dis))
        window.update()
```

更新車的位置與 phi

基本的碰撞偵測

```
if front_sensor_dis - 3 < 0 or right_sensor_dis - 3 < 0 or left_sensor_dis - 3 < 0:
    break
```

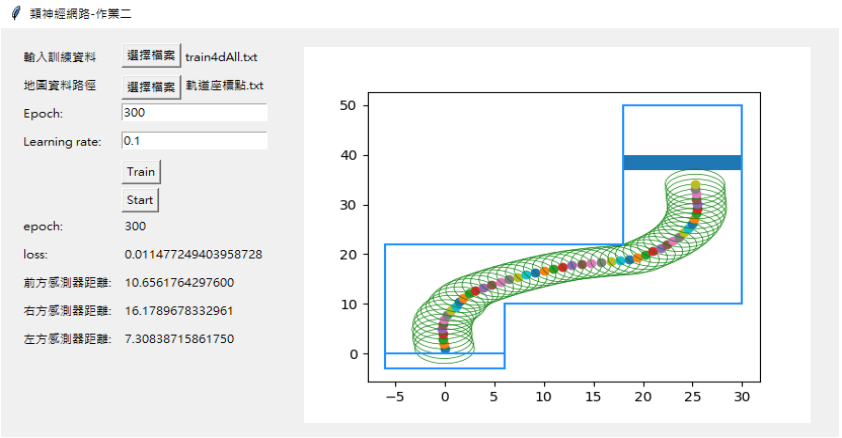
將車目前的位置進行畫圖，並將半徑畫出來

```
84          #動畫畫圖
85          self.plot(canvas,f_plot)
86
87          four_dimension.append([front_sensor_dis,right_sensor_dis,left_sensor_dis,F])
88          six_dimension.append([self.car_x,self.car_y,front_sensor_dis,right_sensor_dis,left_sensor_dis,F])
89
90      return four_dimension,six_dimension
91
92  def plot(self,canvas,f_plot):
93      f_plot.scatter(self.car_x,self.car_y)
94      circle = patches.Circle((self.car_x,self.car_y), radius=3,linewidth=0.5, fill=False, color="g")
95      f_plot.add_patch(circle)
96      canvas.draw()
```

## (3) 實驗結果(包含移動軌跡截圖)

Train4dAll.txt

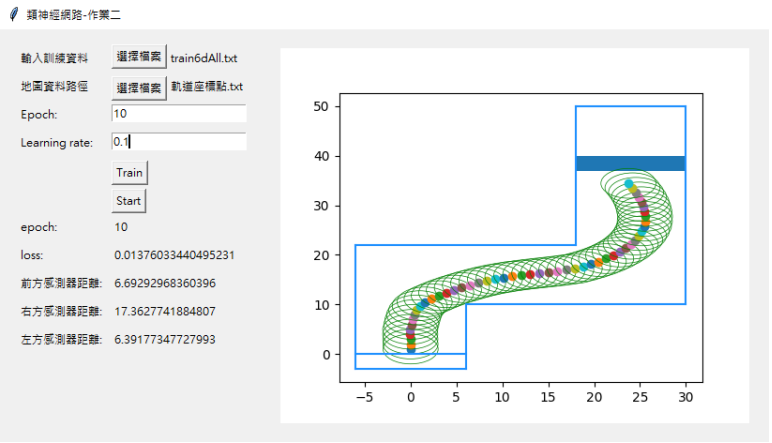
Track4D.txt



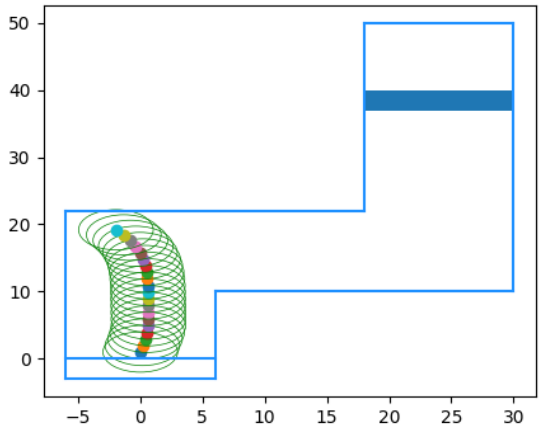

```
22.0000000000000 8.48528137423857 8.48528137423858 -6.877838871672125
21.0939926426109 9.29201086867437 7.76604876868878 -4.465463145168684
20.2530132392281 25.0691654704510 7.26373714368679 11.087006356142616
19.0501876320858 8.87574625404333 7.78513987363405 -5.419646410891744
18.1507977538255 23.7305422503162 7.26723283645272 11.209633267799163
17.0690742851098 40.7232386997804 7.94244251189077 7.441729136266389
16.1557040025118 37.8361912675726 8.65341455897487 10.488652868336317
15.4723449910658 34.6958537190910 10.1827033330733 13.22202761999084
15.2149667803975 31.9249481889381 13.5120015472074 13.1642051512525 53
15.3822956133941 5.52700416320956 14.0311637297385 -22.806349295617885
12.8525654323397 32.6787303009910 12.0726795509726 13.909152309086217
12.5807615114606 30.1105744976738 13.0057455211255 13.675496494180024
12.7150658068294 28.4926800298506 11.2751788053882 14.399736681985082
13.5272169538935 27.5826581016463 10.0466594730108 14.643397791192584
15.4402550027892 14.5219307728466 9.27340659139625 -0.9282794776728451
14.1452548858960 18.4364802358765 8.70430555606019 4.235638951947948
14.1177694266609 16.8707718184664 8.14085663377995 2.4175243457067666
13.6958729000118 16.9969901684250 7.61562245828537 2.7932450961068156
13.4123840541855 16.7616136892137 7.11901510462308 2.6635022328294795
26.2210200026091 16.5642930155121 6.65154706806835 0.5201677029735663
25.1720187026397 17.5016677355752 6.19124762773350 1.8888796821177607
23.8642479828678 17.5822639248489 5.74882721254459 2.843748914972224
22.4245484058993 17.1256960089817 5.33569906243385 3.5948076463630088
20.9365670744304 16.3707378580145 4.96322009175058 4.210431054265285
19.4606918275651 15.4816690409550 4.64202125916116 4.413982121871449
18.0638204542982 14.6437246899703 4.37661576140161 3.850931157132095
16.7946758395069 14.0305496300677 4.15664149670038 2.7179941909879943
15.6446468149515 13.6929994460764 3.96151407008904 1.556377358882763
14.5733297866381 13.5793688776926 3.77482996153716 0.6754753433987233
13.5459384839419 13.6178002609743 3.58894487573089 0.13356747416831638
12.5404853025817 13.7475716967575 33.0265164187241 -21.304034124812635
13.1365139209446 12.5629116626624 31.0656942320301 -24.49539602690292
17.2356238390340 10.6076374676952 4.42765462884343 -1.2145175596163682
16.6454668968970 9.81138118039114 6.17445237055030 -3.559107021377244
17.0195859927189 9.00885427541924 7.12424196152458 -5.638850667319332
18.8956965197614 8.26650102067135 7.46146855696663 -6.363991160367604
22.9967013116415 7.63798559775563 7.60326363244488 -7.131688823895672
27.8606627059890 7.15270766979080 7.62981121817077 -6.356951268187281
26.5599742636756 6.78509392942224 7.71931791981825 -7.078162009544215
25.6108349380090 6.59100857147892 7.74013890678382 -7.548902671491923
25.0407991861203 6.62161971883813 7.72902525453681 -7.72281847551173
23.8904157520711 6.94795905545529 7.70613032607020 -7.791692829319345
```

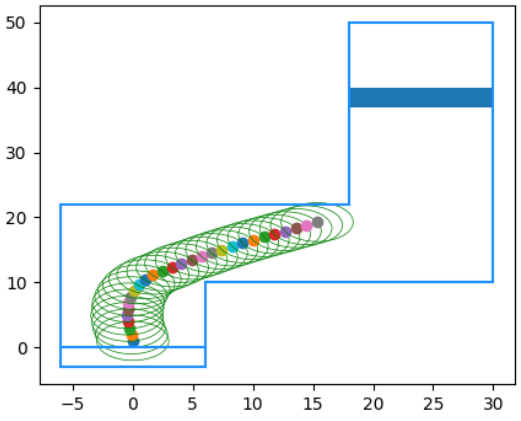
Traind6All.txt

Track6D.txt



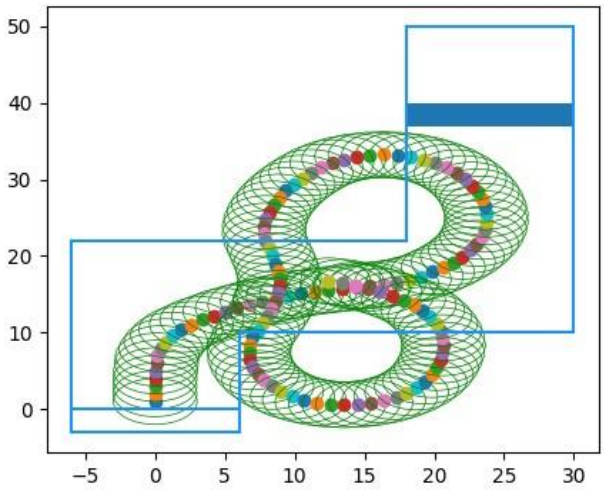

碰撞偵測

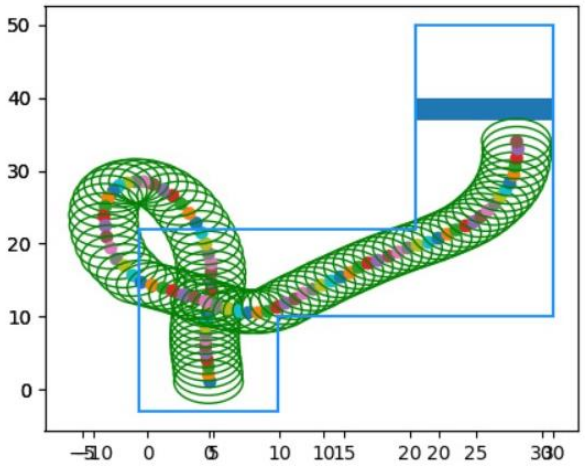




## (4) 分析

在 4D 的資料下，目前試下來 Epoch 數量需要比 6D 的多不少，在 4D 的情況下 epoch 拉到 100 – 200 而 learning rate 為 0.1 的情況下都還會撞牆，測試下來 epoch = 300 learning rate = 0.1 效果是最好的，但是 epoch 拉到太高，則會 overfitting，在還沒有碰撞偵測的時候，發生過以下例子，大約是 epoch 1000 以上就會發生




而在 6D 的情況下，因為資料量比較大的關係，只需要不多 epoch 就能不撞牆的到達終點，在 epoch = 10，learning rate = 0.1 的情況下就可以訓練完畢，不過由於 Kmeans 的關係，如果中心點取的不好，那 10 個 epoch 有時候還是發現撞牆的現象，而 epoch 拉到 100 左右，就大致上都能夠不出錯。

## (5) 有做的加分

1. RBFN
2. 模擬程式