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(1%) 請使用不同的 Autoencoder model，以及不同的降維方式(降到不同維度)，討論其 reconstruction loss & public / private accuracy。（因此模型需要兩種，降維方法也需要兩種，但 clustrering 不用兩種。）

我用 torchsummary.summary 大致描述兩個實作的 autoencoder 架構

Autoencoder1:

Layer (type)	Output Shape	Param #
Conv2d-1	[-1, 16, 32, 32]	448
ReLU-2	[-1, 16, 32, 32]	0
MaxPool2d-3	[[-1, 16, 16, 16], [-1, 16, 16, 16]]	
Conv2d-4	[-1, 64, 16, 16]	9,280
ReLU-5	[-1, 64, 16, 16]	0
MaxPool2d-6	[[-1, 64, 8, 8], [-1, 64, 8, 8]]	
Conv2d-7	[-1, 256, 8, 8]	147,712
ReLU-8	[-1, 256, 8, 8]	0
MaxPool2d-9	[[-1, 256, 4, 4], [-1, 256, 4, 4]]	
Conv2d-10	[-1, 1024, 4, 4]	2,360,320
ReLU-11	[-1, 1024, 4, 4]	0
Conv2d-12	[-1, 1024, 4, 4]	9,438,208
ReLU-13	[-1, 1024, 4, 4]	0
ConvTranspose2d-14	[-1, 256, 4, 4]	2,359,552
ReLU-15	[-1, 256, 4, 4]	0
MaxUnpool2d-16	[-1, 256, 8, 8]	0
ConvTranspose2d-17	[-1, 64, 8, 8]	147,520
ReLU-18	[-1, 64, 8, 8]	0
MaxUnpool2d-19	[-1, 64, 16, 16]	0
ConvTranspose2d-20	[-1, 16, 16, 16]	9,232
ReLU-21	[-1, 16, 16, 16]	0
MaxUnpool2d-22	[-1, 16, 32, 32]	0
ConvTranspose2d-23	[-1, 3, 32, 32]	435
Tanh-24	[-1, 3, 32, 32]	0

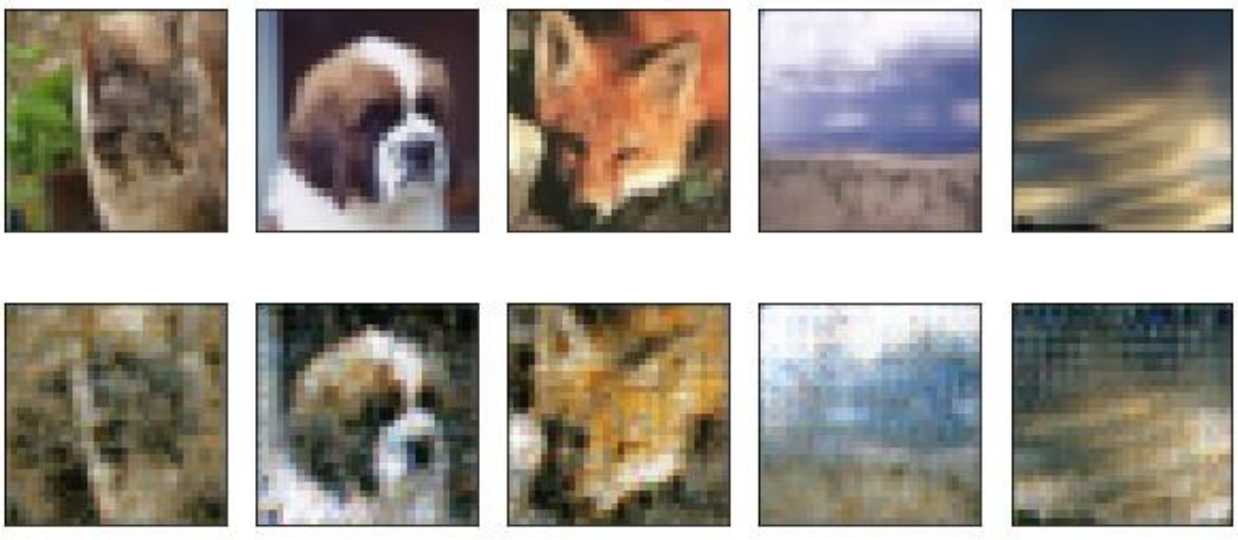
Autoencoder2:

Layer (type)	Output Shape	Param #
Conv2d-1	[-1, 16, 32, 32]	448
ReLU-2	[-1, 16, 32, 32]	0
MaxPool2d-3	[[-1, 16, 16, 16], [-1, 16, 16, 16]]	
Conv2d-4	[-1, 64, 16, 16]	9,280
ReLU-5	[-1, 64, 16, 16]	0
MaxPool2d-6	[[-1, 64, 8, 8], [-1, 64, 8, 8]]	
Conv2d-7	[-1, 128, 8, 8]	73,856
ReLU-8	[-1, 128, 8, 8]	0
ConvTranspose2d-9	[-1, 64, 8, 8]	73,792
ReLU-10	[-1, 64, 8, 8]	0
MaxUnpool2d-11	[-1, 64, 16, 16]	0
ConvTranspose2d-12	[-1, 16, 16, 16]	9,232
ReLU-13	[-1, 16, 16, 16]	0
MaxUnpool2d-14	[-1, 16, 32, 32]	0
ConvTranspose2d-15	[-1, 3, 32, 32]	435
Tanh-16	[-1, 3, 32, 32]	0

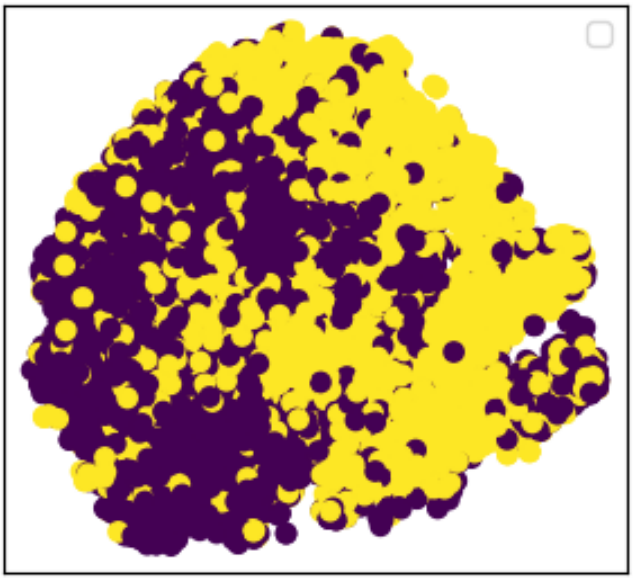
	Final reduced dimension	Construction loss	Public accuracy
Autoencoder1	1024	3.29602	0.77126
Autoencoder2	128	11.60115	0.72079

Autoencoder 1 因為保有較多維度，所以仍可透過模型大致還原原圖，所以會有較高的準確率

(1%) 從 dataset 選出 2 張圖，並貼上原圖以及經過 autoencoder 後 reconstruct 的圖片。



(因為 slide 裡面寫 5 張所以我就挑 5 張了)
上排為原圖
下排為 reconstruct 的圖
(1%) 我們會給你 dataset 的 label。請在二維平面上視覺化 label 的分佈。



(3%)Refer to math problem
https://drive.google.com/file/d/1-rmlFaIj_6hEfJGOHLKUxInoKMsKLHLf/view?usp=sharing

LSTM cell.

$z = w \cdot x + b$ $\quad w = [0,0,0,1]$ $\quad b = 0$ $\quad c' = f(z_i)\,g(z) + c\,f(z_f)$

$z_i = w_i x + b_i$ $\quad w_i = [100,100,0,0]$ $\quad b_i = -10$ $\quad y = f(z_o)\,h(c')$

$z_f = w_f x + b_f$ $\quad w_f = [-100,-100,0,0]$ $\quad b_f = 110$ $\quad f(z) = \frac{1}{1+e^{-z}}$ $\quad g(z) = h(z) = z$

$z_o = w_o x + b_o$ $\quad w_o = [0,0,100,0]$ $\quad b_o = -10$

t=1

$x = [0.1, 0.3]$

$z = [0.1, 0.3] \cdot [0,0,0,1] + 0 = 3$

$z_i = [0.1, 0.3] \cdot [100,100,0,0] - 10 = 90$

$z_f = [0.1, 0.3] \cdot [-100,-100,0,0] + 110 = 10$

$z_o = [0.1, 0.3] \cdot [0,0,100,0] - 10 = -10$

$c' = \frac{1}{1+e^{-90}} \times 90 + 0 \times \frac{1}{1+e^{10}} \fallingdotseq 3$

$y_1 = \frac{1}{1+e^{10}} \times 3 \fallingdotseq 0$ ☆

t=2

$x = [1, 0.1, -2]$

$z = [1, 0.1, -2] \cdot [0,0,0,1] + 0 = -2$

$z_i = [1, 0.1, -2] \cdot [100,100,0,0] - 10 = 90$

$z_f = [1, 0.1, -2] \cdot [-100,-100,0,0] + 110 = 10$

$z_o = [1, 0.1, -2] \cdot [0,0,100,0] - 10 = -10$

$c' = \frac{1}{1+e^{-90}} \times -2 + 3 \times \frac{1}{1+e^{-10}} \fallingdotseq 1$

$y_2 = \frac{1}{1+e^{90}} \times 1 \fallingdotseq 1$ #

t=3

$x = [1,1,1,4]$

$z = [1,1,1,4] \cdot [0,0,0,1] + 0 = 4$

$z_i = [1,1,1,4] \cdot [100,100,0,0] - 10 = 190$

$z_f = [1,1,1,4] \cdot [-100,-100,0,0] + 110 = -90$

$z_o = [1,1,1,4] \cdot [0,0,100,0] - 10 = 90$

$c' = \frac{1}{1+e^{-190}} \times 4 + 1 \times \frac{1}{1+e^{90}} \fallingdotseq 4$

$y_3 = \frac{1}{1+e^{-90}} \times 4 \fallingdotseq 4$ ※

t=4

$x = [0,1,1,0]$

$z = [0,1,1,0] \cdot [0,0,0,1] + 0 = 0$

$z_i = [0,1,1,0] \cdot [100,100,0,0] - 10 = 90$

$z_f = [0,1,1,0] \cdot [-100,-100,0,0] + 110 = 10$

$z_o = [0,1,1,0] \cdot [0,0,100,0] - 10 = 90$

$c' = \frac{1}{1+e^{-90}} \times 0 + \frac{1}{1+e^{-10}} \times 4 \fallingdotseq 4$

$y_4 = \frac{1}{1+e^{90}} \times 4 \fallingdotseq 4$ ※

t=5

$x = [0,1,0,2]$

$z = [0,1,0,2] \cdot [0,0,0,1] + 0 = 2$

$z_i = [0,1,0,2] \cdot [100,100,0,0] - 10 = 90$

$z_f = [0,1,0,2] \cdot [-100,-100,0,0] + 110 = 10$

$z_o = [0,1,0,2] \cdot [0,0,100,0] - 10 = -10$

$c' = \frac{1}{1+e^{90}} \times 2 + 4 \times \frac{1}{1+e^{10}} \fallingdotseq 6$

$y_5 = \frac{1}{1+e^{10}} \times 6 \fallingdotseq 0$ ※

t=6 $x = [0,0,1,-4]$

$z = [0,0,1,-4] \cdot [0,0,0,1] + 0 = -4$

$z_i = [0,0,1,-4] \cdot [100,100,0,0] - 10 = -10$

$z_f = [0,0,1,-4] \cdot [-100,-100,0,0] + 110 = 110$

$z_o = [0,0,1,-4] \cdot [0,0,100,0] - 10 = 90$

$c' = \frac{1}{1+e^{10}} \times -4 + 6 \times \frac{1}{1+e^{110}} \fallingdotseq 6$

$y_6 = \frac{1}{1+e^{-90}} \times 6 \fallingdotseq 6$ #

t=7

$x=[1,1,1,1]$

$z=(1111)\cdot[0,0,0,1]+0=1$

$z_1=[1111]\cdot[100100\,00]-10=90$

$z_2=[1111]\cdot[-100-10\,0\,0]+100=-90$

$z_3=[1111]\cdot[0\,0\,100\,0]-10=90$

$c'=\frac{1}{1+e^{-10}}\times 4+6\times\frac{1}{1+e^{-90}}\approx 1$

$y_7=\frac{1}{1+e^{-90}}\times 1\approx 1$

t=8:

$x=[1012]$

$z=[1012]\cdot[0001]+0=2$

$z_1=[1012]\cdot[100100\,0]-10=90$

$z_2=[1012]\cdot[-100-100\,0\,0]+100=10$

$z_3=[1012]\cdot[0\,0\,100\,0]-10=90$

$c'=\frac{1}{1+e^{-90}}\times 2+1\times\frac{1}{1+e^{-10}}\approx 3$

$y_8=\frac{1}{1+e^{-90}}\times 3=3$

Word Embedding.

$$h=W^Tx=\begin{pmatrix} w_{11} & \cdots & w_{1V} \\ w_{12} & & \vdots \\ \vdots & & \\ w_{1N} & & w_{VN} \end{pmatrix}\times\begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_V \end{pmatrix}=\begin{pmatrix} \sum_{i=1}^{V} w_{i1}x_i \\ \sum_{i=1}^{V} w_{i2}x_i \\ \vdots \\ \sum_{i=1}^{V} w_{iN}x_i \end{pmatrix}$$

$$c' = \frac{1}{1+e^{10}} - 4 + 6 \times (1+e^{-10}) \doteq 1$$

$$y_7 = \frac{1}{1+e^{90 \times 1}} \doteq 1$$ #

$$y_8 = \frac{1}{1+e^{90 \times 3}} = 3$$ #

Word Embedding.

$$h = W^T x = \begin{pmatrix} w_{11} & \cdots & w_{v1} \\ w_{12} & & \vdots \\ \vdots & & \vdots \\ w_{1N} & & w_{vN} \end{pmatrix} \times \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_V \end{pmatrix} = \begin{pmatrix} \sum_{i=1}^{V} w_{i1} x_i \\ \sum_{i=1}^{V} w_{i2} x_i \\ \vdots \\ \sum_{i=1}^{V} w_{iN} x_i \end{pmatrix}$$

$$u = w'^T h = \begin{pmatrix} w'_{11} & \cdots & w'_{v1} \\ \vdots & & \vdots \\ \vdots & & \vdots \\ w'_{1N} & \cdots & w'_{vN} \end{pmatrix} \times h = \begin{pmatrix} \sum_{i=1}^{V} \sum_{j=1}^{N} w_{ij} w'_{j1} x_i \\ \sum_{i=1}^{V} \sum_{j=1}^{N} w_{ij} w'_{j2} x_i \\ \vdots \\ \sum_{i=1}^{V} \sum_{j=1}^{N} w_{ij} w'_{jV} x_i \end{pmatrix}$$

$$L = -\log \prod_{c \in C} \frac{\exp(u_c)}{\sum_{r \in V} \exp(u_r)}$$

$$= -\sum_{c \in C} \left[\log(\exp(u_c)) - \log\left(\sum_{r \in V} \exp(u_r)\right) \right]$$

$$= -\sum_{c \in C} u_c - \log\left(\sum_{r \in V} \exp(u_r)\right)$$

$$u_c = \sum_{i=1}^{V} \sum_{j=1}^{N} w_{ij} w'_{jc} x_i$$

$$u_r = \sum_{i=1}^{V} \sum_{j=1}^{N} w_{ij} w'_{jr} x_i$$

$$\frac{\partial L}{\partial w'^{T}_{ij}} = \frac{\partial L}{\partial w'_{ji}} = -\sum_{c \in C} \left(w'_{ic} x_j - \frac{\sum_{r \in V} \exp(u_r) \times w'_{ir} x_j}{\sum_{r \in V} \exp(u_r)} \right)$$ #

$$\frac{\partial L}{\partial w^{T}_{ij}} = \frac{\partial L}{\partial w'_{ji}} = \begin{cases} -\sum_{i=1}^{V} w_{ij} x_i + \sum_{c \in C} \frac{\left(\sum_{i=1}^{V} w_{ij} x_i\right) \exp(u_i)}{\sum_{r \in V} \exp(u_r)} & \text{if } i \in C \\ 0 & \text{if } i \notin C \end{cases}$$