//These models **Do not contain** Agent Can Hit Enemy Operation

//Message for explaining the mathematical forms for functions

- x_1: the difference of health points of agent and enemy
- x_2: the difference of x-coordinate distance of agent and enemy
- x_3: the difference of x-coordinate relative speed of agent and enemy
- x_4: enemy is attacking (Boolean factor, by depending the action the enemy is using)
- x_5: in attack distance (Boolean factor, by depending the distance of agent and enemy)
- x_6: agent is in corner (Boolean factor, by depending the x-coordinate of the agent)

Aggressive model:

Most learned same loss functions(4 times in 500,loss=1420.35):

01110010010100001001001011010010000010001001001000010010000100101001101110000100

$$f_{MoveForward} = \left(x_1 - \frac{1}{1+e^{-(x_1-0.5)}} + x_2 + \frac{e^{x_2}}{2} - x_3 + \frac{e^{x_3}}{2} - \frac{1}{1+e^{-(x_3-0.5)}} + \frac{1-2*x_5}{2}\right)$$

$$f_{Punch} = \left(x_1 - ln(x_1+1) + \frac{1}{1+e^{-(x_1-0.5)}} - ln(x_2+1) + \frac{1}{1+e^{-(x_2-0.5)}} - ln(x_3+1) - \frac{1}{1+e^{-(x_3-0.5)}} + \frac{1-2*x_4}{2} + \frac{2*x_5-1}{2}\right)$$

Training

1420 loss, 6691 Training data:

action	Loss=0	Loss=1
Action0	1882/68.1%	883/31.9%
Action1	3389/86.3%	537/13.7%
In all	**5271/78.8%**	**1420/21.2%**

Testing

341 loss, 1672 testing data

action	Loss=0	Loss=1
Action0	478/69.3%	213/30.9%
Action1	853/87.0%	128/13.0%
In all	**1331/79.6%**	**341/20.4%**

Defensive model:

Most learned same loss functions(3 times in 500,loss=1311.41):

00010110100110010010010001000010000000100010111111101110110110001010110000001

- $f_{MoveBack} = 4 * \left(\frac{e^{x_1}}{2} + \ln(x_1 + 1) - \frac{1}{1+e^{-(x_1-0.5)}} - x_2 + \frac{e^{x_2}}{2} - \ln(x_2 + 1) + \frac{1}{1+e^{-(x_2-0.5)}} - \frac{e^{x_3}}{2} + \ln(x_3 + 1) + \frac{1-2*x_4}{2}\right)$
- $f_{Guard} = 4 * \left(\frac{e^{x_1}}{2} + \ln(x_1 + 1) + \ln(x_2 + 1) + x_3 - \frac{e^{x_3}}{2} + \frac{1-2*x_4}{2} + \frac{1-2*x_5}{2} + \frac{1-2*x_6}{2}\right)$

Training

1311 loss, 7711 Training data:

action	Loss=0	Loss=1
Action0	3328/90.7%	341/9.3%
Action1	3072/76.0%	970/24.0%
In all	**6400/83.0%**	**1311/17.0%**

Testing

329 loss, 1928 testing data

action	Loss=0	Loss=1
Action0	835/91.2%	82/9.0%
Action1	764/75.6%	247/24.4%
In all	**1599/82.9%**	**329/17.1%**

Hybrid(Aggressive -> Defensive) model 1:

Most learned same loss functions(2 times in 500,loss=3821.42):

```
01101110011101001001011000010110000000100100110010110111001
01100000111000010010000110111010000101011111100010000100
00100010000110010010010110011011010000001
```

$$f_{MoveForward} =$$

$$2 * \left(x_1 - \frac{e^{x_1}}{2} - \frac{1}{1+e^{-(x_1-0.5)}} + x_2 + \ln(x_2+1) - x_3 + \frac{e^{x_3}}{2} + \ln(x_3+1) - \frac{1}{1+e^{-(x_3-0.5)}} + \frac{1-2*x_5}{2} + \frac{1-2*x_6}{2} \right)$$

$$f_{Punch} =$$

$$Min\left(\begin{matrix} x_1, -\ln(x_1+1), \ln(x_1+1), -x_2, -\frac{e^{x_2}}{2}, \frac{e^{x_2}}{2}, \ln(x_2+1), \\ -\frac{1}{1+e^{-(x_2-0.5)}}, \frac{1}{1+e^{-(x_2-0.5)}}, \frac{e^{x_3}}{2}, -\ln(x_3+1), \frac{2*x_5-1}{2}, \frac{1-2*x_5}{2}, \frac{2*x_6-1}{2} \end{matrix} \right)$$

- $f_{MoveBack} = 4 *$

$$Min\left(\begin{matrix} -\frac{e^{x_1}}{2}, \frac{e^{x_1}}{2}, \ln(x_1+1), -\frac{1}{1+e^{-(x_1-0.5)}}, \frac{1}{1+e^{-(x_1-0.5)}}, x_2, -\frac{1}{1+e^{-(x_2-0.5)}}, -x_3, \\ -\frac{e^{x_3}}{2}, \frac{e^{x_3}}{2}, -\ln(x_3+1), \ln(x_3+1), -\frac{1}{1+e^{-(x_3-0.5)}}, \frac{1}{1+e^{-(x_3-0.5)}}, \frac{2*x_4-1}{2}, \frac{2*x_6-1}{2} \end{matrix} \right)$$

$$f_{Guard} = 4 * \left(\frac{e^{x_1}}{2} - \ln(x_2+1) + \frac{1}{1+e^{-(x_2-0.5)}} - \frac{e^{x_3}}{2} + \frac{1-2*x_5}{2} + \frac{2*x_6-1}{2} \right)$$

Training

3821 loss, 7207 Training data:

Action	Loss=0	Loss=1	Loss=2	Loss=3
Move forward	1133/61.6%	642/34.9%	62/3.4%	4/0.2%
Punch	2225/85.4%	350/13.4%	29/1.1%	0
Move back	0	0	47/7.8%	557/92.2%
Guard	1704/79.0%	76/3.5%	340/15.8%	38/1.8%
In all	**5062/70.2%**	**1068/14.8%**	**478/6.6%**	**599/8.3%**

Testing

993 loss, 1804 Testing data:

Action	Loss=0	Loss=1	Loss=2	Loss=3
Move forward	279/60.7%	166/36.1%	12/2.6%	4/0.9%
Punch	546/83.7%	102/15.6%	4/0.6%	0
Move back	0	0	8/5.3%	143/94.7%
Guard	416/77.0%	22/4.1%	92/17.0%	10/1.9%
In all	**1241/68.8%**	**290/16.1%**	**116/6.4%**	**157/8.7%**

Wrong outputs of Hybrid(Aggressive ->Defensive) model in testing data

Action	Move forward	Punch	Move back	Guard
Move forward		163	0	19
Punch	74		0	32
Move back	110	18		23
Guard	47	77	0	

Blue part: the hybrid model chooses the "correct" behavior pattern(aggressive behavior), but finally choose "wrong" action in the corresponding pattern.

Red part: the hybrid model chooses the "correct" behavior pattern(defensive behavior), but get "wrong" action finally.

Yellow part: the model get wrong the behavior pattern choices

Hybrid(Defensive -> Aggressive) model 2:

Most learned same loss functions(1 time in 500 (median individual),loss=5037.45):

00111001101101001100010010100110001000000111000110100011101111111001010000010001110010100100100110000010111001000000111001110000000011010110111111100100100

$$f_{MoveForward} = 0.25 * \begin{pmatrix} -\ln(x_1+1) + \frac{1}{1+e^{-(x_1-0.5)}} \\ -x_2 + \ln(x_2+1) + \ln(x_3+1) + \frac{2*x_4-1}{2} + \frac{2*x_5-1}{2} + \frac{1-2*x_6}{2} \end{pmatrix}$$

$$f_{Punch} = 2 * \frac{18}{30} * \left(-\ln(x_1+1) + \frac{e^{x_2}}{2} + \frac{1}{1+e^{-(x_2-0.5)}} + \frac{e^{x_3}}{2} + \frac{2*x_5-1}{2} + \frac{1-2*x_6}{2}\right)$$

- $f_{MoveBack} = 4 * \frac{13}{30} *$

$$\left(-\ln(x_1+1) + \frac{1}{1+e^{-(x_1-0.5)}} + x_2 - \ln(x_2+1) + \frac{1}{1+e^{-(x_2-0.5)}} + \frac{2*x_4-1}{2} + \frac{2*x_6-1}{2}\right)$$

$$f_{Guard} = 0.5 * Max$$

$$\begin{pmatrix} -x_1, x_1, -\ln(x_1+1), \ln(x_1+1), -\frac{1}{1+e^{-(x_1-0.5)}}, \frac{1}{1+e^{-(x_2-0.5)}}, -x_3, -\frac{e^{x_3}}{2}, -\ln(x_3+1), \ln(x_3+1), \\ \frac{1}{1+e^{-(x_3-0.5)}}, \frac{2*x_4-1}{2}, \frac{1-2*x_4}{2}, \frac{2*x_5-1}{2}, \frac{1-2*x_5}{2}, \frac{2*x_6-1}{2}, \frac{1-2*x_6}{2} \end{pmatrix}$$

Training

5029 loss, 7265 Training data:

Action	Loss=0	Loss=1	Loss=2	Loss=3
Move forward	479/36.0%	583/43.8%	180/13.5%	90/6.8%
Punch	615/45.6%	519/38.5%	124/9.2%	90/6.7%
Move back	2112/65.2%	672/20.8%	188/5.8%	266/8.2%
Guard	713/52.9%	335/24.9%	299/22.2%	0
In all	**3919/53.9%**	**2109/29.0%**	**791/10.9%**	**446/6.1%**

Testing

1271 loss, 1818 Testing data:

Action	Loss=0	Loss=1	Loss=2	Loss=3
Move forward	115/34.6%	138/41.6%	52/15.7%	28/8.4%
Punch	172/50.9%	119/35.2%	22/6.5%	25/7.4%
Move back	526/64.9%	167/20.6%	46/5.7%	71/8.8%
Guard	181/53.7%	77/22.8%	79/23.4%	0
In all	**994/54.7%**	**501/27.6%**	**199/10.9%**	**124/6.8%**

Wrong outputs of Hybrid(Defensive ->Aggressive) model in testing data

Action	Move forward	Punch	Move back	Guard
Move forward		30	128	60
Punch	118		25	23
Move back	41	15		228
Guard	48	23	85	

Blue part: the hybrid model chooses the "correct" behavior pattern(aggressive behavior), but finally choose "wrong" action in the corresponding pattern.

Red part: the hybrid model chooses the "correct" behavior pattern(defensive behavior), but get "wrong" action finally.

Yellow part: the model get wrong the behavior pattern choices