

Computer Intelligence

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รายงานผลการทดลองการบ้าน Neural Network

รายละเอียดการทดลองใช้ข้อมูล Flood data set ในการทดลองที่ 1 และได้ใช้ข้อมูล Cross.pat ในการทดลองที่ 2

- ในการทดลองที่ 1 มี 8 Input Features โดยที่มี Input จาก Station 1, Station 2 จะมี Data เป็นความสูงของระดับน้ำในเวลาที่ t-3, t-2, t-1, t-0 จากที่ส่อง Station ให้ Predict หาระดับน้ำที่สะพานน้ำรัตน์ในเวลา t+7 หา 1 Class Output
- ในการทดลองที่ 2 มี 2 Input Features 2 Class Output ให้หาว่าโปรแกรมจะตอบถูก Class รีเปล่าโดยทำการแสดงเป็น Confusion Matrix
- ในการทดลองแต่ละข้อแต่ละครั้งจะทำการ Random Weight, Bias ให้มีค่าไม่เท่ากัน และกำหนด จำนวน Node ในแต่ละและจำนวน Layer, Learning Rate, Momentum Rate ในแต่ละการทดลองให้ไม่เท่ากัน
- นำข้อมูลมาจากการเว็บ <https://sansanee.cpe.eng.cmu.ac.th/IntroCI/Y2019/CompHw1.htm>

ขั้นตอนการ Preprocessing Data

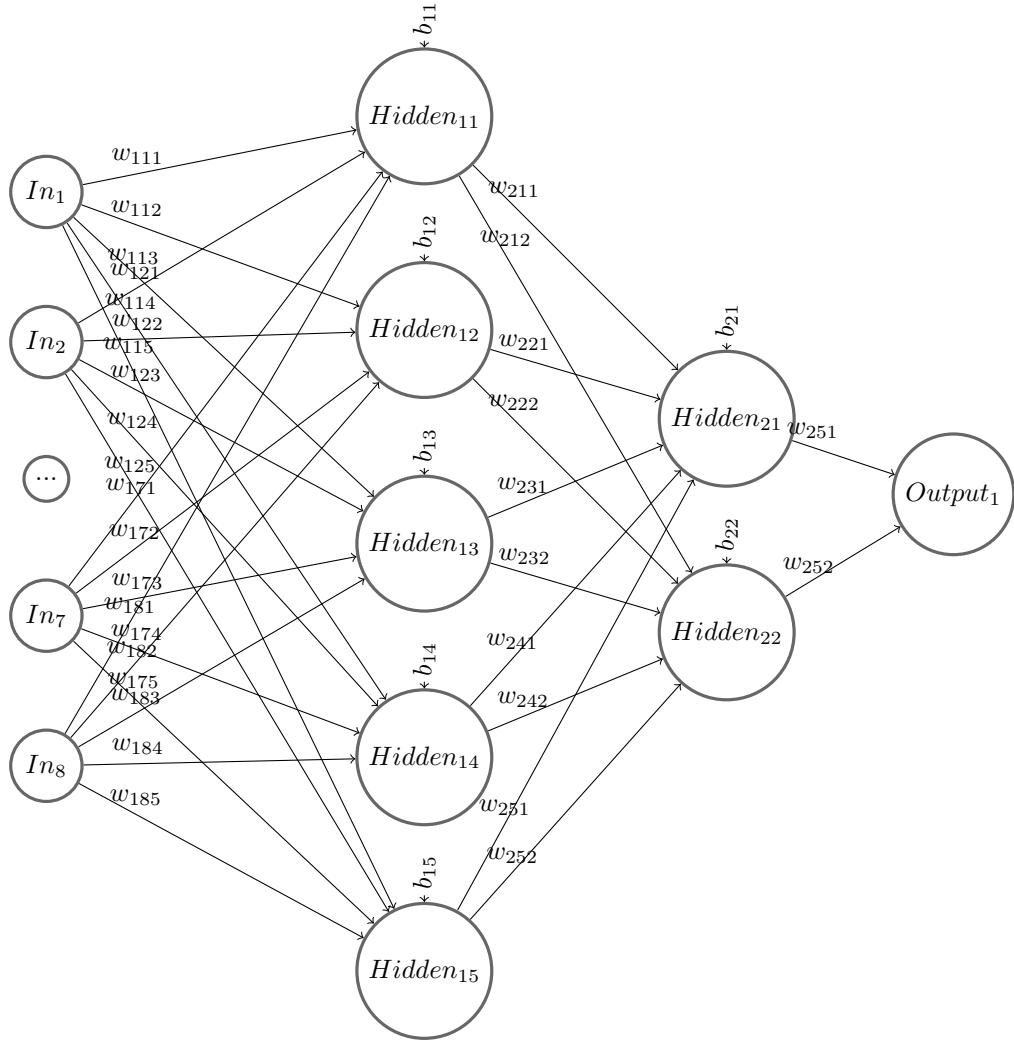
1. การเข้าไปเช็คดู Data ว่าสมบูรณ์รีเปล่า
2. ทำการ Normalize Data ผ่านการทำ Normalization โดย

$$\frac{x - x_{min}}{x_{max} - x_{min}}$$

จะทำให้ Data อยู่ในช่วงระหว่าง [0, 1] ใน Column เดียวกันจะทำการหา x_{max} , x_{min} เพื่อเอามาคิดค่า x แต่ละตัวใน Column

การทดลองที่ 1 เป็นการหาค่า MSE (Mean Square Error)
วิธีการทดลอง 1 ครั้งที่ 1

- การทดลองที่ 1 ทดลองชื่อ 1 โดยโครงสร้าง มี 3 Layer โดยที่ Layer ชั้นแรกมี 5 Node, ชั้นถัดไปมี 2 Node, 1 Output Node, และมี bias ทุกๆ Node



โดยที่ Input Node มีจำนวน Node เท่ากับจำนวน Features ของ Data จะ Predict หาค่า MSE (Mean Square Error) เพื่อหาความถูกต้องของ Data

- โดยที่ Model นี้ มี Learning Rate = 0.1, Momentum Rate = 0.5 กำหนดจำนวน Epoch = 100 epoch

3. สร้าง Cross Validation ขึ้นมา 10 Fold เพื่อทดสอบ Model ที่สร้างขึ้นมา

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 1

Fold 1 Epoch = 1/100, Loss = 0.008269794799764788 Epoch = 2/100, Loss = 0.006985716055587908 Epoch = 3/100, Loss = 0.006912342590740981 Epoch = 4/100, Loss = 0.006898659576150248 Epoch = 5/100, Loss = 0.006889600394625833 Epoch = 6/100, Loss = 0.006881060666834704 Epoch = 7/100, Loss = 0.006871172212542173 Epoch = 8/100, Loss = 0.006857821290865444 Epoch = 9/100, Loss = 0.006838456872357642 Epoch = 10/100, Loss = 0.0068101250941474 Epoch = 11/100, Loss = 0.006769740170419196 Epoch = 12/100, Loss = 0.006714648458024136 Epoch = 13/100, Loss = 0.006643325052037114 Epoch = 14/100, Loss = 0.006555811762281801 Epoch = 15/100, Loss = 0.006453640988957953 Epoch = 16/100, Loss = 0.006339419589707312 Epoch = 17/100, Loss = 0.006216413224596808 Epoch = 18/100, Loss = 0.0060882667082868035 Epoch = 19/100, Loss = 0.005958797523476485 Epoch = 20/100, Loss = 0.005831778498848832 Epoch = 21/100, Loss = 0.005710683695164203 Epoch = 22/100, Loss = 0.005598422875487741 Epoch = 23/100, Loss = 0.005497126940187702 Epoch = 24/100, Loss = 0.005408877494762284 Epoch = 25/100, Loss = 0.005331890273575099 Epoch = 26/100, Loss = 0.005269054244989582 Epoch = 27/100, Loss = 0.005220680139215726 Epoch = 28/100, Loss = 0.005188670340274289 Epoch = 29/100, Loss = 0.005174320026220032 Epoch = 30/100, Loss = 0.00517669298031997 Epoch = 31/100, Loss = 0.005193189503078672 Epoch = 32/100, Loss = 0.005221464435155338 Epoch = 33/100, Loss = 0.005260809351775129 Epoch = 34/100, Loss = 0.005312714235728285 Epoch = 35/100, Loss = 0.005381119350647498 Epoch = 36/100, Loss = 0.0054722616379267895 Epoch = 37/100, Loss = 0.005591800507039849 Epoch = 38/100, Loss = 0.005735140440352575 Epoch = 39/100, Loss = 0.005882850155743524 Epoch = 40/100, Loss = 0.0060258026305392 Epoch = 41/100, Loss = 0.006175314842943757 Epoch = 42/100, Loss = 0.006339708582675777 Epoch = 43/100, Loss = 0.0065178744472157634 Epoch = 44/100, Loss = 0.006705373401882334 Epoch = 45/100, Loss = 0.006897786815696556 Epoch = 46/100, Loss = 0.007091298789334014 Epoch = 47/100, Loss = 0.007282555972388059 Epoch = 48/100, Loss = 0.007468546560444498 Epoch = 49/100, Loss = 0.007646615253963658 Epoch = 50/100, Loss = 0.00781456151639976	Epoch = 51/100, Loss = 0.007970744723414665 Epoch = 52/100, Loss = 0.008114140463468849 Epoch = 53/100, Loss = 0.008244324529473879 Epoch = 54/100, Loss = 0.00836138991826838 Epoch = 55/100, Loss = 0.008465820046370066 Epoch = 56/100, Loss = 0.00855834636170437 Epoch = 57/100, Loss = 0.008639812832630557 Epoch = 58/100, Loss = 0.008711858470339266 Epoch = 59/100, Loss = 0.008772817243558665 Epoch = 60/100, Loss = 0.008825625488036087 Epoch = 61/100, Loss = 0.008869720938210458 Epoch = 62/100, Loss = 0.008904915277703514 Epoch = 63/100, Loss = 0.008930427297149286 Epoch = 64/100, Loss = 0.008944687863415955 Epoch = 65/100, Loss = 0.00894519291009439 Epoch = 66/100, Loss = 0.008928607371276088 Epoch = 67/100, Loss = 0.008891487608407774 Epoch = 68/100, Loss = 0.008832025025468114 Epoch = 69/100, Loss = 0.008752515462264729 Epoch = 70/100, Loss = 0.008660151130237293 Epoch = 71/100, Loss = 0.008563518765223882 Epoch = 72/100, Loss = 0.008468000195748662 Epoch = 73/100, Loss = 0.00837589298527485 Epoch = 74/100, Loss = 0.008284451536638447 Epoch = 75/100, Loss = 0.008195638815437709 Epoch = 76/100, Loss = 0.008109826420637695 Epoch = 77/100, Loss = 0.00802617523809316 Epoch = 78/100, Loss = 0.007949616577686596 Epoch = 79/100, Loss = 0.007881924570812174 Epoch = 80/100, Loss = 0.0078246548099819205 Epoch = 81/100, Loss = 0.0077779627088103145 Epoch = 82/100, Loss = 0.007740958437349349 Epoch = 83/100, Loss = 0.00771227237190385 Epoch = 84/100, Loss = 0.007690462673318398 Epoch = 85/100, Loss = 0.007674214877307941 Epoch = 86/100, Loss = 0.007662407243356021 Epoch = 87/100, Loss = 0.007654111406852511 Epoch = 88/100, Loss = 0.007648568439927386 Epoch = 89/100, Loss = 0.007645159369797459 Epoch = 90/100, Loss = 0.0076433779877178 Epoch = 91/100, Loss = 0.007642888419430729 Epoch = 92/100, Loss = 0.0076431075630989725 Epoch = 93/100, Loss = 0.007643991613633917 Epoch = 94/100, Loss = 0.007645225707582908 Epoch = 95/100, Loss = 0.007646615836417231 Epoch = 96/100, Loss = 0.0076480023799124835 Epoch = 97/100, Loss = 0.007649254887455746 Epoch = 98/100, Loss = 0.007650267247860269 Epoch = 99/100, Loss = 0.007650954733537327 Epoch = 100/100, Loss = 0.007651249991562101 MSE = 0.0728917061535293
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รูปที่ 1: Fold ที่ 1 ครั้งแรก

รูปที่ 2: Fold ที่ 1 ครั้งหลัง

ค่า MSE = 0.0728917061535293

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 2

Fold 2	
Epoch = 1/100, Loss = 0.002900360347070784	Epoch = 51/100, Loss = 0.004512610140622376
Epoch = 2/100, Loss = 0.00311795259457795643	Epoch = 52/100, Loss = 0.004511350644627647
Epoch = 3/100, Loss = 0.0033179039802018226	Epoch = 53/100, Loss = 0.004510057235566805
Epoch = 4/100, Loss = 0.003520164299198556	Epoch = 54/100, Loss = 0.004508725560684613
Epoch = 5/100, Loss = 0.0037176537487963873	Epoch = 55/100, Loss = 0.00450736032755789
Epoch = 6/100, Loss = 0.003902296219000883	Epoch = 56/100, Loss = 0.0045059601790564075
Epoch = 7/100, Loss = 0.00406556544917076	Epoch = 57/100, Loss = 0.004504525249575528
Epoch = 8/100, Loss = 0.004199559370539395	Epoch = 58/100, Loss = 0.004503055650165968
Epoch = 9/100, Loss = 0.004301095897460282	Epoch = 59/100, Loss = 0.004501551466476648
Epoch = 10/100, Loss = 0.004373563591366601	Epoch = 60/100, Loss = 0.004500012757323134
Epoch = 11/100, Loss = 0.004423912500096096	Epoch = 61/100, Loss = 0.00449843953880994
Epoch = 12/100, Loss = 0.0044588750299151955	Epoch = 62/100, Loss = 0.004496831859192054
Epoch = 13/100, Loss = 0.004483349514916301	Epoch = 63/100, Loss = 0.004495189648106144
Epoch = 14/100, Loss = 0.004500563603324562	Epoch = 64/100, Loss = 0.004493512867466958
Epoch = 15/100, Loss = 0.0045123967607171266	Epoch = 65/100, Loss = 0.004491801436534355
Epoch = 16/100, Loss = 0.004520461832200451	Epoch = 66/100, Loss = 0.004490055247603465
Epoch = 17/100, Loss = 0.004525752343484696	Epoch = 67/100, Loss = 0.004488274166808874
Epoch = 18/100, Loss = 0.004529082784270199	Epoch = 68/100, Loss = 0.004486458035112606
Epoch = 19/100, Loss = 0.004531091142041009	Epoch = 69/100, Loss = 0.00448466669493786
Epoch = 20/100, Loss = 0.004532249588706698	Epoch = 70/100, Loss = 0.00448271986437791
Epoch = 21/100, Loss = 0.004532875904332147	Epoch = 71/100, Loss = 0.004488797393357152
Epoch = 22/100, Loss = 0.0045331654957654484	Epoch = 72/100, Loss = 0.00447839011277488
Epoch = 23/100, Loss = 0.0045332329481002995	Epoch = 73/100, Loss = 0.004476844456792577
Epoch = 24/100, Loss = 0.004533145504774782	Epoch = 74/100, Loss = 0.004474813455509282
Epoch = 25/100, Loss = 0.004532944185431238	Epoch = 75/100, Loss = 0.0044727457238885
Epoch = 26/100, Loss = 0.0045326551292600837	Epoch = 76/100, Loss = 0.004470640974101795
Epoch = 27/100, Loss = 0.00453296592768418	Epoch = 77/100, Loss = 0.004468498920098197
Epoch = 28/100, Loss = 0.004531881337381298	Epoch = 78/100, Loss = 0.004466319285200311
Epoch = 29/100, Loss = 0.0045314186744559466	Epoch = 79/100, Loss = 0.004464101811623461
Epoch = 30/100, Loss = 0.0045309152846067825	Epoch = 80/100, Loss = 0.004461846272418596
Epoch = 31/100, Loss = 0.00453037578123786	Epoch = 81/100, Loss = 0.00445955248645518
Epoch = 32/100, Loss = 0.004529803132441094	Epoch = 82/100, Loss = 0.004457220337227888
Epoch = 33/100, Loss = 0.004529199020053919	Epoch = 83/100, Loss = 0.004454849796457262
Epoch = 34/100, Loss = 0.00452856415899167	Epoch = 84/100, Loss = 0.004452440953711464
Epoch = 35/100, Loss = 0.004527898577436632	Epoch = 85/100, Loss = 0.004449994053579233
Epoch = 36/100, Loss = 0.004527201853224237	Epoch = 86/100, Loss = 0.004447509542313144
Epoch = 37/100, Loss = 0.004526473303756697	Epoch = 87/100, Loss = 0.0044449988126346229
Epoch = 38/100, Loss = 0.004525712130639898	Epoch = 88/100, Loss = 0.004442430845671278
Epoch = 39/100, Loss = 0.004524917523506652	Epoch = 89/100, Loss = 0.004439839165797598
Epoch = 40/100, Loss = 0.004524088729341178	Epoch = 90/100, Loss = 0.0044423159928592684
Epoch = 41/100, Loss = 0.004523225094391794	Epoch = 91/100, Loss = 0.004434561317457003
Epoch = 42/100, Loss = 0.004522326085115383	Epoch = 92/100, Loss = 0.0044318813939399826
Epoch = 43/100, Loss = 0.004521391294192728	Epoch = 93/100, Loss = 0.004429179963009643
Epoch = 44/100, Loss = 0.0045204204362812	Epoch = 94/100, Loss = 0.0044264630265974545
Epoch = 45/100, Loss = 0.004519413337302251	Epoch = 95/100, Loss = 0.004423738284645253
Epoch = 46/100, Loss = 0.00451836992007705	Epoch = 96/100, Loss = 0.004421015543157796
Epoch = 47/100, Loss = 0.004517290188344948	Epoch = 97/100, Loss = 0.004418307200831015
Epoch = 48/100, Loss = 0.004516174210570607	Epoch = 98/100, Loss = 0.0044156288162424855
Epoch = 49/100, Loss = 0.004515022104462762	Epoch = 99/100, Loss = 0.004412999746859665
Epoch = 50/100, Loss = 0.004513834022765489	MSE = 0.07019465553786267

รูปที่ 3: Fold ที่ 2 คริ่งแรก

รูปที่ 4: Fold ที่ 2 คริ่งหลัง

ค่า MSE = 0.07019465553786267

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 3

Fold 3	
Epoch = 1/100, Loss = 0.0026134958725185175	Epoch = 51/100, Loss = 0.003898598592742757
Epoch = 2/100, Loss = 0.0036856175998813634	Epoch = 52/100, Loss = 0.0038986359933183053
Epoch = 3/100, Loss = 0.003804776317931566	Epoch = 53/100, Loss = 0.003898699689127643
Epoch = 4/100, Loss = 0.0038526358381841493	Epoch = 54/100, Loss = 0.00389875382292188
Epoch = 5/100, Loss = 0.003889119883516446	Epoch = 55/100, Loss = 0.0038987978016200215
Epoch = 6/100, Loss = 0.003917855413387093	Epoch = 56/100, Loss = 0.00389835510535909
Epoch = 7/100, Loss = 0.00393929459060881	Epoch = 57/100, Loss = 0.003898867443778512
Epoch = 8/100, Loss = 0.003953903258755543	Epoch = 58/100, Loss = 0.003898894689666514
Epoch = 9/100, Loss = 0.003962305303098999	Epoch = 59/100, Loss = 0.0038989181682811467
Epoch = 10/100, Loss = 0.003965261625009922	Epoch = 60/100, Loss = 0.003898938655948321
Epoch = 11/100, Loss = 0.0039636423208654166	Epoch = 61/100, Loss = 0.0038989568064154863
Epoch = 12/100, Loss = 0.003958395601833554	Epoch = 62/100, Loss = 0.003898973169102964
Epoch = 13/100, Loss = 0.003950507733610116	Epoch = 63/100, Loss = 0.0038989882047820745
Epoch = 14/100, Loss = 0.003940953352635765	Epoch = 64/100, Loss = 0.0038990022990237744
Epoch = 15/100, Loss = 0.003930640135019944	Epoch = 65/100, Loss = 0.003899015773685263
Epoch = 16/100, Loss = 0.003920356300012936	Epoch = 66/100, Loss = 0.003899028896727111
Epoch = 17/100, Loss = 0.003910730465478008	Epoch = 67/100, Loss = 0.003899041890575366
Epoch = 18/100, Loss = 0.003902210774546819	Epoch = 68/100, Loss = 0.0038990549392398843
Epoch = 19/100, Loss = 0.003895065339872881	Epoch = 69/100, Loss = 0.0038990681943642997
Epoch = 20/100, Loss = 0.0038894811216097147	Epoch = 70/100, Loss = 0.0038990817803640308
Epoch = 21/100, Loss = 0.0038851951236353465	Epoch = 71/100, Loss = 0.003899095798782877
Epoch = 22/100, Loss = 0.0038822330863741868	Epoch = 72/100, Loss = 0.0038991103319840994
Epoch = 23/100, Loss = 0.00388063402626653	Epoch = 73/100, Loss = 0.003899125446276157
Epoch = 24/100, Loss = 0.0038799031505625456	Epoch = 74/100, Loss = 0.003899141194554415
Epoch = 25/100, Loss = 0.003879933304900565	Epoch = 75/100, Loss = 0.003899157618533075
Epoch = 26/100, Loss = 0.003880532487696256	Epoch = 76/100, Loss = 0.003899174750629567
Epoch = 27/100, Loss = 0.003881530979198693	Epoch = 77/100, Loss = 0.00389919261555236
Epoch = 28/100, Loss = 0.003882786661353329	Epoch = 78/100, Loss = 0.0038992112316375833
Epoch = 29/100, Loss = 0.003884184970393874	Epoch = 79/100, Loss = 0.0038992306119739646
Epoch = 30/100, Loss = 0.0038856376102500063	Epoch = 80/100, Loss = 0.0038992507653470543
Epoch = 31/100, Loss = 0.003887079414997724	Epoch = 81/100, Loss = 0.0038992716970310624
Epoch = 32/100, Loss = 0.0038884647822835615	Epoch = 82/100, Loss = 0.0038992934094515645
Epoch = 33/100, Loss = 0.003897635620127493	Epoch = 83/100, Loss = 0.0038993159027396946
Epoch = 34/100, Loss = 0.00389958398758022	Epoch = 84/100, Loss = 0.0038993391751940085
Epoch = 35/100, Loss = 0.00389204089546742	Epoch = 85/100, Loss = 0.0038993632236641236
Epoch = 36/100, Loss = 0.003893009463123367	Epoch = 86/100, Loss = 0.0038993880438700636
Epoch = 37/100, Loss = 0.00389386715636462	Epoch = 87/100, Loss = 0.0038994136306649174
Epoch = 38/100, Loss = 0.003894620151296589	Epoch = 88/100, Loss = 0.003899439978253082
Epoch = 39/100, Loss = 0.003895276323118283	Epoch = 89/100, Loss = 0.0038994670883674503
Epoch = 40/100, Loss = 0.0038958445338935284	Epoch = 90/100, Loss = 0.003899494930414624
Epoch = 41/100, Loss = 0.003896333893327319	Epoch = 91/100, Loss = 0.003899523521594215
Epoch = 42/100, Loss = 0.003896753339968707	Epoch = 92/100, Loss = 0.003899528469925158
Epoch = 43/100, Loss = 0.0038971113591177763	Epoch = 93/100, Loss = 0.0038995828996592854
Epoch = 44/100, Loss = 0.003897415815925013	Epoch = 94/100, Loss = 0.0038996136726676947
Epoch = 45/100, Loss = 0.003897673871249203	Epoch = 95/100, Loss = 0.003899645159168914
Epoch = 46/100, Loss = 0.003897891955016134	Epoch = 96/100, Loss = 0.0038996773523884646
Epoch = 47/100, Loss = 0.0038980757779528536	Epoch = 97/100, Loss = 0.003899710245732816
Epoch = 48/100, Loss = 0.003898230367582447	Epoch = 98/100, Loss = 0.003899743832728813
Epoch = 49/100, Loss = 0.0038983601183024165	Epoch = 99/100, Loss = 0.0038997781070774047
Epoch = 50/100, Loss = 0.003898468848180905	Epoch = 100/100, Loss = 0.003899813062653757 MSE = 0.04781115546879303

รูปที่ 5: Fold ที่ 3 ครั้งแรก

รูปที่ 6: Fold ที่ 3 ครั้งหลัง

ค่า MSE = 0.04781115546879303

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 4

Fold 4

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Epoch = 1/100, Loss = 0.0053526418598490305
Epoch = 2/100, Loss = 0.005484288660106494
Epoch = 3/100, Loss = 0.005478227773202593
Epoch = 4/100, Loss = 0.005467810870287318
Epoch = 5/100, Loss = 0.005460484496469575
Epoch = 6/100, Loss = 0.005457064966282753
Epoch = 7/100, Loss = 0.005457122039917068
Epoch = 8/100, Loss = 0.0054597566813057545
Epoch = 9/100, Loss = 0.00546083688658318
Epoch = 10/100, Loss = 0.005469429171011974
Epoch = 11/100, Loss = 0.00547533195140789
Epoch = 12/100, Loss = 0.005481477383314916
Epoch = 13/100, Loss = 0.005487633899400161
Epoch = 14/100, Loss = 0.0054936111995032724
Epoch = 15/100, Loss = 0.0054992434072654445
Epoch = 16/100, Loss = 0.005504373251573064
Epoch = 17/100, Loss = 0.005508858949259271
Epoch = 18/100, Loss = 0.005512571964099358
Epoch = 19/100, Loss = 0.005515400140715246
Epoch = 20/100, Loss = 0.00551724958346877
Epoch = 21/100, Loss = 0.005518045674721345
Epoch = 22/100, Loss = 0.005517733188071755
Epoch = 23/100, Loss = 0.005516275554619753
Epoch = 24/100, Loss = 0.005513653630278662
Epoch = 25/100, Loss = 0.005509863875703906
Epoch = 26/100, Loss = 0.0055049164055450215
Epoch = 27/100, Loss = 0.005498832888077896
Epoch = 28/100, Loss = 0.005491644468693897
Epoch = 29/100, Loss = 0.005483389795764298
Epoch = 30/100, Loss = 0.005474113207404155
Epoch = 31/100, Loss = 0.005463863114047735
Epoch = 32/100, Loss = 0.005452690592782722
Epoch = 33/100, Loss = 0.005440648195013826
Epoch = 34/100, Loss = 0.0054277889587525194
Epoch = 35/100, Loss = 0.005414165610066158
Epoch = 36/100, Loss = 0.005399829934283353
Epoch = 37/100, Loss = 0.005384832295790182
Epoch = 38/100, Loss = 0.005369221285083167
Epoch = 39/100, Loss = 0.005353043472659629
Epoch = 40/100, Loss = 0.005336343250928595
Epoch = 41/100, Loss = 0.005319162747304663
Epoch = 42/100, Loss = 0.005301541793774565
Epoch = 43/100, Loss = 0.005283517940342892
Epoch = 44/100, Loss = 0.005265126501763412
Epoch = 45/100, Loss = 0.00524640062879267
Epoch = 46/100, Loss = 0.005227371396862888
Epoch = 47/100, Loss = 0.00520806790633202
Epoch = 48/100, Loss = 0.005188517389983987
Epoch = 49/100, Loss = 0.0051687453240668755
Epoch = 50/100, Loss = 0.005148775540315025

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Epoch = 51/100, Loss = 0.005128630336919645
Epoch = 52/100, Loss = 0.005108330587014427
Epoch = 53/100, Loss = 0.005087895843679942
Epoch = 54/100, Loss = 0.005067344400813355
Epoch = 55/100, Loss = 0.005046693589485163
Epoch = 56/100, Loss = 0.005025959469613698
Epoch = 57/100, Loss = 0.005005157316942364
Epoch = 58/100, Loss = 0.004984301505426807
Epoch = 59/100, Loss = 0.004963405625221364
Epoch = 60/100, Loss = 0.004942482556517906
Epoch = 61/100, Loss = 0.004921544539527539
Epoch = 62/100, Loss = 0.004900603240925698
Epoch = 63/100, Loss = 0.004879669817096418
Epoch = 64/100, Loss = 0.004858754974516311
Epoch = 65/100, Loss = 0.004837869027621851
Epoch = 66/100, Loss = 0.00481702195450868
Epoch = 67/100, Loss = 0.004796223450751436
Epoch = 68/100, Loss = 0.004775482981823067
Epoch = 69/100, Loss = 0.004754809834174742
Epoch = 70/100, Loss = 0.004734213165568892
Epoch = 71/100, Loss = 0.004713702054750693
Epoch = 72/100, Loss = 0.004693285550981037
Epoch = 73/100, Loss = 0.0046729727234397596
Epoch = 74/100, Loss = 0.004652772711064435
Epoch = 75/100, Loss = 0.004632694772945178
Epoch = 76/100, Loss = 0.004612748339604185
Epoch = 77/100, Loss = 0.004592943065436147
Epoch = 78/100, Loss = 0.00457328882574384
Epoch = 79/100, Loss = 0.004553796056453659
Epoch = 80/100, Loss = 0.004534475243331354
Epoch = 81/100, Loss = 0.00451537550024432
Epoch = 82/100, Loss = 0.004496394596104189
Epoch = 83/100, Loss = 0.0044776585787913116
Epoch = 84/100, Loss = 0.00445914234076235
Epoch = 85/100, Loss = 0.0044408594410694615
Epoch = 86/100, Loss = 0.004422842293354765
Epoch = 87/100, Loss = 0.004405050192335529
Epoch = 88/100, Loss = 0.004387558690179
Epoch = 89/100, Loss = 0.00437036173068813
Epoch = 90/100, Loss = 0.00435479367590817
Epoch = 91/100, Loss = 0.004336931136659706
Epoch = 92/100, Loss = 0.0043207378808989534
Epoch = 93/100, Loss = 0.0043049121847164569
Epoch = 94/100, Loss = 0.004289506784561241
Epoch = 95/100, Loss = 0.004274518043681605
Epoch = 96/100, Loss = 0.004259982675464998
Epoch = 97/100, Loss = 0.00424592952807553
Epoch = 98/100, Loss = 0.00423289339778262
Epoch = 99/100, Loss = 0.004219394825271094
Epoch = 100/100, Loss = 0.004206980752330154
MSE = 0.03078781474027614

```

รูปที่ 7: Fold ที่ 4 ครั้งแรก

รูปที่ 8: Fold ที่ 4 ครั้งหลัง

$$\text{ค่า MSE} = 0.03078781474027614$$

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 5

<p>Fold 5</p> <pre> Epoch = 1/100, Loss = 0.00520521611810674 Epoch = 2/100, Loss = 0.0032259337272338956 Epoch = 3/100, Loss = 0.002540401079533273 Epoch = 4/100, Loss = 0.002311324804792783 Epoch = 5/100, Loss = 0.002266746873321282 Epoch = 6/100, Loss = 0.002298142882838726 Epoch = 7/100, Loss = 0.0023578026831078397 Epoch = 8/100, Loss = 0.0024246577416702562 Epoch = 9/100, Loss = 0.0024897991701483464 Epoch = 10/100, Loss = 0.00254983340239991 Epoch = 11/100, Loss = 0.0026038153370227485 Epoch = 12/100, Loss = 0.002651842416193986 Epoch = 13/100, Loss = 0.0026944159235981723 Epoch = 14/100, Loss = 0.0027321553292315084 Epoch = 15/100, Loss = 0.0027656751275149595 Epoch = 16/100, Loss = 0.0027955362976948704 Epoch = 17/100, Loss = 0.002822231606090385 Epoch = 18/100, Loss = 0.002846185718395129 Epoch = 19/100, Loss = 0.0028677612435648488 Epoch = 20/100, Loss = 0.0028872666201749915 Epoch = 21/100, Loss = 0.0029049564029808504 Epoch = 22/100, Loss = 0.002921876600030582 Epoch = 23/100, Loss = 0.00293579466327145 Epoch = 24/100, Loss = 0.0029492810644884512 Epoch = 25/100, Loss = 0.0029616756036251156 Epoch = 26/100, Loss = 0.00297309872887981 Epoch = 27/100, Loss = 0.002983654598071789 Epoch = 28/100, Loss = 0.0029934333614736907 Epoch = 29/100, Loss = 0.003002514531036545 Epoch = 30/100, Loss = 0.0030109661948114837 Epoch = 31/100, Loss = 0.003018849004704777 Epoch = 32/100, Loss = 0.003026216125724509 Epoch = 33/100, Loss = 0.003033114507949287 Epoch = 34/100, Loss = 0.003039585743124326 Epoch = 35/100, Loss = 0.0030456667874145076 Epoch = 36/100, Loss = 0.0030513985733291114 Epoch = 37/100, Loss = 0.003056786529588361 Epoch = 38/100, Loss = 0.003061881024275139 Epoch = 39/100, Loss = 0.003066697743847011 Epoch = 40/100, Loss = 0.0030712580183440744 Epoch = 41/100, Loss = 0.0030755811013141172 Epoch = 42/100, Loss = 0.0030796844115018973 Epoch = 43/100, Loss = 0.0030835837421494343 Epoch = 44/100, Loss = 0.0030887293442773246 Epoch = 45/100, Loss = 0.0030908265774816372 Epoch = 46/100, Loss = 0.0030941950632348957 Epoch = 47/100, Loss = 0.003097409790967727 Epoch = 48/100, Loss = 0.0031004807315633074 Epoch = 49/100, Loss = 0.003103417029975748 Epoch = 50/100, Loss = 0.003106227087127559 </pre>	<pre> Epoch = 51/100, Loss = 0.0031089186331498945 Epoch = 52/100, Loss = 0.003111498791957124 Epoch = 53/100, Loss = 0.0031139741386454695 Epoch = 54/100, Loss = 0.0031163587505725537 Epoch = 55/100, Loss = 0.0031186342529659175 Epoch = 56/100, Loss = 0.0031208298593192393 Epoch = 57/100, Loss = 0.0031229424884223915 Epoch = 58/100, Loss = 0.003124976396432872 Epoch = 59/100, Loss = 0.0031269360065287353 Epoch = 60/100, Loss = 0.0031288251352659955 Epoch = 61/100, Loss = 0.003130647163939973 Epoch = 62/100, Loss = 0.0031324062423601974 Epoch = 63/100, Loss = 0.003134104783759367 Epoch = 64/100, Loss = 0.0031357460069506597 Epoch = 65/100, Loss = 0.0031373326900392263 Epoch = 66/100, Loss = 0.003138867437395061 Epoch = 67/100, Loss = 0.0031403526928617444 Epoch = 68/100, Loss = 0.0031417907517897565 Epoch = 69/100, Loss = 0.0031431837720136335 Epoch = 70/100, Loss = 0.0031445337838786527 Epoch = 71/100, Loss = 0.0031458426994109448 Epoch = 72/100, Loss = 0.0031471123287146056 Epoch = 73/100, Loss = 0.003148344347670029 Epoch = 74/100, Loss = 0.003149540385000065 Epoch = 75/100, Loss = 0.0031507019487631285 Epoch = 76/100, Loss = 0.003151830472326453 Epoch = 77/100, Loss = 0.0031529273118670177 Epoch = 78/100, Loss = 0.0031539937514428267 Epoch = 79/100, Loss = 0.0031558310076729733 Epoch = 80/100, Loss = 0.00315604823406088923 Epoch = 81/100, Loss = 0.003157022524992087 Epoch = 82/100, Loss = 0.0031579789194341734 Epoch = 83/100, Loss = 0.0031589104043648055 Epoch = 84/100, Loss = 0.0031598179179502476 Epoch = 85/100, Loss = 0.0031607023524954448 Epoch = 86/100, Loss = 0.0031615645571843524 Epoch = 87/100, Loss = 0.0031624053406276807 Epoch = 88/100, Loss = 0.003163225473233394 Epoch = 89/100, Loss = 0.003164025689414376 Epoch = 90/100, Loss = 0.00316406689645751 Epoch = 91/100, Loss = 0.0031655691423838816 Epoch = 92/100, Loss = 0.0031663136858575028 Epoch = 93/100, Loss = 0.0031670489297408974 Epoch = 94/100, Loss = 0.0031677514567179255 Epoch = 95/100, Loss = 0.0031684458239451895 Epoch = 96/100, Loss = 0.003169124564421603 Epoch = 97/100, Loss = 0.003169781882715314 Epoch = 98/100, Loss = 0.003170437183947411 Epoch = 99/100, Loss = 0.00317107201935796 Epoch = 100/100, Loss = 0.003171693142927052 MSE = 0.05509968038769853 </pre>
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รูปที่ 9: Fold ที่ 5 ครั้งแรก

รูปที่ 10: Fold ที่ 5 ครั้งหลัง

ค่า MSE = 0.05509968038769853

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 6

Fold 6

```
Epoch = 1/100, Loss = 0.007360142895224479
Epoch = 2/100, Loss = 0.006463824786921681
Epoch = 3/100, Loss = 0.006386021232218621
Epoch = 4/100, Loss = 0.006445204904518914
Epoch = 5/100, Loss = 0.006520122238168554
Epoch = 6/100, Loss = 0.00658297259157885
Epoch = 7/100, Loss = 0.006639657837283113
Epoch = 8/100, Loss = 0.00668109477731093
Epoch = 9/100, Loss = 0.006712650291852941
Epoch = 10/100, Loss = 0.0067364173723185395
Epoch = 11/100, Loss = 0.006754212122945499
Epoch = 12/100, Loss = 0.0067657584484312854
Epoch = 13/100, Loss = 0.00677440795519466
Epoch = 14/100, Loss = 0.006784895316948967
Epoch = 15/100, Loss = 0.006790525434474202
Epoch = 16/100, Loss = 0.006794828895820253
Epoch = 17/100, Loss = 0.006798144292845843
Epoch = 18/100, Loss = 0.006800762914964398
Epoch = 19/100, Loss = 0.0068028731705208896
Epoch = 20/100, Loss = 0.006804619014215669
Epoch = 21/100, Loss = 0.006806105711006723
Epoch = 22/100, Loss = 0.0068074100530490286
Epoch = 23/100, Loss = 0.006808587912403456
Epoch = 24/100, Loss = 0.006809679810280627
Epoch = 25/100, Loss = 0.0068107150169801015
Epoch = 26/100, Loss = 0.006811714566894648
Epoch = 27/100, Loss = 0.006812693473932997
Epoch = 28/100, Loss = 0.006813662358327686
Epoch = 29/100, Loss = 0.006814628648418071
Epoch = 30/100, Loss = 0.006815597415999758
Epoch = 31/100, Loss = 0.0068165720975791
Epoch = 32/100, Loss = 0.006817554883584801
Epoch = 33/100, Loss = 0.006818547101189418
Epoch = 34/100, Loss = 0.006819549456327479
Epoch = 35/100, Loss = 0.006820562215619705
Epoch = 36/100, Loss = 0.0068215853383821485
Epoch = 37/100, Loss = 0.006822618572089819
Epoch = 38/100, Loss = 0.006823661521126247
Epoch = 39/100, Loss = 0.006824713696043545
Epoch = 40/100, Loss = 0.006825774548637844
Epoch = 41/100, Loss = 0.006826843496731867
Epoch = 42/100, Loss = 0.006827919941515836
Epoch = 43/100, Loss = 0.006829003279531192
Epoch = 44/100, Loss = 0.006830092918819123
Epoch = 45/100, Loss = 0.006831188244341062
Epoch = 46/100, Loss = 0.006832288701474984
Epoch = 47/100, Loss = 0.006833393718167467
Epoch = 48/100, Loss = 0.006834502746159835
Epoch = 49/100, Loss = 0.0068356152535862975
```

```
Epoch = 51/100, Loss = 0.006837848662068254
Epoch = 52/100, Loss = 0.0068389685817630665
Epoch = 53/100, Loss = 0.006840890017579913
Epoch = 54/100, Loss = 0.0068412125183700155
Epoch = 55/100, Loss = 0.006842335648894131
Epoch = 56/100, Loss = 0.0068434589854251115
Epoch = 57/100, Loss = 0.0068445821233658844
Epoch = 58/100, Loss = 0.00684579468889411
Epoch = 59/100, Loss = 0.006846826242602122
Epoch = 60/100, Loss = 0.006847946478431092
Epoch = 61/100, Loss = 0.006849065823333035
Epoch = 62/100, Loss = 0.006850181537023259
Epoch = 63/100, Loss = 0.006851295691720871
Epoch = 64/100, Loss = 0.006852407171980755
Epoch = 65/100, Loss = 0.006853515674184237
Epoch = 66/100, Loss = 0.006854620906638782
Epoch = 67/100, Loss = 0.006855722589444338
Epoch = 68/100, Loss = 0.006856820453844023
Epoch = 69/100, Loss = 0.00685791424234592
Epoch = 70/100, Loss = 0.006859003708438346
Epoch = 71/100, Loss = 0.006860088616385493
Epoch = 72/100, Loss = 0.00686116874102286
Epoch = 73/100, Loss = 0.006862243867551362
Epoch = 74/100, Loss = 0.006863313791330149
Epoch = 75/100, Loss = 0.006864378317667353
Epoch = 76/100, Loss = 0.00686543726169096
Epoch = 77/100, Loss = 0.0068664904477260934
Epoch = 78/100, Loss = 0.006867537709898906
Epoch = 79/100, Loss = 0.0068685788911006535
Epoch = 80/100, Loss = 0.00686961384317838
Epoch = 81/100, Loss = 0.00687064242663311
Epoch = 82/100, Loss = 0.006871664518039868
Epoch = 83/100, Loss = 0.0068726799716192786
Epoch = 84/100, Loss = 0.006873688695427622
Epoch = 85/100, Loss = 0.006874690574721629
Epoch = 86/100, Loss = 0.006875685509942008
Epoch = 87/100, Loss = 0.006876673408850332
Epoch = 88/100, Loss = 0.006877654186307625
Epoch = 89/100, Loss = 0.006878627764054312
Epoch = 90/100, Loss = 0.006879594078491677
Epoch = 91/100, Loss = 0.006880553040464843
Epoch = 92/100, Loss = 0.006881504615048141
Epoch = 93/100, Loss = 0.006882448741332347
Epoch = 94/100, Loss = 0.0068833853722149695
Epoch = 95/100, Loss = 0.0068843144661929565
Epoch = 96/100, Loss = 0.006885235987158628
Epoch = 97/100, Loss = 0.006886149904198561
Epoch = 98/100, Loss = 0.006887056191396274
Epoch = 99/100, Loss = 0.006887954827637998
Epoch = 100/100, Loss = 0.006888845796422306
MSE = 0.09061018860406646
```

รูปที่ 11: Fold ที่ 6 ครั้งแรก

รูปที่ 12: Fold ที่ 6 ครั้งหลัง

ค่า MSE = 0.09061018860406646

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 7

Fold 7	
Epoch = 1/100, Loss = 0.002819780276533959	Epoch = 51/100, Loss = 0.002379367688959948
Epoch = 2/100, Loss = 0.00216722064065881	Epoch = 52/100, Loss = 0.002404014661972968
Epoch = 3/100, Loss = 0.0021256039492048248	Epoch = 53/100, Loss = 0.002427858965287644
Epoch = 4/100, Loss = 0.002134831522682471	Epoch = 54/100, Loss = 0.002450506821818119
Epoch = 5/100, Loss = 0.0021461743254461868	Epoch = 55/100, Loss = 0.0024717324888019247
Epoch = 6/100, Loss = 0.002156585364282757	Epoch = 56/100, Loss = 0.0024914371689296188
Epoch = 7/100, Loss = 0.002167038181049669	Epoch = 57/100, Loss = 0.0025096098809604997
Epoch = 8/100, Loss = 0.0021784066344725287	Epoch = 58/100, Loss = 0.0025262956949307
Epoch = 9/100, Loss = 0.0021911558253019767	Epoch = 59/100, Loss = 0.002541572741459323
Epoch = 10/100, Loss = 0.0022053772567110987	Epoch = 60/100, Loss = 0.0025555366529796965
Epoch = 11/100, Loss = 0.00220833567028291	Epoch = 61/100, Loss = 0.002568290606429026
Epoch = 12/100, Loss = 0.002237017564219377	Epoch = 62/100, Loss = 0.0025799391827234755
Epoch = 13/100, Loss = 0.0022532518930743787	Epoch = 63/100, Loss = 0.0025905846745958079
Epoch = 14/100, Loss = 0.0022688258112233584	Epoch = 64/100, Loss = 0.002600324986999737
Epoch = 15/100, Loss = 0.00228130940100551	Epoch = 65/100, Loss = 0.002609251988691675
Epoch = 16/100, Loss = 0.002295749959554648	Epoch = 66/100, Loss = 0.0026174515874514354
Epoch = 17/100, Loss = 0.002306477549905632	Epoch = 67/100, Loss = 0.002625002697074364
Epoch = 18/100, Loss = 0.002315286756821442	Epoch = 68/100, Loss = 0.002631977493769626
Epoch = 19/100, Loss = 0.002322706203056835	Epoch = 69/100, Loss = 0.002638441493100941
Epoch = 20/100, Loss = 0.0023275849234568358	Epoch = 70/100, Loss = 0.002644453786761362
Epoch = 21/100, Loss = 0.002331405121151939	Epoch = 71/100, Loss = 0.002650067378073216
Epoch = 22/100, Loss = 0.0023338996607318342	Epoch = 72/100, Loss = 0.0026553295775261455
Epoch = 23/100, Loss = 0.0023352164766056544	Epoch = 73/100, Loss = 0.0026602824333287096
Epoch = 24/100, Loss = 0.0023354782010993422	Epoch = 74/100, Loss = 0.00266496317678342
Epoch = 25/100, Loss = 0.0023347823796829228	Epoch = 75/100, Loss = 0.00266940466671754
Epoch = 26/100, Loss = 0.002333204210811738	Epoch = 76/100, Loss = 0.0026736358211982033
Epoch = 27/100, Loss = 0.0023388803929273487	Epoch = 77/100, Loss = 0.0026776820282364156
Epoch = 28/100, Loss = 0.002327613398872413	Epoch = 78/100, Loss = 0.002681565398860093
Epoch = 29/100, Loss = 0.002323675958067175	Epoch = 79/100, Loss = 0.0026853057780676873
Epoch = 30/100, Loss = 0.0023190158010168215	Epoch = 80/100, Loss = 0.002688919756632357
Epoch = 31/100, Loss = 0.0023136608866787907	Epoch = 81/100, Loss = 0.0026924222766953887
Epoch = 32/100, Loss = 0.0023076454410382876	Epoch = 82/100, Loss = 0.00269582623919987
Epoch = 33/100, Loss = 0.002301017208452716	Epoch = 83/100, Loss = 0.002699142870480061
Epoch = 34/100, Loss = 0.002293846354950876	Epoch = 84/100, Loss = 0.0027023819313707967
Epoch = 35/100, Loss = 0.00228623643584244	Epoch = 85/100, Loss = 0.002705519021999697
Epoch = 36/100, Loss = 0.0022783376842912565	Epoch = 86/100, Loss = 0.0027086601458640083
Epoch = 37/100, Loss = 0.002270362480565734	Epoch = 87/100, Loss = 0.0027117138511576997
Epoch = 38/100, Loss = 0.002262602057362394	Epoch = 88/100, Loss = 0.002714716158438556
Epoch = 39/100, Loss = 0.002255420877769843	Epoch = 89/100, Loss = 0.0027176742695789896
Epoch = 40/100, Loss = 0.0022493726618256144	Epoch = 90/100, Loss = 0.002720591544010147
Epoch = 41/100, Loss = 0.00224985464159008	Epoch = 91/100, Loss = 0.002723471582502638
Epoch = 42/100, Loss = 0.0022429486866356926	Epoch = 92/100, Loss = 0.0027263175001706933
Epoch = 43/100, Loss = 0.0022439586360993288	Epoch = 93/100, Loss = 0.002729131990031828
Epoch = 44/100, Loss = 0.002248606639018908	Epoch = 94/100, Loss = 0.0027319173783076347
Epoch = 45/100, Loss = 0.0022573450197727364	Epoch = 95/100, Loss = 0.0027346756725161177
Epoch = 46/100, Loss = 0.0022702910466421603	Epoch = 96/100, Loss = 0.002737408603282072
Epoch = 47/100, Loss = 0.002287199938873226	Epoch = 97/100, Loss = 0.002740117666785017
Epoch = 48/100, Loss = 0.0023074681968755445	Epoch = 98/100, Loss = 0.002742804125812446
Epoch = 49/100, Loss = 0.0023302304650190554	Epoch = 99/100, Loss = 0.00274546098278046
Epoch = 50/100, Loss = 0.002354509577888878	Epoch = 100/100, Loss = 0.002748113520019074
MSE = 0.04237248153853396	

รูปที่ 13: Fold ที่ 7 ครั้งแรก

รูปที่ 14: Fold ที่ 7 ครั้งหลัง

ค่า MSE = 0.04237248153853396

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 8

Fold 8	Epoch = 1/100, Loss = 0.0011350001583649115	Epoch = 51/100, Loss = 0.000384557963771416
Epoch = 2/100, Loss = 0.000588431415299459	Epoch = 52/100, Loss = 0.00038461242828774	
Epoch = 3/100, Loss = 0.0004887927883113447	Epoch = 53/100, Loss = 0.00038472322130016294	
Epoch = 4/100, Loss = 0.0004525378452366698	Epoch = 54/100, Loss = 0.00038488405473184697	
Epoch = 5/100, Loss = 0.0004317932321114375	Epoch = 55/100, Loss = 0.0003848838154579032	
Epoch = 6/100, Loss = 0.000417848477629964253	Epoch = 56/100, Loss = 0.0003849625860195252	
Epoch = 7/100, Loss = 0.0004079723535867352	Epoch = 57/100, Loss = 0.00038504044129139195	
Epoch = 8/100, Loss = 0.0004080722161801955	Epoch = 58/100, Loss = 0.0003851174491260888	
Epoch = 9/100, Loss = 0.0003953222331796884	Epoch = 59/100, Loss = 0.00038519367096389543	
Epoch = 10/100, Loss = 0.0003916130732391398	Epoch = 60/100, Loss = 0.0003852691624056221	
Epoch = 11/100, Loss = 0.000388687634243458	Epoch = 61/100, Loss = 0.000385343973744214	
Epoch = 12/100, Loss = 0.00038650280914604253	Epoch = 62/100, Loss = 0.0003854181504575541	
Epoch = 13/100, Loss = 0.0003848770885353486	Epoch = 63/100, Loss = 0.00038549173366151084	
Epoch = 14/100, Loss = 0.00038367741130951647	Epoch = 64/100, Loss = 0.00038556476852529944	
Epoch = 15/100, Loss = 0.0003828044111805654	Epoch = 65/100, Loss = 0.0003856372646508753	
Epoch = 16/100, Loss = 0.00038218281098822217	Epoch = 66/100, Loss = 0.0003857092764185528	
Epoch = 17/100, Loss = 0.0003817548312700794	Epoch = 67/100, Loss = 0.00038578088233018511	
Epoch = 18/100, Loss = 0.00038147581275875886	Epoch = 68/100, Loss = 0.0003858519301483716	
Epoch = 19/100, Loss = 0.0003813109993253665	Epoch = 69/100, Loss = 0.0003859226194457638	
Epoch = 20/100, Loss = 0.00038123325293792356	Epoch = 70/100, Loss = 0.00038599291154696745	
Epoch = 21/100, Loss = 0.00038122135266319764	Epoch = 71/100, Loss = 0.0003860628248849184	
Epoch = 22/100, Loss = 0.00038125870849543847	Epoch = 72/100, Loss = 0.0003861323761618587	
Epoch = 23/100, Loss = 0.0003813323724444135	Epoch = 73/100, Loss = 0.0003862015885207463	
Epoch = 24/100, Loss = 0.0003814322682869378	Epoch = 74/100, Loss = 0.0003862704516997524	
Epoch = 25/100, Loss = 0.00038155058629295524	Epoch = 75/100, Loss = 0.00038633900217135205	
Epoch = 26/100, Loss = 0.00038168139524717436	Epoch = 76/100, Loss = 0.00038640724326757494	
Epoch = 27/100, Loss = 0.0003818198143659517	Epoch = 77/100, Loss = 0.0003864751852926827	
Epoch = 28/100, Loss = 0.0003819626143111551	Epoch = 78/100, Loss = 0.0003865428376246244	
Epoch = 29/100, Loss = 0.00038210708085392134	Epoch = 79/100, Loss = 0.0003866102088601877	
Epoch = 30/100, Loss = 0.0003822512778677682	Epoch = 80/100, Loss = 0.00038667730662709875	
Epoch = 31/100, Loss = 0.0003823938088817133	Epoch = 81/100, Loss = 0.0003867441381977999	
Epoch = 32/100, Loss = 0.0003825336986893534	Epoch = 82/100, Loss = 0.00038681071001582697	
Epoch = 33/100, Loss = 0.0003826702985126229	Epoch = 83/100, Loss = 0.00038687702802552975	
Epoch = 34/100, Loss = 0.000382803209871563	Epoch = 84/100, Loss = 0.0003869439767174683	
Epoch = 35/100, Loss = 0.0003829322235560941	Epoch = 85/100, Loss = 0.00038700892394817436	
Epoch = 36/100, Loss = 0.000383057270955594	Epoch = 86/100, Loss = 0.0003870451144080084	
Epoch = 37/100, Loss = 0.0003831783855691003	Epoch = 87/100, Loss = 0.00038713986436707113	
Epoch = 38/100, Loss = 0.0003832956728916106	Epoch = 88/100, Loss = 0.00038720498661108687	
Epoch = 39/100, Loss = 0.00038340928714491687	Epoch = 89/100, Loss = 0.0003872698817553663	
Epoch = 40/100, Loss = 0.0003835194135437288	Epoch = 90/100, Loss = 0.000387334531093612	
Epoch = 41/100, Loss = 0.0003836262549823669	Epoch = 91/100, Loss = 0.0003873990037352399	
Epoch = 42/100, Loss = 0.00038373002220945816	Epoch = 92/100, Loss = 0.0003874632364710572	
Epoch = 43/100, Loss = 0.00038383499267213107	Epoch = 93/100, Loss = 0.000387527253951659	
Epoch = 44/100, Loss = 0.000383929175749994	Epoch = 94/100, Loss = 0.0003875910586275788	
Epoch = 45/100, Loss = 0.000384249688472784	Epoch = 95/100, Loss = 0.00038765465278198463	
Epoch = 46/100, Loss = 0.0003841184956785062	Epoch = 96/100, Loss = 0.00038771803854611476	
Epoch = 47/100, Loss = 0.00038420993466306146	Epoch = 97/100, Loss = 0.0003877812179130781	
Epoch = 48/100, Loss = 0.00038429945239129287	Epoch = 98/100, Loss = 0.00038784419275035207	
Epoch = 49/100, Loss = 0.000384387203355528	Epoch = 99/100, Loss = 0.0003879069648112316	
Epoch = 50/100, Loss = 0.000384473301364625	Epoch = 100/100, Loss = 0.000387969535448633	
	MSE = 0.07587527884601562	

รูปที่ 15: Fold ที่ 8 ครั้งแรก

รูปที่ 16: Fold ที่ 8 ครั้งหลัง

ค่า MSE = 0.07587527884601562

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 9

Fold 9	
Epoch = 1/100, Loss = 0.0015947243260718519	Epoch = 51/100, Loss = 0.0037710085235013137
Epoch = 2/100, Loss = 0.0023004818257022263	Epoch = 52/100, Loss = 0.0037779908072496813
Epoch = 3/100, Loss = 0.002628466793393923	Epoch = 53/100, Loss = 0.003784917926903608
Epoch = 4/100, Loss = 0.002802413354411638	Epoch = 54/100, Loss = 0.0037917936220971124
Epoch = 5/100, Loss = 0.002916917219802766	Epoch = 55/100, Loss = 0.0037986214422042193
Epoch = 6/100, Loss = 0.0030850354013319205	Epoch = 56/100, Loss = 0.0038054047625165517
Epoch = 7/100, Loss = 0.0030775751096034677	Epoch = 57/100, Loss = 0.0038121467986554
Epoch = 8/100, Loss = 0.0031387720130991906	Epoch = 58/100, Loss = 0.0038188506194502905
Epoch = 9/100, Loss = 0.003190958273246106	Epoch = 59/100, Loss = 0.003825519158481704
Epoch = 10/100, Loss = 0.0032358140003816466	Epoch = 60/100, Loss = 0.0038321552244556236
Epoch = 11/100, Loss = 0.00327467926837792	Epoch = 61/100, Loss = 0.003838761510553672
Epoch = 12/100, Loss = 0.0033086437995661683	Epoch = 62/100, Loss = 0.0038453406028821544
Epoch = 13/100, Loss = 0.003338591900608989	Epoch = 63/100, Loss = 0.0038518949881250143
Epoch = 14/100, Loss = 0.00336523808062459976	Epoch = 64/100, Loss = 0.0038584727060492458
Epoch = 15/100, Loss = 0.003389158359477765	Epoch = 65/100, Loss = 0.0038649391280438203
Epoch = 16/100, Loss = 0.00341081701740409587	Epoch = 66/100, Loss = 0.00387143431845251
Epoch = 17/100, Loss = 0.003430588796254798	Epoch = 67/100, Loss = 0.003877912084272174
Epoch = 18/100, Loss = 0.0034487769345188072	Epoch = 68/100, Loss = 0.003884377207755573
Epoch = 19/100, Loss = 0.003465627631916114	Epoch = 69/100, Loss = 0.0038908308052714147
Epoch = 20/100, Loss = 0.0034813415666396525	Epoch = 70/100, Loss = 0.003897274831357848
Epoch = 21/100, Loss = 0.003496083031387422	Epoch = 71/100, Loss = 0.00390371118246784
Epoch = 22/100, Loss = 0.0035099871694892325	Epoch = 72/100, Loss = 0.0039101417002893185
Epoch = 23/100, Loss = 0.0035231657059529567	Epoch = 73/100, Loss = 0.003916568175109963
Epoch = 24/100, Loss = 0.003535711490872499	Epoch = 74/100, Loss = 0.003922992348509741
Epoch = 25/100, Loss = 0.0035477021073806697	Epoch = 75/100, Loss = 0.00392415916142271
Epoch = 26/100, Loss = 0.003559202743081294	Epoch = 76/100, Loss = 0.003935840530178297
Epoch = 27/100, Loss = 0.0035702684812589434	Epoch = 77/100, Loss = 0.003942267801575323
Epoch = 28/100, Loss = 0.00358094613441374	Epoch = 78/100, Loss = 0.003948699302167187
Epoch = 29/100, Loss = 0.00359127571614036	Epoch = 79/100, Loss = 0.003955136566583985
Epoch = 30/100, Loss = 0.003601291626663535	Epoch = 80/100, Loss = 0.003961581094015029
Epoch = 31/100, Loss = 0.0036110236106434734	Epoch = 81/100, Loss = 0.003968034349823573
Epoch = 32/100, Loss = 0.003620497534889345	Epoch = 82/100, Loss = 0.003974497767020918
Epoch = 33/100, Loss = 0.0036297360203837482	Epoch = 83/100, Loss = 0.003980972747608618
Epoch = 34/100, Loss = 0.003638758959512168	Epoch = 84/100, Loss = 0.003987460063793827
Epoch = 35/100, Loss = 0.003647583940003185	Epoch = 85/100, Loss = 0.00399396285908329
Epoch = 36/100, Loss = 0.0036562265940456107	Epoch = 86/100, Loss = 0.004000048649261631
Epoch = 37/100, Loss = 0.003664700886867273	Epoch = 87/100, Loss = 0.004007015323256125
Epoch = 38/100, Loss = 0.003673019356209	Epoch = 88/100, Loss = 0.0040135681438923316
Epoch = 39/100, Loss = 0.003681193311833292	Epoch = 89/100, Loss = 0.0040201403485429004
Epoch = 40/100, Loss = 0.003689233002396118	Epoch = 90/100, Loss = 0.004026733149670883
Epoch = 41/100, Loss = 0.0036971477555749165	Epoch = 91/100, Loss = 0.004033347735269257
Epoch = 42/100, Loss = 0.0037049460962063365	Epoch = 92/100, Loss = 0.004039985269198542
Epoch = 43/100, Loss = 0.0037126358462796633	Epoch = 93/100, Loss = 0.0040466468914283465
Epoch = 44/100, Loss = 0.0037202242099080404	Epoch = 94/100, Loss = 0.00404833718129567
Epoch = 45/100, Loss = 0.0037277178458183834	Epoch = 95/100, Loss = 0.004060046841782853
Epoch = 46/100, Loss = 0.0037351229294360125	Epoch = 96/100, Loss = 0.004066787331022655
Epoch = 47/100, Loss = 0.0037424452062636356	Epoch = 97/100, Loss = 0.004073556230496249
Epoch = 48/100, Loss = 0.0037496900379525495	Epoch = 98/100, Loss = 0.004080354560566853
Epoch = 49/100, Loss = 0.0037568624422174503	Epoch = 99/100, Loss = 0.004087183316915263
Epoch = 50/100, Loss = 0.0037639671275471825	Epoch = 100/100, Loss = 0.004094043470029261 MSE = 0.05512827988286832

รูปที่ 17: Fold ที่ 9 ครั้งแรก

รูปที่ 18: Fold ที่ 9 ครั้งหลัง

ค่า MSE = 0.05512827988286832

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 1 Fold 10

<p>Fold 10</p> <pre> Epoch = 1/100, Loss = 0.00891675393204277 Epoch = 2/100, Loss = 0.00766443685506088 Epoch = 3/100, Loss = 0.0075728487625421875 Epoch = 4/100, Loss = 0.007559857384860874 Epoch = 5/100, Loss = 0.0075524273597215 Epoch = 6/100, Loss = 0.007543490720403198 Epoch = 7/100, Loss = 0.007531884994918623 Epoch = 8/100, Loss = 0.007517692175967628 Epoch = 9/100, Loss = 0.007501583354628647 Epoch = 10/100, Loss = 0.007484495278415152 Epoch = 11/100, Loss = 0.007467423890560618 Epoch = 12/100, Loss = 0.00745129434325185 Epoch = 13/100, Loss = 0.00743685898302933 Epoch = 14/100, Loss = 0.007424797524983044 Epoch = 15/100, Loss = 0.007415442964518396 Epoch = 16/100, Loss = 0.007409064735947016 Epoch = 17/100, Loss = 0.00740575807755432 Epoch = 18/100, Loss = 0.007405498191905888 Epoch = 19/100, Loss = 0.007408166716052469 Epoch = 20/100, Loss = 0.007413575386773458 Epoch = 21/100, Loss = 0.007421486229908795 Epoch = 22/100, Loss = 0.007431628349269038 Epoch = 23/100, Loss = 0.00743711744718348 Epoch = 24/100, Loss = 0.007457438612738803 Epoch = 25/100, Loss = 0.007472512591133822 Epoch = 26/100, Loss = 0.007488646257423256 Epoch = 27/100, Loss = 0.007505567114393824 Epoch = 28/100, Loss = 0.007523022211795324 Epoch = 29/100, Loss = 0.007540781508665376 Epoch = 30/100, Loss = 0.0075586400651504555 Epoch = 31/100, Loss = 0.00756419159285332 Epoch = 32/100, Loss = 0.007593966443226055 Epoch = 33/100, Loss = 0.00761115527549863 Epoch = 34/100, Loss = 0.007627883383552243 Epoch = 35/100, Loss = 0.0076440710197550835 Epoch = 36/100, Loss = 0.007659658772285347 Epoch = 37/100, Loss = 0.007674605180853067 Epoch = 38/100, Loss = 0.007688842888077715 Epoch = 39/100, Loss = 0.007702483233685269 Epoch = 40/100, Loss = 0.00771530997296985 Epoch = 41/100, Loss = 0.007727641176861372 Epoch = 42/100, Loss = 0.007739220348108321 Epoch = 43/100, Loss = 0.007758126170091573 Epoch = 44/100, Loss = 0.0077604710899158895 Epoch = 45/100, Loss = 0.007770190126793755 Epoch = 46/100, Loss = 0.007779339889498106 Epoch = 47/100, Loss = 0.0077879477823385715 Epoch = 48/100, Loss = 0.0077960413770948546 Epoch = 49/100, Loss = 0.007803647928028941 Epoch = 50/100, Loss = 0.00781079400790516 </pre>	<pre> Epoch = 52/100, Loss = 0.00782380614185252 Epoch = 53/100, Loss = 0.007829719958636688 Epoch = 54/100, Loss = 0.007835268656744275 Epoch = 55/100, Loss = 0.00784047287007495 Epoch = 56/100, Loss = 0.007845535191793696 Epoch = 57/100, Loss = 0.007849923836152583 Epoch = 58/100, Loss = 0.007854205425244395 Epoch = 59/100, Loss = 0.00785821230969182 Epoch = 60/100, Loss = 0.007861959004139727 Epoch = 61/100, Loss = 0.00786545898336885 Epoch = 62/100, Loss = 0.007868724753584803 Epoch = 63/100, Loss = 0.007871767923201264 Epoch = 64/100, Loss = 0.007874599271785724 Epoch = 65/100, Loss = 0.007877228816230163 Epoch = 66/100, Loss = 0.007879665873528804 Epoch = 67/100, Loss = 0.007881919119720159 Epoch = 68/100, Loss = 0.00788396644958584 Epoch = 69/100, Loss = 0.007885906004377082 Epoch = 70/100, Loss = 0.00788765426505999 Epoch = 71/100, Loss = 0.007889248049675356 Epoch = 72/100, Loss = 0.0078906935727892 Epoch = 73/100, Loss = 0.007891996682655413 Epoch = 74/100, Loss = 0.007893162887705214 Epoch = 75/100, Loss = 0.007894197388964498 Epoch = 76/100, Loss = 0.007895186035215215 Epoch = 77/100, Loss = 0.007895890701873187 Epoch = 78/100, Loss = 0.007896558600381938 Epoch = 79/100, Loss = 0.00789711301383882 Epoch = 80/100, Loss = 0.007897557952354542 Epoch = 81/100, Loss = 0.007897897243551688 Epoch = 82/100, Loss = 0.007898134545840176 Epoch = 83/100, Loss = 0.007898273361050213 Epoch = 84/100, Loss = 0.007898317045768459 Epoch = 85/100, Loss = 0.007898268821514768 Epoch = 86/100, Loss = 0.007898131783883893 Epoch = 87/100, Loss = 0.007897988910757447 Epoch = 88/100, Loss = 0.00789760306969537 Epoch = 89/100, Loss = 0.007897217024589462 Epoch = 90/100, Loss = 0.00789675344166642 Epoch = 91/100, Loss = 0.00789621489491011 Epoch = 92/100, Loss = 0.007895603870969466 Epoch = 93/100, Loss = 0.007894922773618794 Epoch = 94/100, Loss = 0.007894173927764862 Epoch = 95/100, Loss = 0.007893359583217182 Epoch = 96/100, Loss = 0.007892481917981147 Epoch = 97/100, Loss = 0.007891543041389344 Epoch = 98/100, Loss = 0.007890544996938807 Epoch = 99/100, Loss = 0.007889489764913406 Epoch = 100/100, Loss = 0.00788837926481525 MSE = 0.11055553775419953 -----</pre>
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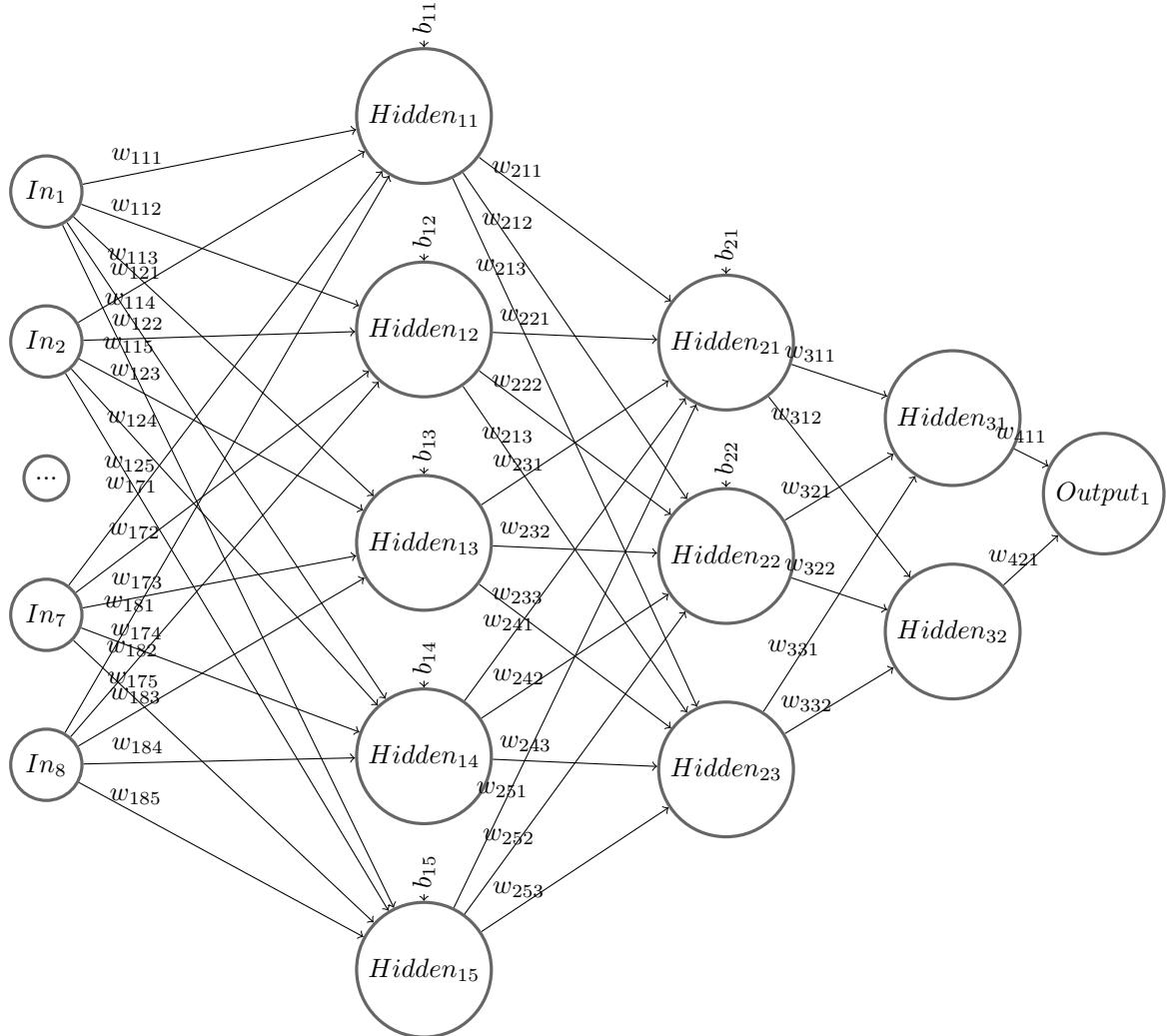
รูปที่ 19: Fold ที่ 10 ครึ่งแรก

รูปที่ 20: Fold ที่ 10 ครึ่งหลัง

$$\text{ค่า MSE} = 0.11055553775419953$$

วิธีการทดลอง 1 ครั้งที่ 2

- การทดลองที่ 2 ทดลองข้อ 1 โดยโครงสร้าง มี 4 Layer โดยที่ Layer ชั้นแรกมี 5 Node, ชั้นต่อไปมี 3 Nodes, ชั้นต่อไปมี 2 Nodes, 1 Output Node, และมี bias ทุกๆ Node



โดยที่ Input Node มีจำนวน Node เท่ากับจำนวน Features ของ Data จะ Predict หาค่า MSE (Mean Square Error) เพื่อหาความถูกต้องของ Data เหมือนเดิม

- โดยที่ Model นี้ มี Learning Rate = 0.01, Momentum Rate = 0.05 กำหนดจำนวน Epoch = 20 epoch

3. สร้าง Cross Validation ขึ้นมา 10 Fold เพื่อทดสอบ Model ที่สร้างขึ้นมา

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 2 Fold 1, 2, 3, 4

Fold 1	Fold 3
Epoch = 1/20, Loss = 6.296200471990964e-07	Epoch = 1/20, Loss = 0.0015295588931968464
Epoch = 2/20, Loss = 0.00010270619943895925	Epoch = 2/20, Loss = 0.0014610342796036156
Epoch = 3/20, Loss = 0.00040529866039294556	Epoch = 3/20, Loss = 0.001397869119861552
Epoch = 4/20, Loss = 0.0008510301195044287	Epoch = 4/20, Loss = 0.0013395890751800182
Epoch = 5/20, Loss = 0.0013889065031059229	Epoch = 5/20, Loss = 0.001285777301059565
Epoch = 6/20, Loss = 0.001976846213984295	Epoch = 6/20, Loss = 0.001236049993745933
Epoch = 7/20, Loss = 0.00258142287719693	Epoch = 7/20, Loss = 0.0011900590864084945
Epoch = 8/20, Loss = 0.0031788576679635393	Epoch = 8/20, Loss = 0.001147490699051344
Epoch = 9/20, Loss = 0.003752171988802544	Epoch = 9/20, Loss = 0.0011080597377197434
Epoch = 10/20, Loss = 0.004290562926386919	Epoch = 10/20, Loss = 0.0010715074061950717
Epoch = 11/20, Loss = 0.004787855732357741	Epoch = 11/20, Loss = 0.0010375985917045858
Epoch = 12/20, Loss = 0.005241289571185784	Epoch = 12/20, Loss = 0.0010061195220129066
Epoch = 13/20, Loss = 0.00565051941247288	Epoch = 13/20, Loss = 0.0009768756653996665
Epoch = 14/20, Loss = 0.006016832273073799	Epoch = 14/20, Loss = 0.0009496898479338966
Epoch = 15/20, Loss = 0.006342553461275508	Epoch = 15/20, Loss = 0.0009244005658967946
Epoch = 16/20, Loss = 0.006630610412125281	Epoch = 16/20, Loss = 0.000900864671966084
Epoch = 17/20, Loss = 0.006884221539791316	Epoch = 17/20, Loss = 0.0008789350001789267
Epoch = 18/20, Loss = 0.007166681087028282	Epoch = 18/20, Loss = 0.0008585011853807854
Epoch = 19/20, Loss = 0.007301215809482289	Epoch = 19/20, Loss = 0.0008394465235255791
Epoch = 20/20, Loss = 0.007470894231708534	Epoch = 20/20, Loss = 0.0008216680098239941
MSE = 0.07812930988685707	MSE = 0.05076398222867832
Fold 2	Fold 4
Epoch = 1/20, Loss = 0.0007165490610944694	Epoch = 1/20, Loss = 0.00013064516850463595
Epoch = 2/20, Loss = 0.0006997623662258247	Epoch = 2/20, Loss = 3.777888038758823e-05
Epoch = 3/20, Loss = 0.0006840189838302833	Epoch = 3/20, Loss = 1.5530097311131132e-06
Epoch = 4/20, Loss = 0.000669248542777429	Epoch = 4/20, Loss = 1.0824527840529386e-05
Epoch = 5/20, Loss = 0.00065388579341785	Epoch = 5/20, Loss = 5.599107068600647e-05
Epoch = 6/20, Loss = 0.0006423705211032895	Epoch = 6/20, Loss = 0.0002888150491605625
Epoch = 7/20, Loss = 0.0006301465250519424	Epoch = 7/20, Loss = 0.00022262213519954216
Epoch = 8/20, Loss = 0.0006186619180489453	Epoch = 8/20, Loss = 0.0003314929240834652
Epoch = 9/20, Loss = 0.0006078684865159363	Epoch = 9/20, Loss = 0.000450783716165549
Epoch = 10/20, Loss = 0.0005977214635453543	Epoch = 10/20, Loss = 0.000576656976739785
Epoch = 11/20, Loss = 0.0005881792612234634	Epoch = 11/20, Loss = 0.0007060209230940886
Epoch = 12/20, Loss = 0.0005792032247967353	Epoch = 12/20, Loss = 0.0008364150247193956
Epoch = 13/20, Loss = 0.0005707574696262713	Epoch = 13/20, Loss = 0.0009659085349049912
Epoch = 14/20, Loss = 0.0005628083603601595	Epoch = 14/20, Loss = 0.0010930118537874473
Epoch = 15/20, Loss = 0.000555324947506609	Epoch = 15/20, Loss = 0.0012165999933329127
Epoch = 16/20, Loss = 0.000548278165503101	Epoch = 16/20, Loss = 0.0013358471217237802
Epoch = 17/20, Loss = 0.0005416409854898216	Epoch = 17/20, Loss = 0.0014501710337451866
Epoch = 18/20, Loss = 0.00053882048996566	Epoch = 18/20, Loss = 0.001559186369493154
Epoch = 19/20, Loss = 0.000529496311674166	Epoch = 19/20, Loss = 0.001662665445957935
Epoch = 20/20, Loss = 0.0005239433594047219	Epoch = 20/20, Loss = 0.0017605056466411457
MSE = 0.09395817216874	MSE = 0.04969366092112835

รูปที่ 21: Fold ที่ 1, 2

รูปที่ 22: Fold ที่ 3, 4

Fold 1 MSE = 0.07812930988685707

Fold 2 MSE = 0.09395817216874000

Fold 3 MSE = 0.05076398222867832

Fold 4 MSE = 0.04969366092112835

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 2 Fold 5, 6, 7, 8

<p>Fold 5</p> <pre>Epoch = 1/20, Loss = 0.009673512485226769 Epoch = 2/20, Loss = 0.008670889424765984 Epoch = 3/20, Loss = 0.007716123381300038 Epoch = 4/20, Loss = 0.006812152189173714 Epoch = 5/20, Loss = 0.005961643524387459 Epoch = 6/20, Loss = 0.005166928016363445 Epoch = 7/20, Loss = 0.004429932900079339 Epoch = 8/20, Loss = 0.003752119889496369 Epoch = 9/20, Loss = 0.0031344312365854552 Epoch = 10/20, Loss = 0.0025772478632694 Epoch = 11/20, Loss = 0.0020803629799185596 Epoch = 12/20, Loss = 0.001642973732967553 Epoch = 13/20, Loss = 0.0012636922731069525 Epoch = 14/20, Loss = 0.0009405762545412492 Epoch = 15/20, Loss = 0.0006711774119018066 Epoch = 16/20, Loss = 0.00045260560137728865 Epoch = 17/20, Loss = 0.00028166471887866495 Epoch = 18/20, Loss = 0.00015463629939476746 Epoch = 19/20, Loss = 6.796639978050851e-05 Epoch = 20/20, Loss = 1.775155260122957e-05 MSE = 0.05083224279448288</pre> <hr/> <p>Fold 6</p> <pre>Epoch = 1/20, Loss = 0.00532768206746262 Epoch = 2/20, Loss = 0.0037391166210125246 Epoch = 3/20, Loss = 0.0024748890001444956 Epoch = 4/20, Loss = 0.0015124301571586734 Epoch = 5/20, Loss = 0.0008208932556999326 Epoch = 6/20, Loss = 0.00036405745022985 Epoch = 7/20, Loss = 0.00010408877277577746 Epoch = 8/20, Loss = 4.0823750940679775e-06 Epoch = 9/20, Loss = 2.999472553269482e-05 Epoch = 10/20, Loss = 0.00015165173023940303 Epoch = 11/20, Loss = 0.00034325211858012017 Epoch = 12/20, Loss = 0.0005833687844122433 Epoch = 13/20, Loss = 0.0008546651667501891 Epoch = 14/20, Loss = 0.001143449792325719 Epoch = 15/20, Loss = 0.0014391646924914114 Epoch = 16/20, Loss = 0.001733871857826005 Epoch = 17/20, Loss = 0.00202176977172322 Epoch = 18/20, Loss = 0.002298775944587375 Epoch = 19/20, Loss = 0.002562154220197466 Epoch = 20/20, Loss = 0.002810214164800078 MSE = 0.07654338238186961</pre> <hr/>	<p>Fold 7</p> <pre>Epoch = 1/20, Loss = 0.014403212474097978 Epoch = 2/20, Loss = 0.012591529234901281 Epoch = 3/20, Loss = 0.010940588289881797 Epoch = 4/20, Loss = 0.00944942092104392 Epoch = 5/20, Loss = 0.00811370413320225 Epoch = 6/20, Loss = 0.006926441259357065 Epoch = 7/20, Loss = 0.005878668869945374 Epoch = 8/20, Loss = 0.004960127656330777 Epoch = 9/20, Loss = 0.004159854948550461 Epoch = 10/20, Loss = 0.0034666760452927944 Epoch = 11/20, Loss = 0.002869587709182987 Epoch = 12/20, Loss = 0.0023580388014794447 Epoch = 13/20, Loss = 0.0019221201349449459 Epoch = 14/20, Loss = 0.0015526789714897958 Epoch = 15/20, Loss = 0.0012413742114994388 Epoch = 16/20, Loss = 0.000986872126283672 Epoch = 17/20, Loss = 0.0007639011508182165 Epoch = 18/20, Loss = 0.0005850594792445753 Epoch = 19/20, Loss = 0.000438911723804538 Epoch = 20/20, Loss = 0.000320852781976888 MSE = 0.0651772578645018</pre> <hr/> <p>Fold 8</p> <pre>Epoch = 1/20, Loss = 0.013586514181721594 Epoch = 2/20, Loss = 0.011551796761431208 Epoch = 3/20, Loss = 0.009812872881135708 Epoch = 4/20, Loss = 0.008335758301206236 Epoch = 5/20, Loss = 0.007086925367030378 Epoch = 6/20, Loss = 0.006034751402607907 Epoch = 7/20, Loss = 0.005150379668194137 Epoch = 8/20, Loss = 0.00440812341054599 Epoch = 9/20, Loss = 0.0037855459687802812 Epoch = 10/20, Loss = 0.00326331991174518 Epoch = 11/20, Loss = 0.0028250359662653824 Epoch = 12/20, Loss = 0.0024567736232726646 Epoch = 13/20, Loss = 0.00214689700182351 Epoch = 14/20, Loss = 0.001885679729850365 Epoch = 15/20, Loss = 0.001650269760661997 Epoch = 16/20, Loss = 0.0014782168598066699 Epoch = 17/20, Loss = 0.0013196751819608428 Epoch = 18/20, Loss = 0.0011847824266054924 Epoch = 19/20, Loss = 0.001069710418444727 Epoch = 20/20, Loss = 0.0009712853236112362 MSE = 0.07372806596454277</pre>
---	---

รูปที่ 23: Fold ที่ 5, 6

รูปที่ 24: Fold ที่ 7, 8

Fold 5 MSE = 0.05083224279448288

Fold 6 MSE = 0.07654338238186961

Fold 7 MSE = 0.06517725786450180

Fold 8 MSE = 0.07372806596454277

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 2 Fold 9, 10

```
Fold 9
Epoch = 1/20, Loss = 0.01678343474329051
Epoch = 2/20, Loss = 0.014647449665353817
Epoch = 3/20, Loss = 0.012598669396359257
Epoch = 4/20, Loss = 0.010662243965582833
Epoch = 5/20, Loss = 0.008861850546045979
Epoch = 6/20, Loss = 0.007218082377812197
Epoch = 7/20, Loss = 0.005746931559303242
Epoch = 8/20, Loss = 0.004458598805387311
Epoch = 9/20, Loss = 0.003356827996725896
Epoch = 10/20, Loss = 0.0024388738212824616
Epoch = 11/20, Loss = 0.0016960915077338576
Epoch = 12/20, Loss = 0.0011150239812727908
Epoch = 13/20, Loss = 0.0006787876731100431
Epoch = 14/20, Loss = 0.00036853797622712724
Epoch = 15/20, Loss = 0.0001648254107380456
Epoch = 16/20, Loss = 4.871401323658859e-05
Epoch = 17/20, Loss = 2.6016696435918127e-06
Epoch = 18/20, Loss = 1.0740274517684625e-05
Epoch = 19/20, Loss = 5.94928942550319e-05
Epoch = 20/20, Loss = 0.00013738472144359245
MSE = 0.05046244096015972

-----
Fold 10
Epoch = 1/20, Loss = 0.04495659371022658
Epoch = 2/20, Loss = 0.03698850427448801
Epoch = 3/20, Loss = 0.029891371245020473
Epoch = 4/20, Loss = 0.02387024769873563
Epoch = 5/20, Loss = 0.01896801842391302
Epoch = 6/20, Loss = 0.015101051136514013
Epoch = 7/20, Loss = 0.012116818931993121
Epoch = 8/20, Loss = 0.009844185541505934
Epoch = 9/20, Loss = 0.008124414314995465
Epoch = 10/20, Loss = 0.0068245837644341206
Epoch = 11/20, Loss = 0.00539866049877251
Epoch = 12/20, Loss = 0.0050990465086548566
Epoch = 13/20, Loss = 0.004516836078858883
Epoch = 14/20, Loss = 0.0040749746942941555
Epoch = 15/20, Loss = 0.0037324539742391023
Epoch = 16/20, Loss = 0.003465337119139213
Epoch = 17/20, Loss = 0.0032558707532135186
Epoch = 18/20, Loss = 0.0030998003748308537
Epoch = 19/20, Loss = 0.0029601544324689825
Epoch = 20/20, Loss = 0.002856370530428446
MSE = 0.05696814386653686
```

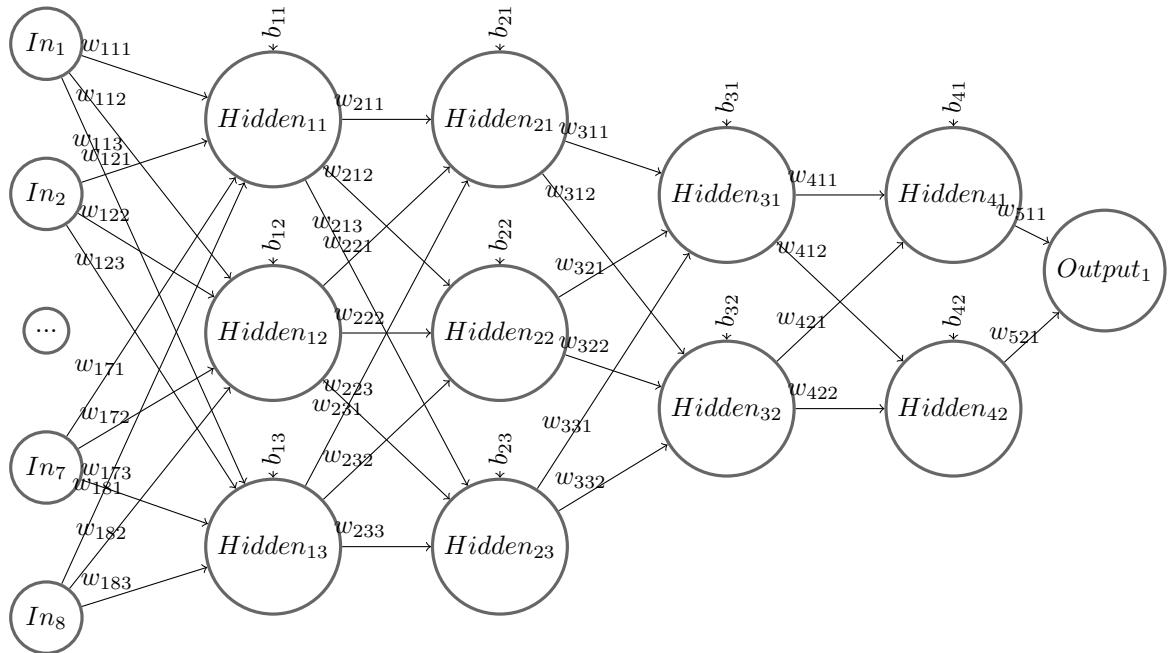
รูปที่ 25: Fold ที่ 9, 10

Fold 9 MSE = 0.05046244096015972

Fold 10 MSE = 0.05696814386653686

วิธีการทดลอง 1 ครั้งที่ 3

- การทดลองที่ 3 ทดลองข้อ 1 โดยโครงสร้าง มี 5 Layer โดยที่ Layer ชั้นแรกมี 3 Node, ชั้นต่อไปมี 3 Nodes, ชั้นต่อไปมี 2 Nodes, 2 Nodes, 1 Output Node, และมี bias ทุกๆ Node



โดยที่ Input Node มีจำนวน Node เท่ากับจำนวน Features ของ Data จะ Predict หาค่า MSE (Mean Square Error) เพื่อหาความถูกต้องของ Data เท่านั้นเดิม

- โดยที่ Model นี้ มี Learning Rate = 0.1, Momentum Rate = 0.5 กำหนดจำนวน Epoch = 5 epoch
- สร้าง Cross Validation ขึ้นมา 10 Fold เพื่อทดสอบ Model ที่สร้างขึ้นมา

ผลการทดลองข้อที่ 1 ทดลองครั้งที่ 3 ทั้ง 10 Fold

```

Fold 1
Epoch = 1/5, Loss = 0.015111316339723716
Epoch = 2/5, Loss = 0.008295237209450464
Epoch = 3/5, Loss = 0.007354555596739244
Epoch = 4/5, Loss = 0.007202524941143698
Epoch = 5/5, Loss = 0.00720738106033777
MSE = 0.07719721720558936
-----
Fold 2
Epoch = 1/5, Loss = 0.0045342447309114015
Epoch = 2/5, Loss = 0.003590199226200387
Epoch = 3/5, Loss = 0.003539076946768477
Epoch = 4/5, Loss = 0.003535112955963195
Epoch = 5/5, Loss = 0.003533853440422422
MSE = 0.08103028842014544
-----
Fold 3
Epoch = 1/5, Loss = 0.00415935027947946
Epoch = 2/5, Loss = 0.003867597988683255
Epoch = 3/5, Loss = 0.003862373720619555
Epoch = 4/5, Loss = 0.0038640843016368356
Epoch = 5/5, Loss = 0.00386610168008349685
MSE = 0.047823785125972976
-----
Fold 4
Epoch = 1/5, Loss = 0.00048483478854632477
Epoch = 2/5, Loss = 0.002720116488060095
Epoch = 3/5, Loss = 0.003752726082630585
Epoch = 4/5, Loss = 0.004677348493696372
Epoch = 5/5, Loss = 0.0041695431265920055
MSE = 0.05273839444708157
-----
Fold 5
Epoch = 1/5, Loss = 9.966816521348297e-05
Epoch = 2/5, Loss = 0.002623767954734276
Epoch = 3/5, Loss = 0.00426409782904214
Epoch = 4/5, Loss = 0.004960689704441978
Epoch = 5/5, Loss = 0.0052368611765332105
MSE = 0.053642859060576
-----
```

รูปที่ 26: Fold ที่ 1, 2, 3, 4,
5

```

Fold 6
Epoch = 1/5, Loss = 0.00617326091863574
Epoch = 2/5, Loss = 0.006710226270820217
Epoch = 3/5, Loss = 0.00672692642875552
Epoch = 4/5, Loss = 0.006727784909012369
Epoch = 5/5, Loss = 0.006728163193684962
MSE = 0.08989324629641908
-----
Fold 7
Epoch = 1/5, Loss = 0.0016253996483126835
Epoch = 2/5, Loss = 0.002328303212681815
Epoch = 3/5, Loss = 0.0023656713690434782
Epoch = 4/5, Loss = 0.0023673386574619816
Epoch = 5/5, Loss = 0.0023672510820945143
MSE = 0.05904268010496601
-----
Fold 8
Epoch = 1/5, Loss = 0.001173047160727208
Epoch = 2/5, Loss = 0.000405002648252956
Epoch = 3/5, Loss = 0.00036296637152537933
Epoch = 4/5, Loss = 0.0003604871839301734
Epoch = 5/5, Loss = 0.00035976672733676387
MSE = 0.07605517957081792
-----
Fold 9
Epoch = 1/5, Loss = 0.005331657001284428
Epoch = 2/5, Loss = 0.005412375678845507
Epoch = 3/5, Loss = 0.005412590925297885
Epoch = 4/5, Loss = 0.005411109578170601
Epoch = 5/5, Loss = 0.005409588970239046
MSE = 0.057530242102317594
-----
Fold 10
Epoch = 1/5, Loss = 0.006443819914058938
Epoch = 2/5, Loss = 0.00796841298386172
Epoch = 3/5, Loss = 0.008061133495393856
Epoch = 4/5, Loss = 0.008068594181162388
Epoch = 5/5, Loss = 0.008070631916652062
MSE = 0.06207303219808048
-----
```

รูปที่ 27: Fold ที่ 6, 7, 8, 9,
10

MSE Fold 1 = 0.87710721720558336
 MSE Fold 2 = 0.88183828042814544
 MSE Fold 3 = 0.047823785125072676
 MSE Fold 4 = 0.8527383944708157
 MSE Fold 5 = 0.8530428598958576
 MSE Fold 6 = 0.088080324629641988
 MSE Fold 7 = 0.05984268816496681
 MSE Fold 8 = 0.87605517957881792
 MSE Fold 9 = 0.857538242102317584
 MSE Fold 10 = 0.86207303219868648

จากการทดลองในข้อที่ 1 ทั้งสามครั้ง

ในการทดลองครั้งที่ 1 Fold ที่ดีที่สุดคือ Fold ที่ 4 มีค่า MSE ≈ 0.03

ในการทดลองครั้งที่ 2 Fold ที่ดีที่สุดคือ Fold ที่ 4 เหมือนกัน มีค่า MSE ≈ 0.049

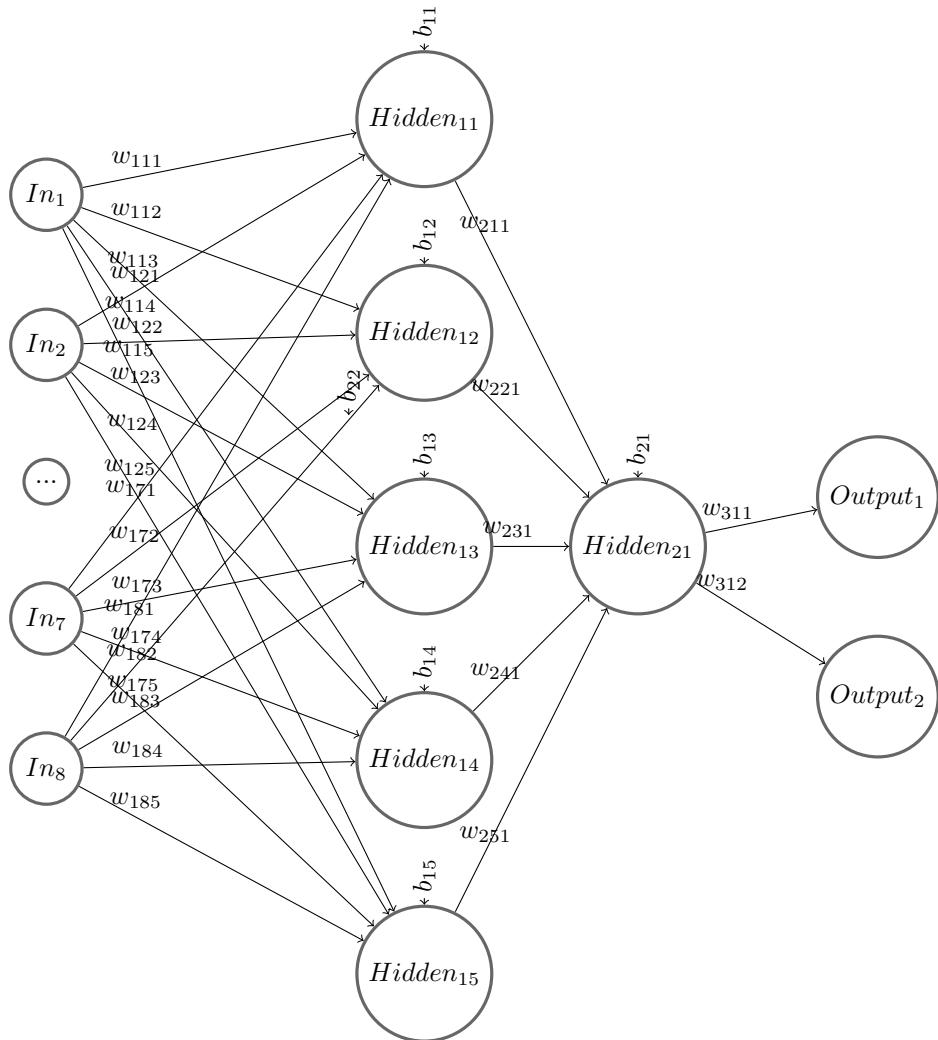
ในการทดลองครั้งที่ 3 Fold ที่ดีที่สุดคือ Fold ที่ 3 มีค่า MSE ≈ 0.048

โดยทดลองกับ เต็ล Model ที่ขนาดของ Layer และ Node ไม่เท่ากันและ Learning Rate, Momentum Rate, weight, bias ก็สุ่มใหม่ทุกครั้งในการทดลองแต่ละครั้ง ในแต่ละครั้งไม่เท่ากันจะมีค่าต่างกันไม่มาก คิดว่าน่าจะเกิดจากการปรับ weight ใหม่ทุกๆ sample ทำให้เต็ล epoch ก็จะมีค่า MSE ที่ต่ำอยู่แล้ว

การทดลองที่ 2 เป็นการหาร่วม Model จะตอบ Class ที่ถูกต้องเปล่า

วิธีการทดลอง 2 ครั้งที่ 1

- การทดลองที่ 1 ทดลองข้อ 2 โดยโครงสร้าง มี 3 Layer โดยที่ Layer ชั้นแรกมี 5 Node, ชั้นก้าดไปมี 1 Nodes, 1 Output Node, และมี bias ทุกๆ Node



โดยที่ Input Node มีจำนวน Node เท่ากับจำนวน Features ของ Data จะ Predict หา Class ที่ถูกต้อง เพื่อหาความถูกต้องของ Model

- โดยที่ Model นี้ มี Learning Rate = 0.01, Momentum Rate = 0.1 กำหนดจำนวน

Epoch = 1 epoch

3. สร้าง Cross Validation ขึ้นมา 10 Fold เพื่อทดสอบ Model ที่สร้างขึ้น

ผลการทดลองที่ 2 ครั้งที่ 1 Fold ที่ 1 ถึง 10

Fold 1 Epoch = 1/1, Loss = 0.06714828307548987 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 2 Epoch = 1/1, Loss = 0.05643903228491662 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 3 Epoch = 1/1, Loss = 0.11852592350332003 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 4 Epoch = 1/1, Loss = 0.11824933050745365 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 5 Epoch = 1/1, Loss = 0.06415385542808859 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 -----	Fold 6 Epoch = 1/1, Loss = 0.047619587414483966 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 7 Epoch = 1/1, Loss = 0.09952561186593367 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 8 Epoch = 1/1, Loss = 0.06853505480210163 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 9 Epoch = 1/1, Loss = 0.10726413110040417 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 10 Epoch = 1/1, Loss = 0.1006112730406315 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 -----
---	--

จุดที่ 28: Fold 1, 2, 3, 4, 5

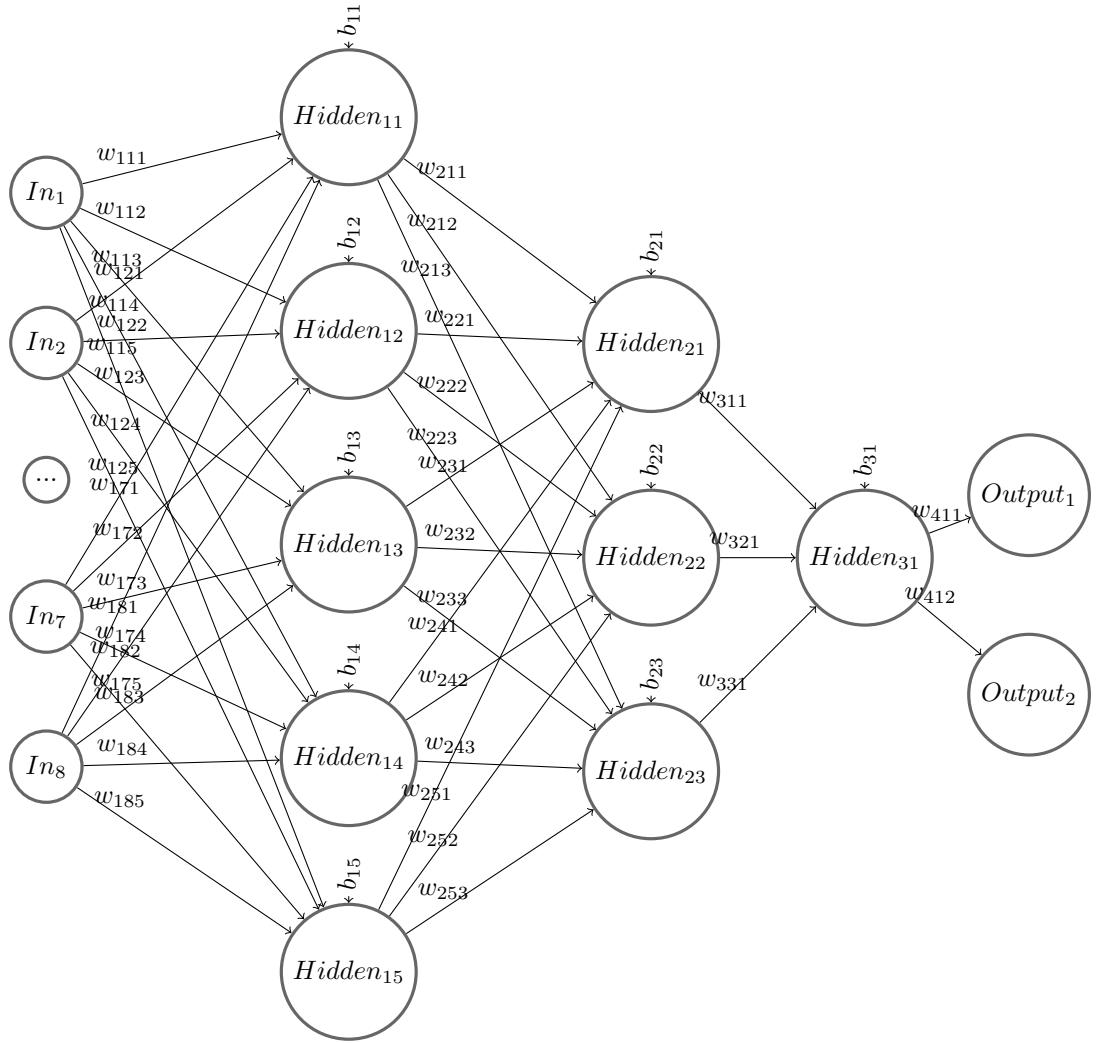
จุดที่ 29: Fold 6, 7, 8, 9,
10

ผลการ Predict Class ของแต่ละ Fold

Fold 1 = 20/20
Fold 2 = 20/20
Fold 3 = 20/20
Fold 4 = 20/20
Fold 5 = 20/20
Fold 6 = 20/20
Fold 7 = 20/20
Fold 8 = 20/20
Fold 9 = 20/20
Fold 10 = 20/20

วิธีการทดลอง 2 ครั้งที่ 2

1. การทดลองที่ 2 ทดลองข้อ 2 โดยโครงสร้าง มี 4 Layer, โดยที่ Layer ชั้นแรกมี 5 Node, ชั้นต่อไปมี 3 Nodes, ชั้นต่อไปมี 1 Nodes, 1 Output Node, และมี bias ทุกๆ Node



โดยที่ Input Node มีจำนวน Node เท่ากับจำนวน Features ของ Data และ Predict หาค่า MSE (Mean Square Error) เพื่อหาความถูกต้องของ Data เพื่อวนเดิม

2. โดยที่ Model นี้ Learning Rate = 100, Momentum Rate = 0.5 กำหนดจำนวน Epoch = 1 epoch
3. สร้าง Cross Validation ขึ้นมา 10 Fold เพื่อทดสอบ Model ที่สร้างขึ้นมา

ผลการทดลองที่ 2 ครั้งที่ 2 Fold ที่ 1 ถึง 10

<pre> Fold 1 Epoch = 1/1, Loss = 0.11126056574404276 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 2 Epoch = 1/1, Loss = 0.16329193560538474 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 3 Epoch = 1/1, Loss = 0.20499475095342348 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 4 Epoch = 1/1, Loss = 0.24017078086034993 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 5 Epoch = 1/1, Loss = 0.4044866979946173 Predict ----- Actual [0. 10.] [0. 10.] Accuracy = 10/20 -----</pre>	<pre> Fold 6 Epoch = 1/1, Loss = 0.16055508409470162 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 7 Epoch = 1/1, Loss = 0.1360091796901602 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 8 Epoch = 1/1, Loss = 0.050851745955791255 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 9 Epoch = 1/1, Loss = 0.09978793625919002 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 10 Epoch = 1/1, Loss = 0.2049997064892423 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 -----</pre>
--	--

รวมที่ 30: Fold 1, 2, 3, 4, 5

รวมที่ 31: Fold 6, 7, 8, 9,
10

ผลการ Predict Class ของแต่ละ Fold

Fold 1 = 20/20
 Fold 2 = 20/20
 Fold 3 = 20/20
 Fold 4 = 20/20
 Fold 5 = 10/20

Fold 6 = 20/20

Fold 7 = 20/20

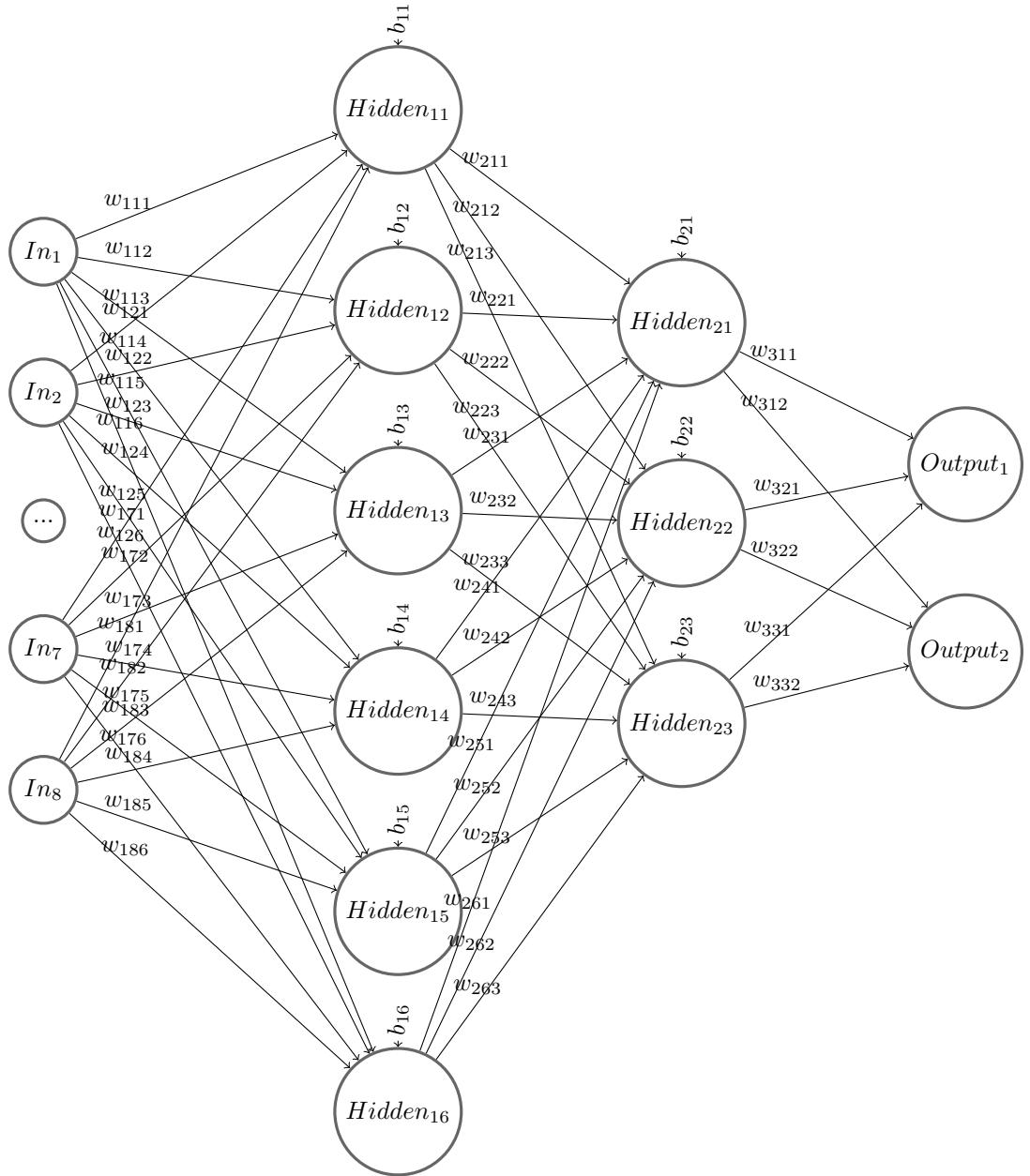
Fold 8 = 20/20

Fold 9 = 20/20

Fold 10 = 20/20

วิธีการทดลอง 2 ครั้งที่ 2

1. การทดลองที่ 2 ทดลองข้อ 2 โดยโครงสร้าง มี 4 Layer, โดยที่ Layer ชั้นแรกมี 5 Node, ชั้นถัดไปมี 3 Nodes, ชั้นถัดไปมี 1 Nodes, 1 Output Node, และมี bias ทุกๆ Node



โดยที่ Input Node มีจำนวน Node เท่ากับจำนวน Features ของ Data จะ Predict หาค่า MSE (Mean Square Error) เพื่อหาความถูกต้องของ Data เหมือนเดิม

2. โดยที่ Model นี้มี Learning Rate = 100, Momentum Rate = 5 กำหนดจำนวน

Epoch = 1 epoch

3. สร้าง Cross Validation ขึ้นมา 10 Fold เพื่อทดสอบ Model ที่สร้างขึ้นมา

ผลการทดลองที่ 2 ครั้งที่ 3 Fold ที่ 1 ถึง 10

Fold 1 Epoch = 1/1, Loss = 0.004999999999999999 Predict ----- Actual [10. 0.] [10. 0.] Accuracy = 10/20 ----- Fold 2 Epoch = 1/1, Loss = 0.004999999999999999 Predict ----- Actual [10. 0.] [10. 0.] Accuracy = 10/20 ----- Fold 3 Epoch = 1/1, Loss = 0.004999999999999999 Predict ----- Actual [10. 0.] [10. 0.] Accuracy = 10/20 ----- Fold 4 Epoch = 1/1, Loss = 0.1458016652389445 Predict ----- Actual [10. 0.] [0. 10.] Accuracy = 20/20 ----- Fold 5 Epoch = 1/1, Loss = 0.004999999999999999 Predict ----- Actual [10. 0.] [10. 0.] Accuracy = 10/20	Fold 6 Epoch = 1/1, Loss = 0.004999999999999999 Predict ----- Actual [10. 0.] [10. 0.] Accuracy = 10/20 ----- Fold 7 Epoch = 1/1, Loss = 0.004999999999999999 Predict ----- Actual [10. 0.] [10. 0.] Accuracy = 10/20 ----- Fold 8 Epoch = 1/1, Loss = 0.12379849542818118 Predict ----- Actual [10. 0.] [3. 7.] Accuracy = 17/20 ----- Fold 9 Epoch = 1/1, Loss = 0.004999999999999999 Predict ----- Actual [10. 0.] [10. 0.] Accuracy = 10/20 ----- Fold 10 Epoch = 1/1, Loss = 0.004999999999999999 Predict ----- Actual [10. 0.] [10. 0.] Accuracy = 10/20
--	---

รูปที่ 32: Fold 1, 2, 3, 4, 5

รูปที่ 33: Fold 6, 7, 8, 9,
10

ผลการ Predict Class ของแต่ละ Fold

Fold 1 = 10/20

Fold 2 = 10/20

Fold 3 = 10/20
Fold 4 = 20/20
Fold 5 = 10/20
Fold 6 = 10/20
Fold 7 = 10/20
Fold 8 = 17/20
Fold 9 = 10/20
Fold 10 = 10/20

จากการทดลองในข้อที่ 2 ทั้งสามครั้ง

ในการทดลองครั้งที่ 1 จะไม่มี Fold ที่เดาผิดพลาดเลย
ในการทดลองครั้งที่ 2 จะมีแค่ Fold ที่ 5 ที่เดาผิดไป 50 %
ในการทดลองครั้งที่ 3 เกือบทุก Fold นั้นเดาผิดไปเยอะมาก มีแค่ Fold 5 ที่เดาถูก Class
หมวด

โดยทดลองกับ แต่ละ Model ที่ขนาดของ Layer และ Node ไม่เท่ากันและ Learning Rate, Momentum Rate, weight, bias ก็สุ่มใหม่ทุกครั้งในการทดลองแต่ละครั้ง ในแต่ละครั้งไม่เท่ากันจะมีค่าต่างกันไม่มาก ใน Fold ที่ 1 นั้นไม่ผิดคิดว่าเพราะ ตัว Learning Rate, Momentum Rate นั้นมีแค่น้อยจัง Learn แบบไม่ก้าวกระโดดมากนัก แต่ในการทดลองที่สองให้ Learning Rate มีค่ามากแต่ Momentum นั้นมีค่าน้อยจึงตอนปรับ Weight ค่า Learning Rate อาจจะกระโดดมากแต่ Momentum ทำให้ค่าไม่กระโดดมากจนเกินไปทำให้ยังเดาถูกอยู่ ในการทดลองที่สามให้ Learning Rate, Momentum Rate นั้นมีค่ามากทำให้ตัว Model ปรับ Weight แบบก้าวกระโดดเลยทำให้เดาผิดไปครึ่งๆไปเลย แต่ทั้ง 3 การทดลองให้ Epoch = 1 เพราะว่าจากการทดลองที่แล้วการปรับ Weight ใน 1 Epoch นั้นทำการปรับเท่ากับขนาดของ Sample อญี่แล้วเลยให้ Epoch เป็น 1 เพื่อลองทดสอบการ Predict Class

ກາດພໍາວກ

```
1 import numpy as np
2 import csv
3 import copy
4
5 data = []
6 abc = 2
7
8 def Normalize(x):
9     mi = x.min()
10    ma = x.max()
11    x = (x - mi)/(ma - mi)
12    return x
13
14 class NeuralNetwork:
15     def __init__(self, input, out):
16         # np.random.seed(1)
17         self.FullInput = input
18         self.FullTrueOutput = out
19         self.Input = None
20         self.weight = []
21         self.bias = []
22         self.predict = 0
23         self.lr = 0
24         self.E = 0
25         self.countLayer = 0
26         self.Node = []
27         self.output = []
28         self.TrueOutput= None
29         self.cou = 0
30         self.deltaWeight = []
31         self.err = []
32         self.deltaBias = []
33         self.gradient = [] # back to front
34         self.momentum = 0
35         self.Loss = []
36         self.minimumLoss = 10000000
37         self.rememberWeightT_1 = []
38         self.countSample = 0
39         self.rememberWeightT_2 = []
40
41     def addLayer(self, node):
42         self.countLayer+=1
43         self.Node.append(node)
44
```

ງົບທີ 34: Function Normalize, ສ້າງ Neural Network

```

45     def sigmoid(self, v):
46         return 1/(1+np.exp(-v))
47
48     def diffsigmoid(self, y):
49         return y*(1-y)
50
51     def createweight(self):
52         for i in range(len(self.Node)):
53             if ( i == 0 ):
54                 self.weight.append(2*np.random.rand(len(self.input), self.Node[i]) - 1)
55                 self.bias.append(2*np.random.rand(self.Node[i]) - 1)
56                 self.deltaweight.append(np.ones((len(self.input), self.Node[i])))
57                 self.deltabias.append(np.ones(self.Node[i]))
58                 self.rememberweightT_1.append(np.zeros((len(self.input), self.Node[i])))
59                 self.rememberweightT_2.append(np.zeros((len(self.input), self.Node[i])))
60             else:
61                 self.weight.append(2*np.random.rand(self.Node[i-1], self.Node[i]) - 1)
62                 self.bias.append(2*np.random.rand(self.Node[i]) - 1)
63                 self.deltaweight.append(np.ones((self.Node[i-1], self.Node[i])))
64                 self.deltabias.append(np.ones(self.Node[i]))
65                 self.rememberweightT_1.append(np.zeros((len(self.input), self.Node[i])))
66                 self.rememberweightT_2.append(np.zeros((len(self.input), self.Node[i])))
67
68     def FeedForward(self):
69         # each sample, each epoch
70         self.output = []
71         self.output.append(self.input.T)
72         out = np.array(self.output[0])
73         for i in range(len(self.Node)): # feed in each layer
74             v = np.dot(out, self.weight[i]) + self.bias[i]
75             out = self.sigmoid(v)
76             self.output.append(out)
77
78     def BackPropagation(self):
79         self.gradient = []
80         self.err = self.TrueOutput - self.output[len(self.output)-1]
81         self.Loss = []
82         Loss = (0.5)*((self.err)**2) # scalar
83         #calculate gradient
84         self.Loss.append(Loss)
85         for i in range(len(self.Node)): # for layer
86             self.gradient.append([])

```

ຈຸບັນ 35: Function sigmoid, diffsigmoid, ສ້າງ Weight, FeedForward, Backprob (ເຮືອນ-ຫຼິມ)

```

87     for j in range(len(self.weight[len(self.Node)-1-i])): # Node in layer
88         inpu = self.output[len(self.Node)-i-1].T[j]
89         for k in range(len(self.weight[len(self.Node)-1-i][j])): # each weight in layer
90             out = self.output[len(self.Node)-i][k]
91             if ( i == 0 ):
92                 gradient = (self.err*self.diffsigmoid(out))
93                 self.gradient[i].append(gradient)
94                 self.deltaweight[len(self.Node)-1-i][j][k] = inpu*self.gradient[i][len(self.gradient[i])-1][k]*self.lr # delta_w scalar in weight 1 line
95             else :
96                 gra = np.sum(self.gradient[i-1])
97                 gradient = gra*(self.diffsigmoid(out))*self.weight[len(self.Node)-i-1][j][k]
98                 self.gradient[i].append(np.array(gradient))
99                 self.deltaweight[len(self.Node)-1-i][j][k] = inpu*self.gradient[i][len(self.gradient[i])-1]*self.lr # delta_w scalar in weight 1 line
100
101             if ( self.countsample <= 1 ):
102                 self.weight[len(self.Node)-1-i][j][k] = self.weight[len(self.Node)-1-i][j][k] + (self.deltaweight[len(self.Node)-1-i][j][k]) # scalar
103             else : # with momentum
104                 a = self.rememberweightT_1[len(self.Node)-1-i][j][k] - self.rememberweightT_2[len(self.Node)-1-i][j][k]
105                 self.weight[len(self.Node)-1-i][j][k] = self.weight[len(self.Node)-1-i][j][k] + self.momentum*(a) + (self.deltaweight[len(self.Node)-1-i][j][k])
106                 self.rememberweightT_2 = copy.deepcopy(self.rememberweightT_1)
107                 self.rememberweightT_1 = copy.deepcopy(self.weight)
108
109     def fit(self, epoch, Learningrate, Momentum):
110         self.lr = Learningrate
111         self.momentum = Momentum
112         self.countsample = 0
113         for i in range(epoch): # epoch
114             for j in range(len(self.Fullinput)): # sample
115                 self.inpu = self.Fullinput[j]
116                 self.TrueOutput = self.FullTrueOutput[j]
117                 if ( i == 0 and j == 0):
118                     self.createweight()
119
120                 self.FeedForward()
121                 self.BackPropagation()
122
123                 self.countsample += 1
124                 sumloss = np.array(self.Loss).mean()
125                 print("Epoch = " + str(i+1) + "/" + str(epoch) + ", Loss =", sumloss)
126
127                 self.minimumLoss = min(sumloss, self.minimumLoss)
128

```

ຈຸບັນ 36: Backprob (ຄົວ), fit (function train)

```

129     def predict_data(self, inpu, output):
130         self.Fullinput = inpu
131         self.FullTrueOutput = output
132         self.Loss = []
133         for j in range(len(self.Fullinput)):
134             self.input = self.Fullinput[j]
135             self.TrueOutput = self.FullTrueOutput[j]
136
137             self.FeedForward()
138
139             self.err = self.TrueOutput - self.output[len(self.output)-1]
140             Loss = (0.5)*((self.err)**2) # scalar
141             self.Loss.append(Loss)
142
143             MeanLoss = np.array(self.Loss).mean()
144             return(MeanLoss)
145
146     def confusion_matrix(self, inpu, output):
147         self.Fullinput = inpu
148         self.FullTrueOutput = output
149         self.Loss = []
150         sizeclass = len(output[0])
151         classconfusion = np.zeros((sizeclass, sizeclass))
152         for j in range(len(self.Fullinput)):
153             self.input = self.Fullinput[j]
154             self.TrueOutput = self.FullTrueOutput[j]
155
156             self.FeedForward()
157
158             self.err = self.TrueOutput - self.output[len(self.output)-1]
159             classconfusion[self.TrueOutput.argmax()][self.err.argmax()] += 1
160
161             print()
162             print("          Predict")
163             print("          |-----")
164             for i in range(sizeclass):
165                 if ( i == 0 ) :
166                     print("Actual |", classconfusion[i])
167                 else :
168                     print("          |", classconfusion[i])
169             accuracy = 0
170             for i in range(len(classconfusion)):

```

ງົບທີ 37: Function Predict (ຄົດ MSE), confusion_{matrix}

```

171     |         accuracy += classconfusion[i][i]
172     |         print()
173     |         print("Accuracy = " + str(int(accuracy)) + "/" + str(len(output)))
174
175     # first
176     if ( abc == 1 ):
177         with open('dataset.csv', 'rt')as f:
178             d = csv.reader(f)
179             for row in d:
180                 data.append(row)
181
182     x_train = []
183     y_true = []
184
185     for i in range(len(data)):
186         if ( i > 1 ):
187             inpu = []
188             for j in range(len(data[i])):
189                 if ( j < 8 ):
190                     inpu.append(float(data[i][j]))
191                 else:
192                     y_true.append(float(data[i][j]))
193             x_train.append(inpu)
194
195     fold = 10
196     crossvalidation = int(len(x_train)*fold/100)
197
198     for i in range(fold):
199         if i == (fold-1) :
200             x_train_testingset = x_train[0+i*crossvalidation:len(x_train)]
201             y_true_testingset = y_true[0+i*crossvalidation:len(y_true)]
202
203             x_train_trainingset = x_train[0:0+i*crossvalidation]
204             y_true_trainingset = y_true[0:0+i*crossvalidation]
205
206         else:
207             x_train_testingset = x_train[0+i*crossvalidation:crossvalidation+i*crossvalidation]
208             y_true_testingset = y_true[0+i*crossvalidation:crossvalidation+i*crossvalidation]
209
210             x_train_trainingset1 = x_train[0:i*crossvalidation]
211             x_train_trainingset2 = x_train[crossvalidation*(i+1):len(x_train)]
212
213             x_train_trainingset = x_train_trainingset1 + x_train_trainingset2

```

§ùñ 38: $\text{confusion}_m\text{atrix}()$, TrainTestsetData

```

215     y_true_trainingset1 = y_true[0:i*crossvalidation]
216     y_true_trainingset2 = y_true[crossvalidation*(i+1):len(x_train)]
217
218     y_true_trainingset = y_true_trainingset1 + y_true_trainingset2
219
220     x_train_trainingset = np.array(x_train_trainingset)
221     y_true_trainingset = np.array(y_true_trainingset)
222
223     x_train_trainingset = Normalize(x_train_trainingset)
224     y_true_trainingset = Normalize(y_true_trainingset)
225
226     nn = NeuralNetwork(x_train_trainingset, y_true_trainingset)
227
228     # nn.addLayer(5)
229     # nn.addLayer(3)
230     # nn.addLayer(1)
231
232     x_train_testingset = np.array(x_train_testingset)
233     y_true_testingset = np.array(y_true_testingset)
234
235     x_train_testingset = Normalize(x_train_testingset)
236     y_true_testingset = Normalize(y_true_testingset)
237
238     print("Fold " + str(i+1))
239     nn.fit(10, 10, 10)
240     print("MSE =", nn.predict_data(x_train_testingset, y_true_testingset))
241     print("-----")
242
243     # second
244     elif ( abc == 2 ):
245         cou = 0
246         with open('cross.pat', 'rt')as f:
247             d = csv.reader(f)
248             for row in d:
249                 if ( cou % 3 != 0 ):
250                     data.append(row)
251                 cou += 1
252         x_train = []
253         y_true = []
254         for i in range(len(data)):
255             data[i][0] = data[i][0].split()
256             inpu = []
257             for row in data[i][0]:

```

รูปที่ 39: แบ่ง Train กับ Test set ของ Data ข้อแรก(ต่อ), เริ่มต้นข้อสอง

```

258     |     inpu.append(float(row))
259     |     if ( i % 2 == 0 ):
260     |         x_train.append(inpu)
261     |     else:
262     |         y_true.append(inpu)
263
264     fold = 10
265     crossvalidation = int(len(x_train)*fold/100)
266
267     for i in range(fold):
268         if i == (fold-1) :
269             x_train_testingset = x_train[0+i*crossvalidation:len(x_train)]
270             y_true_testingset = y_true[0+i*crossvalidation:len(y_true)]
271
272             x_train_trainingset = x_train[0:0+i*crossvalidation]
273             y_true_trainingset = y_true[0:0+i*crossvalidation]
274
275         else:
276             x_train_testingset = x_train[0+i*crossvalidation:crossvalidation+i*crossvalidation]
277             y_true_testingset = y_true[0+i*crossvalidation:crossvalidation+i*crossvalidation]
278
279             x_train_trainingset1 = x_train[0:i*crossvalidation]
280             x_train_trainingset2 = x_train[crossvalidation*(i+1):len(x_train)]
281
282             x_train_trainingset = x_train_trainingset1 + x_train_trainingset2
283
284             y_true_trainingset1 = y_true[0:i*crossvalidation]
285             y_true_trainingset2 = y_true[crossvalidation*(i+1):len(x_train)]
286
287             y_true_trainingset = y_true_trainingset1 + y_true_trainingset2
288
289             x_train_trainingset = np.array(x_train_trainingset)
290             y_true_trainingset = np.array(y_true_trainingset)
291
292             x_train_trainingset = Normalize(x_train_trainingset)
293             y_true_trainingset = Normalize(y_true_trainingset)
294
295         for j in range(len(y_true_trainingset)):
296             if ( y_true_trainingset[j][0] == 0 ):
297                 y_true_trainingset[j][0] = 0.1
298             if ( y_true_trainingset[j][1] == 0 ):
299                 y_true_trainingset[j][1] = 0.1

```

រូបទី 40: ແបង Train ก្នុង Test set នៃ Data ខែសែង(ពេល)

```

300     if ( y_true_trainingset[j][0] == 1 ):
301         y_true_trainingset[j][0] = 0.9
302     if ( y_true_trainingset[j][1] == 1 ):
303         y_true_trainingset[j][1] = 0.9
304
305     x_train_testingset = np.array(x_train_testingset)
306     y_true_testingset = np.array(y_true_testingset)
307
308     nn = NeuralNetwork(x_train_trainingset, y_true_trainingset)
309
310     x_train_testingset = Normalize(x_train_testingset)
311     y_true_testingset = Normalize(y_true_testingset)
312
313     for j in range(len(y_true_testingset)):
314         if ( y_true_testingset[j][0] == 0 ):
315             y_true_testingset[j][0] = 0.1
316         if ( y_true_testingset[j][1] == 0 ):
317             y_true_testingset[j][1] = 0.1
318         if ( y_true_testingset[j][0] == 1 ):
319             y_true_testingset[j][0] = 0.9
320         if ( y_true_testingset[j][1] == 1 ):
321             y_true_testingset[j][1] = 0.9
322
323         # nn.addLayer(6)
324         # nn.addLayer(3)
325         # # nn.addLayer(1)
326         # nn.addLayer(2)
327
328         print("Fold " + str(i+1))
329         nn.fit(1, 100, 5)
330         nn.confusion_matrix(x_train_testingset, y_true_testingset)
331         print("-----")

```

រូបទី 41: ແប់នៃ Train ក្នុង Test set នៃទាំង Data ខ្លួនសង(គប)