Tema 2 ML

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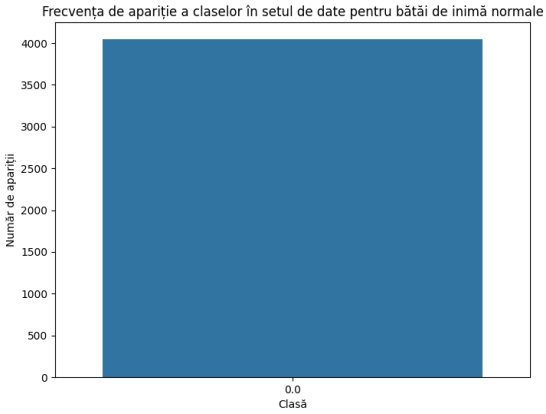
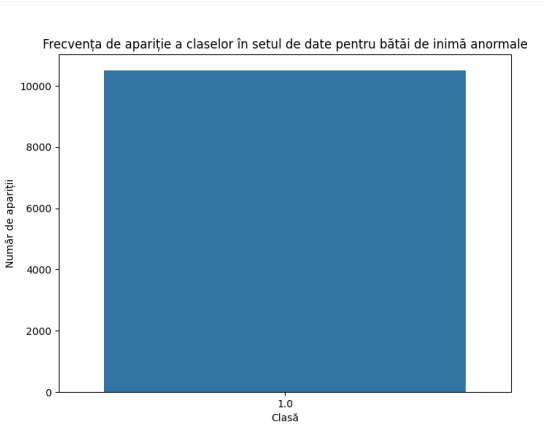
Explorarea Datelor Secvențiale

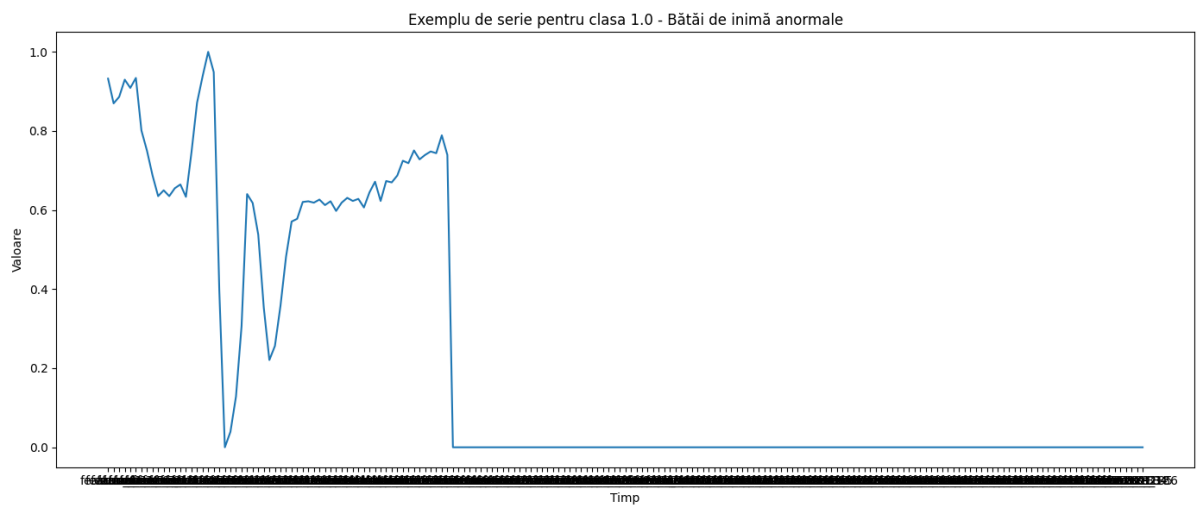
Am citit mai intai datele din cele doua fisiere si am separat ultima coloana(target-ul) de restul coloanelor.

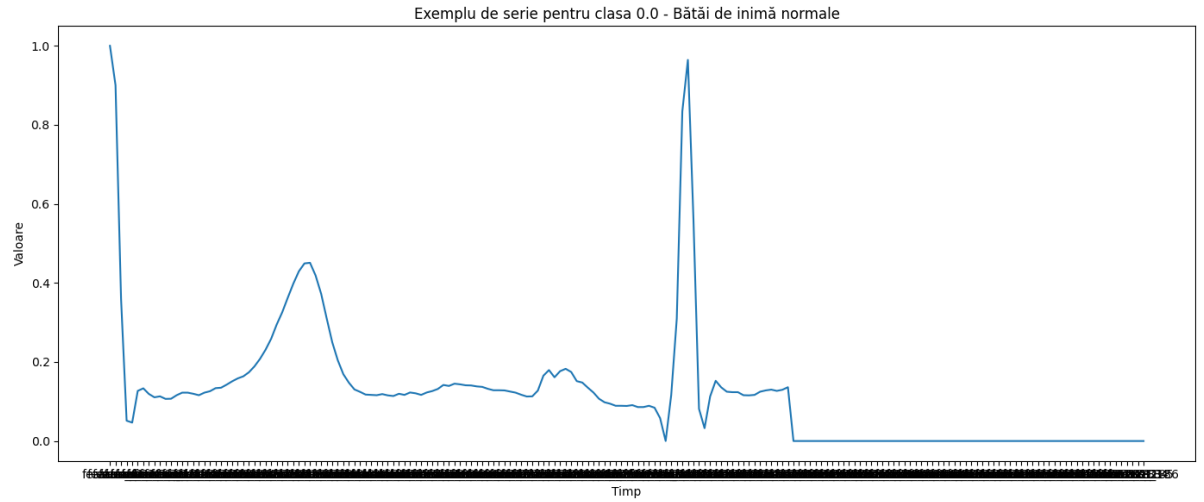
Analiza echilibrului de clase e practic doar numarul total de intrari din fiecare fisier, pentru ca fisierul abnormal are doar o clasa si cel normal la fel.





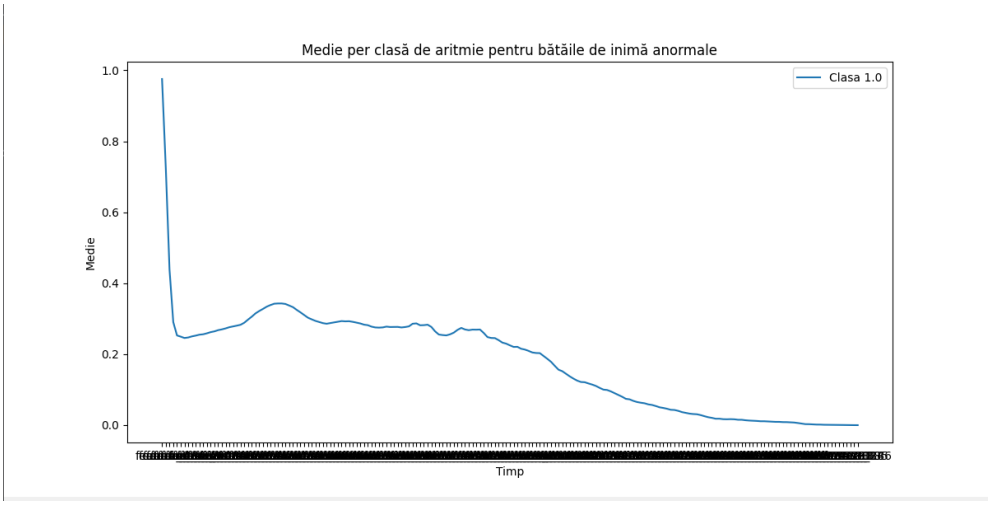
Mai jos sunt cate un exemplu de serie pentru fiecare categorie de aritmie din setul de date PTB.

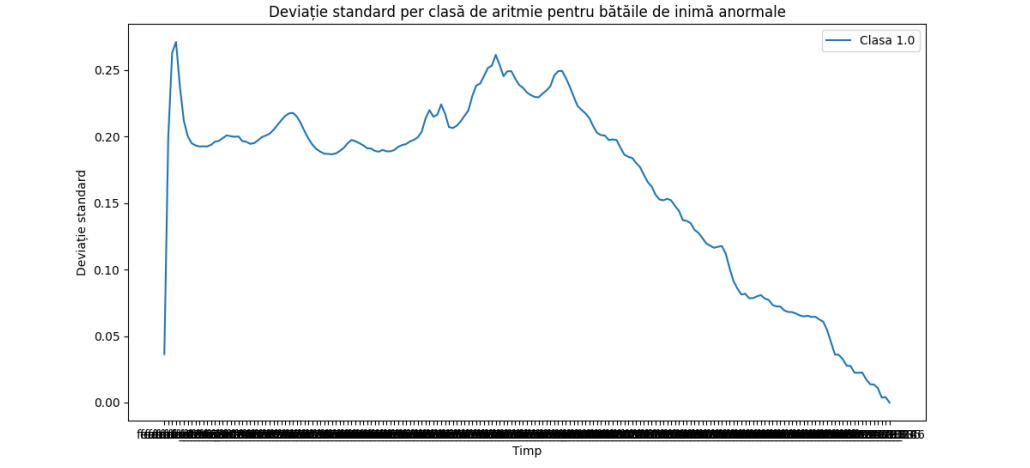




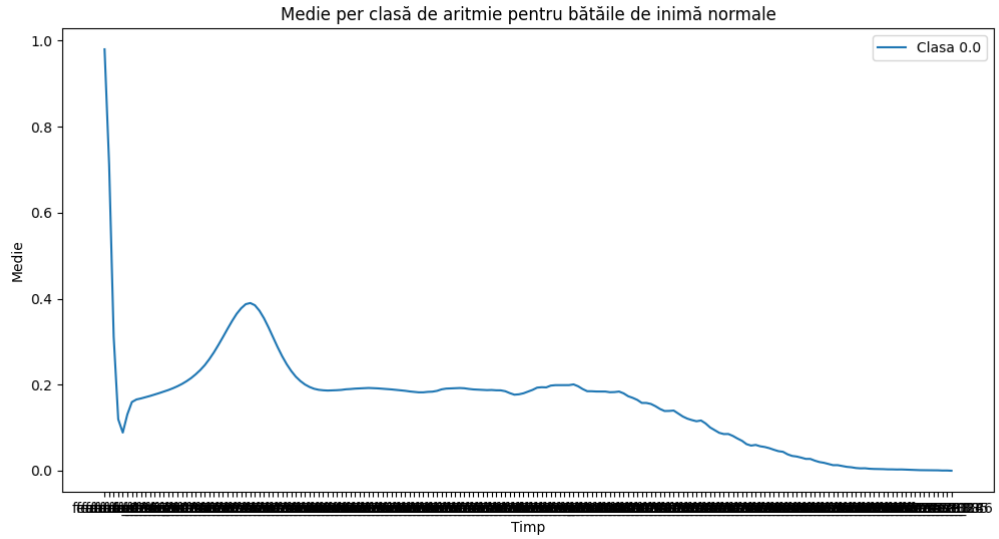
Am facut un grafic al mediei și deviației standard per unitate de timp, pentru fiecare clasă de aritmie.

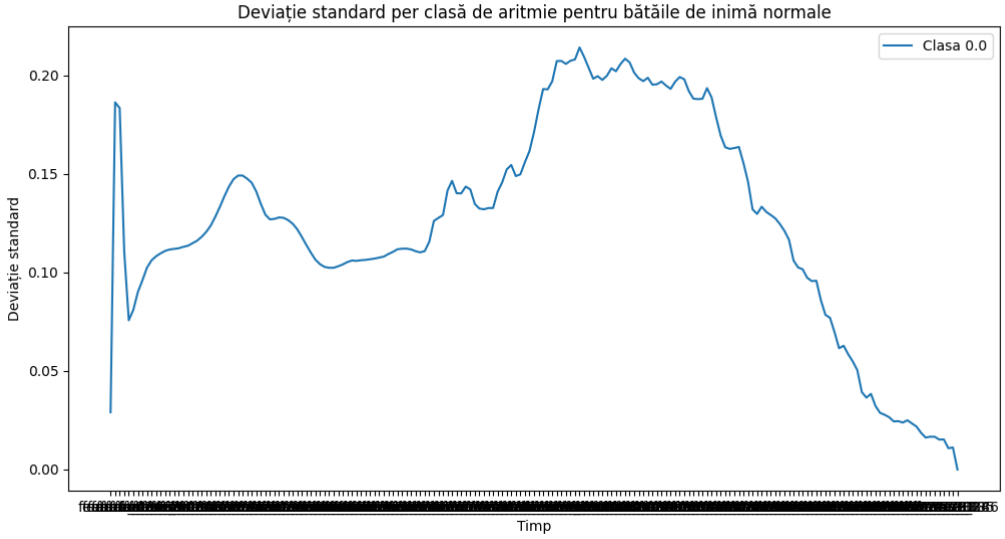
Anormale:





Normale:


Medie per clasă de aritmie pentru bătăile de inimă normale
Clasa 0.0
Medie
Timp


Deviație standard per clasă de aritmie pentru bătăile de inimă normale
Clasa 0.0
Deviație standard
Timp

Arhitectura de tip MLP

Mai intai am preprocesat datele pentru patients ca la tema 1, pentru a avea toate categoriile numerice, si toate atributele standardizate. Am separat setul de date in train si test, atat pt coloanele normale cat si pt target(diagnostic/1/0). Am unit apoi cele doua seturi de date ptb(normal si abnormal). Functia train_and_test imi antreneaza si testeaza in functie de numarul de epoci primite. Ea pastreaza toate datele necesare pentru tabelele cu precizie, f1, etc, si totodata pt graficele cerute. Mi-am facut o lista de hidden sizes, si am executat aceasta functie pt fiecare configuratie, retinand statisticile.

Am folosit urmatorii parametrii de optimizare pentru fiecare rulare: **learning rate** 0.001 pentru fiecare rulare(am incercat si cu learning rate mai mare dar rezultatele erau mult mai proaste, uneori rezultand chiar in erori).

criterion = nn.CrossEntropyLoss()
Pierderea prin entropie încrucișată crește pe măsură ce probabilitatea prezisă se îndepărtează de eticheta reală. Este deosebit de potrivită pentru problemele de clasificare unde valorile țintă sunt întregi.

optimizer = optim.Adam(model.parameters()

Este robust la gradienti zgomotoși, ceea ce îl face potrivit pentru datele reale care conțin adesea zgomot, precum in setul nostru de date.

Adam menține două medii mobile pentru fiecare greutate: unul pentru gradienti (primul moment) și unul pentru gradientii pătrați (al doilea moment).

Aceste medii mobile sunt apoi utilizate pentru a ajusta adaptiv rata de învățare pentru fiecare greutate individuală.

Include mecanisme pentru prevenirea oscilațiilor și a depășirii, făcând convergența mai stabilă și mai rapidă.

Am folosit aceste hidden_sizes:

```python
# Configuratii pentru arhitecturile MLP
mlp_hidden_sizes = [[64, 32], [128, 64], [128, 64, 32], [256, 128, 64, 32]]
```

Si am variat numarul de epoci intre 10-20-30.
Pentru 10 epoci, am avut urmatoarele loss-uri pe fiecare epoca:

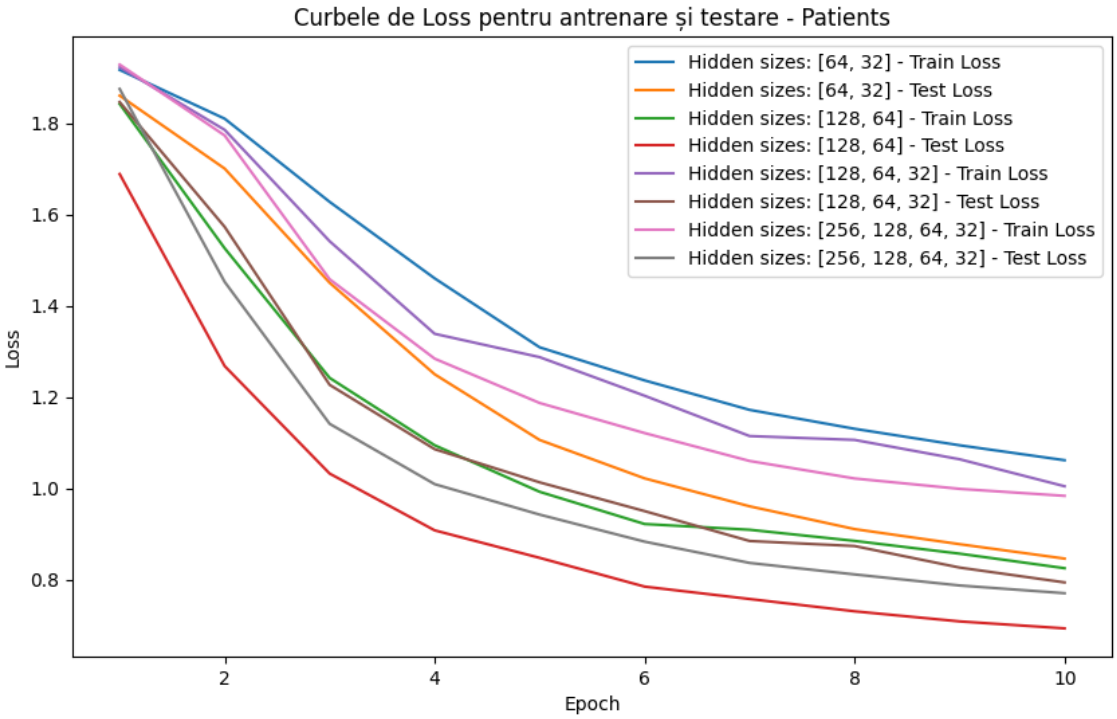
```
MLP for patients with hidden sizes: [64, 32]
Epoch 1/10, Loss: 1.917585497101148
Epoch 2/10, Loss: 1.8106938153505325
Epoch 3/10, Loss: 1.6284221510092418
Epoch 4/10, Loss: 1.4608762885133426
Epoch 5/10, Loss: 1.3098081921537716
Epoch 6/10, Loss: 1.2372820886472862
Epoch 7/10, Loss: 1.1727414031823475
Epoch 8/10, Loss: 1.1312795703609784
Epoch 9/10, Loss: 1.0951530771950881
Epoch 10/10, Loss: 1.0624308437108994
Accuracy: 56.42297650130549%
MLP for patients with hidden sizes: [128, 64]
Epoch 1/10, Loss: 1.8429399356245995
Epoch 2/10, Loss: 1.5267977962891262
Epoch 3/10, Loss: 1.2427460923790932
Epoch 4/10, Loss: 1.0952286459505558
Epoch 5/10, Loss: 0.9932457022368908
Epoch 6/10, Loss: 0.9226628678540388
Epoch 7/10, Loss: 0.9100979802509149
Epoch 8/10, Loss: 0.8856835775077343
Epoch 9/10, Loss: 0.8577133466800054
Epoch 10/10, Loss: 0.8258242396016916
Accuracy: 66.08355091383812%
```

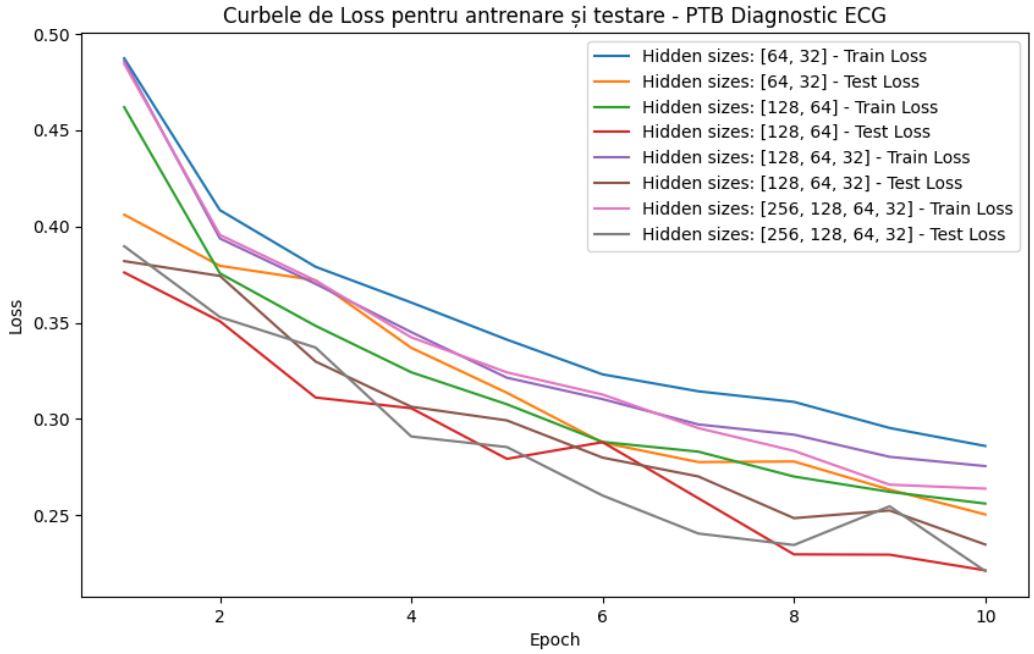
```
MLP for patients with hidden sizes: [128, 64, 32]
Epoch 1/10, Loss: 1.9234534526864688
Epoch 2/10, Loss: 1.7862417995929718
Epoch 3/10, Loss: 1.5421873802940052
Epoch 4/10, Loss: 1.339391641318798
Epoch 5/10, Loss: 1.288243015607198
Epoch 6/10, Loss: 1.2036958013971646
Epoch 7/10, Loss: 1.115360140800476
Epoch 8/10, Loss: 1.1069155496855576
Epoch 9/10, Loss: 1.064543171475331
Epoch 10/10, Loss: 1.0053714501361053
Accuracy: 60.887728459530024%
MLP for patients with hidden sizes: [256, 128, 64, 32]
Epoch 1/10, Loss: 1.9292619650562604
Epoch 2/10, Loss: 1.773902786274751
Epoch 3/10, Loss: 1.4588923528790474
Epoch 4/10, Loss: 1.284924726933241
Epoch 5/10, Loss: 1.187806876997153
Epoch 6/10, Loss: 1.121905201425155
Epoch 7/10, Loss: 1.060778945684433
Epoch 8/10, Loss: 1.0224260427057743
Epoch 9/10, Loss: 0.9997079695264498
Epoch 10/10, Loss: 0.9843458433945974
Accuracy: 59.1644908616188%
```

```
MLP for PTB Diagnostic ECG with hidden sizes: [64, 32]
Epoch 1/10, Loss: 0.4873514858657842
Epoch 2/10, Loss: 0.4084728700774057
Epoch 3/10, Loss: 0.3790395986493472
Epoch 4/10, Loss: 0.36048543756152246
Epoch 5/10, Loss: 0.3412061316053291
Epoch 6/10, Loss: 0.32316768468245044
Epoch 7/10, Loss: 0.31437011306675583
Epoch 8/10, Loss: 0.3088680364109658
Epoch 9/10, Loss: 0.2953214959988555
Epoch 10/10, Loss: 0.28595939100525536
Accuracy: 85.84335279972518%
MLP for PTB Diagnostic ECG with hidden sizes: [128, 64]
Epoch 1/10, Loss: 0.46191601414274386
Epoch 2/10, Loss: 0.37563733056515125
Epoch 3/10, Loss: 0.3483653726404185
Epoch 4/10, Loss: 0.32424786246821774
Epoch 5/10, Loss: 0.3076146119530057
Epoch 6/10, Loss: 0.2880556817360959
Epoch 7/10, Loss: 0.2830146265390155
Epoch 8/10, Loss: 0.27008891682867164
Epoch 9/10, Loss: 0.2621309603103897
Epoch 10/10, Loss: 0.25602349743328906
Accuracy: 87.57128134661627%
```

```
MLP for PTB Diagnostic ECG with hidden sizes: [128, 64, 32]
Epoch 1/10, Loss: 0.4860130787550748
Epoch 2/10, Loss: 0.39376010496046515
Epoch 3/10, Loss: 0.3701767495700291
Epoch 4/10, Loss: 0.34510793528714023
Epoch 5/10, Loss: 0.3214303058787034
Epoch 6/10, Loss: 0.310301390220667
Epoch 7/10, Loss: 0.2971559089332164
Epoch 8/10, Loss: 0.29185131974108924
Epoch 9/10, Loss: 0.28032601483493713
Epoch 10/10, Loss: 0.2755153724043579
Accuracy: 86.83957402954312%
MLP for PTB Diagnostic ECG with hidden sizes: [256, 128, 64, 32]
Epoch 1/10, Loss: 0.4845301294392282
Epoch 2/10, Loss: 0.3956013203567856
Epoch 3/10, Loss: 0.3718968930725868
Epoch 4/10, Loss: 0.3424071937308207
Epoch 5/10, Loss: 0.324198713894565
Epoch 6/10, Loss: 0.3126708309647146
Epoch 7/10, Loss: 0.29524843687457697
Epoch 8/10, Loss: 0.28342901724953573
Epoch 9/10, Loss: 0.26586573923027124
Epoch 10/10, Loss: 0.2638117189181375
Accuracy: 86.97354860872552%
```

Graficele pentru 10 epoci:





Statisticile pentru 10 epoci:

```
Results for MLP - Patients

Hidden sizes: [64, 32]
Hidden sizes: [128, 64]
Hidden sizes: [128, 64, 32]
Hidden sizes: [256, 128, 64, 32]
```

accuracy	precision
0.564230	[0.6333333333333333, 0.3982142857142857, 0.6473429951690821, 0.32751091703056767, 0.45100105374077976, 0.7305263157894737, 0.8588640275387264]
0.660836	[0.6895424836601307, 0.4299610894941634 5, 0.6382978723404256, 0.5561097256857855, 0.6106983655274889, 0.7609682299546142, 0.8453125]
0.608877	[0.5779601406799532, 0.3507853403141361, 0.5737704918032787, 0.5808080808080808, 0.5107655502392344, 0.7580919931856 9, 0.8116591928251121]
0.591645	[0.635077793493635, 0.4198895027624309, 0.4909090909090909, 0.5399239543726235, 0.39978448275862066, 0.7369281045751634, 0.85828025477707]

recall
[0.6031746031746031, 0.4207547169811321, 0.335, 0.2777777777777778, 0.7133333333333334, 0.5982758620689655, 0.9072727272727272]
[0.6698412698412698, 0.4169811320754717, 0.525, 0.412962962962963, 0.685, 0.8672413793103448, 0.9836363636363636]
[0.7825396825396825, 0.2528301886792453, 0.4375, 0.21296296296296297, 0.7116666666666667, 0.7672413793103449, 0.9872727272727273]
[0.7126984126984127, 0.28679245283018867, 0.405, 0.26296296296296295, 0.6183333333333333, 0.7775862068965518, 0.98]

f1
[0.6178861788617886, 0.4091743119266055, 0.4415156507413509, 0.30060120240480964, 0.552614590058102, 0.6578199052132702, 0.8824049513704686]
[0.679549114331723, 0.42337164750957856, 0.5761316872427984, 0.47396386822529224, 0.6457187745483111, 0.8106365834004835, 0.9092436974789916]
[0.6648685097774781, 0.29385964912280704, 0.49645390070921985, 0.3116531165311653, 0.5947075208913649, 0.7626392459297343, 0.8908941755537325]
[0.6716529543754675, 0.34080717488789236, 0.4438356164383562, 0.35367372353673726, 0.4856020942408377, 0.7567114093959731, 0.9151103565365025]

```
Results for MLP - PTB Diagnostic ECG

Hidden sizes: [64, 32]
Hidden sizes: [128, 64]
Hidden sizes: [128, 64, 32]
Hidden sizes: [256, 128, 64, 32]
```

accuracy	precision	recall	f1
0.858434	[0.6997374129466835, 0.9267357869392168]	[0.8043307086614173, 0.8776174965100046]	[0.7483973380548263, 0.901508090150809]
0.875713	[0.7512556504269211, 0.9225858318358082]	[0.7851706036745407, 0.9078175895765472]	[0.7678388090349076, 0.9151421334083872]
0.868396	[0.7424804812492001, 0.9145889092360426]	[0.7612860892388451, 0.9063750581665891]	[0.751765696883302, 0.9104634585271227]
0.869735	[0.7324508136992957, 0.9238838858018777]	[0.7914698162729659, 0.8974872033503956]	[0.7608174593162609, 0.9104942642685172]

Este cate o statistica pentru fiecare clasa, de asta patients are 7 iar ptb doar 2.

Se observa clar o acuratete mult mai buna, si in general statistici mult mai bune pentru setul de date ptb.

30 de epoci:

```
MLP for patients with hidden sizes: [64, 32]
Epoch 1/30, Loss: 1.9386666888991992
Epoch 2/30, Loss: 1.8418920586506526
Epoch 3/30, Loss: 1.673185256620248
Epoch 4/30, Loss: 1.5128387610117595
Epoch 5/30, Loss: 1.3750211969017982
Epoch 6/30, Loss: 1.2838847090800602
Epoch 7/30, Loss: 1.2132297108570735
Epoch 8/30, Loss: 1.1601095957060654
Epoch 9/30, Loss: 1.1570532905558746
Epoch 10/30, Loss: 1.08741103981932
Epoch 11/30, Loss: 1.0619588034848373
Epoch 12/30, Loss: 1.0391149160762627
Epoch 13/30, Loss: 0.9990708145002524
Epoch 14/30, Loss: 0.9911690019071102
Epoch 15/30, Loss: 0.9861453374226888
Epoch 16/30, Loss: 0.9637472232182821
Epoch 17/30, Loss: 0.9170914304753145
Epoch 18/30, Loss: 0.9342822308341662
Epoch 19/30, Loss: 0.8990049908558527
Epoch 20/30, Loss: 0.9240252487361431
Epoch 21/30, Loss: 0.9127279532452425
Epoch 22/30, Loss: 0.8739842101931572
Epoch 23/30, Loss: 0.8499628851811091
Epoch 24/30, Loss: 0.8562487009912729
Epoch 25/30, Loss: 0.8623949823280176
Epoch 26/30, Loss: 0.8281691757341226
Epoch 27/30, Loss: 0.8391725551337004
Epoch 28/30, Loss: 0.811476302643617
Epoch 29/30, Loss: 0.8248810892303785
Epoch 30/30, Loss: 0.8215452072521051
Accuracy: 68.44212358572672%
```

```
MLP for patients with hidden sizes: [128, 64]
Epoch 1/30, Loss: 1.8772808586557705
Epoch 2/30, Loss: 1.5894477466742198
Epoch 3/30, Loss: 1.277950434635083
Epoch 4/30, Loss: 1.1295397157470386
Epoch 5/30, Loss: 1.0468209298948448
Epoch 6/30, Loss: 0.9850050744911035
Epoch 7/30, Loss: 0.9330906085669994
Epoch 8/30, Loss: 0.9221744773288568
Epoch 9/30, Loss: 0.8731697921951612
Epoch 10/30, Loss: 0.814011923968792
Epoch 11/30, Loss: 0.8340111995736758
Epoch 12/30, Loss: 0.8000422281523546
Epoch 13/30, Loss: 0.7704465805242459
Epoch 14/30, Loss: 0.746372585495313
Epoch 15/30, Loss: 0.7649880597988764
Epoch 16/30, Loss: 0.7346558297673861
Epoch 17/30, Loss: 0.713601923858126
Epoch 18/30, Loss: 0.713344274709622
Epoch 19/30, Loss: 0.6673061475157738
Epoch 20/30, Loss: 0.6557189772526423
Epoch 21/30, Loss: 0.6852806638926268
Epoch 22/30, Loss: 0.6856497799356779
Epoch 23/30, Loss: 0.6666090544313192
Epoch 24/30, Loss: 0.6278045947353045
Epoch 25/30, Loss: 0.6365775081018606
Epoch 26/30, Loss: 0.6379536197831234
Epoch 27/30, Loss: 0.6235201197365919
Epoch 28/30, Loss: 0.6058719176799059
Epoch 29/30, Loss: 0.5863704277823368
Epoch 30/30, Loss: 0.6106859985738993
Accuracy: 73.50739773716275%
```

```
MLP for patients with hidden sizes: [128, 64, 32]
Epoch 1/30, Loss: 1.920025239388148
Epoch 2/30, Loss: 1.7857900659243267
Epoch 3/30, Loss: 1.51821830868721
Epoch 4/30, Loss: 1.3342258880535762
Epoch 5/30, Loss: 1.2337204366922379
Epoch 6/30, Loss: 1.191203497350216
Epoch 7/30, Loss: 1.126971957584222
Epoch 8/30, Loss: 1.0689283274114132
Epoch 9/30, Loss: 1.0205657134453456
Epoch 10/30, Loss: 1.035872037212054
Epoch 11/30, Loss: 0.9965682551264763
Epoch 12/30, Loss: 0.9730835047860941
Epoch 13/30, Loss: 0.9459005432824293
Epoch 14/30, Loss: 0.9153774976730347
Epoch 15/30, Loss: 0.9078335762023926
Epoch 16/30, Loss: 0.8968837584058443
Epoch 17/30, Loss: 0.8711956677337488
Epoch 18/30, Loss: 0.8720493167638779
Epoch 19/30, Loss: 0.870917002360026
Epoch 20/30, Loss: 0.8283854636053244
Epoch 21/30, Loss: 0.7903439725438753
Epoch 22/30, Loss: 0.8387716561555862
Epoch 23/30, Loss: 0.8046050940950712
Epoch 24/30, Loss: 0.7878299932926893
Epoch 25/30, Loss: 0.7692893048127493
Epoch 26/30, Loss: 0.7687783384074768
Epoch 27/30, Loss: 0.7454209383577108
Epoch 28/30, Loss: 0.7774684137354294
Epoch 29/30, Loss: 0.7510545297215382
Epoch 30/30, Loss: 0.7337292979160944
Accuracy: 70.75718015665797%
```

```
MLP for patients with hidden sizes: [256, 128, 64, 32]
Epoch 1/30, Loss: 1.9424455737074215
Epoch 2/30, Loss: 1.7919700692097347
Epoch 3/30, Loss: 1.4267933170000713
Epoch 4/30, Loss: 1.2877492246528466
Epoch 5/30, Loss: 1.1814203324417274
Epoch 6/30, Loss: 1.1167559971412022
Epoch 7/30, Loss: 1.0774362571537495
Epoch 8/30, Loss: 1.0239038988947868
Epoch 9/30, Loss: 1.0108985838790734
Epoch 10/30, Loss: 0.9606776287158331
Epoch 11/30, Loss: 0.9818560443818569
Epoch 12/30, Loss: 0.9443268664181232
Epoch 13/30, Loss: 0.9186070933938026
Epoch 14/30, Loss: 0.8914611761768659
Epoch 15/30, Loss: 0.883027195930481
Epoch 16/30, Loss: 0.8417814293255409
Epoch 17/30, Loss: 0.8359170164912939
Epoch 18/30, Loss: 0.8299112742145857
Epoch 19/30, Loss: 0.802145862330993
Epoch 20/30, Loss: 0.7923255929102501
Epoch 21/30, Loss: 0.7558877437065045
Epoch 22/30, Loss: 0.7678527471919855
Epoch 23/30, Loss: 0.7943331822752953
Epoch 24/30, Loss: 0.7298886055747668
Epoch 25/30, Loss: 0.7413567590216795
Epoch 26/30, Loss: 0.7385929264128208
Epoch 27/30, Loss: 0.7128941938281059
Epoch 28/30, Loss: 0.7056936329851548
Epoch 29/30, Loss: 0.6943316515535116
Epoch 30/30, Loss: 0.7000666602204243
Accuracy: 69.62576153176676%
```

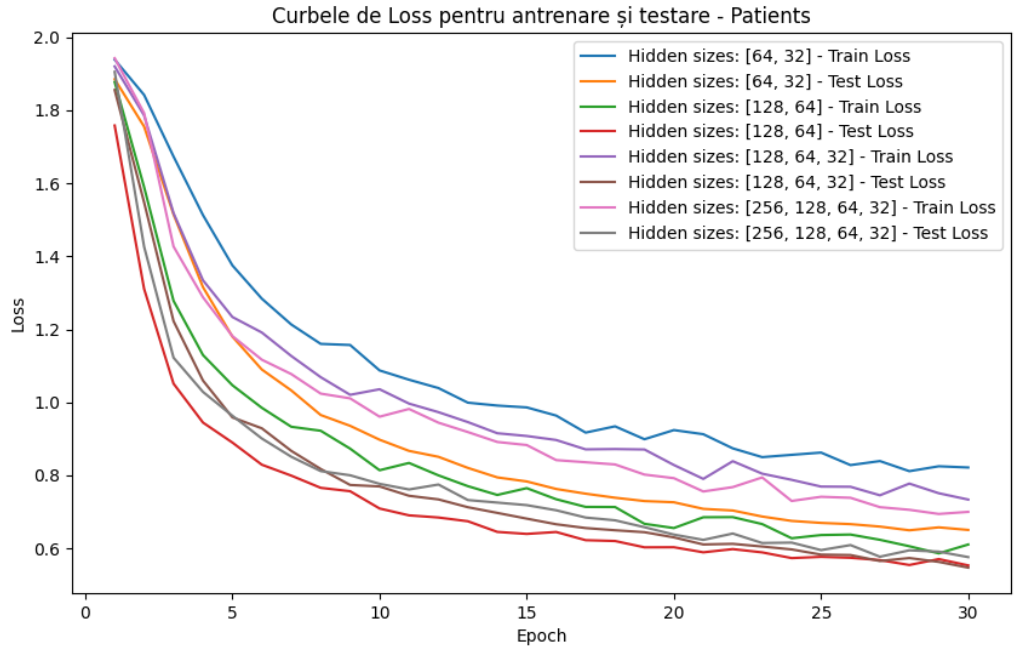
```
MLP for PTB Diagnostic ECG with hidden sizes: [64, 32]
Epoch 1/30, Loss: 0.48189008915489845
Epoch 2/30, Loss: 0.4017183117895991
Epoch 3/30, Loss: 0.3794600148122389
Epoch 4/30, Loss: 0.3534807199714603
Epoch 5/30, Loss: 0.33896142446978406
Epoch 6/30, Loss: 0.3237981989283811
Epoch 7/30, Loss: 0.30977537616022993
Epoch 8/30, Loss: 0.3010761976487689
Epoch 9/30, Loss: 0.28889570090469424
Epoch 10/30, Loss: 0.28399614387979877
Epoch 11/30, Loss: 0.2814954928030352
Epoch 12/30, Loss: 0.2686693979590967
Epoch 13/30, Loss: 0.2738586488783687
Epoch 14/30, Loss: 0.2616570774506737
Epoch 15/30, Loss: 0.25453315877898053
Epoch 16/30, Loss: 0.25151703885377763
Epoch 17/30, Loss: 0.24504971686382215
Epoch 18/30, Loss: 0.24408567780731144
Epoch 19/30, Loss: 0.24013816454744602
Epoch 20/30, Loss: 0.23479920976723617
Epoch 21/30, Loss: 0.23710973446185774
Epoch 22/30, Loss: 0.23601932204481993
Epoch 23/30, Loss: 0.2359634280143367
Epoch 24/30, Loss: 0.2368159858960208
Epoch 25/30, Loss: 0.22478178869114146
Epoch 26/30, Loss: 0.22495826091207974
Epoch 27/30, Loss: 0.22124173554622537
Epoch 28/30, Loss: 0.22011355183772988
Epoch 29/30, Loss: 0.2192850321797388
Epoch 30/30, Loss: 0.21930200237125813
Accuracy: 90.11107294171534%
```

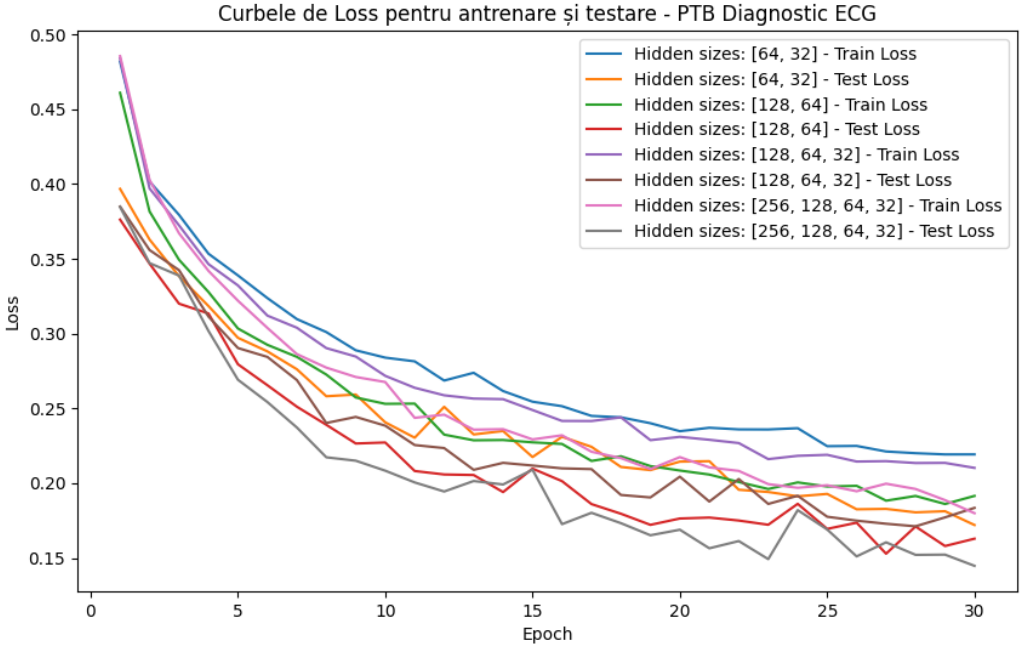
```
MLP for PTB Diagnostic ECG with hidden sizes: [128, 64]
Epoch 1/30, Loss: 0.46105708431575326
Epoch 2/30, Loss: 0.3817416426244673
Epoch 3/30, Loss: 0.3494254835564029
Epoch 4/30, Loss: 0.32787923782982015
Epoch 5/30, Loss: 0.30348102756581463
Epoch 6/30, Loss: 0.2925516282013812
Epoch 7/30, Loss: 0.28451157050145853
Epoch 8/30, Loss: 0.2726700972192563
Epoch 9/30, Loss: 0.2573495656865966
Epoch 10/30, Loss: 0.25310331417227183
Epoch 11/30, Loss: 0.25324689756546703
Epoch 12/30, Loss: 0.23252263747073793
Epoch 13/30, Loss: 0.22873119365137357
Epoch 14/30, Loss: 0.22890829466856444
Epoch 15/30, Loss: 0.22734814164853032
Epoch 16/30, Loss: 0.22629084443202713
Epoch 17/30, Loss: 0.21493704760303864
Epoch 18/30, Loss: 0.2180393238725898
Epoch 19/30, Loss: 0.21148365536438568
Epoch 20/30, Loss: 0.20851713327875177
Epoch 21/30, Loss: 0.20582273594298206
Epoch 22/30, Loss: 0.20083576587161847
Epoch 23/30, Loss: 0.196161671925418
Epoch 24/30, Loss: 0.2005805595583477
Epoch 25/30, Loss: 0.197807221151479
Epoch 26/30, Loss: 0.19829253848273676
Epoch 27/30, Loss: 0.18835603686274735
Epoch 28/30, Loss: 0.19150734143229303
Epoch 29/30, Loss: 0.18613520603381342
Epoch 30/30, Loss: 0.1915381231887655
Accuracy: 91.00538188480476%
```

```
MLP for PTB Diagnostic ECG with hidden sizes: [128, 64, 32]
Epoch 1/30, Loss: 0.4841594103682827
Epoch 2/30, Loss: 0.39712632590761554
Epoch 3/30, Loss: 0.3724475011720762
Epoch 4/30, Loss: 0.3465260760960998
Epoch 5/30, Loss: 0.3322815743612719
Epoch 6/30, Loss: 0.3120840878154223
Epoch 7/30, Loss: 0.30399260321979993
Epoch 8/30, Loss: 0.29036449078102033
Epoch 9/30, Loss: 0.28472289017268587
Epoch 10/30, Loss: 0.27182089031807016
Epoch 11/30, Loss: 0.2638442416235313
Epoch 12/30, Loss: 0.2588115178642201
Epoch 13/30, Loss: 0.25661277518208536
Epoch 14/30, Loss: 0.2562277724577503
Epoch 15/30, Loss: 0.248960324757538
Epoch 16/30, Loss: 0.24167245792245473
Epoch 17/30, Loss: 0.24160826750672781
Epoch 18/30, Loss: 0.24404876637221365
Epoch 19/30, Loss: 0.22880940528197602
Epoch 20/30, Loss: 0.2310372657746404
Epoch 21/30, Loss: 0.2290691512299108
Epoch 22/30, Loss: 0.2268740380141925
Epoch 23/30, Loss: 0.21613973870382205
Epoch 24/30, Loss: 0.21835041647920242
Epoch 25/30, Loss: 0.2190160228574014
Epoch 26/30, Loss: 0.21451975406239648
Epoch 27/30, Loss: 0.21477764781441663
Epoch 28/30, Loss: 0.2135174259707168
Epoch 29/30, Loss: 0.2136095113601986
Epoch 30/30, Loss: 0.21028040600224182
Accuracy: 90.31604259704568%
```

```
MLP for PTB Diagnostic ECG with hidden sizes: [256, 128, 64, 32]
Epoch 1/30, Loss: 0.48560781866967023
Epoch 2/30, Loss: 0.40281782495778995
Epoch 3/30, Loss: 0.36715450326165
Epoch 4/30, Loss: 0.34201650395170674
Epoch 5/30, Loss: 0.3220583679420607
Epoch 6/30, Loss: 0.30386619980109264
Epoch 7/30, Loss: 0.28635029908228704
Epoch 8/30, Loss: 0.27731434242533787
Epoch 9/30, Loss: 0.2710544342523093
Epoch 10/30, Loss: 0.267685136235841
Epoch 11/30, Loss: 0.2437449115338725
Epoch 12/30, Loss: 0.24586812859135015
Epoch 13/30, Loss: 0.23584803891787817
Epoch 14/30, Loss: 0.23616467361021173
Epoch 15/30, Loss: 0.22931691505792703
Epoch 16/30, Loss: 0.23207541892898606
Epoch 17/30, Loss: 0.22107366475552975
Epoch 18/30, Loss: 0.21681398899386545
Epoch 19/30, Loss: 0.2094618680037476
Epoch 20/30, Loss: 0.21747488857011546
Epoch 21/30, Loss: 0.21062404555933817
Epoch 22/30, Loss: 0.20825473577357256
Epoch 23/30, Loss: 0.19943003134883858
Epoch 24/30, Loss: 0.19696339549865205
Epoch 25/30, Loss: 0.19868422781659678
Epoch 26/30, Loss: 0.1946514748282485
Epoch 27/30, Loss: 0.1997106868650887
Epoch 28/30, Loss: 0.19618513561007414
Epoch 29/30, Loss: 0.18873204887015643
Epoch 30/30, Loss: 0.17998707343588818
Accuracy: 91.29623268063666%
```

Graficele pentru 30 de epoci:





Statistici pentru 30 de epoci:

```
Results for MLP - Patients

Hidden sizes: [64, 32]
Hidden sizes: [128, 64]
Hidden sizes: [128, 64, 32]
Hidden sizes: [256, 128, 64, 32]
```

accuracy	precision
0.684421	[0.65, 0.5118845500848896, 0.5786963434022258, 0.6368989205103042, 0.6397240019714144, 0.7836734693877551, 0.880065717415115]
0.735074	[0.7156421789105447, 0.5708367854183927, 0.5991501416430595, 0.6830427892234548, 0.7335844994617868, 0.8062130177514792, 0.9401858304297329]
0.707572	[0.6458610004426738, 0.5354406130268199, 0.5403120936280884, 0.7285067873303167, 0.727728285077951, 0.838569880823402, 0.852260778128286]
0.696258	[0.66875, 0.5739130434782609, 0.5837600585223116, 0.6998106060606061, 0.5645161290322581, 0.8257372654155496, 0.9294187425860023]

recall
[0.7634920634920634, 0.37924528301886795, 0.6066666666666667, 0.4006172839506173, 0.7211111111111111, 0.8827586206896552, 0.973939393939394]
[0.7576719576719577, 0.4333333333333335, 0.705, 0.5320987654320988, 0.7572222222222222, 0.9396551724137931, 0.9812121212121212]
[0.771957671957672, 0.35157232704402513, 0.6925, 0.49691358024691357, 0.7261111111111112, 0.8896551724137931, 0.9824242424242424]
[0.7925925925925926, 0.3320754716981132, 0.665, 0.4561728395061728, 0.7388888888888889, 0.8850574712643678, 0.9496969696969697]

f1
[0.7021897810218978, 0.4356936416184971, 0.5923515052888527, 0.49185297461159533, 0.677983807782711, 0.8302702702702702, 0.9246260069044879]
[0.7360575687483937, 0.4926707186271005, 0.6477794793261868, 0.5981956974323387, 0.7452159650082012, 0.8678343949044586, 0.9602609727164887]
[0.7033020004820438, 0.42444950645406226, 0.6070124178232287, 0.5908256880733945, 0.7269187986651835, 0.8633575013943112, 0.9127252252252253]
[0.7254237288135593, 0.4207171314741036, 0.6217374366965329, 0.5523168908819133, 0.6400384985563041, 0.8543689320388349, 0.9394484412470024]

```
Results for MLP - PTB Diagnostic ECG

Hidden sizes: [64, 32]              [0
Hidden sizes: [128, 64]             [0
Hidden sizes: [128, 64, 32]
Hidden sizes: [256, 128, 64, 32]  [0.
```

accuracy	precision	recall	f1
0.901111	[0.8075858489750022, 0.9347900573137303]	[0.8168416447944007, 0.930991158678455]	[0.8121873776695229, 0.9328867405461695]
0.910054	[0.8253610304002775, 0.9404397006425915]	[0.8325459317585302, 0.9375368388397705]	[0.8289379124109846, 0.9389860262076573]
0.903160	[0.811093351764655, 0.9363674607749957]	[0.8213473315835521, 0.9321700015511091]	[0.8161881371036102, 0.9342640166030579]
0.912962	[0.8279107749172648, 0.9438521455442299]	[0.8426509186351706, 0.9378935939196525]	[0.8352158172003382, 0.9408634358491593]

Arhitectura de tip convolutional

Am folosit aceeasi functie de antrenare si testare. Arhitectura functioneaza astfel:
Mai intai creeam primul strat convolutional, facand calculele cu ReLU.

ReLU(x)=max(0,x)

Acest lucru înseamnă că:

Dacă intrarea x este mai mică sau egală cu zero, ieșirea va fi zero.

Dacă intrarea x este mai mare decât zero, ieșirea va fi x.

Am folosit Max Pooling, care ajută la reducerea numărului de parametri și a complexității computaționale a rețelei, contribuind în același timp la prevenirea suprapotrivirii (overfitting).

Apoi creeam al doilea strat convolutional. Apoi calculăm dimensiunea de ieșire după straturile convoluționale pentru lungimea maximă a secvențelor si putem obtine astfel stratul liniar final. Cu functia forward, ca in laboratoare, dupa o mica preprocesare, aplicam straturile convolutionale si pe cel liniar si returnam rezultatul.

Am folosit 3 marimi de kernel:

```
kernel_sizes = [3, 5, 7]
```

Am rulat modelul pe 10-20-30 de epoci, luand rezultatele doar pentru rularile cu 10 si 30 pentru ca intre ele ar trebui sa fie cea mai mare diferenta.

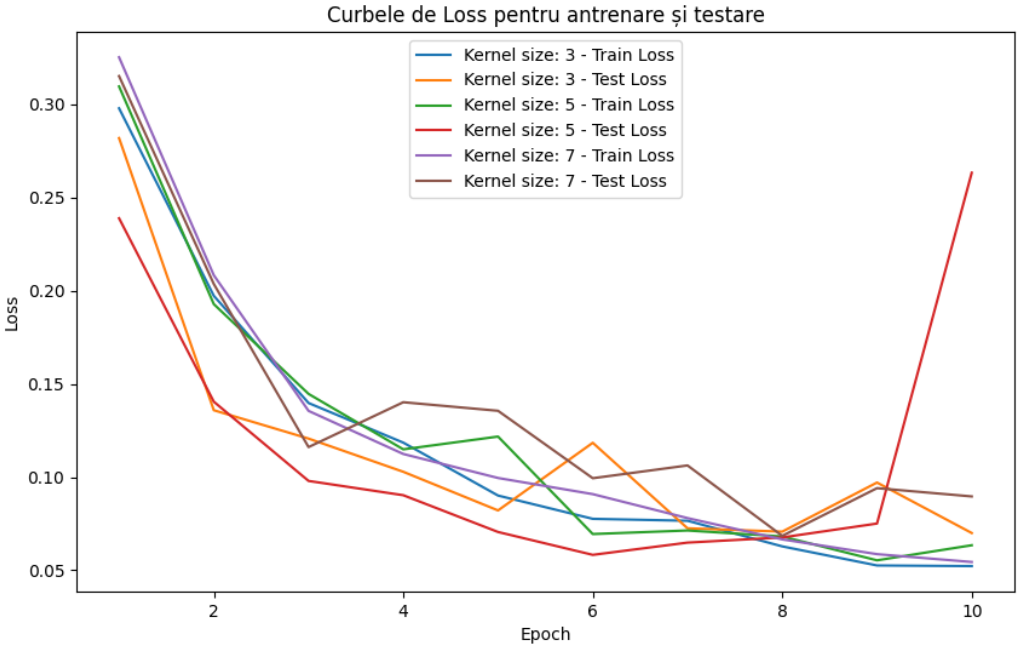
10 epoci:

```
Experiment with ConvNet kernel size: 3
Epoch 1/10, Loss: 0.29789401815979033
Epoch 2/10, Loss: 0.19728144396423966
Epoch 3/10, Loss: 0.139758225074959
Epoch 4/10, Loss: 0.1185044190874528
Epoch 5/10, Loss: 0.09010975414779611
Epoch 6/10, Loss: 0.07761791511374823
Epoch 7/10, Loss: 0.07657507605656244
Epoch 8/10, Loss: 0.06283488638115699
Epoch 9/10, Loss: 0.052595252957282033
Epoch 10/10, Loss: 0.05224672770786488
Accuracy: 95.70250772930264%
```

```
Experiment with ConvNet kernel size: 5
Epoch 1/10, Loss: 0.3096359143402059
Epoch 2/10, Loss: 0.1928212577067725
Epoch 3/10, Loss: 0.1446534201763775
Epoch 4/10, Loss: 0.11490037635859143
Epoch 5/10, Loss: 0.12176044928587994
Epoch 6/10, Loss: 0.06945167477933464
Epoch 7/10, Loss: 0.07136072894394561
Epoch 8/10, Loss: 0.06815198960472256
Epoch 9/10, Loss: 0.055351637852004636
Epoch 10/10, Loss: 0.06344520850305363
Accuracy: 95.70250772930264%
```

```
Experiment with ConvNet kernel size: 7
Epoch 1/10, Loss: 0.32529126135325365
Epoch 2/10, Loss: 0.20832132249251828
Epoch 3/10, Loss: 0.13553839694749523
Epoch 4/10, Loss: 0.11241788332411957
Epoch 5/10, Loss: 0.09953386364965239
Epoch 6/10, Loss: 0.09086789959494107
Epoch 7/10, Loss: 0.07801017933844967
Epoch 8/10, Loss: 0.06658452608722396
Epoch 9/10, Loss: 0.05866415358956387
Epoch 10/10, Loss: 0.05445476956595155
Accuracy: 94.67536928890415%
```

Grafic pentru 10 epoci:



Statistici pentru 10 epoci:

```
Results for ConvNet - PTB Diagnostic ECG

Kernel size: 3    [0.29789401815979033, 0
Kernel size: 5    [0.3096359143402059, 0.
Kernel size: 7  [0.32529126135325365, 0.2
```

accuracy	precision	recall	f1
0.957025	[0.9003142677561282, 0.9783502718033562]	[0.9398950131233595, 0.9630991158678455]	[0.9196789727126806, 0.9706647907140344]
0.957025	[0.9162201019474578, 0.971573698681206]	[0.9199475065616798, 0.9701721731037692]	[0.9180800209547508, 0.9708724300915039]
0.946754	[0.8828203834510595, 0.9706826550845057]	[0.918503937007874, 0.9567705909725454]	[0.9003087213789555, 0.963676415448069]

30 epoci:

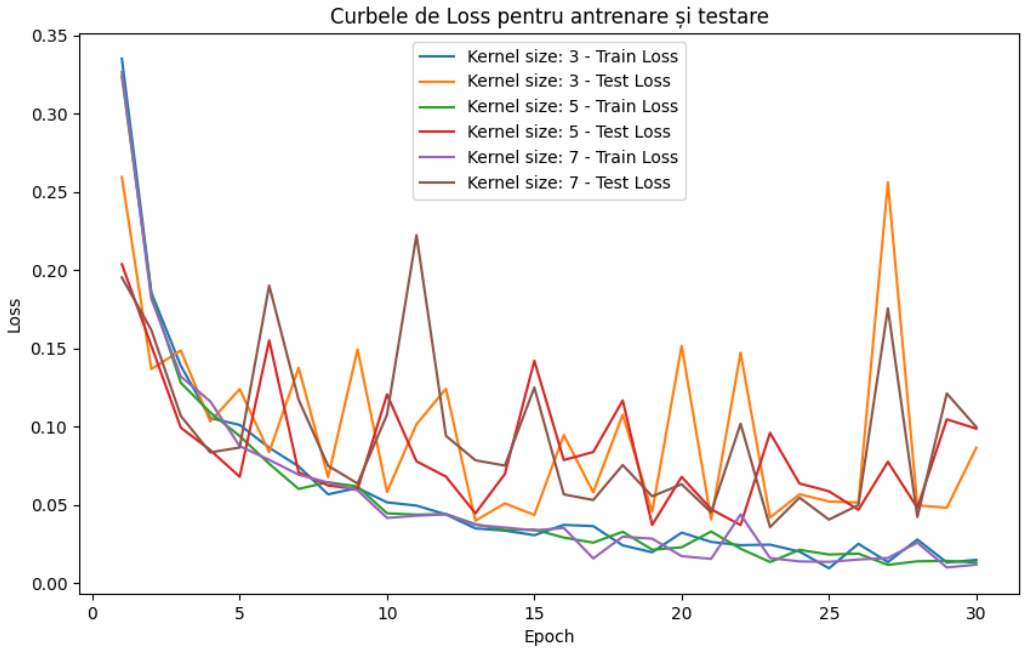
```
Experiment with ConvNet kernel size: 3
Epoch 1/30, Loss: 0.3349785566698391
Epoch 2/30, Loss: 0.18569101071353633
Epoch 3/30, Loss: 0.13896033656527543
Epoch 4/30, Loss: 0.10559662503118698
Epoch 5/30, Loss: 0.10120764639545846
Epoch 6/30, Loss: 0.0866723541326432
Epoch 7/30, Loss: 0.07471571940990103
Epoch 8/30, Loss: 0.05690716615920262
Epoch 9/30, Loss: 0.06097160568486408
Epoch 10/30, Loss: 0.051737794535526245
Epoch 11/30, Loss: 0.04971418653008436
Epoch 12/30, Loss: 0.04405072429917809
Epoch 13/30, Loss: 0.03514137665934958
Epoch 14/30, Loss: 0.03373312492276655
Epoch 15/30, Loss: 0.03082796469427374
Epoch 16/30, Loss: 0.03739748185372654
Epoch 17/30, Loss: 0.0365908081165109
Epoch 18/30, Loss: 0.024302583840096134
Epoch 19/30, Loss: 0.01991087358436454
Epoch 20/30, Loss: 0.03245069484850379
Epoch 21/30, Loss: 0.02653802554162282
Epoch 22/30, Loss: 0.024441473405314246
Epoch 23/30, Loss: 0.024772621670878264
Epoch 24/30, Loss: 0.020334056900317813
Epoch 25/30, Loss: 0.009672356792249887
Epoch 26/30, Loss: 0.025285176315174886
Epoch 27/30, Loss: 0.013664803616748131
Epoch 28/30, Loss: 0.028052758743217634
Epoch 29/30, Loss: 0.013386492613423027
Epoch 30/30, Loss: 0.015050421981348856
Accuracy: 96.81438222832932%
```

```
Experiment with ConvNet kernel size: 5
Epoch 1/30, Loss: 0.3238081050791092
Epoch 2/30, Loss: 0.18473932115299688
Epoch 3/30, Loss: 0.12814932496921455
Epoch 4/30, Loss: 0.1091319670412014
Epoch 5/30, Loss: 0.09411705497544832
Epoch 6/30, Loss: 0.07643163031489067
Epoch 7/30, Loss: 0.060351829371059436
Epoch 8/30, Loss: 0.06461086407576298
Epoch 9/30, Loss: 0.06190676647839699
Epoch 10/30, Loss: 0.04478260708376663
Epoch 11/30, Loss: 0.043893533434359366
Epoch 12/30, Loss: 0.0443041499192087
Epoch 13/30, Loss: 0.03782674851830522
Epoch 14/30, Loss: 0.03409018742008861
Epoch 15/30, Loss: 0.034409215661251255
Epoch 16/30, Loss: 0.02929027588898252
Epoch 17/30, Loss: 0.026066723684709938
Epoch 18/30, Loss: 0.03300260997815173
Epoch 19/30, Loss: 0.02156060290196495
Epoch 20/30, Loss: 0.023081608278896586
Epoch 21/30, Loss: 0.033135043990454166
Epoch 22/30, Loss: 0.02218765539071303
Epoch 23/30, Loss: 0.013680474231133192
Epoch 24/30, Loss: 0.021463590732929624
Epoch 25/30, Loss: 0.01846708487845627
Epoch 26/30, Loss: 0.019031548076812184
Epoch 27/30, Loss: 0.011851834802475604
Epoch 28/30, Loss: 0.01415415734518919
Epoch 29/30, Loss: 0.014424368502109796
Epoch 30/30, Loss: 0.013308451269599923
Accuracy: 97.17508301843581%
```

```
Experiment with ConvNet kernel size: 7
Epoch 1/30, Loss: 0.3265848268376111
Epoch 2/30, Loss: 0.1818345342660425
Epoch 3/30, Loss: 0.1321142753944374
Epoch 4/30, Loss: 0.11626928501921081
Epoch 5/30, Loss: 0.08765626157593023
Epoch 6/30, Loss: 0.0789194986925225
Epoch 7/30, Loss: 0.06943610728818125
Epoch 8/30, Loss: 0.06445244766687361
Epoch 9/30, Loss: 0.05946336860210727
Epoch 10/30, Loss: 0.0418159739852494
Epoch 11/30, Loss: 0.043254296824330934
Epoch 12/30, Loss: 0.04416059928109542
Epoch 13/30, Loss: 0.03732560266747656
Epoch 14/30, Loss: 0.035705094548725204
Epoch 15/30, Loss: 0.03386368703234309
Epoch 16/30, Loss: 0.03546456748633748
Epoch 17/30, Loss: 0.015990690840696046
Epoch 18/30, Loss: 0.029846600319585408
Epoch 19/30, Loss: 0.028594563131803995
Epoch 20/30, Loss: 0.01743198009337373
Epoch 21/30, Loss: 0.01568920440857275
Epoch 22/30, Loss: 0.044044058479422735
Epoch 23/30, Loss: 0.016230222112046628
Epoch 24/30, Loss: 0.014066279261257208
Epoch 25/30, Loss: 0.01378633175025263
Epoch 26/30, Loss: 0.015259164461735213
Epoch 27/30, Loss: 0.016262212866262577
Epoch 28/30, Loss: 0.026058156605898518
Epoch 29/30, Loss: 0.010209339642172851
Epoch 30/30, Loss: 0.012007281175216461
Accuracy: 96.69643879537388%
```

Se poate observa clar o imbunatatire mare intre 10 si 30 de epoci, insa numarul de kernel-uri nu pare sa influenteze atat de dramatic rezultatul. Poate daca alegeam un size mult mai mare sau mult mai mic am fi vazut diferente mai substantiale.

Grafic pentru 30 de epoci:



Statistici pentru 30 de epoci:

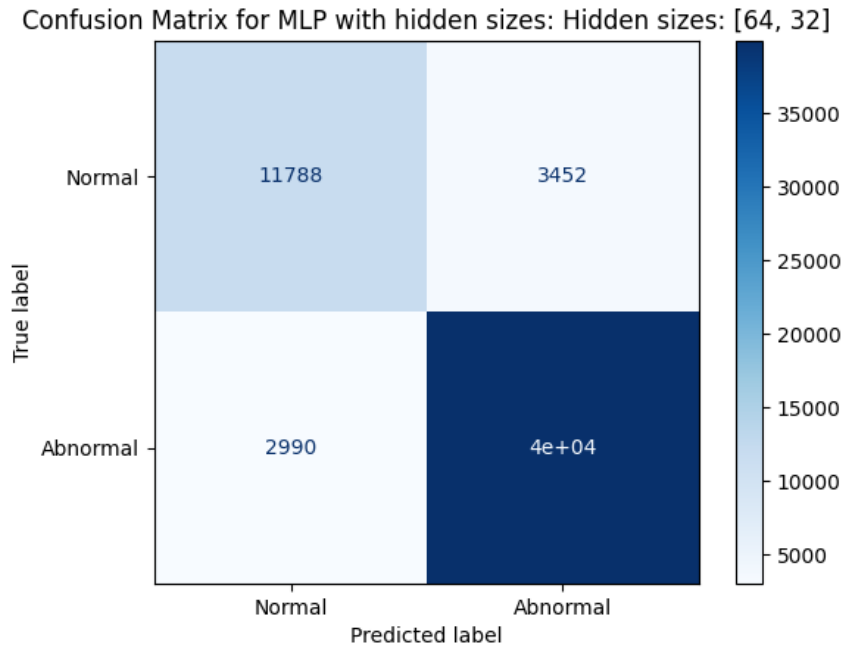
```
Results for ConvNet - PTB Diagnostic ECG

Kernel size: 3   [0.3349785566698391, 0.1
Kernel size: 5  [0.3238081050791092, 0.18
Kernel size: 7   [0.3265848268376111, 0.1
```

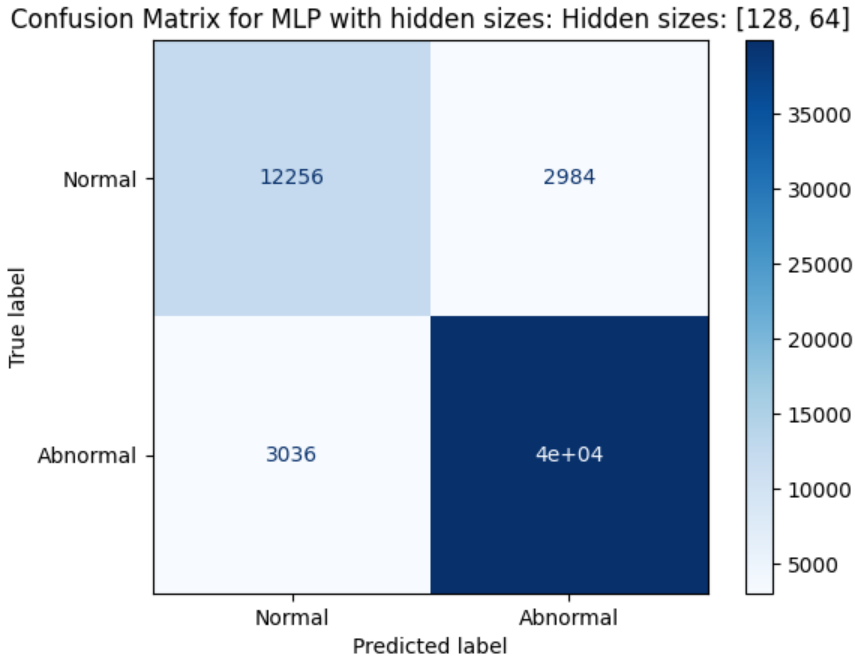
accuracy	precision	recall	f1
0.968144	[0.9378489183531054, 0.978929225800441]	[0.9406386701662293, 0.9778966961377384]	[0.9392417227221106, 0.9784126885591905]
0.971751	[0.9418851570964247, 0.9824760719010194]	[0.9507436570428697, 0.9791996277338297]	[0.9462936758463045, 0.980835113614294]
0.966964	[0.9324529118856896, 0.9793726161749825]	[0.9420384951881015, 0.9758026989297348]	[0.9372211946469372, 0.9775843984305194]

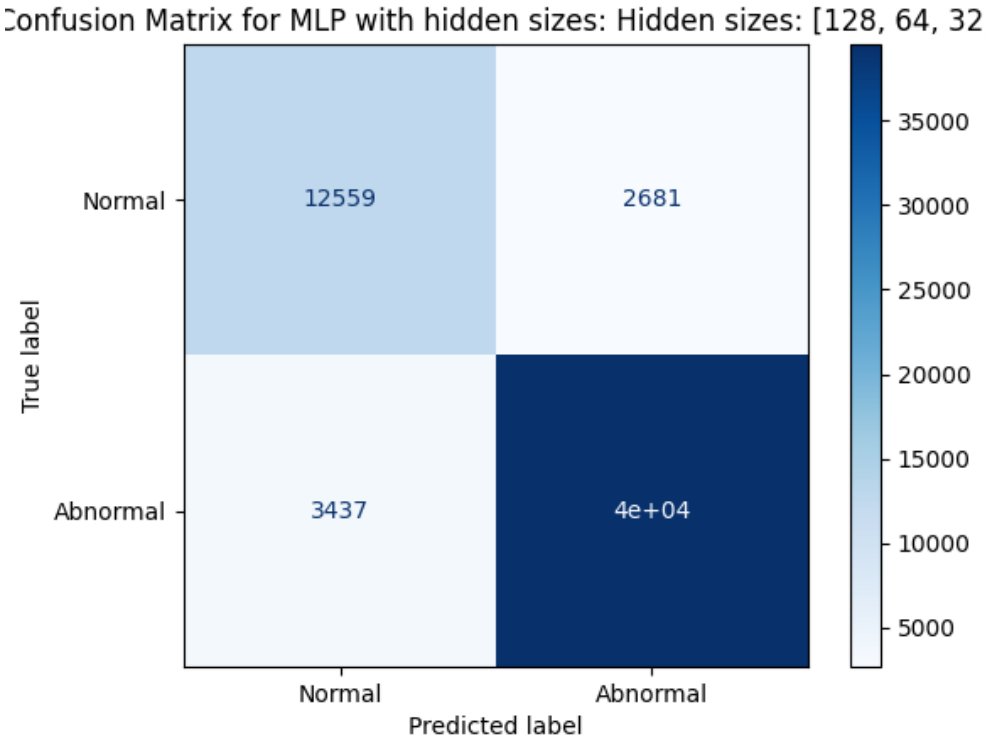
Matrice de confuzii

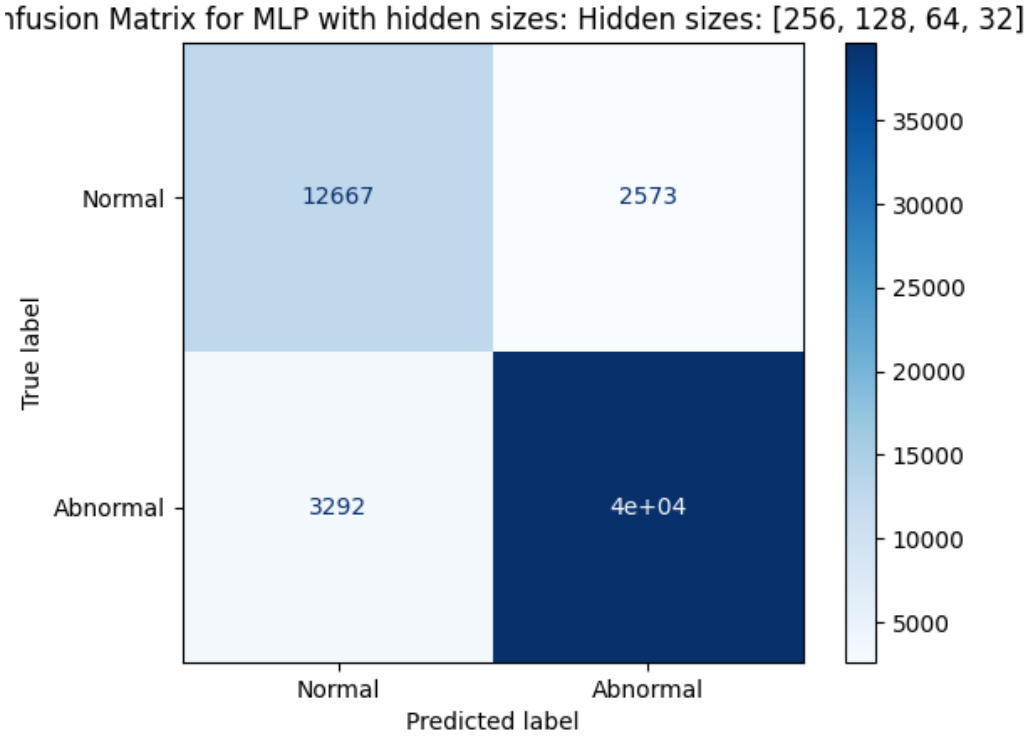
Am facut matricele de confuzii doar pentru seturile de date ptb concatenate. Ele au fost antrenate si testate cu 20 de epoci pentru acest subpunct.

MLP:

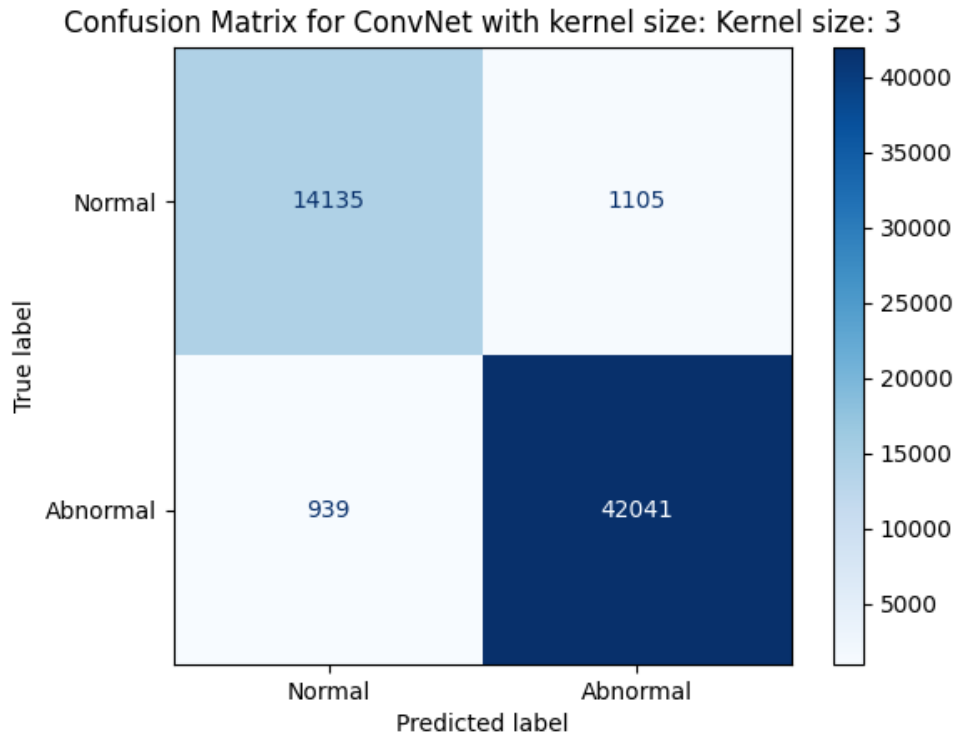


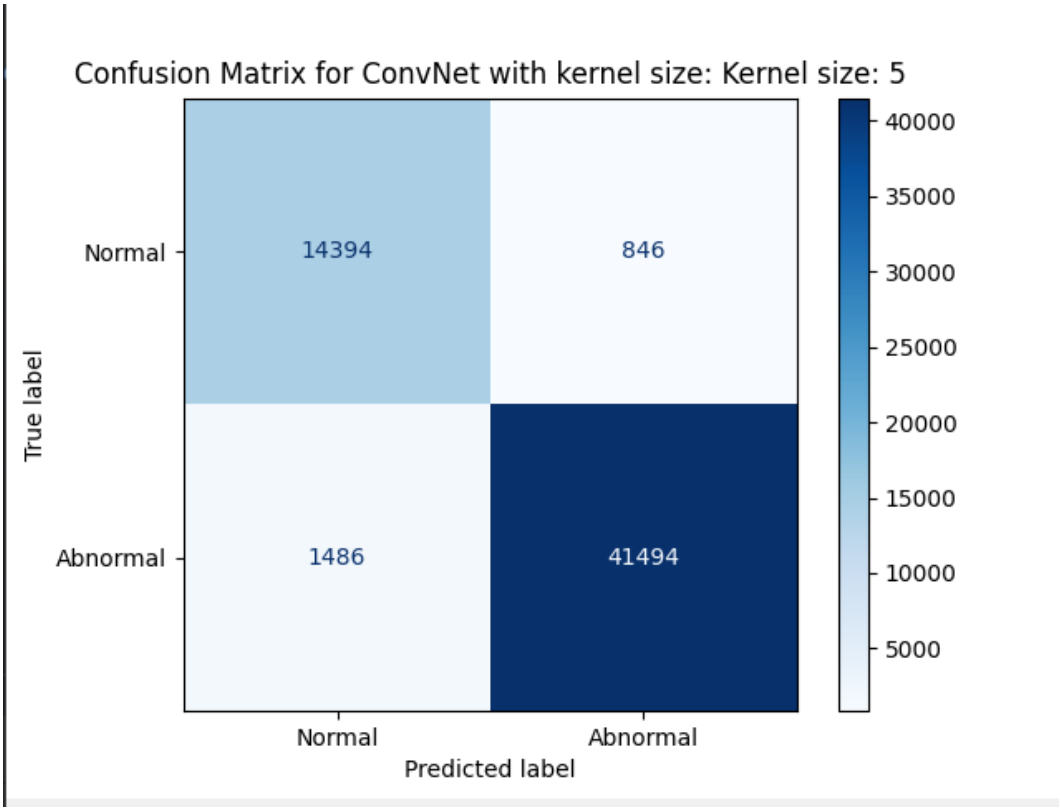


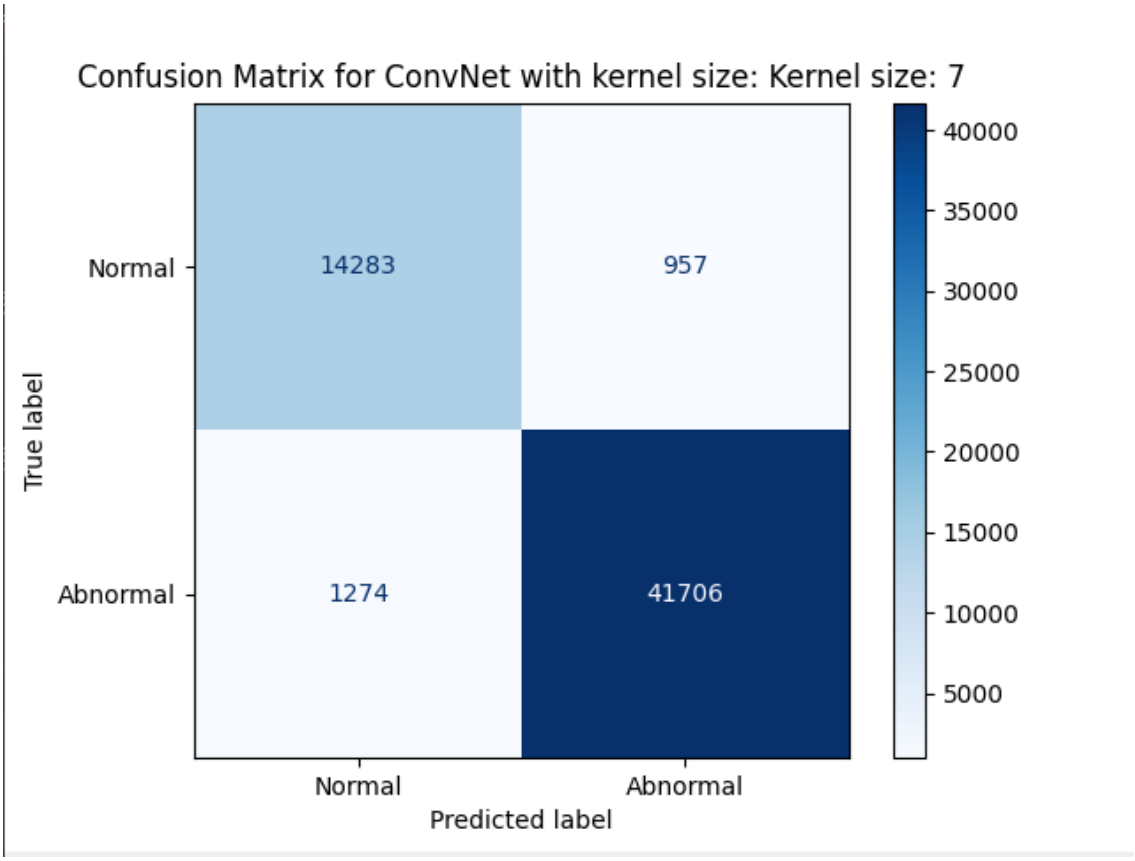

Confusion Matrix for MLP with hidden sizes: Hidden sizes: [128, 64, 32]
Normal
Abnormal
True label
12559
2681
3437
4e+04
35000
30000
25000
20000
15000
10000
5000
Normal
Abnormal
Predicted label


nfusion Matrix for MLP with hidden sizes: Hidden sizes: [256, 128, 64, 32]
Normal
Abnormal
True label
12667
2573
3292
4e+04
35000
30000
25000
20000
15000
10000
5000
Normal
Abnormal
Predicted label

ConvNet:


Confusion Matrix for ConvNet with kernel size: Kernel size: 3
Normal
Abnormal
True label
14135
1105
939
42041
Normal
Abnormal
Predicted label
40000
35000
30000
25000
20000
15000
10000
5000


Confusion Matrix for ConvNet with kernel size: Kernel size: 5
Normal
Abnormal
True label
14394
846
1486
41494
Normal
Abnormal
Predicted label
40000
35000
30000
25000
20000
15000
10000
5000


Confusion Matrix for ConvNet with kernel size: Kernel size: 7
Normal
Abnormal
True label
14283
957
1274
41706
Normal
Abnormal
Predicted label
40000
35000
30000
25000
20000
15000
10000
5000