

# Research Diary: Cross-device portability of the EMSCA iPhone Experiment

## INTRODUCTION

Target devices: *iPhone (Apple Processors)*

Selected Activities: *calendar-app, camera-photo, camera-video, email-app, gallery-app, home-screen, idle, phone-app, sms-app, web-browser-app (10 activities).*

Selected Device Details:

System-on-Chip	Architecture	CPU Frequency	Remarks	Devices
Apple A5	ARMv7-A	1GHz (2 cores)	Existing dataset	<b>iPhone 4S</b> , iPad 2 , iPod touch (5th generation, Apple TV (3rd generation), iPad Mini (1st generation)
Apple A8	ARMv8	1.4GHz(2 cores)		iPhone 6, iPhone 6 Plus, iPad mini 4, iPod touch (6th generation) , HomePod
Apple A9	ARMv8-A	1.85GHz (2 cores)		<b>iPhone 6S</b> , iPhone 6S Plus, iPhone SE (1st generation), iPad (5th generation)
Apple A11 Bionic	ARMv8-A	2.39GHz (6 cores)	Implementation of Neural Engine Machine Learning	<b>iPhone 8</b> , iPhone 8 Plus, iPhone X
Apple A14 Bionic	ARMv8.5-A	3.1 GHz(6 cores)	Hexa-core (2x3.1 GHz Firestorm + 4x1.8 GHz Icestorm)	iPhone12 Mini
Apple A15 Bionic	ARMv8.5-A	3.23 GHz (6 cores)	2x3.23 GHz Avalanche + 4x1.82 GHz Blizzard	<b>iPhone 13</b> , iPhone 13 Mini, iPhone 13 Pro, 13 Pro Max, iPad Mini (6th generation), iPhone SE (3rd generation).

Apple A16 Bionic (4 nm)	ARMv8.6-A	3.46 GHz (6 cores)	Hexa-core (2x3.46 GHz Everest + 4x2.02 GHz Sawtooth)	<b>iPhone14 Pro, iPhone 14 Pro Max</b>
----------------------------	-----------	--------------------	--	--

## RELATED LITERATURE

1. <https://ieeexplore.ieee.org/abstract/document/9586100>
2. <https://dl.acm.org/doi/abs/10.1145/3489517.3530517>
3. <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9218693>
4. <https://dl.acm.org/doi/pdf/10.1145/3316781.3317934>
5. <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8777157>
6. <https://dl.acm.org/doi/pdf/10.1145/3465380>
7. <https://tches.iacr.org/index.php/TCHES/article/view/9059/8646>
8. <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9586100>
9. <https://eprint.iacr.org/2020/1258.pdf>
10. [https://en.wikipedia.org/wiki/Apple\\_silicon](https://en.wikipedia.org/wiki/Apple_silicon)
11. <https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8906945>
12. <https://ieeexplore.ieee.org/abstract/document/9308332>
13. [https://github.com/thuml/Transfer-Learning-Library/blob/master/examples/domain\\_generalization/re\\_identification/baseline.py](https://github.com/thuml/Transfer-Learning-Library/blob/master/examples/domain_generalization/re_identification/baseline.py)

## **EXPERIMENT: 01**

Create a custom model for a few devices, then train the MLP deep learning model on a training dataset to validate overall accuracy. The h-loop near field probe, which is coupled to the hackRF one device, was used to capture EM signals from each smartphone for each of the ten tasks mentioned above. Afterwards, 10000 samples from each activity are gathered for machine learning analysis. Activity is considered as a class/label in this instance. The activities in the dataset are organized in the same chronological order. The dataset was further divided into training and testing portions, and the model was trained and tested with the splitted dataset. The average accuracy of almost all bespoke models is 100% when testing each specific device.

Model: "sequential"

Layer (type)	Output Shape	Param #
=====		
dense (Dense)	(None, 1400)	2868600
dense_1 (Dense)	(None, 800)	1120800
dense_2 (Dense)	(None, 500)	400500
dense_3 (Dense)	(None, 200)	100200
dense_4 (Dense)	(None, 100)	20100
dense_5 (Dense)	(None, 10)	1010
=====		
Total params: 4,511,210		
Trainable params: 4,511,210		
Non-trainable params: 0		

---

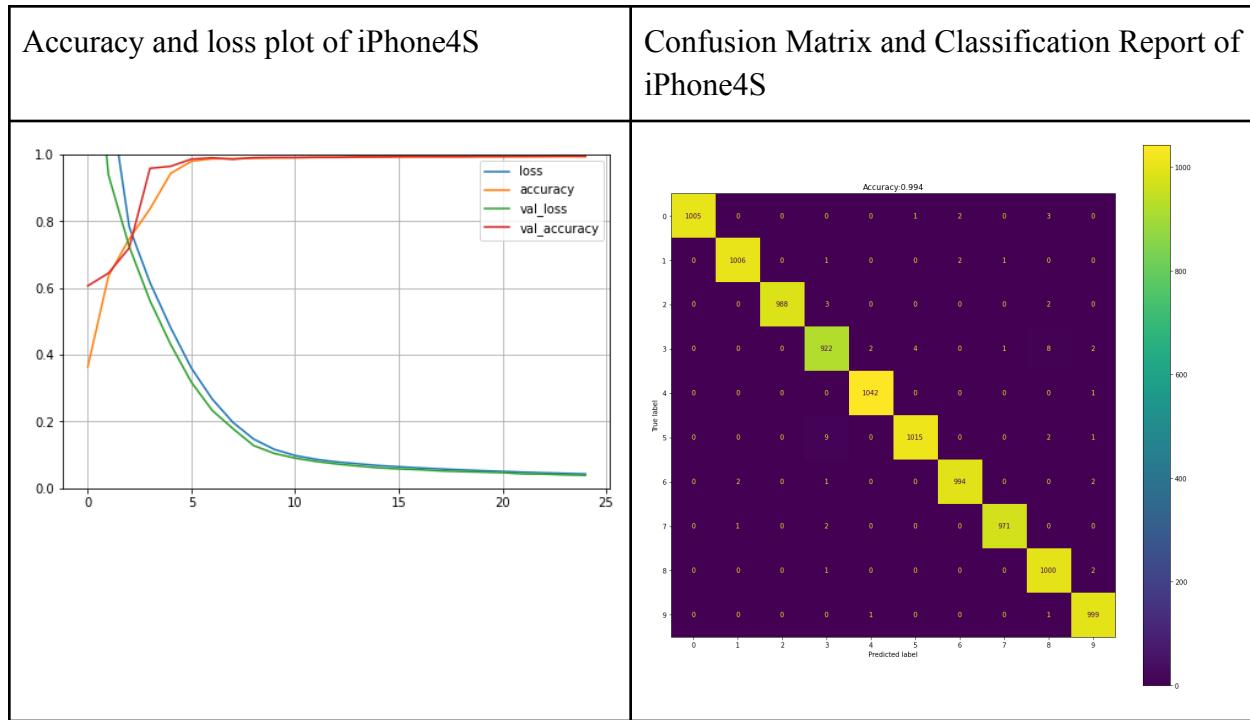
### ***Results of existing dataset:***

#### **iPhone4S**

Reproduce the result from existing dataset

An existing dataset from iPhone4S is used to re-create a custom model of the device.

Smartphone Name	iPhone4S
Training Accuracy at 25th epoch	0.9938
Learning time	26 minutes
Testing Accuracy	0.9942



### ***Result of newly collected dataset:***

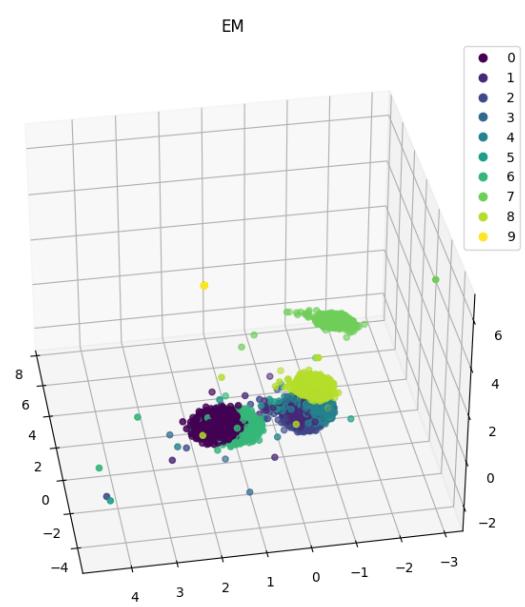
#### **iPhone13**

Three iPhone 13 smartphones (identical devices) were selected to analyze the experiment. Three devices are named iPhone13\_I, iPhone13\_II and iPhone13\_III respectively.

Results Comparison three iPhones

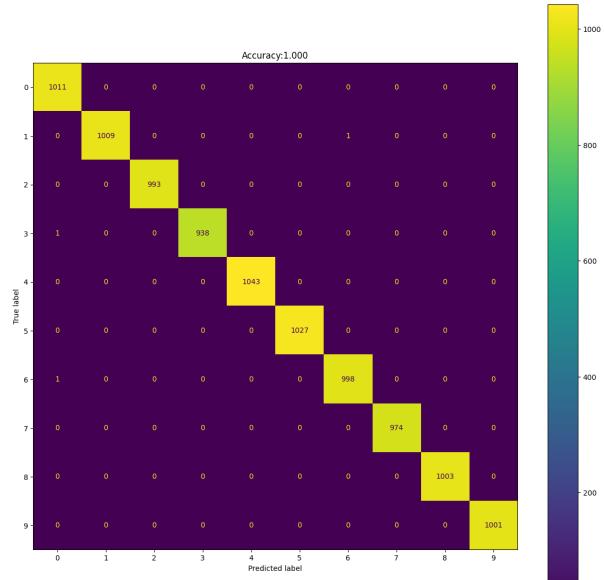
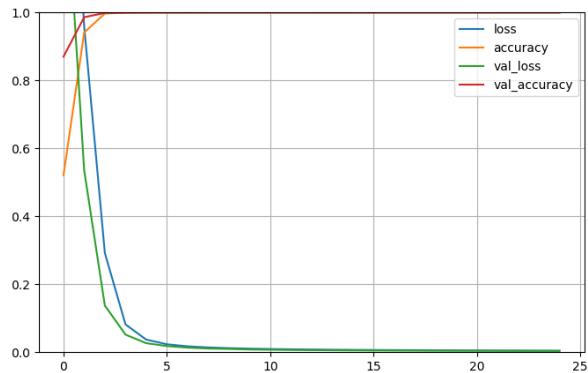
Smartphone Name	iPhone13_I	iPhone13_II	iPhone13_III
Training Accuracy at 25th epoch	0.9998	0.9997	0.9994
Learning Time	11m 34.7s	11m 19.4s	10m 41.1s
Testing Accuracy	0.9997	0.9998	0.9989

## Clustering of iPhone13\_I for each 10 activities

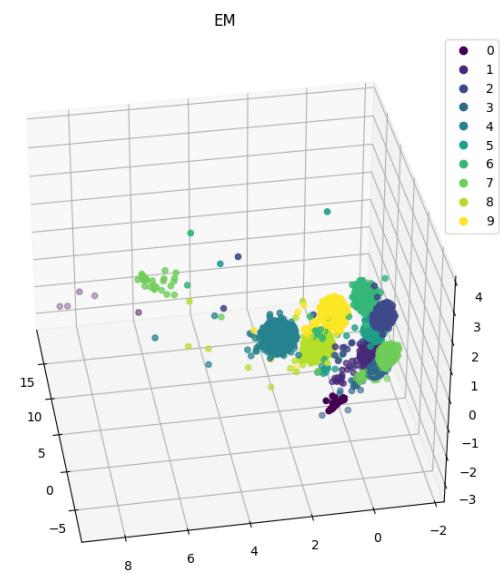


## Accuracy and loss plot of iPhone13\_I

## Confusion Matrix and Classification Report of iPhone13\_I

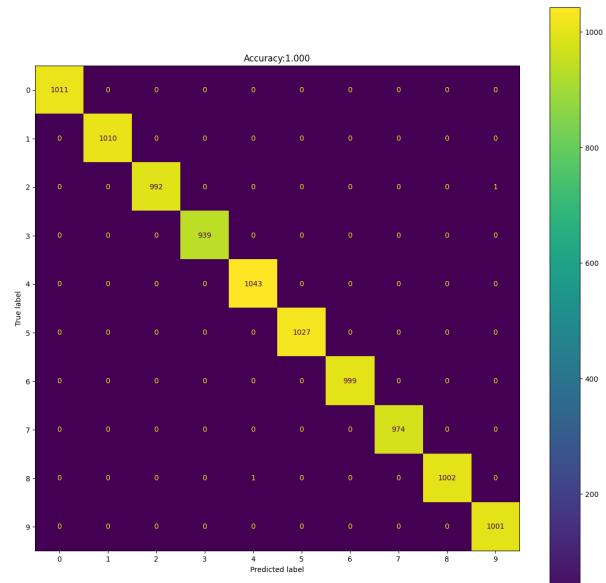
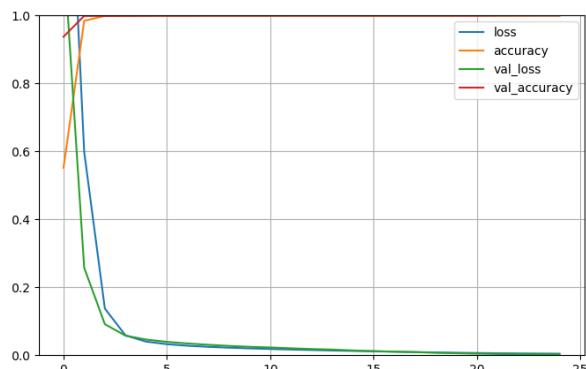


Clustering of iPhone13\_II for each 10 activities

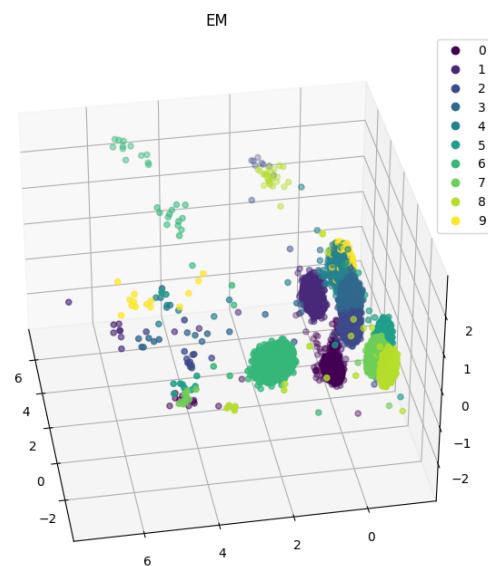


## Accuracy and loss plot of iPhone13\_II

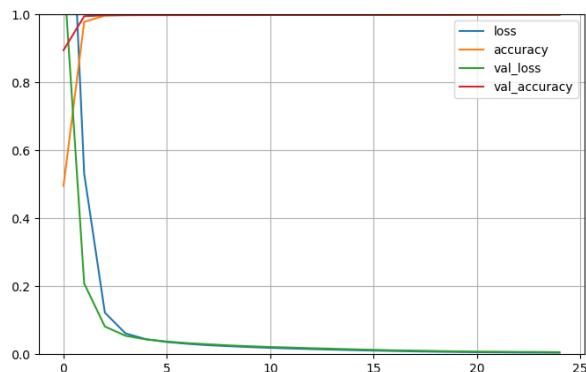
## Confusion Matrix and Classification Report of iPhone13\_II



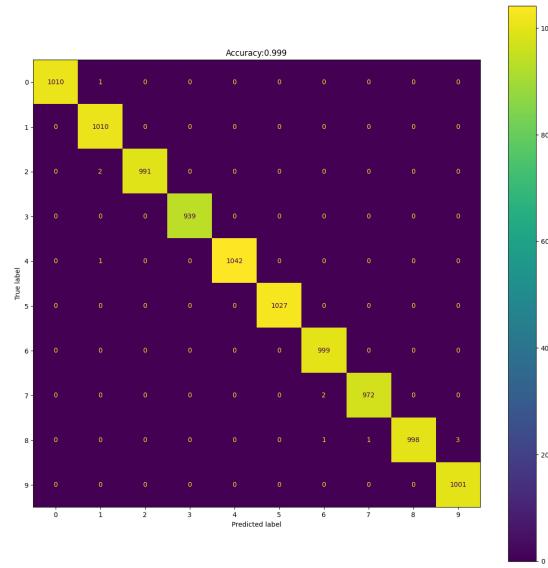
## Clustering of iPhone13\_III for each 10 activities



### Accuracy and loss plot of iPhone13\_III



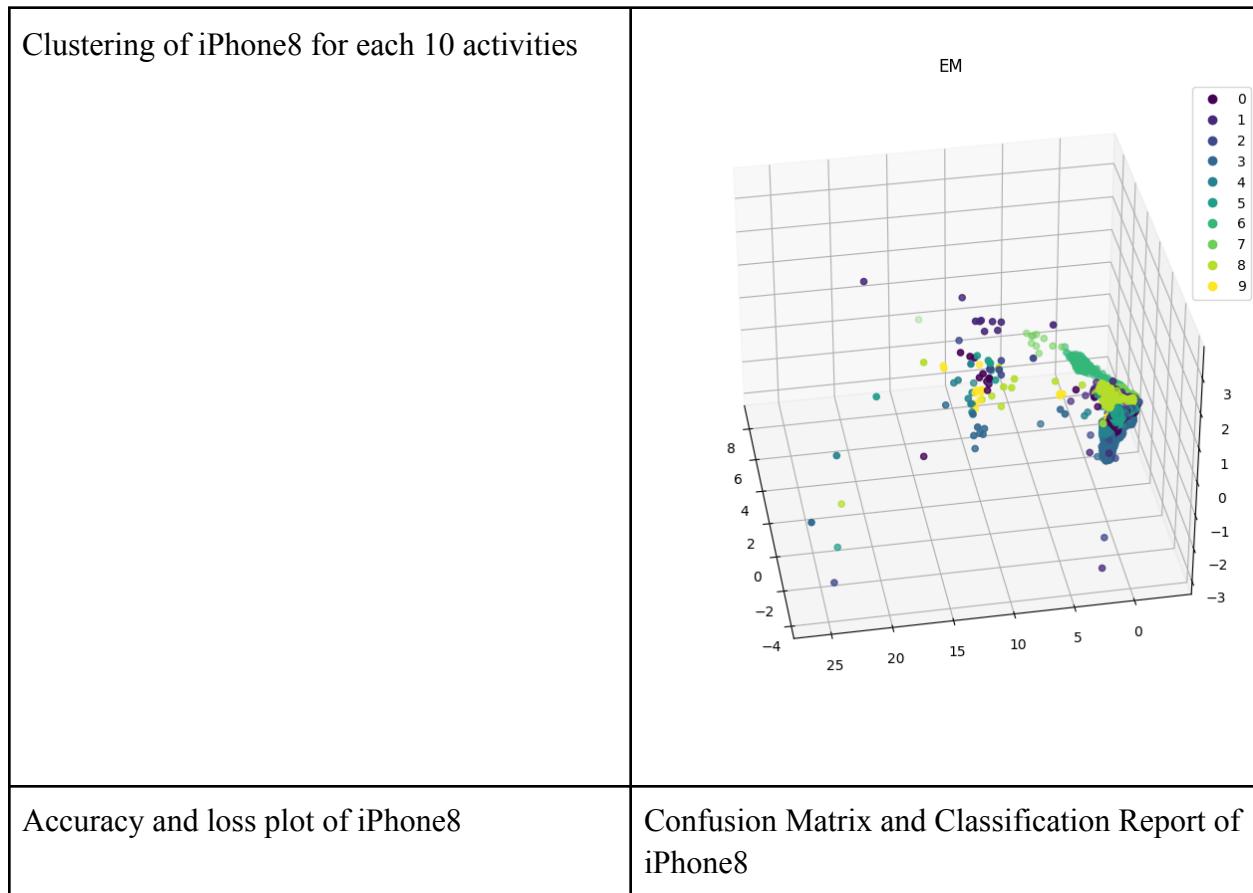
## Confusion Matrix and Classification Report of iPhone13\_III

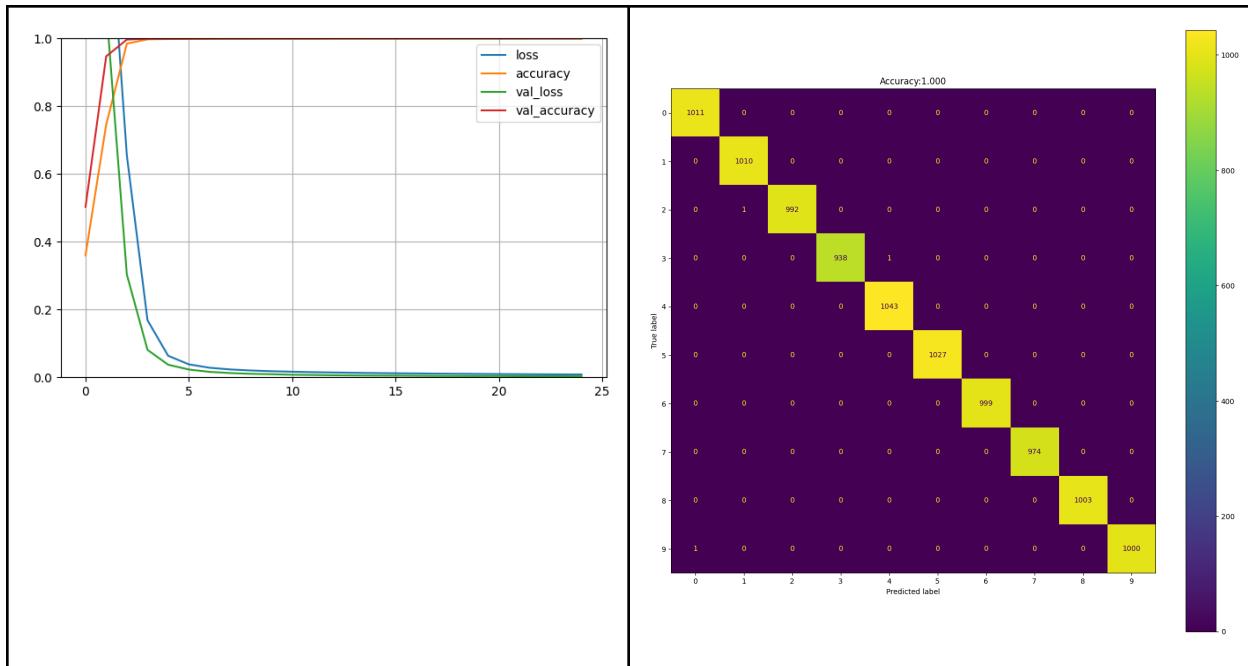


## iPhone8

An iPhone8 is used to create a custom model of the device.

Smartphone Name	iPhone8
Training Accuracy at 25th epoch	0.9997
Learning Time	11m 27.1s
Testing Accuracy	0.9997



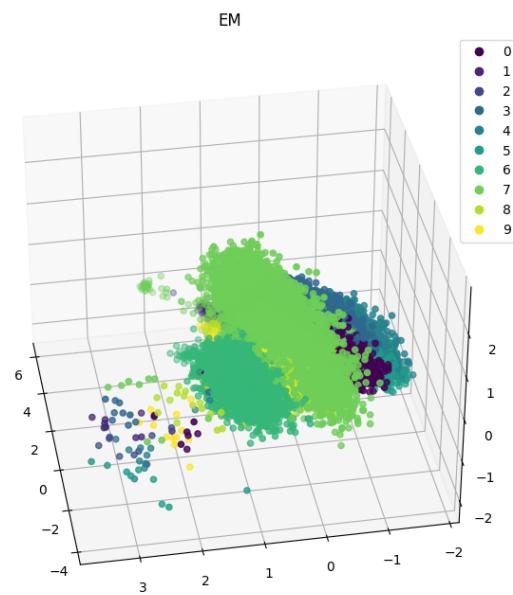


## iPhone6S

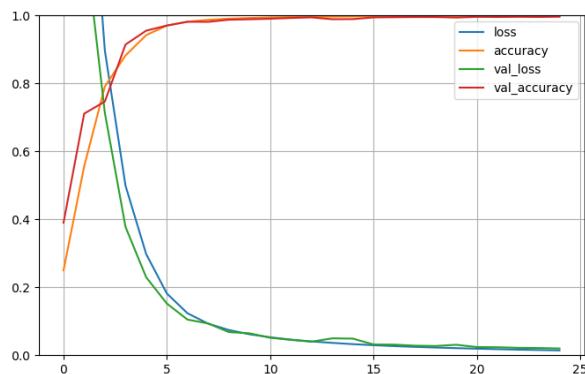
An iPhone6S is used to create a custom model of the device.

Smartphone Name	iPhone6S
Training Accuracy at 25th epoch	0.9991
Learning Time	10m 26.8s
Testing Accuracy	0.9951

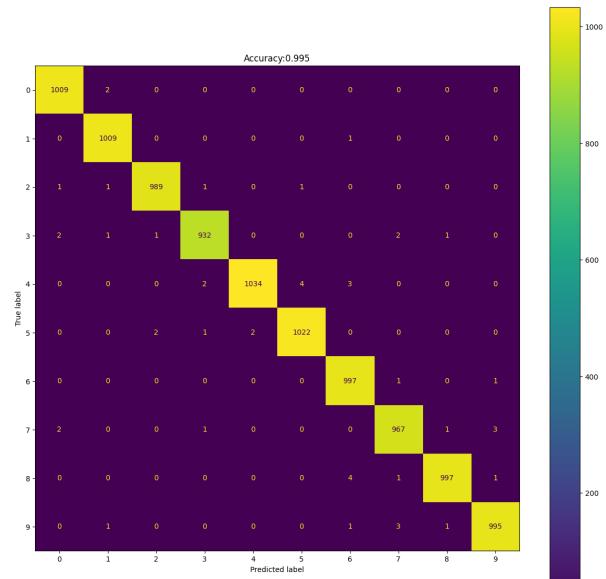
Clustering of iPhone6S for each 10 activities



Accuracy and loss plot of iPhone6S



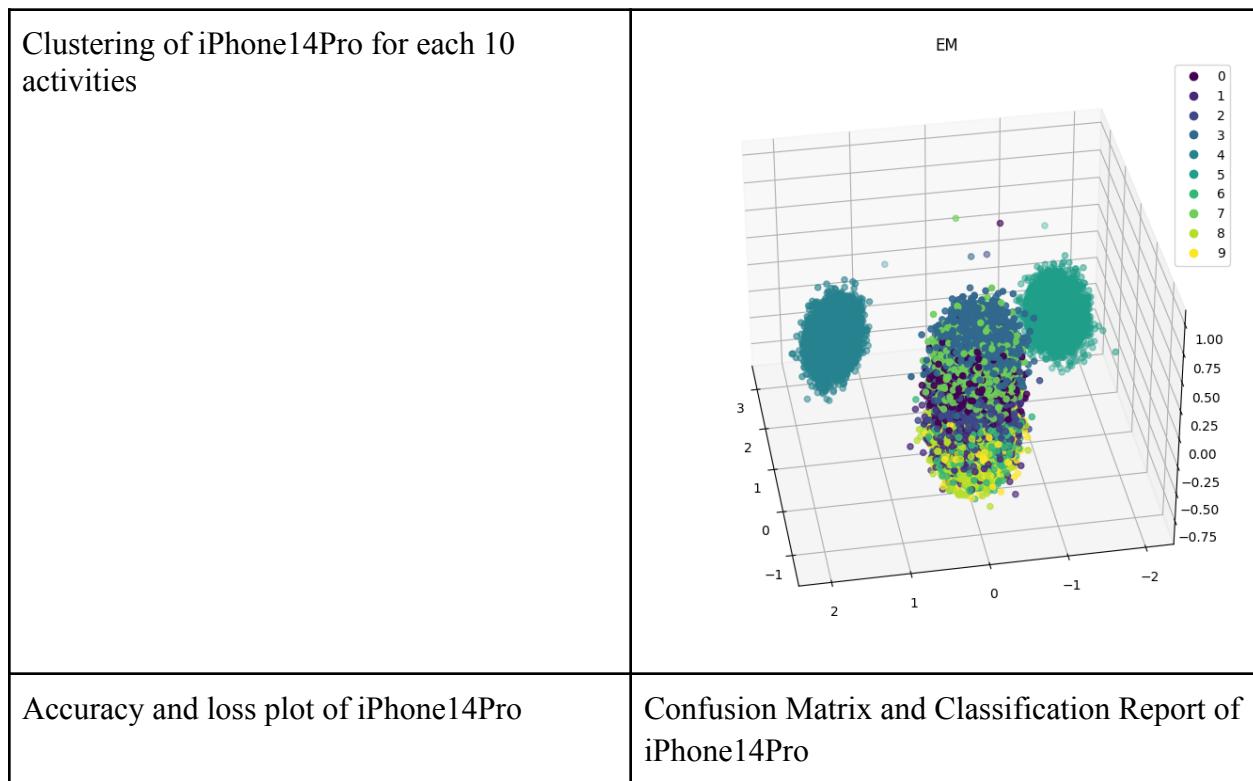
Confusion Matrix and Classification Report of iPhone6S

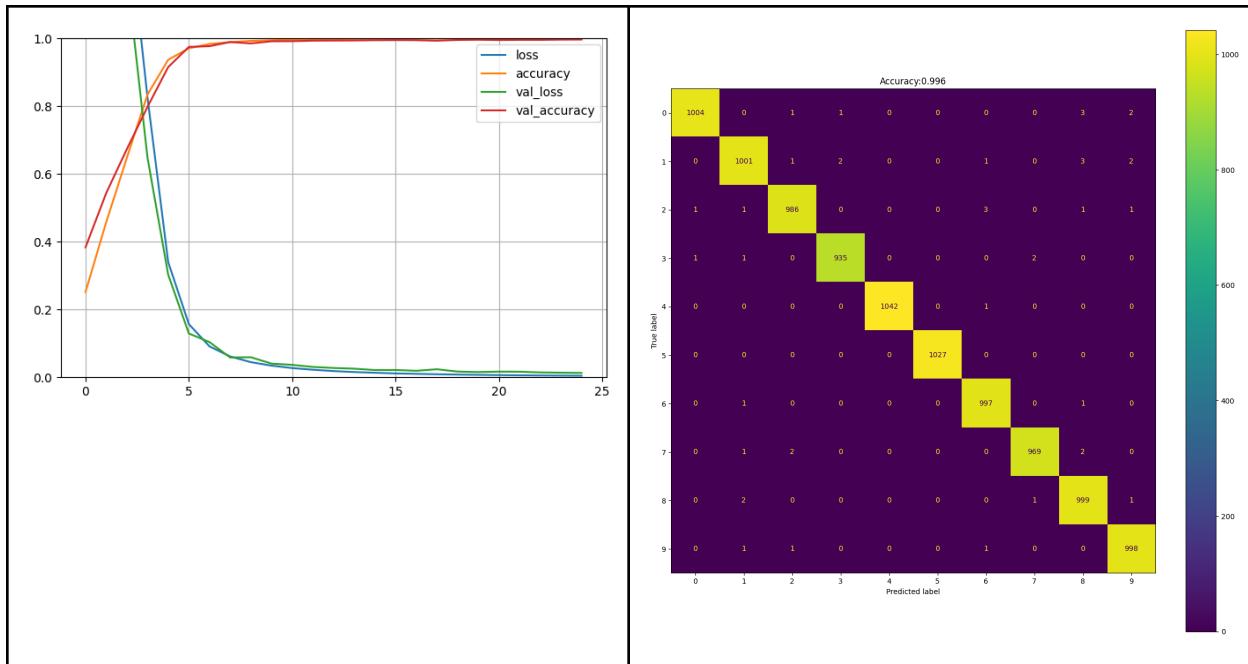


## iPhone14Pro

An iPhone14Pro is used to create a custom model of the device.

Smartphone Name	iPhone14Pro
Training Accuracy at 25th epoch	1.0000
Learning Time	9m 35.1s
Testing Accuracy	0.9958



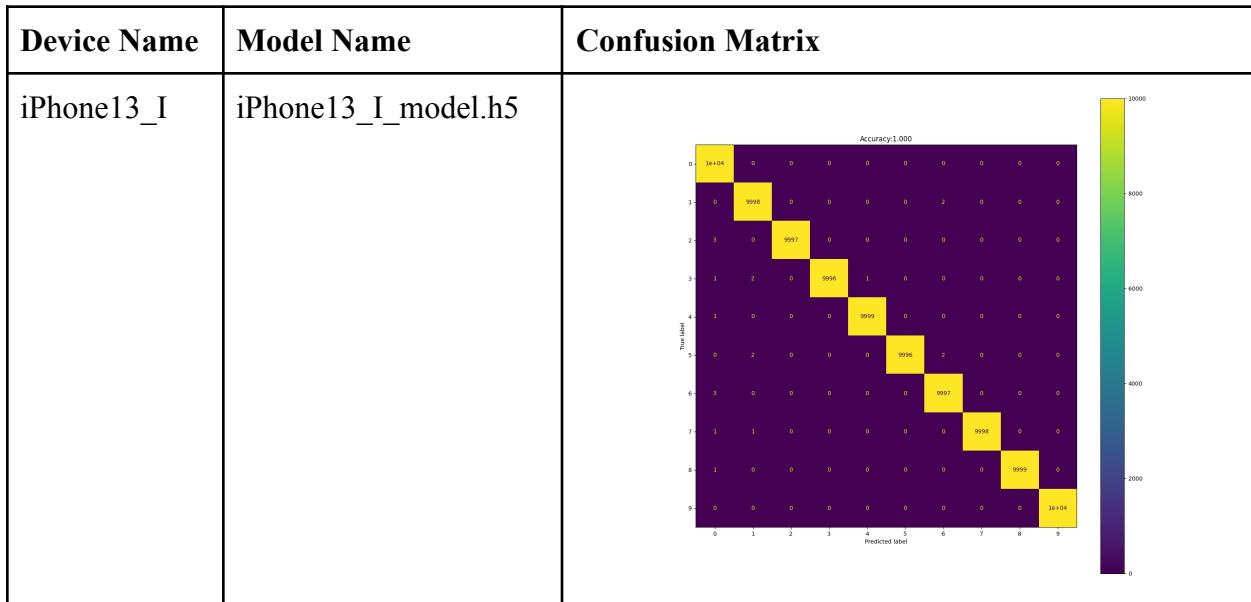


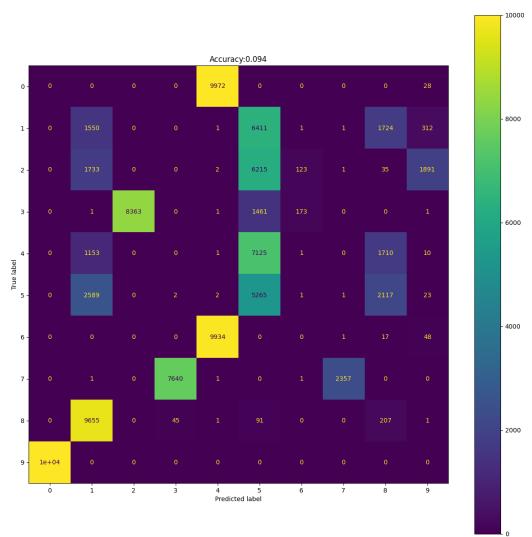
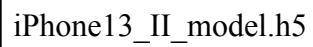
## EXPERIMENT: 02

Cross model testing: EM signals have already been captured by three identical iPhone 13 devices. A custom model of each device was saved in *.h5* format for further usage. In this experiment, a previously saved model of a device is used to test the accuracy of the same and other two devices. Likewise, for all three devices, the accuracy of alternative models was also evaluated. This instance, the dataset is evaluated in its whole rather than being divided into a training and testing dataset. Even if the device was a replica, accuracy still falls short of perfection.

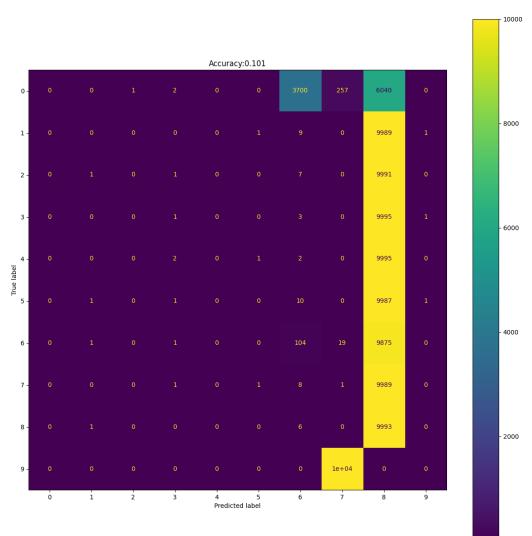
Model_Name	Testing Accuracy		
	iPhone13_I	iPhone13_II	iPhone13_III
iPhone13_I_model.h5	<b>0.9998</b>	0.1050	0.2232
iPhone13_II_model.h5	0.0938	<b>0.9998</b>	0.1063
iPhone13_III_model.h5	0.1010	0.1000	<b>0.9994</b>

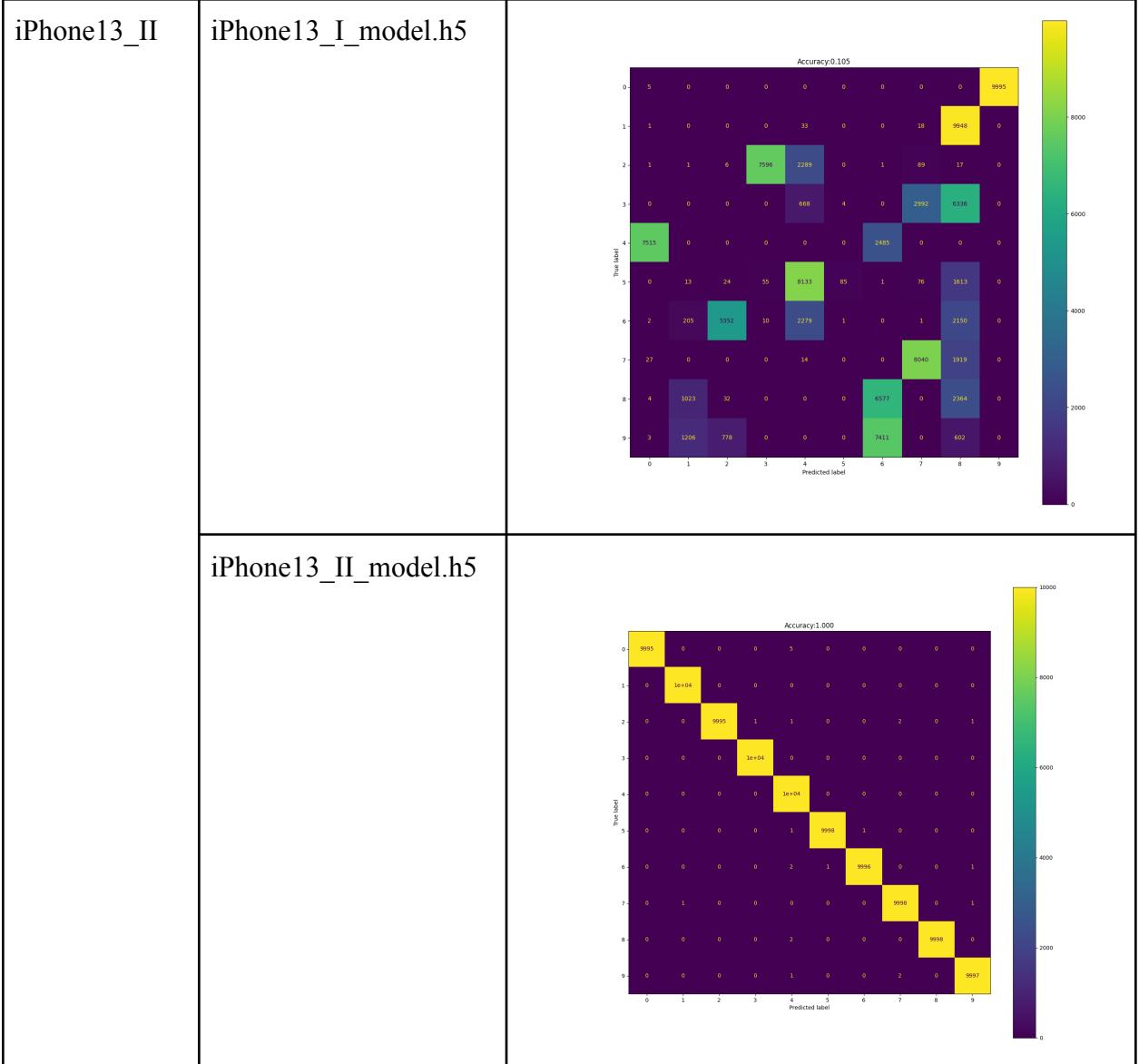
Confusion Matrix and Classification Report of cross models

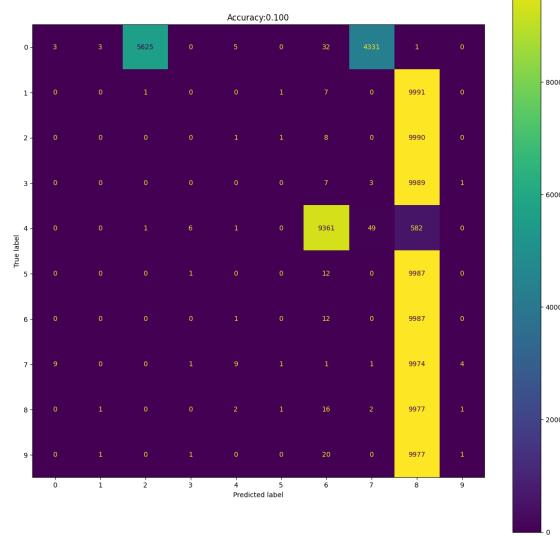
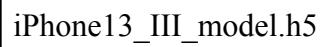




iPhone13\_III\_model.h5

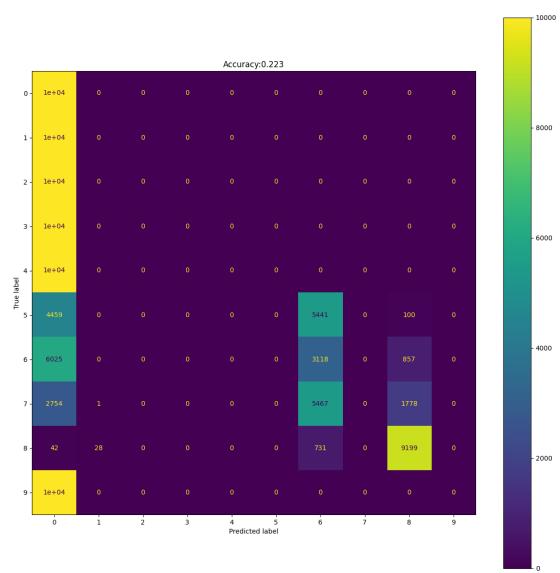


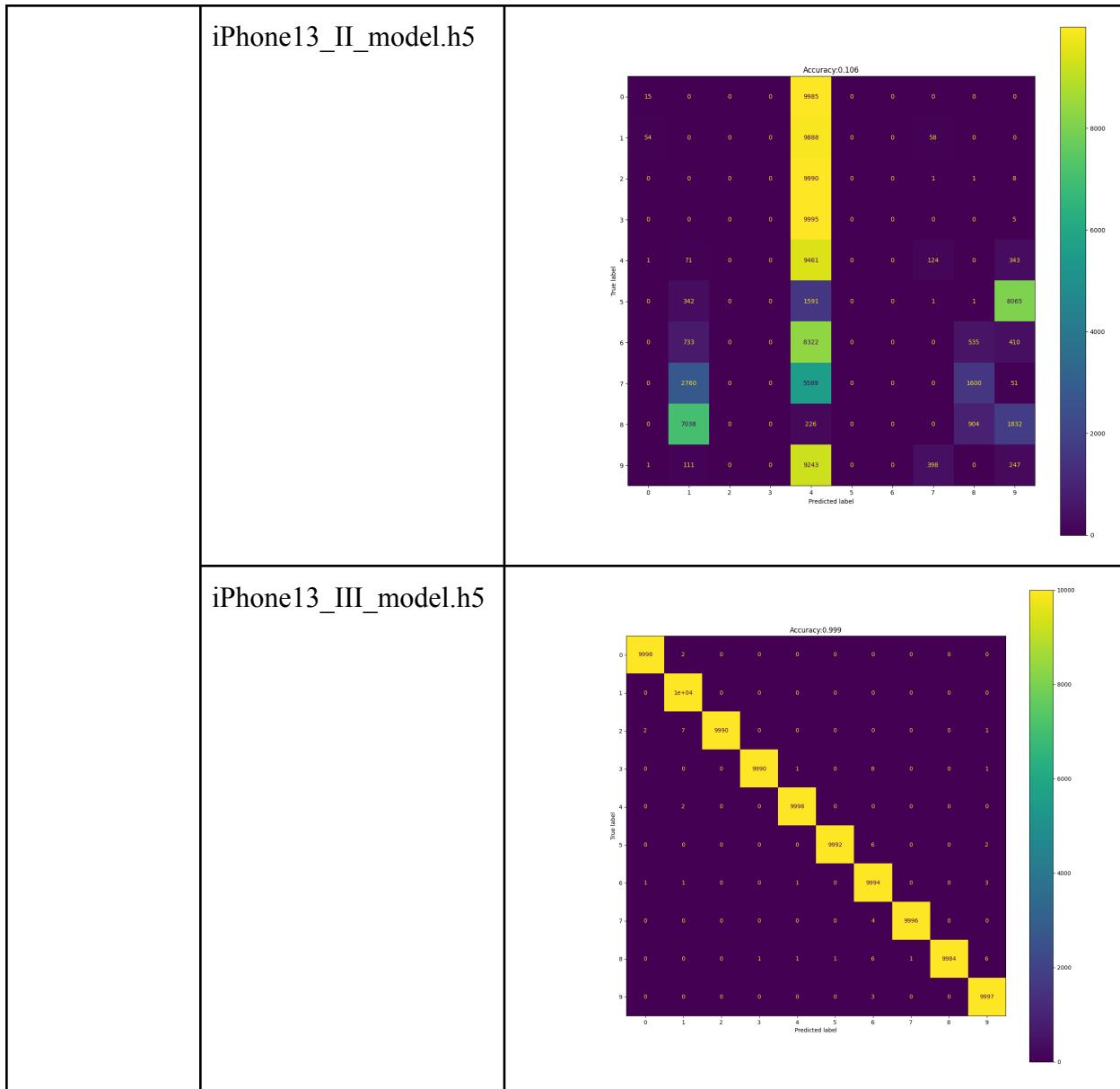




iPhone13\_III

iPhone13\_I\_model.h5





### Solution for the Experiment 02:

- Regression technique to identify the similar features among two devices and eliminate others.
- Transfer learning technique to re modification the original model while using other devices.

## EXPERIMENT: 03

Apply the MLP model to the combined activity from two iPhone13s to validate the accuracy. Then, check each device separately, along with a third device that wasn't previously included in the training dataset.

Combine the similar activity of iphone13\_II and iPhone13\_III as a single label and create a dataset for each 10 activities from both iPhone13 smartphones. Altogether 200000 data per activity from each activity from both smartphones. For example, 10000 samples of calendar-app from iPhone13\_II and 10000 samples of calendar-app from iPhone13\_III. Likewise combined similar activities of both smartphones as a one label and created a dataset.

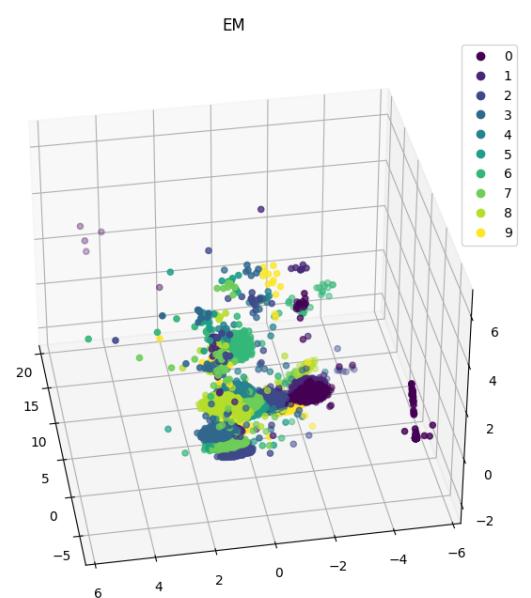
### Model

Model: "sequential\_1"

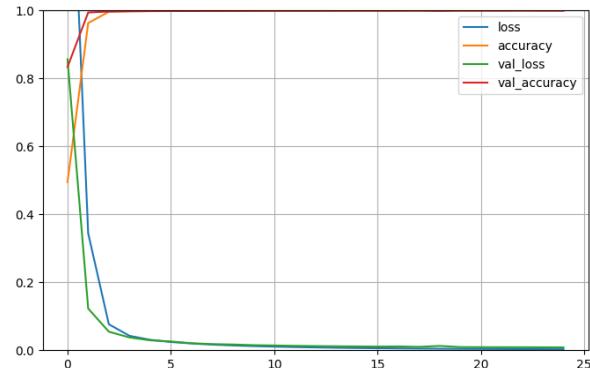
Layer (type)	Output Shape	Param #
=====		
dense_6 (Dense)	(None, 1400)	2868600
dense_7 (Dense)	(None, 800)	1120800
dense_8 (Dense)	(None, 500)	400500
dense_9 (Dense)	(None, 200)	100200
dense_10 (Dense)	(None, 100)	20100
dense_11 (Dense)	(None, 10)	1010
=====		
Total params: 4,511,210		
Trainable params: 4,511,210		
Non-trainable params: 0		

Smartphone Name	iPhone13_II & iPhone13_III
Training Accuracy at 25th epoch	0.9998
Learning Time	20m 36.7s
Testing Accuracy	0.9994

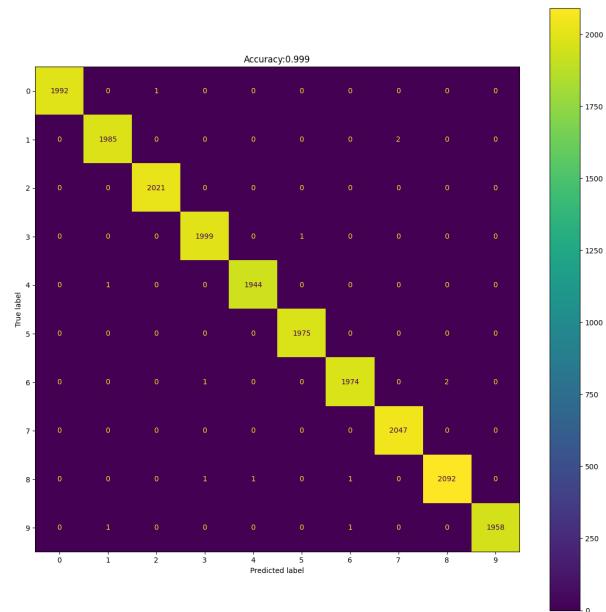
Clustering of iPhone13\_II&III for each 10 activities



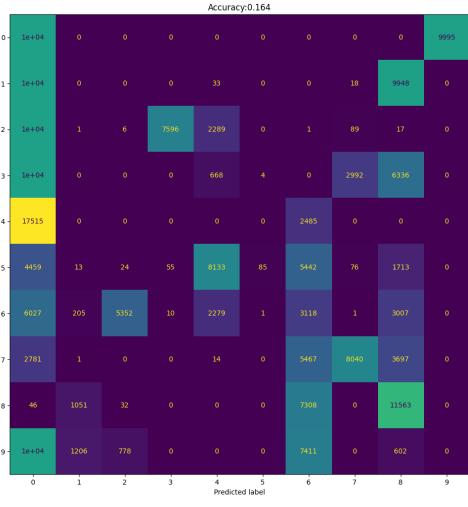
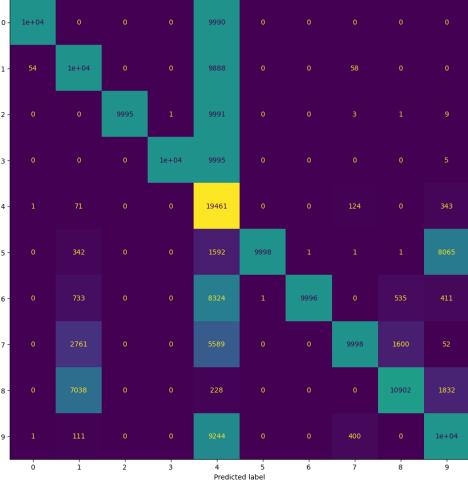
Accuracy and loss plot of iPhone13\_II & iPhone13\_III

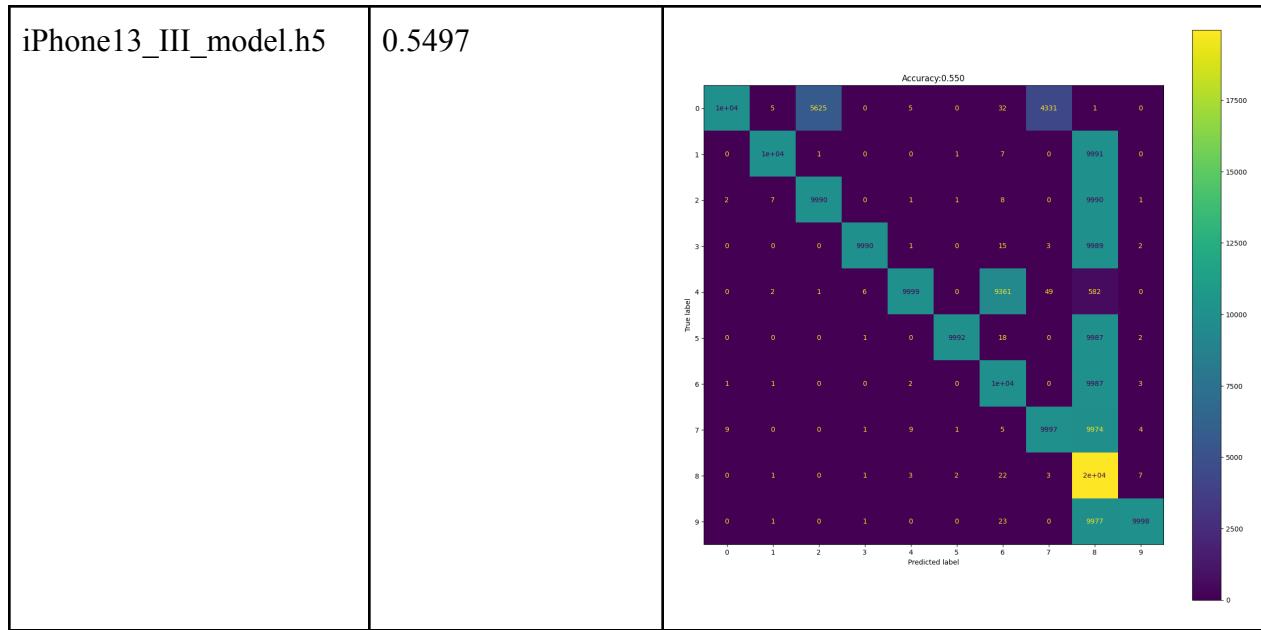


Confusion Matrix and Classification Report of iPhone13\_II & iPhone13\_III

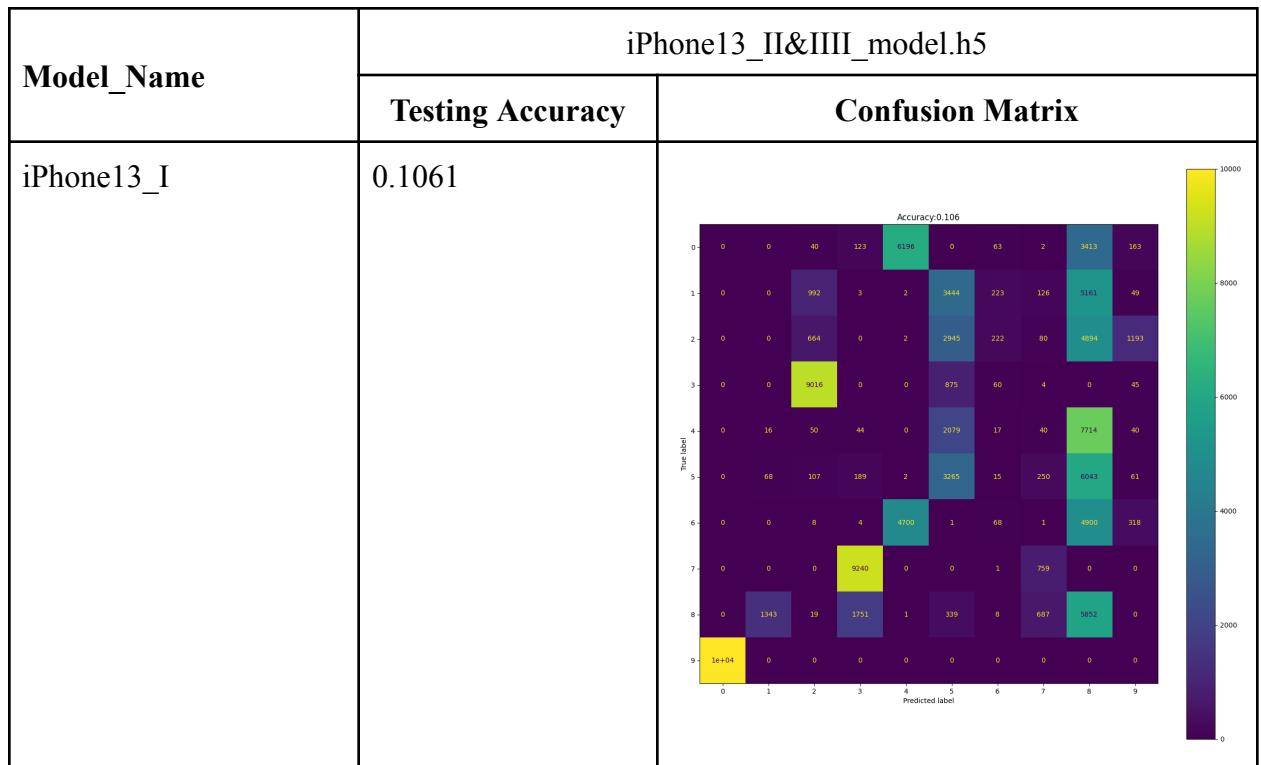


Testing individual model the combined dataset

Model_Name	iPhone13_II&III									
	Testing Accuracy	Confusion Matrix								
iPhone13_I_model.h5	0.1641									
										
iPhone13_II_model.h5	0.5530									
										

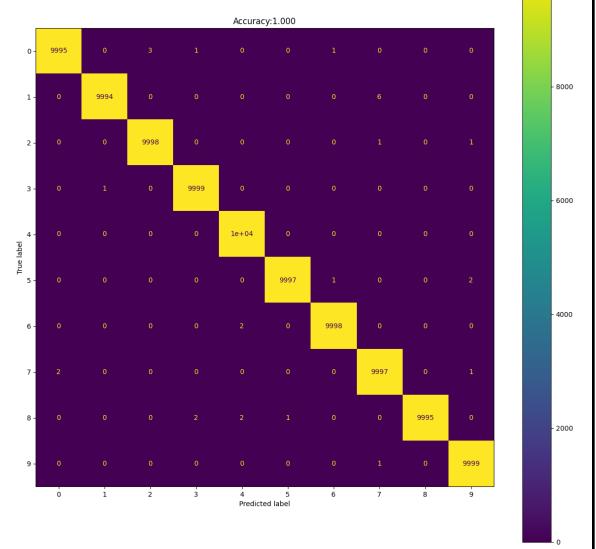


Testing individual dataset of each iPhone13 (I, II & III)



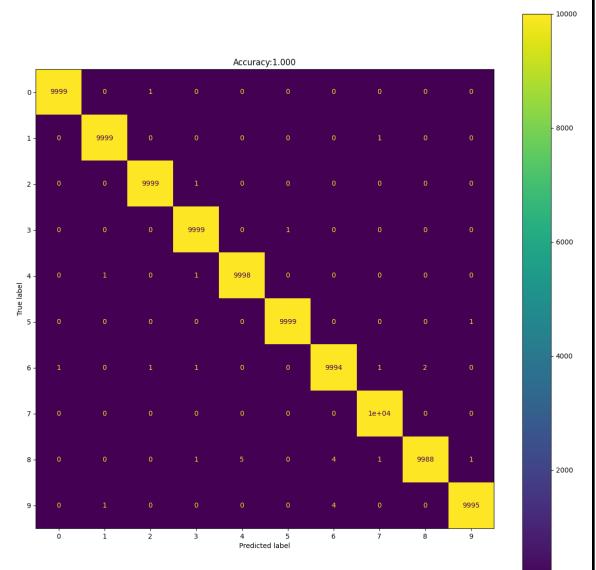
iPhone13\_II

0.9997



iPhone13\_III

0.9997



## EXPERIMENT: 04

Select **idle** activity from each three iPhone13, create a combined models between each phone and test the accuracy

1. Create a combine model between iPhone13\_II & iPhone13\_III with idle activity (2-class dataset)

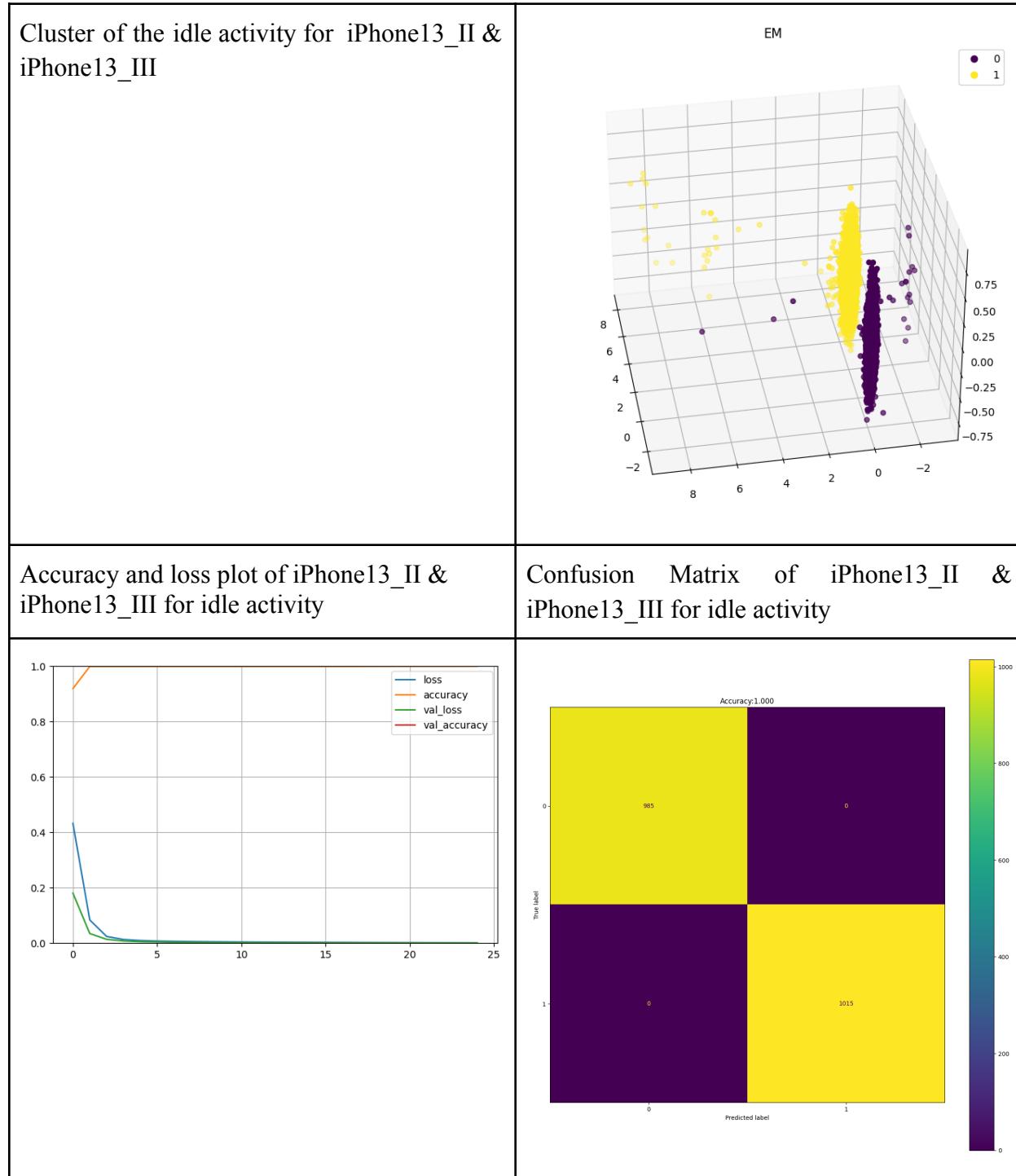
### Model

Model: "sequential\_3"

Layer (type)	Output Shape	Param #
<hr/>		
dense_19 (Dense)	(None, 1400)	2868600
dense_20 (Dense)	(None, 800)	1120800
dense_21 (Dense)	(None, 500)	400500
dense_22 (Dense)	(None, 200)	100200
dense_23 (Dense)	(None, 100)	20100
dense_24 (Dense)	(None, 50)	5050
dense_25 (Dense)	(None, 2)	102
<hr/>		
Total params: 4,515,352		
Trainable params: 4,515,352		
Non-trainable params: 0		

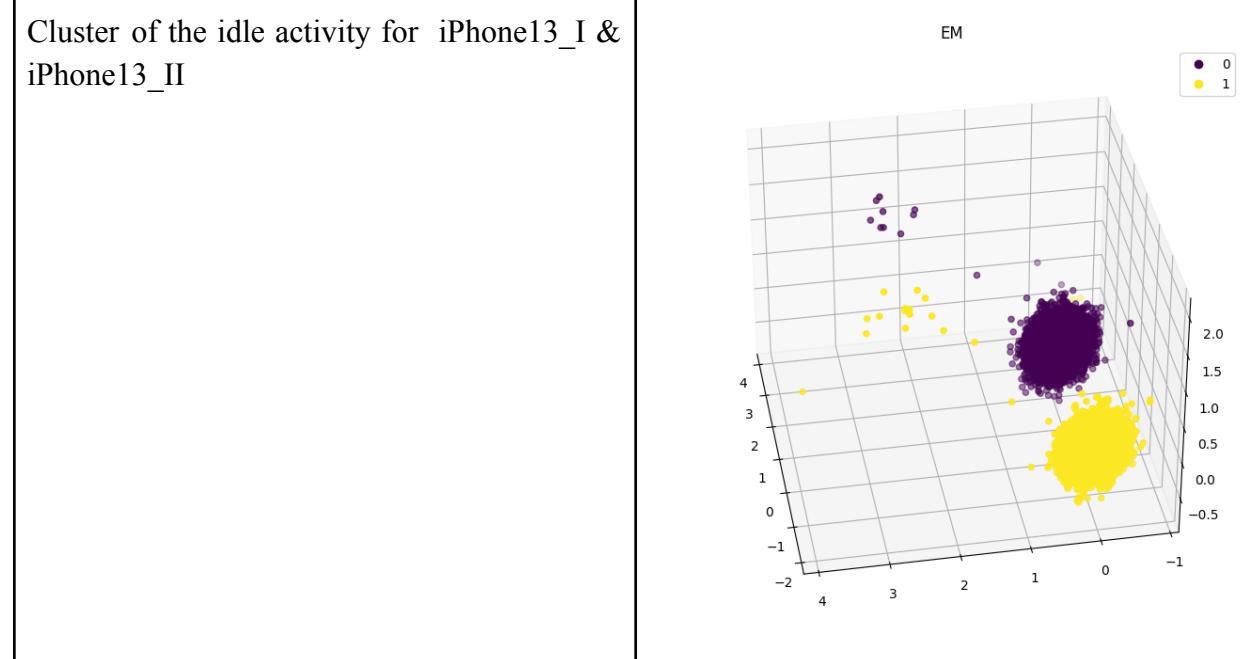
Dataset Combination	iPhone13_II & iPhone13_III	iPhone13_I & iPhone13_II	iPhone13_I & iPhone13_III	iPhone13_I, iPhone13_II & iPhone13_III
Activity	Idle			
Training Accuracy at 25th epoch	0.9998	0.9999	0.9994	0.9995
Learning Time	2m 17.4s	2m 15.5s	2m 40.3s	3m 39.6s
Testing Accuracy	1.0000	0.9990	0.9995	0.9997

1. Create a combine model between iPhone13\_II & iPhone13\_III with idle activity (2-class dataset)  
Cluster of the idle activity for iPhone13\_II & iPhone13\_III

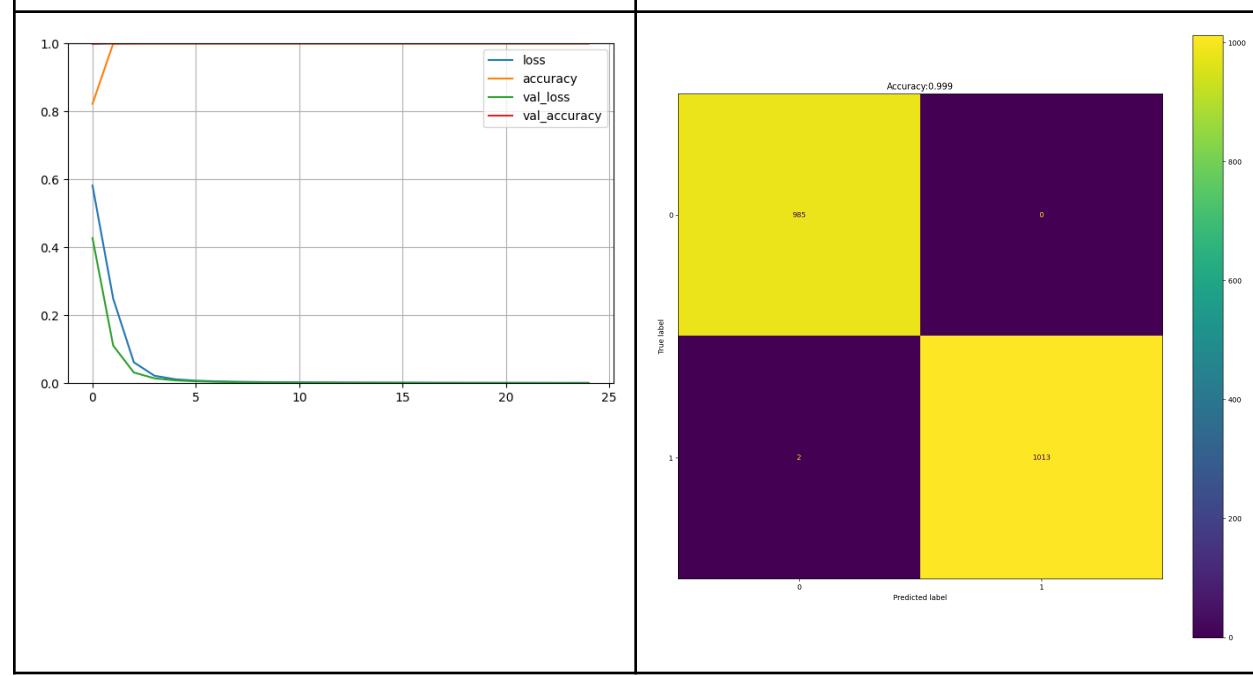


2. Create a combine model between iPhone13\_I & iPhone13\_II with idle activity (2-class dataset)

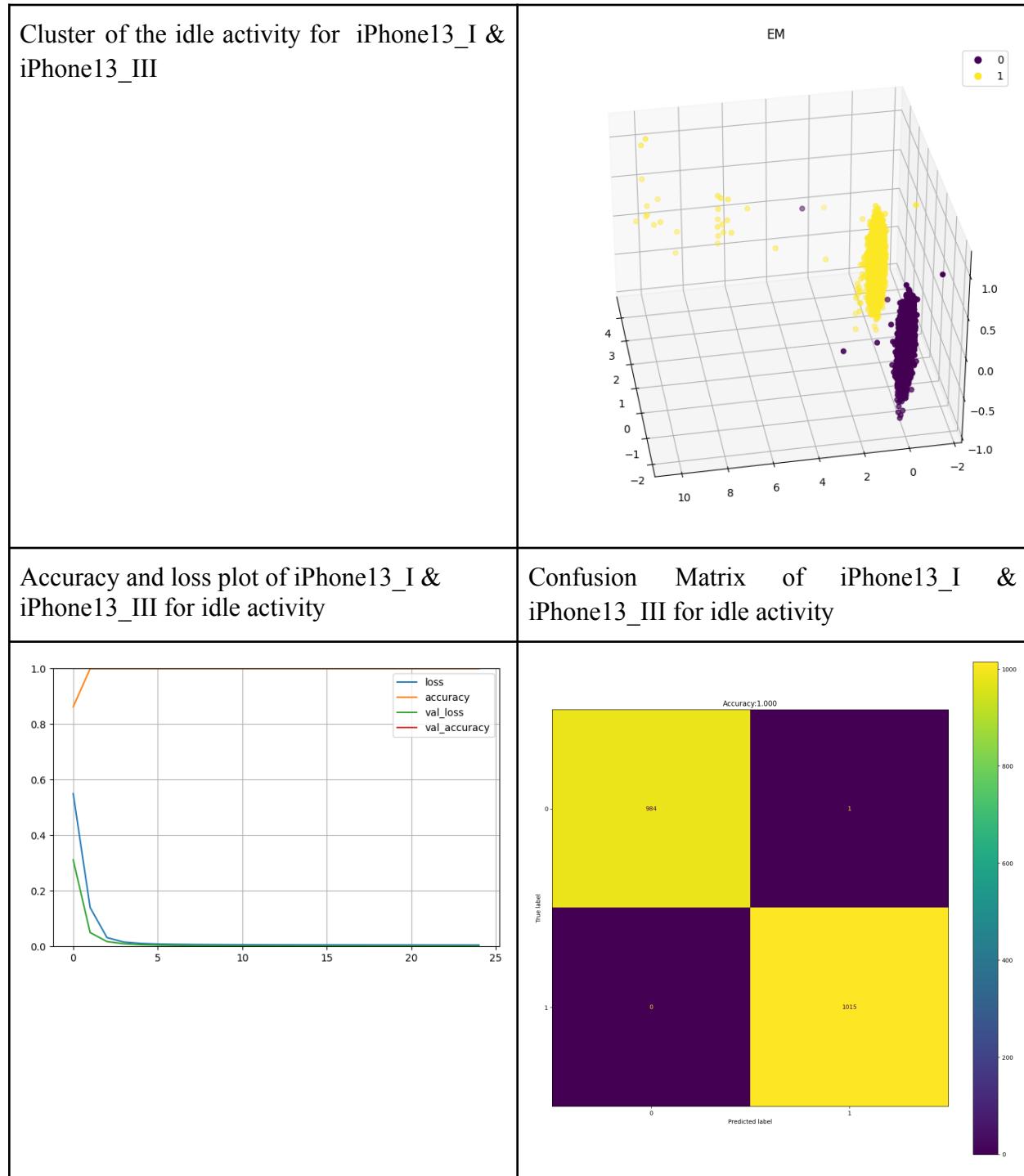
Cluster of the idle activity for iPhone13\_I & iPhone13\_II



Accuracy and loss plot of iPhone13\_I & iPhone13\_II for idle activity



3. Create a combine model between iPhone13\_I & iPhone13\_III with idle activity (2-class dataset)  
 Cluster of the idle activity for iPhone13\_I & iPhone13\_III



4. Create a combine model between iPhone13\_I, iPhone13\_II, & iPhone13\_III with idle activity (3-class dataset)

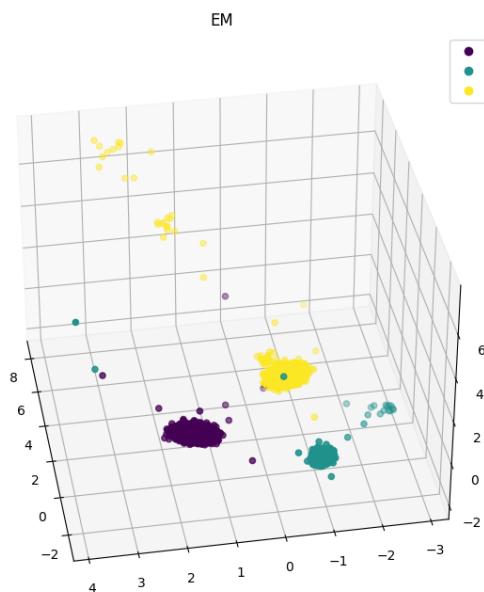
### Model

Model: "sequential\_6"

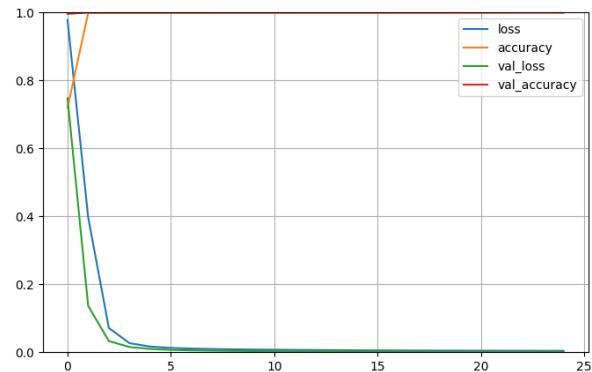
Layer (type)	Output Shape	Param #
<hr/>		
dense_40 (Dense)	(None, 1400)	2868600
dense_41 (Dense)	(None, 800)	1120800
dense_42 (Dense)	(None, 500)	400500
dense_43 (Dense)	(None, 200)	100200
dense_44 (Dense)	(None, 100)	20100
dense_45 (Dense)	(None, 50)	5050
dense_46 (Dense)	(None, 3)	153
<hr/>		
Total params: 4,515,403		
Trainable params: 4,515,403		
Non-trainable params: 0		

---

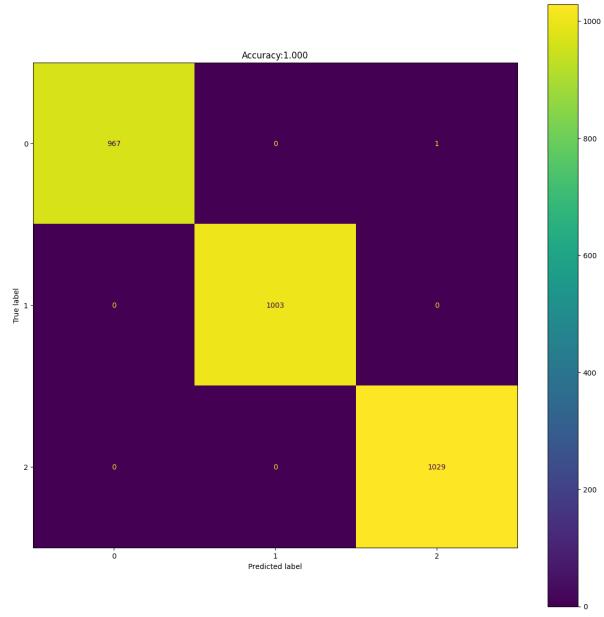
Cluster of the idle activity for iPhone13\_I, iPhone13\_II, & iPhone13\_III



Accuracy and loss plot of iPhone13\_I, iPhone13\_II, & iPhone13\_III for idle activity



Confusion Matrix of iPhone13\_I, iPhone13\_II, & iPhone13\_III for idle activity

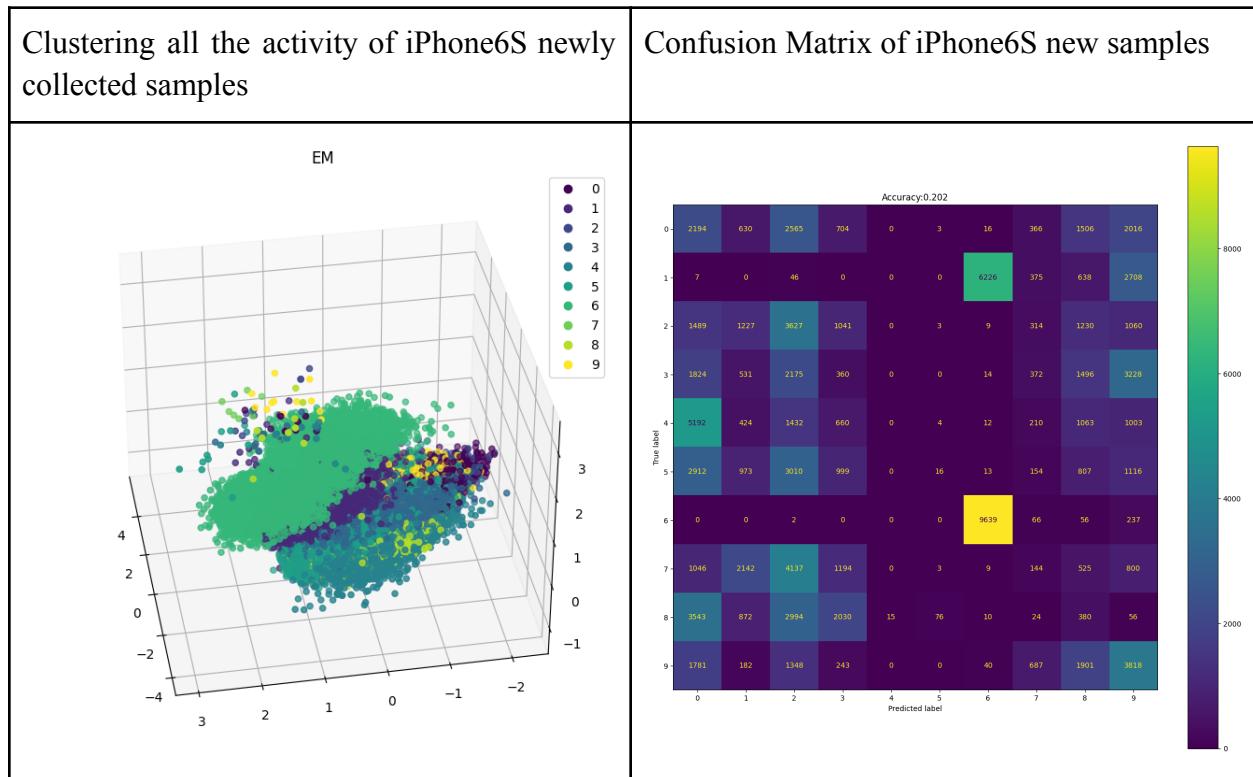


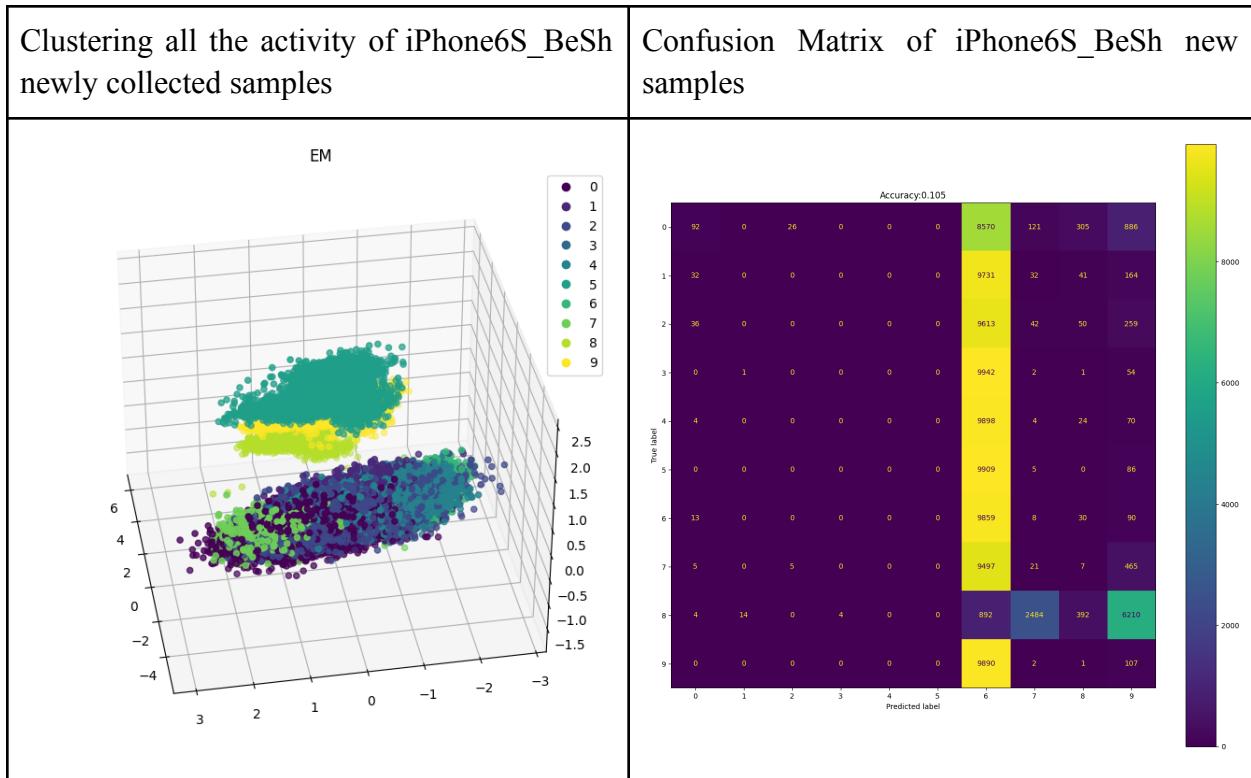
## EXPERIMENT: 05

Get the different samples from iPhone6S, iPhone13, and iPhone14Pro then test the newly collected samples with already created models for the above mentioned smartphones for the validation of different samples from a particular device.

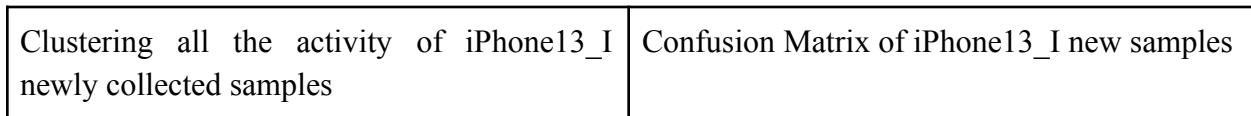
Model Name	Smartphone Dataset	Testing Accuracy
iPhone6s_I_model.h5	iPhone6S_I(ii)	0.2018
	iPhone6S_I_Besh	0.1047
iPhone13_I_model.h5	iPhone13_I(ii)	0.0151
		0.1146
iPhone14Pro_I_model.h5	iPhone14Pro_I(ii)	0.1224

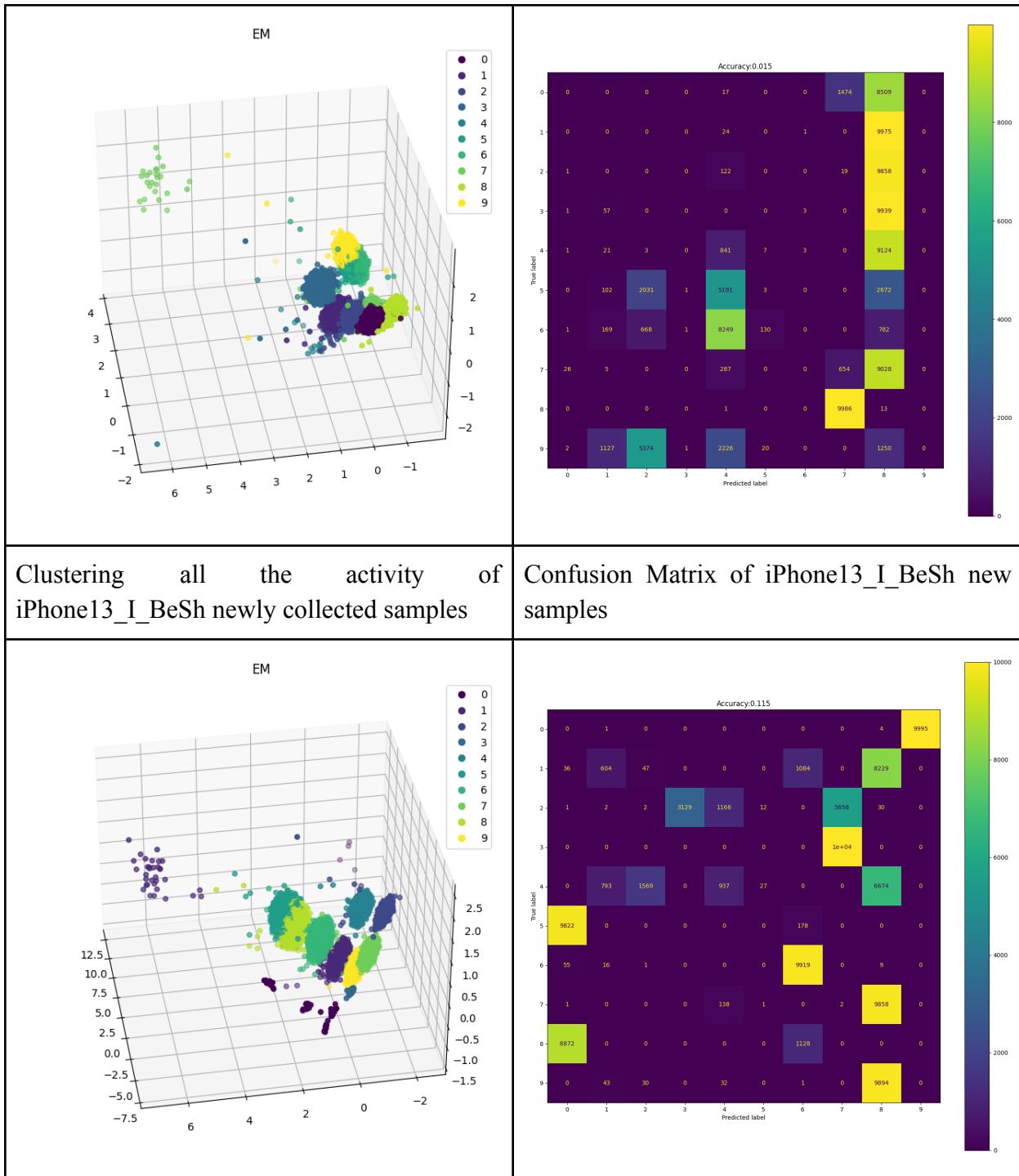
Validate the model again from new samples of iPhone 6S\_I(ii) and iPhone 6S\_I\_BeSh



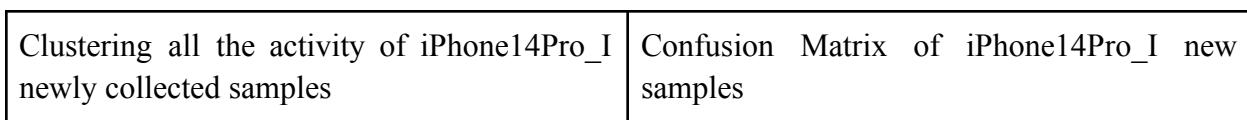


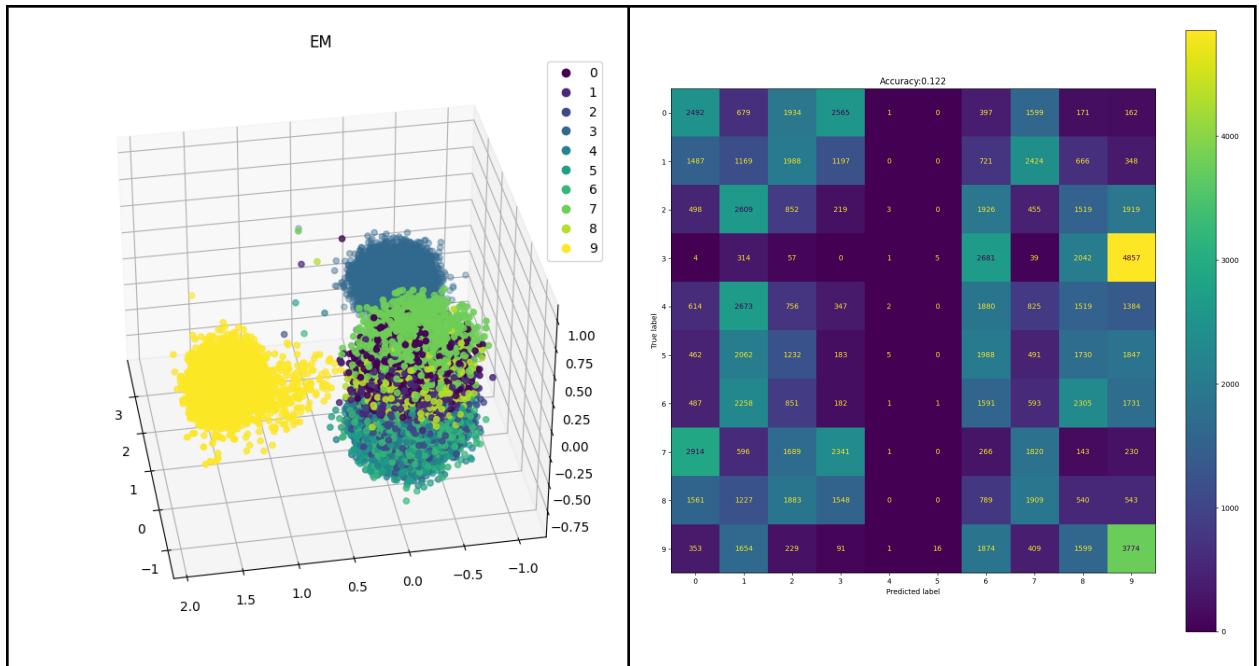
*Validate the model again from new samples of iPhone13\_I(ii) and iPhone13\_I\_BeSh*





Validate the model again from new samples of iPhone14Pro\_I(ii)





## EXPERIMENT: 06

Apply transfer learning on both newly collected samples by only training the last layer (output layer) to increase the accuracy on EXPERIMENT: 05

### Model

Model: "sequential\_1"

Layer (type)	Output Shape	Param #
<hr/>		
dense_6 (Dense)	(None, 1400)	2868600
dense_7 (Dense)	(None, 800)	1120800
dense_8 (Dense)	(None, 500)	400500
dense_9 (Dense)	(None, 200)	100200
dense_10 (Dense)	(None, 100)	20100
dense_11 (Dense)	(None, 10)	1010
<hr/>		
Total params: 4,511,210		
Trainable params: 1,010		
Non-trainable params: 4,510,200		

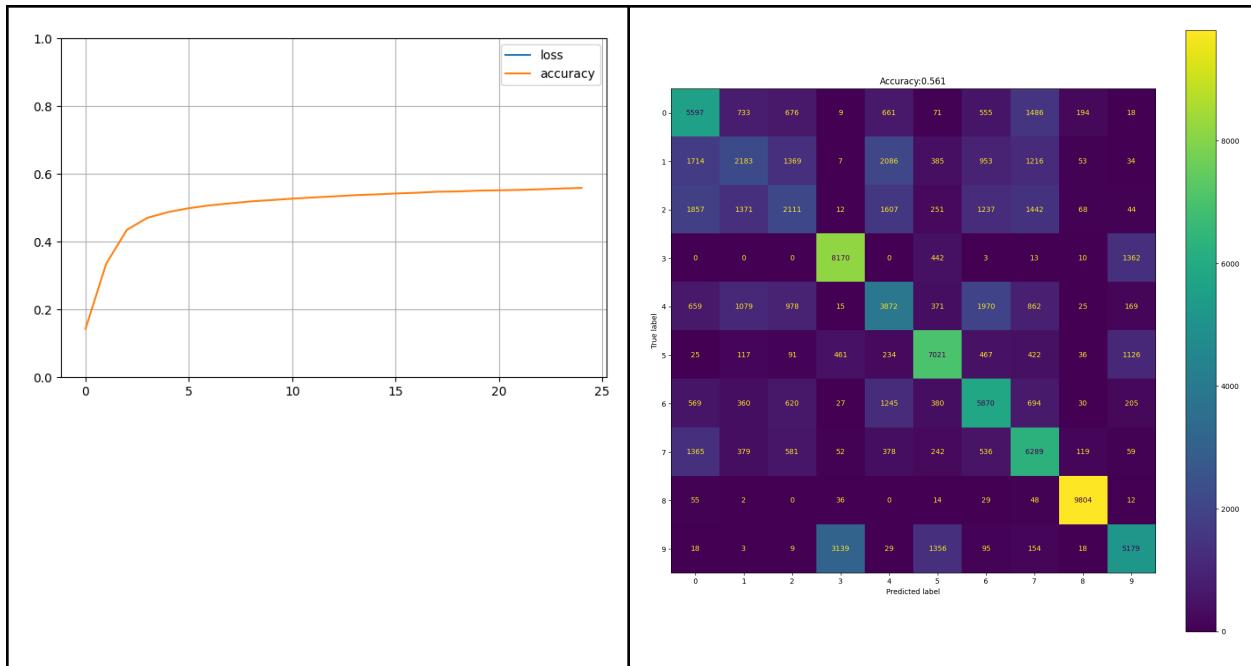
**Observation:** The training time is comparably less than originally training a complete model and accuracy also reached the expected level.

Model Name	Smartphone dataset	Training accuracy at 25th epochs	Learning Time	Testing Accuracy
iPhone6s_I_mod el.h5	iPhone6S_I(ii)	0.4686	6m 42.4s	0.4705
	iPhone6S_I_BeSh	<b>0.5588</b>	<b>5m 42.2s</b>	<b>0.5610</b>
iPhone13_I_mo del.h5	iPhone13_I(ii)	0.7981	6m 39.5s	0.7990
	iPhone13_I_BeSh	<b>0.9209</b>	<b>5m 55.6s</b>	<b>0.9223</b>

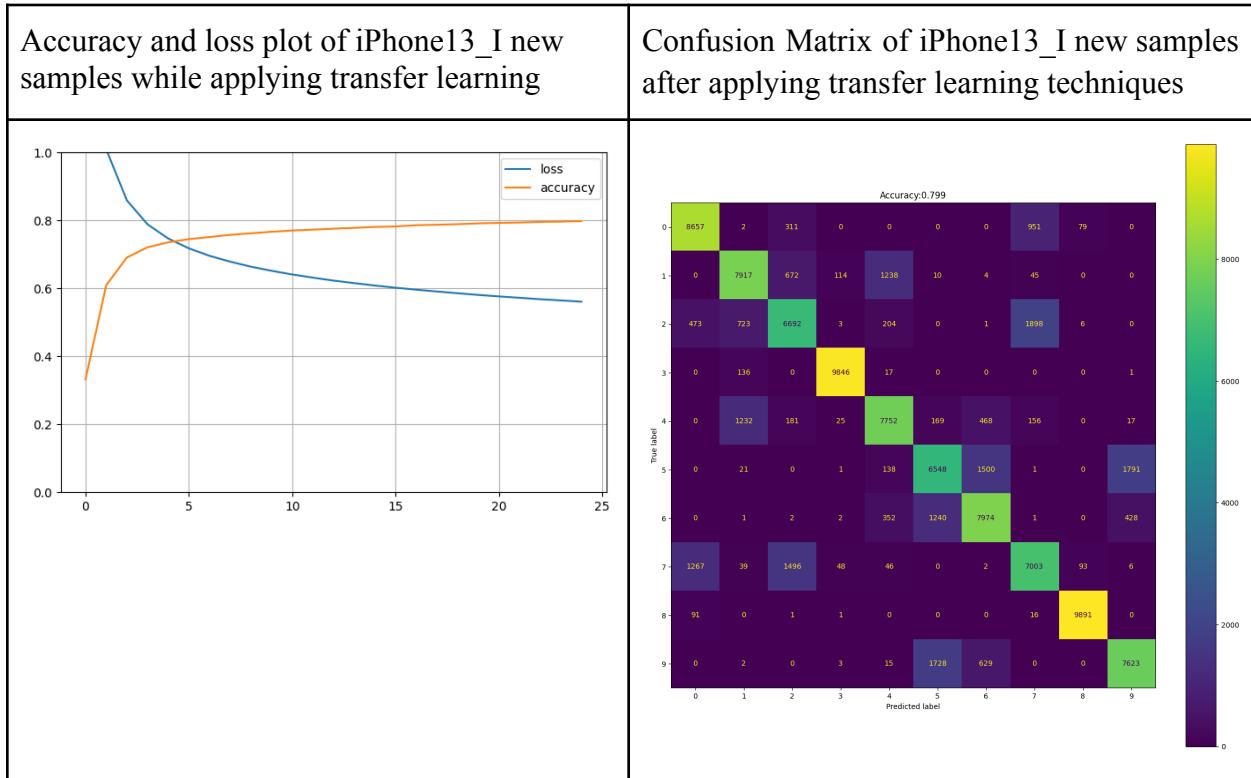
iPhone14Pro_I_model.h5	iPhone14Pro_I(ii)	0.3943	5m 38.7s	0.3967
------------------------	-------------------	--------	----------	--------

## iPhone6S

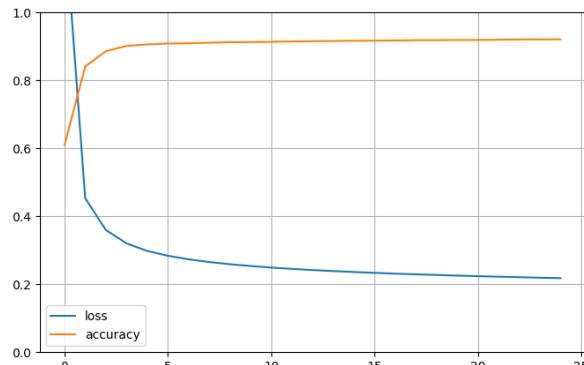
Accuracy and loss plot of iPhone6S new samples while applying transfer learning	Confusion Matrix of iPhone6S new samples after applying transfer learning techniques																																																																																																																																						
<p>Line plot showing loss and accuracy over 25 epochs. Loss decreases from approximately 0.5 to 0.1. Accuracy increases from approximately 0.25 to 0.45.</p>	<p>Confusion Matrix of iPhone6S new samples after applying transfer learning techniques</p> <p>Accuracy: 0.470</p> <table border="1"> <caption>Confusion Matrix Data (Approximate Values)</caption> <thead> <tr> <th colspan="2"></th> <th>0</th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th>5</th> <th>6</th> <th>7</th> <th>8</th> <th>9</th> </tr> <tr> <th rowspan="2">True Label</th> <th>Predicted Label</th> <th>0</th> <th>79</th> <th>761</th> <th>2085</th> <th>2031</th> <th>520</th> <th>11</th> <th>989</th> <th>753</th> <th>1903</th> </tr> </thead> <tbody> <tr> <th>0</th> <td>868</td> <td>0</td> <td>2174</td> <td>1410</td> <td>1165</td> <td>702</td> <td>10</td> <td>2302</td> <td>1112</td> <td>666</td> </tr> <tr> <th>1</th> <td>0</td> <td>8086</td> <td>0</td> <td>26</td> <td>0</td> <td>0</td> <td>1509</td> <td>0</td> <td>0</td> <td>379</td> </tr> <tr> <th>2</th> <td>449</td> <td>10</td> <td>2174</td> <td>1410</td> <td>1165</td> <td>702</td> <td>10</td> <td>2302</td> <td>1112</td> <td>666</td> </tr> <tr> <th>3</th> <td>227</td> <td>109</td> <td>643</td> <td>3944</td> <td>1417</td> <td>499</td> <td>10</td> <td>646</td> <td>324</td> <td>2181</td> </tr> <tr> <th>4</th> <td>210</td> <td>10</td> <td>311</td> <td>926</td> <td>5540</td> <td>496</td> <td>13</td> <td>269</td> <td>1125</td> <td>1100</td> </tr> <tr> <th>5</th> <td>263</td> <td>12</td> <td>876</td> <td>1605</td> <td>2085</td> <td>1151</td> <td>14</td> <td>1309</td> <td>1975</td> <td>710</td> </tr> <tr> <th>6</th> <td>0</td> <td>1344</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>8642</td> <td>0</td> <td>0</td> <td>14</td> </tr> <tr> <th>7</th> <td>309</td> <td>1</td> <td>1293</td> <td>865</td> <td>303</td> <td>594</td> <td>11</td> <td>3216</td> <td>1265</td> <td>143</td> </tr> <tr> <th>8</th> <td>103</td> <td>2</td> <td>502</td> <td>175</td> <td>1349</td> <td>635</td> <td>9</td> <td>890</td> <td>6305</td> <td>30</td> </tr> <tr> <th>9</th> <td>311</td> <td>508</td> <td>326</td> <td>1751</td> <td>1480</td> <td>175</td> <td>14</td> <td>216</td> <td>95</td> <td>5124</td> </tr> </tbody> </table>			0	1	2	3	4	5	6	7	8	9	True Label	Predicted Label	0	79	761	2085	2031	520	11	989	753	1903	0	868	0	2174	1410	1165	702	10	2302	1112	666	1	0	8086	0	26	0	0	1509	0	0	379	2	449	10	2174	1410	1165	702	10	2302	1112	666	3	227	109	643	3944	1417	499	10	646	324	2181	4	210	10	311	926	5540	496	13	269	1125	1100	5	263	12	876	1605	2085	1151	14	1309	1975	710	6	0	1344	0	0	0	0	8642	0	0	14	7	309	1	1293	865	303	594	11	3216	1265	143	8	103	2	502	175	1349	635	9	890	6305	30	9	311	508	326	1751	1480	175	14	216	95	5124
		0	1	2	3	4	5	6	7	8	9																																																																																																																												
True Label	Predicted Label	0	79	761	2085	2031	520	11	989	753	1903																																																																																																																												
	0	868	0	2174	1410	1165	702	10	2302	1112	666																																																																																																																												
1	0	8086	0	26	0	0	1509	0	0	379																																																																																																																													
2	449	10	2174	1410	1165	702	10	2302	1112	666																																																																																																																													
3	227	109	643	3944	1417	499	10	646	324	2181																																																																																																																													
4	210	10	311	926	5540	496	13	269	1125	1100																																																																																																																													
5	263	12	876	1605	2085	1151	14	1309	1975	710																																																																																																																													
6	0	1344	0	0	0	0	8642	0	0	14																																																																																																																													
7	309	1	1293	865	303	594	11	3216	1265	143																																																																																																																													
8	103	2	502	175	1349	635	9	890	6305	30																																																																																																																													
9	311	508	326	1751	1480	175	14	216	95	5124																																																																																																																													
Accuracy and loss plot of iPhone6S_BeSh new samples while applying transfer learning	Confusion Matrix of iPhone6S_BeSh new samples after applying transfer learning techniques																																																																																																																																						



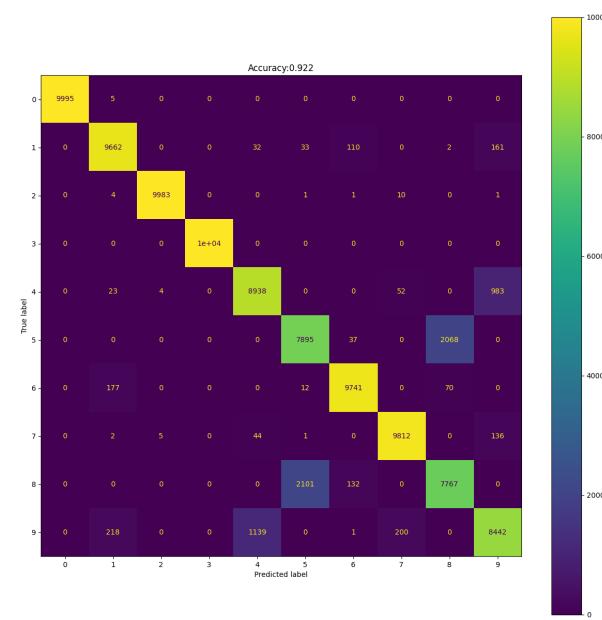
## iPhone13\_I



Accuracy and loss plot of iPhone13\_I\_BeSh new samples while applying transfer learning

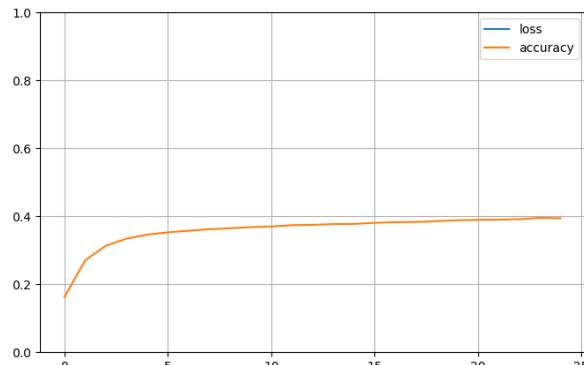


Confusion Matrix of iPhone13\_I\_BeSh new samples after applying transfer learning techniques

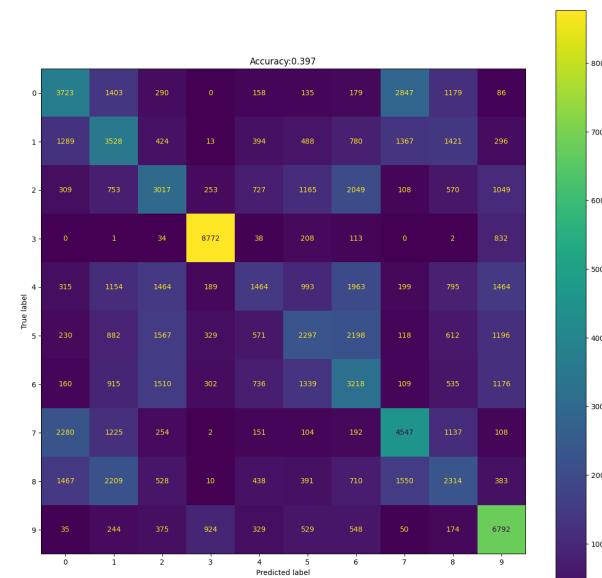


## iPhone14Pro\_I

Accuracy and loss plot of iPhone14Pro\_I new samples while applying transfer learning



Confusion Matrix of iPhone14Pro\_I new samples after applying transfer learning techniques



## EXPERIMENT: 07

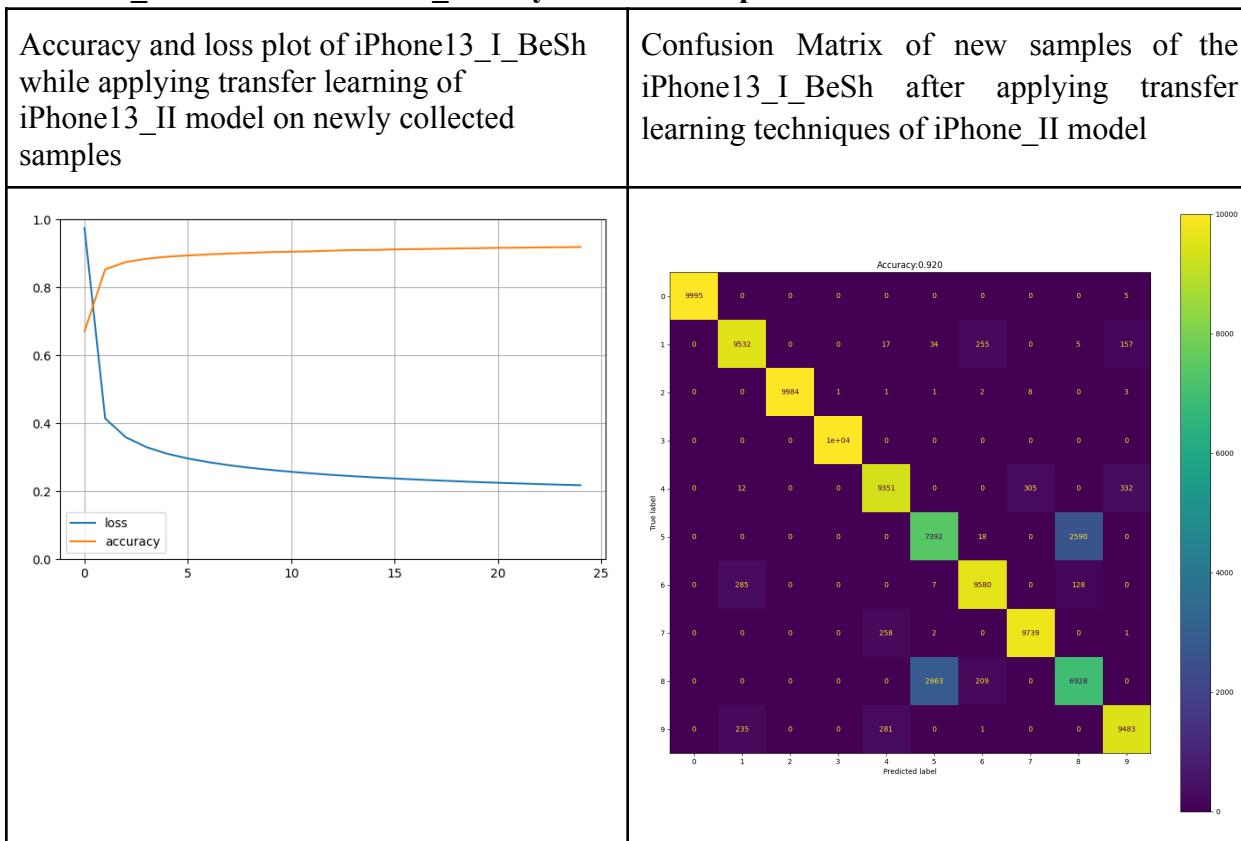
Apply transfer learning to newly collected samples by only training the last layer (output layer) of all three iPhone13 models to increase the accuracy while doing cross-device experiments in between the similar versions of smartphones.

Model Name	Smartphone dataset	Training accuracy at 25th epochs	Learning Time	Testing Accuracy
iPhone13_I_mo del.h5	iPhone13_I(ii)	0.7981	6m 39.5s	0.7990
	iPhone13_I_BeSh	0.9209	5m 55.6s	0.9223
iPhone13_II_mo del.h5	iPhone13_I(ii)			
	iPhone13_I_BeSh	0.9190	5m 21.4s	0.9198
iPhone13_III_mo del.h5	iPhone13_I(ii)			
	iPhone13_I_BeSh	0.8964	6m 17.3s	0.8941

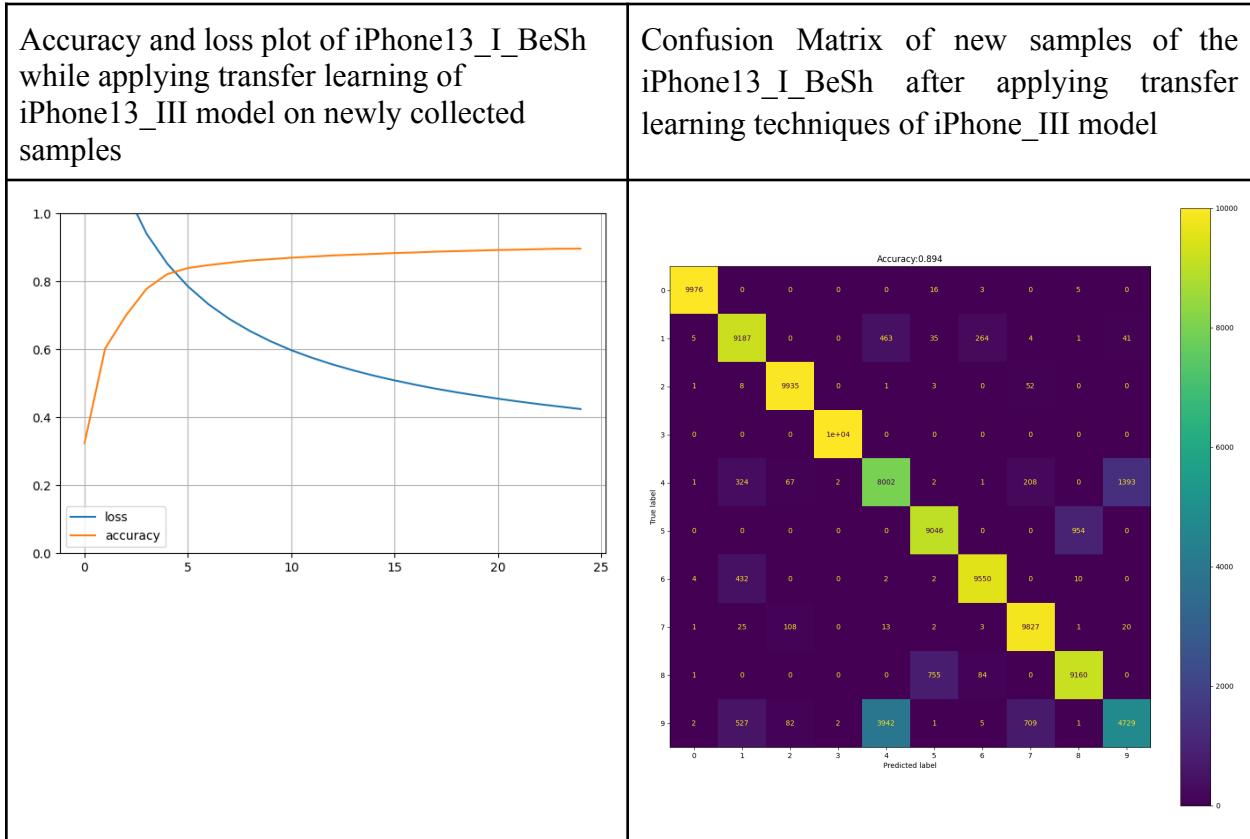
### iPhone13\_I model to iPhone13\_I newly collected samples

This result is already explained in EXPERIMENT: 06

### iPhone13\_II model to iPhone13\_I newly collected samples



### **iPhone13\_III model to iPhone13\_I newly collected samples**



### **EXPERIMENT: 08**

Create own models for newly collected dataset for both iPhone6S, iPhone13 and iPhone14Pro to validate the accuracy and training time with transfer learning models

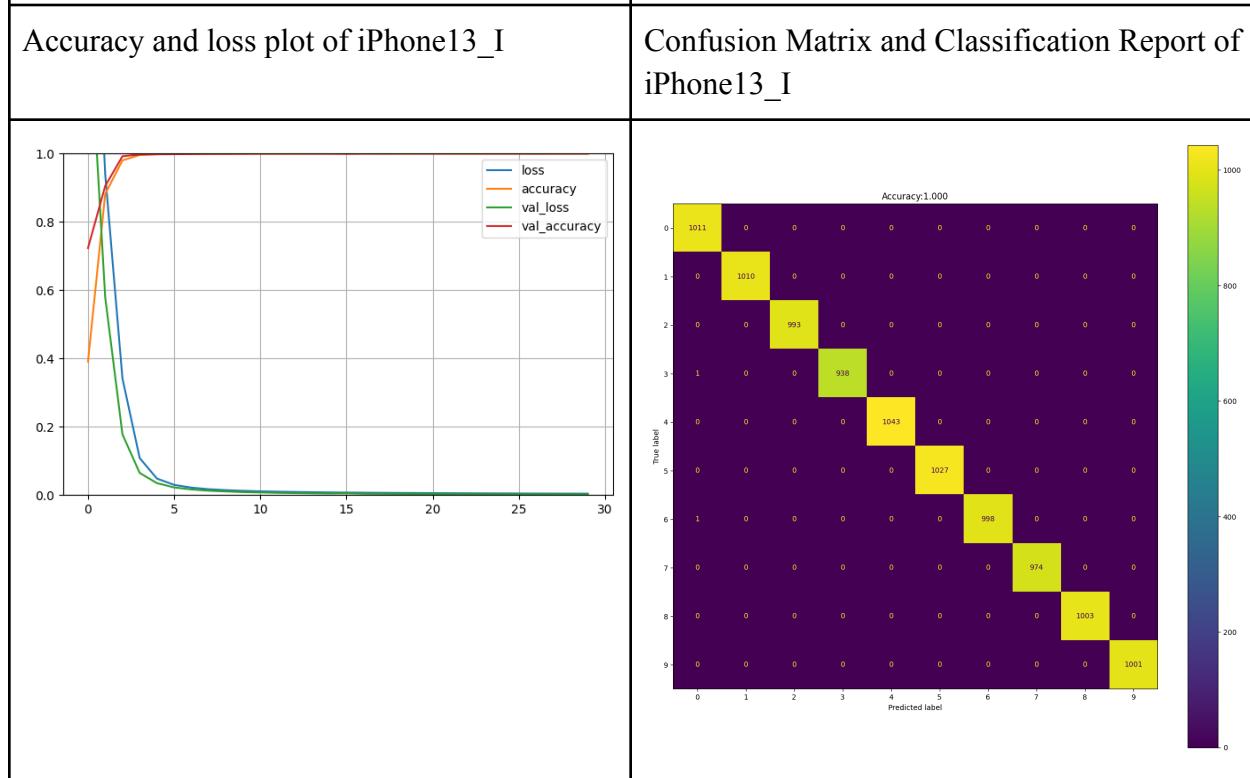
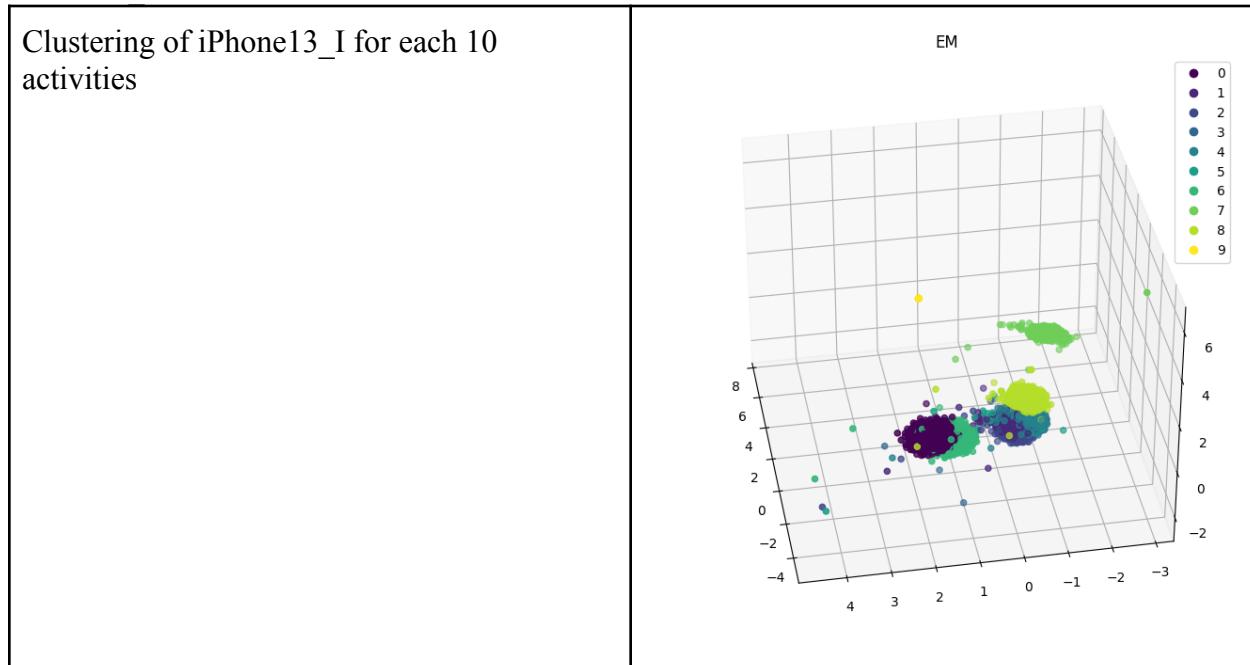
### **iPhone13**

Own model creation for iPhone13 datasets

Smartphone Dataset	Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone13_I	0.9998	15m 6.9s	0.9998
iPhone13_I(ii)	0.9998	14m 57.1s	0.9999
iPhone13_I(iii)	0.9996	13m 0.8s	0.9990
iPhone13_I_BeSh	0.9997	13m 51.8s	0.9997
iPhone13_I_data1	0.9998	15m 19.3s	0.9997

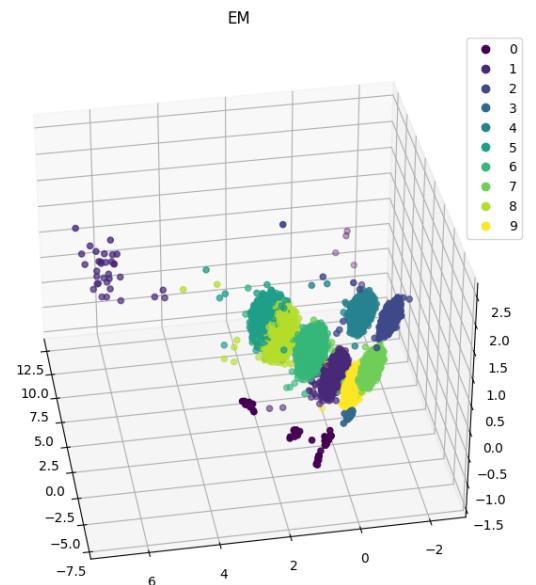
iPhone13_I_data2	0.9998	12m 41.6s	0.9998
iPhone13_II	0.9997	12m 40.3s	0.9996
iPhone13_III	0.9994	15m 8.7s	0.9991

iPhone13 I



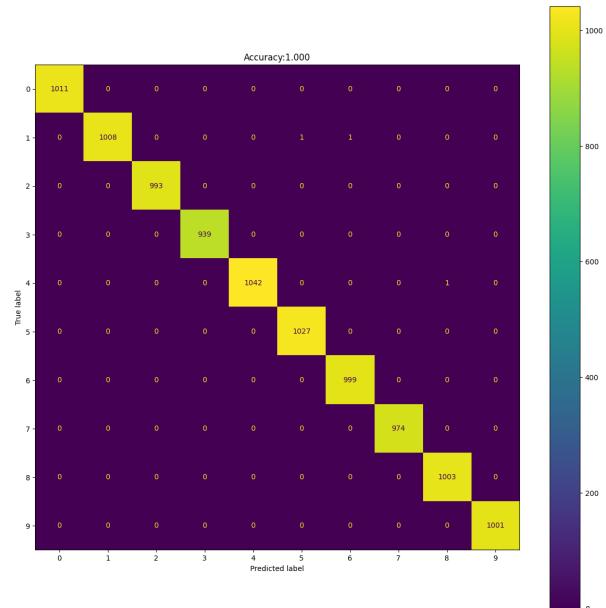
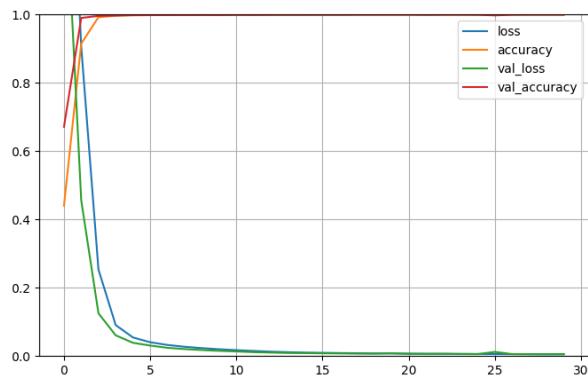
iPhone13\_I\_Besh

## Clustering of iPhone13\_I\_BeSh for each 10 activities



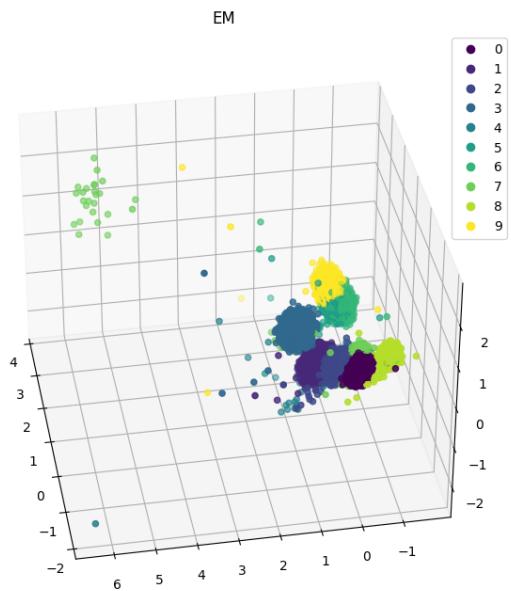
## Accuracy and loss plot of iPhone13\_I\_BeSh

## Confusion Matrix and Classification Report of iPhone13\_I\_BeSh



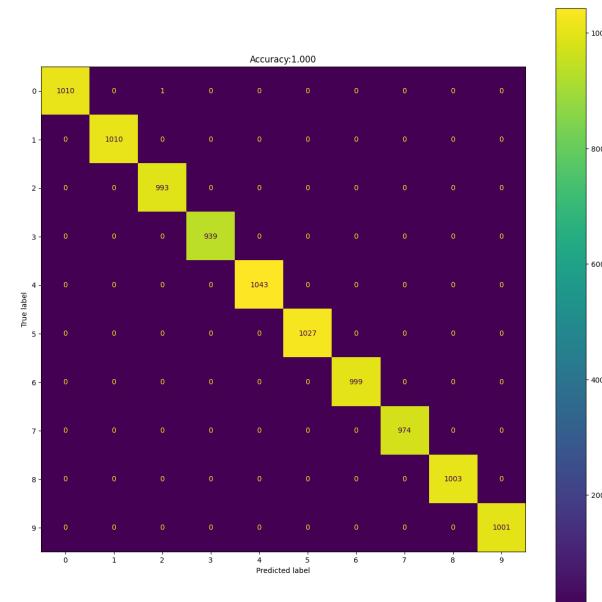
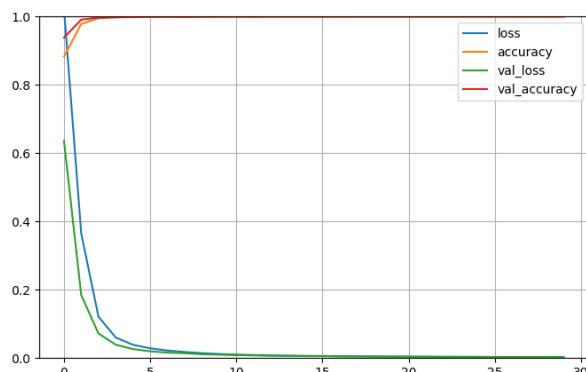
### iPhone13 I(ii)

## Clustering of iPhone13\_I(ii) for each 10 activities



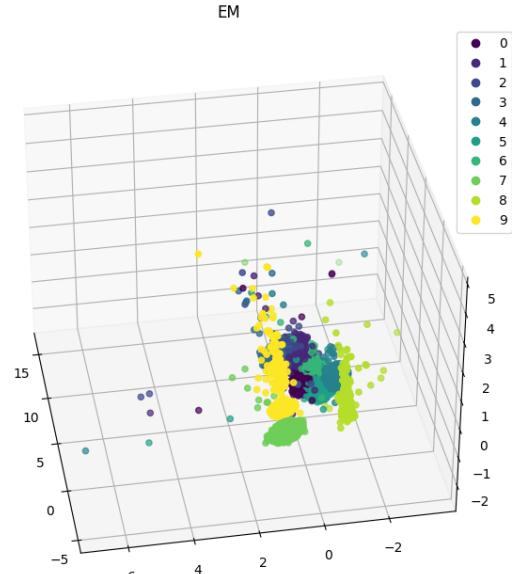
## Accuracy and loss plot of iPhone13\_I(ii)

## Confusion Matrix and Classification Report of iPhone13\_I(ii)



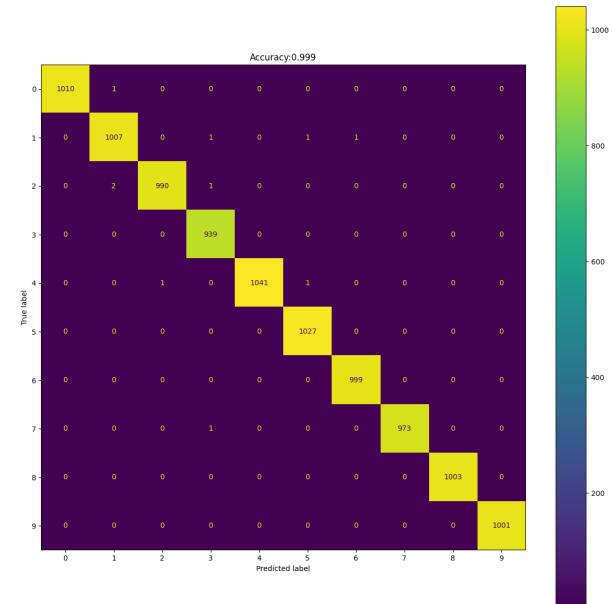
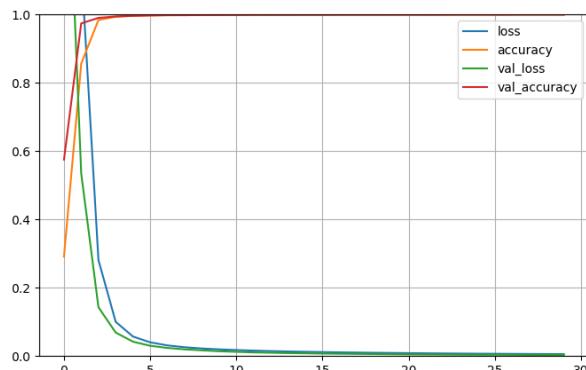
### iPhone13 I(iii)

### Clustering of iPhone13\_I(iii) for each 10 activities



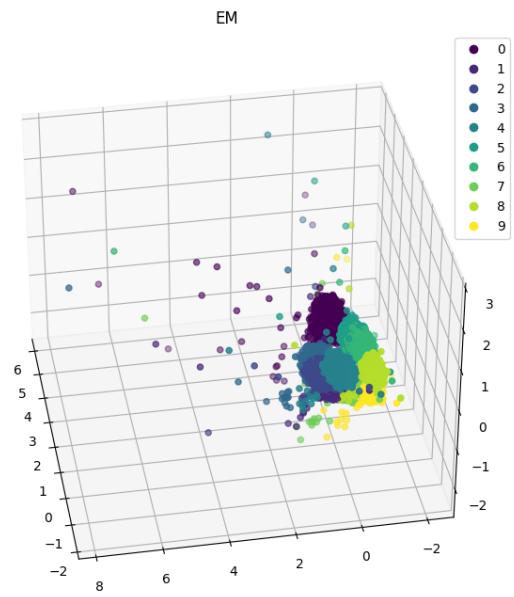
### Accuracy and loss plot of iPhone13\_I(iii)

## Confusion Matrix and Classification Report of iPhone13\_I(iii)



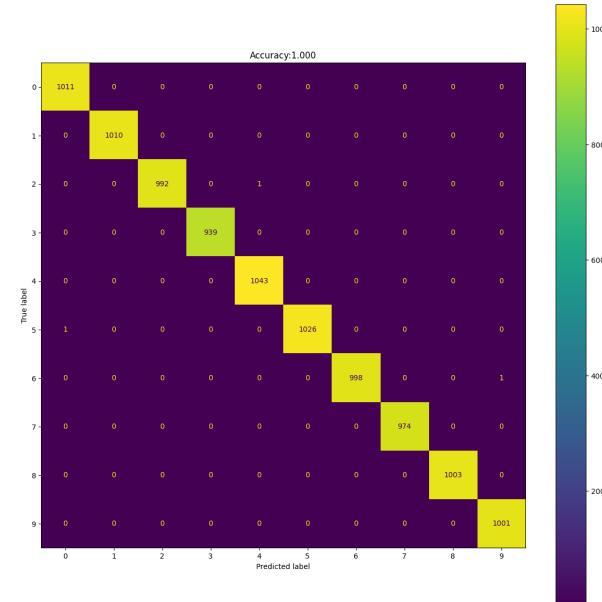
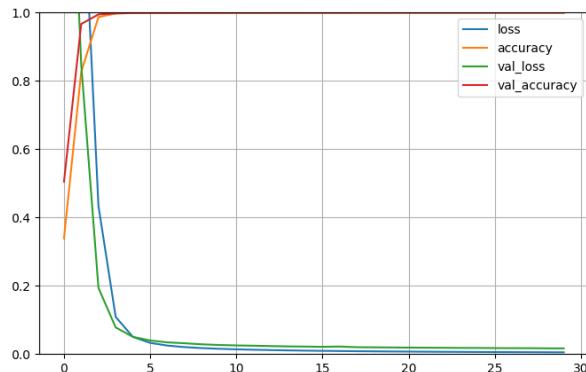
iPhone13 I data1

## Clustering of iPhone13\_I\_data1 for each 10 activities



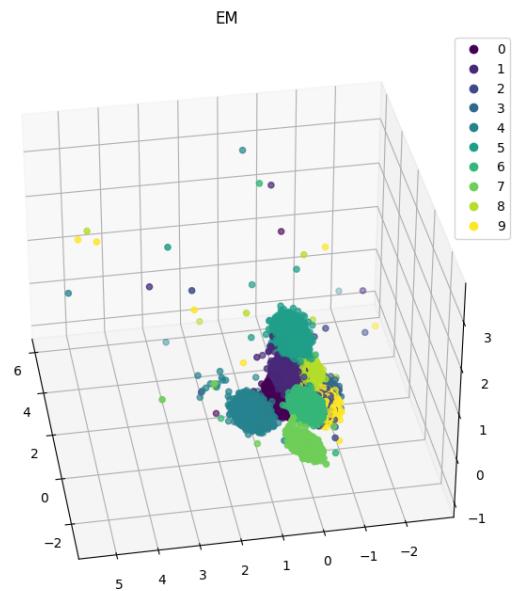
## Accuracy and loss plot of iPhone13\_I\_data1

## Confusion Matrix and Classification Report of iPhone13\_I\_data1



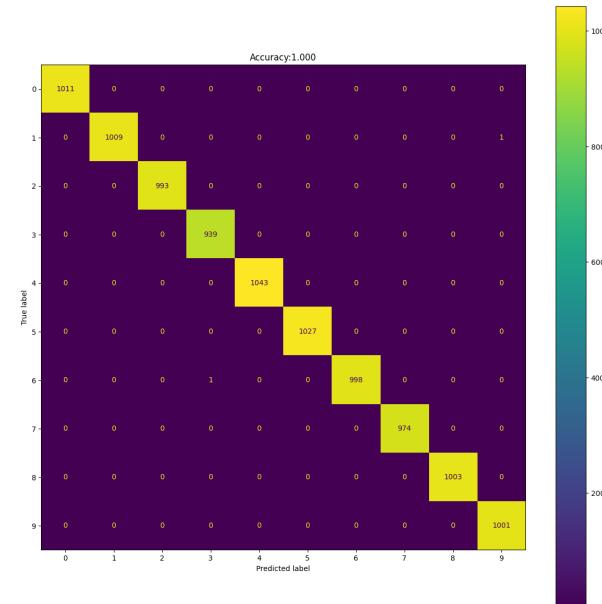
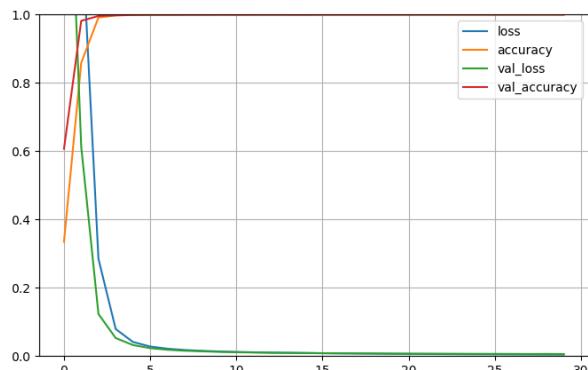
iPhone13 I data2

## Clustering of iPhone13\_I\_data2 for each 10 activities



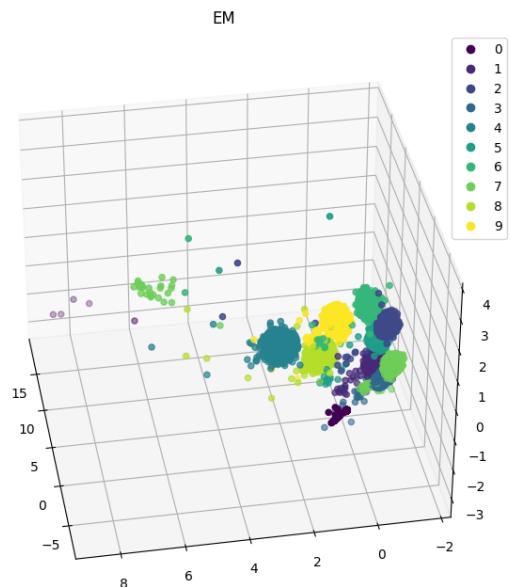
## Accuracy and loss plot of iPhone13\_I\_data2

## Confusion Matrix and Classification Report of iPhone13\_I\_data2



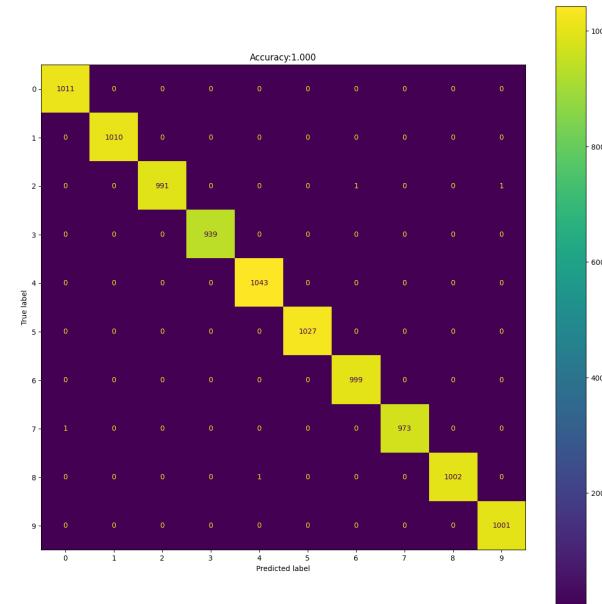
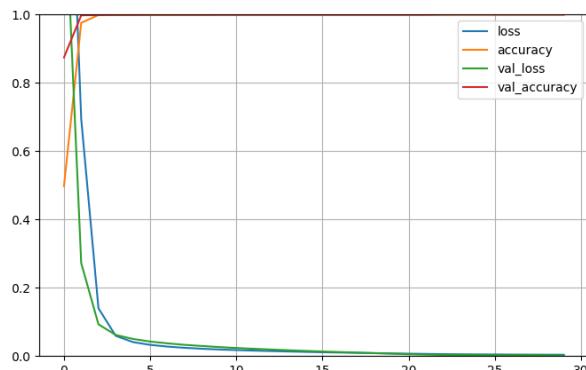
## iPhone13 II

## Clustering of iPhone13\_II for each 10 activities



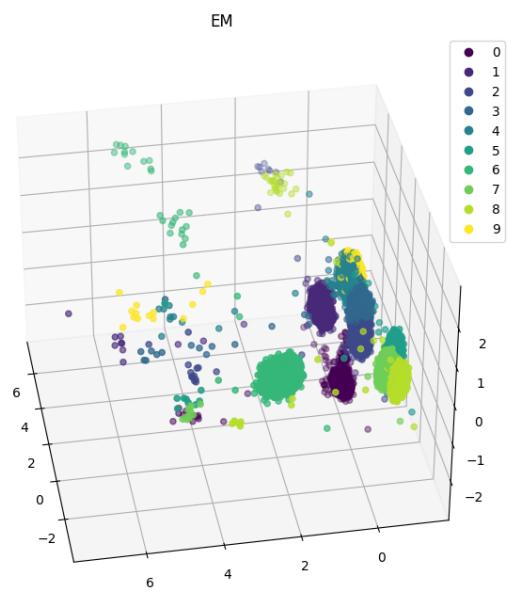
## Accuracy and loss plot of iPhone13\_II

## Confusion Matrix and Classification Report of iPhone13\_II



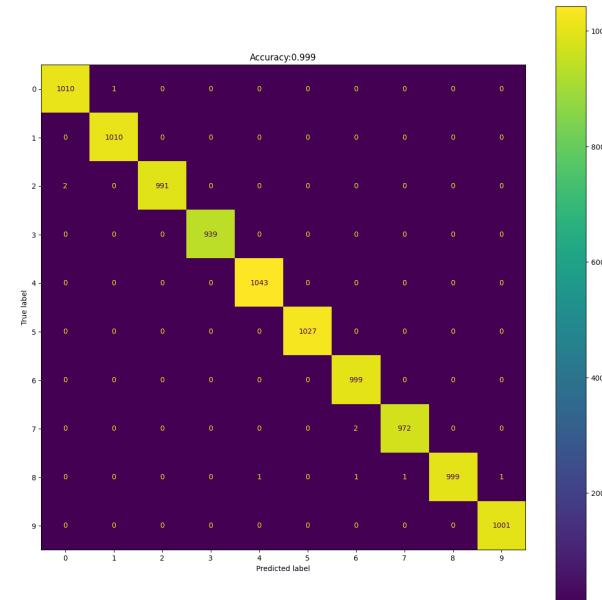
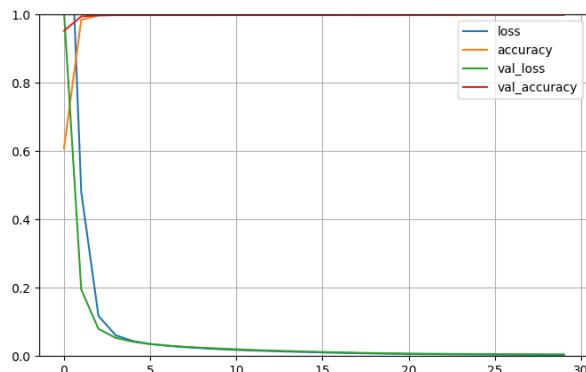
iPhone13 III

## Clustering of iPhone13\_III for each 10 activities



### Accuracy and loss plot of iPhone13\_III

## Confusion Matrix and Classification Report of iPhone13\_III

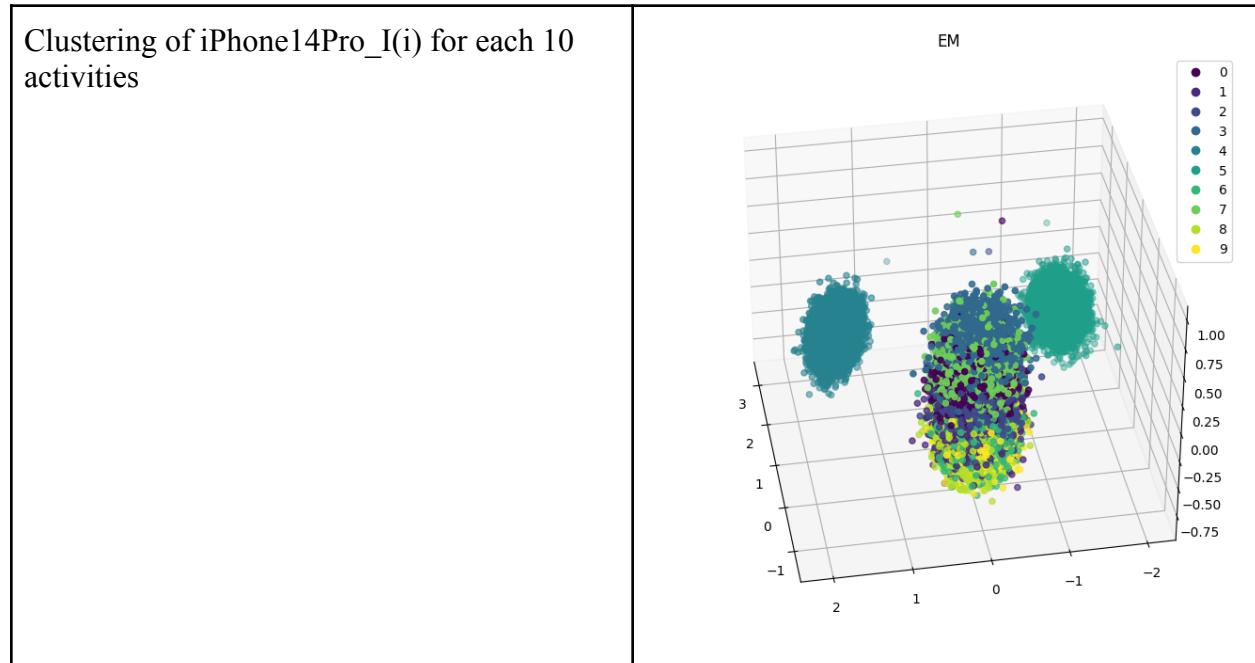


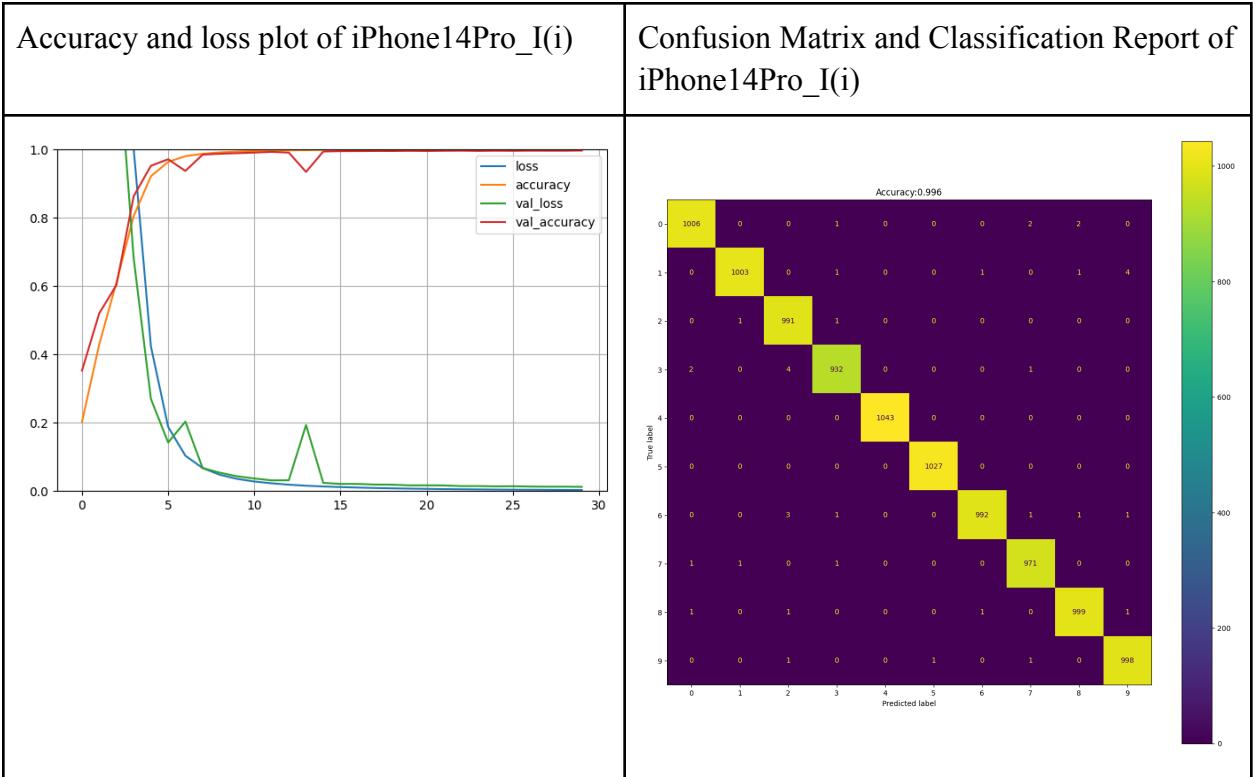
## iPhone14Pro

Own model creation for iPhone14Pro datasets

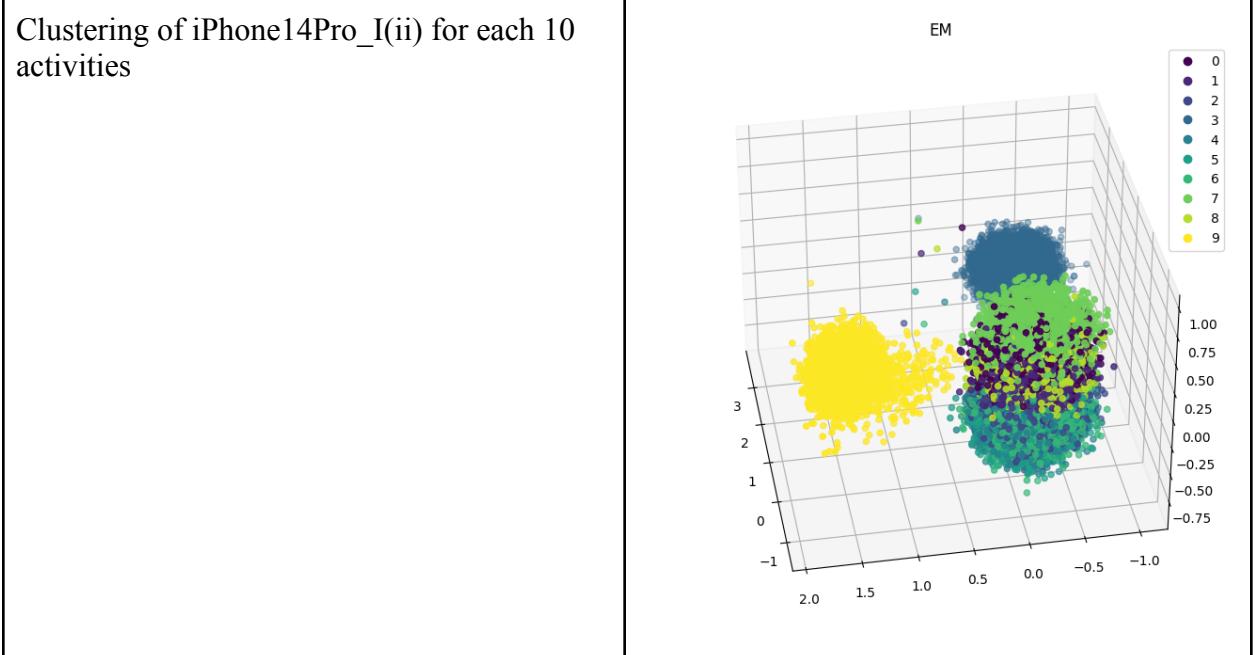
Smartphone Dataset	Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone14Pro_I(i)	1.0000	14m 9.3s	0.9962
iPhone14Pro_I(ii)	1.0000	13m 21.7s	0.9975
iPhone14Pro_I(iii)	1.0000	14m 14.1s	0.9942
iPhone14Pro_I(iv)	1.0000	15m 34.9s	0.9927
iPhone14Pro_I(v)	0.9998	14m 59.7s	0.9990

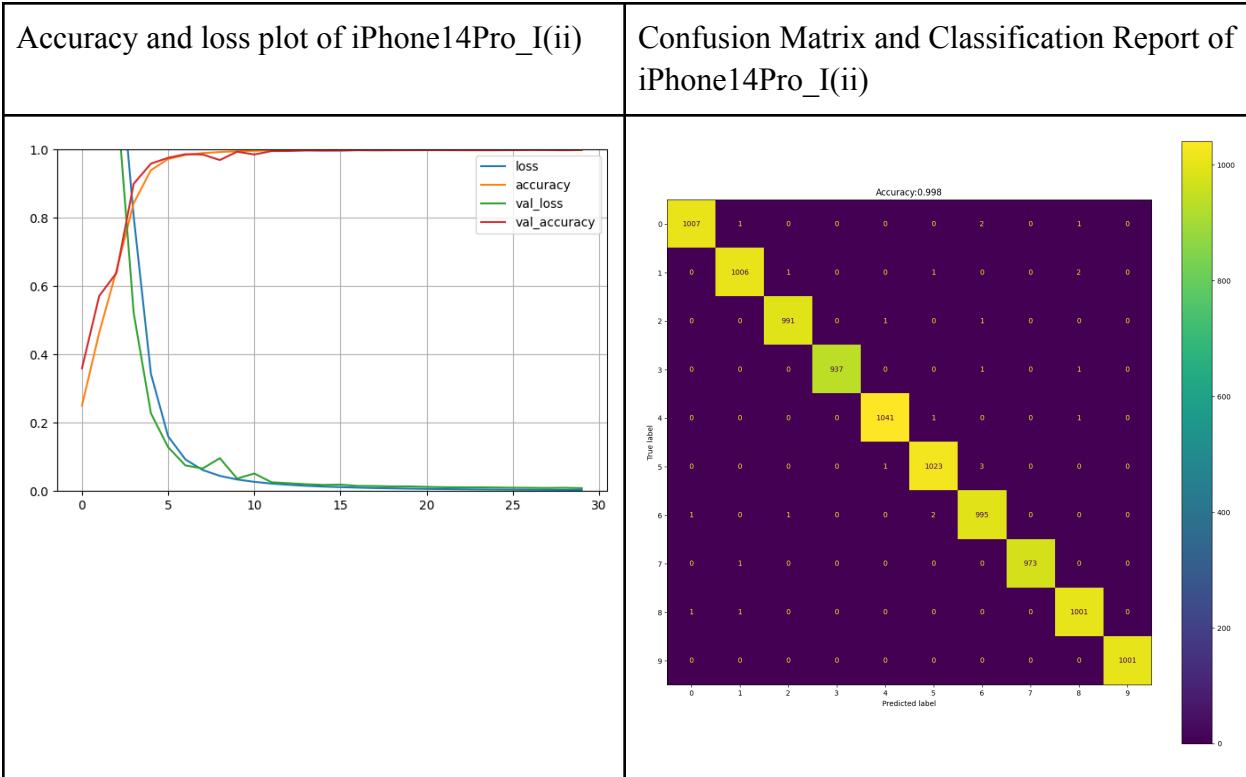
iPhone14Pro\_I(i)



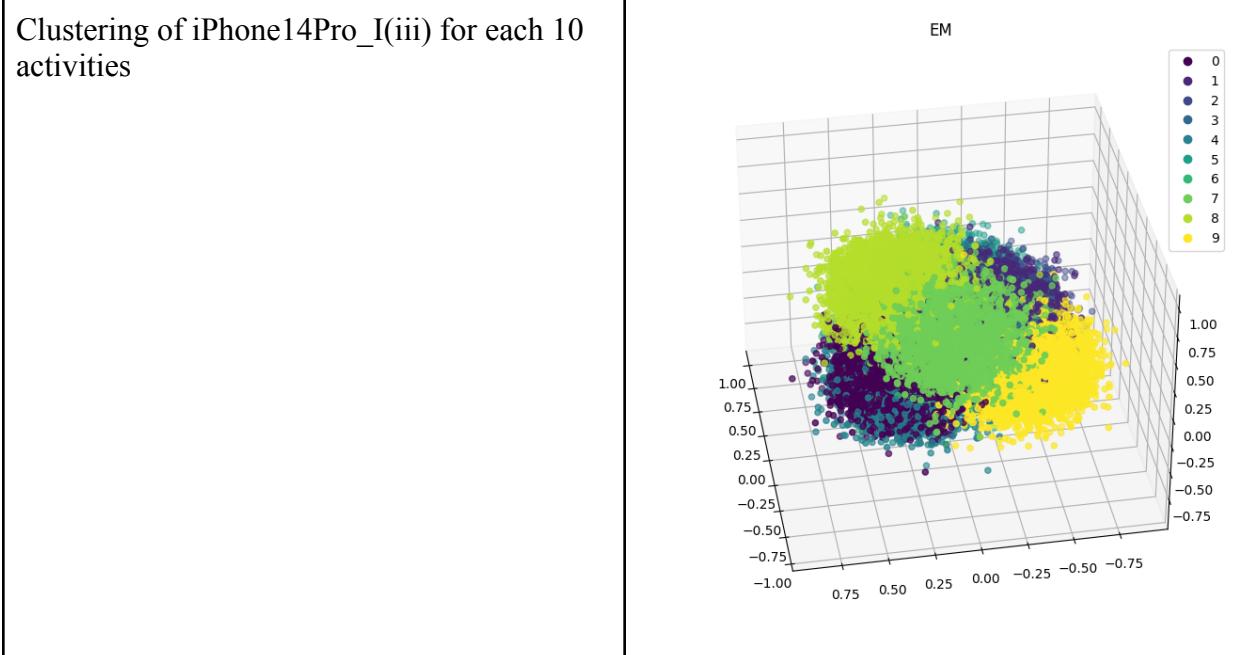


iPhone14Pro\_I(ii)

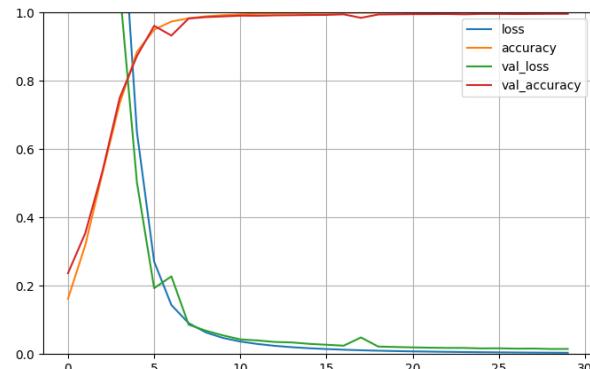




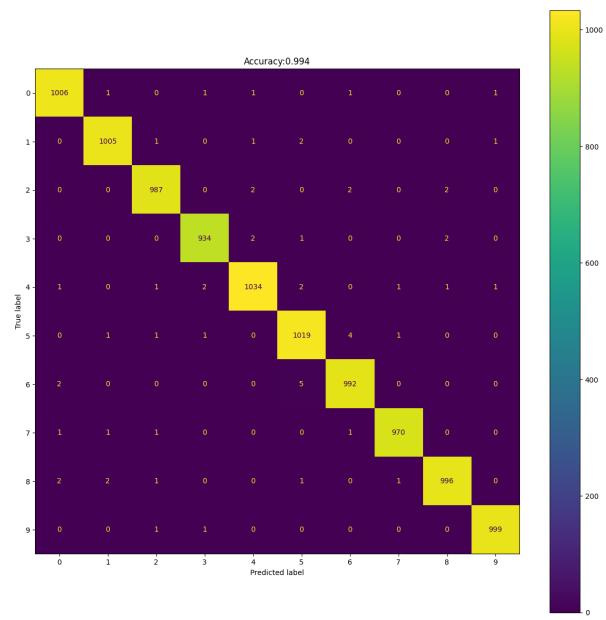
iPhone14Pro\_I(iii)



Accuracy and loss plot of iPhone14Pro\_I(iii)

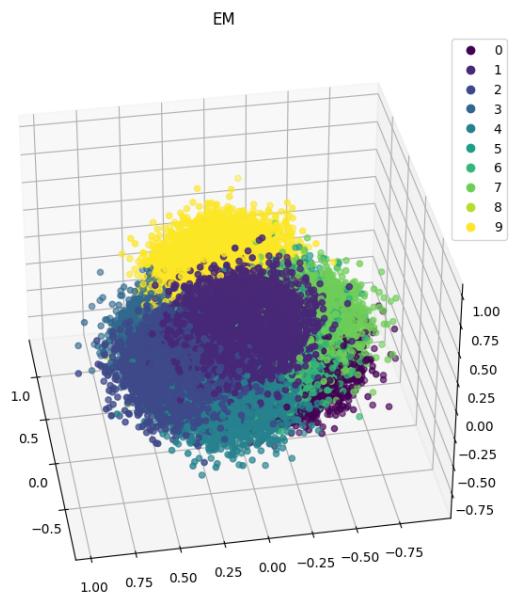


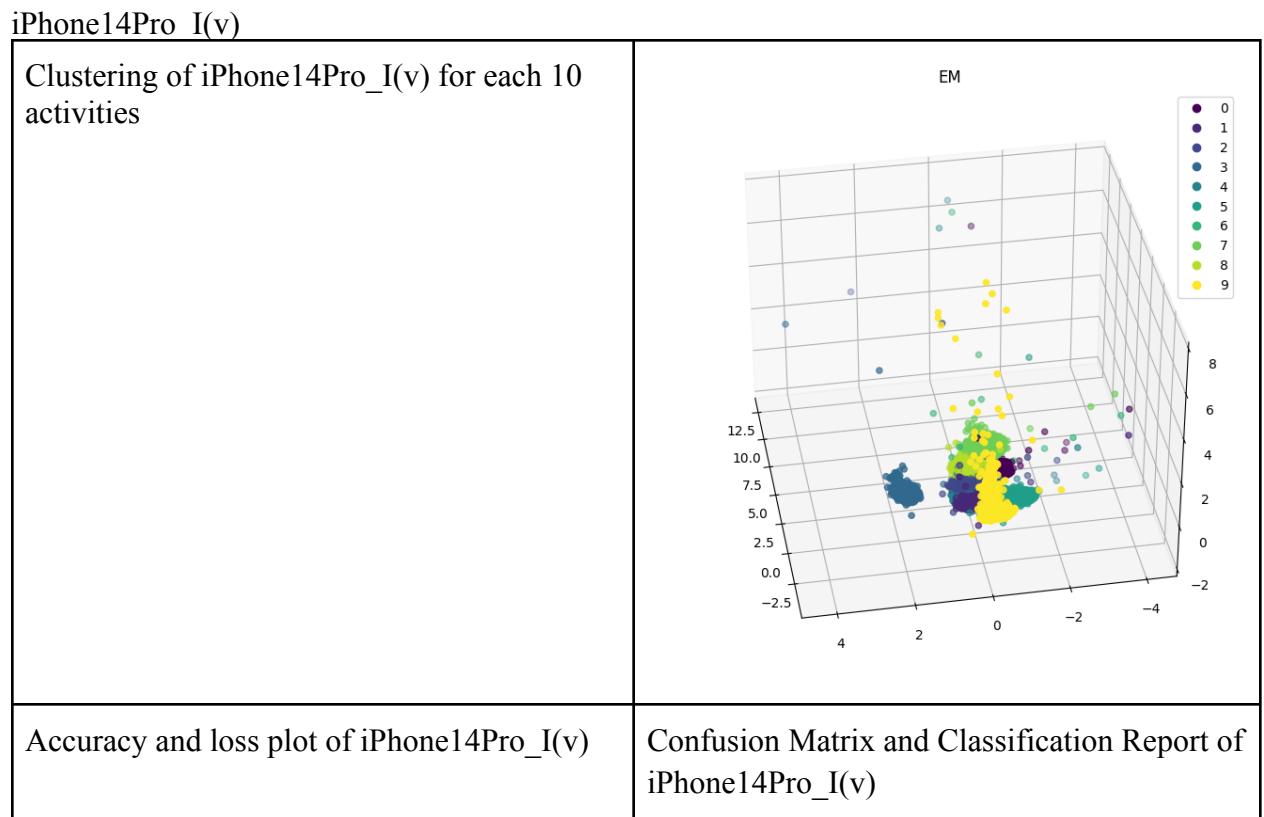
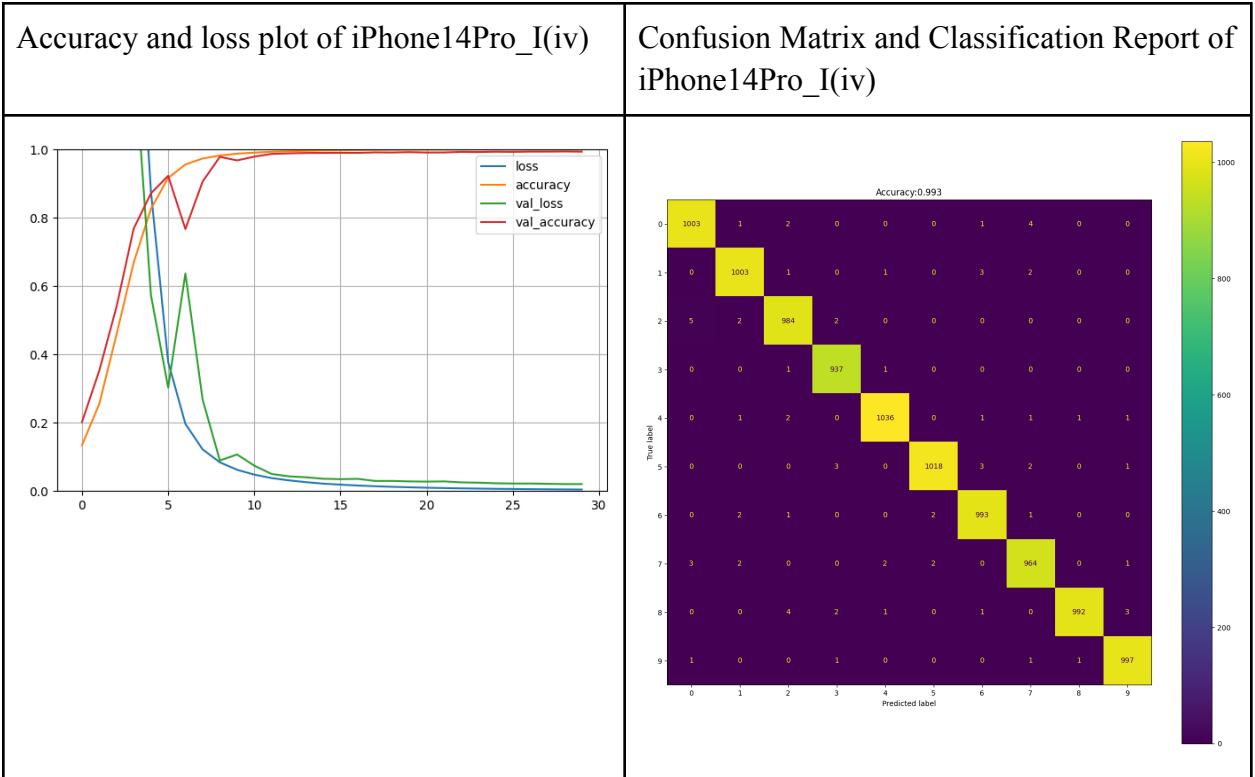
Confusion Matrix and Classification Report of iPhone14Pro\_I(iii)

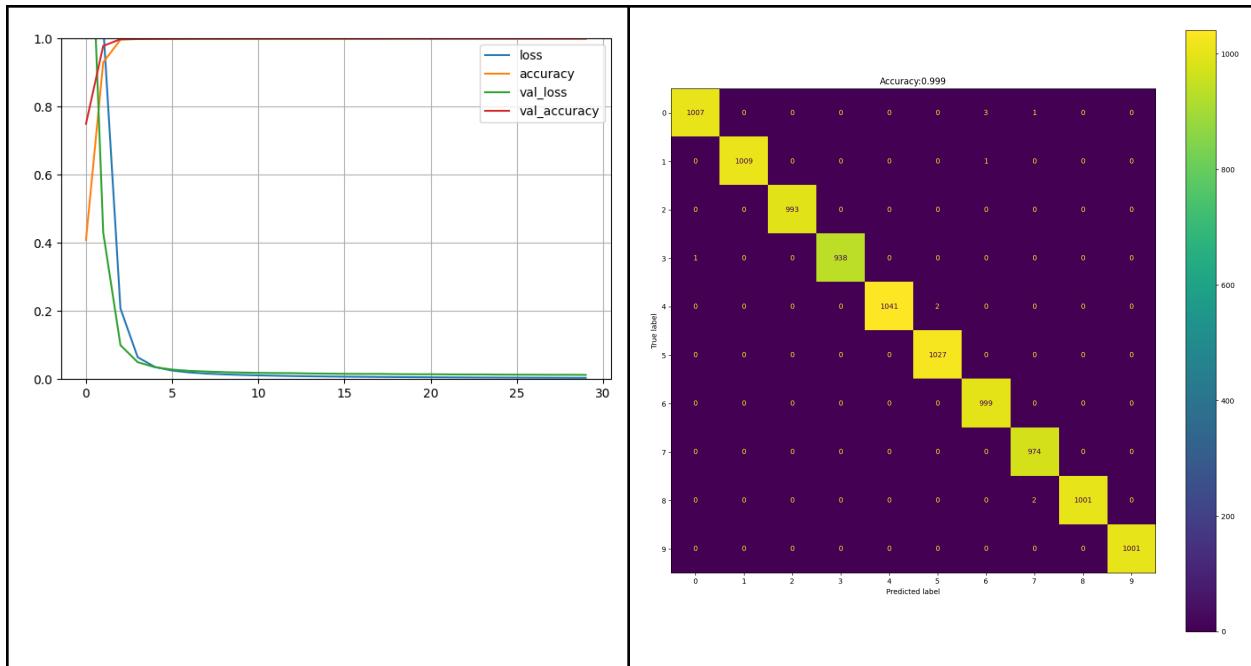


iPhone14Pro\_I(iv)

Clustering of iPhone14Pro\_I(iv) for each 10 activities







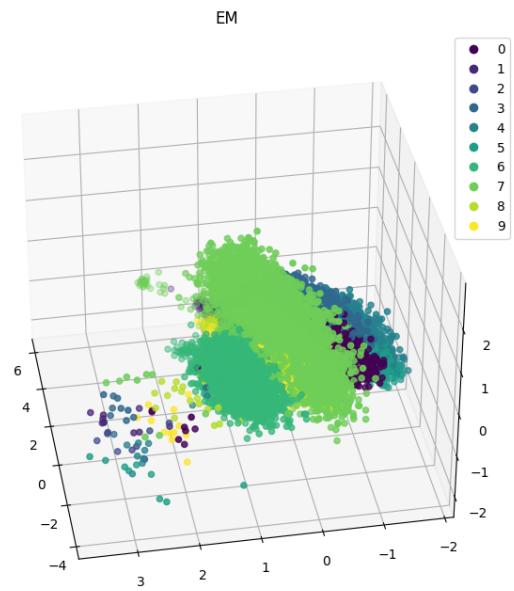
## iPhone6S

Own model creation for iPhone6S datasets

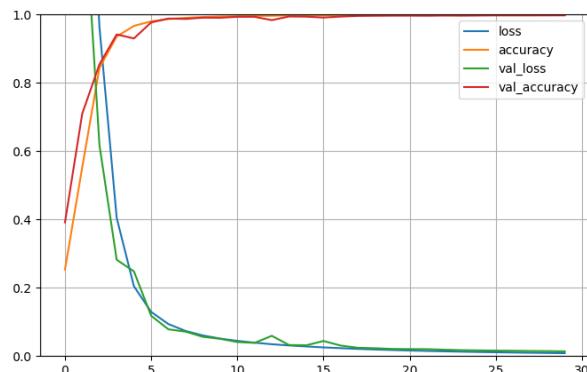
Smartphone Dataset	Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone6S_I	0.9995	13m 20.7s	0.9961
iPhone6S_I_BeSh	1.0000	12m 19.7s	0.9982
iPhone6S_I(ii)	0.9995	14m 15.5s	0.9965

## iPhone6S\_I

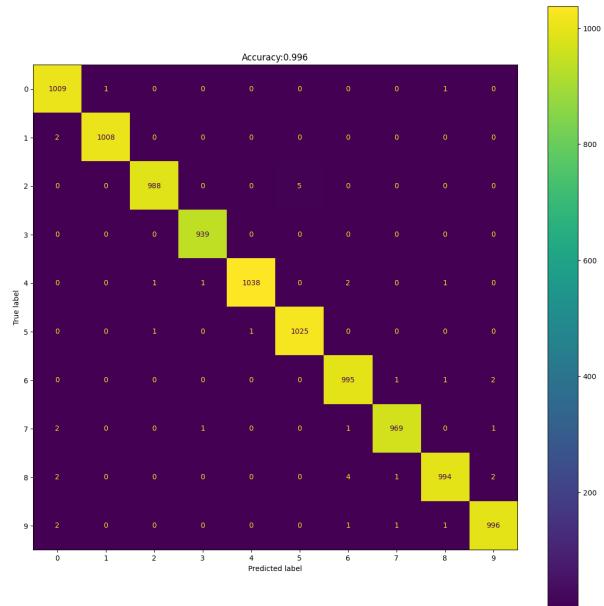
Clustering of iPhone6S\_I for each 10 activities



Accuracy and loss plot of iPhone6S\_I

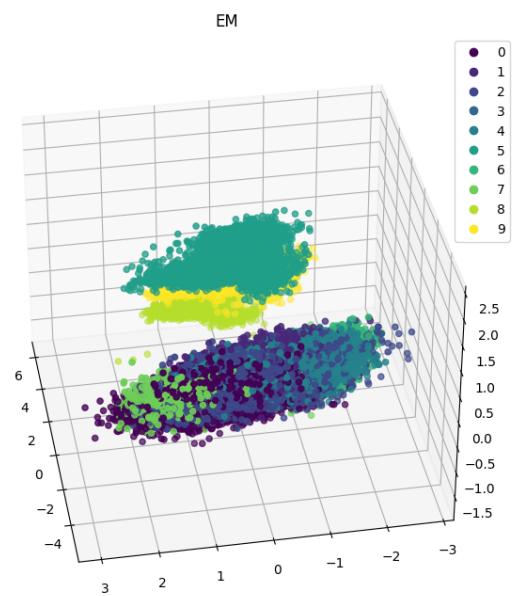


Confusion Matrix and Classification Report of iPhone6S\_I

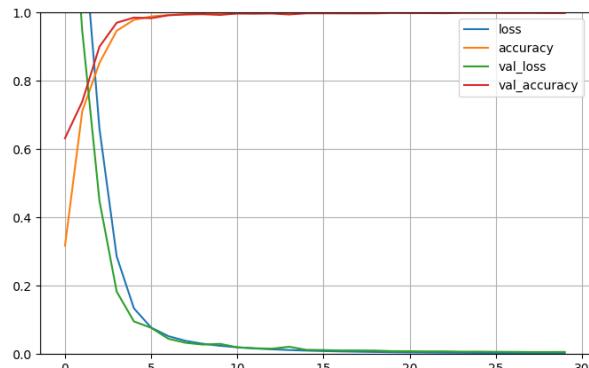


## iPhone6S\_I\_Besh

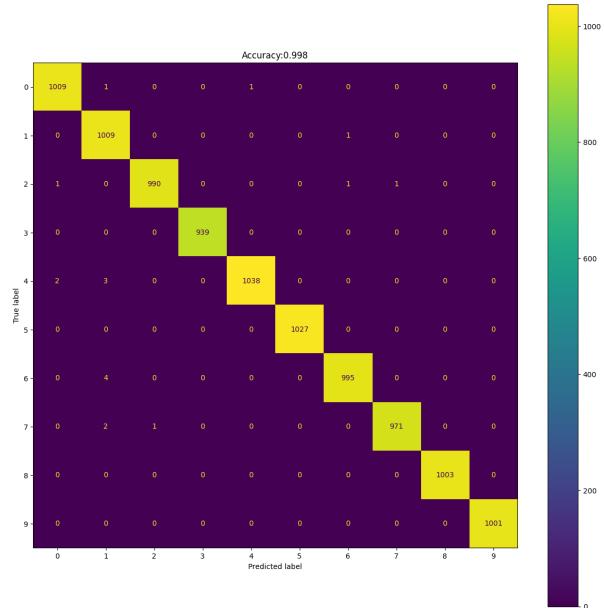
Clustering of iPhone6S\_I\_BeSh for each 10 activities



Accuracy and loss plot of iPhone6S\_I\_BeSh

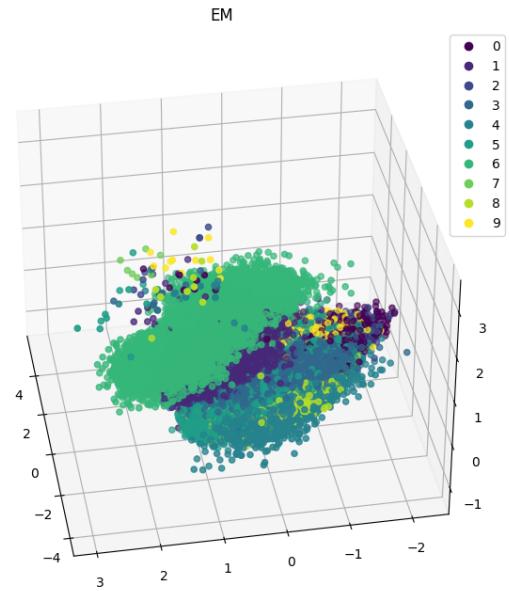


Confusion Matrix and Classification Report of iPhone6S\_I\_BeSh

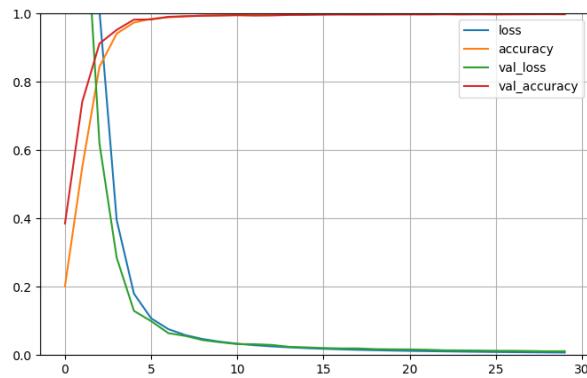


## iPhone6S\_I(ii)

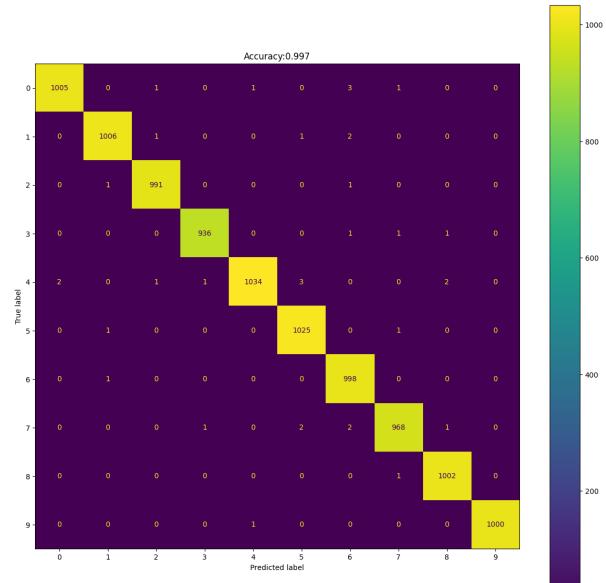
Clustering of iPhone6S\_I(ii) for each 10 activities



Accuracy and loss plot of iPhone6S\_I(ii)



Confusion Matrix and Classification Report of iPhone6S\_I(ii)



## **EXPERIMENT: 09**

Apply transfer learning all three iPhone13 dataset by only training the last layer (output layer) of all three iPhone13 models to increase the accuracy while doing cross-device, cross-model experiments in between the similar versions of smartphones. Also do the same for the collected dataset from iPhone14Pro and iPhone6S

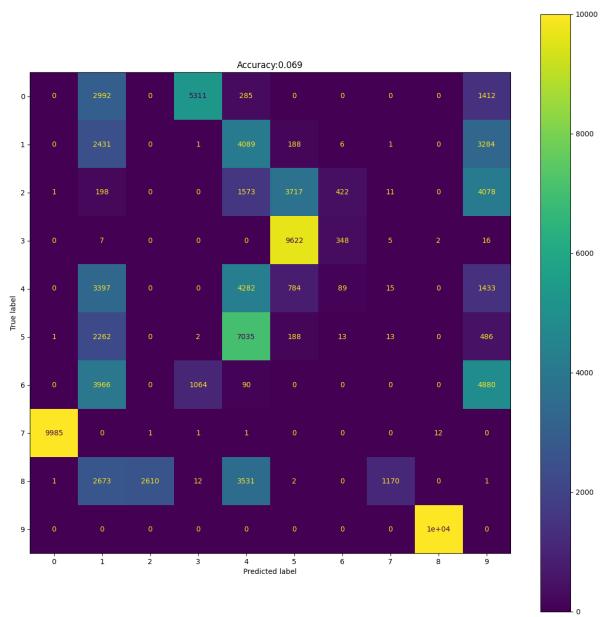
### **iPhone13**

#### **iPhone13\_I**

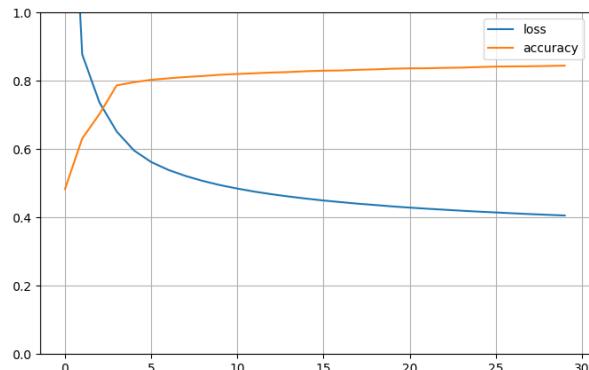
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone13_I(ii)_model.h5	0.0690	0.8447	6m 57.8s	0.8458
iPhone13_I(iii)_model.h5	0.0131	0.7439	7m 22.8s	0.7429
iPhone13_I_BeSh	0.0978	0.8207	5m 59.3s	0.8223
iPhone13_I_data1	0.1334	0.7799	7m 50.2s	0.7809
iPhone13_I_data2	0.2507	0.8248	7m 47.1s	0.8255
iPhone13_II	0.0818	0.8067	6m 39.7s	0.8092
iPhone13_III	0.1001	0.7389	6m 0.2s	0.7400

## iPHONE13\_I(ii)\_model.h5

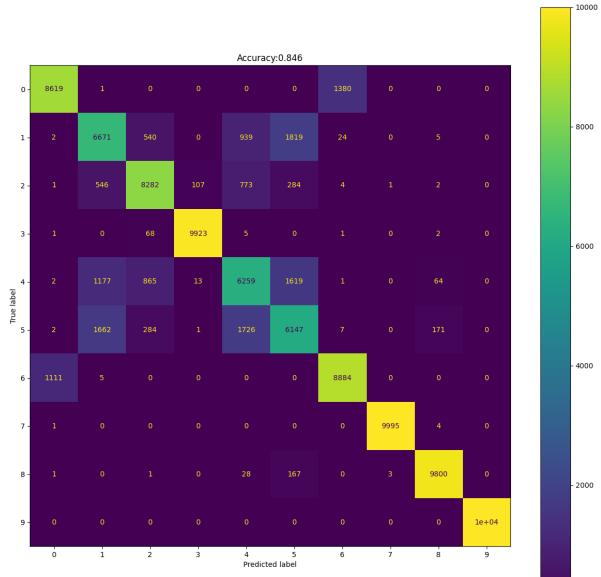
Confusion matrix Before training  
iphone13\_I(ii) model



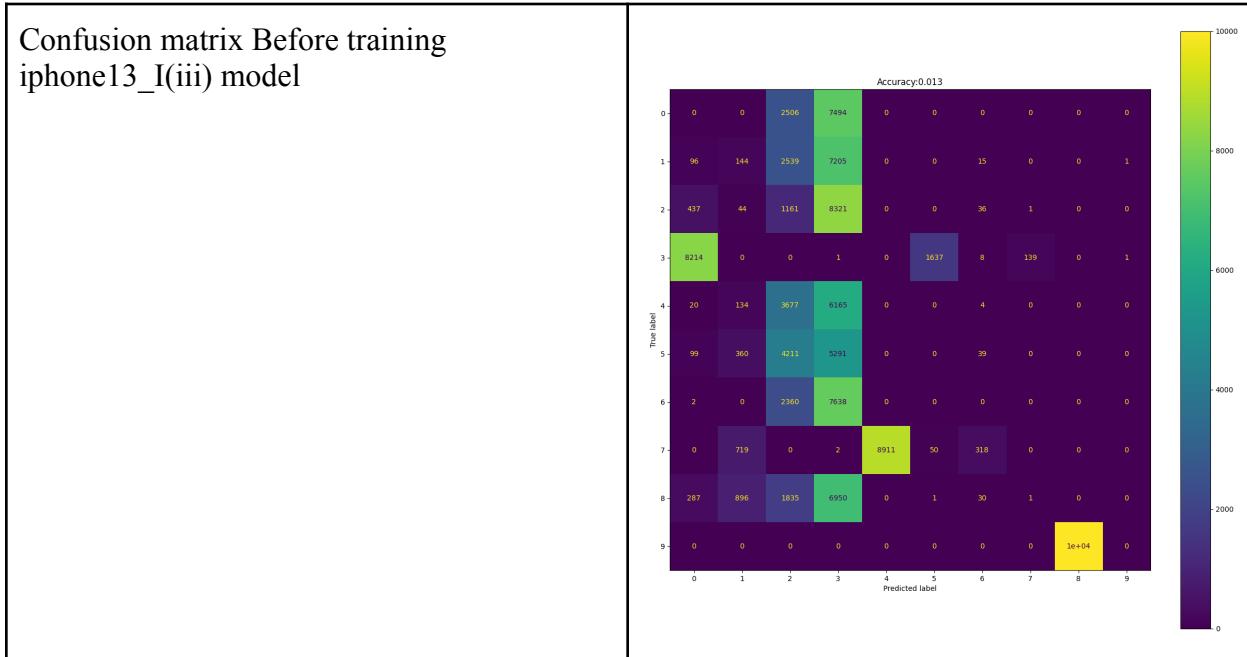
Accuracy and loss plot After apply transfer learning on iphone13\_I(ii) model



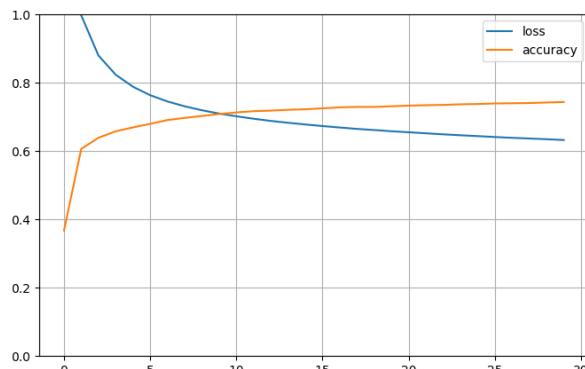
Confusion matrix After apply transfer learning on iphone13\_I(ii) model



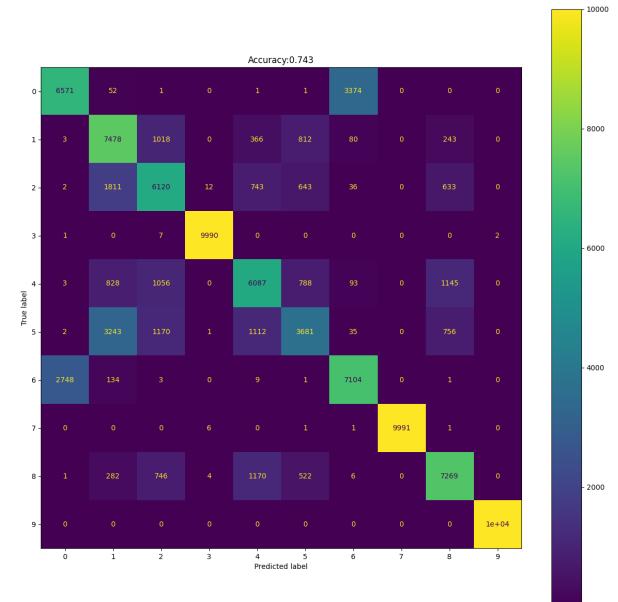
## iPHONE13\_I(ii)\_model.h5



Accuracy and loss plot After apply transfer learning on iphone13\_J(iii) model

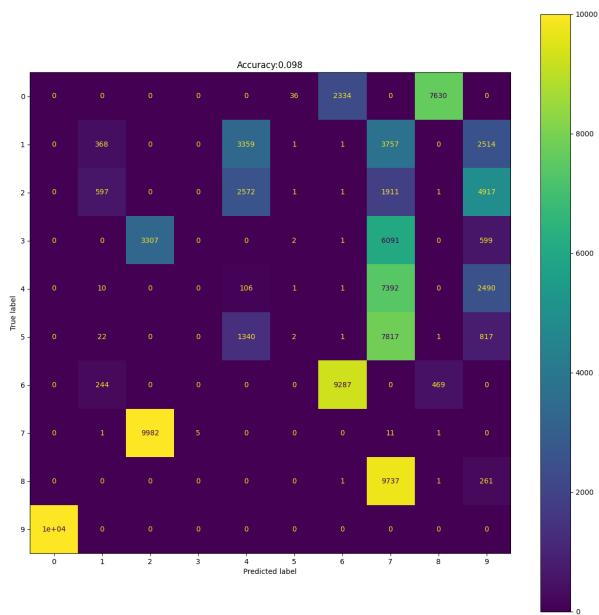


## Confusion matrix After apply transfer learning on iphone13\_I(iii) model

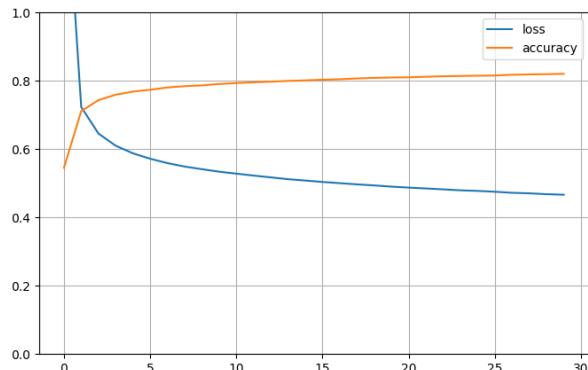


## iPHONE13\_I\_BeSh\_model.h5

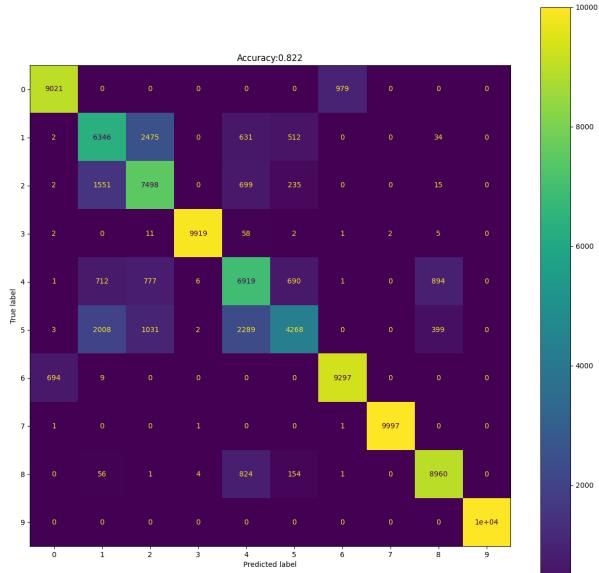
## Confusion matrix Before training iphone13\_I\_BeSh model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_BeSh model

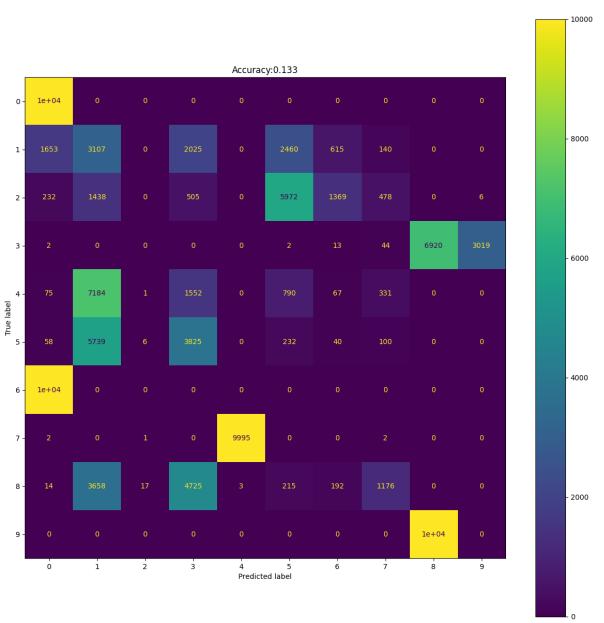


## Confusion matrix After apply transfer learning on iphone13\_I\_BeSh model

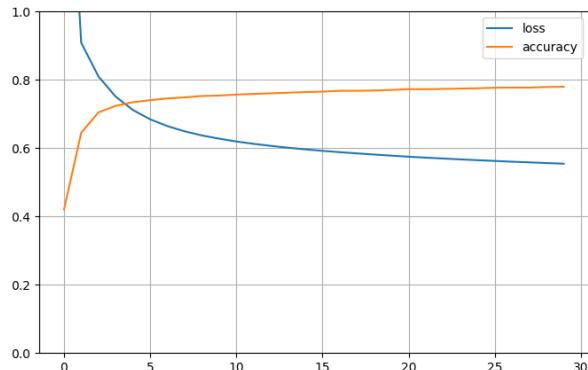


## iPHONE13\_I\_data1\_model.h5

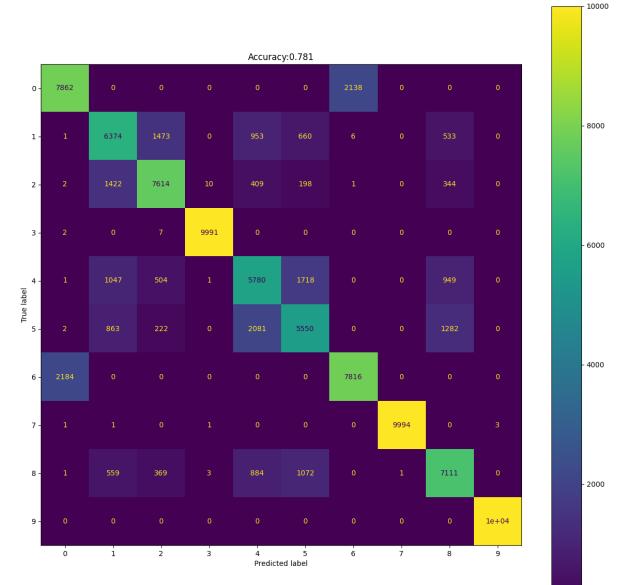
Confusion matrix Before training  
iphone13\_I\_data1 model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data1 model

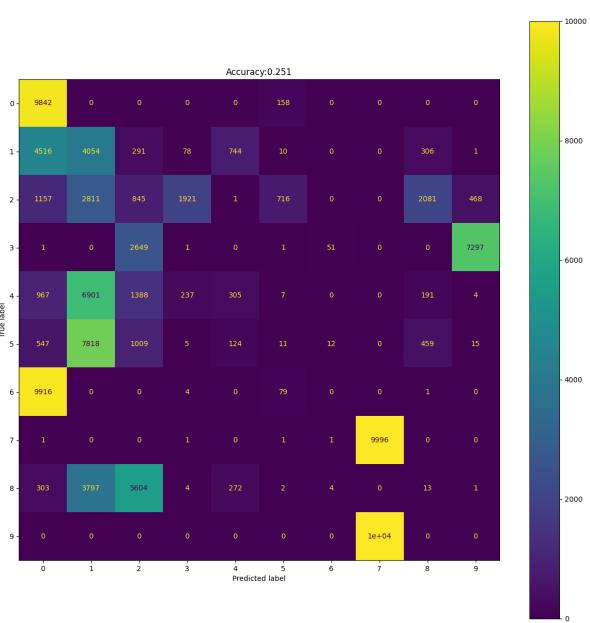


Confusion matrix After apply transfer learning on iphone13\_I\_data1 model



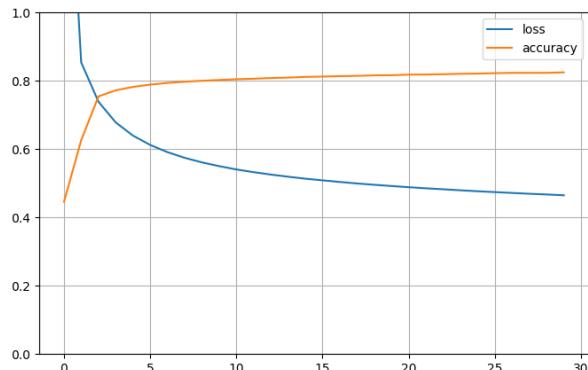
iPHONE13\_I\_data2\_model.h5

## Confusion matrix Before training iphone13\_I\_data2 model

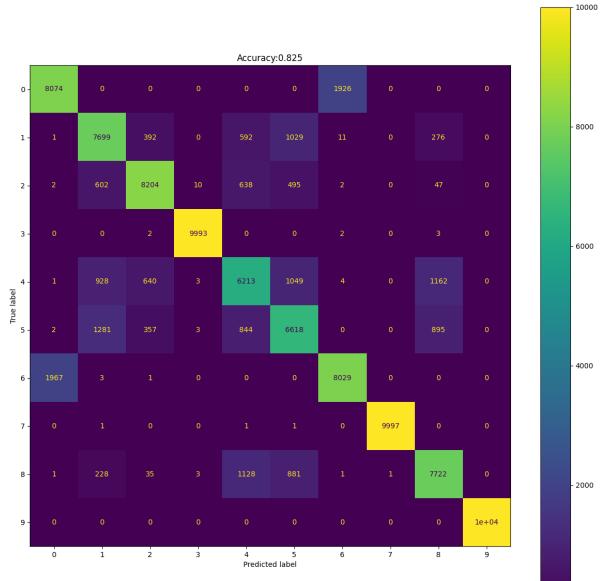


S

Accuracy and loss plot After apply transfer learning on iphone13\_I\_data2 model

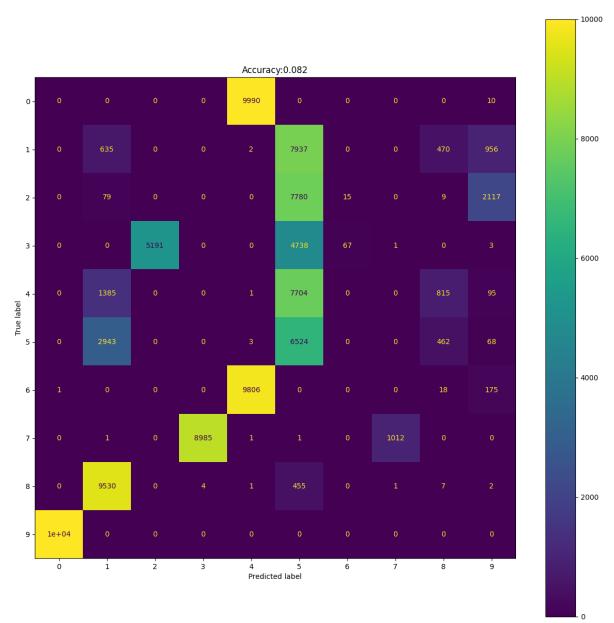


Confusion matrix After apply transfer learning on iphone13\_I\_data2 model

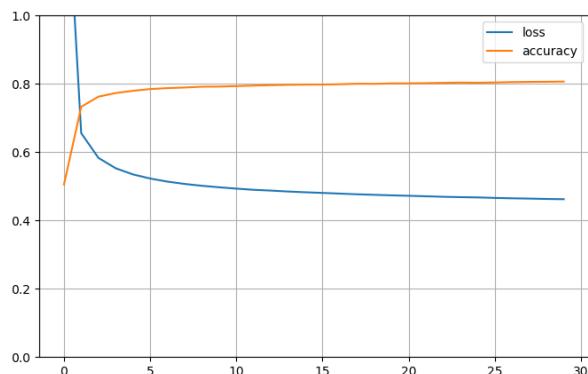


iPHONE13\_II\_model.h5

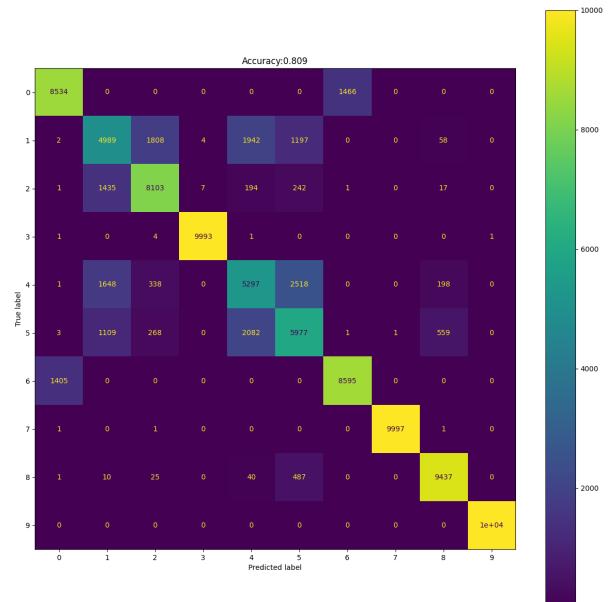
## Confusion matrix Before training iphone13\_II model



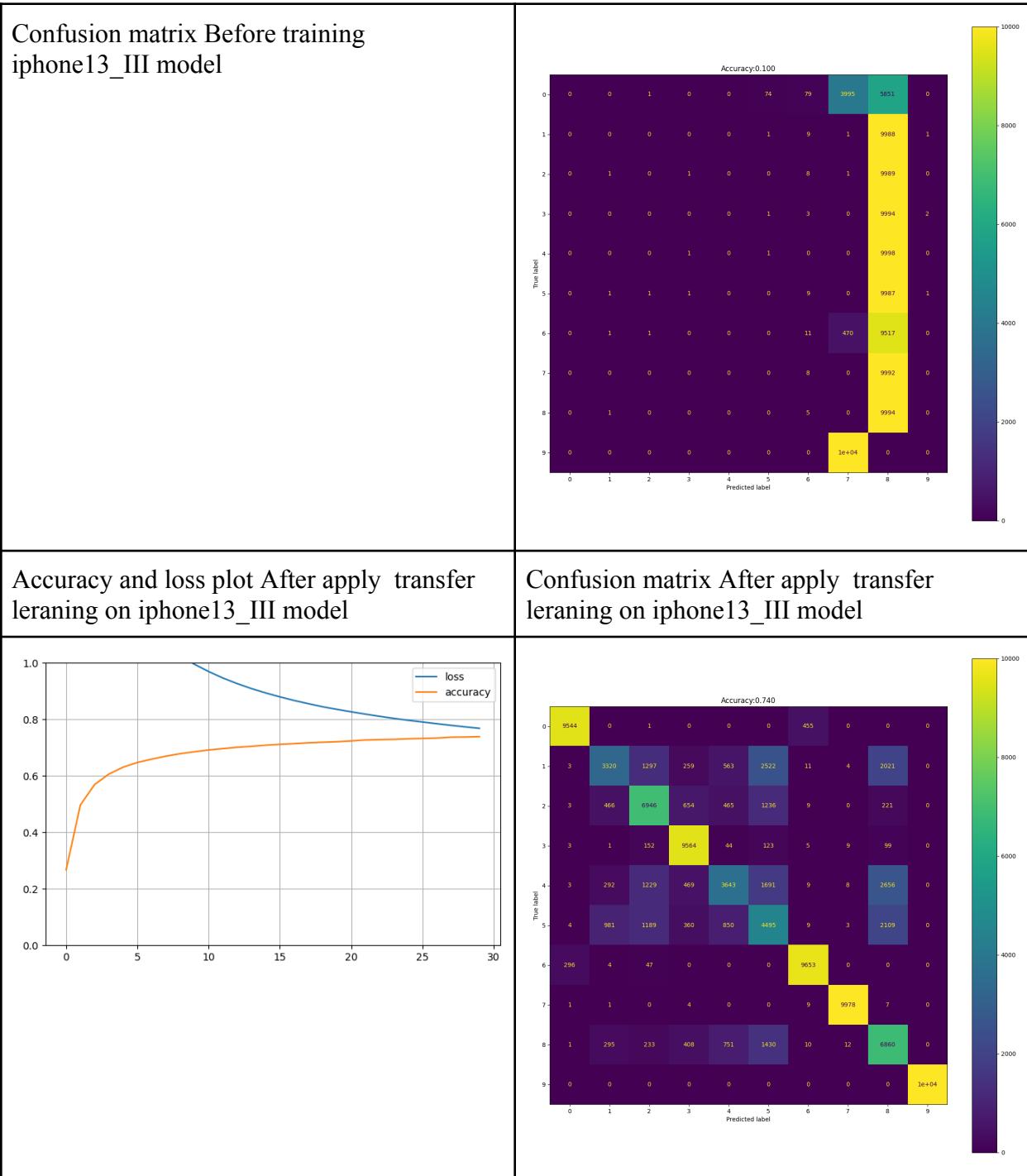
## Accuracy and loss plot After apply transfer learning on iphone13\_II model



## Confusion matrix After apply transfer learning on iphone13\_II model



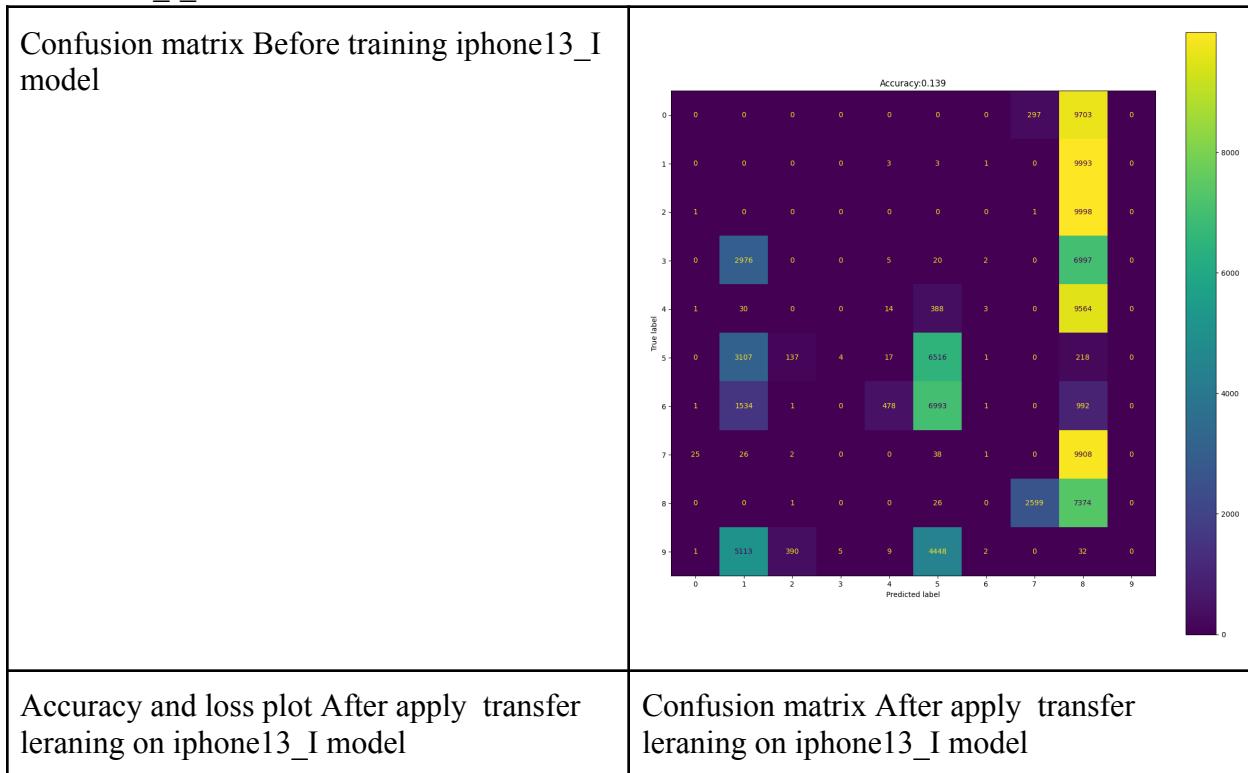
iPHONE13\_III\_model.h5

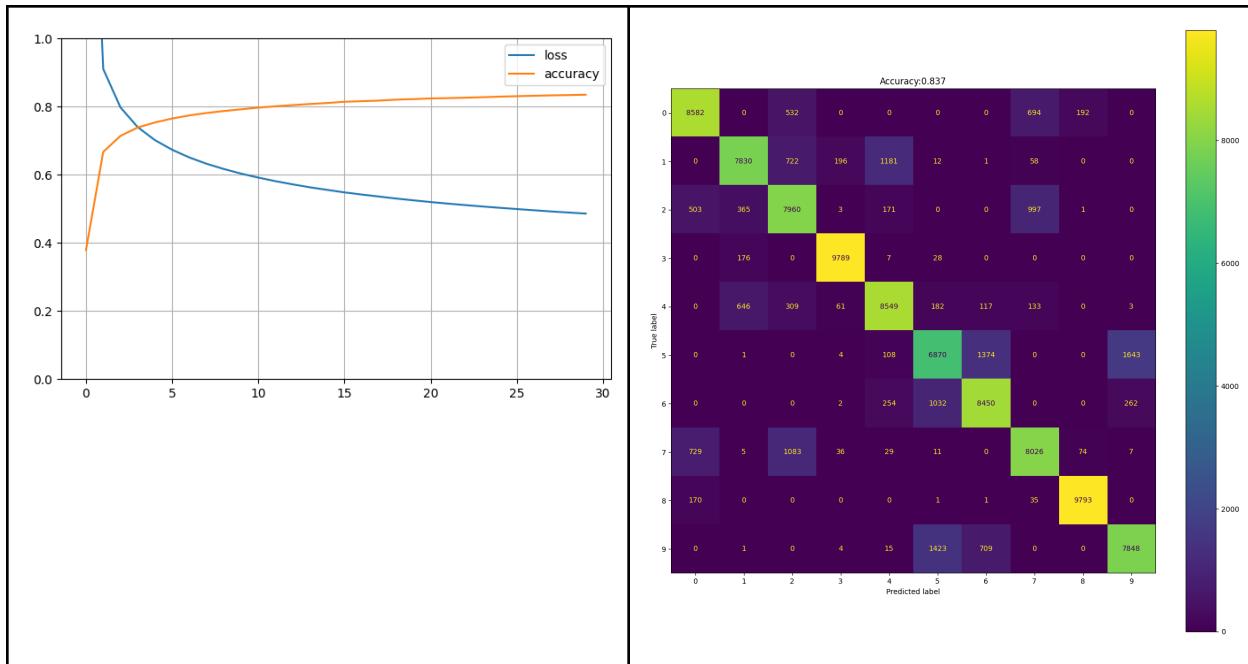


### iPhone13\_I(ii) dataset

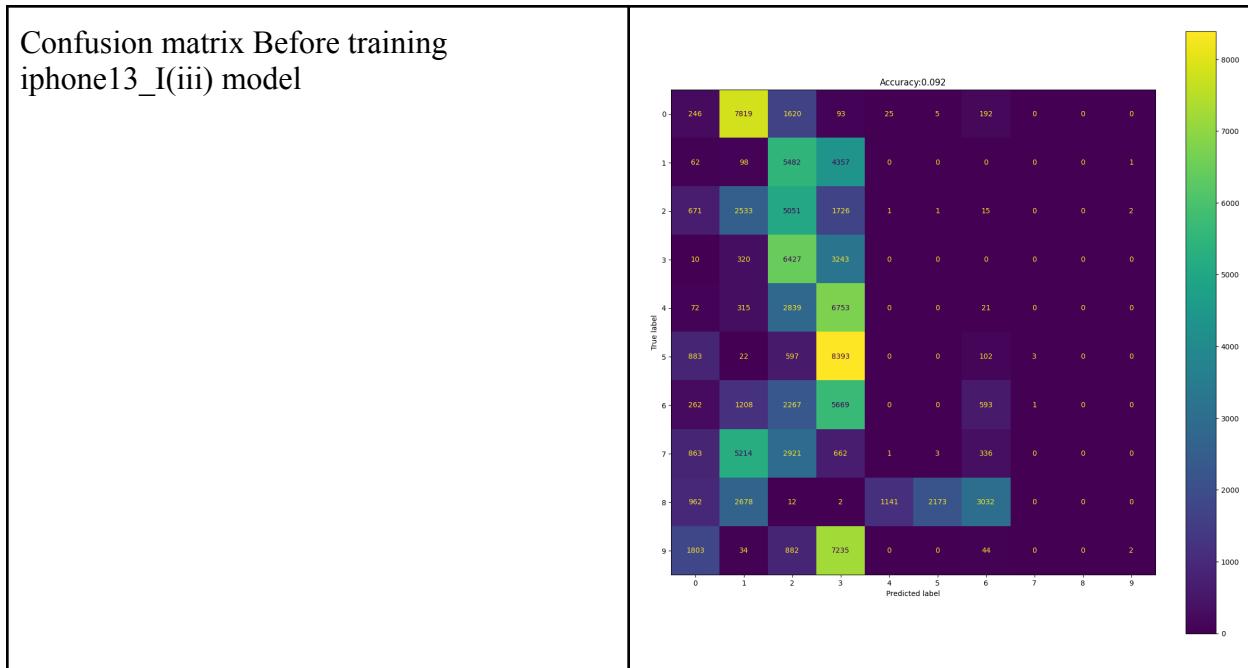
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone13_I_model.h5	0.1391	0.8350	7m 3.1s	0.8370
iPhone13_I(iii)_model.h5	0.0923	0.6891	6m 56.6s	0.6899
iPhone13_I_BeSh	0.1957	0.8134	6m 53.4s	0.8116
iPhone13_I_data1	0.1931	0.8055	6m 39.8s	0.8068
iPhone13_I_data2	0.1491	0.7862	6m 55.6s	0.7863
iPhone13_II	0.2102	0.8503	7m 4.5s	0.8509
iPhone13_III	0.1000	0.6851	7m 41.8s	0.6868

### iPHONE13\_I\_model.h5

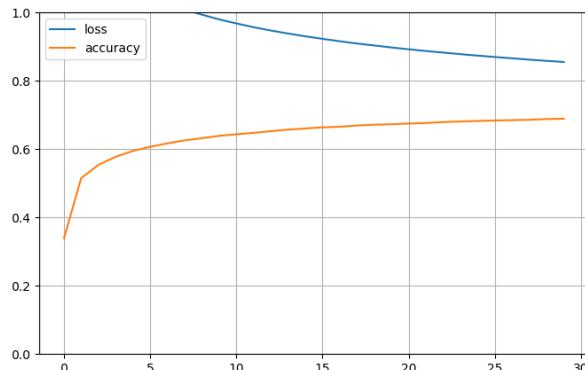




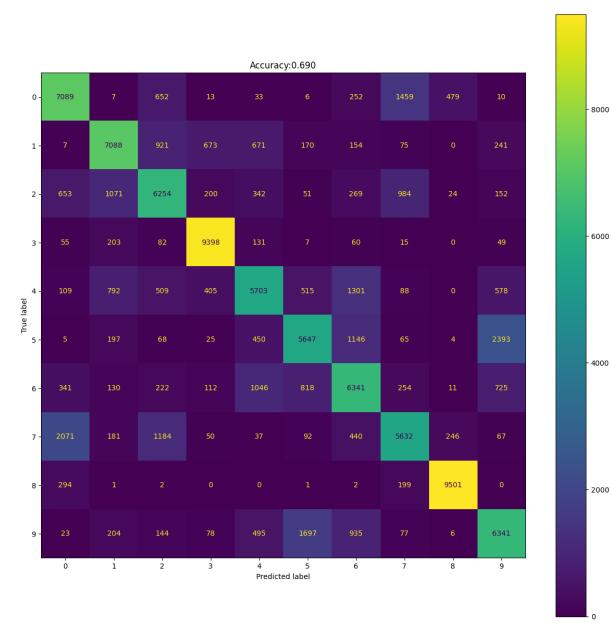
iPHONE13\_I(iii)\_model.h5



Accuracy and loss plot After apply transfer learning on iphone13\_I(iii) model

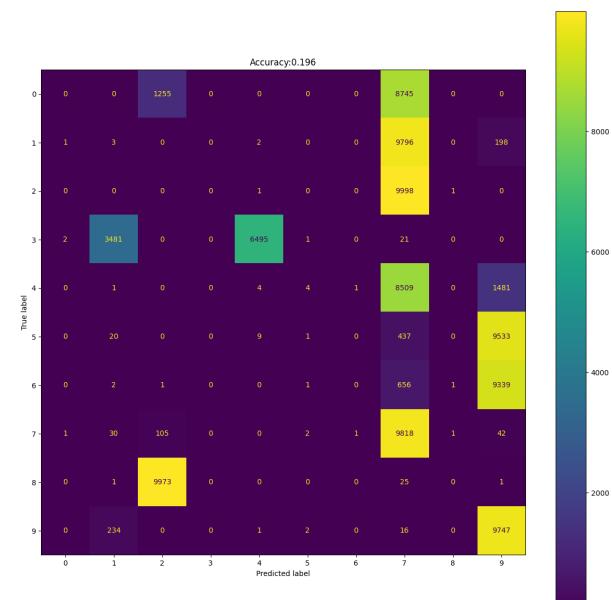


Confusion matrix After apply transfer learning on iphone13\_I(iii) model

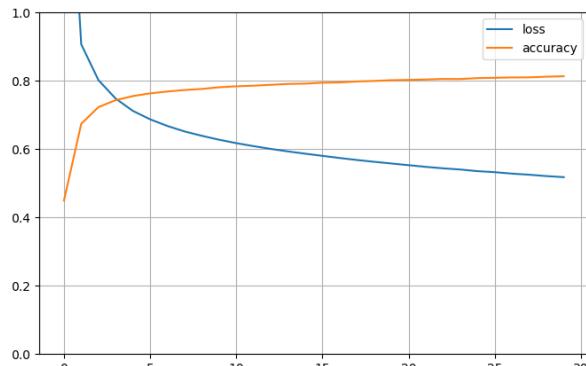


iPhone13\_I\_BeSh\_model.h5

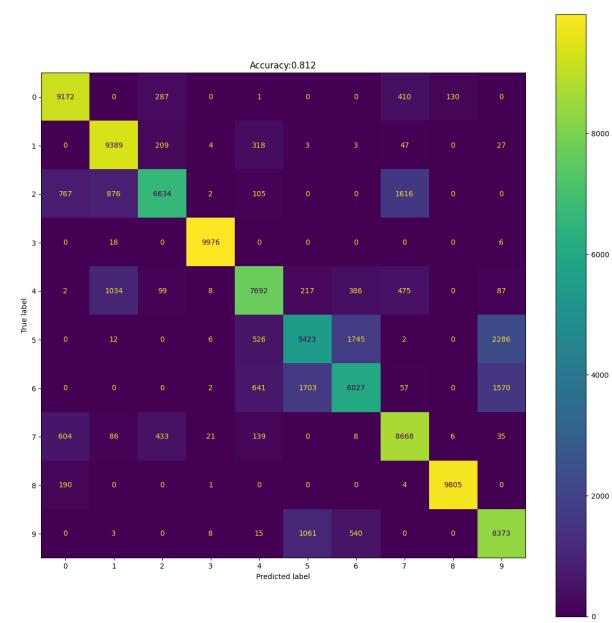
Confusion matrix Before training  
iphone13\_I\_BeSh model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_BeSh model

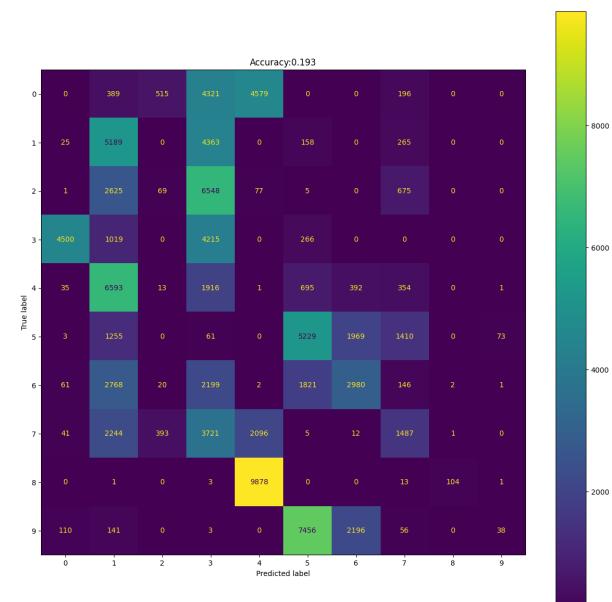


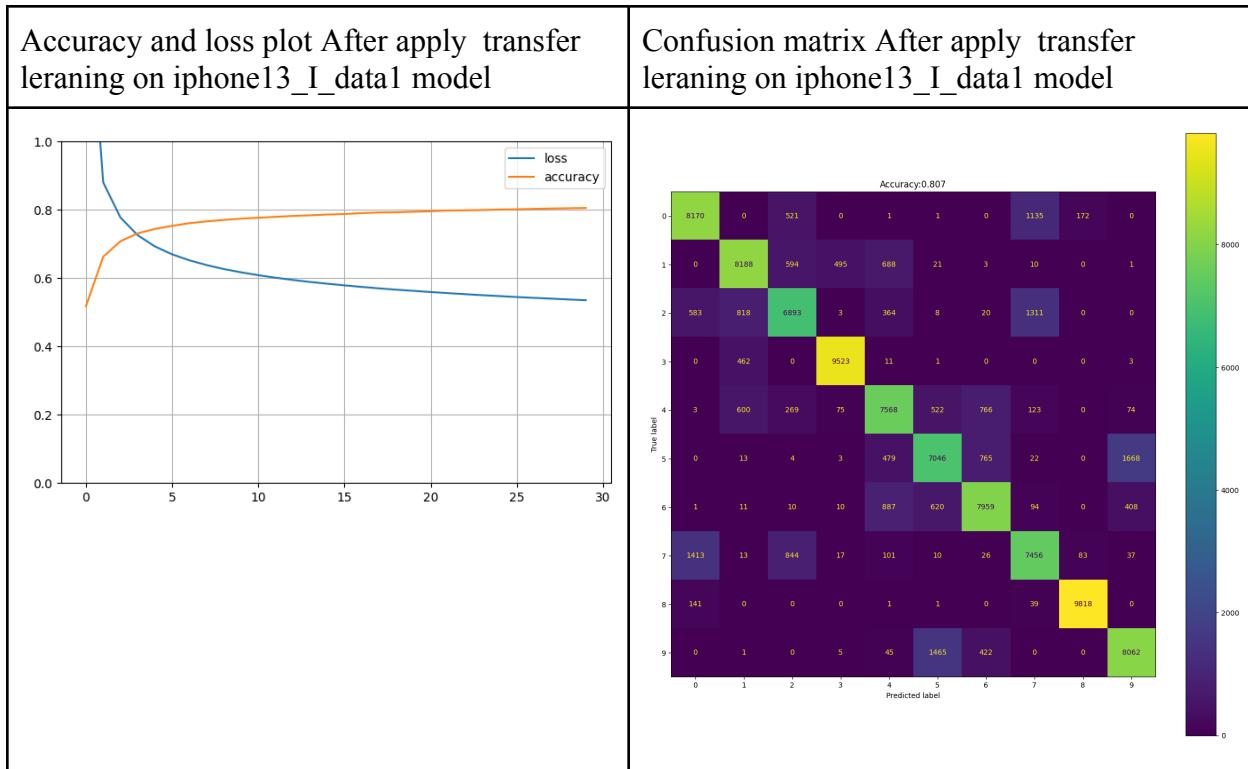
Confusion matrix After apply transfer learning on iphone13\_I\_BeSh model



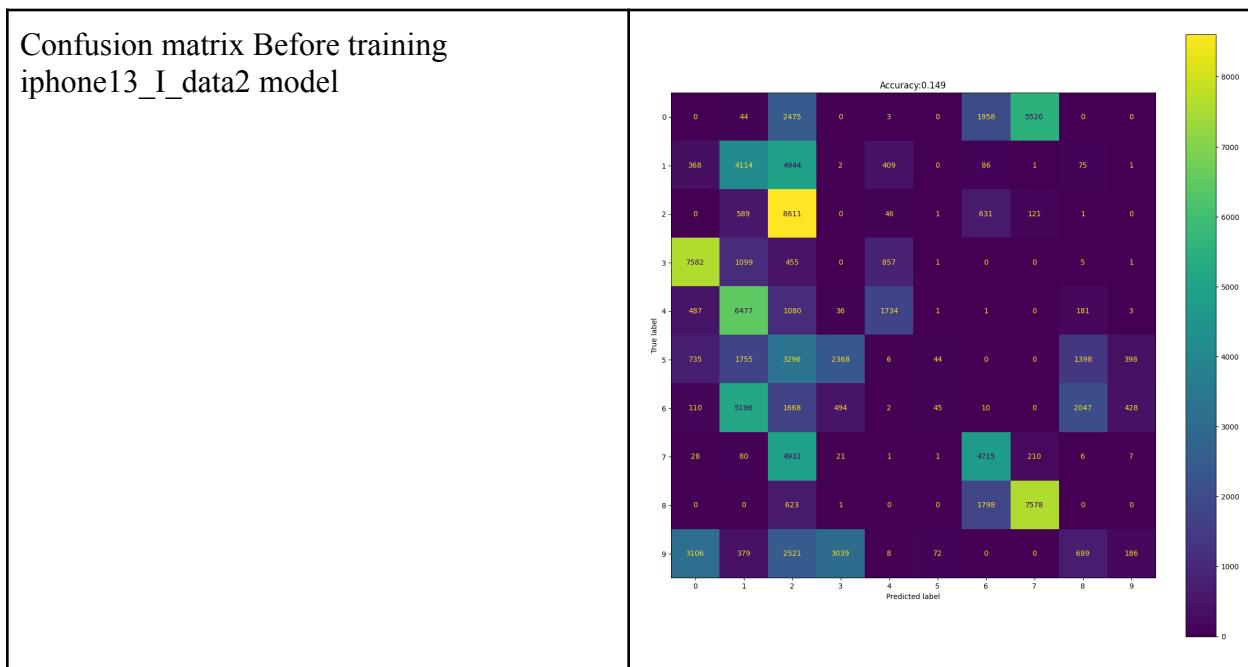
iPHONE13\_I\_data1\_model.h5

Confusion matrix Before training iphone13\_I\_data1 model

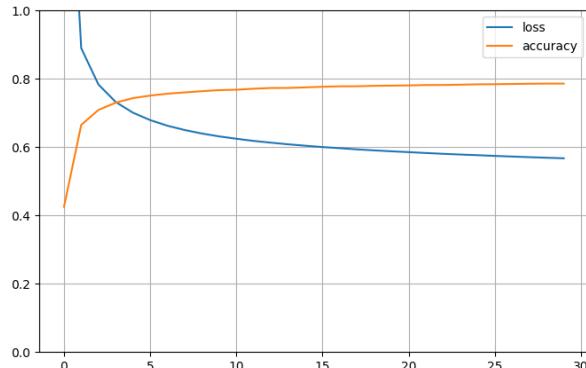




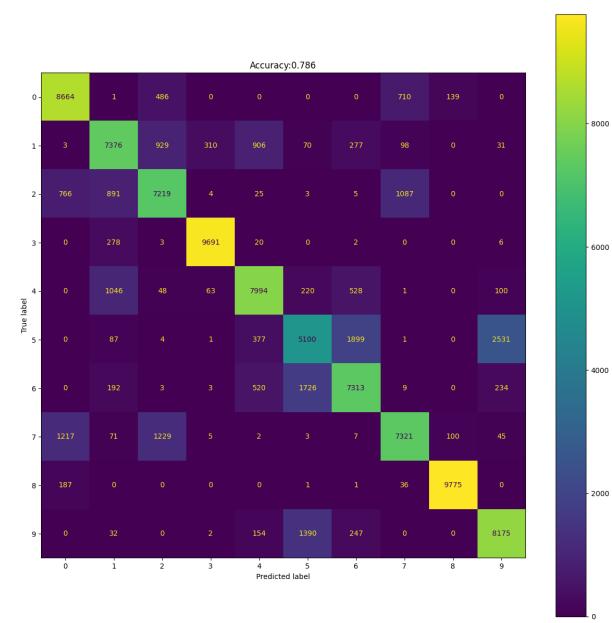
iPHONE13\_I\_data2\_model.h5



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data2 model

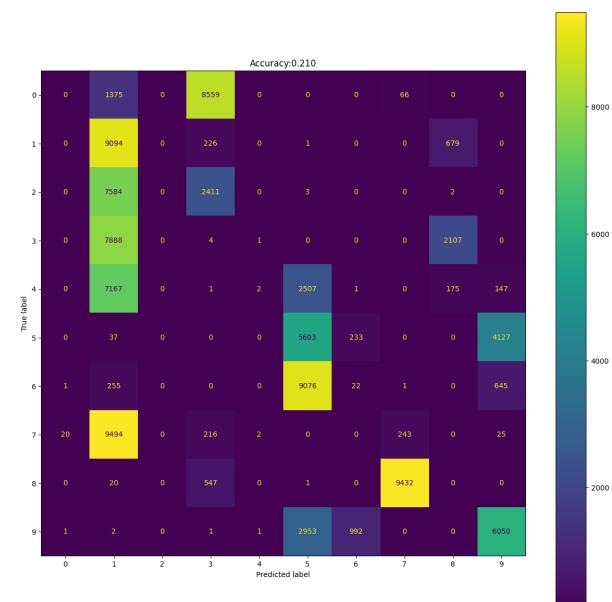


Confusion matrix After apply transfer learning on iphone13\_I\_data2 model

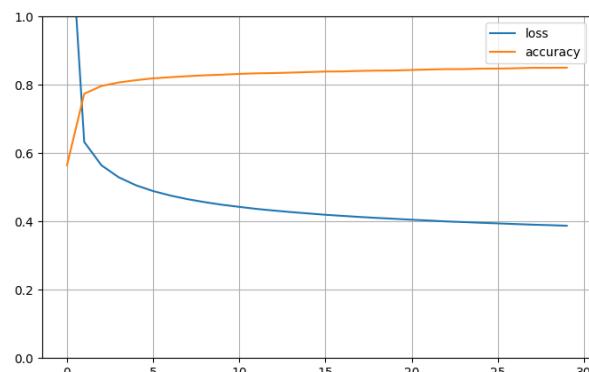


iPHONE13\_II\_model.h5

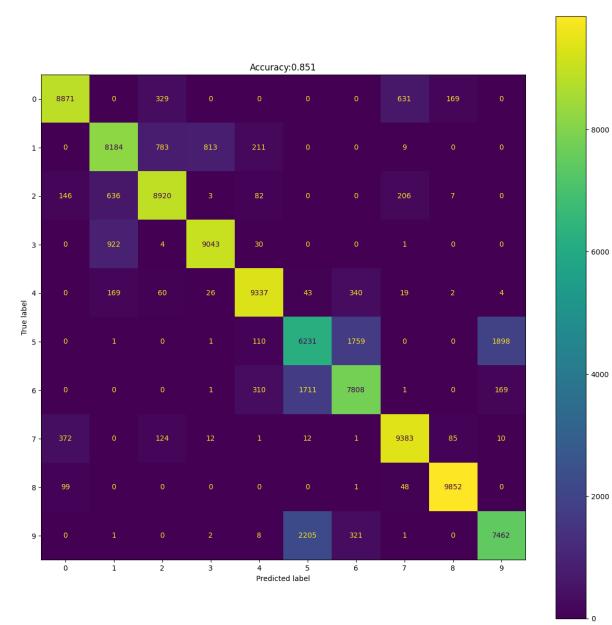
Confusion matrix Before training iphone13\_II model



Accuracy and loss plot After apply transfer learning on iphone13\_II model

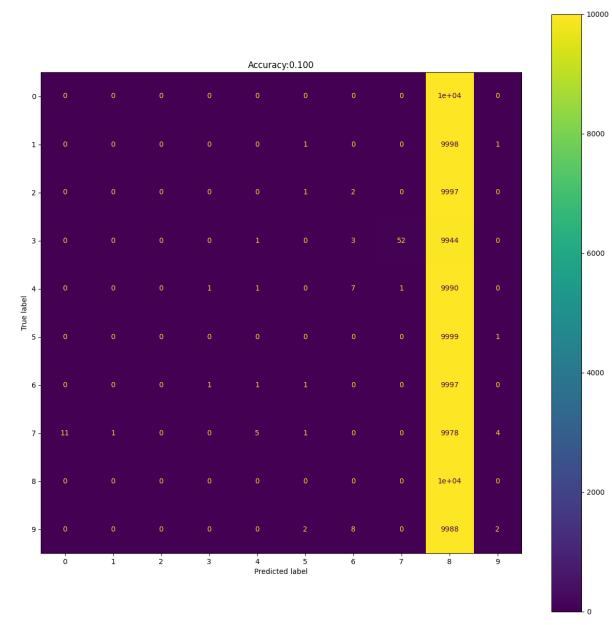


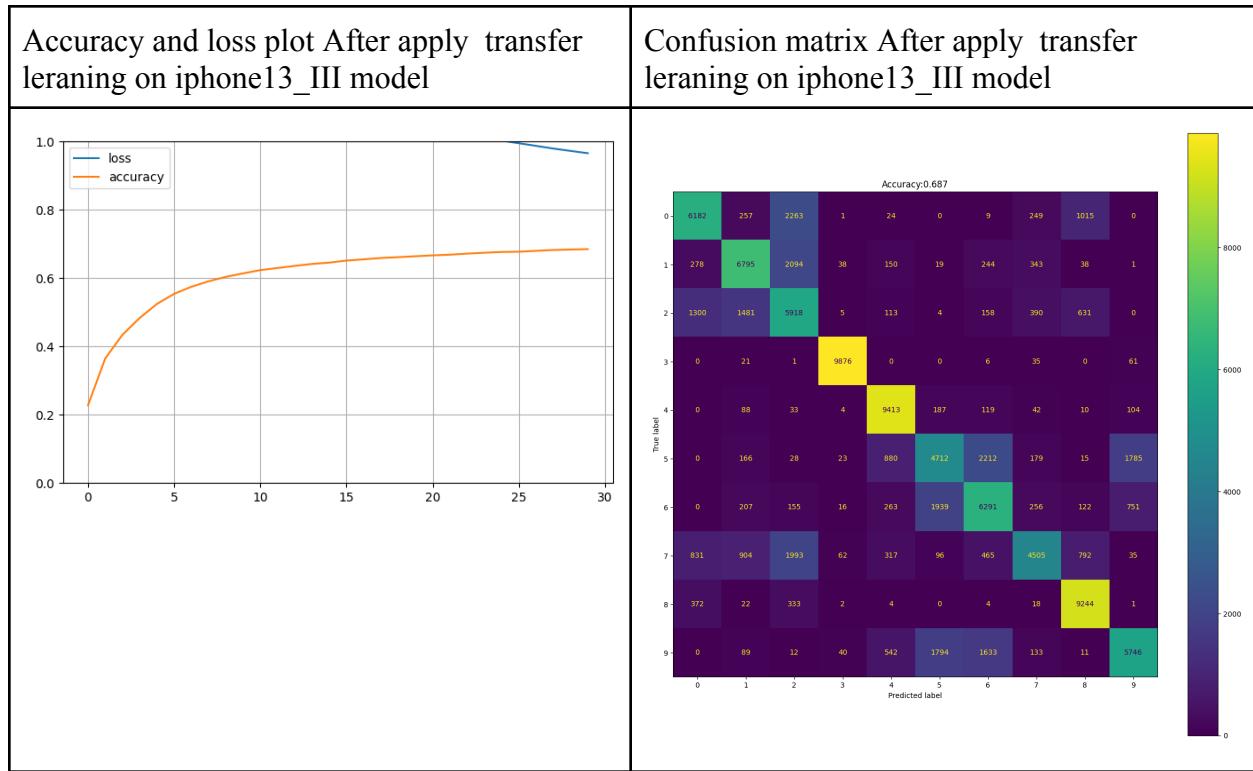
Confusion matrix After apply transfer learning on iphone13\_II model



iPHONE13\_III\_model.h5

Confusion matrix Before training iphone13\_III model



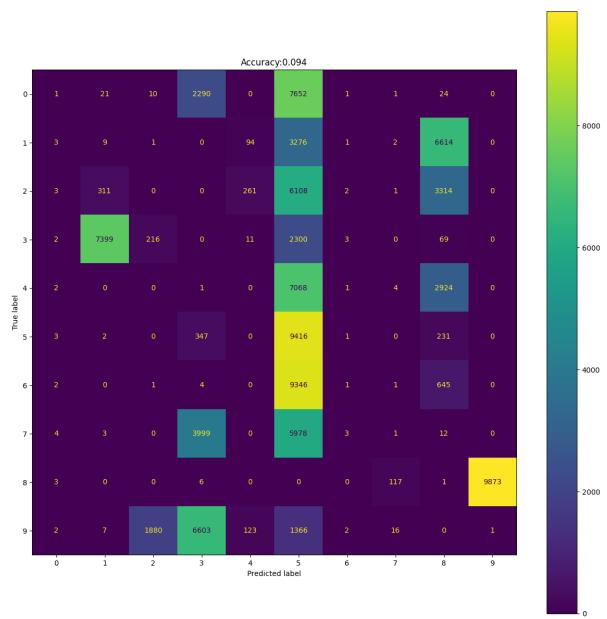


### iPhone13\_I(iii) dataset

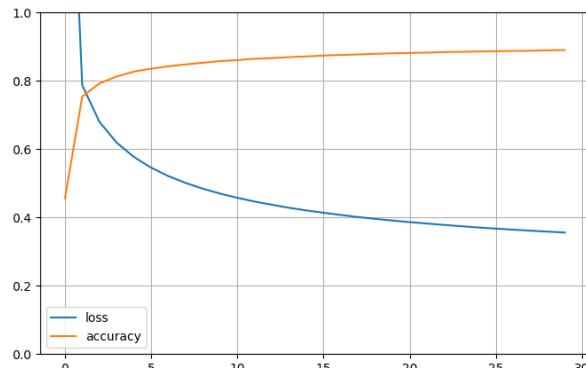
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone13_I_model.h5	0.0943	0.8902	6m 21.8s	0.8909
iPhone13_I(ii)_model.h5	0.2478	0.8514	6m 43.5s	0.8527
iPhone13_I_BeSh	0.0035	0.8798	6m 43.4s	0.8781
iPhone13_I_data1	0.3220	0.9023	6m 53.2s	0.9028
iPhone13_I_data2	0.1212	0.8509	6m 30.2s	0.8517
iPhone13_II	0.0412	0.9004	7m 22.6s	0.9008
iPhone13_III	0.0997	0.7340	6m 35.6s	0.7418

## iPHONE13\_I\_model.h5

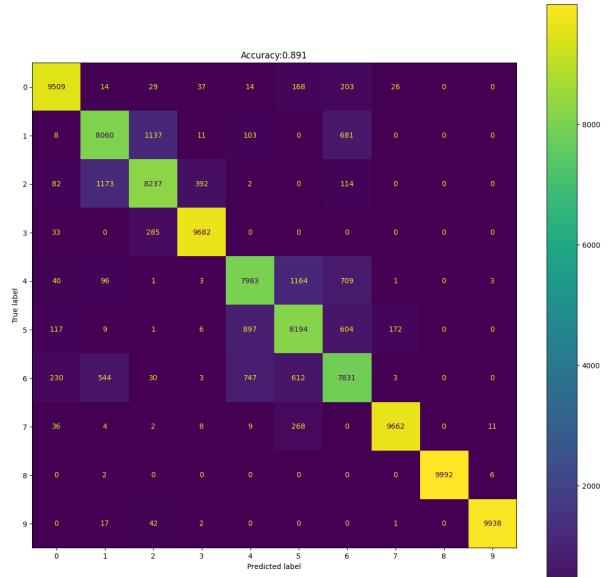
Confusion matrix Before training iphone13\_I model



Accuracy and loss plot After apply transfer learning on iphone13\_I model

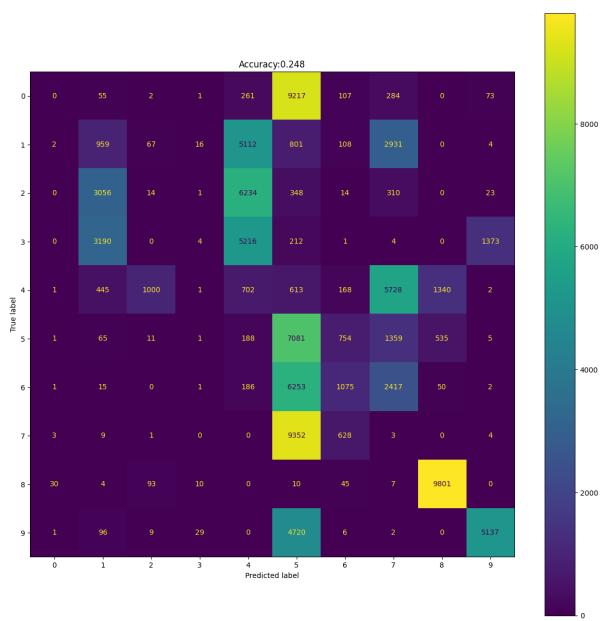


Confusion matrix After apply transfer learning on iphone13\_I model

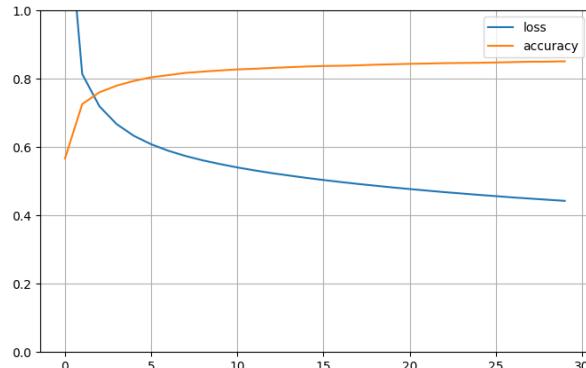


## iPHONE13\_I(ii)\_model.h5

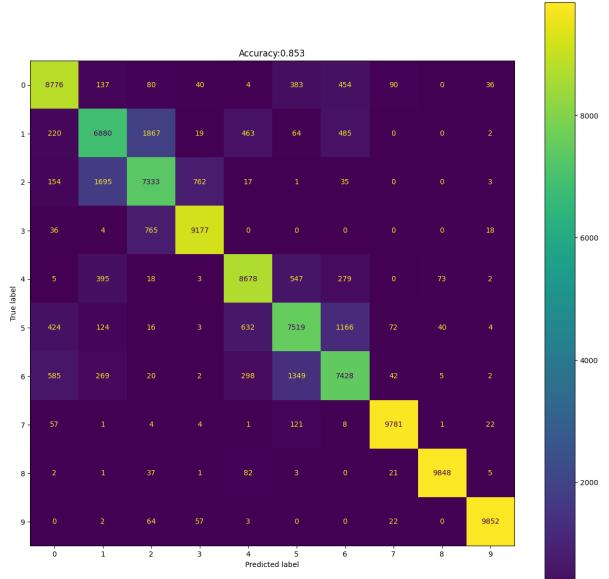
Confusion matrix Before training  
iphone13\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(ii) model

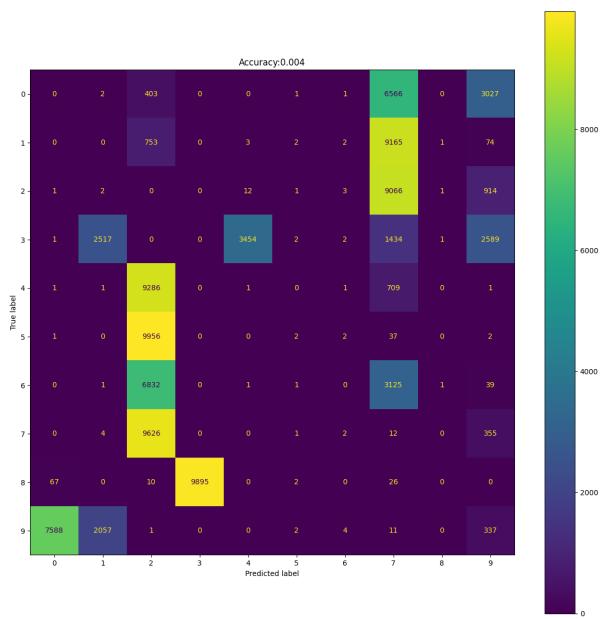


Confusion matrix After apply transfer learning on iphone13\_I(ii) model

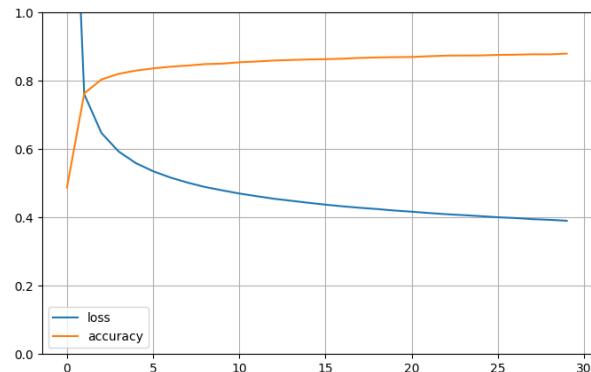


## iPHONE13\_I\_BeSh\_model.h5

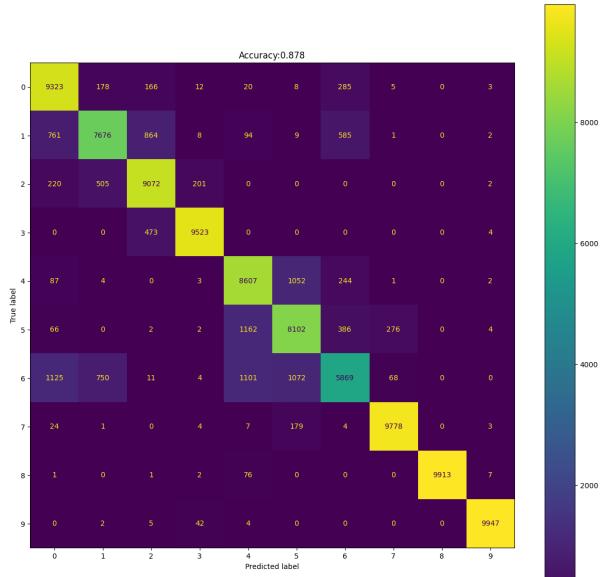
Confusion matrix Before training  
iphone13\_I\_BeSh model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_BeSh model

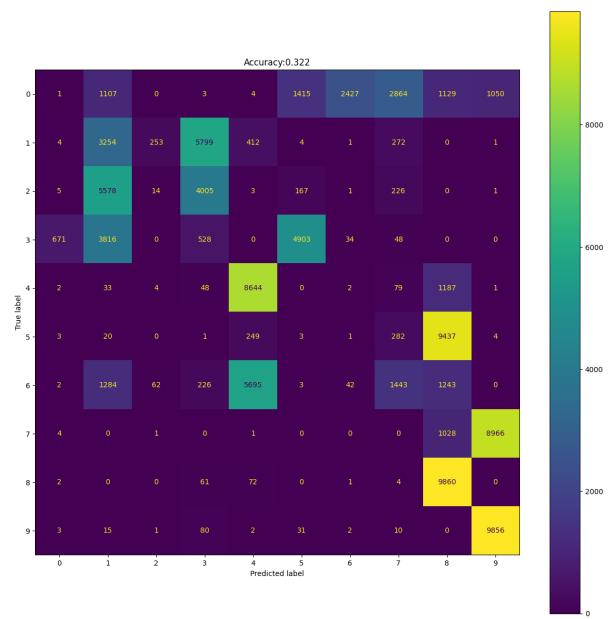


Confusion matrix After apply transfer learning on iphone13\_I\_BeSh model

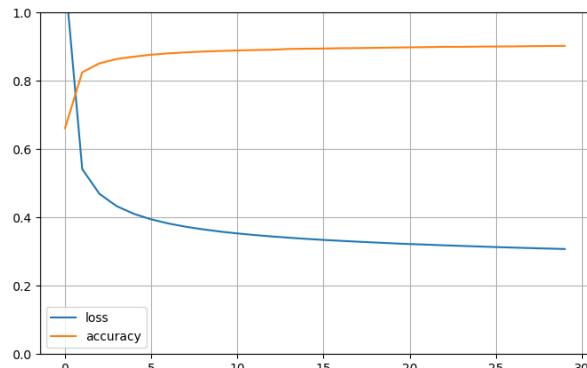


## iPHONE13\_I\_data1\_model.h5

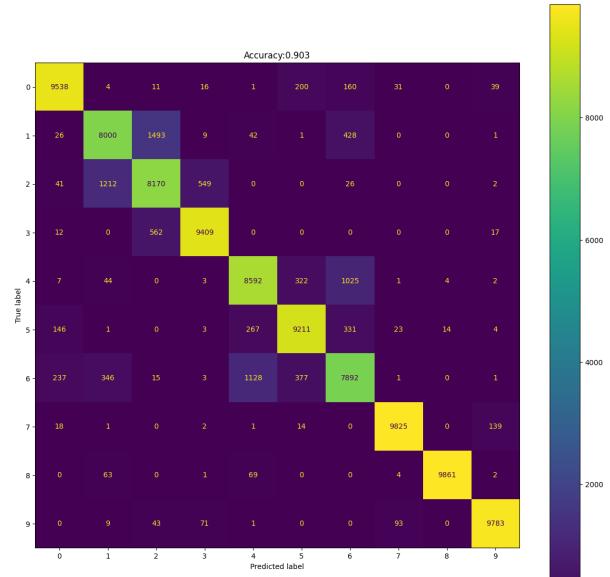
## Confusion matrix Before training iphone13\_I\_data1 model



## Accuracy and loss plot After apply transfer learning on iphone13\_I\_data1 model

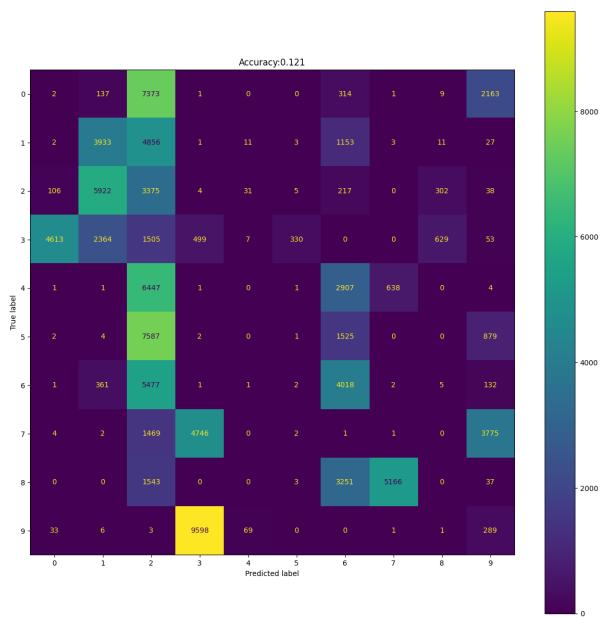


## Confusion matrix After apply transfer learning on iphone13\_I\_data1 model

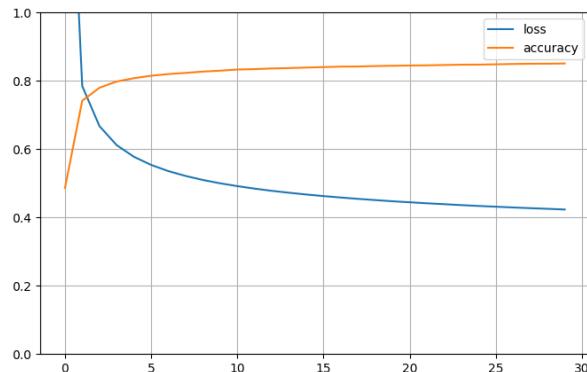


## iPHONE13\_I\_data2\_model.h5

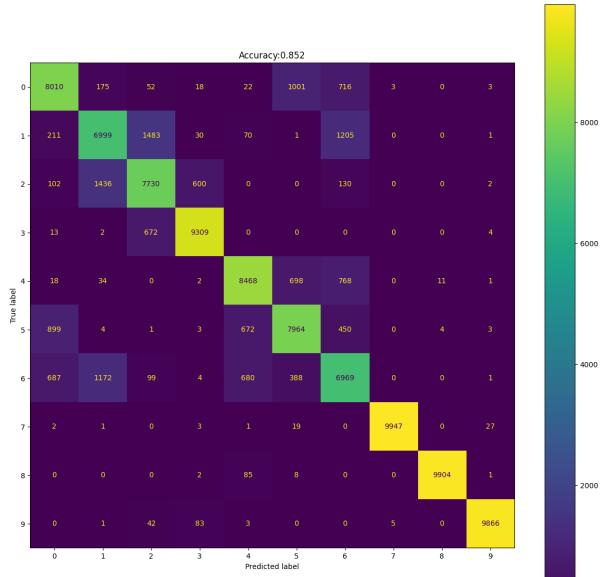
Confusion matrix Before training  
iphone13\_I\_data2 model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data2 model

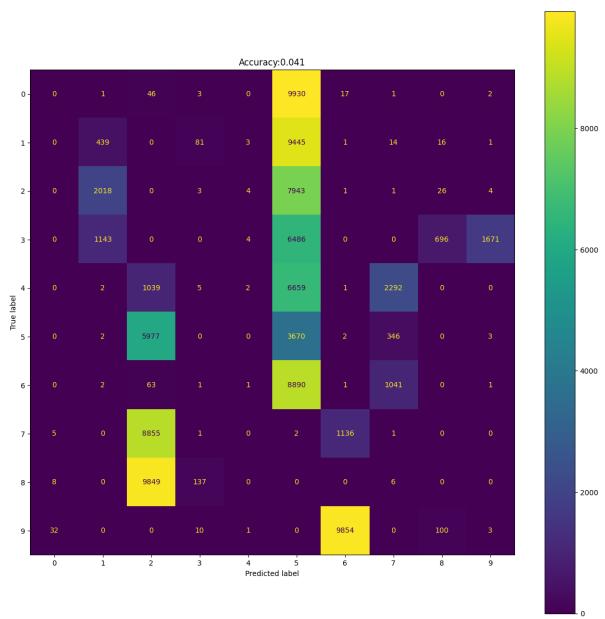


Confusion matrix After apply transfer learning on iphone13\_I\_data2 model

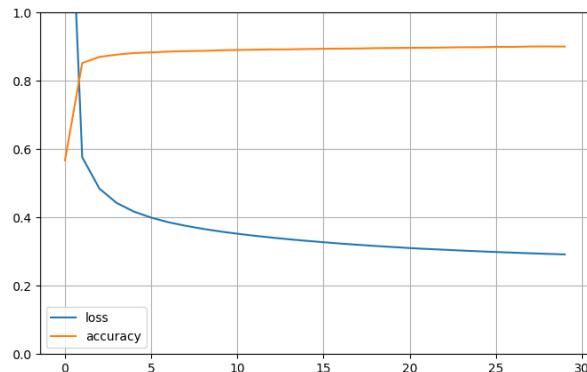


## iPHONE13\_II\_model.h5

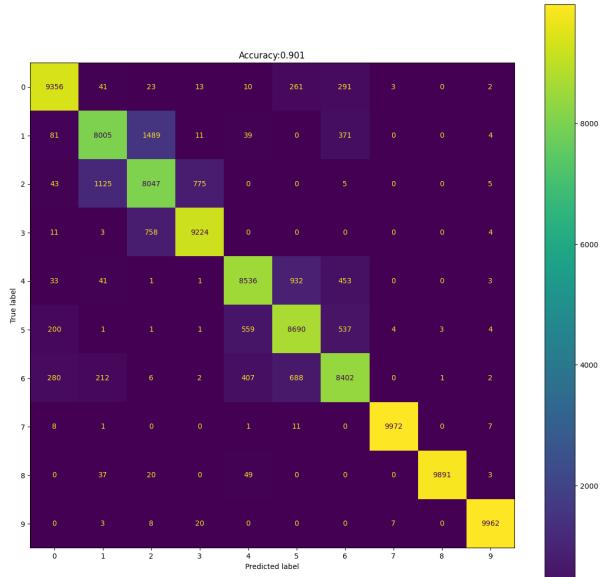
Confusion matrix Before training iphone13\_II model



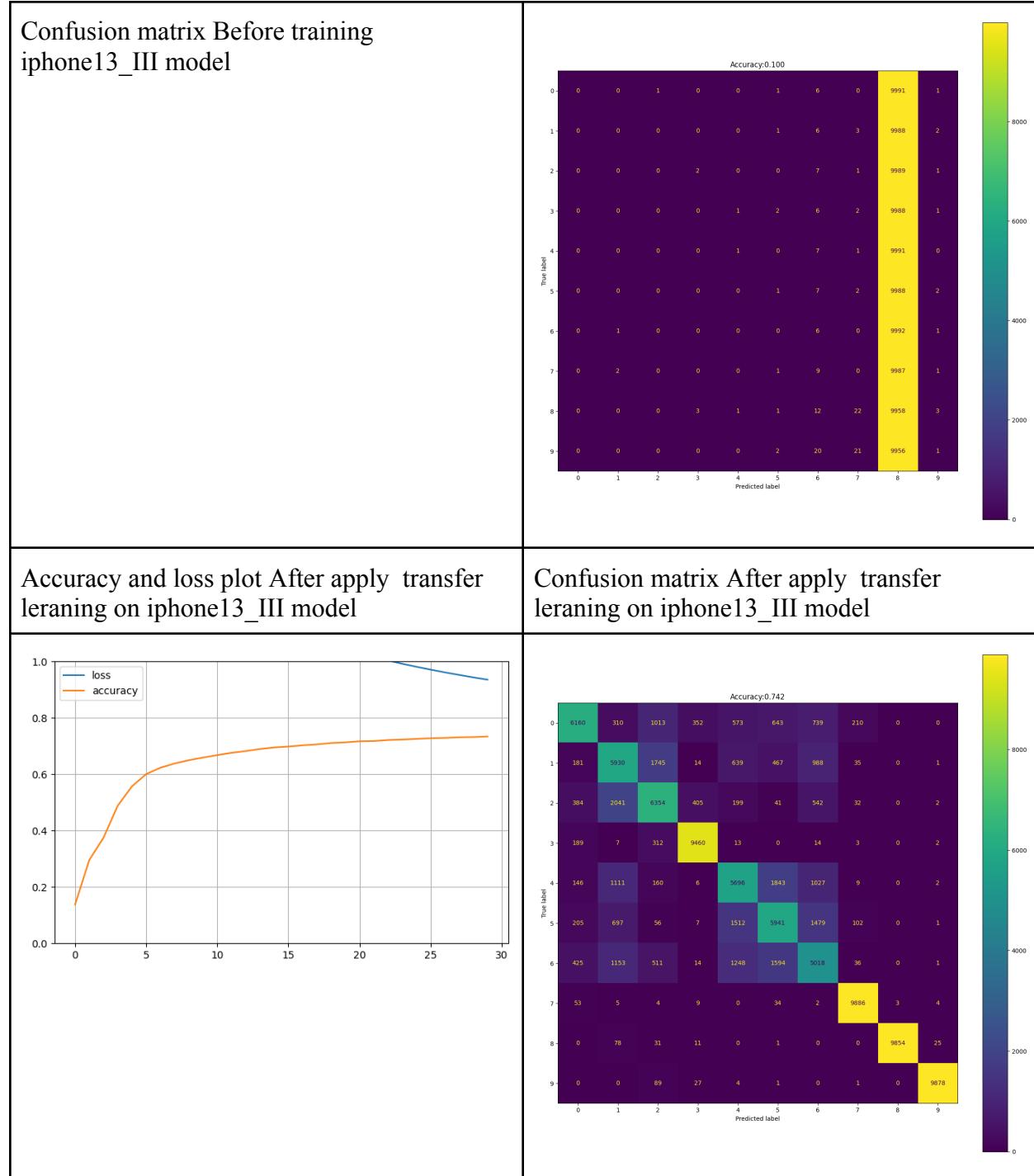
Accuracy and loss plot After apply transfer learning on iphone13\_II model



Confusion matrix After apply transfer learning on iphone13\_II model



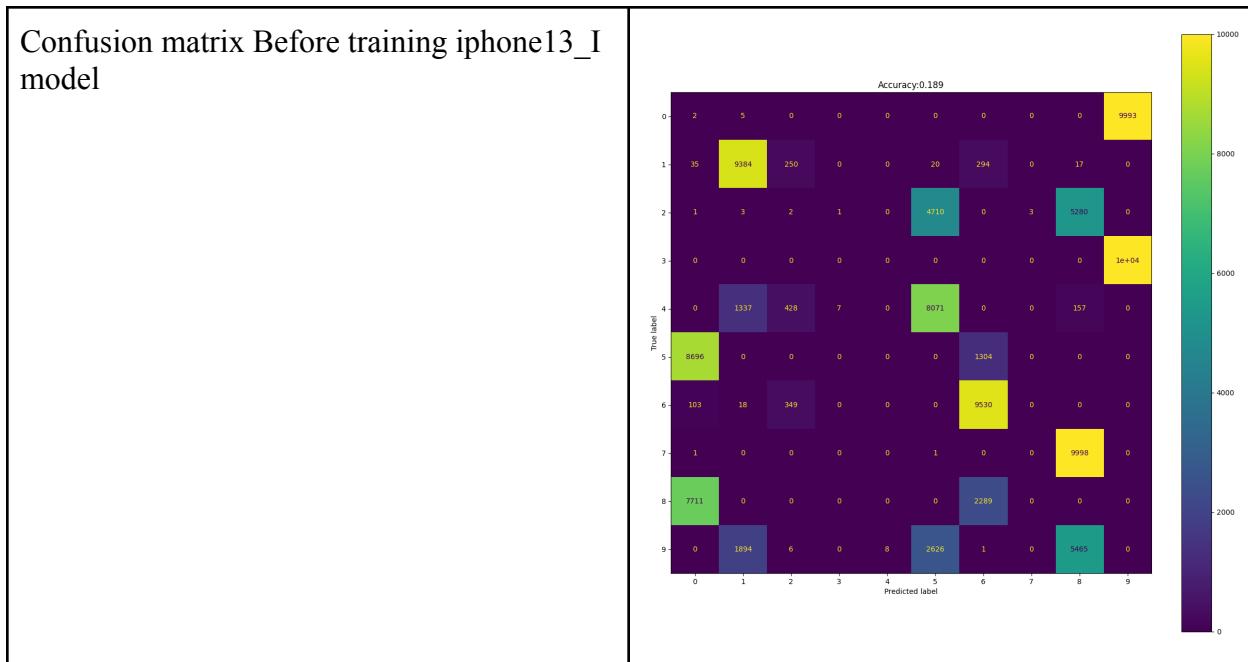
iPHONE13\_III\_model.h5



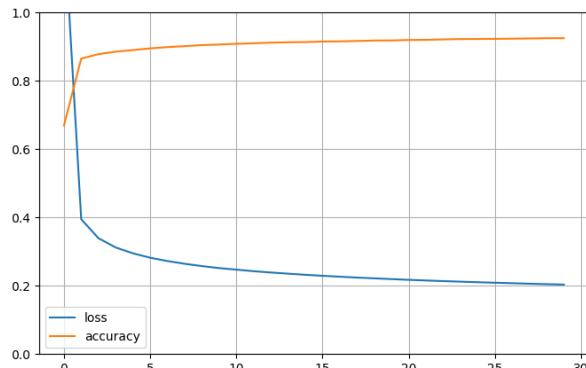
### iPhone13\_I\_BeSh dataset

Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone13_I_model.h5	0.1892	0.9250	6m 50.1s	0.9262
iPhone13_I(ii)_model.h5	0.0968	0.9184	9m 2.7s	0.9177
iPhone13_I(iii)_model.h5	0.0000	0.8185	7m 22.6s	0.8158
iPhone13_I_data1	0.0042	0.8794	7m 36.4s	0.8771
iPhone13_I_data2	0.0597	0.8839	6m 41.6s	0.8792
iPhone13_II	0.1796	0.9345	6m 28.8s	0.9334
iPhone13_III	0.0308	0.9183	6m 52.8s	0.9194

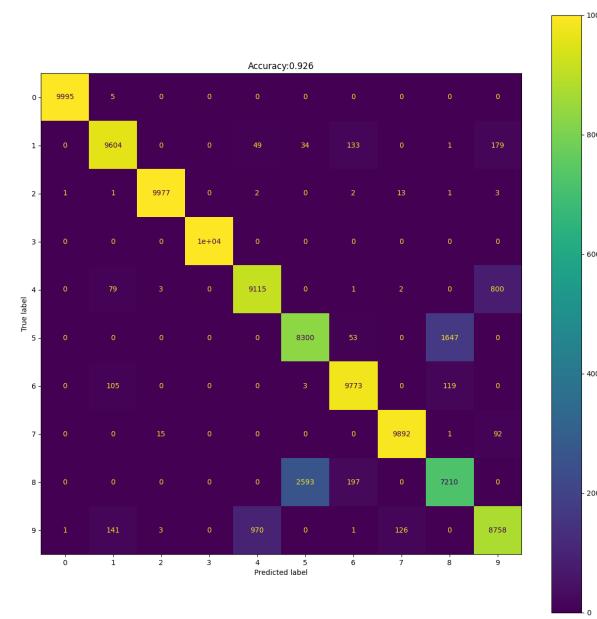
### iPhone13\_I\_model.h5



Accuracy and loss plot After apply transfer learning on iphone13\_I model

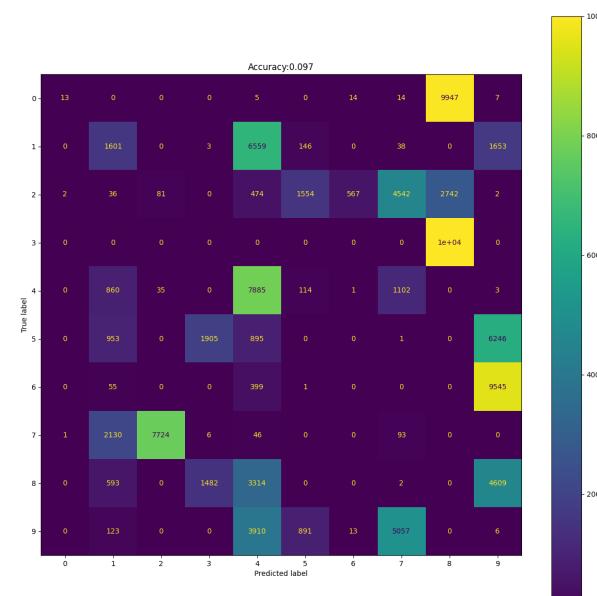


Confusion matrix After apply transfer learning on iphone13\_I model

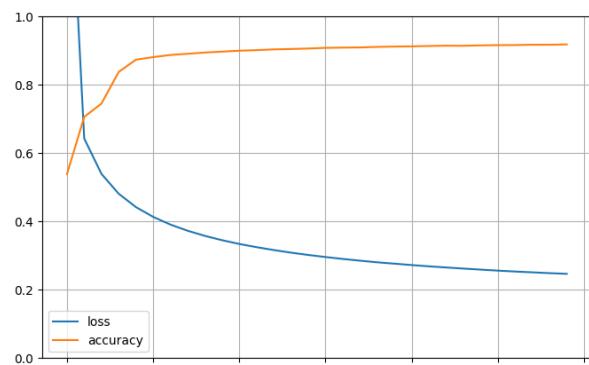


iPHONE13\_I(ii)\_model.h5

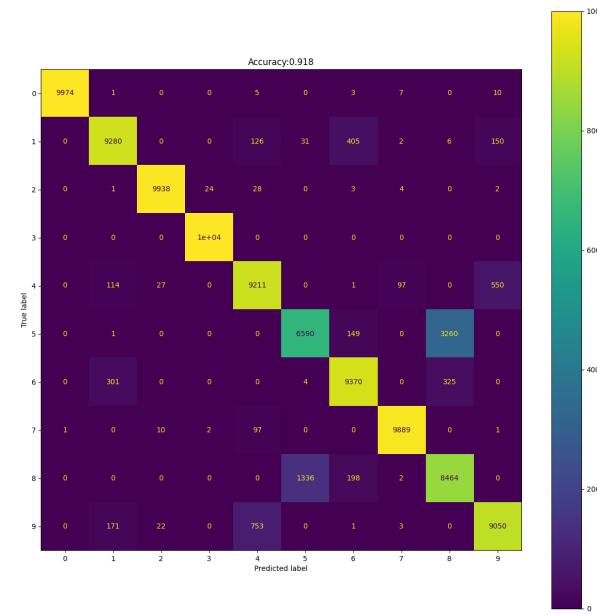
Confusion matrix Before training iphone13\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(ii) model

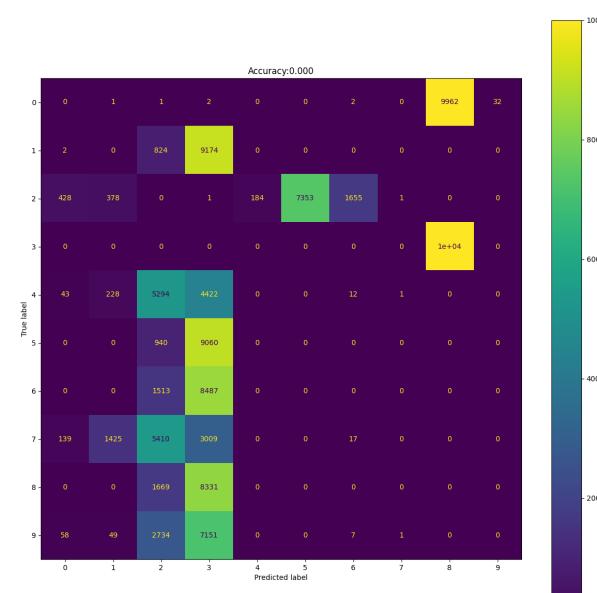


Confusion matrix After apply transfer learning on iphone13\_I(ii) model

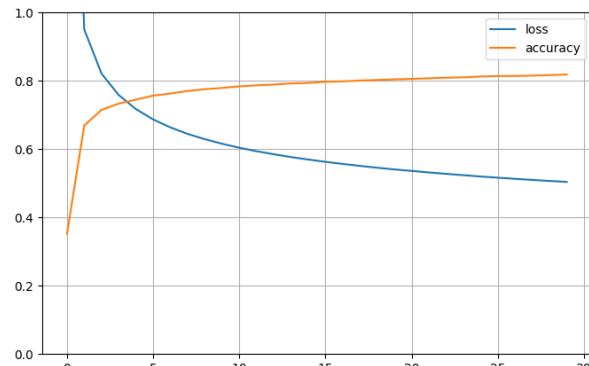


iPHONE13\_I(iii)\_model.h5

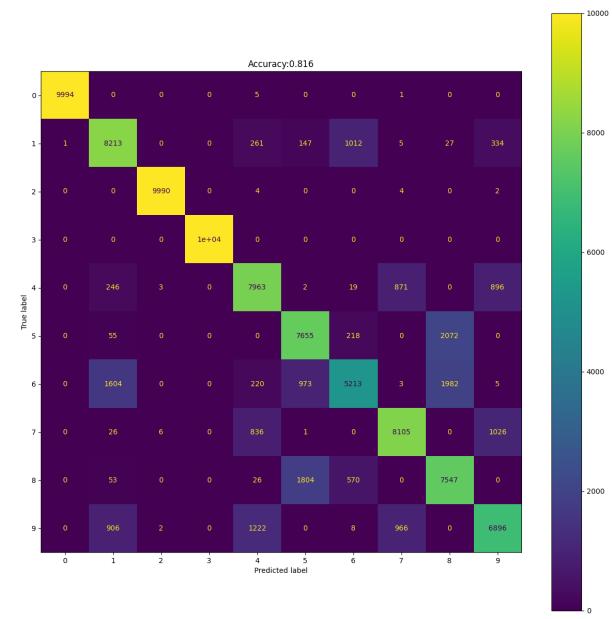
Confusion matrix Before training iphone13\_I(iii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(iii) model

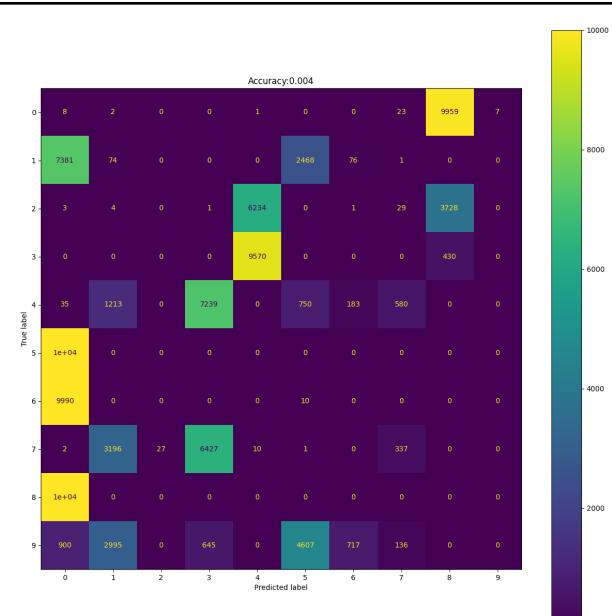


Confusion matrix After apply transfer learning on iphone13\_I(iii) model

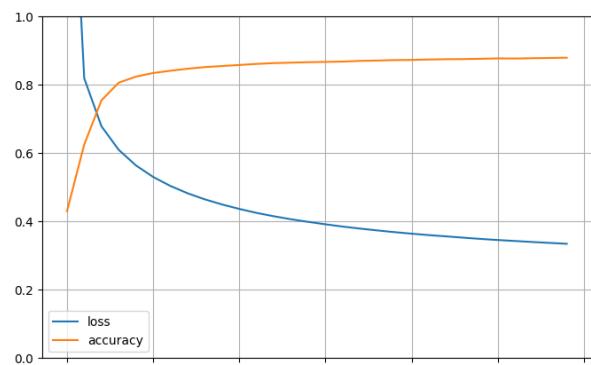


iPHONE13\_I\_data1\_model.h5

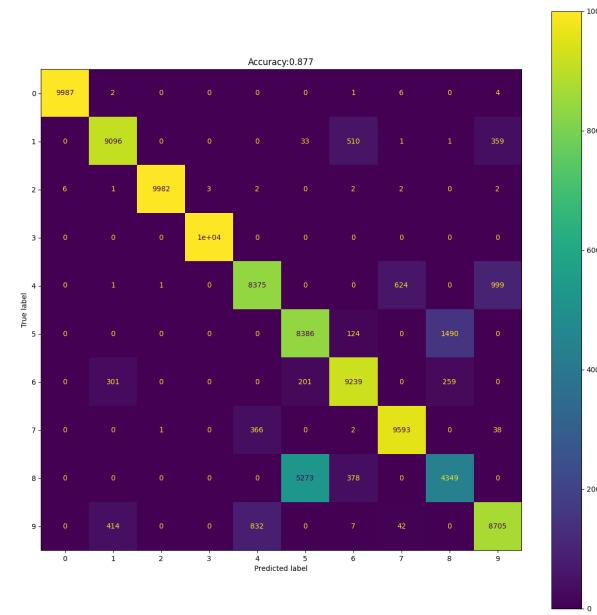
Confusion matrix Before training iphone13\_I\_data1 model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data1 model

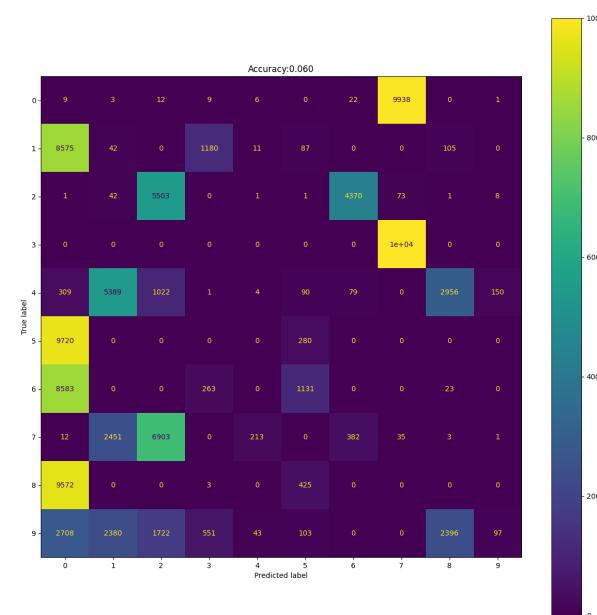


Confusion matrix After apply transfer learning on iphone13\_I\_data1 model

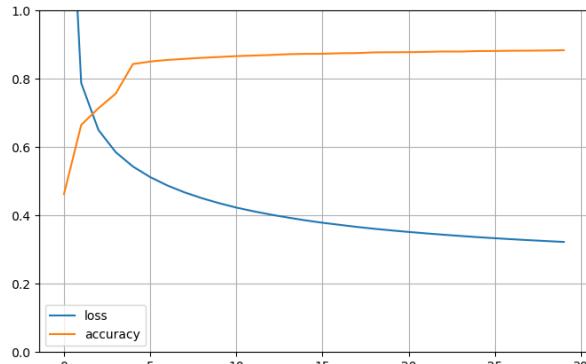


iPHONE13\_I\_data2\_model.h5

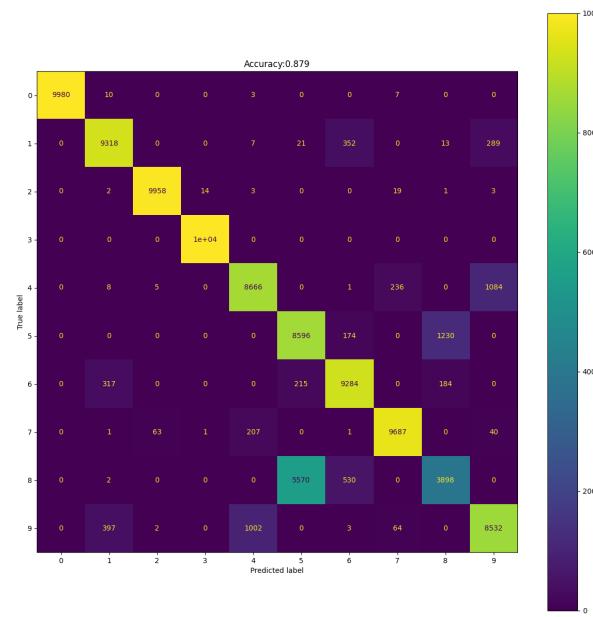
Confusion matrix Before training iphone13\_I\_data2 model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data2 model

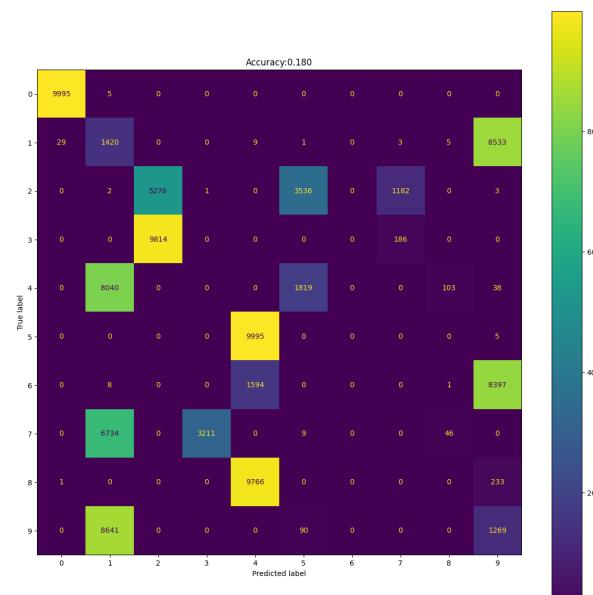


Confusion matrix After apply transfer learning on iphone13\_I\_data2 model

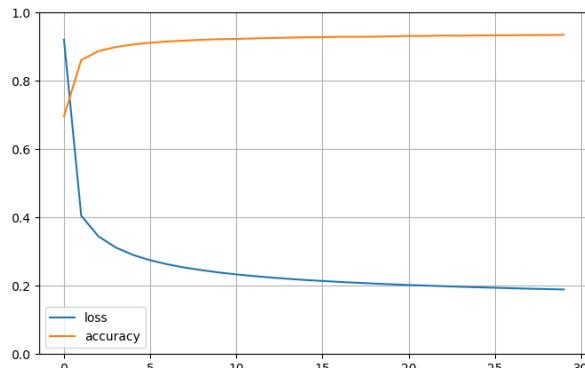


iPHONE13\_II\_model.h5

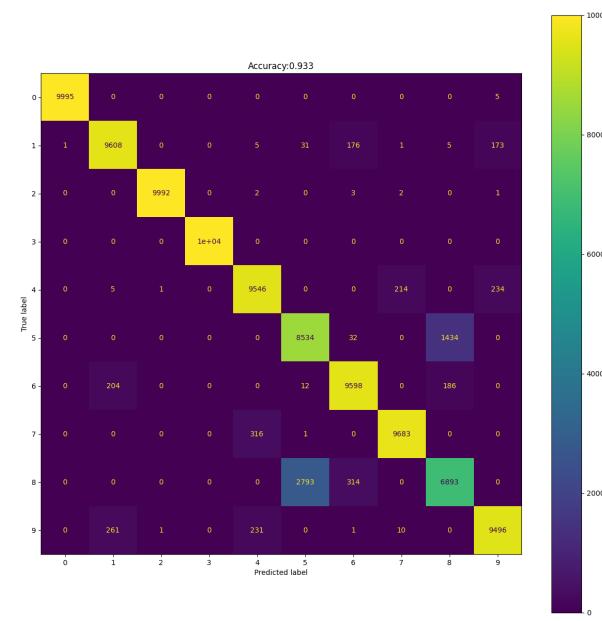
Confusion matrix Before training iphone13\_II model



Accuracy and loss plot After apply transfer learning on iphone13\_II model

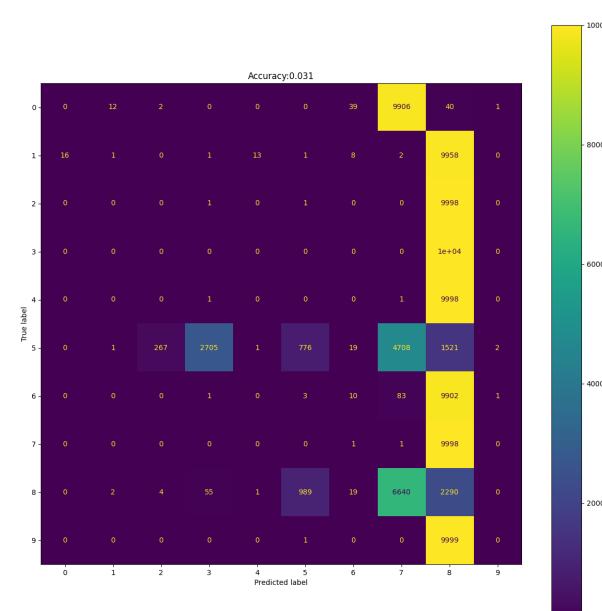


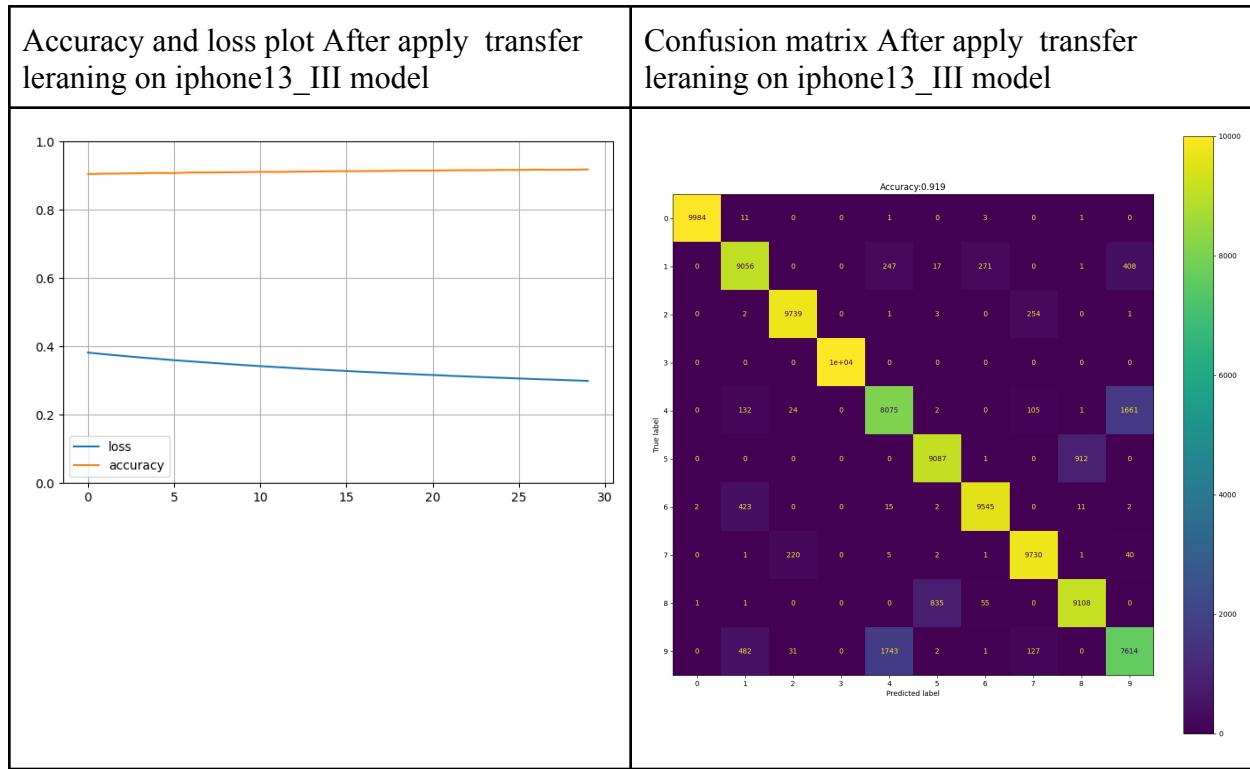
Confusion matrix After apply transfer learning on iphone13\_II model



iPHONE13\_III\_model.h5

Confusion matrix Before training iphone13\_III model



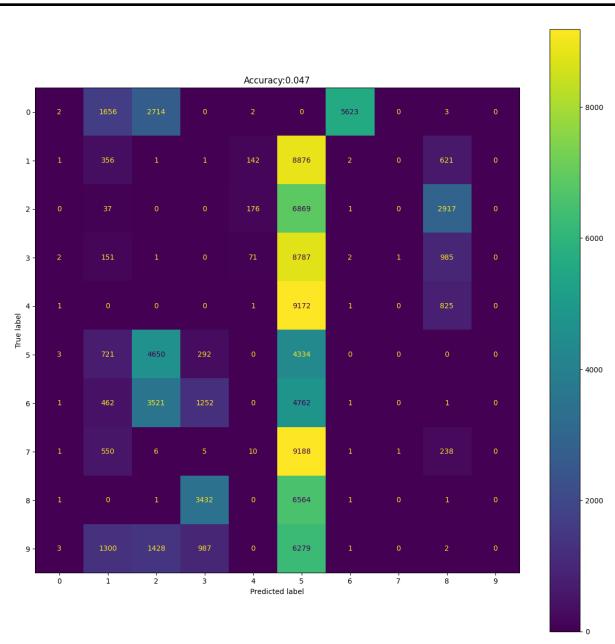


### iPhone13\_I\_data1 dataset

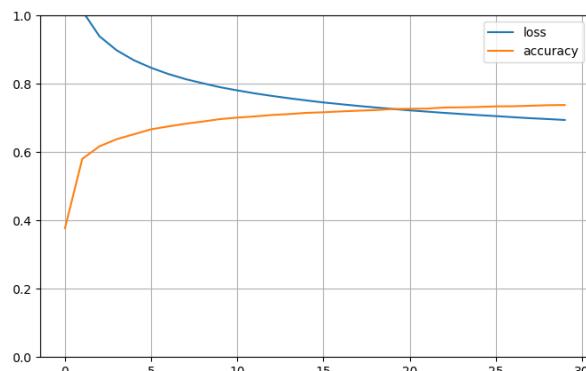
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone13_I_model.h5	0.0470	0.7381	7m 5.3s	0.7359
iPhone13_I(ii)_model.h5	0.1325	0.8023	6m 52.1s	0.8023
iPhone13_I(iii)_model.h5	0.0579	0.7182	7m 42.4s	0.7189
iPhone13_I_Besh_model.h5	0.1644	0.6759	8m 7.5s	0.6657
iPhone13_I_data2	0.1312	0.8653	8m 40.5s	0.8655
iPhone13_II	0.1119	0.7845	7m 43.1s	0.7844
iPhone13_III	0.1000	0.5890	7m 0.5s	0.5884

## iPHONE13\_I\_model.h5

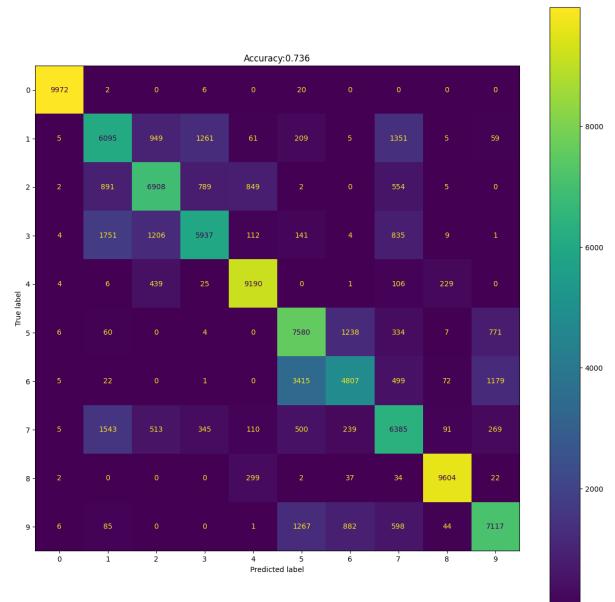
Confusion matrix Before training iphone13\_I model



Accuracy and loss plot After apply transfer learning on iphone13\_I model

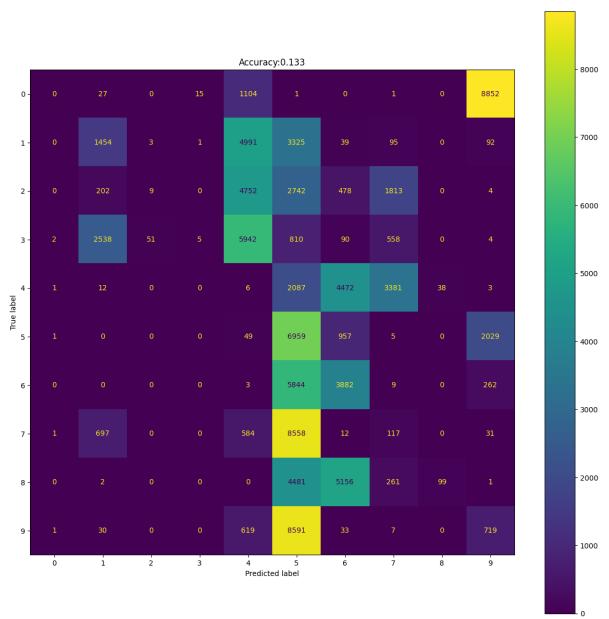


Confusion matrix After apply transfer learning on iphone13\_I model

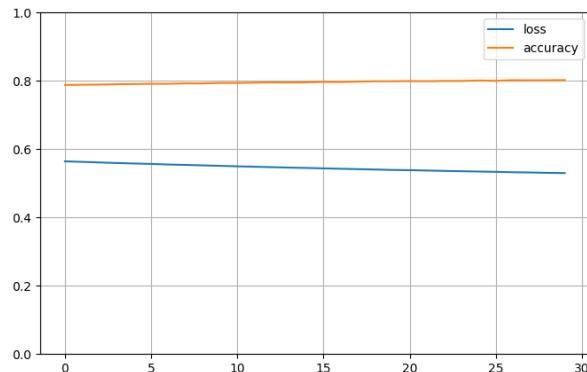


iPHONE13\_I(ii)\_model.h5

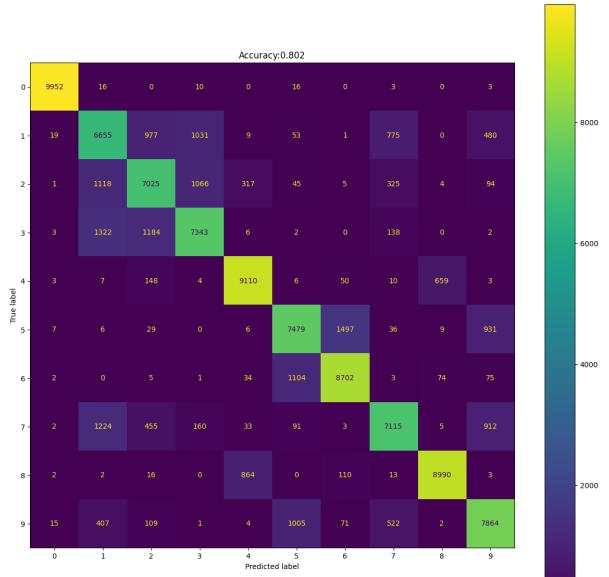
Confusion matrix Before training  
iphone13\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(ii) model

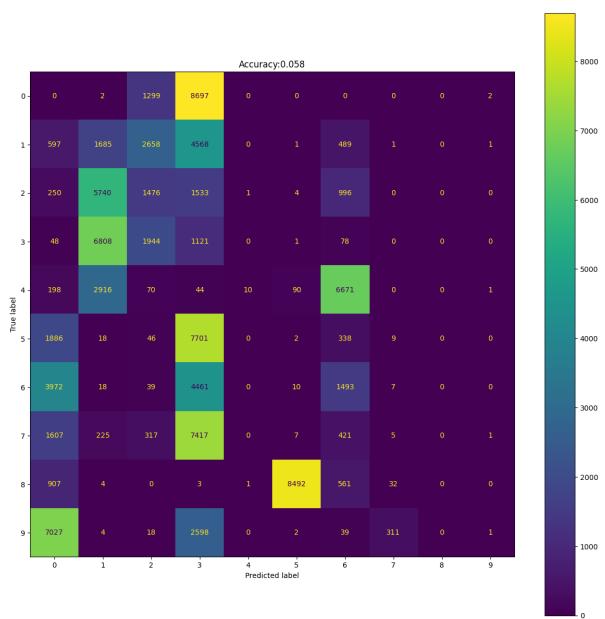


Confusion matrix After apply transfer learning on iphone13\_I(ii) model

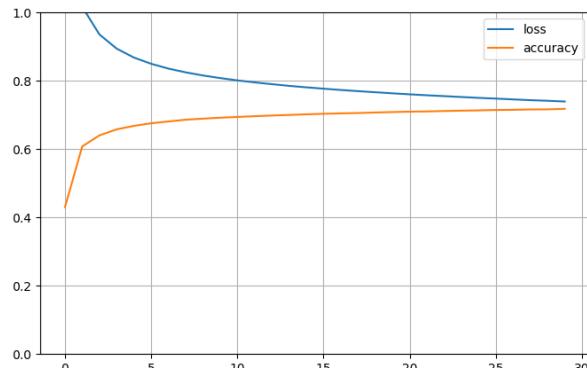


### iPHONE13\_I(iii)\_model.h5

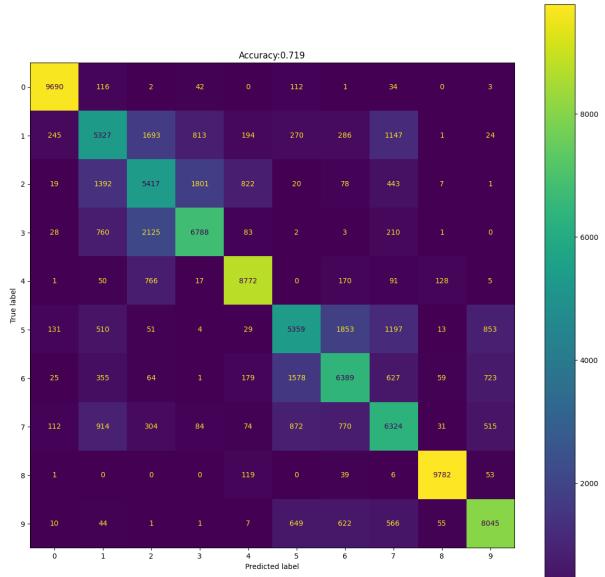
Confusion matrix Before training  
iphone13\_I(iii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(iii) model

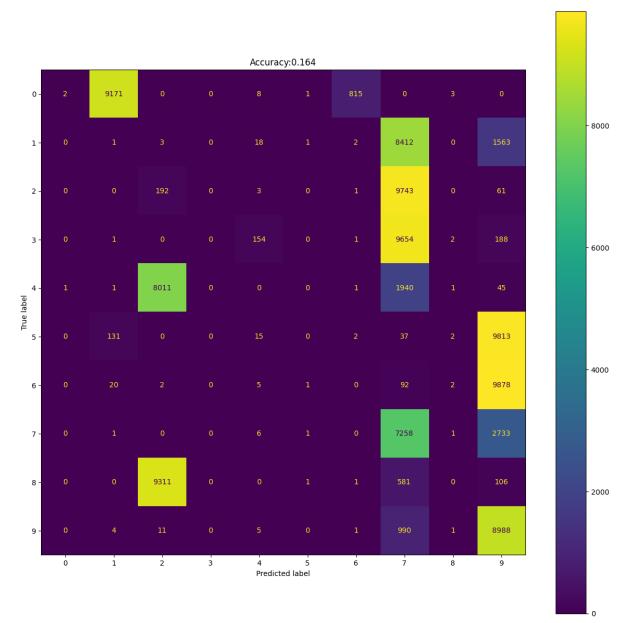


Confusion matrix After apply transfer learning on iphone13\_I(iii) model

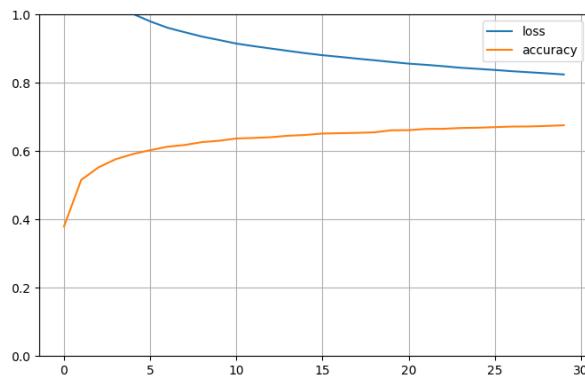


## iPHONE13\_I\_BeSh\_model.h5

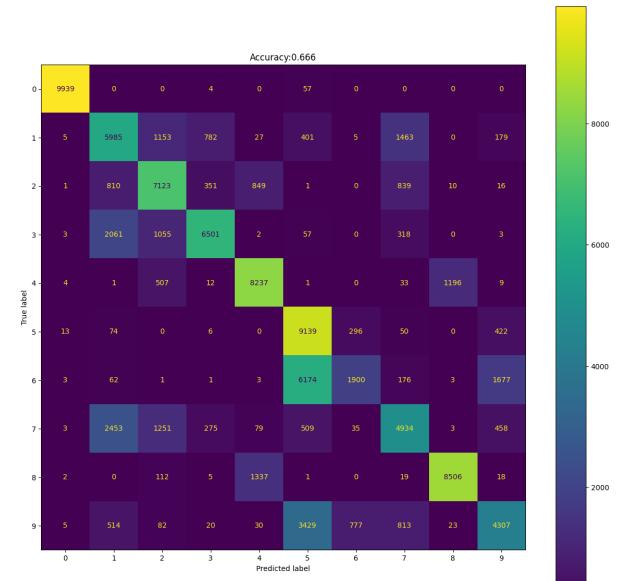
Confusion matrix Before training  
iphone13\_I\_BeSh model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_BeSh model

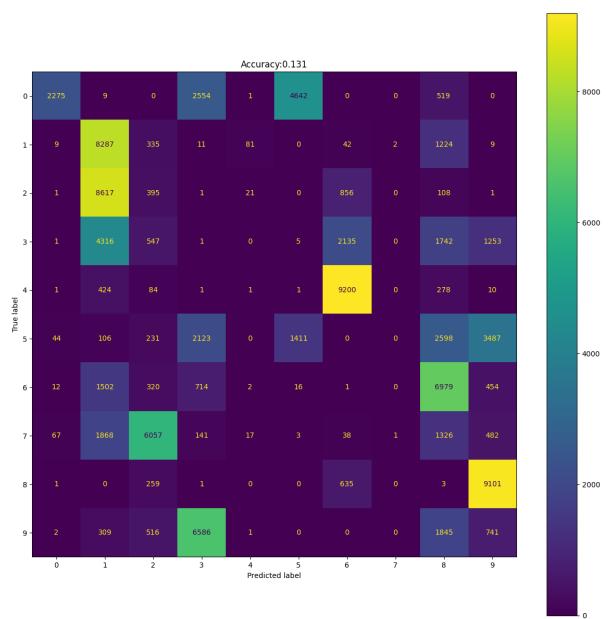


Confusion matrix After apply transfer learning on iphone13\_I\_BeSh model

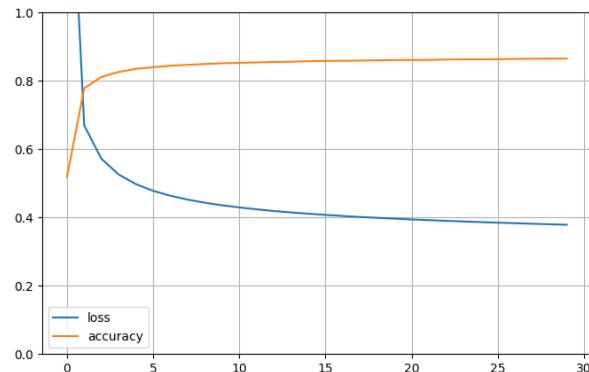


## iPHONE13\_I\_data2\_model.h5

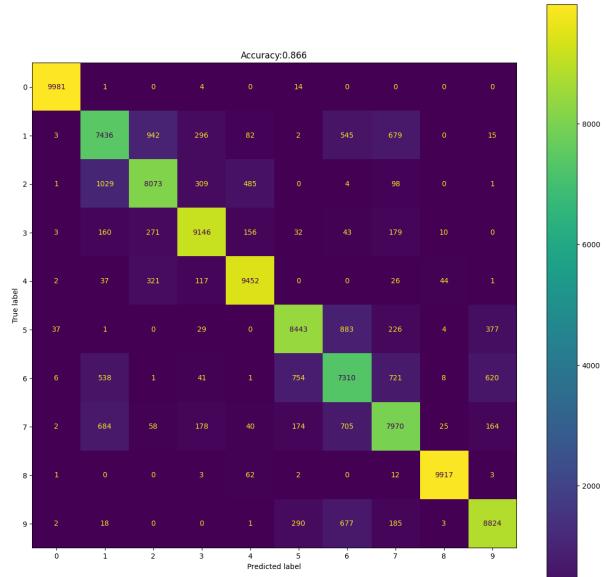
Confusion matrix Before training  
iphone13\_I\_data2 model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data2 model

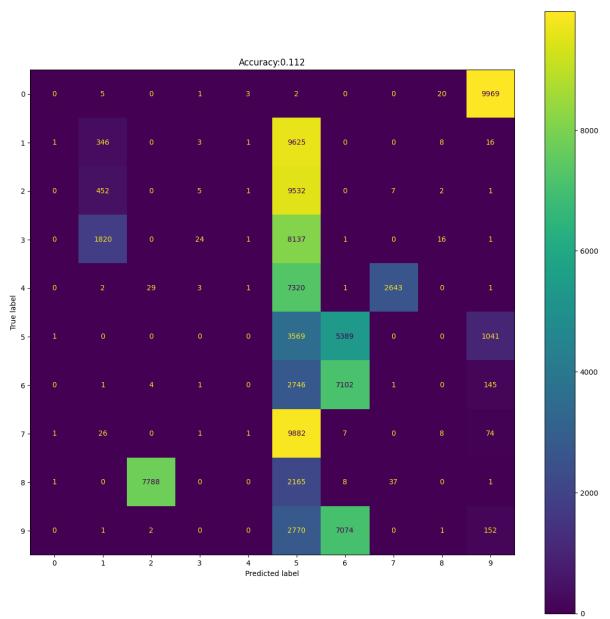


Confusion matrix After apply transfer learning on iphone13\_I\_data2 model

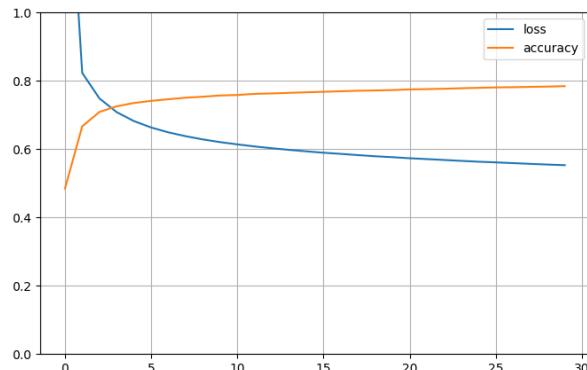


## iPHONE13\_II\_model.h5

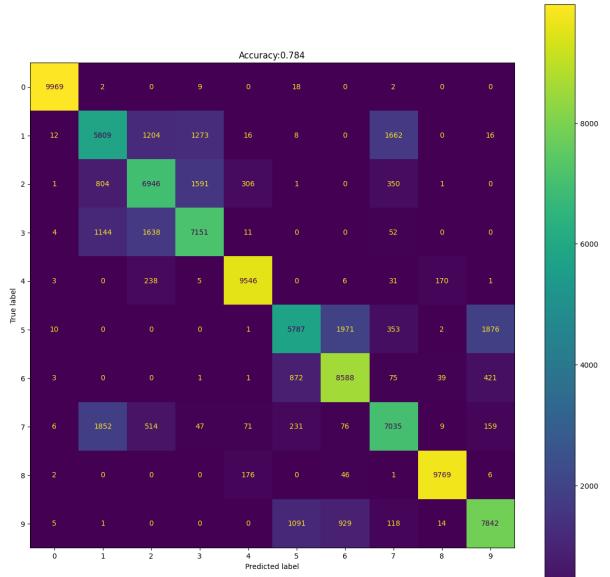
Confusion matrix Before training iphone13\_II model



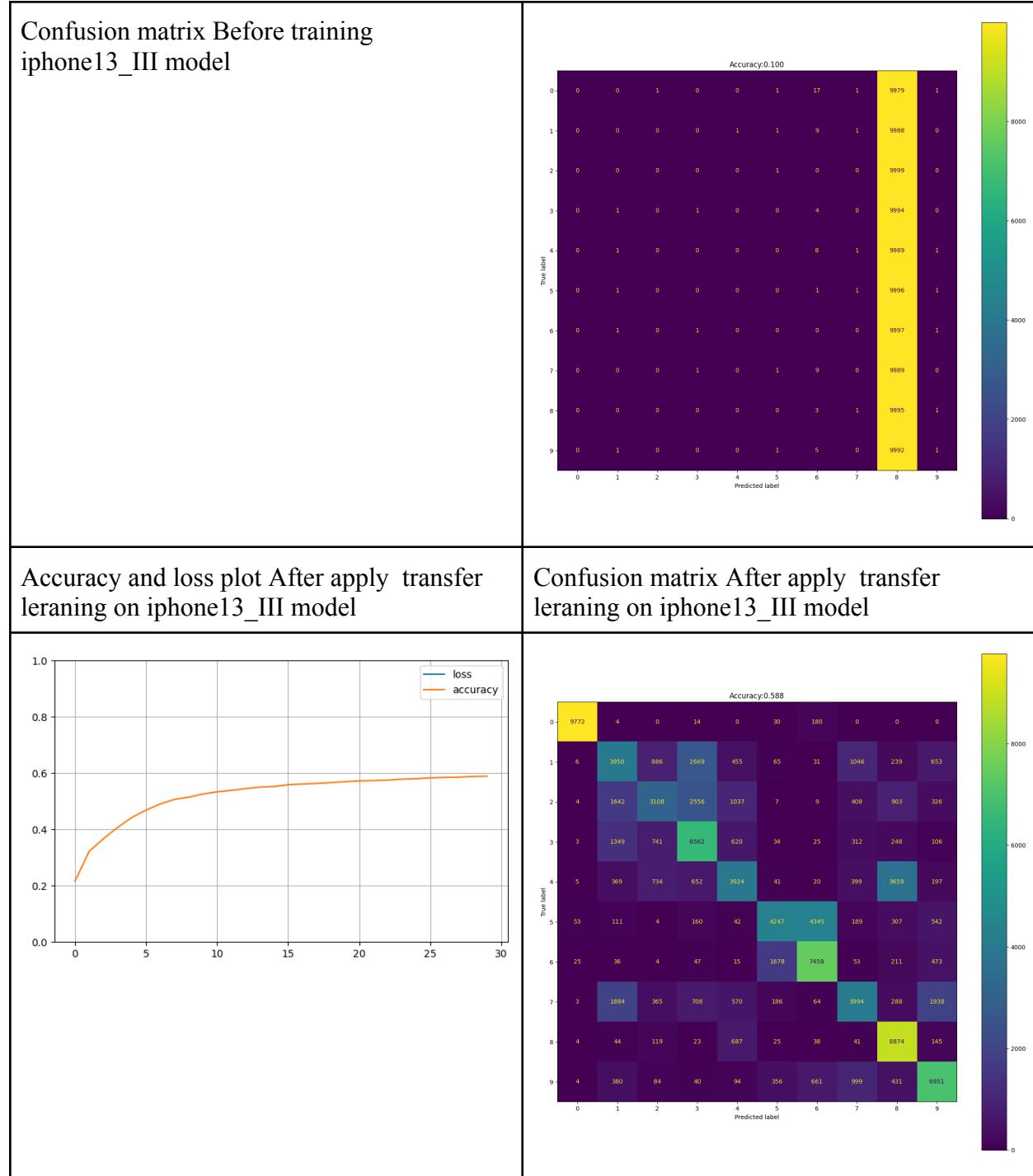
Accuracy and loss plot After apply transfer learning on iphone13\_II model



Confusion matrix After apply transfer learning on iphone13\_II model



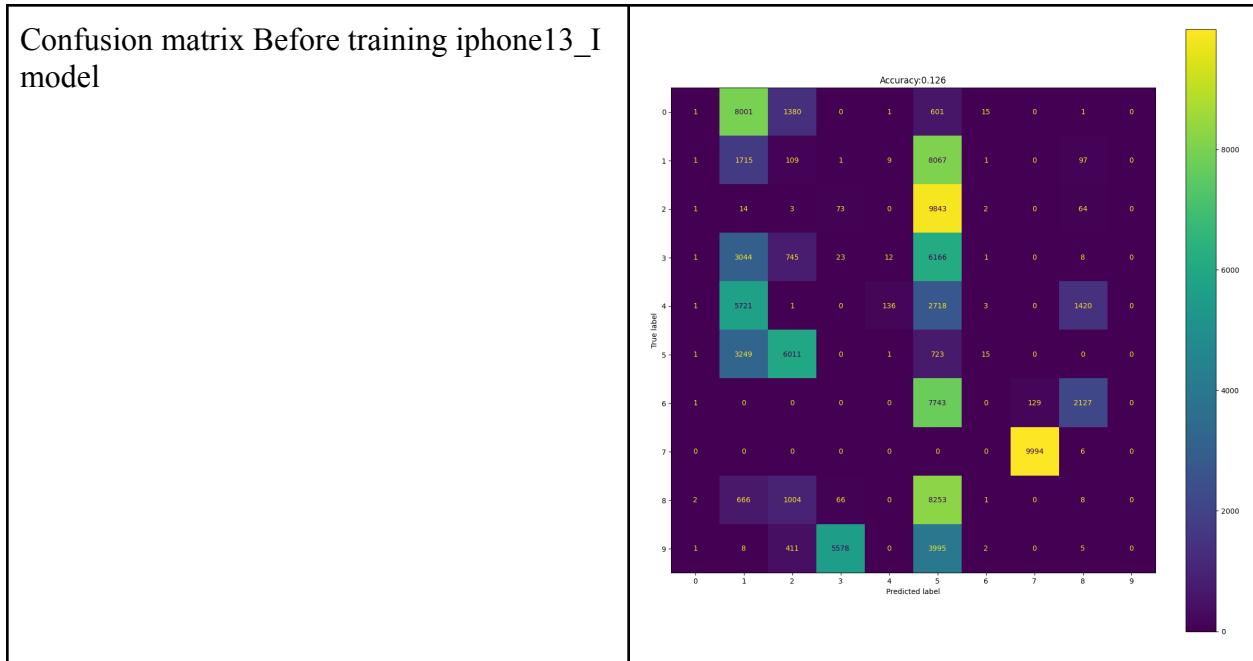
iPHONE13\_III\_model.h5



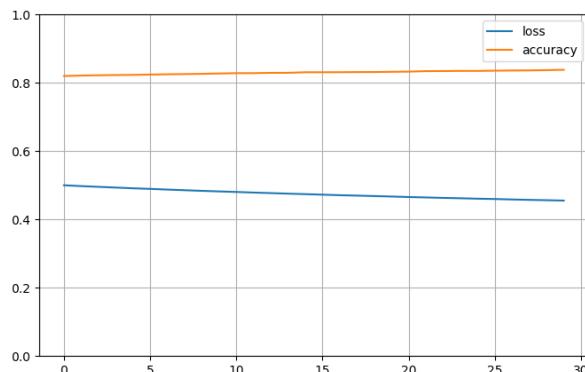
### iPhone13\_I\_data2 dataset

Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone13_I_model.h5	0.1260	0.8383	6m 50.4s	0.8382
iPhone13_I(ii)_model.h5	0.1066	0.7878	7m 37.3s	0.7869
iPhone13_I(iii)_model.h5	0.1200	0.7297	9m 22.2s	0.7318
iPhone13_I_Besh_model.h5	0.0857	0.7641	7m 45.3s	0.7675
iPhone13_I_data1	0.1439	0.8996	7m 33.8s	0.9004
iPhone13_II	0.0857	0.8072	7m 28.9s	0.8081
iPhone13_III	0.1000	0.6976	7m 39.8s	0.6973

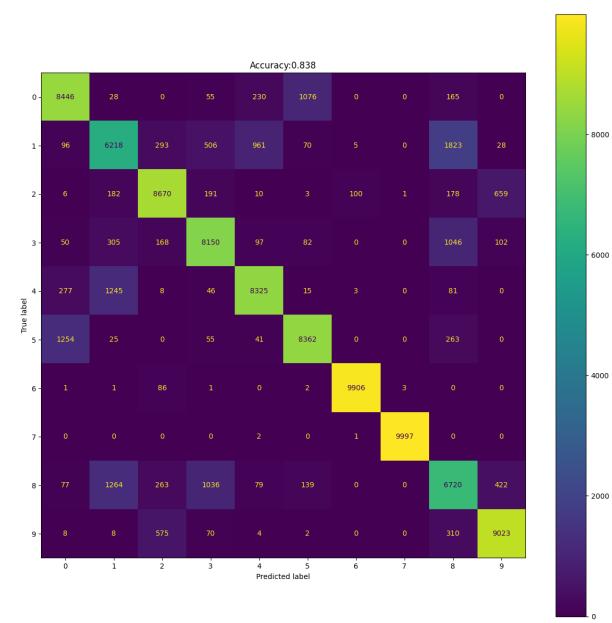
### iPhone13\_I\_model.h5



Accuracy and loss plot After apply transfer learning on iphone13\_I model

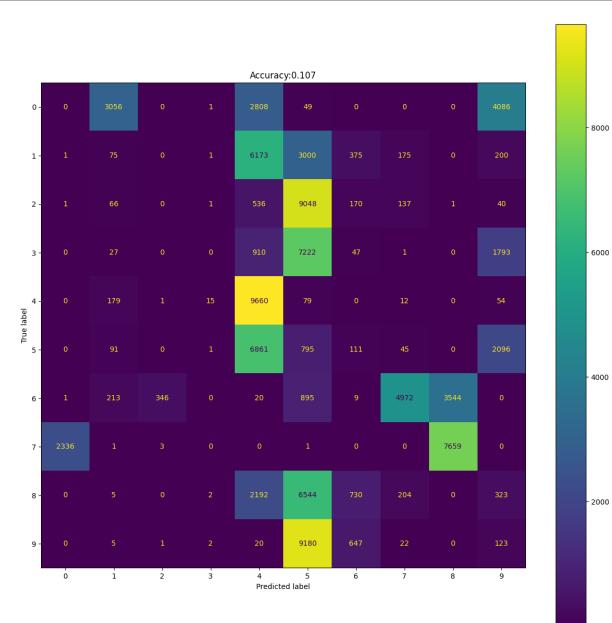


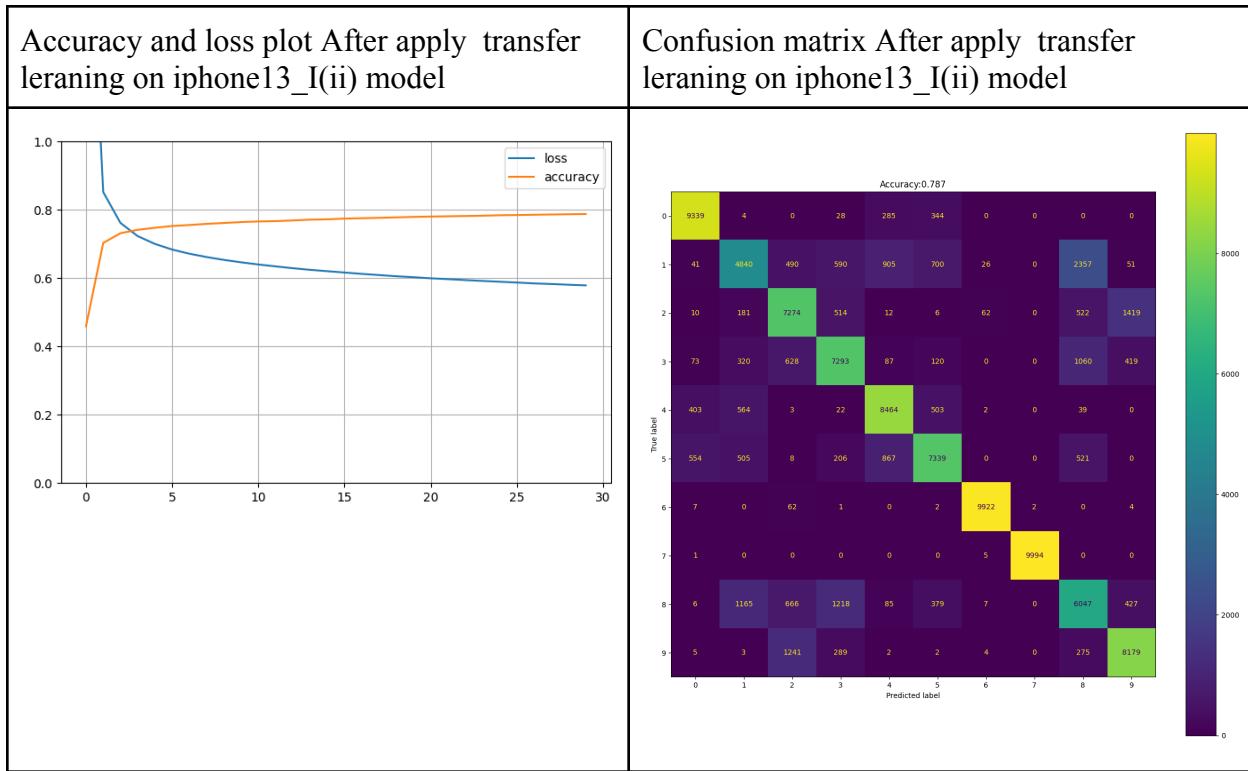
Confusion matrix After apply transfer learning on iphone13\_I model



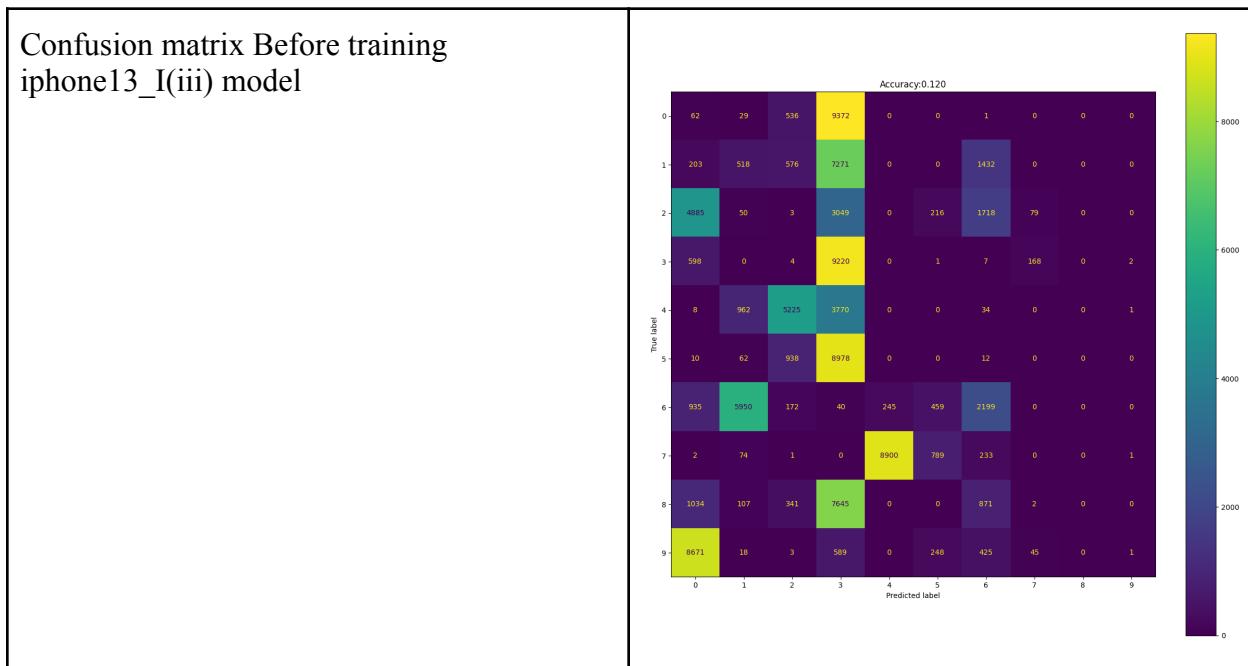
iPHONE13\_I(ii)\_model.h5

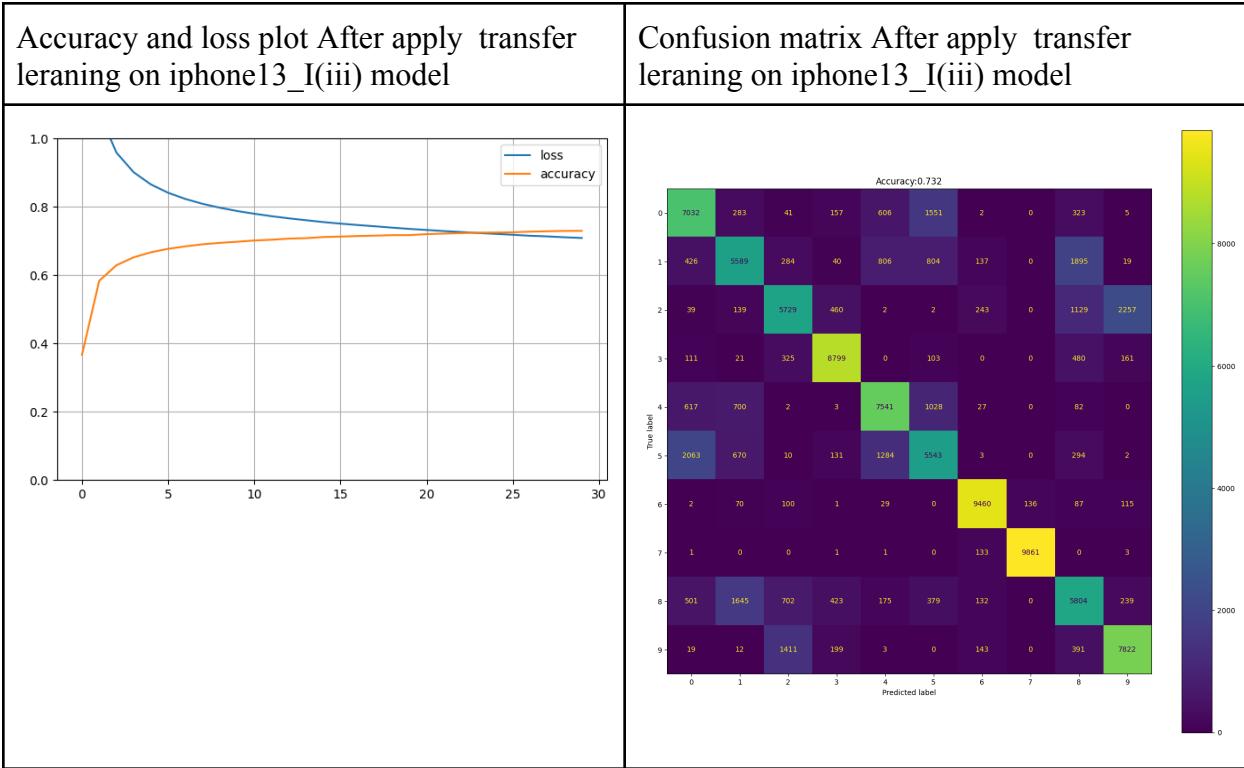
Confusion matrix Before training iphone13\_I(ii) model



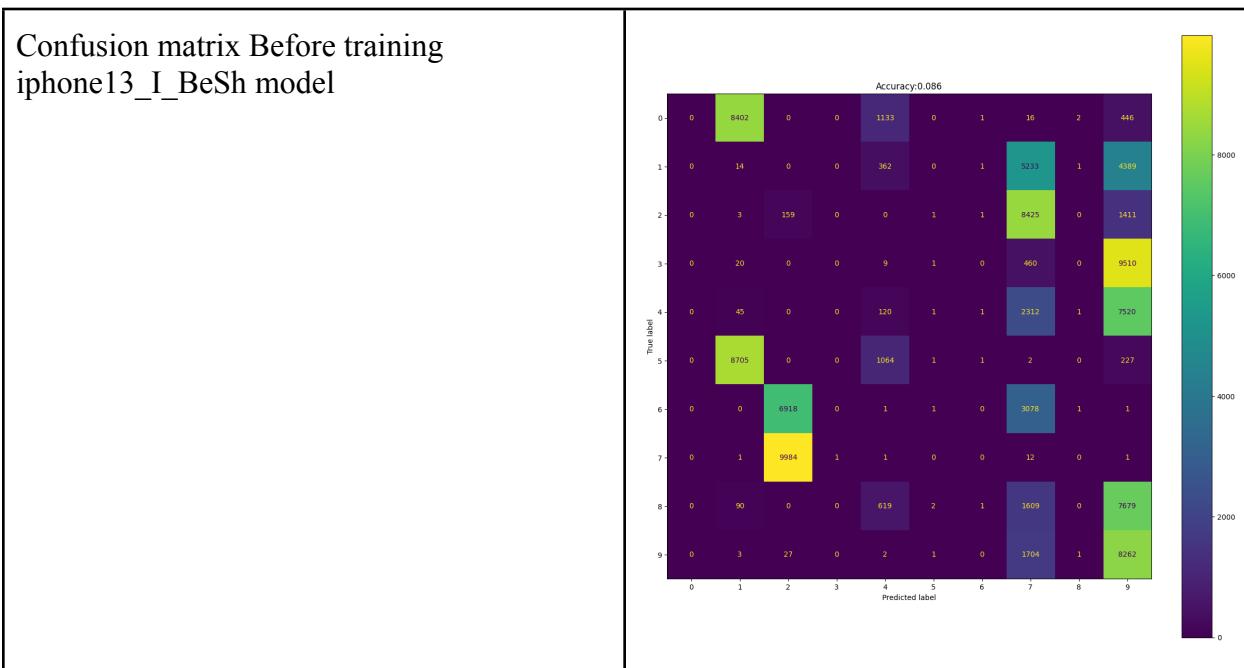


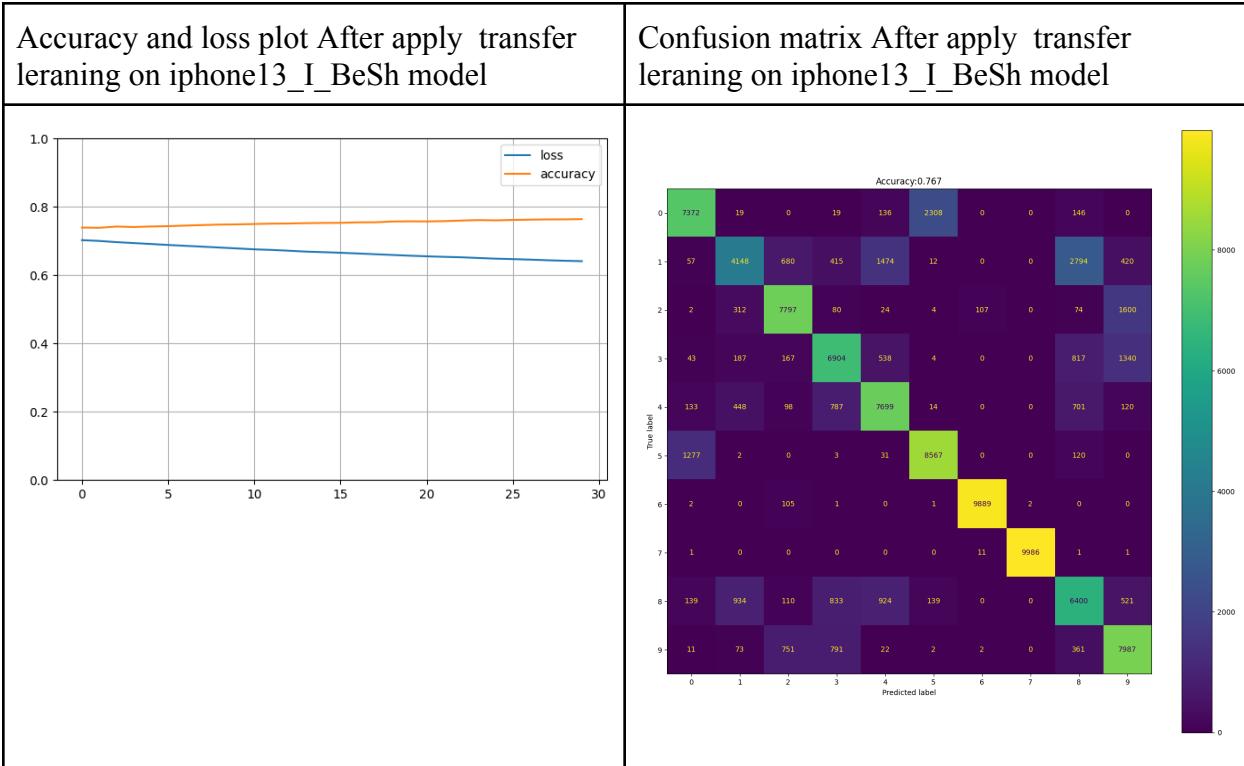
iPHONE13\_I(iii)\_model.h5



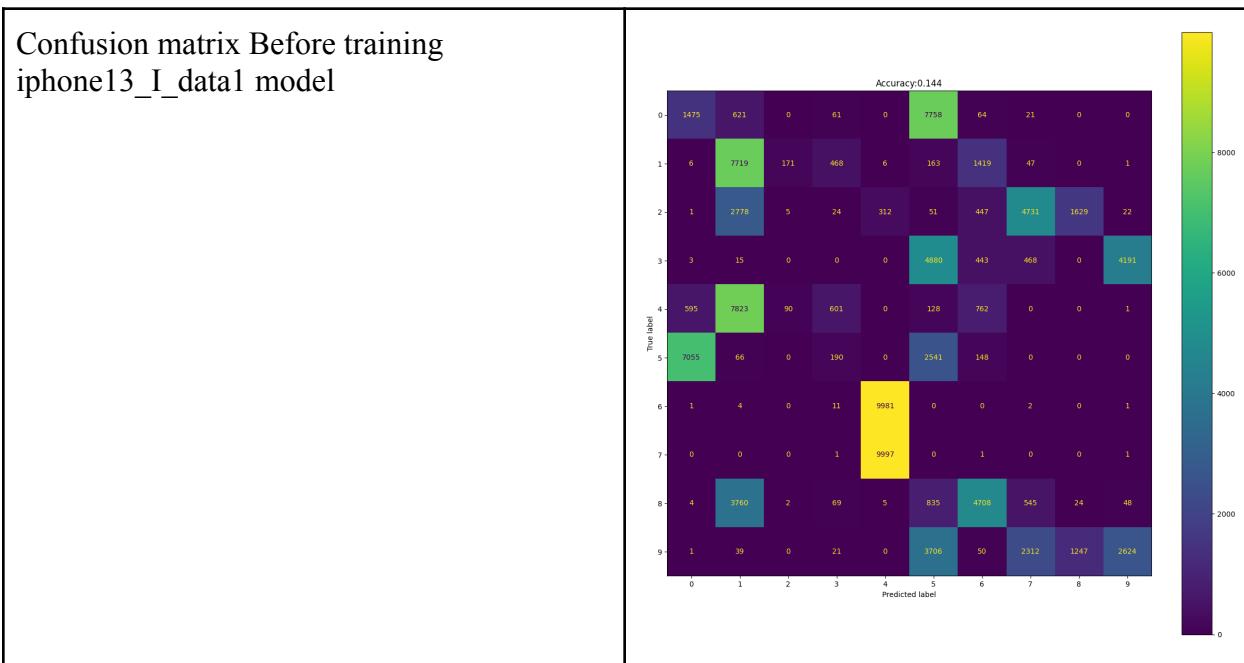


iPHONE13\_I\_BeSh\_model.h5

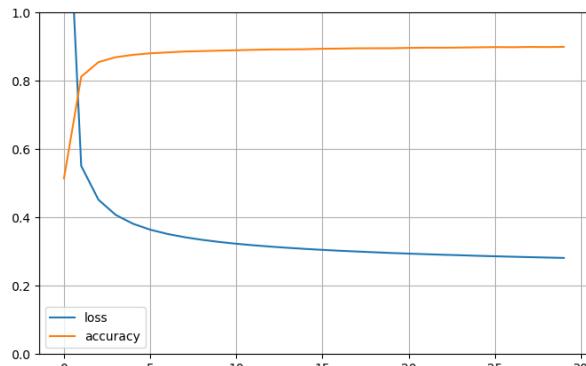




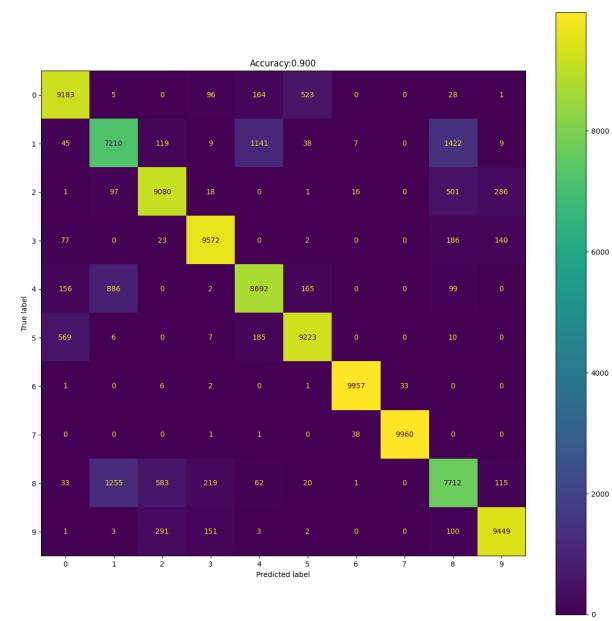
iPHONE13\_I\_data1\_model.h5



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data1 model

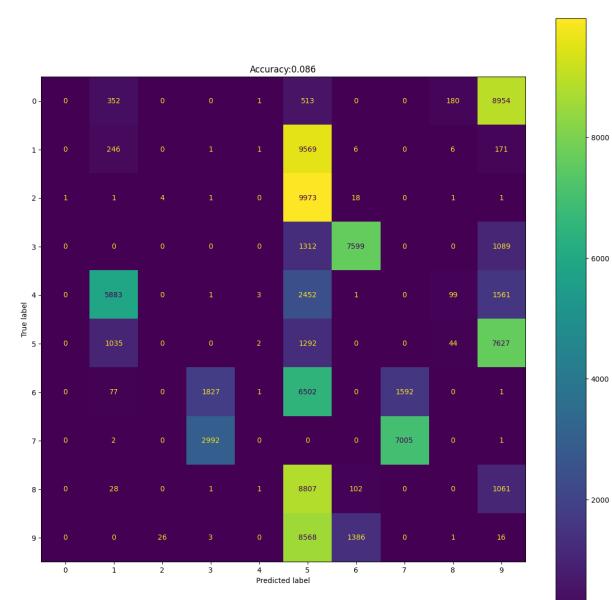


Confusion matrix After apply transfer learning on iphone13\_I\_data1 model

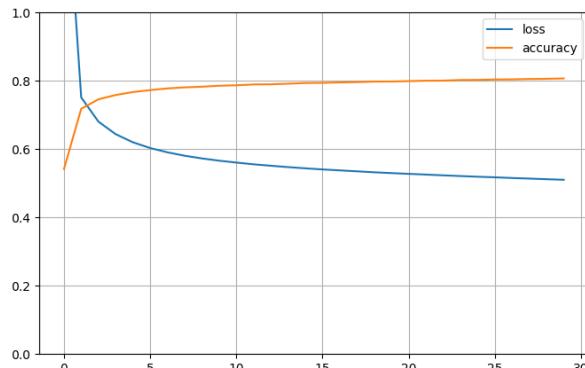


iPHONE13\_II\_model.h5

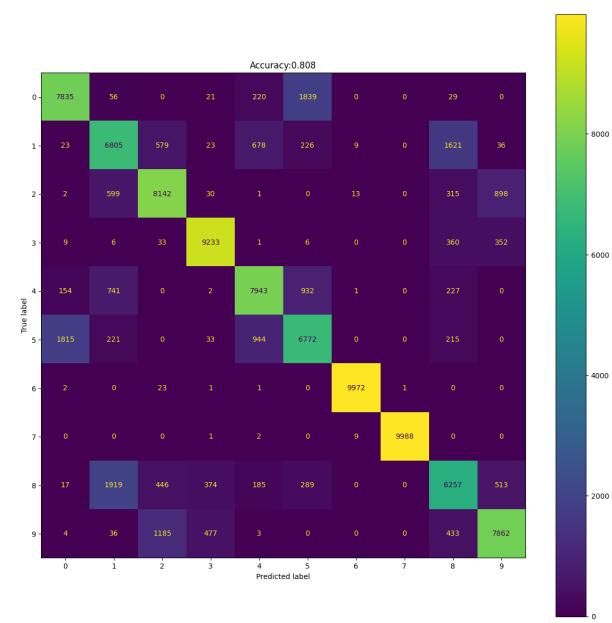
Confusion matrix Before training iphone13\_II model



Accuracy and loss plot After apply transfer learning on iphone13\_II model

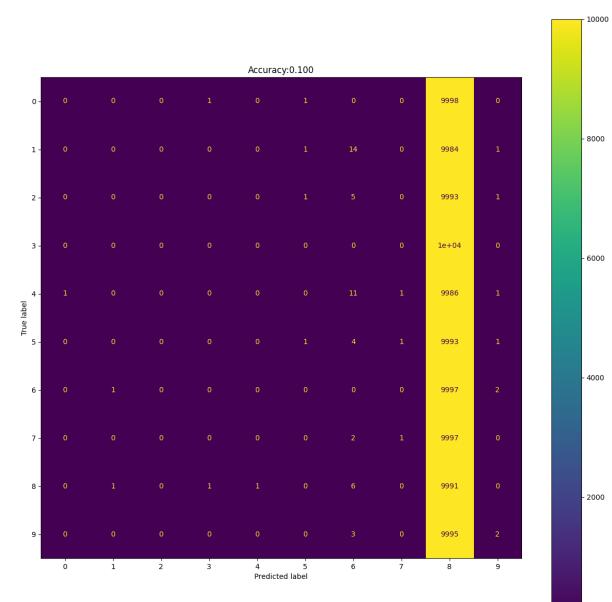


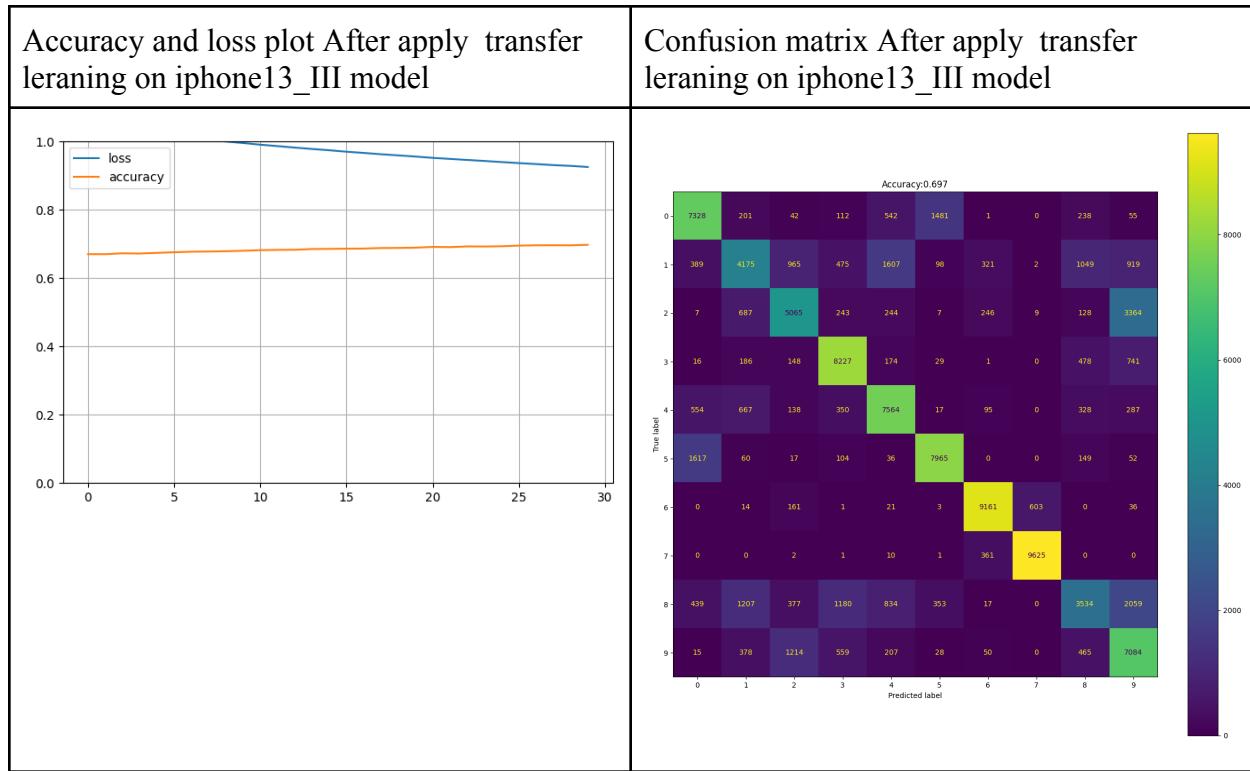
Confusion matrix After apply transfer learning on iphone13\_II model



iPHONE13\_III\_model.h5

Confusion matrix Before training iphone13\_III model



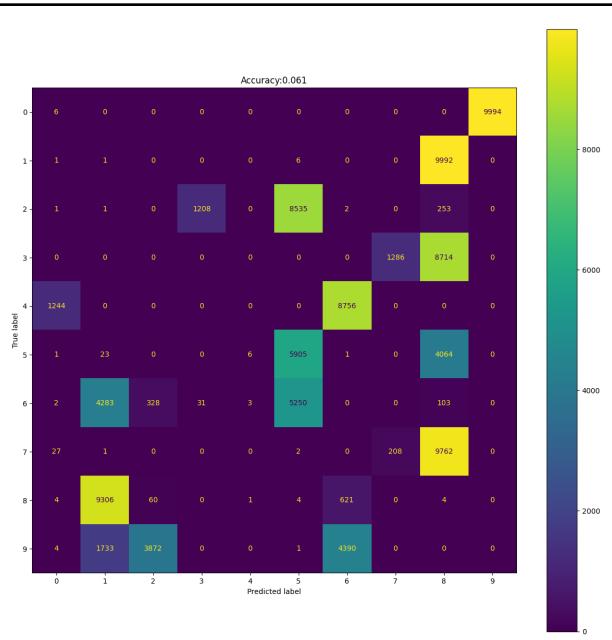


## iPhone13\_II dataset

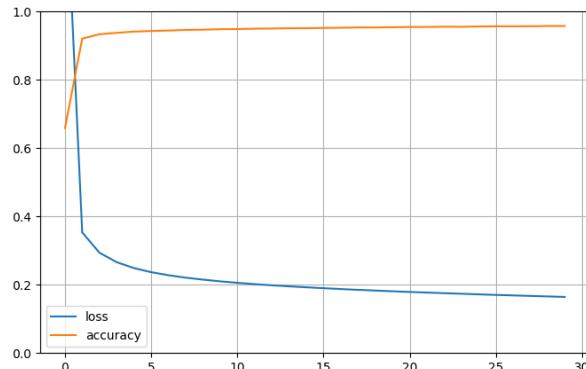
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone13_I_model.h5	0.0612	0.9577	6m 45.6s	0.9572
iPhone13_I(ii)_model.h5	0.1540	0.9858	7m 40.4s	0.9858
iPhone13_I(iii)_model.h5	0.0291	0.8807	7m 30.5s	0.8813
iPhone13_I_Besh_model.h5	0.1997	0.9802	8m 5.7s	0.9808
iPhone13_I_data1	0.0708	0.9597	6m 3.8s	0.9601
iPhone13_I_data2	0.1375	0.9489	6m 48.5s	0.9488
iPhone13_III	0.0997	0.9011	6m 13.7s	0.9024

## iPHONE13\_I\_model.h5

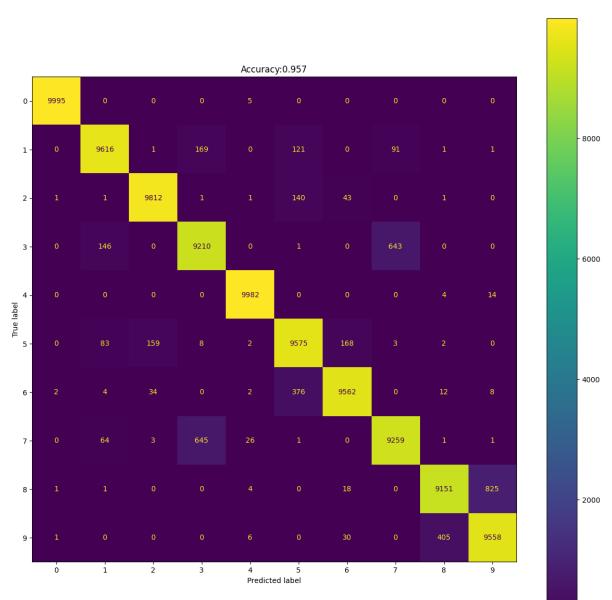
Confusion matrix Before training iphone13\_I model



Accuracy and loss plot After apply transfer learning on iphone13\_I model

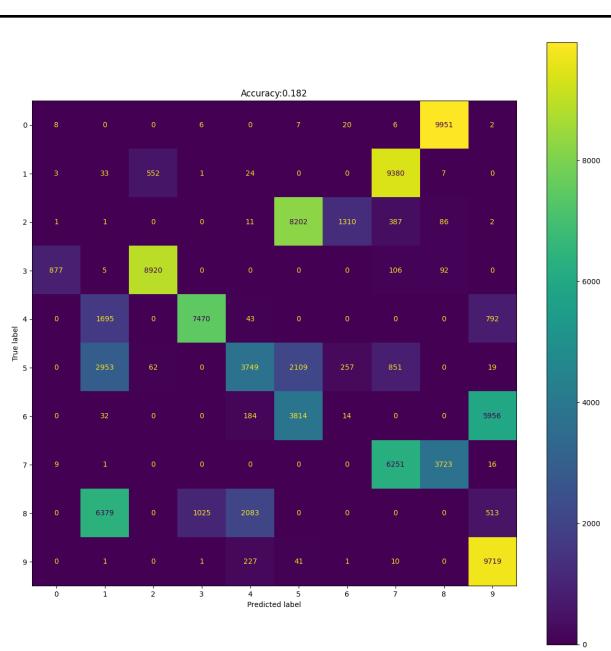


Confusion matrix After apply transfer learning on iphone13\_I model

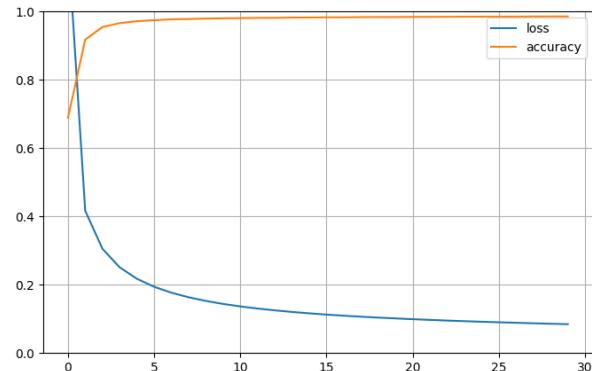


## iPHONE13\_I(ii)\_model.h5

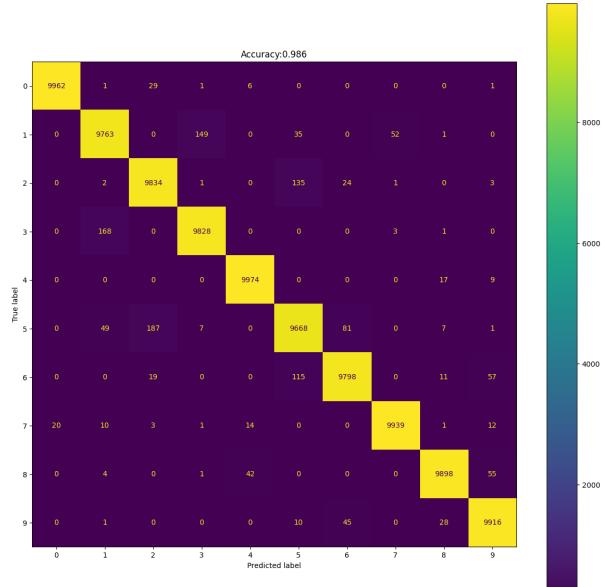
Confusion matrix Before training  
iphone13\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(ii) model

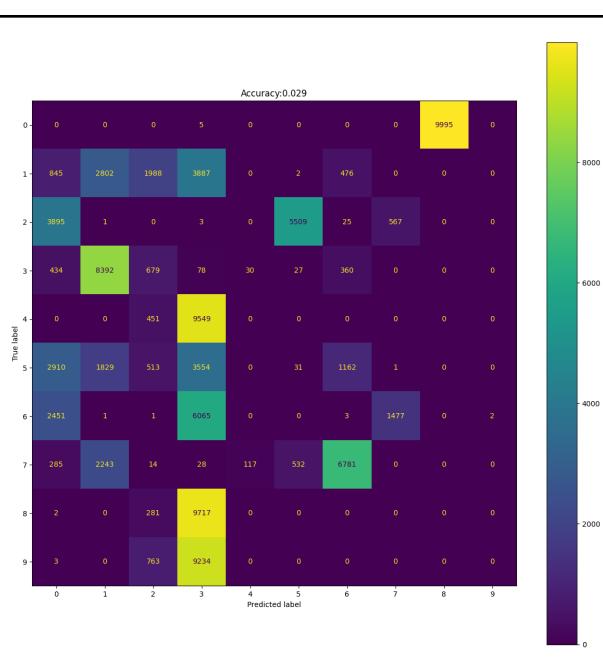


Confusion matrix After apply transfer learning on iphone13\_I(ii) model

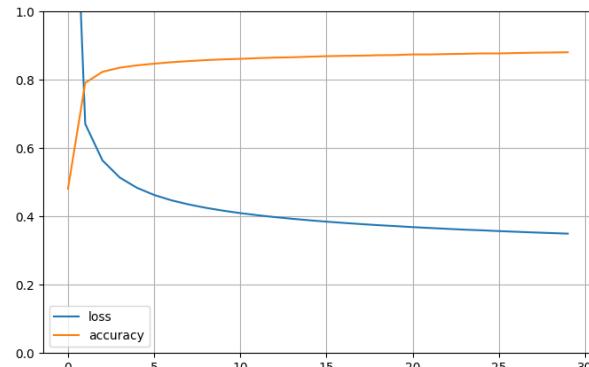


### iPHONE13\_I(iii)\_model.h5

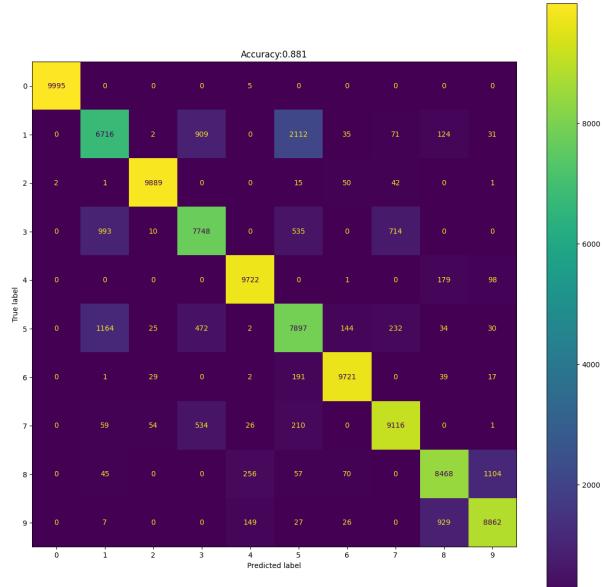
Confusion matrix Before training  
iphone13\_I(iii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(iii) model

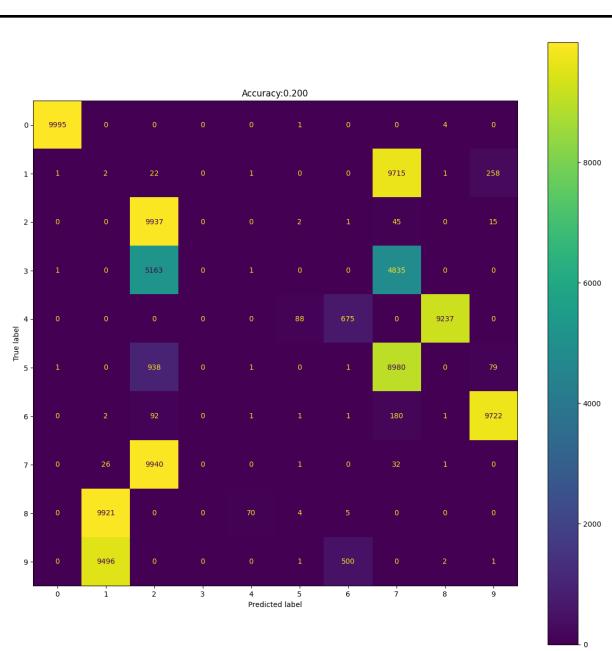


Confusion matrix After apply transfer learning on iphone13\_I(iii) model

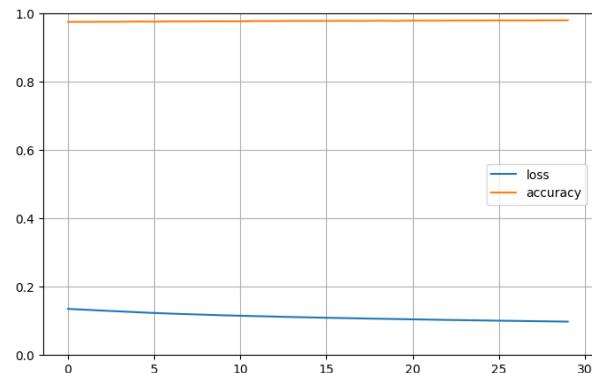


## iPHONE13\_I\_BeSh\_model.h5

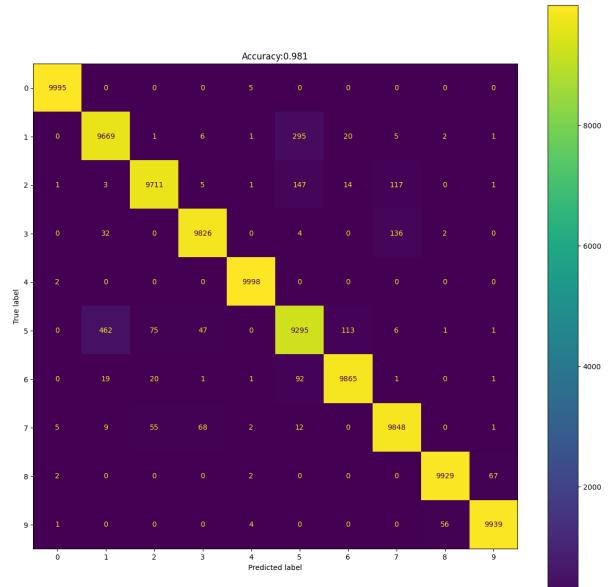
Confusion matrix Before training  
iphone13\_I\_BeSh model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_BeSh model

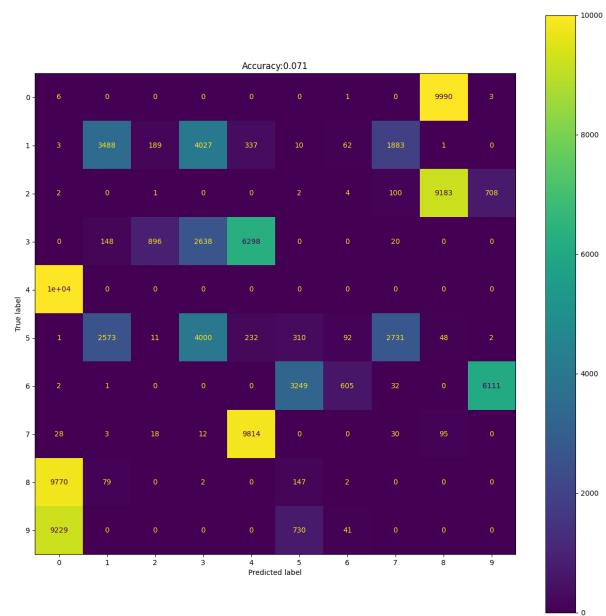


Confusion matrix After apply transfer learning on iphone13\_I\_BeSh model

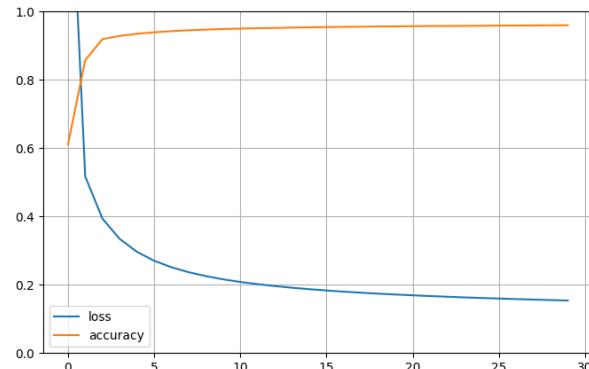


## iPHONE13\_I\_data1\_model.h5

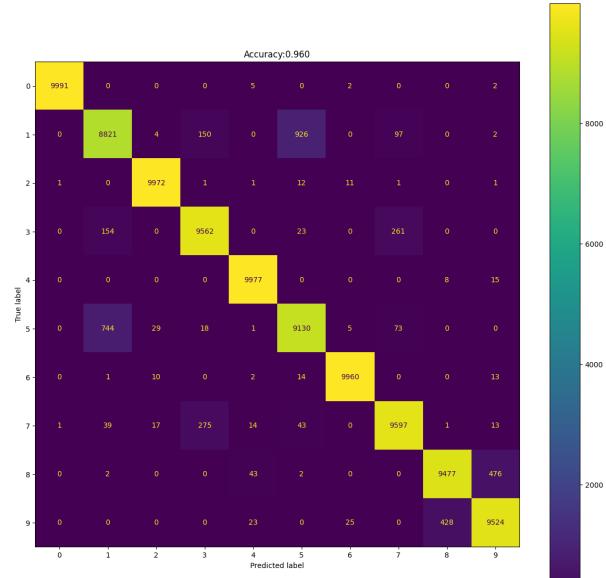
Confusion matrix Before training  
iphone13\_I\_data1 model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data1 model

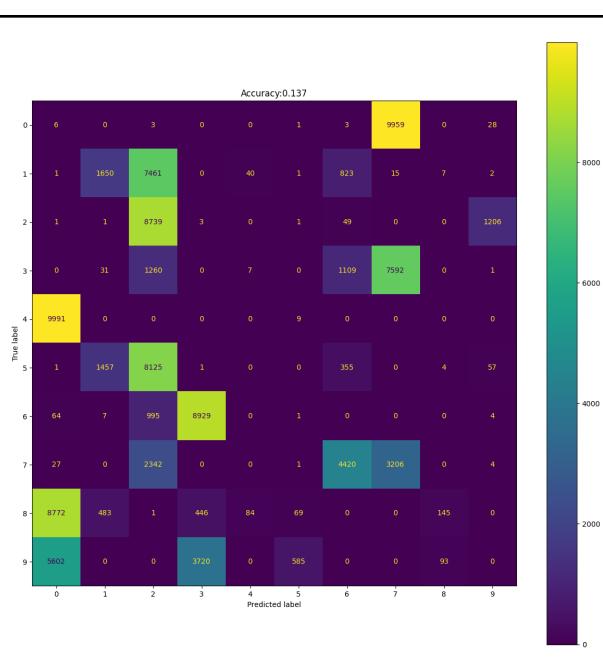


Confusion matrix After apply transfer learning on iphone13\_I\_data1 model

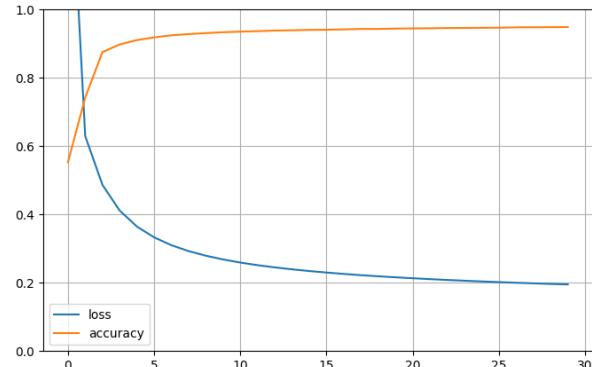


## iPHONE13\_I\_data2\_model.h5

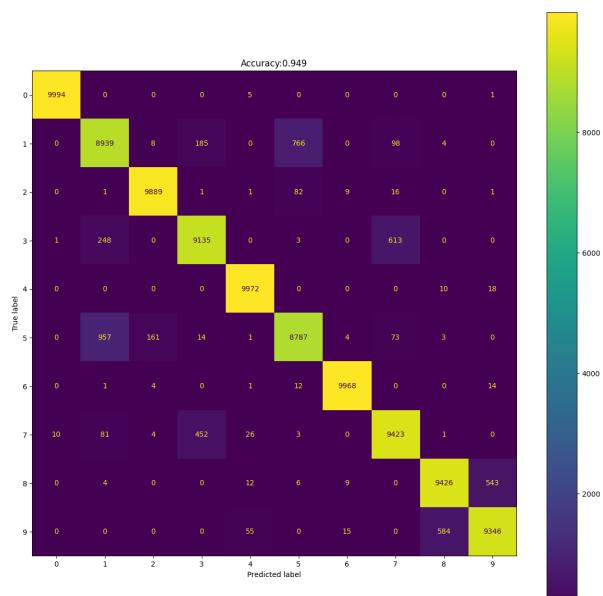
Confusion matrix Before training  
iphone13\_I\_data2 model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data2 model

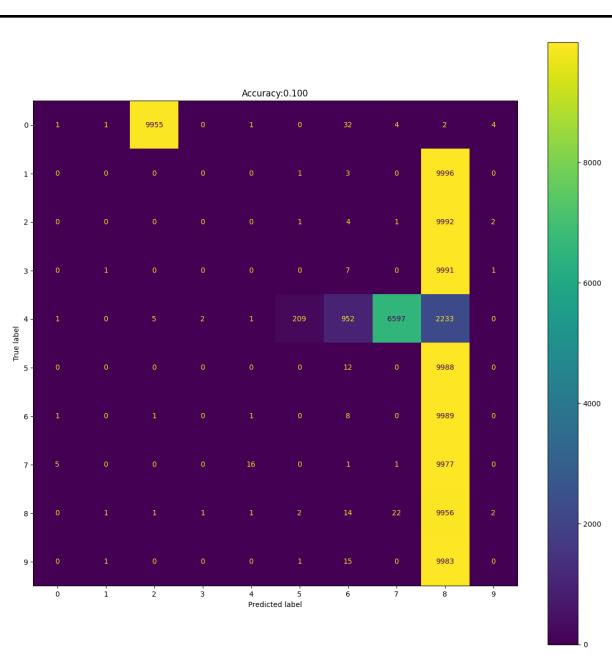


Confusion matrix After apply transfer learning on iphone13\_I\_data2 model

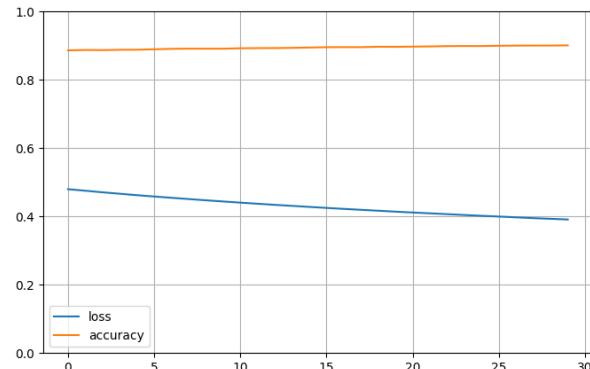


## iPHONE13\_III\_model.h5

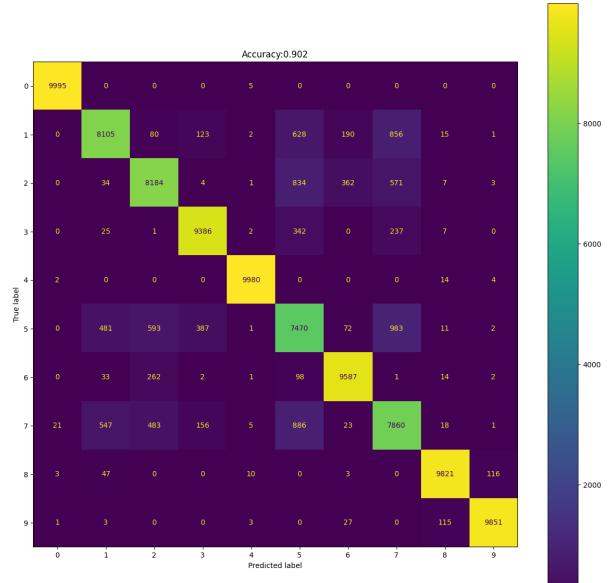
Confusion matrix Before training  
iphone13\_III model



Accuracy and loss plot After apply transfer learning on iphone13\_III model



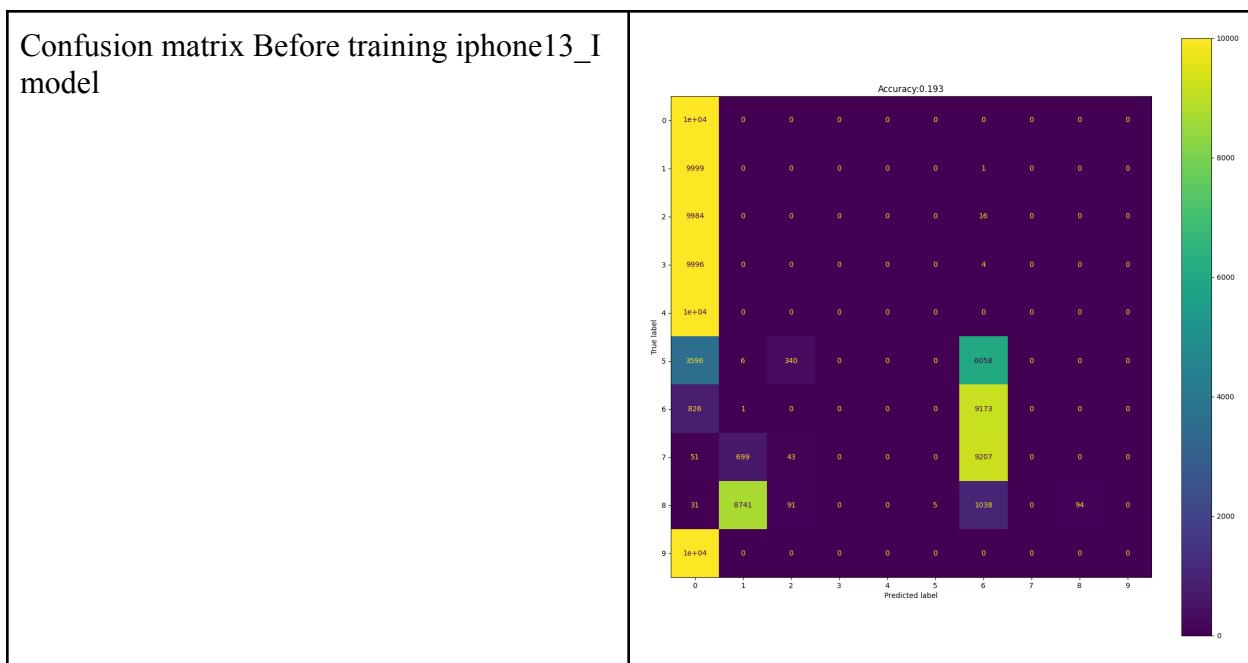
Confusion matrix After apply transfer learning on iphone13\_III model



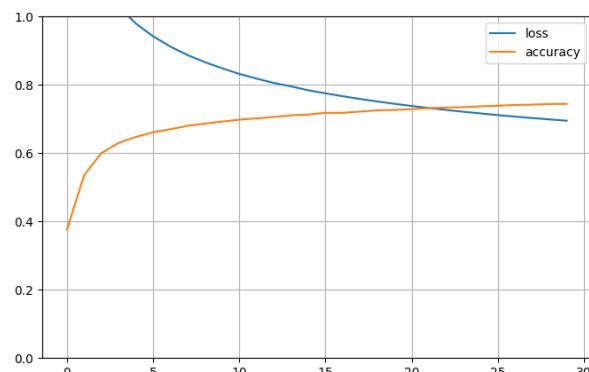
### **iPhone13 III dataset**

Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone13_I_model.h5	0.1927	0.7444	6m 11.3s	0.7409
iPhone13_I(ii)_model.h5	0.1179	0.7760	6m 4.7s	0.7743
iPhone13_I(iii)_model.h5	0.1041	0.6644	6m 44.4s	0.6533
iPhone13_I_Besh_model.h5	0.0884	0.7729	6m 19.7s	0.7625
iPhone13_I_data1	0.1002	0.7101	7m 18.6s	0.7086
iPhone13_I_data2	0.0989	0.6885	7m 14.8s	0.6916
iPhone13_II	0.1139	0.7910	7m 9.8s	0.7784

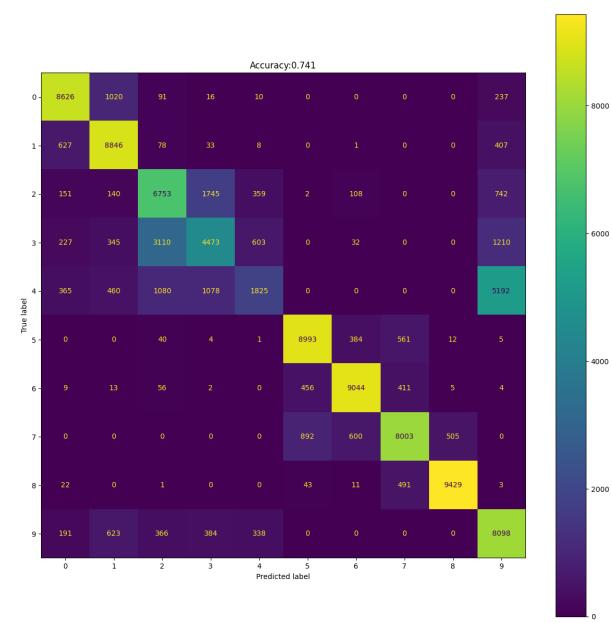
iPHONE13\_I\_model.h5



Accuracy and loss plot After apply transfer learning on iphone13\_I model

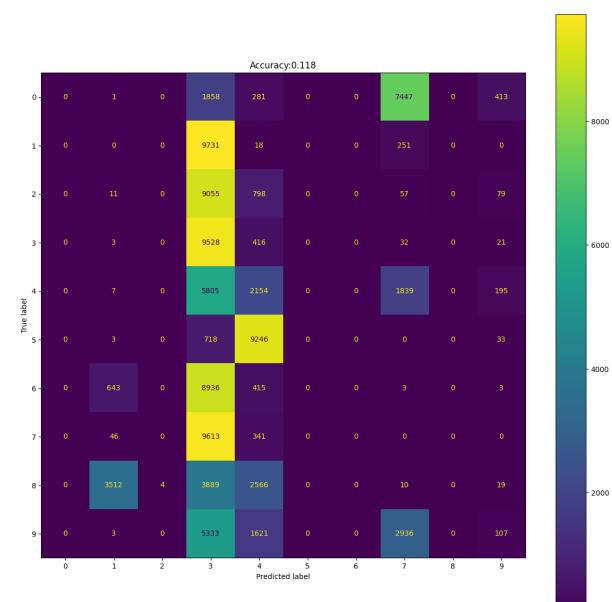


Confusion matrix After apply transfer learning on iphone13\_I model

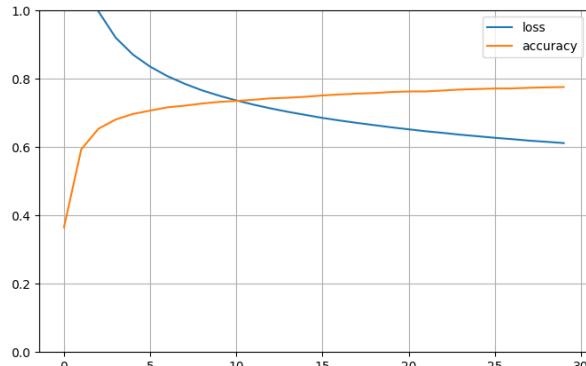


iPHONE13\_I(ii)\_model.h5

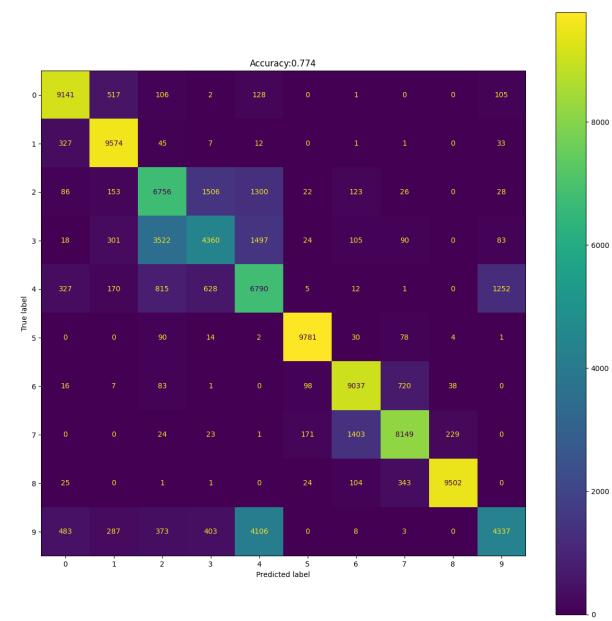
Confusion matrix Before training iphone13\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(ii) model

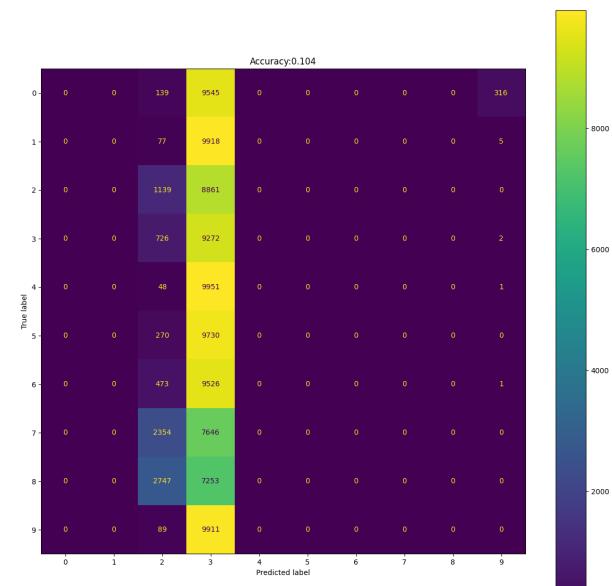


Confusion matrix After apply transfer learning on iphone13\_I(ii) model

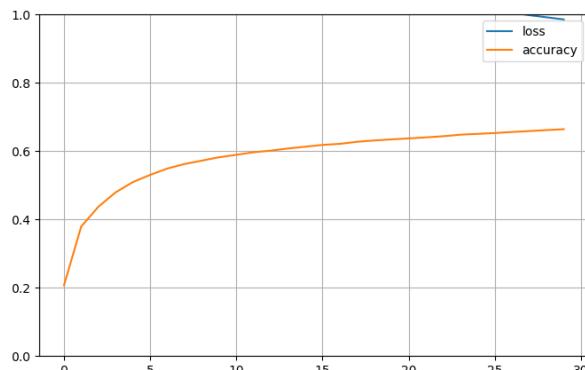


iPhone13\_I(iii)\_model.h5

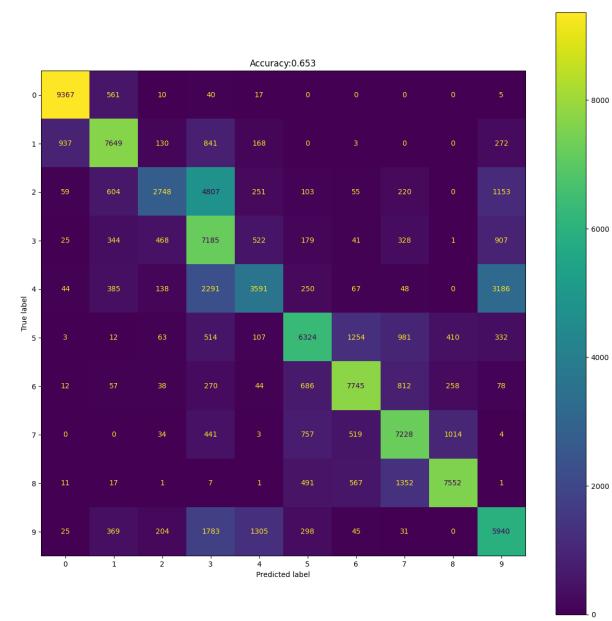
Confusion matrix Before training iphone13\_I(iii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(iii) model

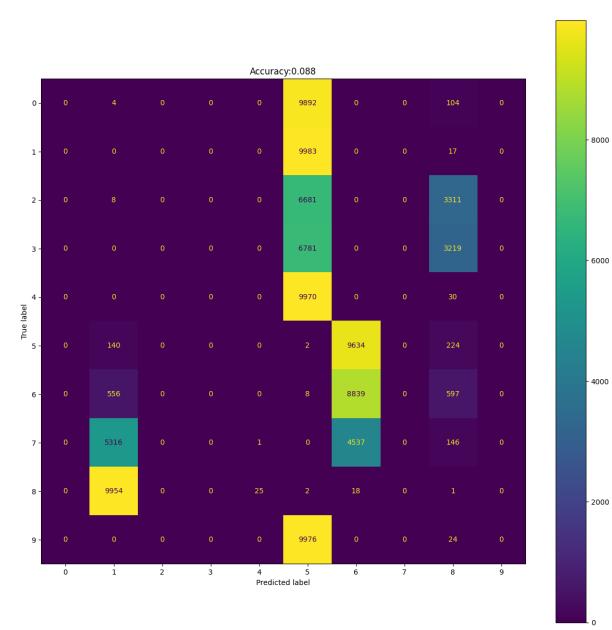


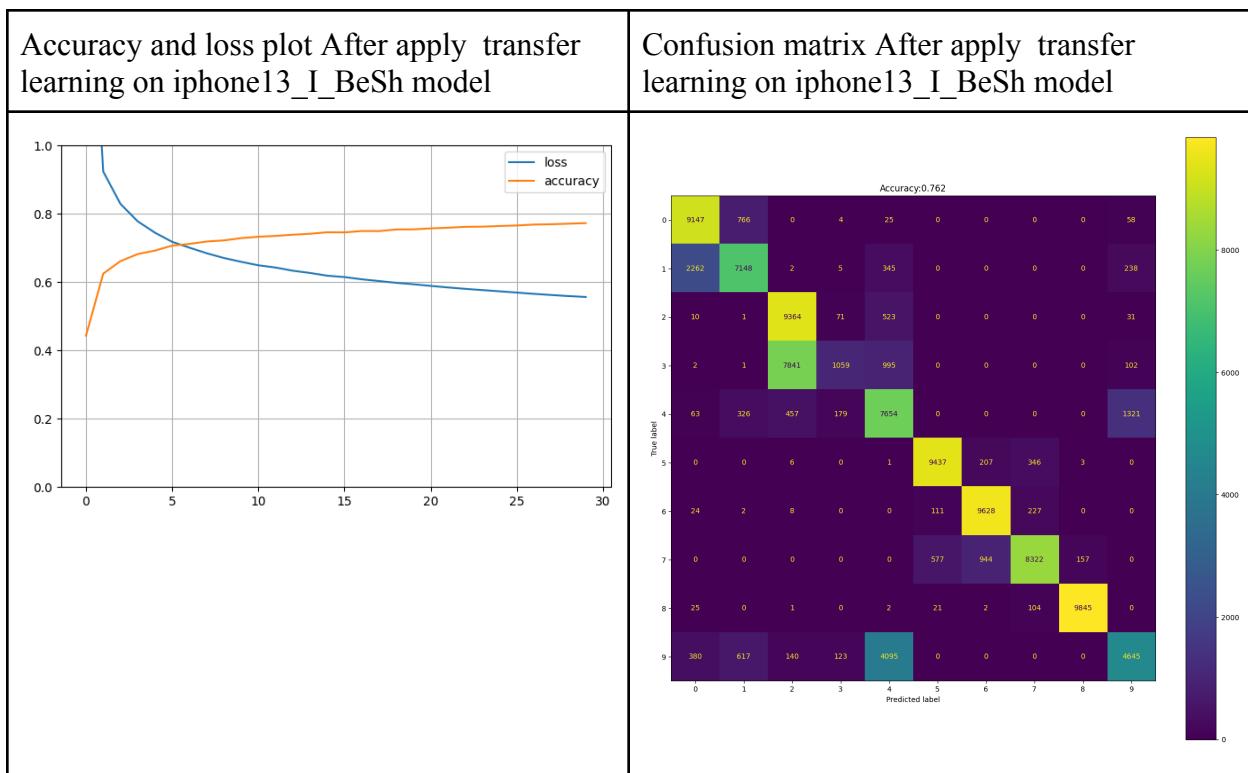
Confusion matrix After apply transfer learning on iphone13\_I(iii) model



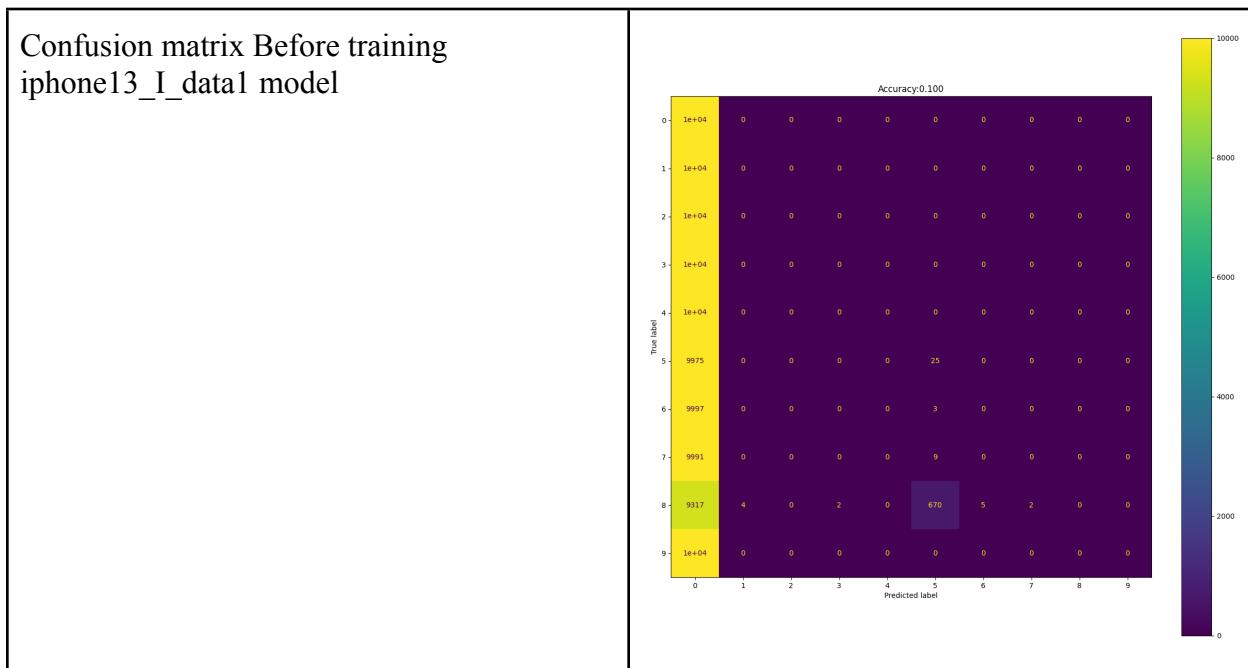
iPHONE13\_I\_BeSh\_model.h5

Confusion matrix Before training iphone13\_I\_BeSh model

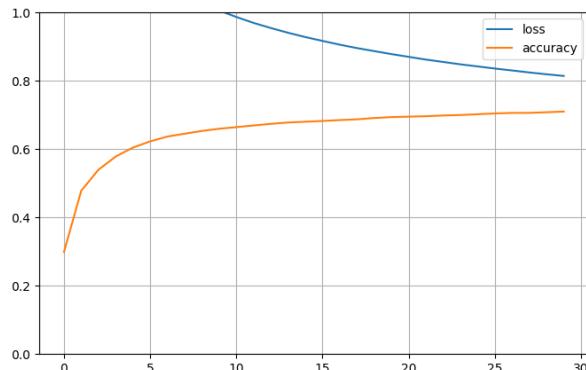




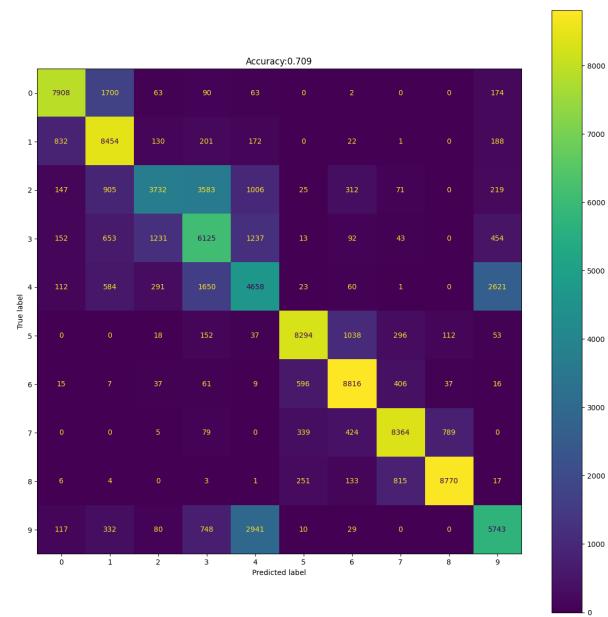
iPHONE13\_I\_data1\_model.h5



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data1 model

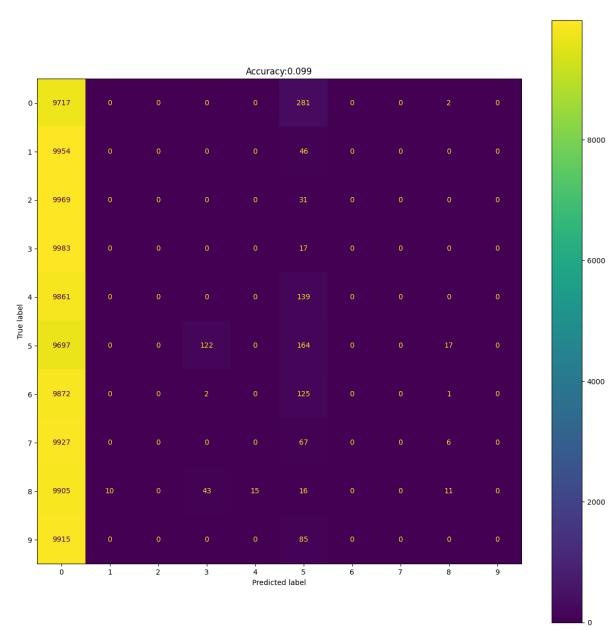


Confusion matrix After apply transfer learning on iphone13\_I\_data1 model

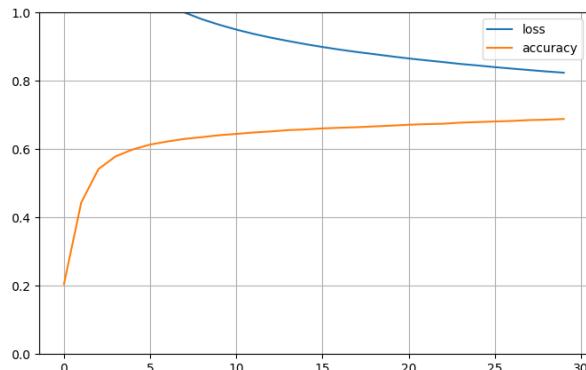


iPHONE13\_I\_data2\_model.h5

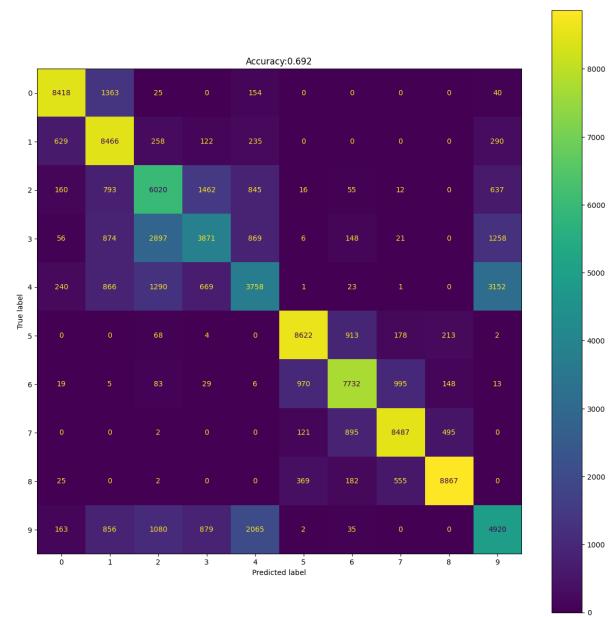
Confusion matrix Before training iphone13\_I\_data2 model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_data2 model

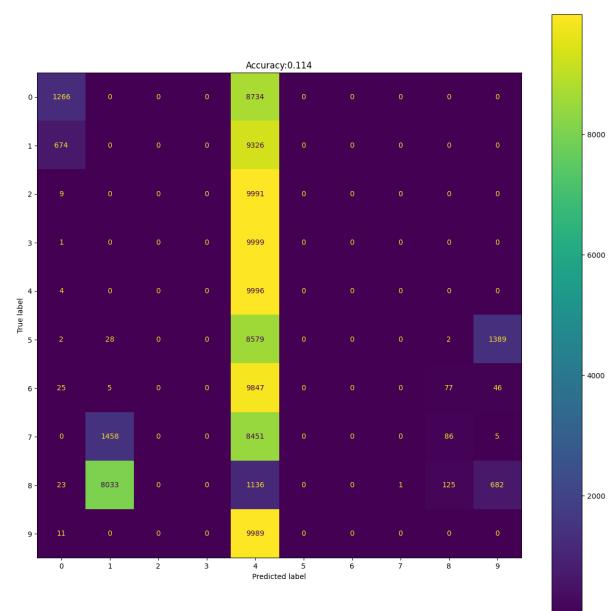


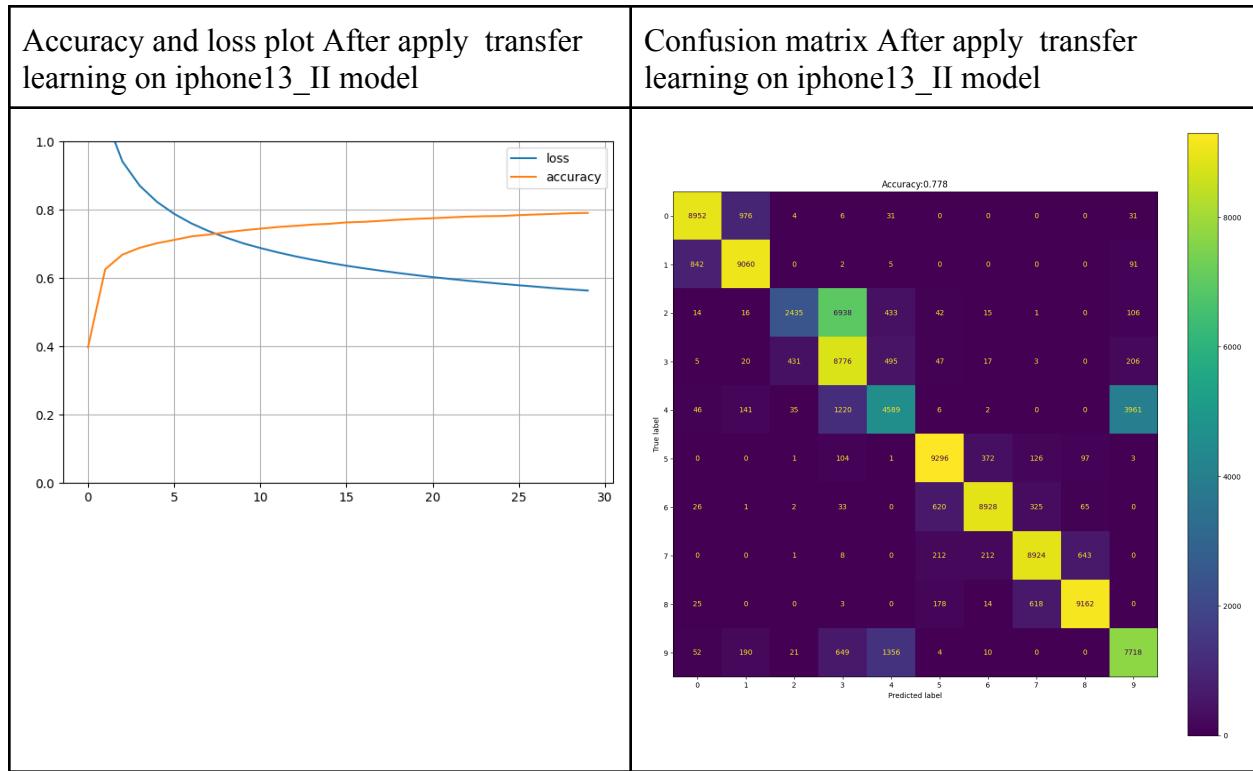
Confusion matrix After apply transfer learning on iphone13\_I\_data2 model



iPHONE13\_II\_model.h5

Confusion matrix Before training iphone13\_II model





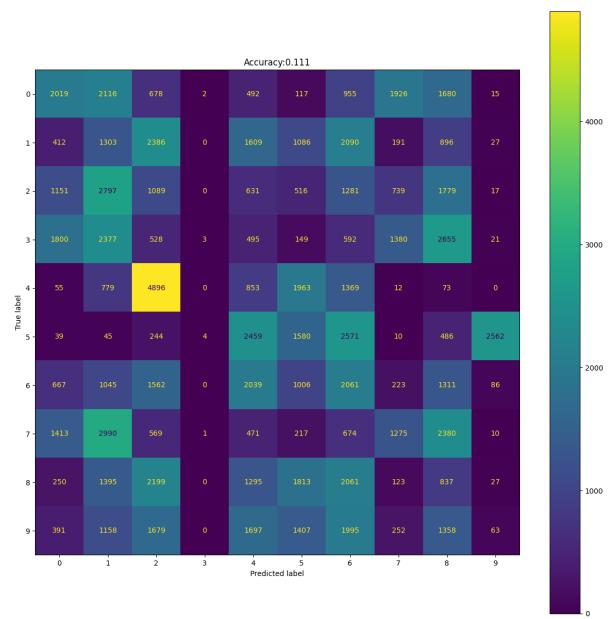
## iPhone14Pro

### iPhone14Pro\_I(i) dataset

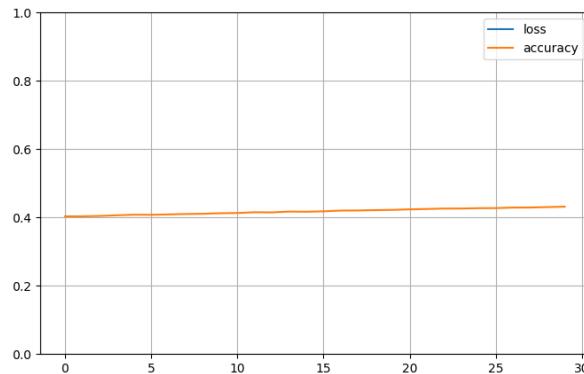
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone14Pro_I(ii)_model.h5	0.1108	0.4317	6m 29.2s	0.4279
iPhone14Pro_I(iii)_model.h5	0.1046	0.2956	7m 44.8s	0.2965
iPhone14Pro_I(iv)_model.h5	0.0916	0.3546	6m 0.9s	0.3521
iPhone14Pro_I(v)_model.h5	0.0999	0.3178	5m 36.3s	0.3239

## iPHONE14Pro\_I(ii)\_model.h5

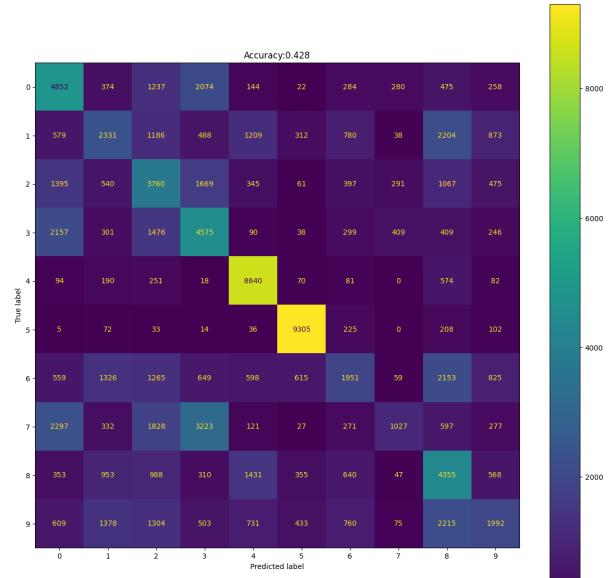
Confusion matrix Before training  
iphone14Pro\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(ii) model

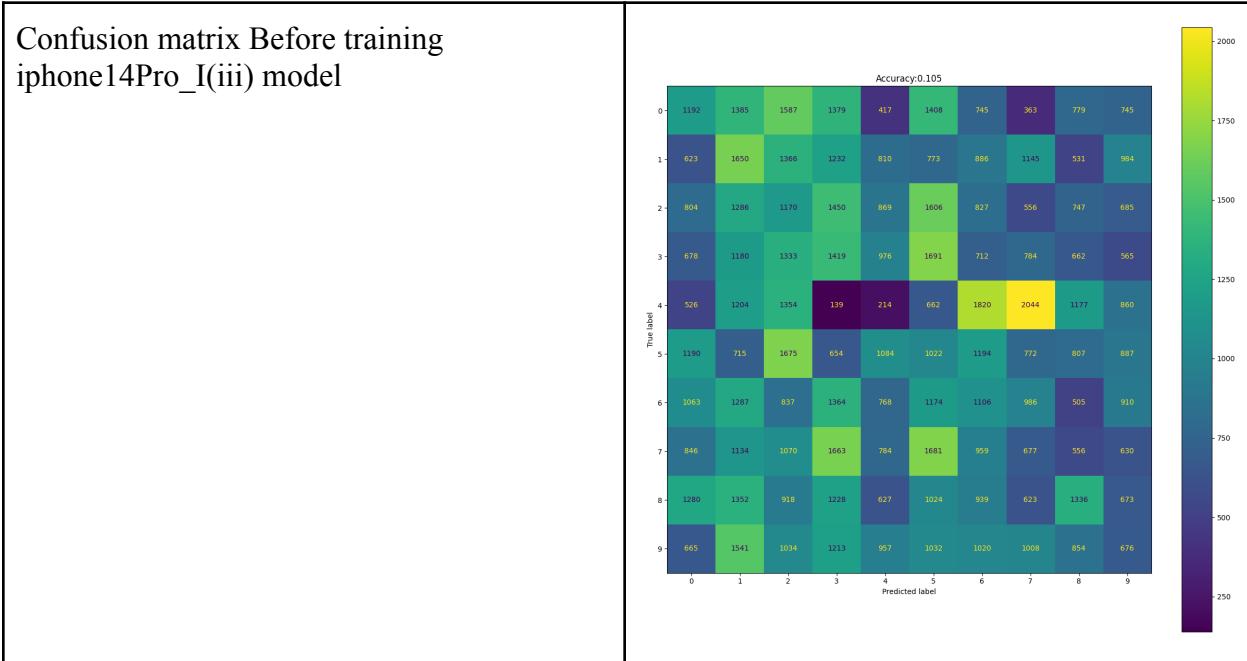


Confusion matrix After apply transfer learning on iphone14Pro\_I(ii) model

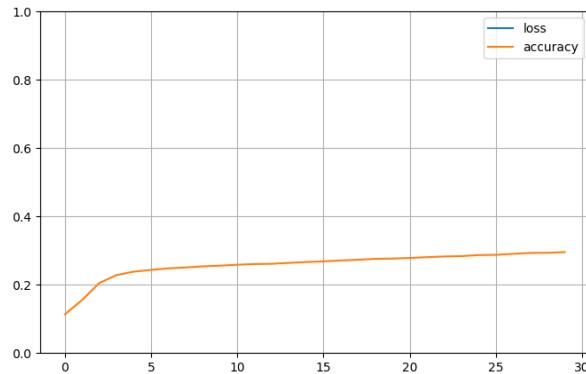


## iPHONE14Pro\_I(iii)\_model.h5

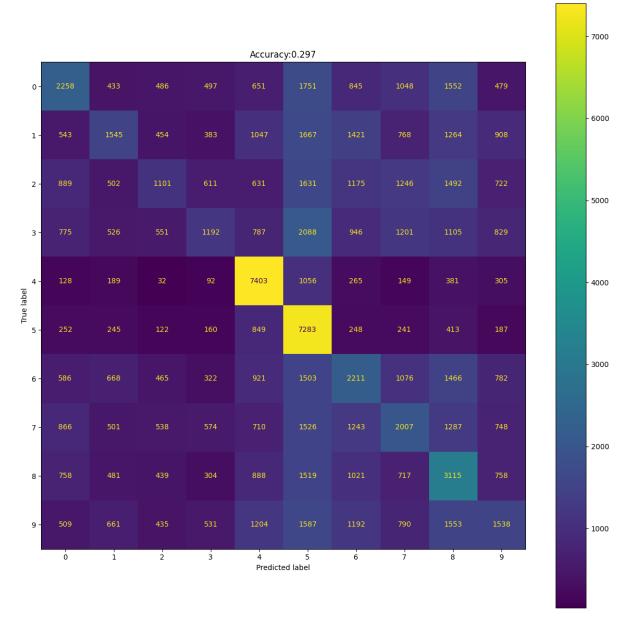
Confusion matrix Before training  
iphone14Pro\_I(iii) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(iii) model

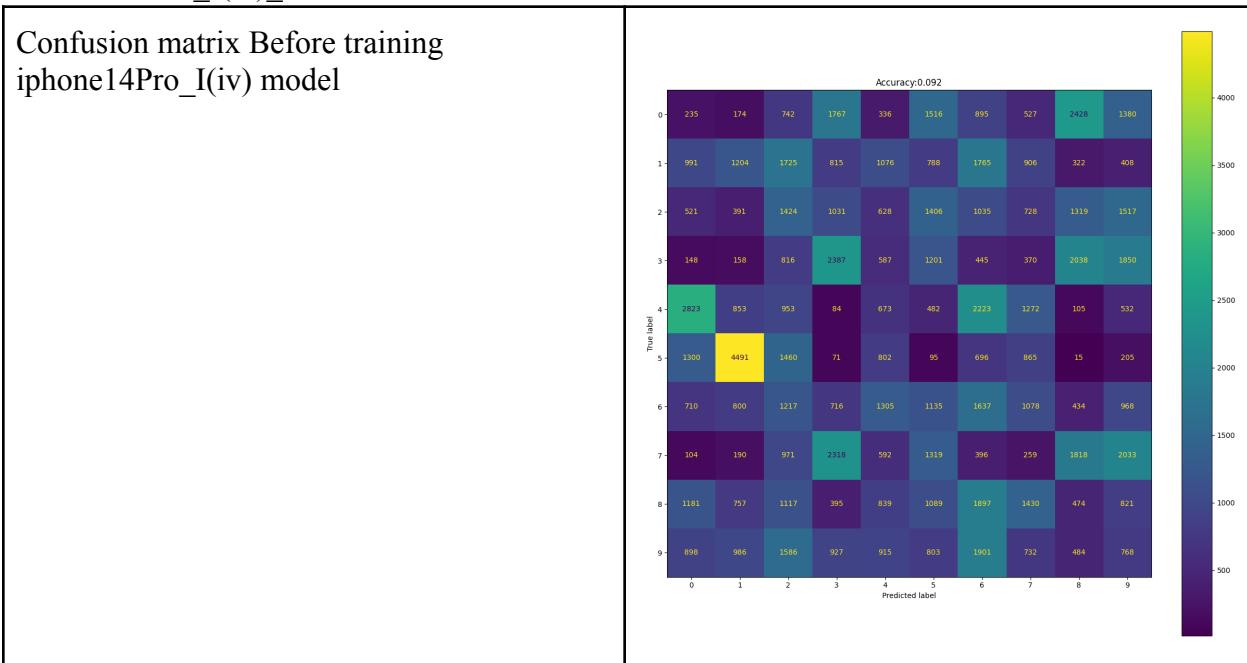


Confusion matrix After apply transfer learning on iphone14Pro\_I(iii) model

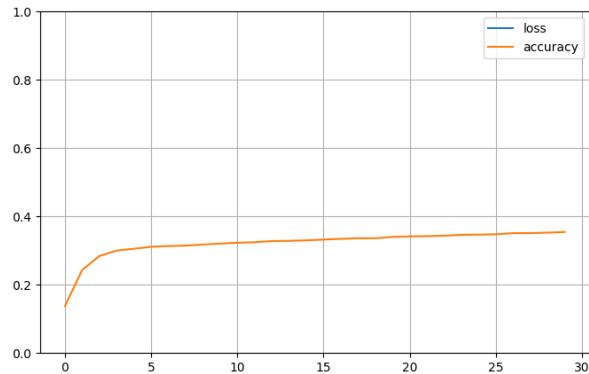


## iPHONE14Pro\_I(iv)\_model.h5

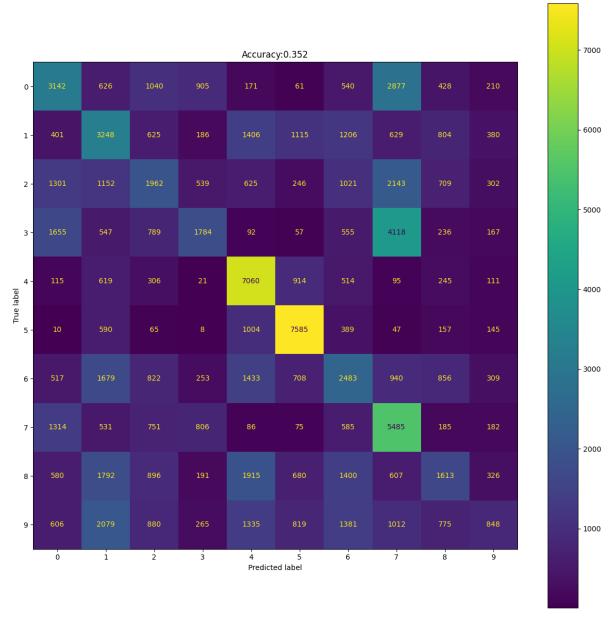
Confusion matrix Before training  
iphone14Pro\_I(iv) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(iv) model

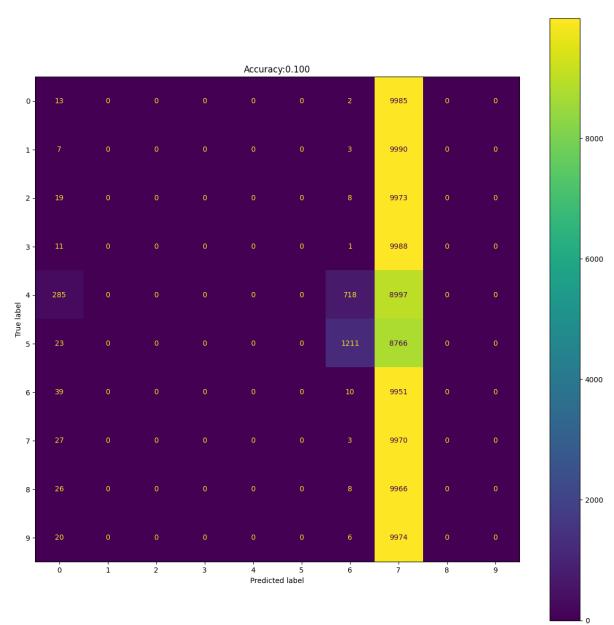


Confusion matrix After apply transfer learning on iphone14Pro\_I(iv) model

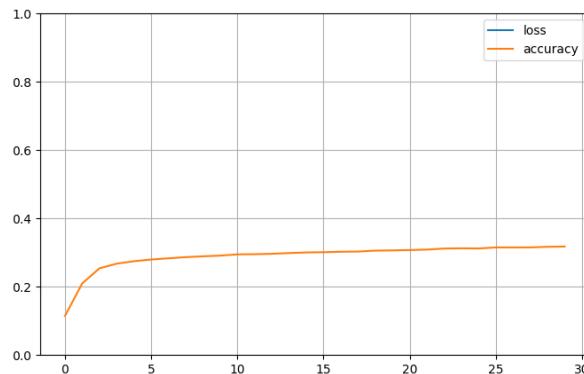


## iPHONE14Pro\_I(v)\_model.h5

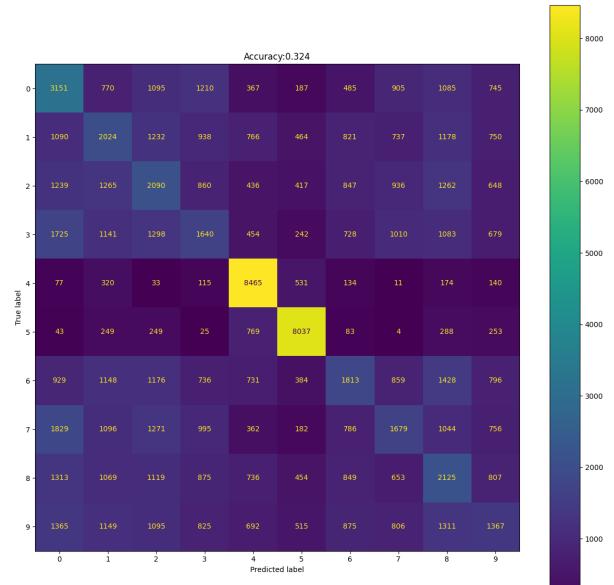
Confusion matrix Before training  
iphone14Pro\_I(v) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(v) model



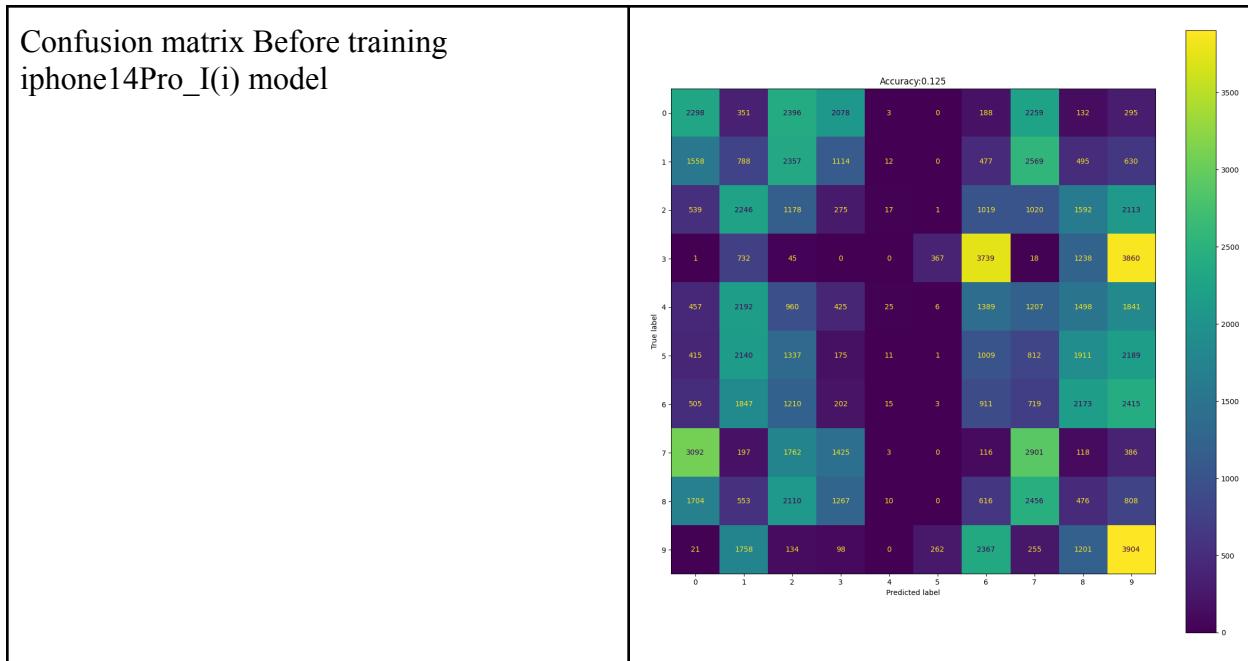
Confusion matrix After apply transfer learning on iphone14Pro\_I(v) model

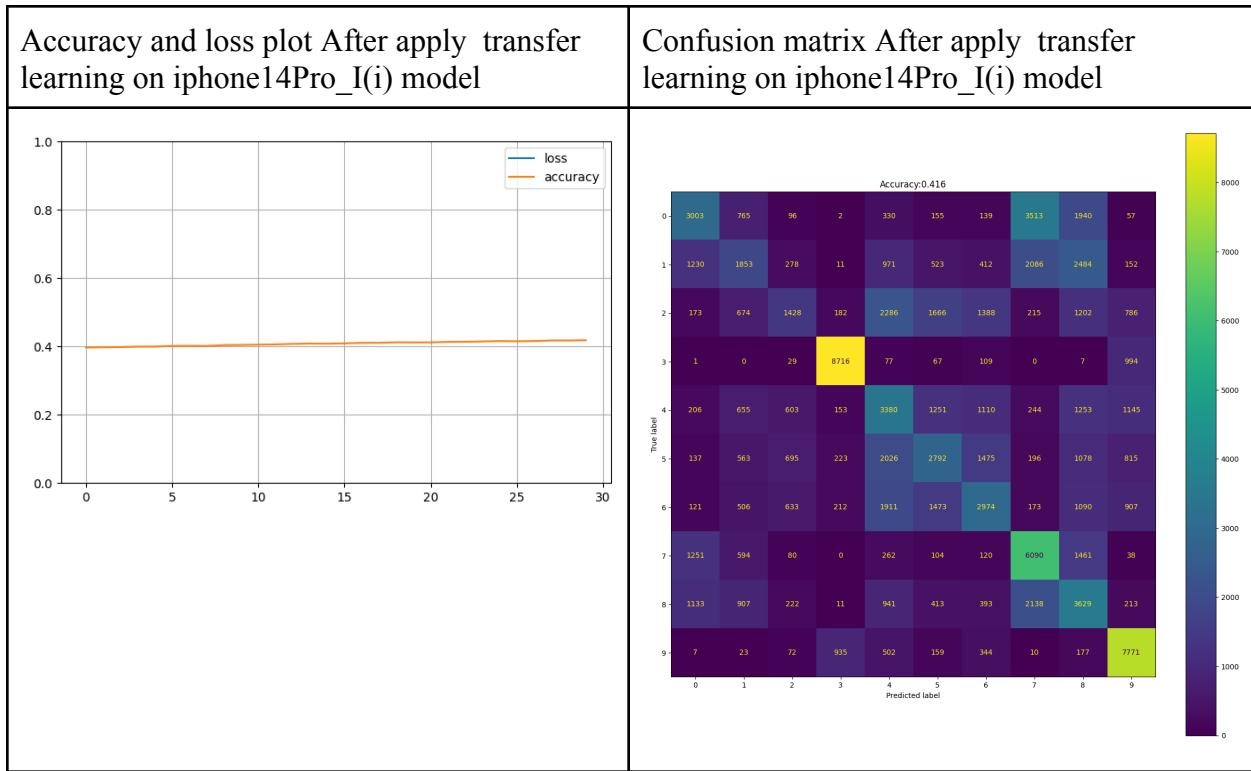


## iPhone14Pro\_I(ii) dataset

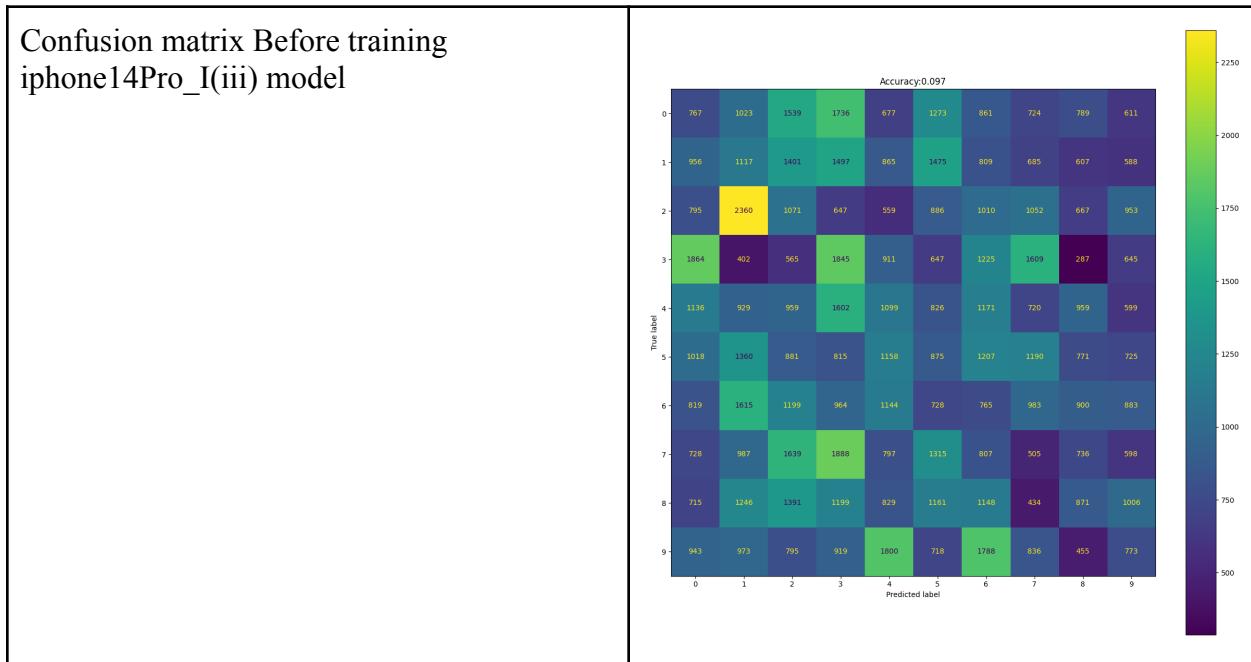
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone14Pro_I(i)_model.h5	0.1248	0.4181	6m 39.7s	0.4164
iPhone14Pro_I(iii)_model.h5	0.0969	0.2953	6m 43.3s	0.2967
iPhone14Pro_I(iv)_model.h5	0.0756	0.3604	7m 9.2s	0.3608
iPhone14Pro_I(v)_model.h5	0.1000	0.3092	6m 44.2s	0.3109

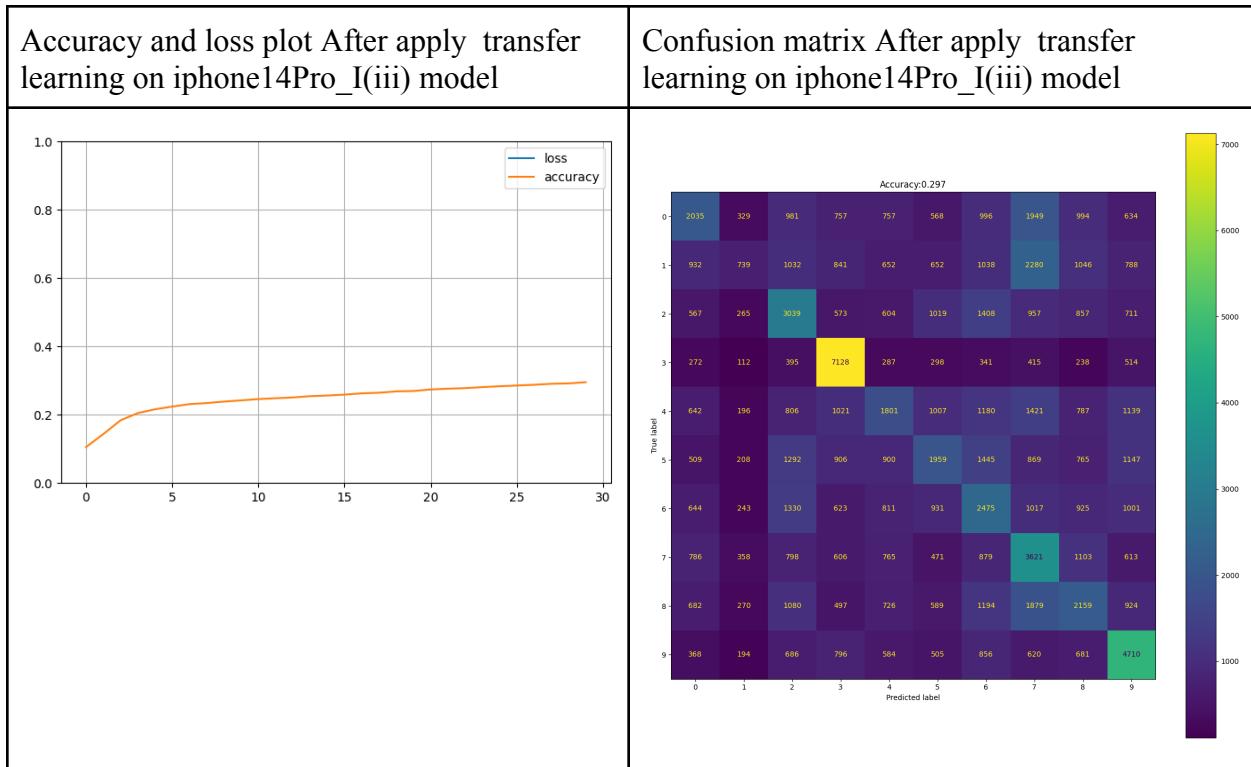
iPhone14Pro\_I(i)\_model.h5



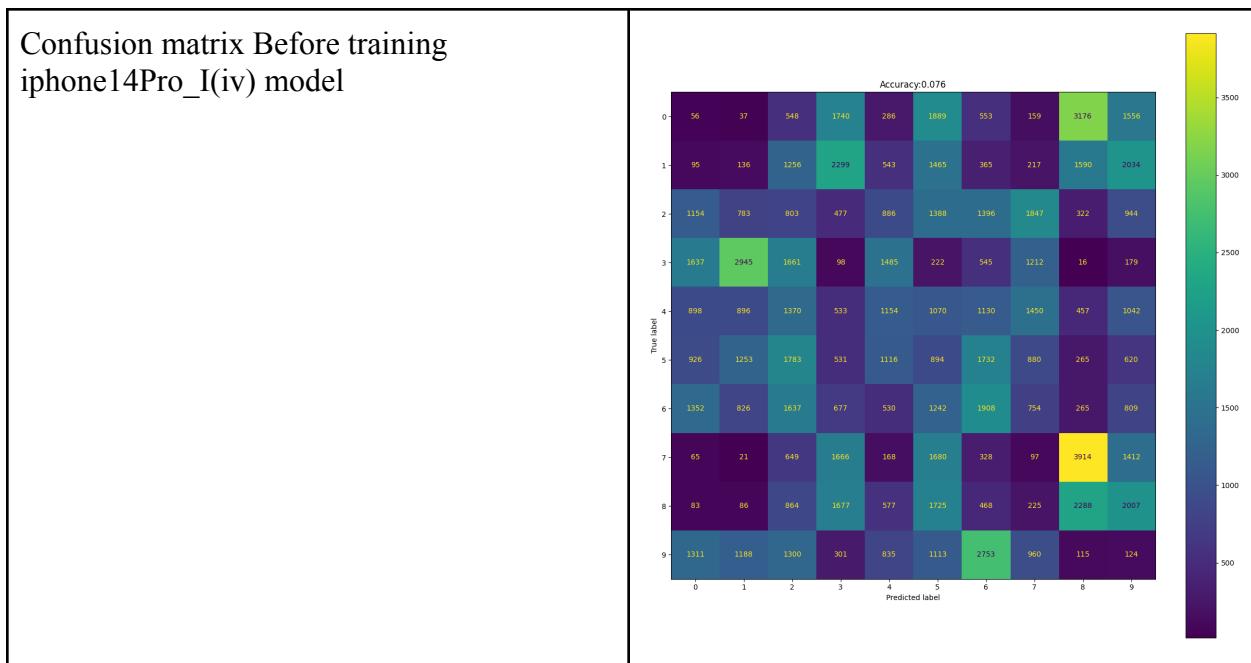


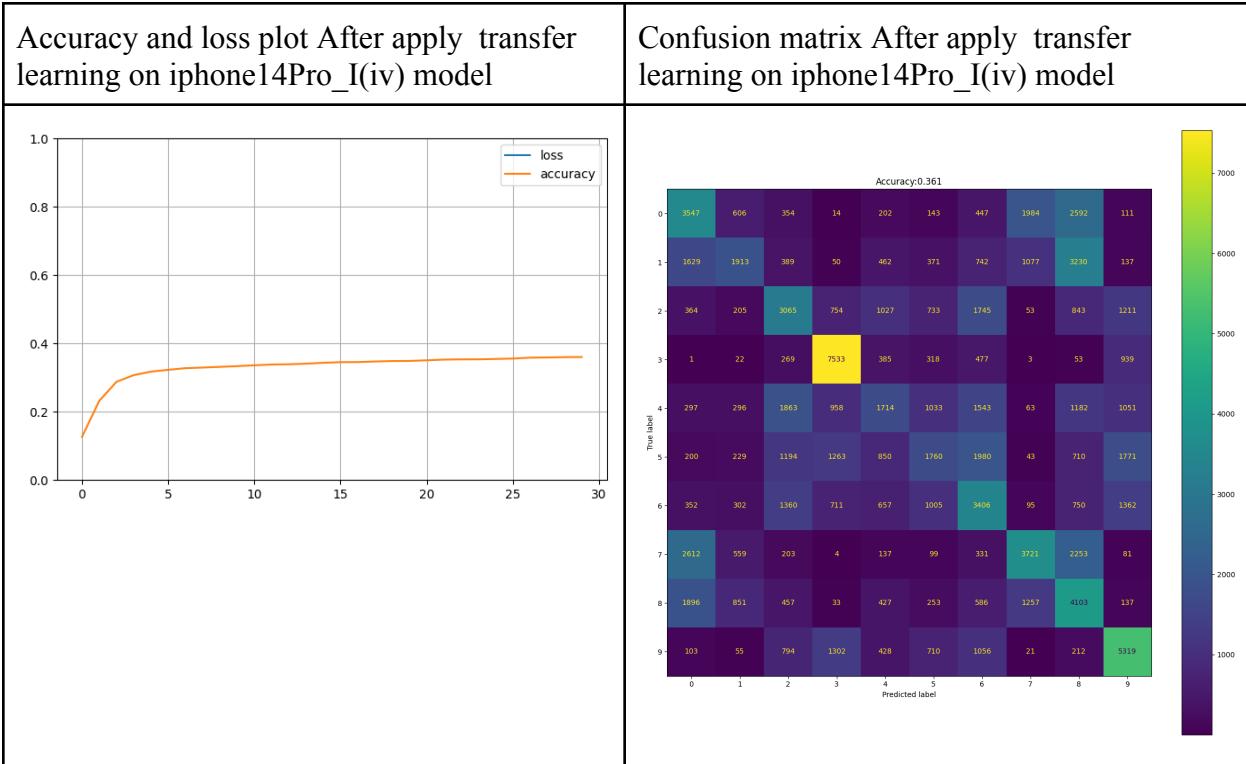
iPHONE14Pro\_I(iii)\_model.h5



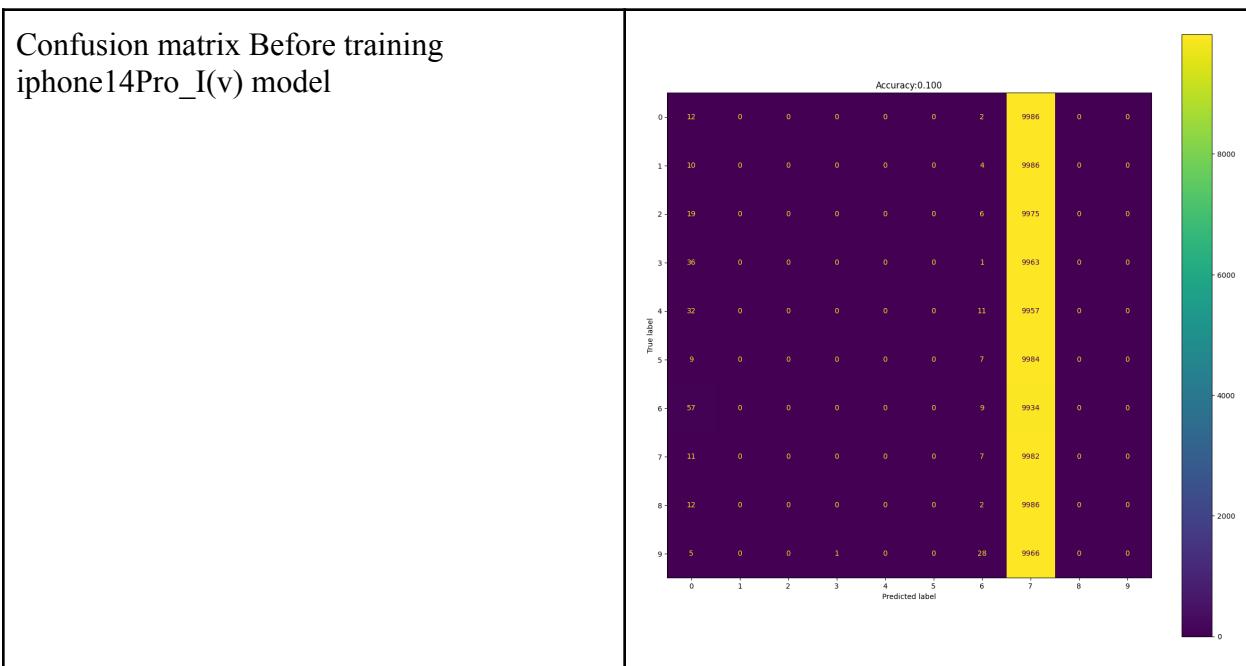


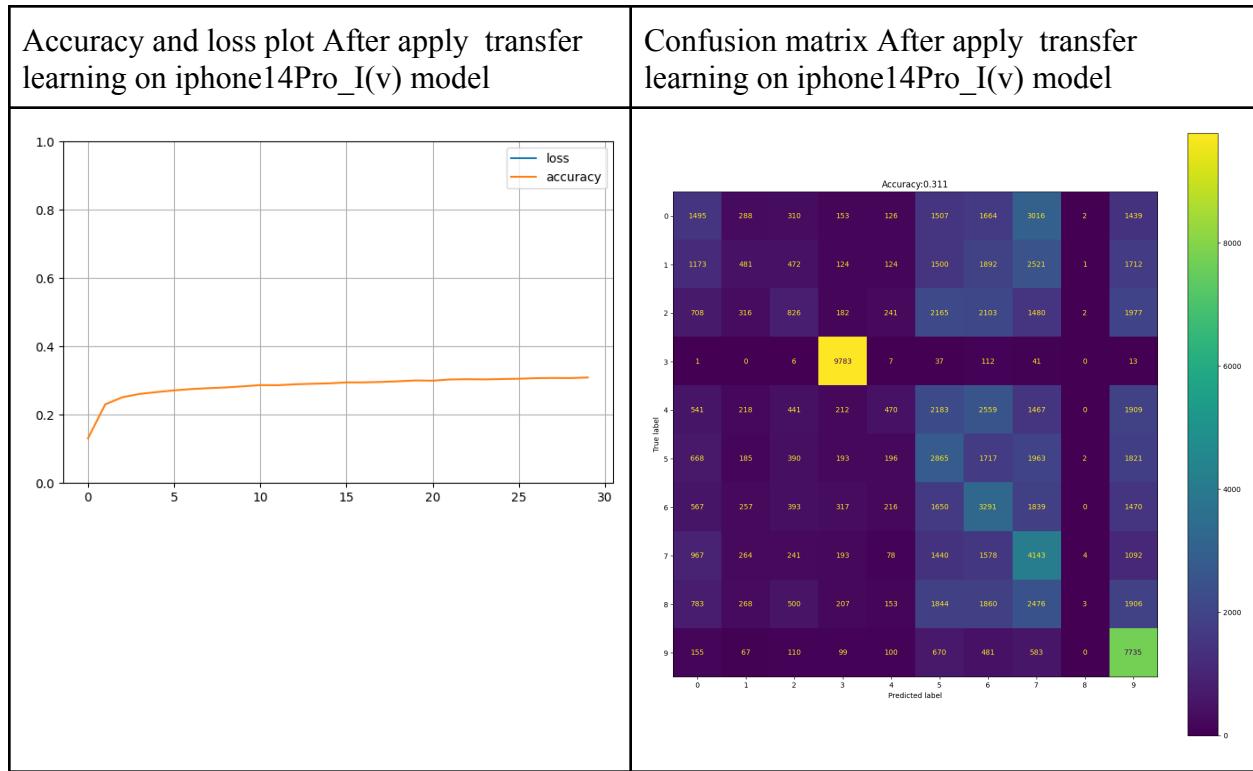
iPHONE14Pro\_I(iv)\_model.h5





iPHONE14Pro\_I(v)\_model.h5



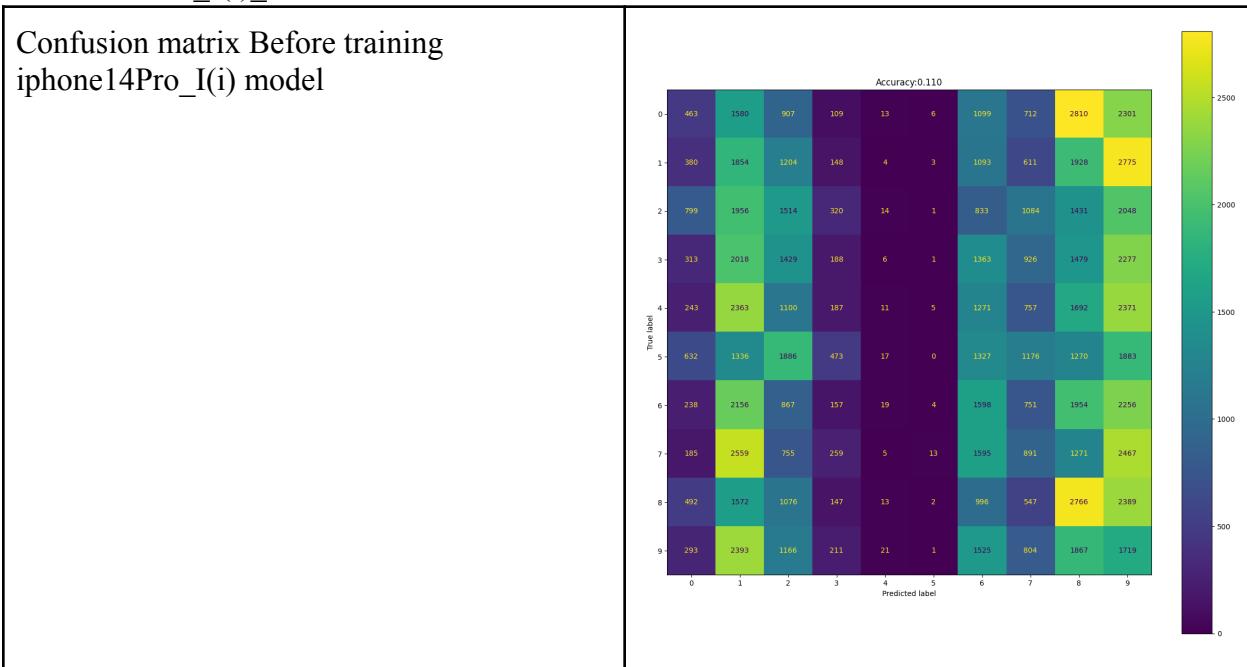


### iPhone14Pro\_I(iii) dataset

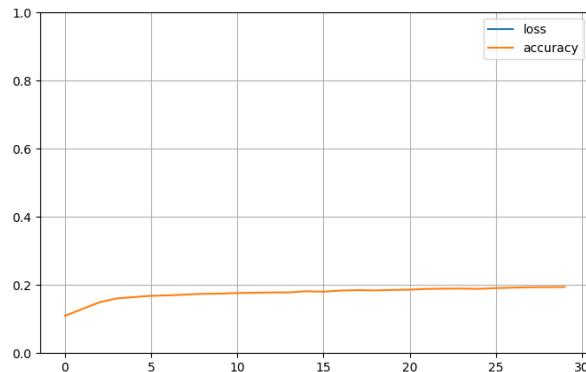
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone14Pro_I(i)_model.h5	0.1100	0.1941	7m 32.3s	0.1941
iPhone14Pro_I(ii)_model.h5	0.0904	0.2060	7m 41.0s	0.2065
iPhone14Pro_I(iv)_model.h5	0.1049	0.2125	6m 59.7s	0.2118
iPhone14Pro_I(v)_model.h5	0.1000	0.1801	7m 40.7s	0.1796

iPHONE14Pro\_I(i)\_model.h5

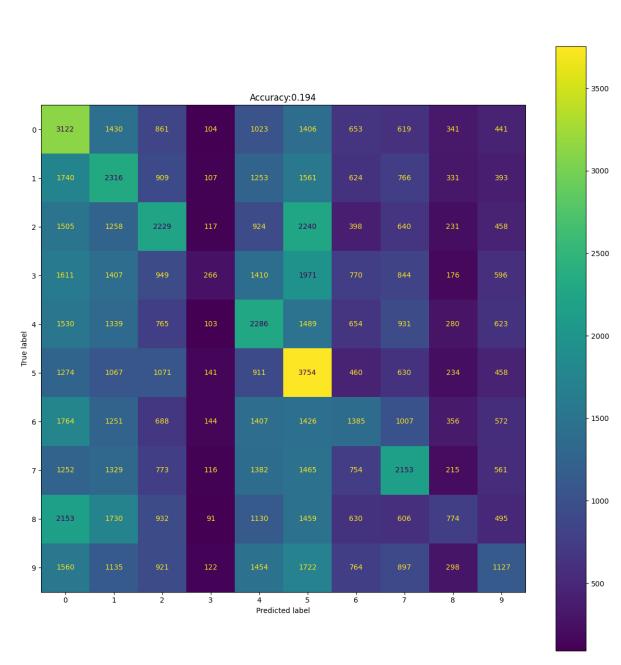
Confusion matrix Before training  
iphone14Pro\_I(i) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(i) model

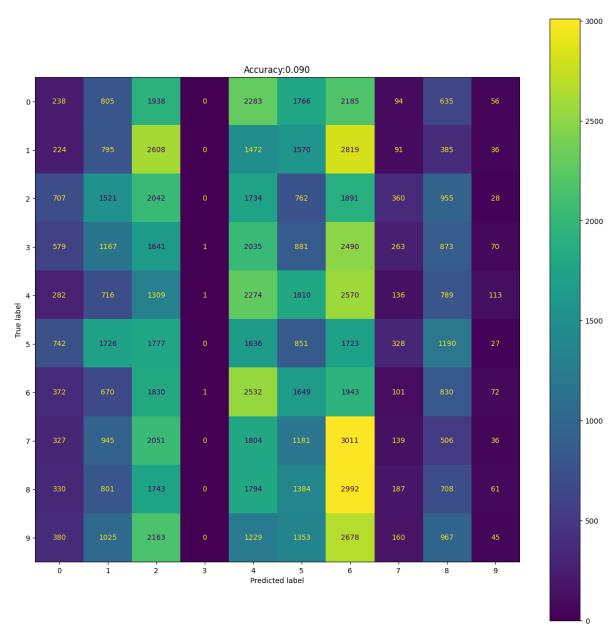


Confusion matrix After apply transfer learning on iphone14Pro\_I(i) model

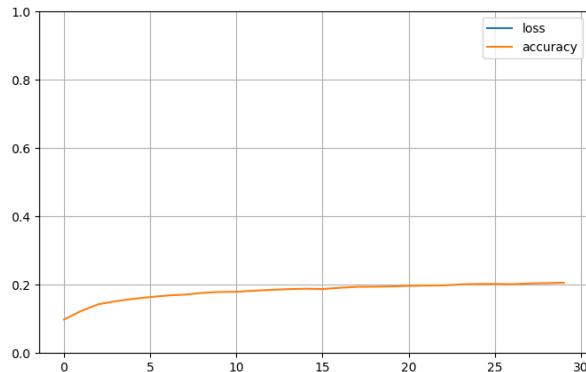


## iPHONE14Pro\_I(ii)\_model.h5

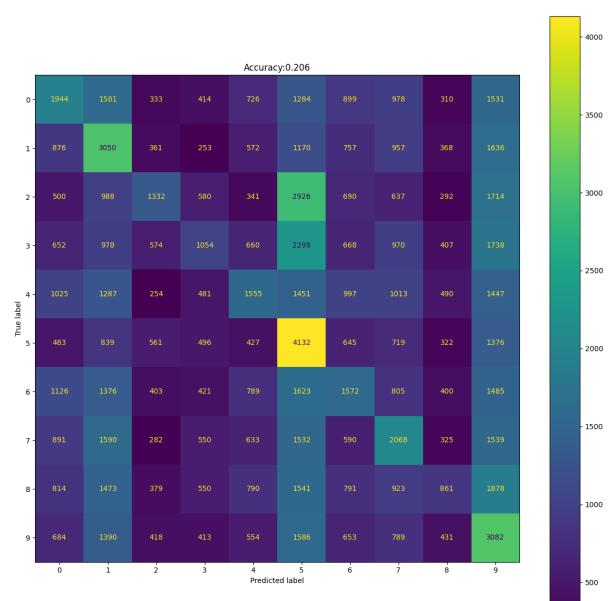
Confusion matrix Before training  
iphone14Pro\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(ii) model

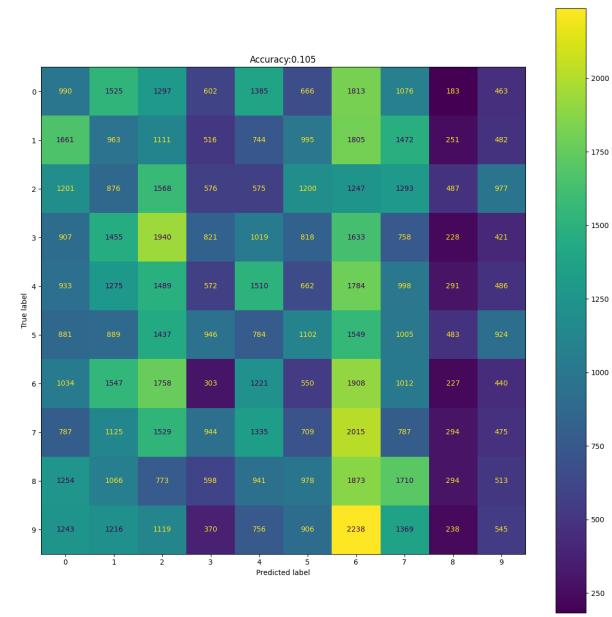


Confusion matrix After apply transfer learning on iphone14Pro\_I(ii) model

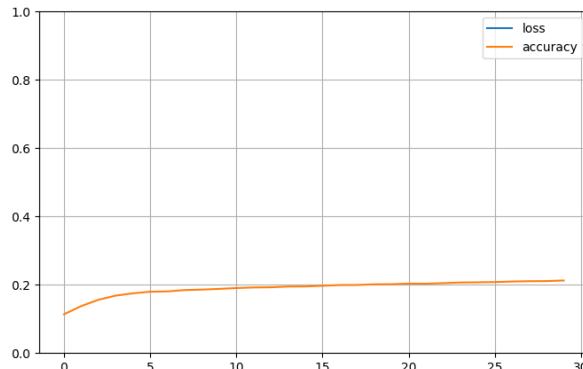


## iPHONE14Pro\_I(iv)\_model.h5

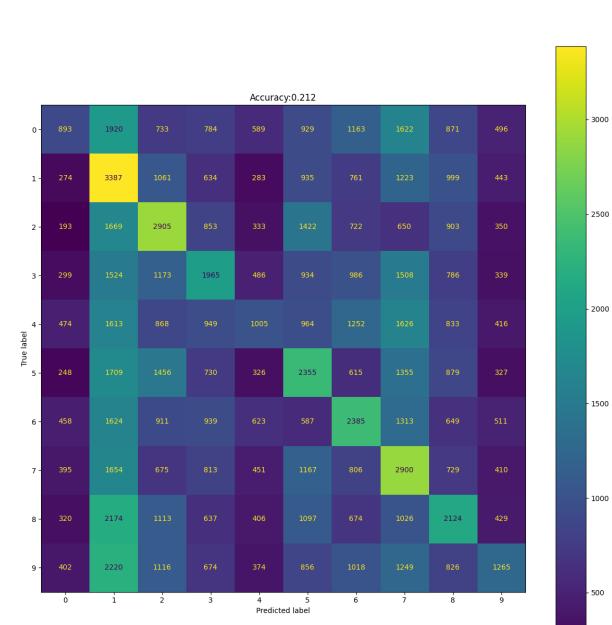
Confusion matrix Before training  
iphone14Pro\_I(iv) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(iv) model

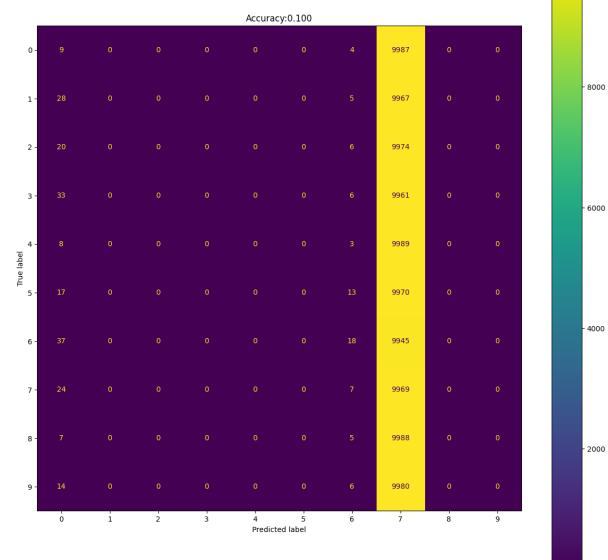


Confusion matrix After apply transfer learning on iphone14Pro\_I(iv) model

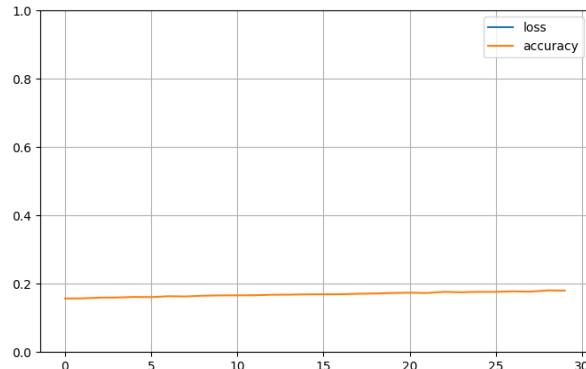


## iPHONE14Pro\_I(v)\_model.h5

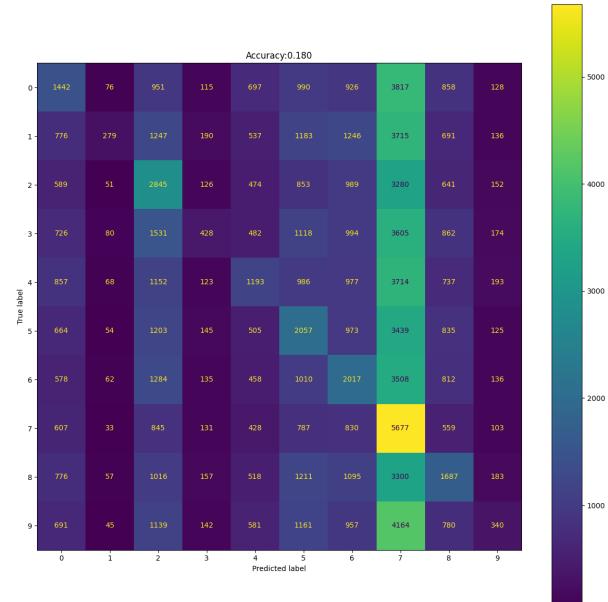
Confusion matrix Before training  
iphone14Pro\_I(v) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(v) model



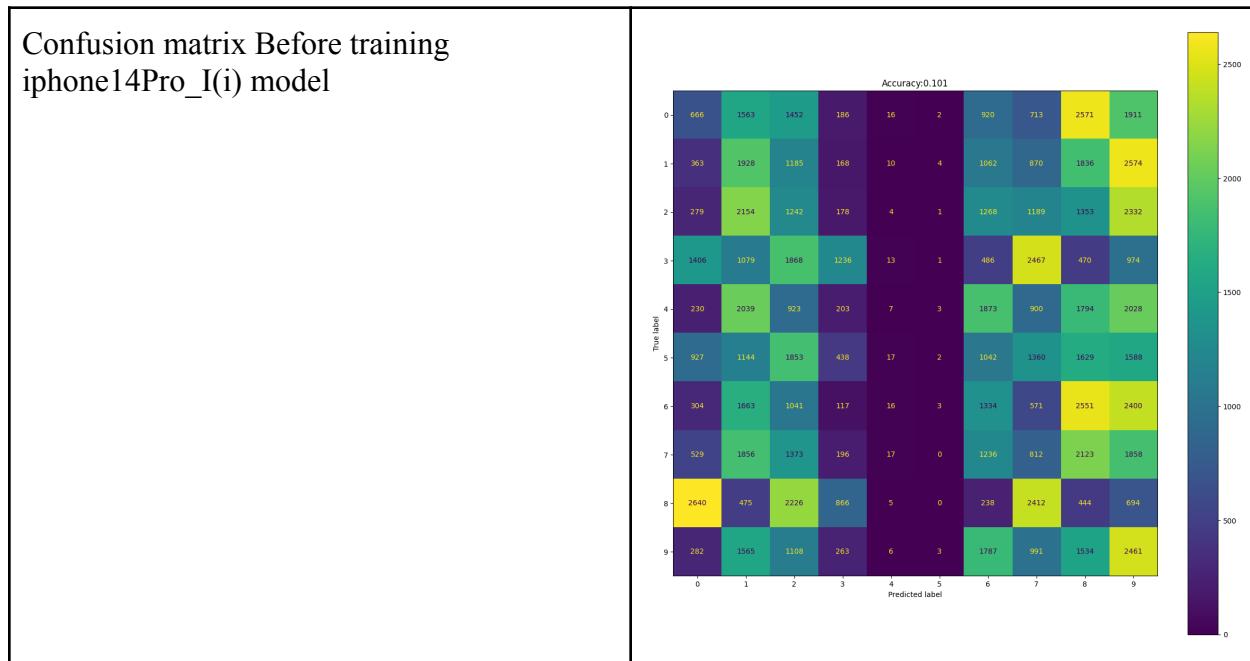
Confusion matrix After apply transfer learning on iphone14Pro\_I(v) model

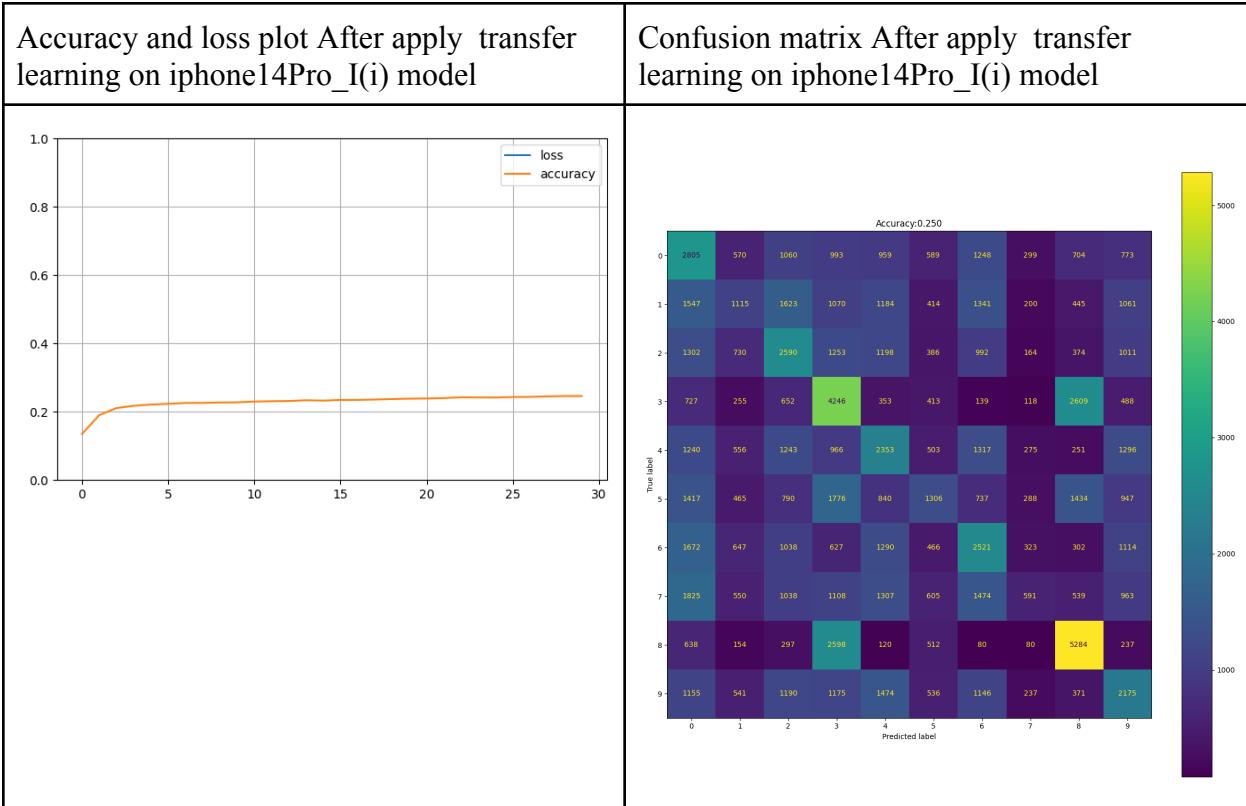


## iPhone14Pro\_I(iv) dataset

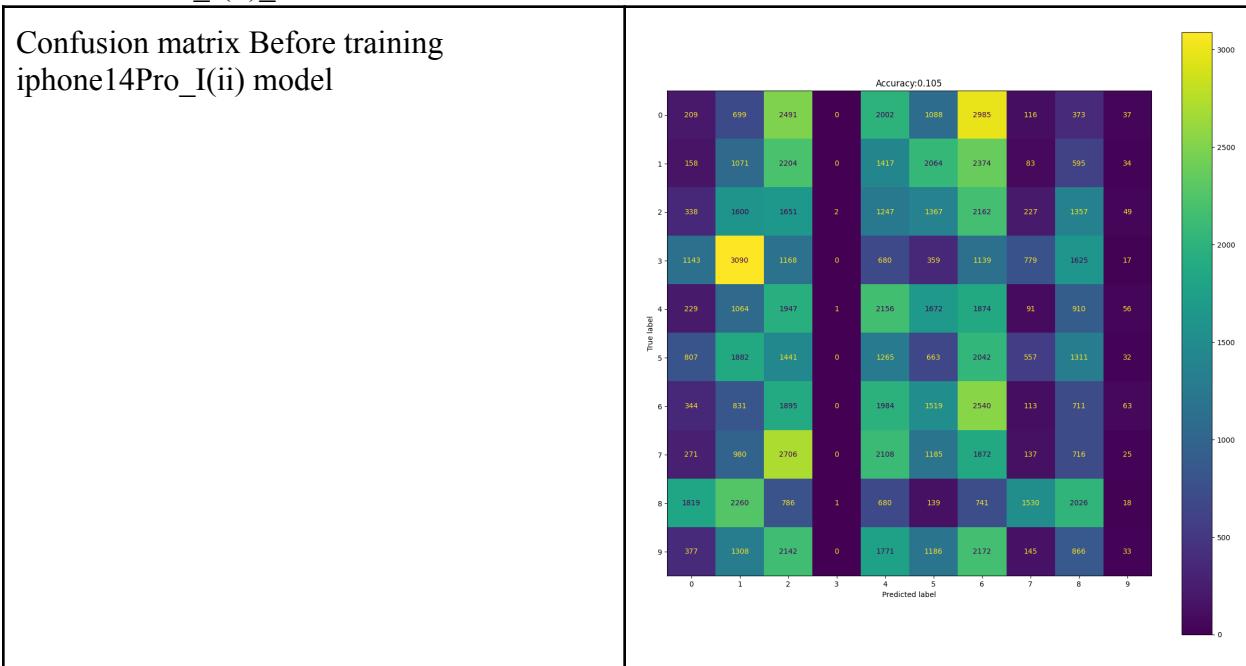
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone14Pro_I(i)_model.h5	0.1013	0.2460	5m 52.9s	0.2499
iPhone14Pro_I(ii)_model.h5	0.1049	0.2507	5m 49.1s	0.2521
iPhone14Pro_I(iii)_model.h5	0.1027	0.2278	5m 56.3s	0.2272
iPhone14Pro_I(v)_model.h5	0.1000	0.1567	6m 1.9s	0.1642

iPhone14Pro\_I(i)\_model.h5

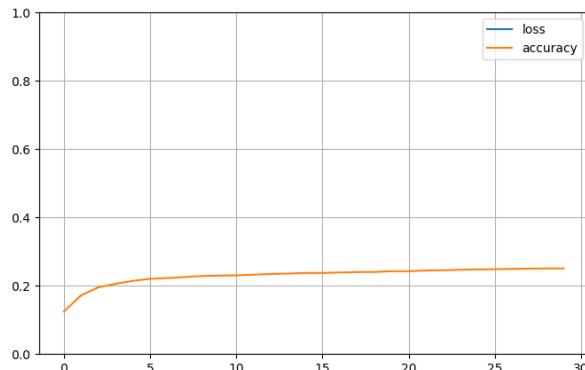




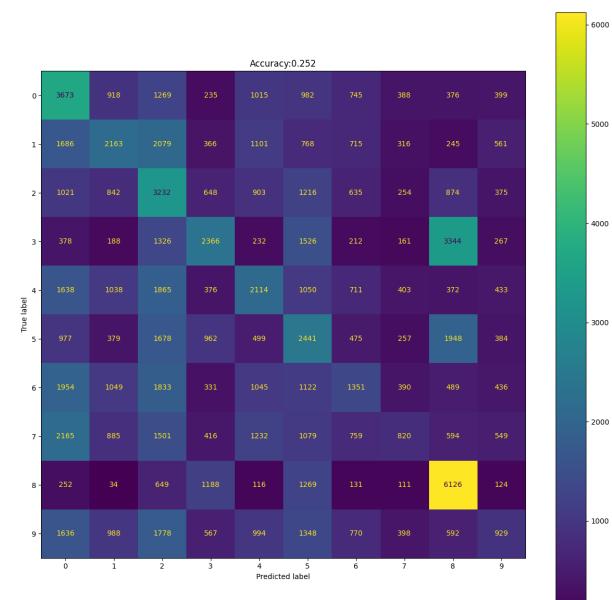
iPhone14Pro\_I(ii)\_model.h5



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(ii) model

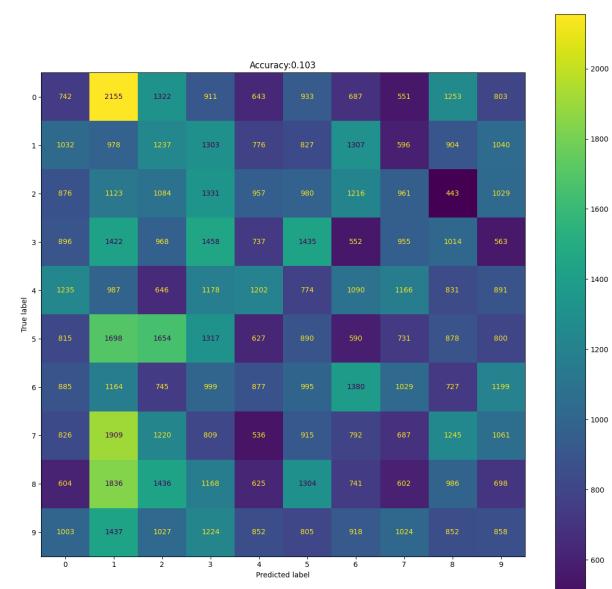


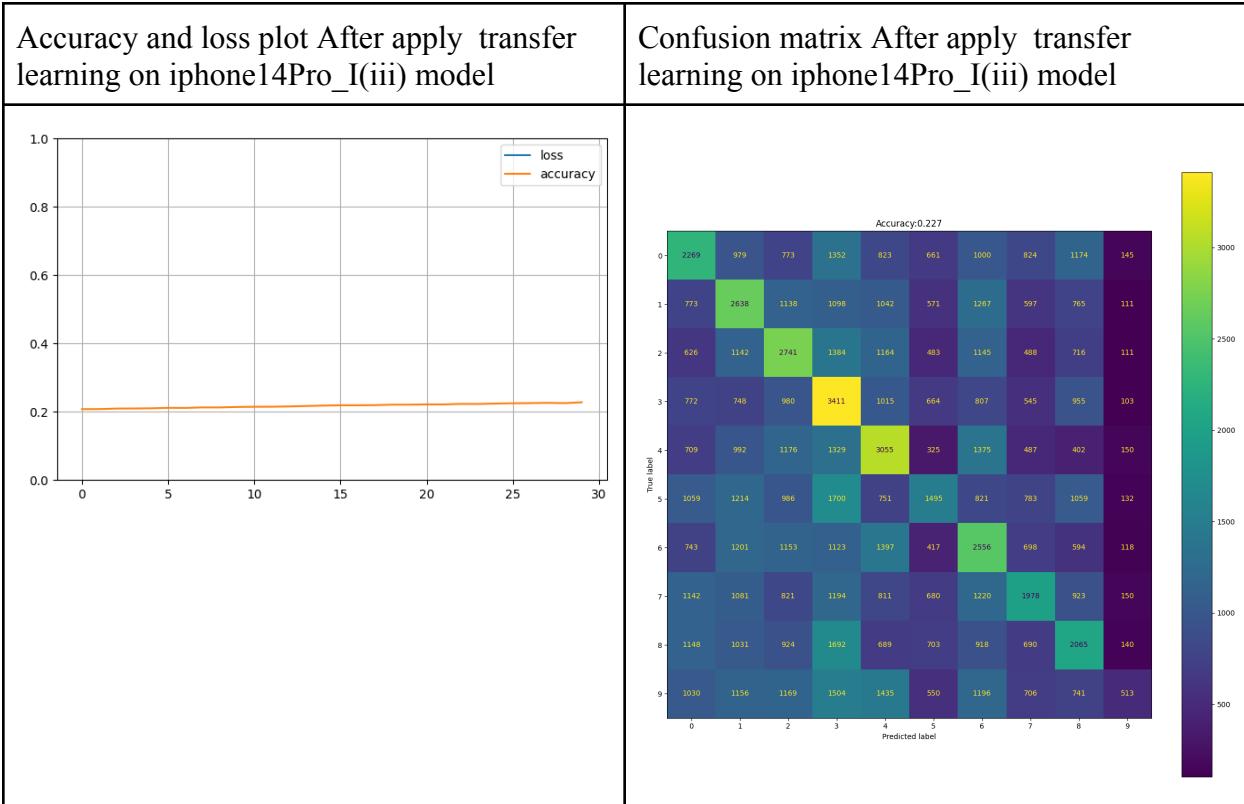
Confusion matrix After apply transfer learning on iphone14Pro\_I(ii) model



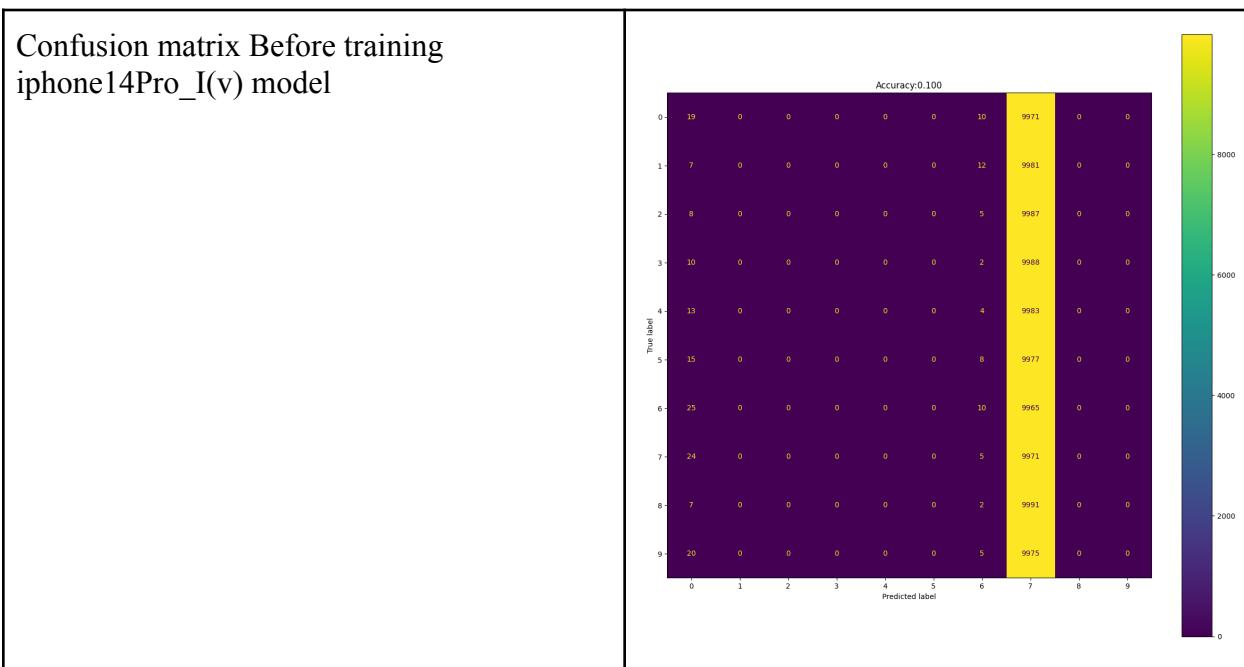
iPHONE14Pro\_I(iii)\_model.h5

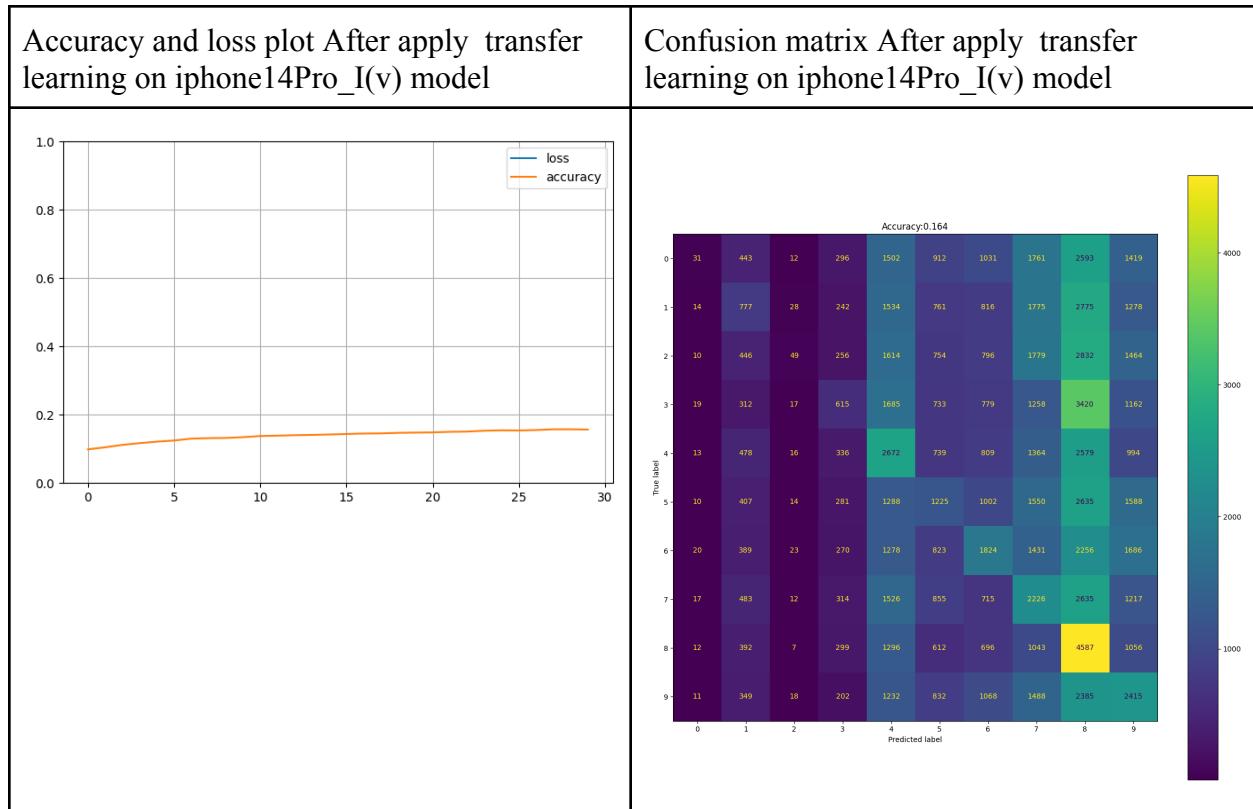
Confusion matrix Before training iphone14Pro\_I(iii) model





iPHONE14Pro\_I(v)\_model.h5



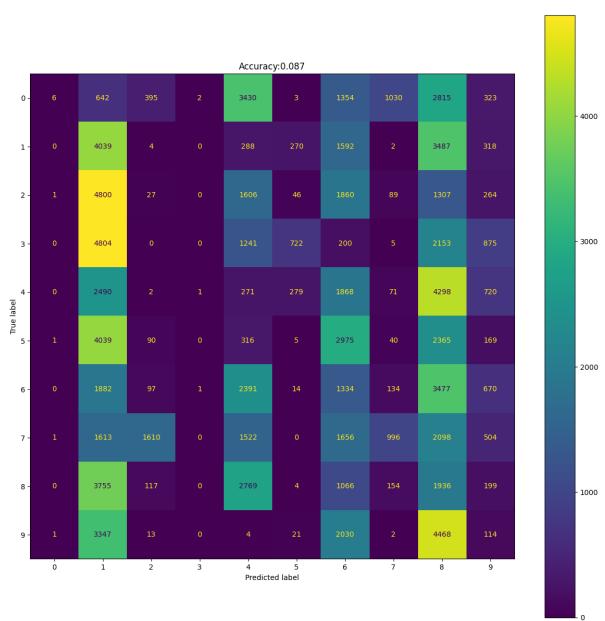


### iPhone14Pro\_I(v) dataset

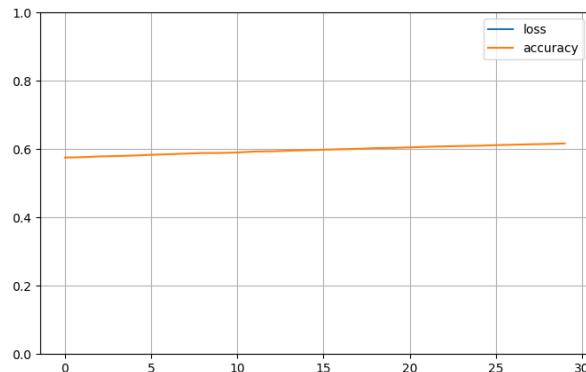
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iPhone14Pro_I(i)_model.h5	0.0873	0.6167	5m 40.6s	0.6161
iPhone14Pro_I(ii)_model.h5	0.0836	0.6330	5m 48.6s	0.6336
iPhone14Pro_I(iii)_model.h5	0.0962	0.4784	6m 5.7s	0.4801
iPhone14Pro_I(iv)_model.h5	0.1036	0.4865	5m 50.7s	0.4868

## iPHONE14Pro\_I(i)\_model.h5

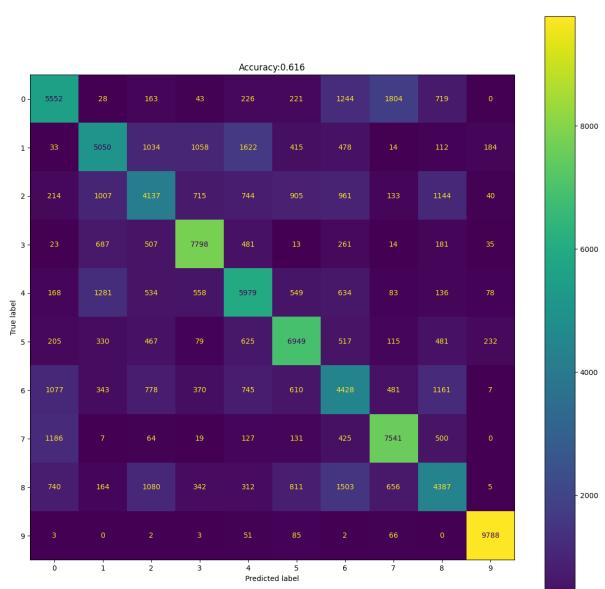
Confusion matrix Before training  
iphone14Pro\_I(i) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(i) model

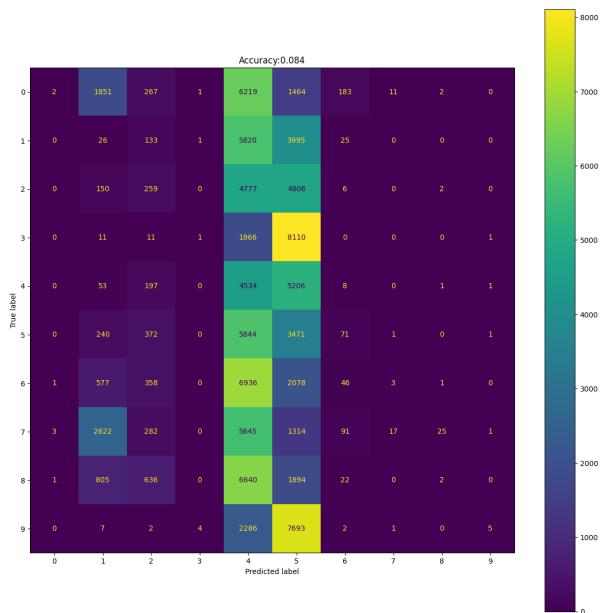


Confusion matrix After apply transfer learning on iphone14Pro\_I(i) model

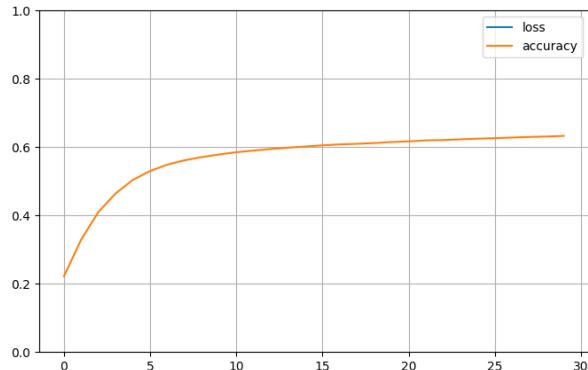


## iPHONE14Pro\_I(ii)\_model.h5

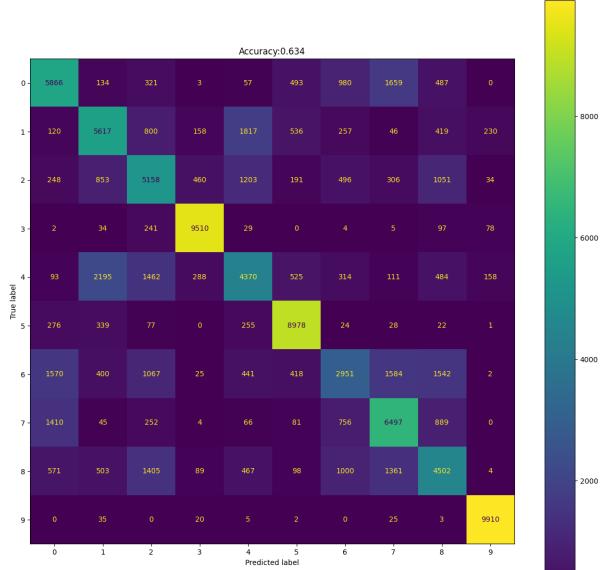
Confusion matrix Before training  
iphone14Pro\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(ii) model

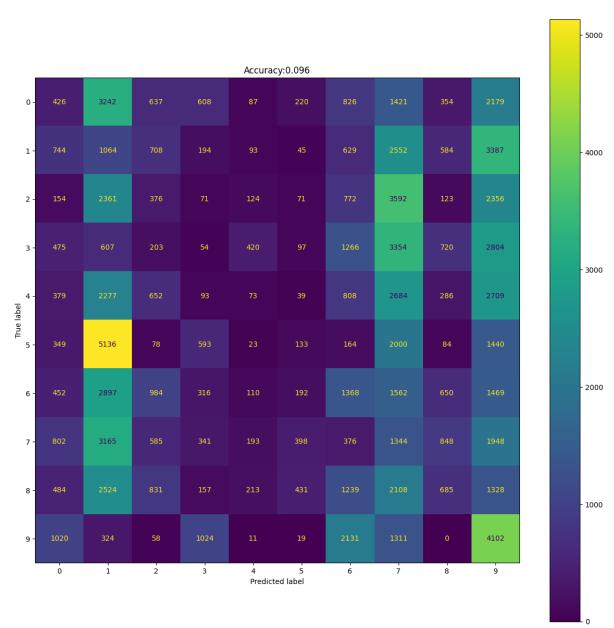


Confusion matrix After apply transfer learning on iphone14Pro\_I(ii) model

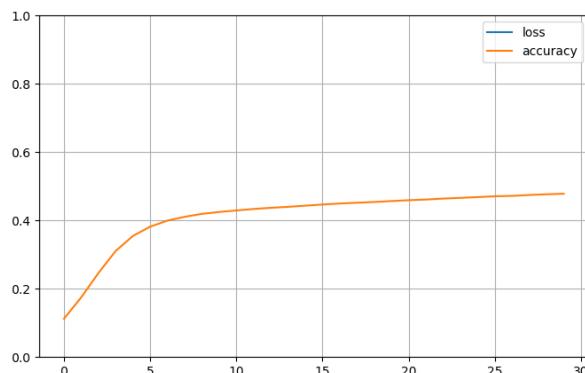


## iPHONE14Pro\_I(iii)\_model.h5

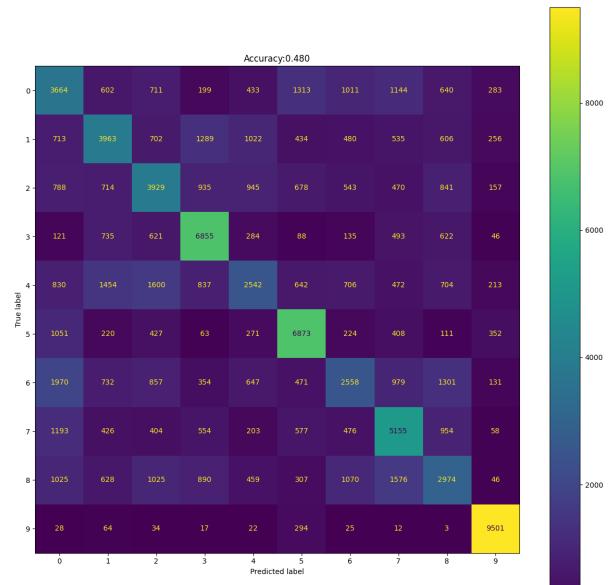
Confusion matrix Before training  
iphone14Pro\_I(iii) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(iii) model

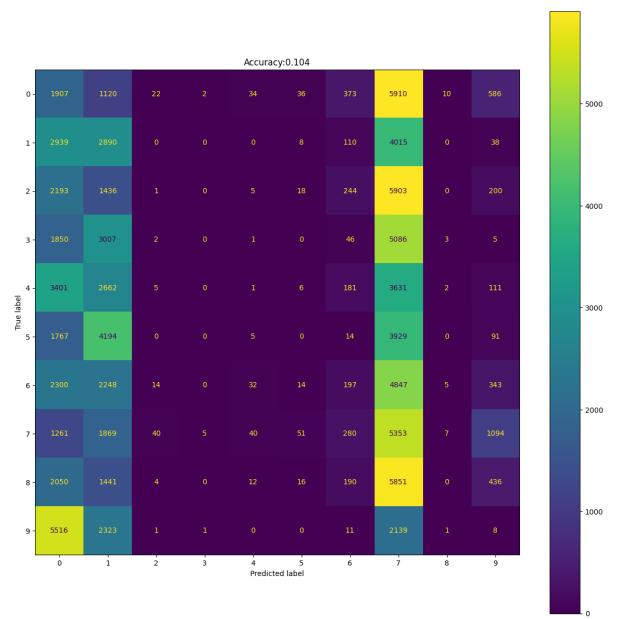


Confusion matrix After apply transfer learning on iphone14Pro\_I(iii) model

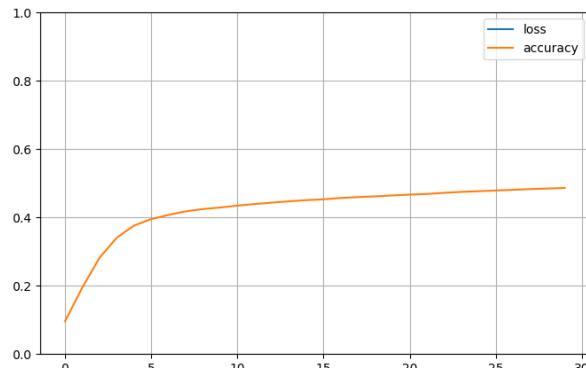


## iPHONE14Pro\_I(iv)\_model.h5

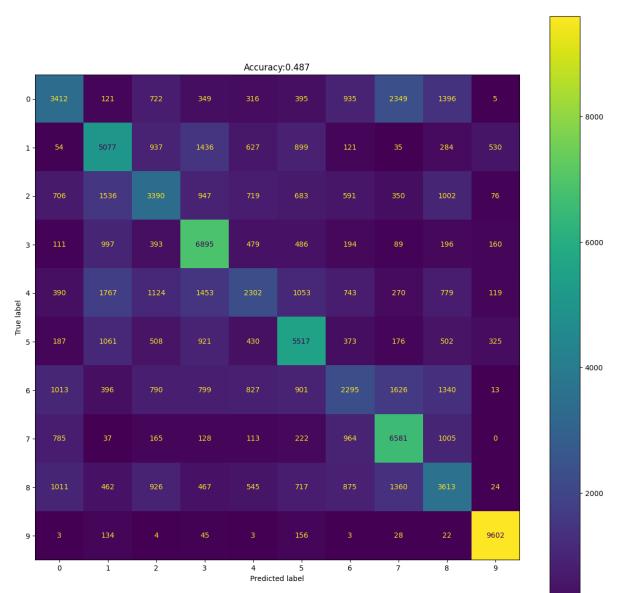
Confusion matrix Before training  
iphone14Pro\_I(iv) model



Accuracy and loss plot After apply transfer learning on iphone14Pro\_I(iv) model



Confusion matrix After apply transfer learning on iphone14Pro\_I(iv) model

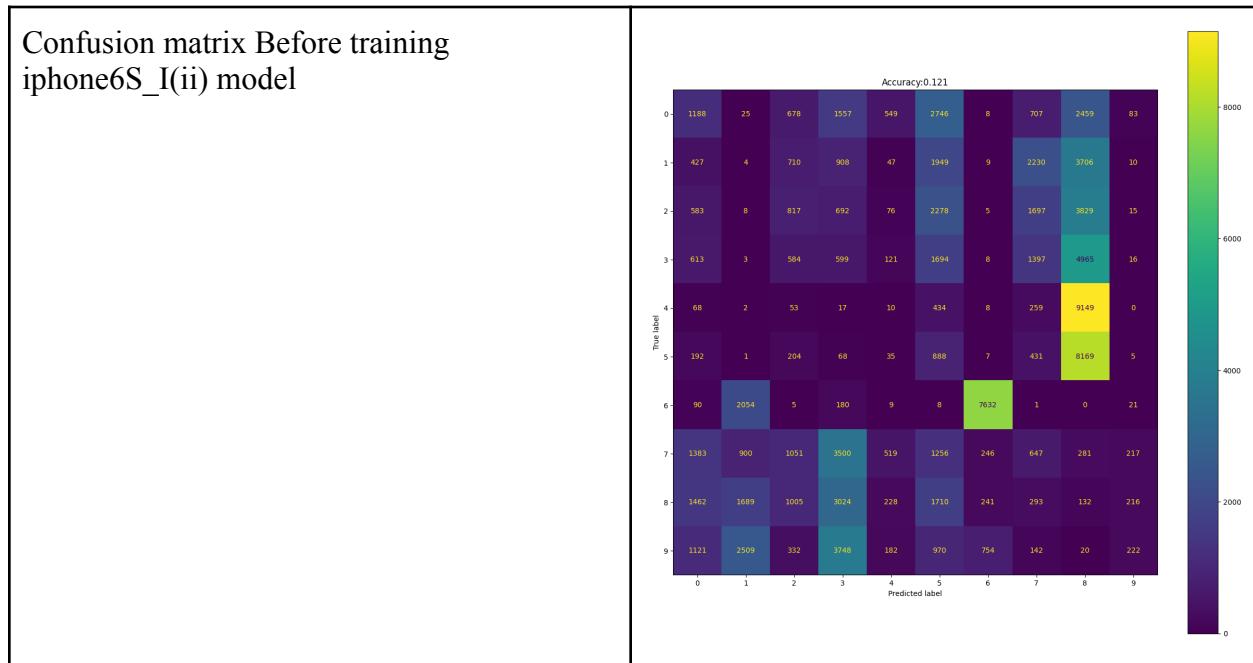


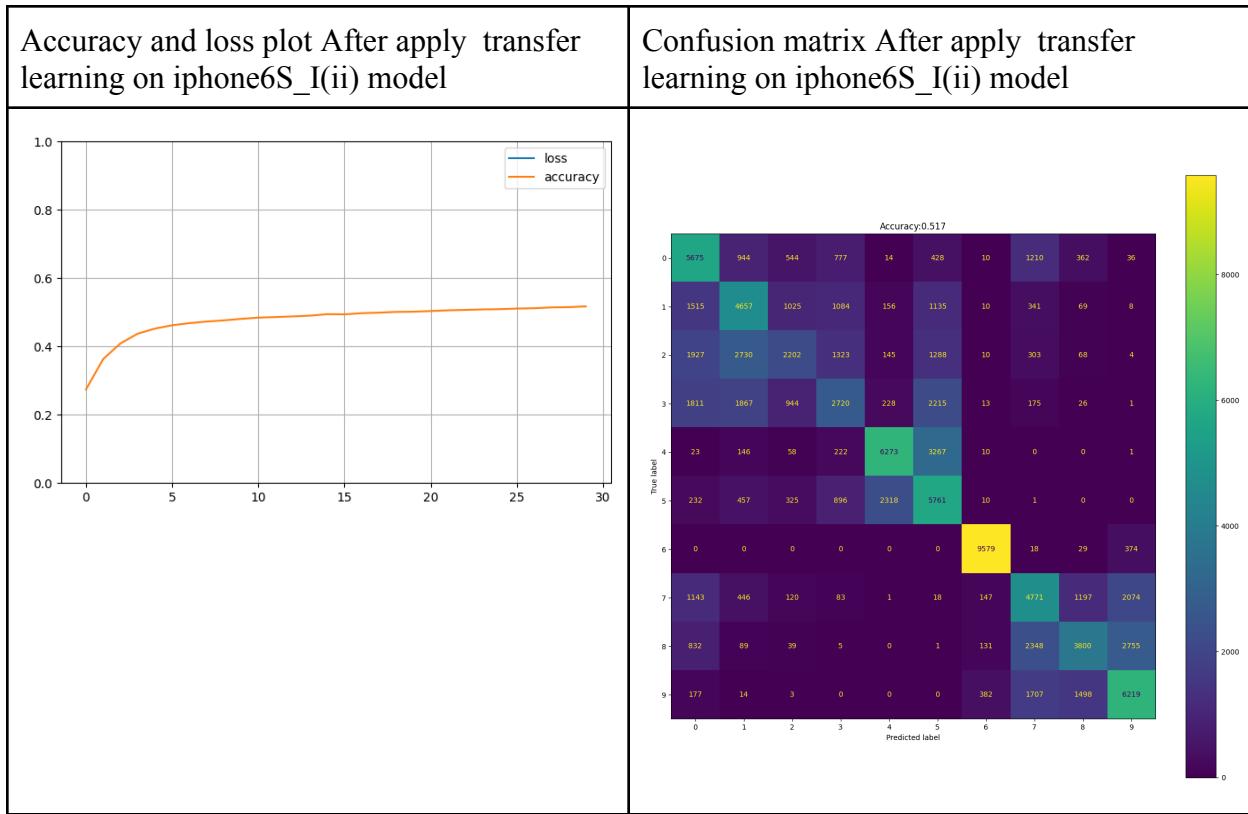
## iPhone6S

### iPhone6S\_I dataset

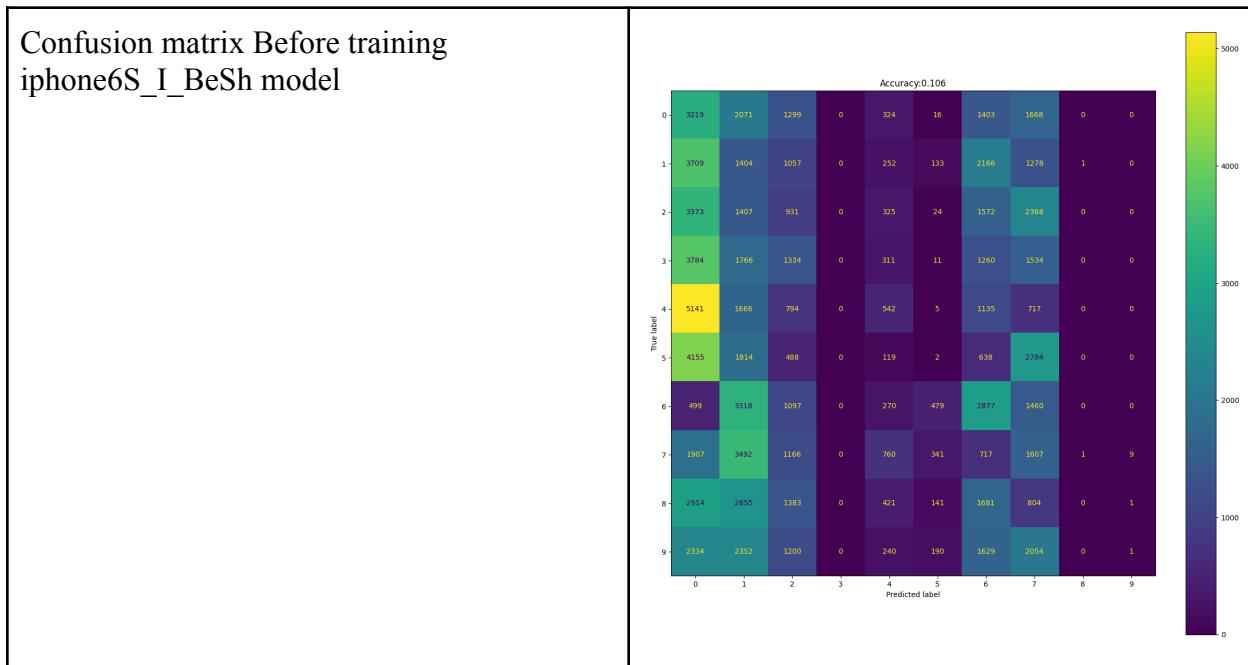
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iphone6S_I(ii)_model.h5	0.1214	0.5174	6m 30.9s	0.5166
iphone6S_I_BeSh_model.h5	0.1058	0.3555	6m 17.7s	0.3624

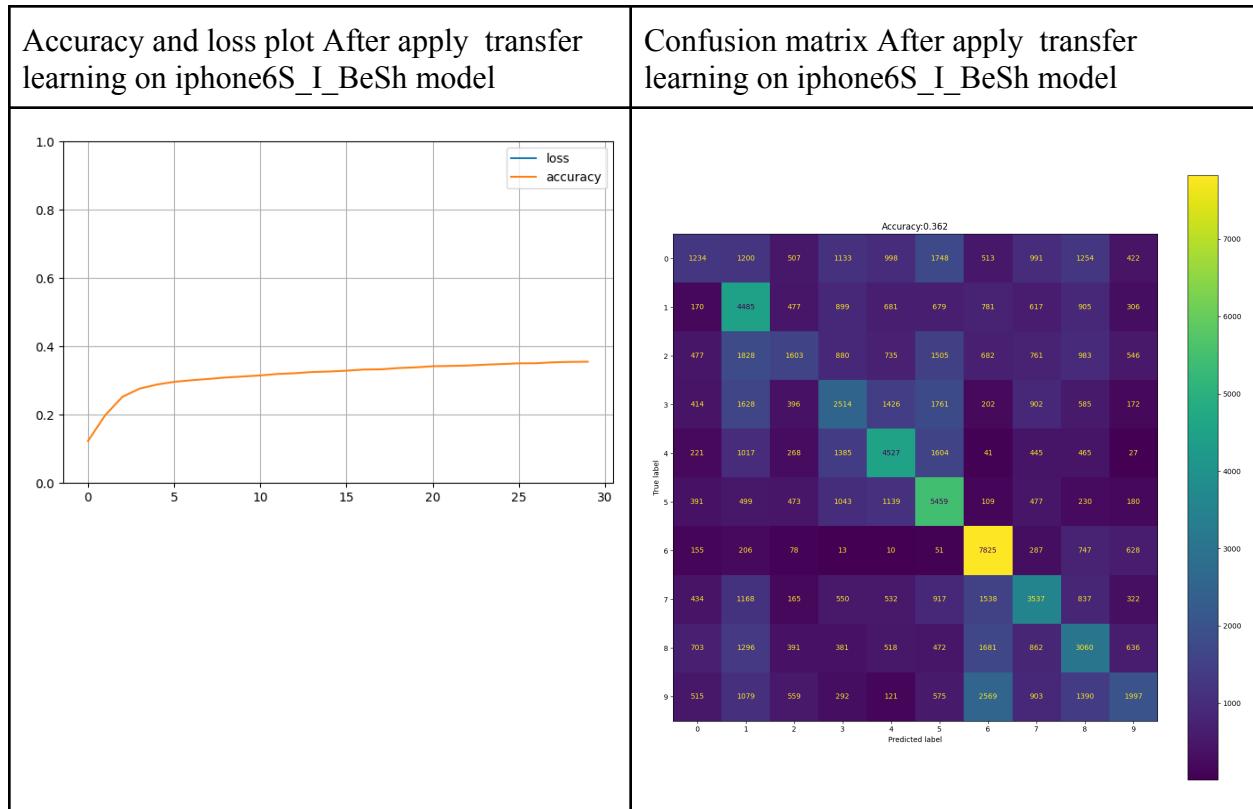
iPhone6S\_I(ii)\_model.h5





iPHONE6S\_I\_BeSh\_model.h5



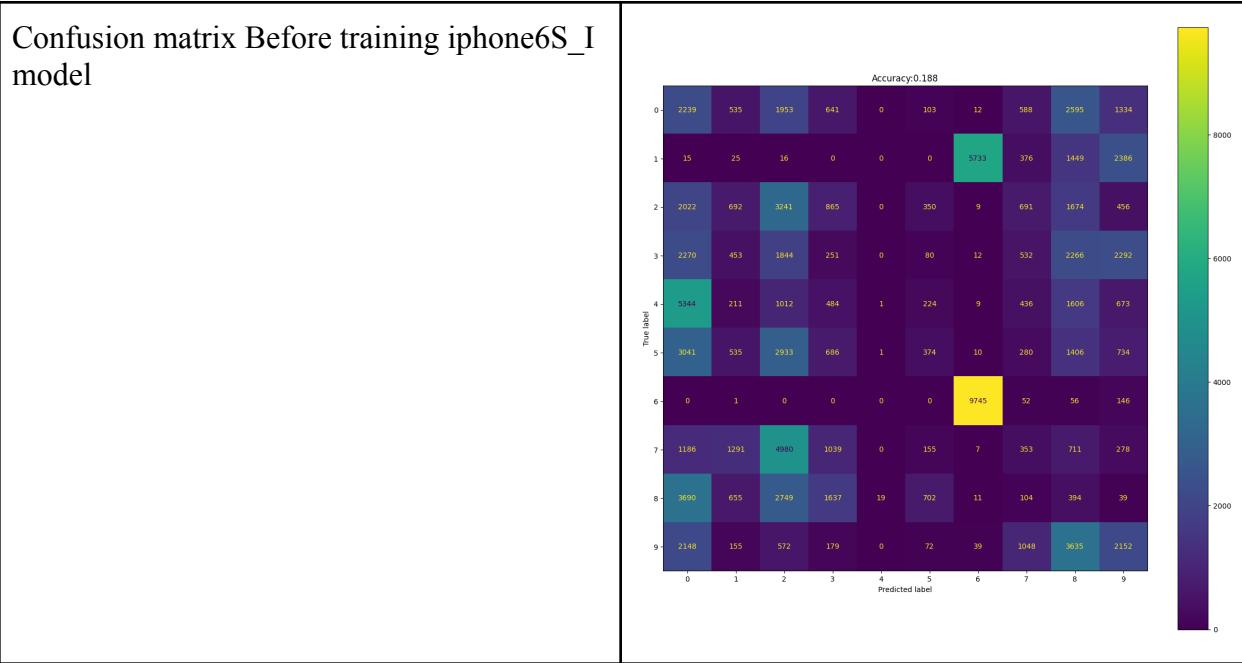


## iPhone6S\_I(ii) dataset

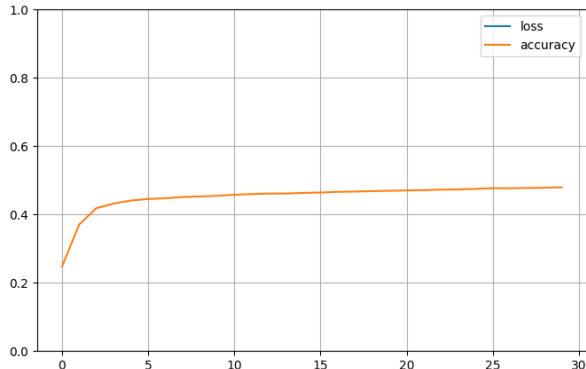
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iphone6S_I_model.h5	0.1877	0.4797	5m 39.5s	0.4795
iphone6S_I_BeSh_model.h5	0.1224	0.3911	6m 33.2s	0.3753

## iPHONE6S\_I\_model.h5

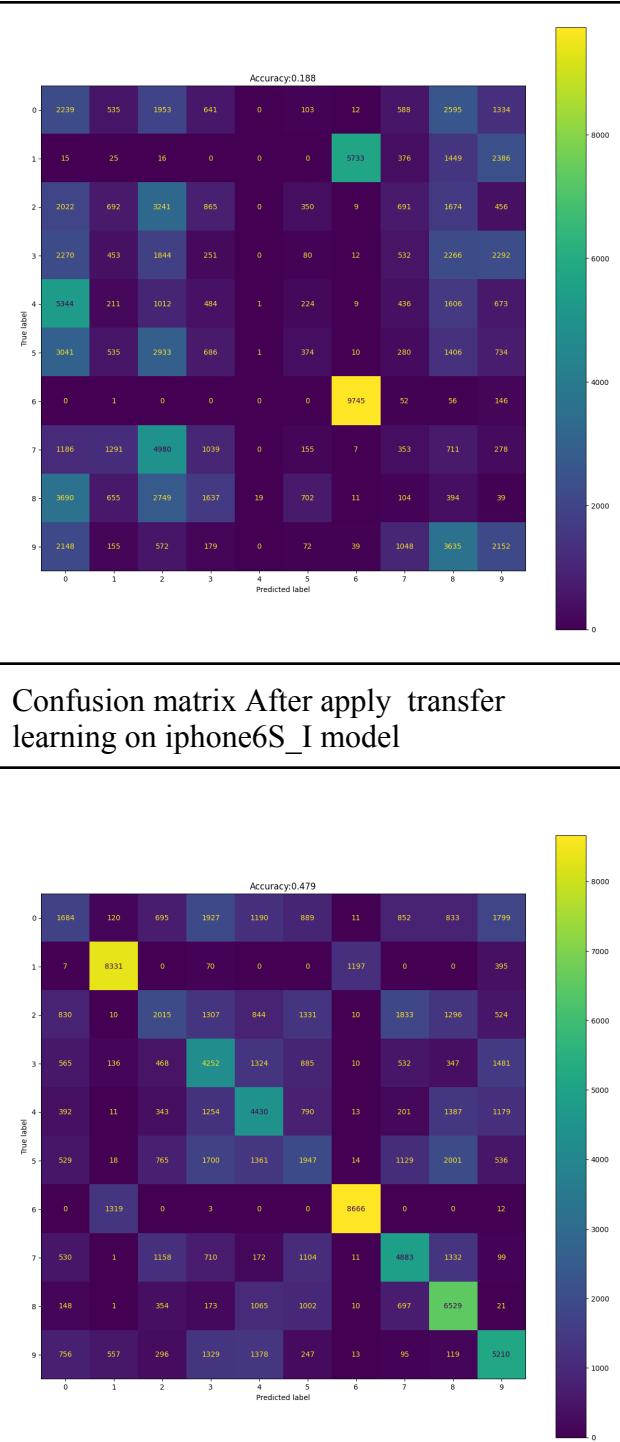
Confusion matrix Before training iphone6S\_I model



Accuracy and loss plot After apply transfer learning on iphone6S\_I model

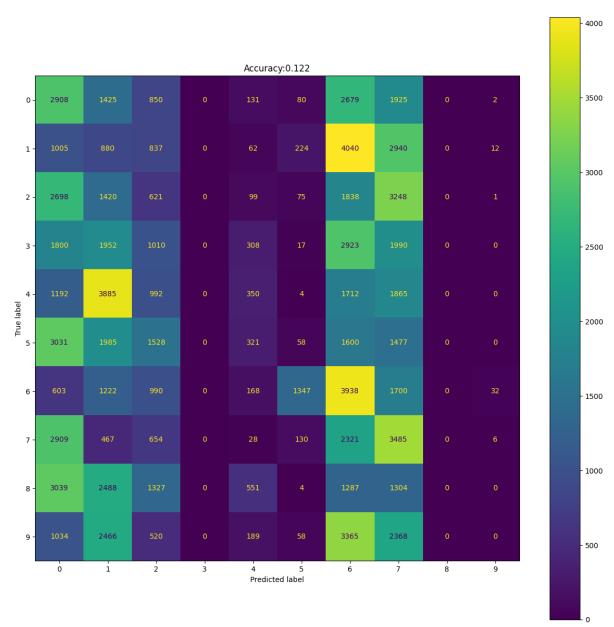


Confusion matrix After apply transfer learning on iphone6S\_I model

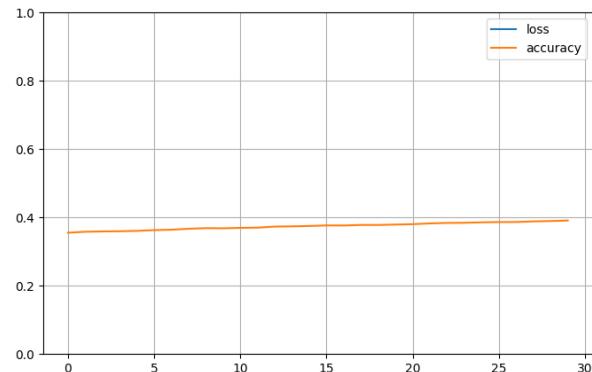


## iPHONE6S\_I\_BeSh\_model.h5

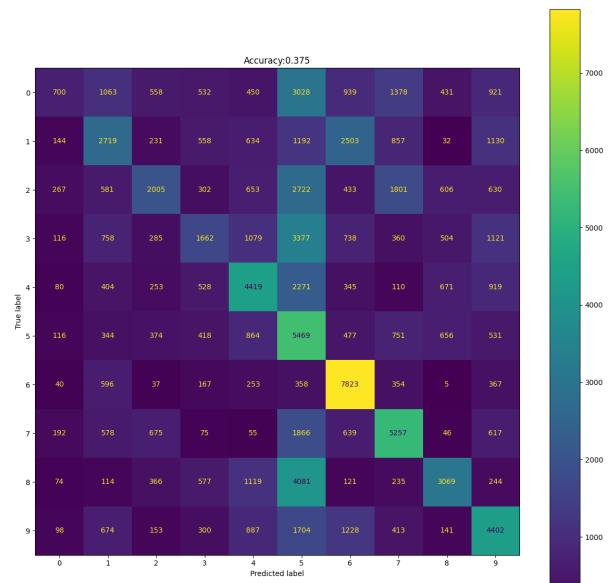
Confusion matrix Before training  
iphone6S\_I\_BeSh model



Accuracy and loss plot After apply transfer learning on iphone6S\_I\_BeSh model



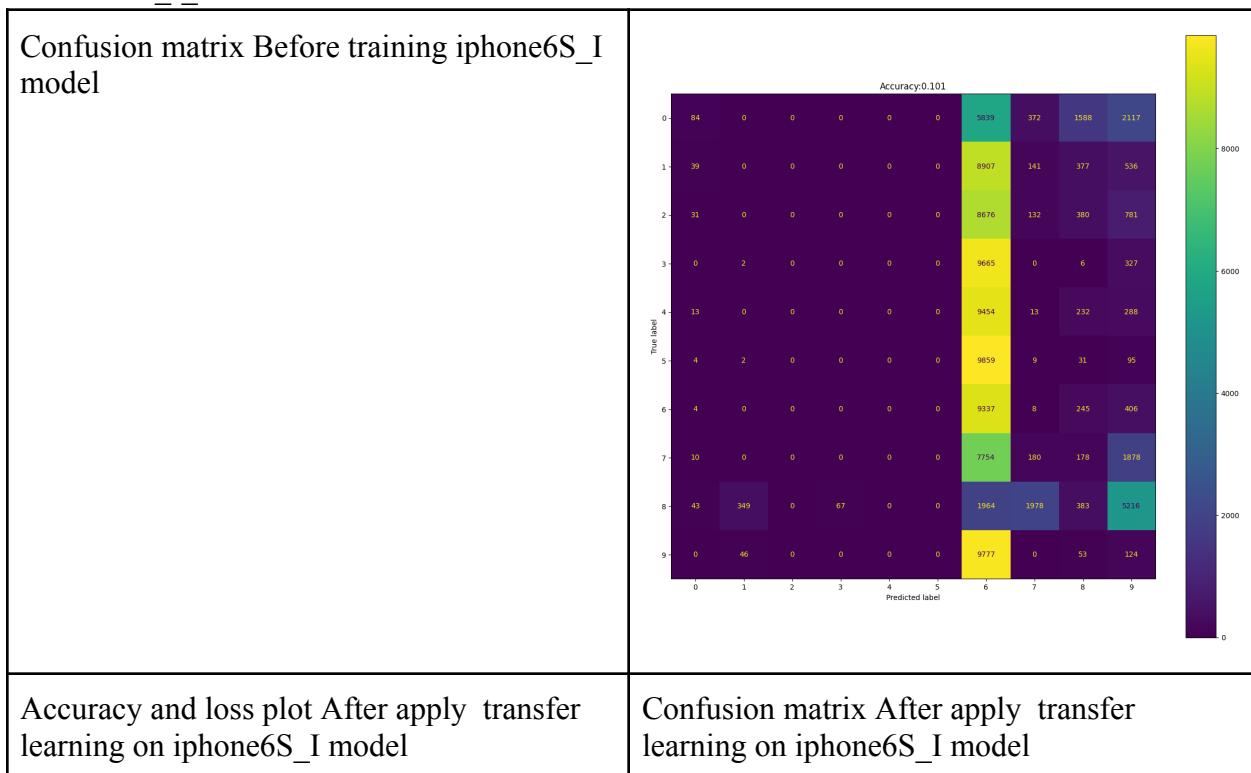
Confusion matrix After apply transfer learning on iphone6S\_I\_BeSh model

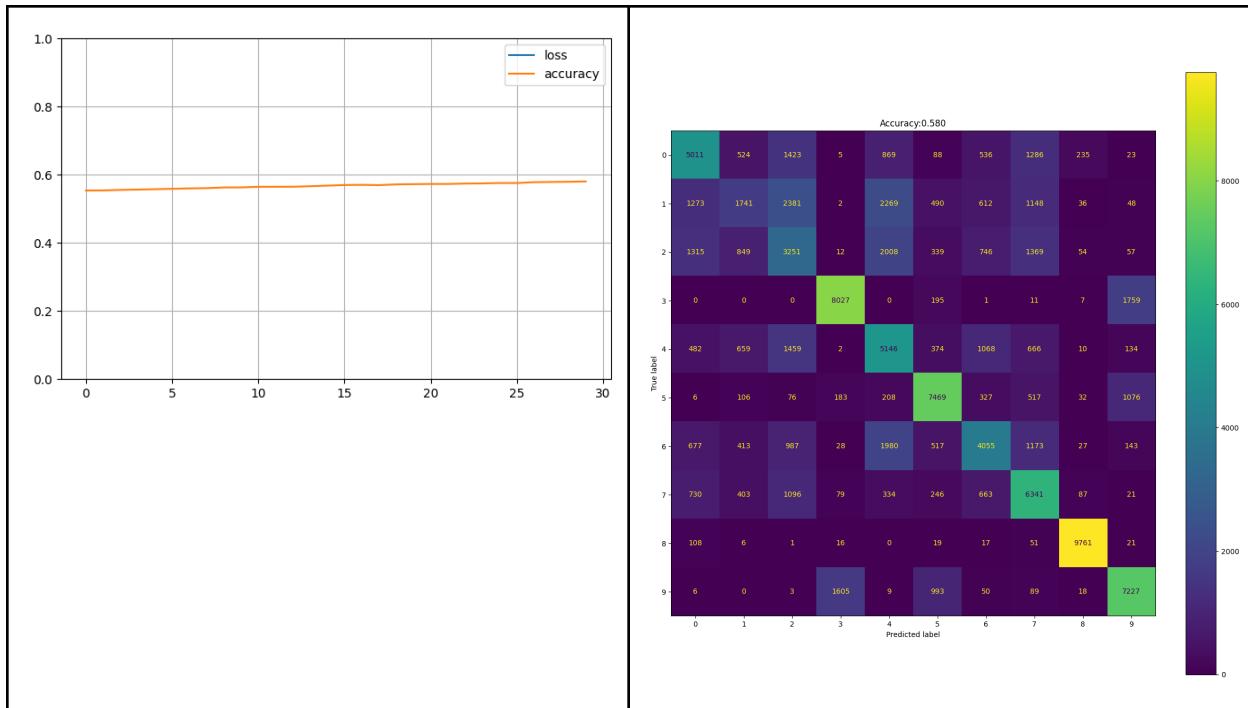


### iPhone6S\_I BeSh dataset

Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iphone6S_I_model.h5	0.1011	0.5804	7m 17.2s	0.5803
iphone6S_I(ii)_model.h5	0.1186	0.6049	6m 58.4s	0.6069

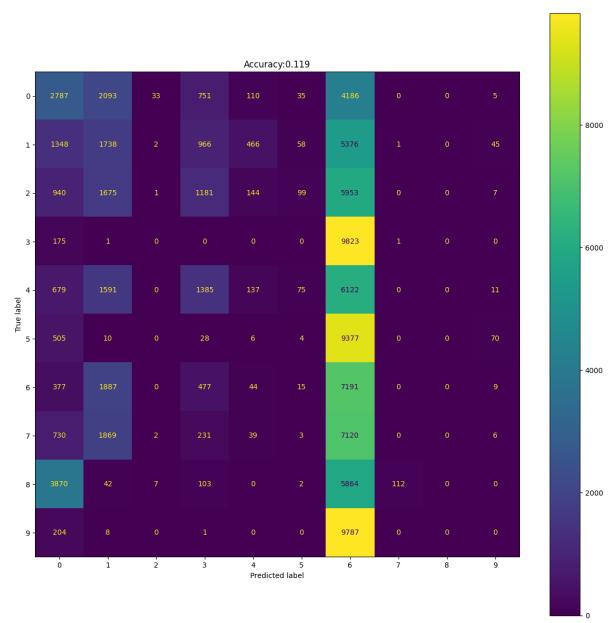
iPHONE6S\_I\_model.h5





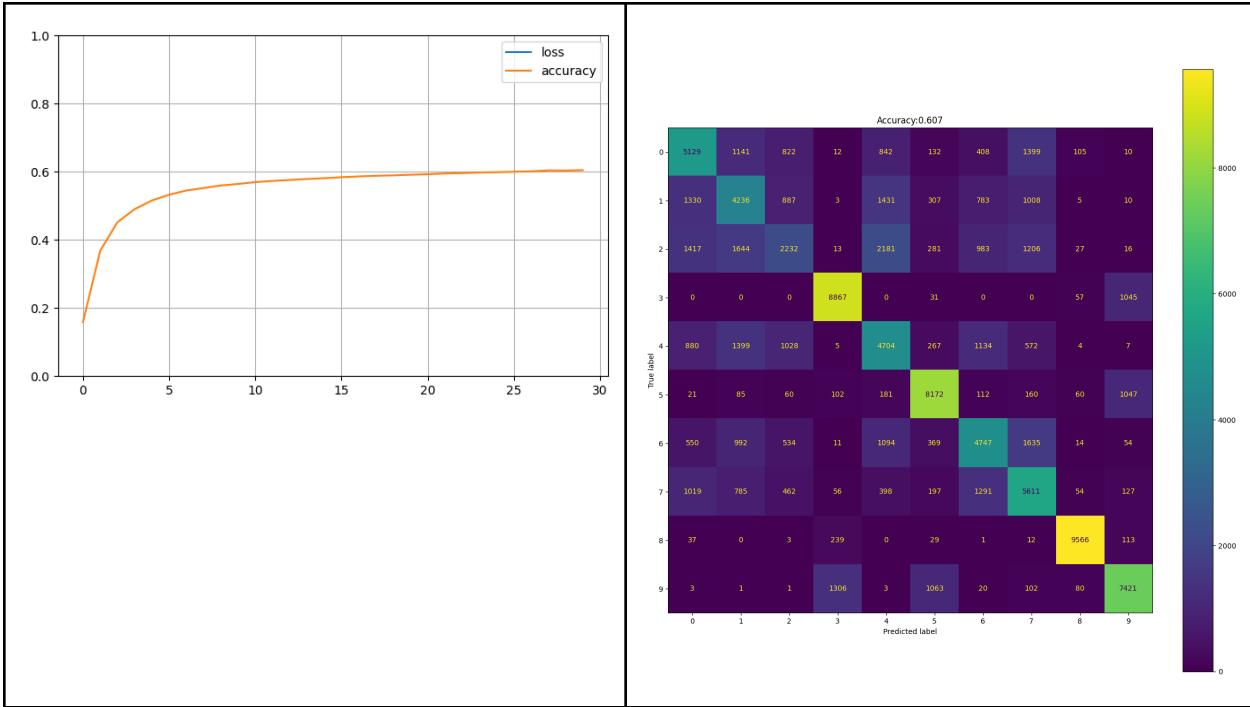
iPHONE6S\_I(ii)\_model.h5

Confusion matrix Before training  
iphone6S\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone6S\_I(ii) model

Confusion matrix After apply transfer learning on iphone6S\_I(ii) model



## EXPERIMENT: 10

Mix all the collected samples from iPhone13 and check the accuracy.

Choose three different iPhone13 EMside-channel samples and also multiple set of samples collected from iphone13\_I

Pool all the collected samples according to the class label and keep one set of samples for testing.  
Shape of the dataset: (600000, 2048)

Model:

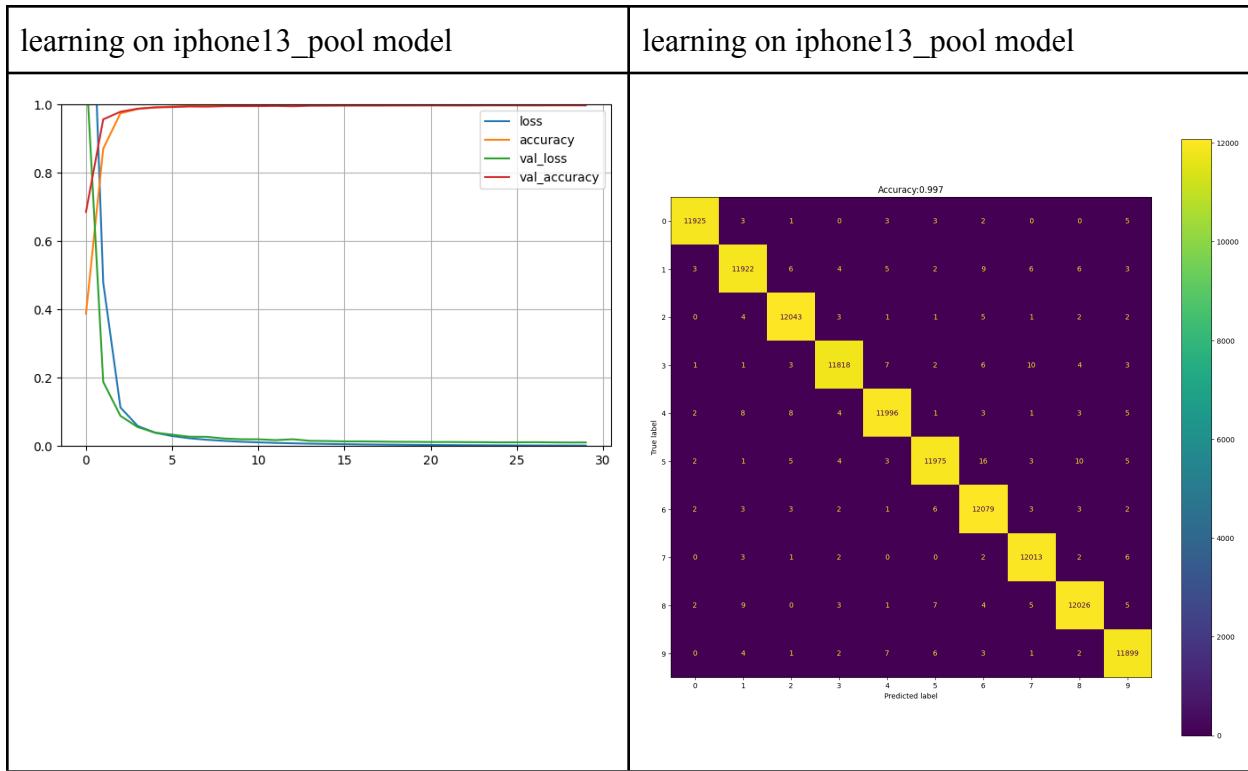
Model: "sequential"

Layer (type)	Output Shape	Param #
<hr/>		
dense (Dense)	(None, 1400)	2868600
dense_1 (Dense)	(None, 800)	1120800
dense_2 (Dense)	(None, 500)	400500
dense_3 (Dense)	(None, 200)	100200
dense_4 (Dense)	(None, 100)	20100
dense_5 (Dense)	(None, 10)	1010
<hr/>		
Total params: 4,511,210		
Trainable params: 4,511,210		
Non-trainable params: 0		

Smartphone Name	iPhone13
Training Accuracy at 30th epoch	1.0000
Learning Time	97m 16.6s
Testing Accuracy	0.9975

Accuracy and loss plot After apply transfer

Confusion matrix After apply transfer

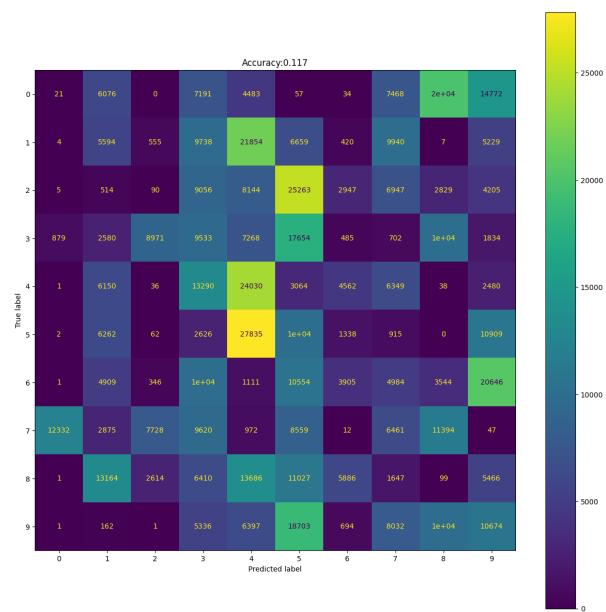


### iPhone13\_I pool dataset

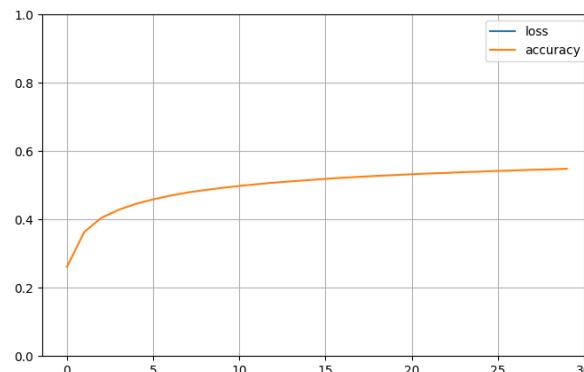
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iphone13_I(ii)_model.h5	0.1174	0.5487	47m 0.1s	0.5515
iphone13_I(iii)_model.h5	0.0540	0.4161	40m 40.9s	0.4182

## iPHONE13\_I(ii)\_model.h5

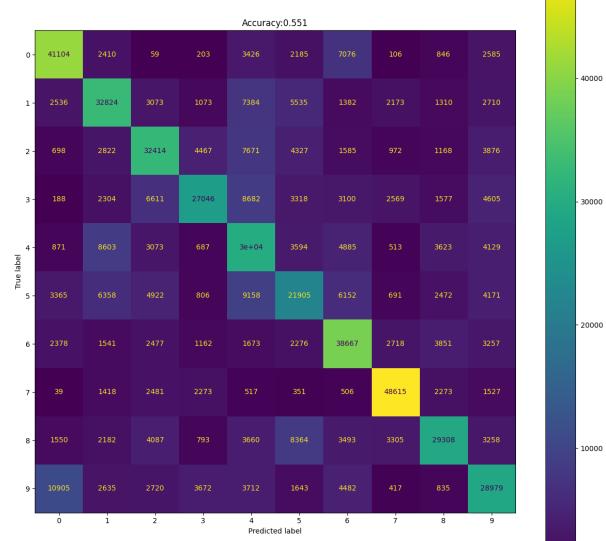
Confusion matrix Before training  
iphone13\_I(ii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(ii) model

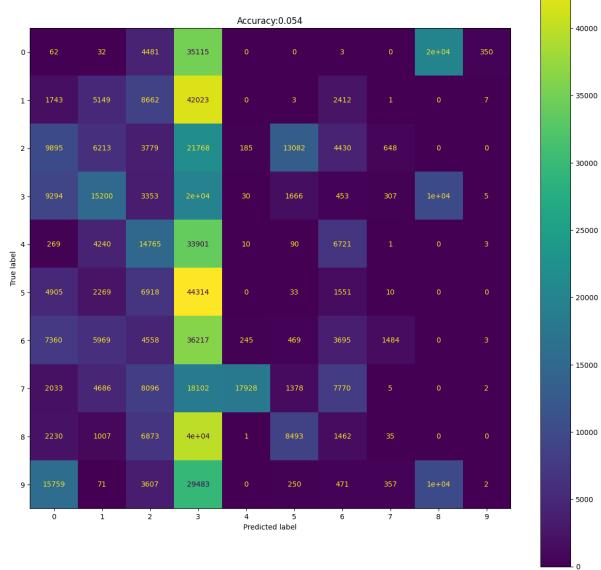


Confusion matrix After apply transfer learning on iphone13\_I(ii) model

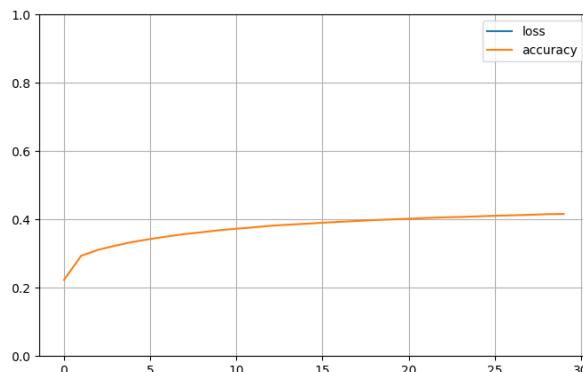


### iPHONE13\_I(iii)\_model.h5

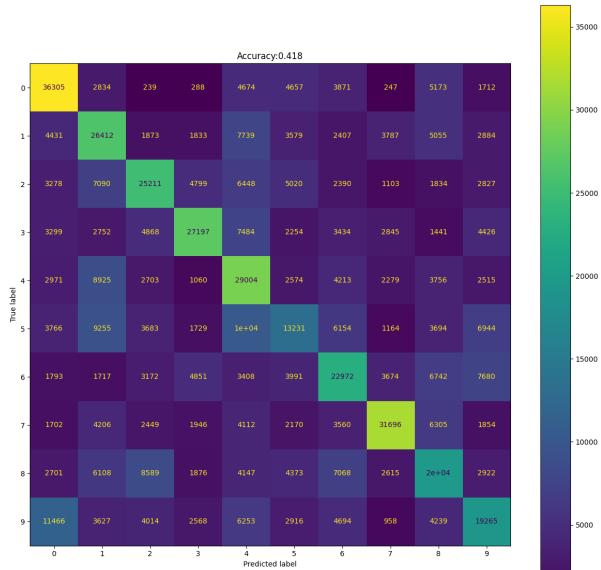
Confusion matrix Before training  
iphone13\_I(iii) model



Accuracy and loss plot After apply transfer learning on iphone13\_I(iii) model



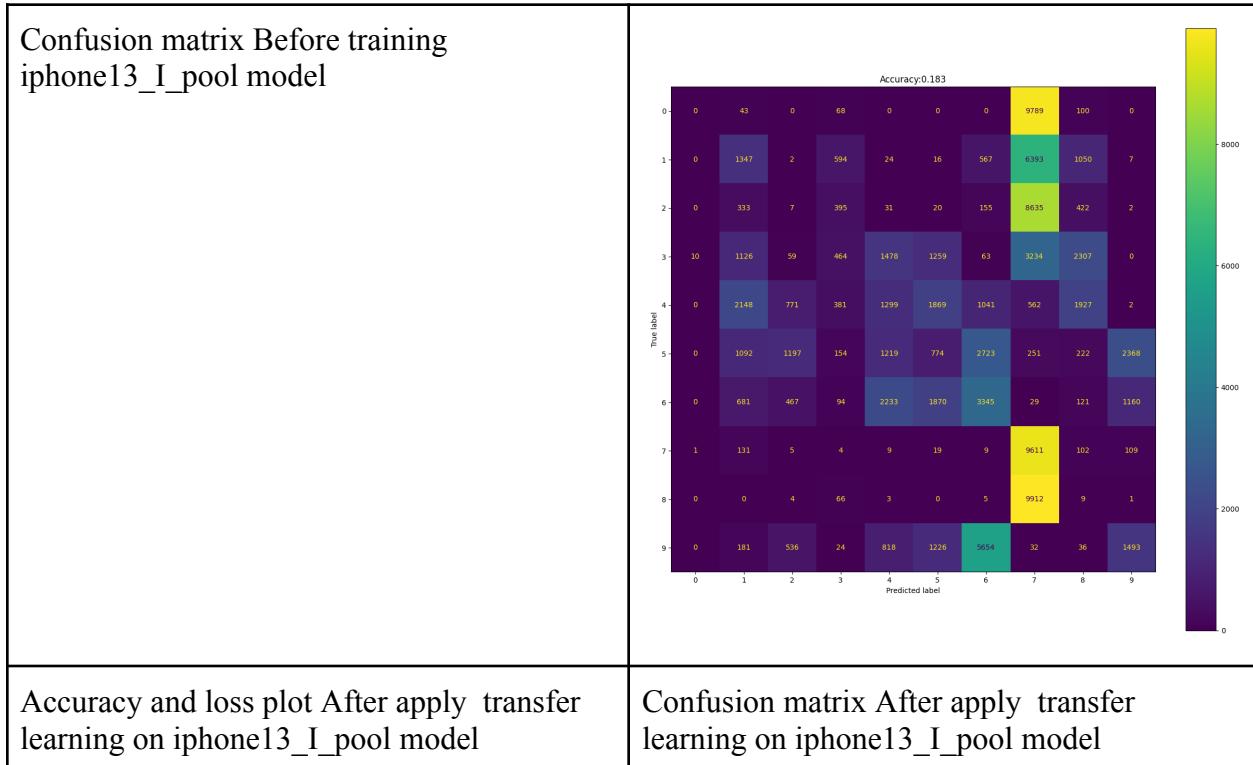
Confusion matrix After apply transfer learning on iphone13\_I(iii) model

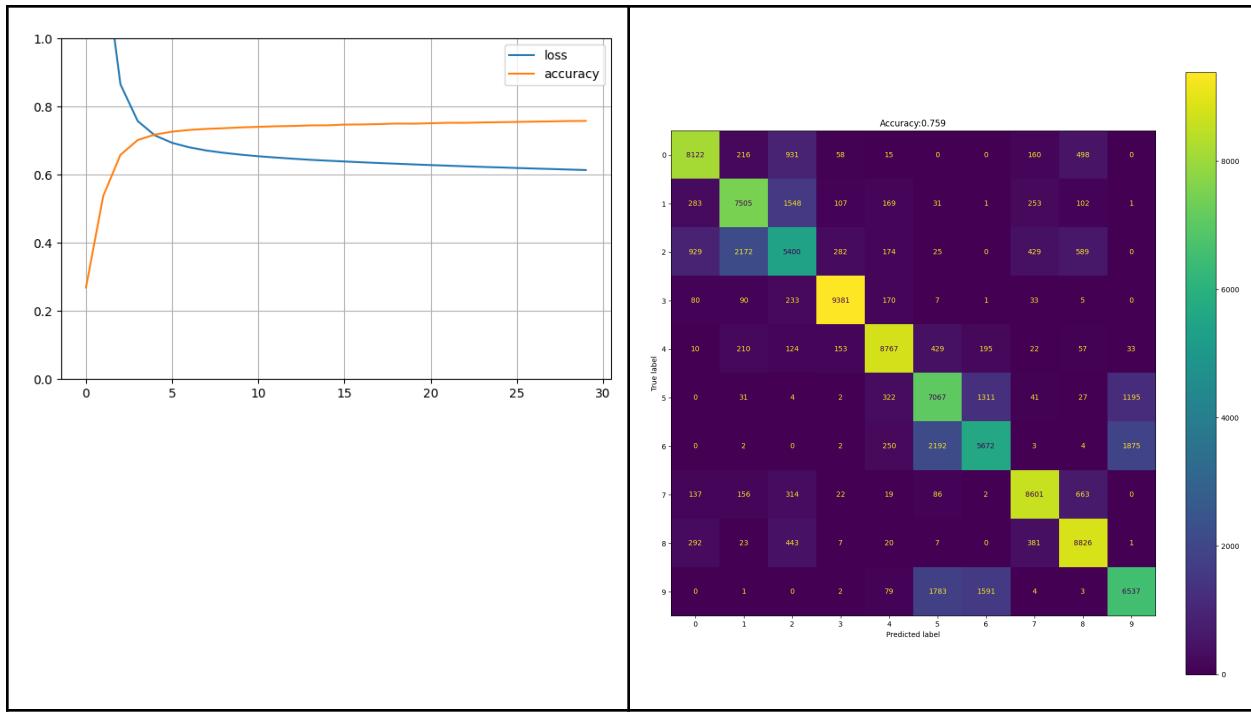


### iPhone13\_I(ii) dataset

Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iphone13_pool_model.h5	0.1835	0.7581	8m 22.7s	0.7588

iPHONE13\_I\_pool\_model.h5



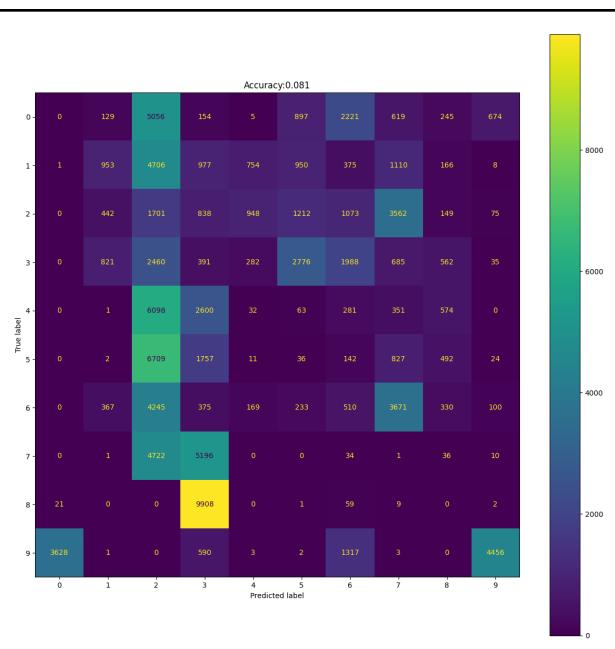


### iPhone13\_I(iii) dataset

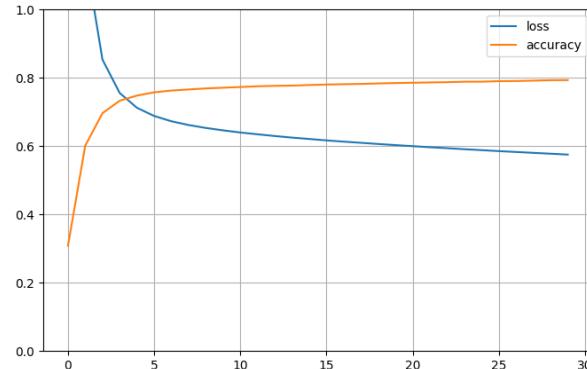
Model Name	Cross-Model Accuracy (without training)	Transfer Learning		
		Training Accuracy at 30th epoch	Learning Time	Testing Accuracy
iphone13_pool_model.h5	0.0808	0.7934	7m 58.8s	0.7946

iPHONE13\_I\_pool\_model.h5

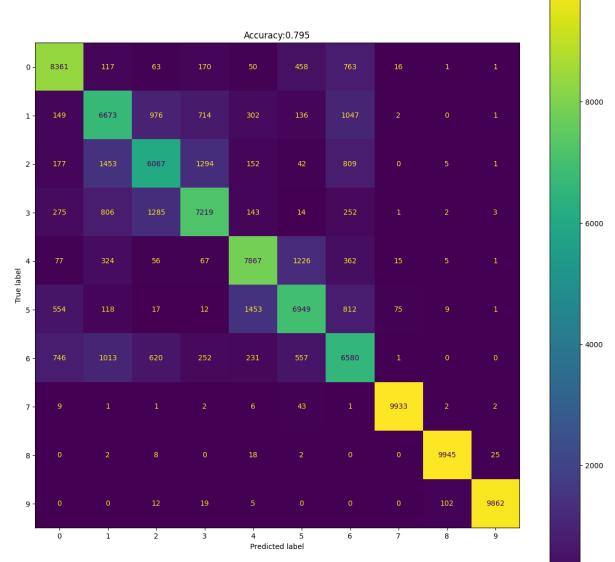
Confusion matrix Before training  
iphone13\_I\_pool model



Accuracy and loss plot After apply transfer learning on iphone13\_I\_pool model



Confusion matrix After apply transfer learning on iphone13\_I\_pool model



## SUMMARY

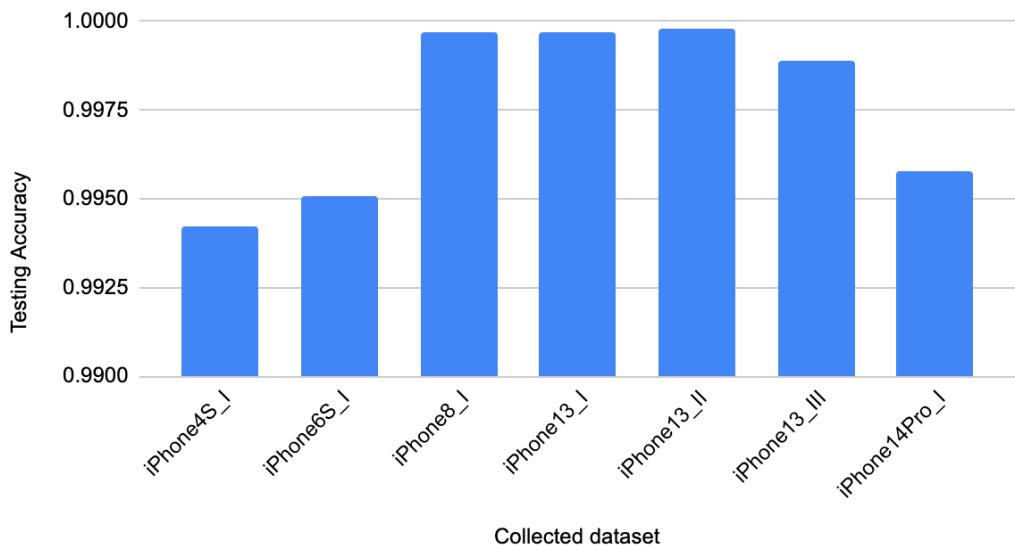
### Types of collected dataset

- iPhone4S\_I (Existing dataset)
- iPhone6s\_I (multiple samples)
- iPhone8\_I
- iPhone13\_I (multiple samples), iPhone13\_II, iPhone13\_III
- iPhone14pro\_I (multiple samples)

### Primary Results

Device	Architecture	System-on-Chip	CPU Frequency	Collected dataset	Testing Accuracy
iPhone4S	ARMv7-A	Apple A5	1GHz (2 cores)	iPhone4S_I	0.9942
iPhone6S		Apple A9	1.85GHz (2 cores)	iPhone6S_I	0.9951
iPhone8	ARMv8-A	Apple A11 Bionic	2.39GHz (6 cores)	iPhone8_I	0.9997
				iPhone13_I	0.9997
iPhone13	ARMv8.5-A	Apple A15 Bionic	3.23 GHz (6 cores)	iPhone13_II	0.9998
				iPhone13_III	0.9989
iPhone14Pro	ARMv8.6-A	Apple A16 Bionic	3.46 GHz (6 cores)	iPhone14Pro_I	0.9958

### Testing Accuracy vs. Collected dataset



### **iPhone13 Cross-model Implementation**

<b>Model_Name</b>	<b>Testing Accuracy</b>		
	iPhone13_I	iPhone13_II	iPhone13_III
iPhone13_I_model.h5	<b>0.9998</b>	0.1050	0.2232
iPhone13_II_model.h5	0.0938	<b>0.9998</b>	0.1063
iPhone13_III_model.h5	0.1010	0.1000	<b>0.9994</b>

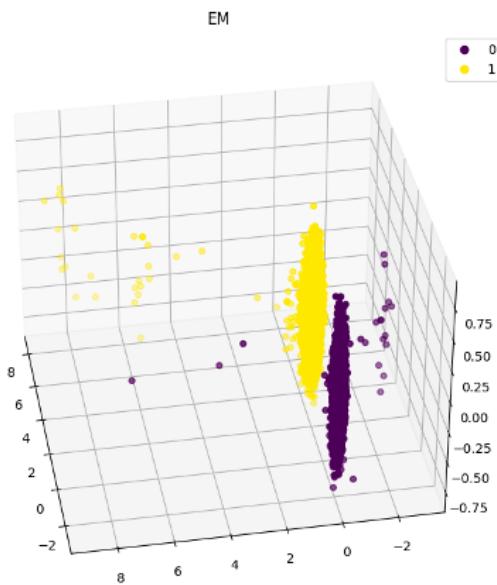
### **Combined Model**

<b>Model_Name</b>	<b>Testing Accuracy</b>			
	iPhone13_II & iPhone13_III	iPhone13_I	iPhone13_II	iPhone13_III
iPhone13_II&III_model.h5	0.9994	0.1061	0.9997	0.9997

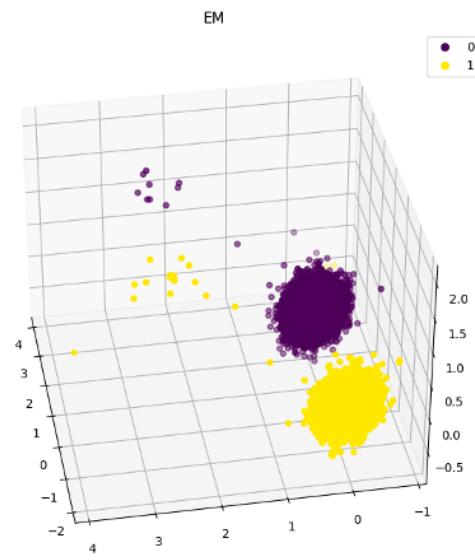
<b>Dataset_Name</b>	<b>Testing Accuracy</b>		
	iPhone13_I_model	iPhone13_II_model	iPhone13_III_model
iPhone13_II&iPhone13_III	0.1641	0.5530	0.5497

### **Idle Activity**

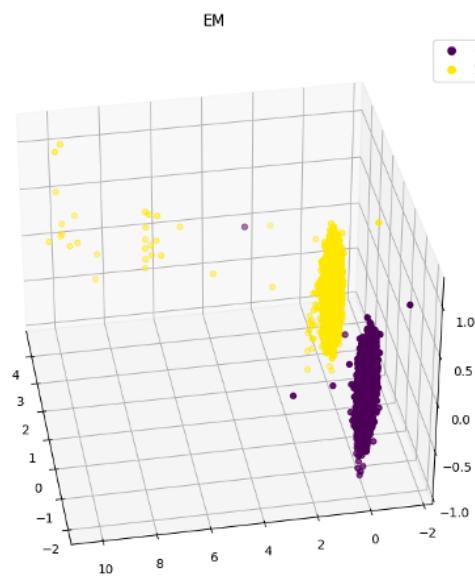
Dataset Combination	iPhone13_II & iPhone13_III	iPhone13_I & iPhone13_II	iPhone13_I & iPhone13_III	iPhone13_I, iPhone13_II & iPhone13_III
Testing Accuracy	1.0000	0.9990	0.9995	0.9997



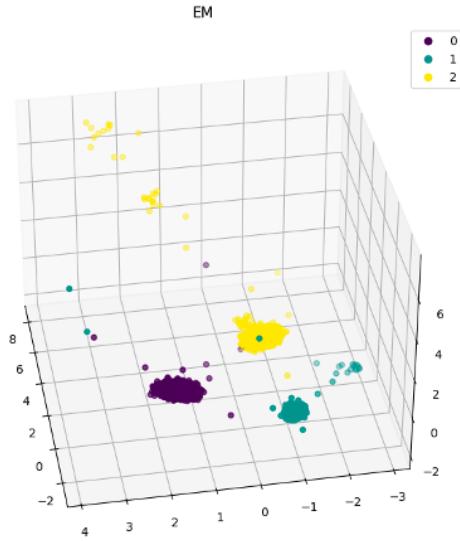
iPhone13\_II & iPhone13\_III



iPhone13\_I & iPhone13\_II



iPhone13\_I & iPhone13\_III



iPhone13\_I, iPhone13\_II & iPhone13\_III

## Comparison-Cross modal-Transfer learning

Same smartphone different samples

Model_Name	Testing Accuracy		Transfer Learning (Training the output layer only)	
	iPhone6S_I (new samples)	iPhone13_I (new samples)	iPhone6S_I (new samples)	iPhone13_I (new samples)
iPhone6s_I_model.h5	0.1149	-	0.5323	-
Phone13_I_model.h5	-	0.1085	-	0.9310

## iPhone13 samples

Model Name	Testing Accuracy		
	iPhone13_I	iPhone13_II	iPhone13_III
iPhone13_I_model.h5	-	0.9559	0.7034
iPhone13_II_model.h5	0.8146	-	0.7378
iPhone13_III_model.h5	0.7000	0.8669	-

## Complete Observation

### iPhone13

Device Name (dataset)	Training Mode	Model Name							
		iPhone 13_I	iPhone 13_I(ii)	iPhone 13_I(iii)	iPhone 13_I_BeSh	iPhone 13_I_data1	iPhone 13_I_data2	iPhone 13_II	iPhone 13_III
iPhone 13_I	Direct	<b>0.9998</b>	0.0690	0.0131	0.0978	0.1334	0.2507	0.0818	0.1001
	Trans	-	<b>0.8458</b>	<b>0.7429</b>	<b>0.8223</b>	<b>0.7809</b>	<b>0.8255</b>	<b>0.8092</b>	<b>0.7400</b>
iPhone 13_I(ii)	Direct	0.1391	<b>0.9999</b>	0.0923	0.1957	0.1931	0.1491	0.2102	0.1000
	Trans	<b>0.8370</b>	-	<b>0.6899</b>	<b>0.8116</b>	<b>0.8068</b>	<b>0.7863</b>	<b>0.8509</b>	<b>0.6868</b>
iPhone 13_I(iii)	Direct	0.0943	0.2478	<b>0.9990</b>	0.0035	0.3220	0.1212	0.0412	0.0997
	Trans	<b>0.8909</b>	<b>0.8527</b>	-	<b>0.8781</b>	<b>0.9028</b>	<b>0.8517</b>	<b>0.9008</b>	<b>0.7418</b>
iPhone 13_I_BeSh	Direct	0.1892	0.0968	0.0000	<b>0.9997</b>	0.0042	0.0597	0.1796	0.0308
	Trans	<b>0.9262</b>	<b>0.9177</b>	<b>0.8158</b>	-	<b>0.8771</b>	<b>0.8792</b>	<b>0.9334</b>	<b>0.9194</b>
iPhone 13_I_data1	Direct	0.0470	0.1325	0.0579	0.1644	<b>0.9997</b>	0.1312	0.1119	0.1000
	Trans	<b>0.7359</b>	<b>0.8023</b>	<b>0.7189</b>	<b>0.6657</b>	-	<b>0.8655</b>	<b>0.7844</b>	<b>0.5884</b>
iPhone 13_I_data2	Direct	0.1260	0.1066	0.1200	0.0857	0.1439	<b>0.9998</b>	0.0857	0.1000
	Trans	<b>0.8382</b>	<b>0.7869</b>	<b>0.7318</b>	<b>0.7675</b>	<b>0.9004</b>	-	<b>0.8081</b>	<b>0.6973</b>
iPhone 13_II	Direct	0.0612	0.1540	0.0291	0.1997	0.0708	0.1375	<b>0.9996</b>	0.0997
	Trans	<b>0.9572</b>	<b>0.9858</b>	<b>0.8813</b>	<b>0.9808</b>	<b>0.9601</b>	<b>0.9488</b>	-	<b>0.9024</b>
iPhone 13_III	Direct	0.1927	0.1179	0.1041	0.0884	0.1002	0.0989	0.1139	<b>0.9991</b>
	Trans	<b>0.7409</b>	<b>0.7743</b>	<b>0.6533</b>	<b>0.7625</b>	<b>0.7086</b>	<b>0.6916</b>	<b>0.7784</b>	-

### iPhone14Pro

Device Name (dataset)	Trainin g Mode	Model Name				
		iPhone 14Pro_I(i)	iPhone 14Pro_I(ii)	iPhone 14Pro_I(iii)	iPhone 14Pro_I(iv)	iPhone 14Pro_I(v)
iPhone 14Pro_I(i)	Direct	<b>0.9962</b>	0.1108	0.1046	0.0916	0.0999
	Trans	-	0.4279	0.2965	0.3521	0.3239
iPhone 14Pro_I(ii)	Direct	0.1248	<b>0.9975</b>	0.0969	0.0756	0.1000
	Trans	0.4164	-	0.2967	0.3608	0.3109
iPhone 14Pro_I(iii)	Direct	0.1100	0.0904	<b>0.9942</b>	0.1049	0.1000
	Trans	0.1941	0.2065	-	0.2118	0.1796
iPhone 14Pro_I(iv)	Direct	0.1013	0.1049	0.1027	<b>0.9927</b>	0.1000
	Trans	0.2499	0.2521	0.2272	-	0.1642
iPhone 14Pro_I(v)	Direct	0.0873	0.0836	0.0962	0.1036	<b>0.9990</b>
	Trans	0.6161	0.6336	0.4801	0.4868	-

### iPhone6S

Device Name (dataset)	Training Mode	Model Name		
		iPhone6S_I	iPhone6S_I(ii)	iPhone6S_I_BeSh
iPhone6S_I	Direct	<b>0.9961</b>	0.1214	0.1058
	Trans	-	0.5166	0.3624
iPhone6S_I(ii)	Direct	0.1877	<b>0.9982</b>	0.1224
	Trans	0.4795	-	0.3753
iPhone6S_I_BeSh	Direct	0.1011	0.1186	<b>0.9965</b>
	Trans	0.5803	0.6069	-

## Pool Dataset

### iPhone13\_pool dataset/model

Model Name	iPhone13_pool_dataset		iphone13_I(ii)_dataset		iphone13_I(iii)_dataset	
	Direct	Trans	Direct	Trans	Direct	Trans
iphone13_I_Pool_model.h5	0.9975	-	0.1835	0.7588	0.0808	0.7946
iphone13_I(ii)_model.h5	0.1174	0.5515	-	-	-	-
iphone13_I(iii)_model.h5	0.0540	0.4182	-	-	-	-