Internship Training

at

NAVIO HEALTH AND EDUCATION PRIVATE LIMITED

Study/Project

USE OF CONVOLUTIONAL NEURAL NETWORKS (CNNs) FOR MONITORING PERSONAL CARE AND NURSING CARE OF BED RIDDEN PATIENTS

by

Lt Col Someshwar Singh

Enroll No. PG/17/069

Under the guidance of

Dr. Pradeep Panda, Professor & Dean (Academics) & Mentor

Post Graduate Diploma in Hospital and Health Management (Health IT)

2017-19

International Institute of Health Management Research
New Delhi

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(Completion of Dissertation from respective organization)

The certificate is awarded to

Name Lt Col Someshwar Singh

in recognition of having successfully completed his
Internship in the department of

Health Information Technology

and has successfully completed his/her Project on

USE OF CONVOLUTIONAL NEURAL NETWORKS (CNNs) FOR MONITORING PERSONAL CARE AND NURSING CARE OF BED RIDDEN PATIENTS

10 May 2019

NAVIO HEALTH AND EDUCATION PRIVATE LIMITED

He comes across as a committed, sincere & diligent person who has a strong drive & zeal for learning.

We wish him/her all the best for future endeavors.

Training & Development **Zonal Head-Human Resources**

Navio Health & Education Pvt. Ltd.

Director

Navio Health & Education Pvt. Ltd. Delhi

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Lt Col Someshwar Singh, student of Post Graduate Diploma in Hospital and Health Management (PGDHM), Health IT, from International Institute of Health Management Research, New Delhi has undergone internship training at **NAVIO HEALTH AND EDUCATION PRIVATE LIMITED** from 06 Feb 2019 to 30 Apr 2019.

The Candidate has successfully carried out the study designated to him during internship training and his approach to the study has been sincere, scientific and analytical. The Internship is in fulfillment of the course requirements.

I wish him all success in all his/her future endeavors.

Dr Pradeep K Panda
Dean, Academics and Student Affairs
IIHMR, New Delhi

CERTIFICATE OF APPROVAL

The following dissertation titled **"USE OF CONVOLUTIONAL NEURAL NETWORKS (CNNs) FOR MONITORING PERSONAL CARE AND NURSING CARE OF BED RIDDEN PATIENTS"** at **"NAVIO HEALTH AND EDUCATION PRIVATE LIMITED"** is hereby approved as a certified study in management carried out and presented in a manner satisfactorily to warrant its acceptance as a prerequisite for the award of **Post Graduate Diploma in Health and Hospital Management** for which it has been submitted. It is understood that by this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the dissertation only for the purpose it is submitted.

Dissertation Examination Committee for evaluation of dissertation.

Name	Signature
Prof. A.K Sood	
Dr Preetha G S	
Dr. Vinay Tripathi	
Dr. Anandhi	
Dr. Nishikant	

CERTIFICATE FROM DISSERTATION ADVISORY COMMITTEE

This is to certify that Lt Col Someshwar Singh, a graduate student of the **Post- Graduate Diploma in Health and Hospital Management, Health IT** has worked under our guidance and supervision. He is submitting this dissertation titled **"USE OF CONVOLUTIONAL NEURAL NETWORKS (CNNs) FOR MONITORING PERSONAL CARE AND NURSING CARE OF BED RIDDEN PATIENTS"** at **"NAVIO HEALTH AND EDUCATION PRIVATE LIMITED"** in partial fulfillment of the requirements for the award of the **Post- Graduate Diploma in Health and Hospital Management (Health IT).**

This dissertation has the requisite standard and to the best of our knowledge no part of it has been reproduced from any other dissertation, monograph, report or book.

Dr Pradeep K Panda
Dean, Academics and Student Affairs
IIHMR, New Delhi

Capt(IN) Harsh Kumar Singh (Retd)
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INTERNATIONAL INSTITUTE OF HEALTH MANAGEMENT RESEARCH, NEW DELHI

CERTIFICATE BY SCHOLAR

This is to certify that the dissertation titled "**USE OF CONVOLUTIONAL NEURAL NETWORKS (CNNs) FOR MONITORING PERSONAL CARE AND NURSING CARE OF BED RIDDEN PATIENTS"** and submitted by Lt Col Someshwar Singh, Enrollment No PG/17/069, under the supervision of Dr Pradeep K Panda, Dean, Academics and Student Affairs for award of Postgraduate Diploma in Hospital and Health Management, Health IT, of the Institute carried out during the period from 06 Feb 2019 to 30 Apr 2019 embodies my original work and has not formed the basis for the award of any degree, diploma associate ship, fellowship, titles in this or any other Institute or other similar institution of higher learning.

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FEEDBACK FORM

Name of the Student: Lt Col Someshwar Singh

Dissertation Organisation: NAVIO HEALTH AND EDUCATION PRIVATE LIMITED

Area of Dissertation: Reserch & Development (Use Of Convolutional Neural Networks For Monitoring Personal Care And Nursing Care Of Bed Ridden Patients)

Attendance: As per organizational and project requirements.

Objectives achieved: He has understood and learned about day to day operational management and functioning of the company. He has also learnt the development of CNN models and of writing a well researched dissertation.

Deliverables: **At** the end of the project dissertation, one existing model for the use cases was identified (Face Recognition) and six models were developed, validated and tested. The deliverables also include the Research Report.

Strengths: He has come across as a committed, sincere & diligent person who has a strong drive & zeal for learning. He has good technical, analytical and writing skills, which come out as his strengths.

Suggestions for Improvement: Nil

Suggestions for Institute : Nil

Date: 10 May 2019
Place: New Delhi

Signature of the Organisation Mentor

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CERTIFICATE ON PLAGIARISM CHECK

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Title of the Dissertation/Summer Assignment	Use Of Convolutional Neural Networks (CNNs) For Monitoring Personal Care And Nursing Care Of Bed Ridden Patients
Plagiarism detect software used	TURNITIN
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Thank you,

Lt Col Someshwar Singh

ACRONYMS / ABBREVIATIONS

Acronym	Full Form
IIHMR	International Institute of Health Management and Research
IT	Information Technology
AI	Artificial Intelligence
CNN	Convolutional Neural Network
HCP	Health care providers
ADLs	Activities of Daily Living
IADLs	Instrumental Activities of Daily Living
BP	Blood Pressure
IoT	Internet of Things
ReLU	Rectified Linear Unit
3D	Three Dimensional
MR	Misclassification Rate
TP	True Positive
TN	True Negative
FP	False Positive
FN	False Negative
CDM	Change Detection Model

Table of Contents

INTERNSHIP REPORT

1.0 Introduction

Navio Health And Education Private Limited is a startup currently working in the field of training of Nurses and Paramedics. It provides training solutions to a variety of healthcare professionals- doctors, nurses and paramedics. Directors of Navio Health And Education Private Limited are Suman Singh and Manreet Kahlon. The startup was incorporated on 26 December 2018.

2.0 Organization

The start up being at a nascent stage has a flat structure.

3.0 Mission

To ensure quality healthcare delivery for patients by empowering healthcare providers (HCPs) through experiential learning.

4.0 Vision

To prepare excellent highly skilled HCPs having the capacity to transform the communities through their services and empathetic care.

5.0 Work Focus

Though currently the start up is into training of health care providers to make them employable for the industry, however, the company intends to roll out into the home care / elderly care business too. The training includes both clinical and non clinical aspects. The training especially focuses on Home Healthcare and Elderly Care which encompasses both nursing and personal care of elders in home setting.

5.1 Home Healthcare and Elderly Care

Old age brings many challenges not only for the old but for their near and dear ones too. Old age and disabilities brings many challenges for the elders / disabled, on various aspects of Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs). The ADLs include aspects like bathing, toileting, dressing, grooming, feeding and mobility. A person who is not capable of undertaking his ADLs, definitely requires full time personal care. The IADLs include activities like housekeeping, laundry, shopping, cooking, money management, medication management, driving e.t.c. A person should be capable of undertaking the IADLs for him/her to stay independently, else they have to depend upon others for various essential activities. Disabled or the old find it difficult to undertake some activities of IADLs and the ADLs. Such people require not only personal care but also nursing care in home setting. The nursing care includes aspects of help with medication, physiotherapy, dressing of wounds, monitoring of vitals e.t.c. Home care for seniors is the concept of healthcare and personal care provided to them at home. It intends to delay or prevent moving of elders to a nursing homes. Children staying away from home are always bothered about providing trustworthy health care and personal care for their aged parents back at home. Recently, many companies have mushroomed to fill up this space.

5.1.1 Home Care Challenge

Home care companies can stay in business as long as they gain and keep the **trust** of their clients. To build and maintain this trust the companies have to depend upon numerous employees (HCPs). Care Managers are placed locally over few HCPs to task and monitor the delivery of the services. However, due to challenges of time and space it is practically not possible for the managers to monitor all the activities of the HCPs placed under them.

5.1.2 Intended Solution

The company was exploring possibilities to find solutions to the above mentioned challenge. One way the company intended to solve it was by building a custom software solution for it. As part of that they wanted to explore if Convolutional Neural Networks (CNNs) models could be used for automated, real time, truthful reporting to help them not only overcome this challenge but also to enhance the overall quality of patient care.

5.1.3 Use Cases

To test and validate the concept, out of the many possible use cases, they initially intended trying out only a few basic ones :-

(a) Person identification and verification.

(b) Bed State (Empty or occupied).

(c) Patient states A (Sleeping or awake).

(d) Patient states B (Eating, drinking, reading)

(e) Nursing care (BP measurement, injection, medication)

(f) Patient reaction to care / interaction with staff.

(g) Change Detection (Patient movement).

6.0 Research Project

The startup wanted to undertake a project to identify or develop CNN models and to gauge the suitability for the above mentioned specif use cases. Being from Health IT background the project was assigned to me, to be undertake as an in-house, single person, research project.

PROJECT REPORT

USE OF CONVOLUTIONAL NEURAL NETWORKS (CNNs) FOR MONITORING PERSONAL CARE AND NURSING CARE OF BED RIDDEN PATIENTS

(Lt Col Someshwar Singh)

Abstract

Old age and disabilities, bring many challenges on various counts of Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs). Bed ridden people require not only personal care, social care but also nursing care in home setting. Recently, many companies have mushroomed to fill up this space. To build and maintain client trust, the companies have to depend upon the good work of numerous Health Care Providers (HCP's) they employ. Care Managers placed over such employees face a daunting task of monitoring the activities of the HCP's placed under them. This thesis aimed to answer the question linked with this challenge. That is, if Convolutional Neural Networks (CNNs) can be used for monitoring personal care and nursing care being provided to people in the home setting. This applied research involved both research and development work. Seven basic use cases for CNN models had already been listed, even before work began on the research project. Literature review was carried out to identify existing suitable models and other contemporary material on the subject. Only, one existing model for face recognition was found. CNN models for the balance six use cases were then developed and validated.

The CNN models were developed as sleek yet efficient models for them to run on light resources in a home setting. Subsequently, multiple experiments were run using the CNN models so developed. The results were captured and analyzed using the confusion matrix and metrics like accuracy. Overall, promising results were achieved. Hence, it can be said with some degree of confidence, that, CNN models can be used for monitoring the nursing care and personal care being provided to the people confined to bed in home settings.

Keywords

CNN models, Monitoring, Nursing care, Personal care, home care.

1.0 Introduction

1.1 Home Care

Both personal care and nursing care are important for old people and disabled people confined to bed. Sharon A. Levine, et al, in their work on Home Care, have stated that home care is the concept of diagnostic, therapeutic, or social support service provided at home. It intends to delay or prevent moving to nursing homes [1]. By this definition, it encompasses any nursing care and personal care services provided to the needy at home.

1.2 Quality Care Challenge

People hire a Health Care Provider (HCP), from one of the home care companies operating in the vicinity .Such companies assign a HCP for a patient who is supervised by a local care manager. The care manager has to rely on the reporting by the HCP and the feedback he gets from the families. At times, family members may not be present to monitor the delivery of care. In such situations, some patients either due to their medication or medical condition may not be in a position to identify the deficiencies in the services/care provided, which could be detrimental to their health. Some other patients who are able to discriminate so, may not complain, but the deficiencies in quality care services, subsequently reflect through the change of home care provider company.

1.3 Quality Care Possible Solution

In 2012, The European Observatory on Health Systems and Policies, In their work on "Home Care across Europe, Current structure and future challenges", have stated that Quality control is one of the major challenges linked with home care. Also, that the quality of service depends upon timely coordination and efficient monitoring of such services [2, p 115]. In the home setting, not only is it important that the right care is delivered, but it is also important that the care is delivered timely and that too with positivity to render quality services. Hence, real time monitoring of the care being provided to the bed ridden patients becomes imperative.

1.4 CNN Based Technical Solution?

Any application build to solve the real time, home based, nursing care and personal care monitoring problems should be able to solve some basic computer vision tasks like, whether the bed is occupied or vacant, identify people, identify various patient activities, identify key nursing care activities, identify change in patient states and also, identify the response of patient to the care being provided. In 2016, Ashwin Bhandare et al, in their classic work on Applications of Convolutional Neural Networks, have stated that, in the field of Artificial Intelligence (AI), CNNs, are being used successfully to solve computer vision problems like image classification, objects detection, object localization e.t.c [3]. It was thus felt prudent, to explore if, CNN models could be used to solve the personal care and nursing care monitoring problems.

1.5 Research Question

Are there any CNN models of healthcare which are being used to monitor personal care? Are there any specific models related to nursing care?

1.6 Research Objectives

To identify or develop CNN models for monitoring personal care and nursing care of bed ridden patients.

1.6.1 Specific Objective I

To make CNN model for those use cases for which they don’t exist.

1.6.2 Specific Objective II

To test the CNN models made by running experiments on them.

1.6.3 Expected Outcomes

It was expected that at the end of the project dissertation, either the existing models for the use cases would have been identified **OR** the models would have been developed and tested.

2.0 Literature Review

2.1 The Need

For the research project undertaken, the research problem, came from an existing industry challenge. To reiterate, it was the **challenge of monitoring** personal care and nursing care being provided to bed ridden patients by HCPs, in a home setting. The research question and objectives were also known at the outset. The aim of undertaking the literature review were twofold, firstly to identify if a similar research had been undertaken in the past and secondly to identify existing CNN models, to solve the computer vision challenges as per the objective of the research. The literature review on the first aspect was to help in identifying as to how to undertake the applied research and get new learning's. The literature review on the second aspect was to help in deciding if CNN models were to be developed or some existing suitable models could be used.

2.2 Search Tools

The literature review was carried out in two parts. The research aspect and tech involved being contemporary, relevant literature was more likely to have been found published in the recent past and that too on the internet. Hence, “Google Advanced Search” was used as a tool for literature review for the first part. A time range filter was also applied to the search results. For CNN model search, GitHub database was used.

2.3 Part – I (Literature Search)

The search parameters used in "Google Advanced Search" for the literature review were as per table 2.1.

Table 2.1: (Search Parameters – Part I)

Item	Details
Search words (All)	CNN, Monitoring, personal care, nursing care
Search words (Any)	AI, Neural network, Deep learning,
Language	English
Region	Any region
Terms appearing	Any where on the page
File Type	Pdf
Usage Rights	Not filtered by license
Time Range (Filter)	20 Feb 2014 to 20 Feb 2019
Addl Filter	First two pages only (Manual Filter)

2.3.1 Result Details

From the first two pages of google search results a total of 20 results were obtained. The search result details and their relevance was as per Appx A.

2.3.2 Details of Relevant Result

Almost all the results dwelled upon the theoretical knowledge and theoretical use cases for AI, Deep Neural Networks (DNNs) and the CNNs for healthcare. Mostof them covered the aspect of DNNs or CNNs for monitoring personal care or nursing care. Only one relevant result was found. Syed Umar Amin, et al, In 2018 wrote a paper on "Cognitive Smart

Healthcare for Pathology Detection and Monitoring”. The research was an Exploratory research. Objective of the paper was to propose a cognitive healthcare framework that adopted the Internet of Things (IoT)–cloud technologies. In that paper they had used preexisting CNNs to classifies EEGs [4].

2.3.3 Learning

The proposed framework used smart sensors for communications and deep learning for intelligent decision-making within the smart city perspective. The paper talked about an emotion-based cognitive system that could detect patients facial expressions. The paper also touched upon use of CNN with dropout technique for classifying EEGs. The author also said that the CNN models had shown excellent results for end-to-end feature learning [4].

2.4 Part – II (Model Search)

2.4.1 Common Filters

Multiple searches were conducted, to identify the various models. The common search parameters used were as per table 2.2.

Table 2.2: (Common Search Parameters – Part II)

Item	Details
Database	GitHub
Language	Python
License	MIT
Sort	Most Stars

2.4.2 Search Terms Used

For the multiple searches conducted, the unique search terms used were, Bed State, Bed Empty or Occupied, Patient State, Sleeping or awake, Eating drinking reading, Nursing care, BP measurement injection, medication, Patient reaction to care, Patient active, face recognition.

2.4.3 Result Details

The search results obtained were as per Appx B.

2.4.4 Relevant Result Details (Top three)

Existing models was found only for the face recognition use case. The top three python based models found were as listed in table 2.3.

Table 2.3: (Existing Face Recognition Models)

Software Name	Maker	Accuracy
face_recognition	Ageit Gey	99.38%
facenet	David Sandberg	99.4%
face.evoLVe.PyTorch	Zhao J	NA

2.4.5 Learning

It was found that models for face recognition already existed and were available for use under permissive license regimes. Hence CNN model for face recognition use case was not required to be developed.

2.5 Conclusion (literature review)

It was learnt that the health industry was working on the use of DNNs and CNNs for many aspects linked with healthcare. Also, it was observed that using CNNs to solve computer vision problems was the correct approach. However, literature on monitoring nursing care or personal care using CNNs was not found in the top 20 search results. Hence, the project research was planned to be undertaken as a novelty. As software's for face recognition existed, it was planned to develop CNN models for all other use cases only as part of the research.

3.0 Methodology

3.1 Research Design

The research being an applied research project, the problem area, the research question, and the research objectives to include the specific use cases for CNN models were known at the outset. It was planned to conduct literature review to identify suitable existing material on the subject and also for identifying existing models . CNN models were to be developed and tested for the use cases for which existing models were not found. The models developed were then planned to be analyzed using confusion matrix, to be made from the primary data obtained by running experiments on the models made.

3.2 Methods

3.2.1 Data Modeling

No primary data was collected. For training, validation and experiments on models, thousands of freely available images hosted on “Google Images” (**secondary data**) was used. Python Script, “**google-images-download**”, available on GitHub (https://github.com/hardikvasa/google-images-download) was used to download images from 'Google Images' For developing various models. Data augmentation allows us to increase our data set by using data that we already have. Minor alterations to the pictures are made, such as rotations, flips, scaling and translations. Data augmentation was done using Keras “Image DataGenerator”. Specific classes for classification were then identified to meet the different use case requirement. Bolei Zhou et al, in their work on “Learning Deep Features for Scene Recognition using Places Database” have said that for a dataset, expected to generalize well, it should have high diversity of image data [5, p4]. Hence, it was ensured during model training that the images used within the classes were as generic as possible. After download, the images were manually checked to confirm their utility for training. The entire dataset so downloaded was divided into three parts, train, validation and test sets. The validation set was used to monitor learning while the test set was used to run the experiments.

3.2.2 Building CNN Models

The CNN models were built using the Keras framework and python libraries. CNNs have a deep learning architecture inspired by the neurons present in the brain. Jiuxiang Gu et al, in their work on “Recent Advances in Convolutional Neural Networks For CNNs” have observed that increasing depth, increases the complexity of the network, which results in over fitting [6]. As the models were to be developed for use in home setting, the models were kept as simple as possible, this also avoided the problem of over fitting. The common factors for all the models developed were that they used the two dimensional convolution layers, Rectified Linear Unit (ReLU) as the activation function in all layers less the last dense layer, batch normalization function, Max pooling as pooling function, dropout technique for training the model, Flatten function was used to convert 3D feature maps to 1D feature vectors and dense layers were used after converting the feature maps to 1D.

3.2.3 Training CNN Models

Training CNN is an optimization issue. Best results are found by minimizing the loss function. R. G. J. Wijnhoven and et.al, in their work on "Fast training of object detection using stochastic gradient descent" have stated that Stochastic gradient descent is a common solution for optimizing CNN network [7]. However, Adam optimizer, being fast, easy to use and efficient has been used in all the models for training. The CNN models built were trained on the downloaded images using the technique of supervised learning. The model weights were saved based on the best result for validation and not for performance on training data.

3.2.4 Testing CNN Models

Testing the CNN models formed part of the experiments. Each classification model was tested on 100 images of each class as applicable for that model. The data so generated was saved as the primary data for analysis.

3.2.5 Analysis & Conclusions

Emma Beauxis-Aussalet et al, in their work on “Visualization of Confusion Matrix for Non-Expert Users”, have said that in classification problem, Confusion matrices are used to evaluate errors. Supervised machine learning is a typical use case area for use of confusion matrices [8]. Hence, confusion matrix were used to analyse the results of the experiments. Confusion matrix were created using the primary data obtained by running of experiments.

4.0 Bed State (Empty or occupied)

4.1 Purpose

The purpose for this model was to ascertain if a bed was occupied or vacant, that is the patient was there on the bed or not.

4.2 Data modeling

As it was a classification problem two classes of images were created. One class having occupied beds and the other having empty beds. The beds for both the classes included the beds used in home and hospital settings. The occupied beds class had people either sleeping or sitting on them. The images were obtained from the internet. A total of 1253 images of occupied bed class and 1305 of empty bed class were used as part of the training set. A total of 510 images of occupied bed and 540 of empty bed were used as part of the validation set. All images downloaded were of different size and dimensions. However, while feeding them for training and validation they were resized to 28 x 28.

4.3 Building CNN

The common features for all models have already been discussed before. The varying aspects were that two dense layers were used after converting the feature maps to 1D. Sigmoid activation was used in the last dense layer. The model had a total of 36,437 parameters. The model summary is as per Appx C.

4.4 Training CNN

The model had a total of 36,437 parameters out of which 36,285 parameters were trainable. For compiling the model, Binary cross entropy was used as the loss function. Adm optimizer was used in the model. Accuracy metrics was used while training the model. Training was carried out in 600 epochs. Steps per epoch were set to 360. Validation steps were set to 360. Batch size was set to 90. The model was trained to optimize the validation accuracy. Validation accuracy of 96% was achieved. The training steps (curtailed) are as per Appx D.

4.5 Testing & Results

To test the Bed State CNN, 100 images of each class (not used for training the model) were put in the test folder separately and the model was used for making predictions on them. The two classes were "Occupied" and "Empty". First the predictions were made upon the "Occupied" class of images and then on the "Empty" class of images. The model made a total of 200 predictions. Out of those 200 cases, the model predicted "Occupied" class 102 times, and "Empty" class 98 times. In reality, 100 beds were occupied and 100 were not.

The details of the result are as per Appx E. The misclassified results are in "**Bold**" and "*Italics*". The confusion matrix for the same is as per table 4.1.

Table 4.1 : (Confusion Matrix)

	Predicted : Occupied	Predicted : Empty	
Actual : Occupied	TP = 96	FN = 4	100
Actual : Empty	FP = 6	TN = 94	100
	102	98	

4.6 Analysis of Results

4.6.2 Accuracy

Accuracy = (TP+TN)/total

= (96+94)/200

= 0.95

4.6.3 Misclassification Rate (MR) / Error Rate

MR = (FP+FN)/total

= (6+4)/200

= 0.05

4.6.4 True Positive Rate (TPR) / Sensitivity

TPR = TP/actual occupied

= 96/100

= 0.96

4.6.5 False Positive Rate (FPR)

FPR = FP/actual empty

= 6/100

= 0.06

4.6.6 True Negative Rate (TNR) / Specificity

TNR = TN/actual empty

= 94/100

= 0.94

4.6.7 Precision

Precision = TP/predicted occupied

= 96/102

= 0. 94

4.6.8 Conclusion

The CNN model for detecting bed states of "Occupied" and "Empty" has a very good performance. The accuracy of the model is high at 95%. Also, scope for further improvement of the model does exist. This model would be the first in chain of models as part of the planned application. If the patient is occupying the bed than only other models will fire, based on the logic of the application.

5.0 Patient State A (Sleeping or awake)

5.1 Purpose

The purpose of this model was to ascertain if a patient on the bed was sleeping or awake.

5.2 Data modeling

As it is was a classification problem, two classes of images were created. One class having patients sleeping and the other having patients awake. The images were obtained from the internet. A total of 1045 images of patients awake class and 1771 of patients sleeping were used as part of the training set. A total of 573 images of patients awake and 543 of patients sleeping were used as part of the validation set. All images downloaded were of different size and dimensions. However, while feeding them for training and validation they were resized to 28 x 28.

5.3 Building CNN

The common features for all models have already been discussed before. The varying aspects were that, two dense layers were used after converting the feature maps to 1D. Sigmoid activation was used in the last dense layer. The model had a total of 46,773 parameters. The model summary is as per Appx F.

5.4 Training CNN

The model had a total of 46,773 parameters out of which 46,589 parameters were trainable. For compiling the model, Binary cross entropy was used as the loss function. Adm optimizer was used in the model. Accuracy metrics was used while training the model. The training was carried out over 500 epochs. Steps per epoch was set to 210. Validation steps were set to 210. Batch size was set to 70. The model was trained to optimize the validation accuracy. Validation accuracy of 81% was achieved. The training steps (curtailed) are as per Appx G.

5.5 Testing & Results

To test the Patient State CNN, 100 images of each class (not used for training the model) were put in the test folder separately and the model was used for making prediction on them. The two classes were "Awake" and "Sleeping". First the predictions were made upon the patient "Awake" images and then on the patient "Sleeping" images. The model made a total of 200 predictions. Out of those 200 cases, the model predicted "Awake" class, 113 times, and "Sleeping" class 87 times. In reality, 100 patients were Awake and 100 were not. The details of the result are as per Appx H. The misclassified results are in "**Bold**" and "*Italics*". The confusion matrix for the same is as per table 5.1.

Table 5.1 : (Confusion Matrix)

	Predicted : Awake	Predicted : Sleeping	
Actual : Awake	TP = 99	FN = 1	100
Actual : Sleeping	FP = 14	TN = 86	100
	113	87	

5.6 Analysis of Results

5.6.1 Accuracy

Accuracy = (TP+TN)/total

= (99+86)/200

= 0.925

5.6.2 Misclassification Rate (MR) / Error Rate

MR = (FP+FN)/total

= (14+1)/200

= 0.075

5.6.3 True Positive Rate (TPR) / Sensitivity

TPR = TP/actual awake

= 99/100

= 0.99

5.6.4 False Positive Rate (FPR)

FPR = FP/actual sleeping

= 14/100

= 0.14

5.6.5 True Negative Rate (TNR) / Specificity

TNR = TN/actual sleeping

= 86/100

= 0.86

5.6.6 Precision

Precision = TP/predicted awake

= 99/113

= 0. 876

5.6.7 Conclusion

The CNN model for detecting patient states of "Awake" and "Sleeping" has good performance. The accuracy of the model is high. It can be used to monitor the times when either the patient is sleeping or awake. This monitoring can be done for medical, social and care giving reasons. The model can be deployed as a self learning model to get better performance from it in future.

6.0 Patient state B (Drinking, Eating, Reading)

6.1 Purpose

The purpose of this model was to ascertain the activity a patient was engaged in. That is whether the patient was eating, drinking or reading.

6.2 Data modeling

As it was a classification problem three classes of images were created for patients awake on the bed and engaged in some activity. The first class was of patient drinking, second of patient eating and the third of patient reading. The images were obtained from the internet. A total of 769 images of patients drinking, 819 images of patients eating and 700 images of patients reading were used as part of the training set. A total of 311 images of patients drinking, 306 images of patients eating and 311 images of patients reading were used as part of the validation set. All images downloaded were of different size and dimensions. However, while feeding them for training and validation they were resized to 40 x 40.

6.3 Building CNN

The common features for all models have already been discussed before. The varying aspects were that, three dense layers were used after converting the feature maps to 1D. Softmax activation was used in the last dense layer. The model had a total of 315,743 parameters. The model summary is as per Appx I.

6.4 Training CNN

The model had a total of 315,743 parameters out of which 314,961 parameters were trainable. For compiling the model Categorical cross entropy was used as the loss function. Adm optimizer was used in the model. Accuracy metrics was used while training the model. The model was trained in 500 epochs. Steps per epoch were set to 480. Validation steps were set to 480. Batch size was set to 120. The model was trained to optimize the validation accuracy. Validation accuracy of 86% was achieved. The training steps (curtailed) are as per Appx J.

6.5 Testing & Results

To test the Patient State B CNN, 100 images of each class (not used for training the model) were put in the test folder separately and the model was used for making prediction on them. The three classes were "Drinking" , “Eating” and "Reading". First the predictions were made upon the "Drinking" class of images, then on “Eating” class of images and finally on the "Reading" class of images. The model made a total of 300 predictions. Out of those 300 cases, the model predicted "Drinking" class 103 times, "Eating" class 88 times and "Reading" class 109 times. The details of the result are as per Appx K. The misclassified results are in “**Bold**” and “*Italics*”. The confusion matrix for the same is as per table 6.1.

Table 6.1 : (Confusion Matrix)

	Predicted Drinking	Predicted Eating	Predicted Reading	Total	Recall Rate
Drinking	82	15	3	100	82%
Eating	19	72	9	100	72%
Reading	2	1	97	100	97%

Total	103	88	109	**300**	**83.6%**
Precision	80%	82%	89%	**83.6%**	

6.6 Analysis of Results

6.6.1 Accuracy

Accuracy = (82+72+97)/300

= 0.836

6.6.2 Misclassification Rate (MR)

MR = (15+3+19+9+2+1)/300

= 0.164

6.6.3 Conclusion

Both the "Recall Rate" and "Precision" of the model are currently satisfactory. The scope for improvement in performance exists. Being part of a proof of concept, the CNN model for patient states was trained to pick up three patient activities only. A similar model incorporating all possible patient state classes in the home setting can be made and tried out in the future.

7.0 Nursing Activities (Blood Pressure, Injection, Medicine)

7.1 Purpose

The purpose of this model was to monitor the nursing care a patient is given. Three nursing activities are monitored using the model, taking of Blood Pressure" (BP), giving injection, and that of patient taking medicines.

7.2 Data modeling

As it is a classification problem, three classes of images have been created for patients being nursed. The first class is of “BP”, second of “Injection” and the third of “Patient taking medicines”. The images were obtained from the internet. A total of 1891 images of blood pressure, 1968 images of injection and 1077 images of patients taking medicine were used as part of the training set. A total of 790 images of blood pressure, 602 images of injection and 549 images of patients taking medicine were used as part of the validation set. All images downloaded were of different size and dimensions. However, while feeding them for training and validation they were resized to 40 x 40.

7.3 Building CNN

The common features for all models have already been discussed before. The varying aspects were that three dense layers were used after converting the feature maps to 1D. Softmax activation was used in the last dense layer. The model had a total of 987,967 parameters. The model summary is as per Appx L.

7.4 Training CNN

The model had a total of 987,967 parameters out of which 986,787 parameters were trainable. For compiling the model Categorical cross entropy was used as the loss function. Adm optimizer was used in the model. Accuracy metrics was used while training the model. The model was trained in 500 epochs. Steps per epoch were set to 600.

Validation steps were set to 450. Batch size was set to 150. The model was trained to optimize the validation accuracy. Validation accuracy of 94% was achieved. The training steps (curtailed) are as per Appx M.

7.5 Testing & Results

To test the Nursing Activities, CNN, 100 images of each class (not used for training the model) were put in the test folder separately and the model was used for making prediction on them. The three classes were "BP" , “Injection” and "Medicine". First the predictions were made upon the "BP" class of images, then on “Injection” class of images and finally on the "Medicine" images. The model made a total of 300 predictions. Out of those 300 cases, the model predicted "BP" 103 times, "Injection" class 88 times and "Medicine" class 109 times. The details of the result are as per Appx N. The misclassified results are in “**Bold**” and “*Italics*”. The confusion matrix for the same is as per table 7.1.

Table 7.1 : (Confusion Matrix)

	Predicted BP	Predicted Injection	Predicted Medicine	Total	Recall Rate
BP	93	7	0	100	93%
Injection	3	94	3	100	94%
Medicine	0	1	99	100	99%
Total	96	102	102	**300**	**95.3%**

Precision	97%	92%	97%	**95.3%**	

7.6 Analysis of Results

7.6.1 Accuracy

Accuracy = (93+94+99)/300

= 0.953

7.6.2 Misclassification Rate (MR) / Error Rate

MR = (7+3+3+1)/300

= 0.047

7.6.3 Conclusion

Both the “Recall Rate” and “Precision” of the model are high. The CNN model for nursing care being a prototype was trained to pick up three nursing care activities only. A similar model incorporating all possible nursing care classes in the home setting can be made and tried out in the future.

8.0 Patient Mood (Negative, Neutral, Positive)

8.1 Purpose

The purpose of this model was to monitor patient response to care received by them. To test the concept three response moods are monitored using the model, negative response, neutral, and a positive response.

8.2 Data modeling

As it is a classification problem three classes of images were created for patients response moods. The first class was of negative response, second of neutral and the third of positive response. The images were obtained from the internet. A total of 1669 images of negative mood, 1743 images of neutral mood and 2060 images of positive mood were used as part of the training set. A total of 695 images of negative mood, 625 images of neutral mood and 1089 images of positive mood were used as part of the validation set. All images downloaded were of different size and dimensions. However, while feeding them for training and validation they were resized to 28 x 28.

8.3 Building CNN

The common features for all models have already been discussed before. The varying aspects were that, three dense layers were used after converting the feature maps to 1D. Softmax activation was used in the last dense layer. The model had a total of 402,523 parameters. The model summary is as per Appx O.

8.4 Training CNN

The model had a total of 402,523 parameters out of which 400,275 parameters were trainable. For compiling the model, Sparse cross entropy was used as the loss function. Adm optimizer was used in the model. Accuracy metrics was used while training the model. The model was trained over 1000 epochs. Steps per epoch were set to 420. Validation steps were set to 420. Batch size was set to 105. The model was trained to optimize the validation accuracy. Validation accuracy of 84% was achieved. The training steps (curtailed) are as per Appx P.

8.5 Testing & Results

To test the Patient Mood, CNN, 100 images of each class (not used for training the model) were put in the test folder separately and the model was used for making prediction on them. The three classes were "Negative" , “Neutral” and "Positive". First the predictions were made upon the "Negative" class of images, then on “Neutral” class of images and finally on the "Positive" class. The model made a total of 300 predictions. Out of those 300 cases, the model predicted "Negative" class 82 times, "Neutral" class 91 times and "Positive" class 127 times. The details of the result are as per Appx Q. The misclassified results are in “**Bold**” and “*Italics*”. The confusion matrix for the same is as per table 8.1.

Table 8.1 : (Confusion Matrix)

	Predicted Negative	Predicted Neutral	Predicted Positive	Total	Recall Rate
Negative	76	6	18	100	76%
Neutral	4	76	20	100	76%
Positive	2	9	89	100	89%
Total	82	91	127	**300**	**80.4%**
Precision	92.6%	83.5%	70%	**82%**	

8.6 Analysis of Results

8.6.1 Accuracy

Accuracy = (76+76+89)/300

= 0.804

8.6.2 Misclassification Rate (MR) / Error Rate

MR = (6+18+4+20+2+9)/300

= 0.196

8.6.3 Conclusion

The CNN model can be used with a certain degree of surety to register correct patient response, to the care being provided to him/her in the home setting by a HCP. The model could be deployed as a self learning model, to further improve its performance. Also, it could be used to register the moods of patient over a length of time for medical and social reasons too.

9.0 Change Detection

9.1 Purpose

The purpose of this model was to ascertain if there was any patient activity or any change in patient state. The activity could be even a slight movement. This was not a classification but a comparison problem as it involved change detection between two images.

9.2 Model Building

The model built, was not a pure CNN model, but built using it. Firstly a CNN model was trained to identify 37 different objects, which included recognition of "Person" object, "Face" object and many other objects which could be found in a house setting. Using this model a sub model was created which was not for classification of objects, but for returning the feature maps of the input image. This sub model was used to return the feature maps of both the new image and the reference image. In the model, then structural similarity index between the two feature maps is calculated using the python scikit library to detect the changes. The two sub units work together to constitute the Change Detection Model (CDM). If two images are the same, then the CDM returns 1 else depending upon the difference it returns a float value less than 1. The sub model summary is as per Appx R.

9.3 Data modeling

The CDM compares changes in two images. The input image dimensions are 90 x 90. The sub model returns feature map of shape (11, 11, 128) . A script using CV2 library of python is used to capture image frames from video/video feed. The first image is used as the reference image. It is compared to the new image using the CDM. If change below a threshold is detected then it is registered as change detection. Also, the new image is then stored as reference image and the old reference image is deleted. This process goes on continuously to detect all changes.

9.4 Experiments & Results

To test the model three separate experiments were run. The first experiment included 50 sets of two images each. Both the images in each set were actually the same image. The result details for the first experiment are as per Appx S. The second experiment included 50 sets of two images each. Both the images in each set were actually the same image, but for the “temperature” parameter altered in the second image using the “Shotwell” software. This was done to depict change in room lighting conditions. The result details for the second experiment are as per Appx T. In the third experiment, 50 sets of two images per set were compared. All other factors, less the changed position of person in image were constant, including the lighting conditions. The change in position was very slight. The result details for the third experiment are as per Appx U.

9.5 Analysis of Results

For the first experiment (50 sets of same images), the CDM predicted “No Change” for all 50 sets by returning a result of 1.0. Hence, if there is no change, then accuracy of CDM is 100%. For the second experiment (50 sets of same images, but with different lighting), the CDM predicted “Change” for all 50 sets by returning results, whose average was 0.21, min (Maximum distance between the two images) was 0.04 and max (Minimum distance between the two images) was 0.42. If the structural similarity index (CDM result) between the two feature maps is less than 0.21, then we can consider it to be due to change in room lighting conditions too. For the third experiment (50 sets of images with slight movement of patient), the CDM predicted “Change” for all 50 sets by returning results, whose average was 0.51, min (Maximum distance between the two images) was 0.14 and max (Minimum distance between the two images) was 0.97. If the structural similarity index (CDM result) between the two feature maps is around 0.51, then we can consider it to be due to some movement of the patient in the room. Based on results, the threshold to register change if set at 0.90, will have a detection of about 94% for the patient movements.

9.6 Conclusion

The CDM model, is very sensitive and can easily detect differences between two images. This gives it the capability to pick up even very small patient movements, however, on the flip side, it can give false alarm for change detection even with slight change in room lighting condition. However, the CDM can be configured to reasonably guess / differentiate between the changes occurring due to change in lighting condition or due to movement.

10.0 Final Conclusion And Future Work

10.1 Conclusion

Old age and disabilities bring many challenges on various counts of ADLs and IADLs. Bed ridden people require not only personal care but also nursing care in home setting. Home care is the concept of healthcare and personal care being provided at home. Recently, many companies have mushroomed to fill up this space. Home care companies can stay in business as long as they can gain and keep the **trust** of their clients. To build and maintain this trust the companies have to depend upon the good work of numerous employees they employ. Care Managers face a challenge in monitoring the activities of the HCPs placed under them. This thesis was undertaken to answer the moot question of, if CNNs can be used for solving this existing problem of monitoring personal care and nursing care being provided in the home setting. This applied research is a novelty in this field which involved both research and development work to complete it. To start with, seven specific use cases for CNN models were given as terms of reference. Literature review was carried out to identify suitable existing models, only one existing model for face recognition was found. CNN models for the balance six use cases were then developed, validated and tested as part of this research work. The CNN models were developed as sleek yet efficient models for them to run on not so powerful machines in the home setting. The CNN models developed were analyzed using the confusion matrix. Overall, promising results were achieved. Hence, it can be safely concluded that CNN models can be used to monitor the nursing care and personal care being provided to the people confined to bed in the home setting.

10.2 Future Work

The CNN models were developed as part of proof of concept project. Hence, all the possible use cases were not covered. Also, the training of the models happened using limited training data, improvisation and in limited time. Hence, there exists a scope for further improvement. In a future work, endevour could be made to overcome the existing short comings, while trying to develop holistic CNN models for monitoring the nursing care and personal care being provided to the people confined to bed. It would also be prudent to explore the use of Recurrent Neural Networks for speech recognition to monitoring nursing care and personal care in the home setting.

11.0 Reference List

[1] Sharon A. Levine; Jeremy Boal; Peter A. Boling, Home Care, JAMA, 2003, 290(9), 1203- 1207.
Available from: http://www.bumc.bu.edu/im-residency/files/2013/03/Levine-Home-Care-article-2003-wk-1.pdf

[2] The European Observatory on Health Systems and Policies, Home Care across Europe Current structure and future challenges, WHO, 2012, ISBN 978 92890 02882
Available from: http://www.euro.who.int/__data/assets/pdf_file/0008/181799/e96757.pdf

[3] Ashwin Bhandare et al, Applications of Convolutional Neural Networks, IJCSIT, 2016, Vol. 7 (5) , 2206-2215.
Available from: https://ijcsit.com/docs/Volume%207/vol7issue5/ijcsit20160705014.pdf

[4] Syed Umar Amin et al, Cognitive Smart Healthcare for PathologyDetection and Monitoring, IEEE, 2019, Vol 7, 10.1109 / ACCESS.2019.2891390
Available from: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8605339

[5] Bolei Zhou et al, Learning Deep Features for Scene Recognition using Places Database, MIT, Available from: http://places.csail.mit.edu/places_NIPS14.pdf

[6] Jiuxiang Gu et al, Recent Advances in Convolutional Neural Networks, NTU Singapore, 2017, Available from: https://arxiv.org/pdf/1512.07108.pdf

[7] R. G. J. Wijnhoven, P. H. N. de With, Fast training of object detection using stochastic gradient descent, in: International Conference on Pattern Recognition (ICPR), 2010, pp. 424–427. Available from: https://ieeexplore.ieee.org/document/5597822

[8] Emma Beauxis-Aussalet et al, Visualization of Confusion Matrix for Non-Expert Users, CWI, Available from :
https://pdfs.semanticscholar.org/1e04/b2882ddd6e07f411e3a77d9d20bdd21273a8.pdf

Appx A
(Refers to para 2.3.1)

LITERATURE REVIEW : PART I (RESULT DETAILS)

Title	Author	Relevent
Deep Learning for Medical Image	Muhammad Imran Razzak, Saeeda	No

Processing: Overview, Challenges and Future	Naz and Ahmad Zaib	
Artificial intelligence and deep learning in ophthalmology	Daniel Shu Wei Ting, Louis R Pasquale, Lily Peng, John Peter Campbell,Aaron Y Lee, Rajiv Raman, Gavin Siew Wei Tan,	No
Artificial intelligence in healthcare: past, present and future	Fei Jiang, Yong Jiang, Hui Zhi, Yi Dong, Hao Li, Sufeng Ma, Yilong Wang, Qiang Dong, Haipeng Shen, Yongjun Wang	No
Deep learning for healthcare: review, opportunities and challenges	Riccardo Miotto, Fei Wang, Shuang Wang, Xiaoqian Jiang and Joel T. Dudley	No
Artificial Intelligence for Health and Health Care	JSR-17-Task-002, JASON, The MITRE Corporation	No
Deep Learning Models for Health Care:Challenges and Solutions	Yan Liu , Jimeng Sun	No
Cognitive Smart Healthcare for Pathology Detection and Monitoring	SYED UMAR AMIN, M. SHAMIM HOSSAIN	Yes
Accurate real time localization tracking in a clinical environment using Bluetooth Low Energy and deep learning	Zohaib Iqbal, Da Luo,Peter Henry,Samaneh Kazemifar	No
Big Sensed Data Meets Deep Learning for Smarter Health Care in Smart Cities	Alex Adim Obinikpo and Burak Kantarci	No

Title	Author	Relevent
Deep Sense : a Unified Deep Learning Framework for Time-Series Mobile Sensing Data Processing	Shuochao Yao, Shaohan Hu, Yiran Zhao	No
Reimagining healthcare opportunities with artificial intelligence	Infosys	No
Deep Sense : a Unified Deep Learning Framework for Time-Series Mobile Sensing Data Processing	Shuochao Yao, Shaohan Hu, Yiran Zhao	No
2018 Artificial Intelligence and Cloud Computing Conference	AICCC	No
Doctor ai: interpretable deep learning for modeling electronic health records	Edward Choi	No
Deep Learning in Medical Imaging: General Overview	June-Goo Lee, PhD, Sanghoon Jun, PhD	No
RAIM: Recurrent Attentive and Intensive Model of Multi model Patient Monitoring Data	Yanbo XuGeorgia , Siddharth Biswal, Shriprasad R Deshpande	No
Artificial Intelligence & Machine Learning - in Health Sector	Dr. Anjali Mathur	No
From Perception to Cognition: Towards Human-Understanding and Human-Centricity in AI	Kenneth Kwok, PhD	No
Clinical Intervention Prediction and Understanding with Deep Neural Networks	Harini Suresh, Nathan Hunt, Alistair Johnson	No
Future of patient data	Accenture	No

Appx B
(Refers to para 2.4.3)

LITERATURE REVIEW : PART II (RESULT DETAILS)

Search terms	Search Results
Bed State	We couldn’t find any repositories matching 'bed State language:Python license:mit
Bed Empty or Occupied	We couldn’t find any repositories matching 'bed empty or occupied language:Python license:mit
Patient State	We couldn’t find any repositories matching 'Patient State language:Python license:mit
Sleeping or awake	We couldn’t find any repositories matching 'Sleeping Awake language:Python license:mit
Eating, drinking, reading	We couldn’t find any repositories matching 'Eating, drinking, reading language:Python
Nursing care	We couldn’t find any repositories matching 'Nursing care language:Python license:mit
BP measurement, injection, medication	We couldn’t find any repositories matching 'BP measurement, injection, medication language : Python license:mit
Patient reaction to care	We couldn’t find any repositories matching 'Patient reaction to care language:Python license:mit
Patient active	We couldn’t find any repositories matching 'Patient active language:Python license:mit
face recognition	534 results found

Appx C
(Refers to para 4.3)

MODEL SUMMARY : BED STATE

Layer (type)	Output Shape	Param #
conv2d_21 (Conv2D)	(None, 26, 26, 20)	560
activation_31 (Activation)	(None, 26, 26, 20)	0
conv2d_22 (Conv2D)	(None, 24, 24, 20)	3620
activation_32 (Activation)	(None, 24, 24, 20)	0
batch_normalization_16 (Batc	(None, 24, 24, 20)	80
max_pooling2d_11 (MaxPooling	(None, 12, 12, 20)	0
dropout_16 (Dropout)	(None, 12, 12, 20)	0
conv2d_23 (Conv2D)	(None, 10, 10, 40)	7240
activation_33 (Activation)	(None, 10, 10, 40)	0
conv2d_24 (Conv2D)	(None, 8, 8, 40)	14440
activation_34 (Activation)	(None, 8, 8, 40)	0
batch_normalization_17 (Batc	(None, 8, 8, 40)	160
max_pooling2d_12 (MaxPooling	(None, 4, 4, 40)	0
dropout_17 (Dropout)	(None, 4, 4, 40)	0
flatten_6 (Flatten)	(None, 640)	0
dense_11 (Dense)	(None, 16)	10256
activation_35 (Activation)	(None, 16)	0
batch_normalization_18 (Batc	(None, 16)	64
dropout_18 (Dropout)	(None, 16)	0
dense_12 (Dense)	(None, 1)	17
activation_36 (Activation)	(None, 1)	0

Appx D
(Refers to para 4.4)

TRAINING METRICS (CURTAILED) : BED STATE

```
Epoch 480/600
4/4 [==============================] - 3s 718ms/step - loss: 0.0573 -
acc: 0.9778 - val_loss: 0.2166 - val_acc: 0.9333

Epoch 00480: val_acc did not improve from 0.95278
Epoch 481/600
4/4 [==============================] - 2s 607ms/step - loss: 0.0739 -
acc: 0.9639 - val_loss: 0.2127 - val_acc: 0.9357

Epoch 00481: val_acc did not improve from 0.95278
Epoch 482/600
4/4 [==============================] - 3s 667ms/step - loss: 0.0504 -
acc: 0.9917 - val_loss: 0.2179 - val_acc: 0.9333

Epoch 00482: val_acc did not improve from 0.95278
Epoch 483/600
4/4 [==============================] - 2s 617ms/step - loss: 0.0562 -
acc: 0.9736 - val_loss: 0.3032 - val_acc: 0.9000

Epoch 00483: val_acc did not improve from 0.95278
Epoch 484/600
4/4 [==============================] - 2s 595ms/step - loss: 0.0528 -
acc: 0.9722 - val_loss: 0.3216 - val_acc: 0.9056

Epoch 00484: val_acc did not improve from 0.95278
Epoch 485/600
4/4 [==============================] - 3s 771ms/step - loss: 0.0595 -
acc: 0.9806 - val_loss: 0.2735 - val_acc: 0.9064

Epoch 00485: val_acc did not improve from 0.95278
Epoch 486/600
4/4 [==============================] - 3s 773ms/step - loss: 0.0417 -
acc: 0.9861 - val_loss: 0.2180 - val_acc: 0.9417

Epoch 00486: val_acc did not improve from 0.95278
Epoch 487/600
4/4 [==============================] - 2s 609ms/step - loss: 0.0409 -
acc: 0.9861 - val_loss: 0.3282 - val_acc: 0.8917

Epoch 00487: val_acc did not improve from 0.95278
Epoch 488/600
4/4 [==============================] - 3s 686ms/step - loss: 0.0470 -
acc: 0.9806 - val_loss: 0.3425 - val_acc: 0.9123
```

```
Epoch 00488: val_acc did not improve from 0.95278
Epoch 489/600
4/4 [==============================] - 2s 550ms/step - loss: 0.0534 -
acc: 0.9806 - val_loss: 0.2587 - val_acc: 0.9194

Epoch 00489: val_acc did not improve from 0.95278
Epoch 490/600
4/4 [==============================] - 3s 815ms/step - loss: 0.0521 -
acc: 0.9778 - val_loss: 0.1492 - val_acc: 0.9639

Epoch 00490: val_acc improved from 0.95278 to 0.96389, saving model to
bedState.h5
Epoch 491/600
4/4 [==============================] - 2s 601ms/step - loss: 0.0565 -
acc: 0.9694 - val_loss: 0.1622 - val_acc: 0.9415

Epoch 00491: val_acc did not improve from 0.96389
```

Appx E
(Refers to para 4.5)

TESTING DETAILS : BED STATE

The result array for 100 Occupied beds images is as under:-

array([

[1.75382149e-06],	[7.00689182e-02],	[1.02073175e-03],
[2.56248513e-05],	[3.52715801e-06],	[1.39317650e-03],
[6.49995542e-08],	[4.97940890e-02],	[1.08629225e-04],
[7.09494780e-05],	[3.36724142e-08],	[1.14878356e-01],
[1.19536244e-05],	[8.50921750e-01],	[4.10053850e-04],
[6.01025313e-05],	[4.17177866e-08],	[3.74510182e-06],
[2.20561906e-05],	[3.80162545e-03],	[3.09137860e-03],
[9.05824571e-09],	[4.77712922e-04],	[3.85101231e-07],
[7.77794630e-04],	[6.40729629e-03],	[8.77641432e-05],
[7.79015409e-07],	[5.18170372e-03],	[4.30295995e-06],
[2.06132755e-02],	[4.25341896e-05],	[2.27364432e-03],
[3.53680139e-06],	[3.13781175e-06],	[9.86925443e-06],
[1.28915394e-03],	[1.53849001e-07],	[4.59637260e-04],
[4.46965096e-08],	[6.99692146e-06],	[2.31926762e-07],
[1.92848649e-02],	[9.35479417e-04],	[4.90435516e-04],
[9.11817096e-06],	[2.24382849e-03],	***[9.98891890e-01]***,
[1.57345021e-05],	[3.18637831e-07],	[7.86648598e-05],
[7.45214969e-02],	[2.26428147e-05],	[8.11023274e-05],
[7.35732319e-04],	[2.35579559e-03],	[1.33102098e-02],
[1.37994505e-09],	[1.33308102e-04],	[1.78918344e-06],
[1.04649194e-01],	[3.50137129e-02],	[1.79391718e-05],
[1.07324794e-02],	[5.35861496e-03],	[4.25170735e-03],
[1.44578121e-03],	[7.52536803e-02],	[4.89243947e-04],
[8.90567762e-08],	***[8.56600463e-01]***,	[9.08477604e-03],
[2.43751286e-03],	***[5.61044574e-01]***,	[1.71493649e-01],
[1.34706615e-05],	[2.26927757e-01],	***[9.65077162e-01]***,
[1.67363385e-08],	[3.55975237e-04],	[2.89666513e-03],
[1.73055795e-07],	[2.37425888e-06],	[1.52866319e-02],
[2.45094988e-02],	[9.84009355e-04],	[4.20065771e-06],
[1.45686686e-03],	[1.30548115e-05],	[8.43582238e-05],
[7.85014499e-03],	[8.02423642e-07],	[4.21637878e-06],
[3.30335715e-05],	[4.92409636e-05],	[1.73218416e-06],
[7.49528408e-03],	[4.91467655e-01],	[6.44569576e-04],

[2.00938853e-03]], dtype=float32)

The result array for 100 Empty beds images is as under:-

```
array([
[0.99999976], [0.70963943],       [0.999858  ], [0.48596087],
[0.6453823 ], [0.99701023],       [0.99999917], [0.6126634 ],
[0.99930835], [0.9999082 ],       [0.99999404], [0.20680709],
[0.99958795], [0.9978346 ],       [0.99763787], [0.99998784],
[0.57971257], [0.96859086],       [0.9999999 ], [0.96897215],
[0.9999627 ], [0.9822693 ],       [0.9927873 ], [0.99782026],
[0.9982216 ], [0.99999106],       [0.9981079 ], [0.99426174],
[0.99965084], [0.9796041 ],       [0.9216895 ], [0.95085096],
[0.996491  ], [0.9999865 ],       [0.99773055], [0.9983285 ],
[0.999848  ], [0.99456835],       [0.99999976], [1.        ],
[0.9996933 ], [0.91641057],       [0.9890454 ], [0.9911243 ],
[0.9967585 ], [0.9992078 ],       [0.9996933 ], [0.99998105],
[0.99766195], [1.        ],       [0.9982181 ], [0.9951208 ],
[0.9999865 ], [0.73169154],       [0.9284711 ], [0.98590046],
[0.9999993 ], [0.9818803 ],       [0.9294876 ], [0.99821645],
[0.8986142 ], [0.96707773],       [0.898103  ], [0.9970583 ],
[0.9993137 ], [0.9996375 ],       [0.9968526 ], [0.99366814],
[0.99739254], [0.93159306],       [0.99935275], [0.9998456 ],
[0.99999046], [0.9658104 ],       [0.999796  ], [0.9648568 ],
[0.9205518 ], [0.9975331 ],       [0.99960536], [0.99995816],
[0.06955335], [0.9998895 ],       [0.42153665], [0.9999902 ],
[0.99917394], [0.9964689 ],       [0.00260377], [0.9999522 ],
[0.99982303], [0.99921036],       [0.99736625], [0.99875927],
[0.9968953 ], [0.9979984 ],       [0.9999969 ], [0.9996705 ],
[0.32300192], [0.99843234],       [0.9999926 ], [0.999764  ]],
dtype=float32)
```

Appx F
(Refers to para 5.3)

MODEL SUMMARY : PATIENT STATE

Layer (type)	Output Shape	Param #
conv2d_5 (Conv2D)	(None, 26, 26, 20)	560
activation_7 (Activation)	(None, 26, 26, 20)	0
conv2d_6 (Conv2D)	(None, 24, 24, 20)	3620
activation_8 (Activation)	(None, 24, 24, 20)	0
batch_normalization_4 (Batch	(None, 24, 24, 20)	80
max_pooling2d_3 (MaxPooling2	(None, 12, 12, 20)	0
dropout_4 (Dropout)	(None, 12, 12, 20)	0
conv2d_7 (Conv2D)	(None, 10, 10, 40)	7240
activation_9 (Activation)	(None, 10, 10, 40)	0
conv2d_8 (Conv2D)	(None, 8, 8, 40)	14440
activation_10 (Activation)	(None, 8, 8, 40)	0
batch_normalization_5 (Batch	(None, 8, 8, 40)	160
max_pooling2d_4 (MaxPooling2	(None, 4, 4, 40)	0
dropout_5 (Dropout)	(None, 4, 4, 40)	0
flatten_2 (Flatten)	(None, 640)	0
dense_3 (Dense)	(None, 32)	20512
activation_11 (Activation)	(None, 32)	0
batch_normalization_6 (Batch	(None, 32)	128
dropout_6 (Dropout)	(None, 32)	0
dense_4 (Dense)	(None, 1)	33
activation_12 (Activation)	(None, 1)	0

Appx G
(Refers to para 5.4)

TRAINING METRICS (CURTAILED) : PATIENT STATE

Epoch 430/500

```
3/3 [==============================] - 1s 431ms/step - loss: 0.3889 -
acc: 0.8255 - val_loss: 0.6634 - val_acc: 0.6381

Epoch 00430: val_acc did not improve from 0.80476
Epoch 431/500
3/3 [==============================] - 2s 566ms/step - loss: 0.4243 -
acc: 0.8048 - val_loss: 0.6907 - val_acc: 0.6059

Epoch 00431: val_acc did not improve from 0.80476
Epoch 432/500
3/3 [==============================] - 2s 542ms/step - loss: 0.4429 -
acc: 0.7857 - val_loss: 0.5655 - val_acc: 0.7333

Epoch 00432: val_acc did not improve from 0.80476
Epoch 433/500
3/3 [==============================] - 2s 535ms/step - loss: 0.4035 -
acc: 0.8095 - val_loss: 0.4714 - val_acc: 0.7714

Epoch 00433: val_acc did not improve from 0.80476
Epoch 434/500
3/3 [==============================] - 1s 464ms/step - loss: 0.4224 -
acc: 0.7952 - val_loss: 0.8198 - val_acc: 0.6524

Epoch 00434: val_acc did not improve from 0.80476
Epoch 435/500
3/3 [==============================] - 2s 516ms/step - loss: 0.4200 -
acc: 0.8143 - val_loss: 0.7219 - val_acc: 0.6333

Epoch 00435: val_acc did not improve from 0.80476
Epoch 436/500
3/3 [==============================] - 2s 524ms/step - loss: 0.4072 -
acc: 0.8286 - val_loss: 0.5540 - val_acc: 0.7143

Epoch 00436: val_acc did not improve from 0.80476
Epoch 437/500
3/3 [==============================] - 2s 617ms/step - loss: 0.3936 -
acc: 0.8333 - val_loss: 0.4378 - val_acc: 0.8118

Epoch 00437: val_acc improved from 0.80476 to 0.81176, saving model to
patientState28.h5
Epoch 438/500
3/3 [==============================] - 2s 508ms/step - loss: 0.3752 -
acc: 0.8000 - val_loss: 0.5884 - val_acc: 0.7190
```

```
Epoch 00438: val_acc did not improve from 0.81176
Epoch 439/500
3/3 [==============================] - 2s 551ms/step - loss: 0.3236 -
acc: 0.8571 - val_loss: 0.5407 - val_acc: 0.7381

Epoch 00439: val_acc did not improve from 0.81176
Epoch 440/500
3/3 [==============================] - 2s 667ms/step - loss: 0.3373 -
acc: 0.8429 - val_loss: 0.5699 - val_acc: 0.7476

Epoch 00440: val_acc did not improve from 0.81176
Epoch 441/500
3/3 [==============================] - 2s 552ms/step - loss: 0.4250 -
acc: 0.8000 - val_loss: 0.4766 - val_acc: 0.7619

Epoch 00441: val_acc did not improve from 0.81176
```

Appx H
(Refers to para 5.5)

<u>TESTING DETAILS : PATIENT STATE</u>

The result array for 100 Awake patients images is as under:-

```
array([
[2.9045273501e-03],        [2.23644380e-03],       [2.68822312e-01],
[5.53588152e-01],         [7.78558031e-02],       [2.52649430e-02],
[1.84388965e-01],         [1.38826044e-02],       [7.31833931e-03],
[2.73582613e-04],         [8.59161764e-02],       [1.77985907e-03],
[1.15737200e-01],         [4.15434852e-06],       [6.04771040e-02],
[3.02746799e-03],         [1.86573401e-01],       [2.05946103e-01],
[3.38905379e-02],         [3.33922029e-01],       [9.07899998e-03],
[7.73091142e-06],         [3.66053954e-02],       [3.49311411e-01],
[4.25077882e-03],         [2.98205484e-02],       [1.77325368e-01],
[3.03508520e-01],         [4.27926145e-02],       [6.18537609e-03],
[2.90574469e-02],         [1.02936618e-01],       [3.67404550e-01],
[7.19557181e-02],         [8.57453677e-04],       [1.00426807e-03],
[1.61137339e-02],         [3.54400324e-03],       [1.05381375e-02],
[4.71937925e-01],         [2.10367814e-02],       [9.51535106e-02],
[1.82521269e-01],         [2.47940928e-01],       [7.57957324e-02],
[2.48822033e-01],         [2.48560245e-04],       [1.31547853e-01],
[7.09705008e-03],         [1.18567623e-01],       [1.91641622e-03],
[3.46045531e-02],         [6.36430108e-04],       [1.09569514e-02],
[1.07854167e-02],         [2.90363748e-02],       [2.59899534e-02],
[2.61908825e-02],         [2.96925573e-05],       [1.79754086e-02],
[1.70986250e-01],         [7.44035002e-04],       [7.96510652e-02],
[1.12788320e-01],         [1.01562858e-01],       [4.15491580e-04],
[3.57104652e-02],         [1.43298751e-03],       [4.23873439e-02],
[3.08520272e-02],         [2.22064834e-02],       [1.53158084e-02],
[4.43464629e-02],         [8.79953514e-05],       [1.13659492e-03],
[1.97490258e-03],         [1.93220451e-02],       [2.89815497e-02],
[1.34248480e-01],         [6.25779899e-03],       [2.02144422e-02],
[5.80386072e-03],         [2.09196638e-02],       [9.74558145e-02],
[2.22763815e-03],         [1.07092615e-02],       [2.19521360e-04],
[1.31632358e-01],         [5.27028739e-01],       [4.18169610e-03],
[2.19659638e-02],         [1.31512970e-01],       [1.07615314e-01],
[2.46584058e-01],         [1.13687404e-01],       [3.47197533e-01],
[2.01922711e-02],         [2.29777712e-02],       [1.47754084e-02],
[3.11659486e-03]], dtype=float32)
```

The result array for 100 Sleeping patients images is as under:-

array([
[0.24788207], [0.9997148], [0.987927], [0.9776444],
[0.9685693], [0.9946227], ***[0.19054443]***, [0.99969554],
[0.932695], [0.99997926], ***[0.11049751]***, [0.998268],
[0.99284184], [0.9980849], [0.8037333], [0.79553473],
[0.98000526], [0.99748826], [0.8411465], [0.99993026],
[0.9999223], [0.9079609], [0.9827581], [0.9880227],
[0.983723], [0.63554657], [0.84366834], [0.66066945],
[0.64422864], [0.9875258], [0.94057465], [0.9982439],
[0.98482174], [0.52915096], [0.72397876], [0.9976164],
[0.9994048], [0.983043], [0.99860805], [0.99997663],
[0.99569184], ***[0.00386594]***, [0.8792759], [0.94625187],
[0.91477126], [0.87098813], [0.66844845], [0.9648031],
[0.35838374], [0.9921812], [0.9999752], [0.72161573],
[0.79360807], [0.7295056], [0.7489248], [0.86106396],
[0.5716132], [0.9995634], [0.998645], [0.96699923],
[0.02564389], [0.998109], [0.9999647], [0.97115886],
[0.93317884], [0.91642016], [0.87671304], [0.9320346],
[0.9993376], [0.9997638], [0.97607476], [0.60558575],
[0.79258865], [0.98558515], [0.9941824], ***[0.00941105]***,
[0.03407755], [0.9998846], [0.9994017], [0.99999213],
[0.9862834], [0.9739533], [0.8333069], ***[0.08603293]***,
[0.9610382], [0.9709583], [0.73997957], [0.70285875],
[0.4111911], ***[0.3239083]***, [0.64924645], [0.6090989],
[0.8647815], [0.85295373], ***[0.01809484]***, [0.99894553],
[0.4384678], [0.9878754], ***[0.4483933]***, [0.7887465]
], dtype=float32)

Appx I
(Refers to para 6.3)

<u>MODEL SUMMARY : PATIENT STATE B</u>

Layer (type)	Output Shape	Param #
conv2d_6 (Conv2D)	(None, 38, 38, 32)	896
batch_normalization_8 (Batch	(None, 38, 38, 32)	128
activation_9 (Activation)	(None, 38, 38, 32)	0
conv2d_7 (Conv2D)	(None, 36, 36, 32)	9248
batch_normalization_9 (Batch	(None, 36, 36, 32)	128
activation_10 (Activation)	(None, 36, 36, 32)	0
max_pooling2d_3 (MaxPooling2	(None, 18, 18, 32)	0
dropout_5 (Dropout)	(None, 18, 18, 32)	0
conv2d_8 (Conv2D)	(None, 16, 16, 64)	18496
batch_normalization_10 (Batc	(None, 16, 16, 64)	256
activation_11 (Activation)	(None, 16, 16, 64)	0
conv2d_9 (Conv2D)	(None, 14, 14, 64)	36928
batch_normalization_11 (Batc	(None, 14, 14, 64)	256
activation_12 (Activation)	(None, 14, 14, 64)	0
conv2d_10 (Conv2D)	(None, 12, 12, 64)	36928
batch_normalization_12 (Batc	(None, 12, 12, 64)	256
activation_13 (Activation)	(None, 12, 12, 64)	0
max_pooling2d_4 (MaxPooling2	(None, 6, 6, 64)	0
dropout_6 (Dropout)	(None, 6, 6, 64)	0
flatten_2 (Flatten)	(None, 2304)	0
dense_4 (Dense)	(None, 90)	207450

```
activation_14 (Activation)   (None, 90)                0
_________________________________________________________________
batch_normalization_13 (Batc (None, 90)                360
_________________________________________________________________
dropout_7 (Dropout)          (None, 90)                0
_________________________________________________________________
dense_5 (Dense)              (None, 45)                4095
_________________________________________________________________
activation_15 (Activation)   (None, 45)                0
_________________________________________________________________
batch_normalization_14 (Batc (None, 45)                180
_________________________________________________________________
dropout_8 (Dropout)          (None, 45)                0
_________________________________________________________________
dense_6 (Dense)              (None, 3)                 138
_________________________________________________________________
activation_16 (Activation)   (None, 3)                 0
=================================================================
```

Appx J
(Refers to para 6.4)

TRAINING METRICS (CURTAILED) : PATIENT STATE B

```
Epoch 165/500
4/4 [==============================] - 5s 1s/step - loss: 0.1479 - acc:
0.9491 - val_loss: 0.9585 - val_acc: 0.7500

Epoch 00165: val_acc did not improve from 0.86161
Epoch 166/500
4/4 [==============================] - 6s 2s/step - loss: 0.0985 - acc:
0.9667 - val_loss: 1.7002 - val_acc: 0.6049

Epoch 00166: val_acc did not improve from 0.86161
Epoch 167/500
4/4 [==============================] - 6s 2s/step - loss: 0.1067 - acc:
0.9646 - val_loss: 1.8986 - val_acc: 0.6271

Epoch 00167: val_acc did not improve from 0.86161
Epoch 168/500
4/4 [==============================] - 6s 2s/step - loss: 0.1006 - acc:
0.9625 - val_loss: 1.7770 - val_acc: 0.6250

Epoch 00168: val_acc did not improve from 0.86161
Epoch 169/500
4/4 [==============================] - 6s 1s/step - loss: 0.0756 - acc:
0.9854 - val_loss: 1.6611 - val_acc: 0.6521

Epoch 00169: val_acc did not improve from 0.86161
Epoch 170/500
4/4 [==============================] - 5s 1s/step - loss: 0.1099 - acc:
0.9646 - val_loss: 1.5485 - val_acc: 0.6696

Epoch 00170: val_acc did not improve from 0.86161
Epoch 171/500
4/4 [==============================] - 7s 2s/step - loss: 0.0851 - acc:
0.9688 - val_loss: 1.0935 - val_acc: 0.7271

Epoch 00171: val_acc did not improve from 0.86161
Epoch 172/500
4/4 [==============================] - 6s 2s/step - loss: 0.0829 - acc:
0.9708 - val_loss: 0.7581 - val_acc: 0.7902

Epoch 00172: val_acc did not improve from 0.86161
Epoch 173/500
4/4 [==============================] - 6s 1s/step - loss: 0.0655 - acc:
0.9875 - val_loss: 0.6840 - val_acc: 0.7979

Epoch 00173: val_acc did not improve from 0.86161
```

```
Epoch 174/500
4/4 [==============================] - 7s 2s/step - loss: 0.0942 - acc:
0.9646 - val_loss: 0.9495 - val_acc: 0.7433

Epoch 00174: val_acc did not improve from 0.86161
Epoch 175/500
4/4 [==============================] - 8s 2s/step - loss: 0.1289 - acc:
0.9329 - val_loss: 1.2890 - val_acc: 0.6833

Epoch 00175: val_acc did not improve from 0.86161
Epoch 176/500
4/4 [==============================] - 6s 2s/step - loss: 0.0732 - acc:
0.9792 - val_loss: 2.2714 - val_acc: 0.5737

Epoch 00176: val_acc did not improve from 0.86161
Epoch 177/500
4/4 [==============================] - 6s 2s/step - loss: 0.1158 - acc:
0.9604 - val_loss: 2.0808 - val_acc: 0.6167

Epoch 00177: val_acc did not improve from 0.86161
Epoch 178/500
4/4 [==============================] - 6s 1s/step - loss: 0.1327 - acc:
0.9521 - val_loss: 1.2950 - val_acc: 0.7009

Epoch 00178: val_acc did not improve from 0.86161
Epoch 179/500
4/4 [==============================] - 6s 2s/step - loss: 0.0778 - acc:
0.9771 - val_loss: 0.6981 - val_acc: 0.7979

Epoch 00179: val_acc did not improve from 0.86161
Epoch 180/500
4/4 [==============================] - 6s 1s/step - loss: 0.2752 - acc:
0.9123 - val_loss: 0.5177 - val_acc: 0.8393

Epoch 00180: val_acc did not improve from 0.86161
```

Appx K
(Refers to para 6.5)

TESTING DETAILS : PATIENT STATE

The result array for 100 Drinking images is as under:-

```
[[9.96732473e-01 3.20608355e-03 6.14720484e-05]
 [9.52539861e-01 4.53649424e-02 2.09515379e-03]
 [9.99542594e-01 3.98594915e-04 5.89103875e-05]
 [6.53517008e-01 3.35903078e-01 1.05799502e-02]
 [9.98854637e-01 1.04263844e-03 1.02813981e-04]
 [9.13806558e-01 8.10060129e-02 5.18740295e-03]
 [9.94434416e-01 5.55898575e-03 6.58607678e-06]
 [8.82054925e-01 1.12870835e-01 5.07421978e-03]
 [9.62250888e-01 3.35967317e-02 4.15232126e-03]
 [9.89326954e-01 9.79132019e-03 8.81657586e-04]
 [8.06574225e-01 1.92308635e-01 1.11713307e-03]
 [9.26558733e-01 7.22337738e-02 1.20747823e-03]
 [9.56368983e-01 2.59942356e-02 1.76368635e-02]
 [9.87610877e-01 1.22410944e-02 1.47981773e-04]
 [9.97103751e-01 2.79543037e-03 1.00832425e-04]
 [1.31674185e-01 8.68275106e-01 5.07056684e-05]
 [5.40164351e-01 4.57860917e-01 1.97470025e-03]
 [9.57231998e-01 4.16928232e-02 1.07517431e-03]
 [9.82961714e-01 1.67135037e-02 3.24808381e-04]
 [9.26268578e-01 7.36702681e-02 6.11591167e-05]
 [9.94431436e-01 5.45280287e-03 1.15664276e-04]
 [8.30811918e-01 1.68171316e-01 1.01672648e-03]
 [9.20901537e-01 7.75835589e-02 1.51495647e-03]
 [6.65911794e-01 3.30604643e-01 3.48358718e-03]
 [9.72892165e-01 2.66003702e-02 5.07518416e-04]
 [9.67999458e-01 3.15631293e-02 4.37390729e-04]
 [9.82188761e-01 1.60377510e-02 1.77353853e-03]
 [8.45725894e-01 1.25766411e-01 2.85076741e-02]
 [9.92466390e-01 7.46284518e-03 7.07125146e-05]
 [9.96267021e-01 1.65147323e-03 2.08160421e-03]
 [9.70018029e-01 2.86290292e-02 1.35293545e-03]
 [4.54678722e-02 1.27064884e-02 9.41825628e-01]
 [8.47012877e-01 1.51330248e-01 1.65688538e-03]
 [9.65933621e-01 3.32110412e-02 8.55290738e-04]
 [9.96298015e-01 3.69328773e-03 8.65409129e-06]
 [1.52341858e-01 6.29744768e-01 2.17913434e-01]
 [9.96551514e-01 3.39216576e-03 5.62668793e-05]
 [5.90895414e-01 3.08061004e-01 1.01043597e-01]
 [1.86007433e-02 9.80368674e-01 1.03051192e-03]
 [2.28488054e-02 8.60239983e-01 1.16911143e-01]
 [5.21421492e-01 4.73075241e-01 5.50324703e-03]
 [7.68248737e-01 2.30720073e-01 1.03125453e-03]
 [9.95639205e-01 2.55455473e-03 1.80626067e-03]
```

```
[9.96504784e-01 3.15144914e-03 3.43743595e-04]
[8.58157694e-01 1.41785875e-01 5.64497495e-05]
[9.47281301e-01 4.83319759e-02 4.38669464e-03]
[6.38360202e-01 3.56937468e-01 4.70233802e-03]
[9.99261916e-01 6.63271116e-04 7.48566672e-05]
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The result array for 100 Reading images is as under:-

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Appx L
(Refers to para 7.3)

MODEL SUMMARY : NURSING ACTIVITIES

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 38, 38, 32)	896
batch_normalization_1 (Batch	(None, 38, 38, 32)	128
activation_1 (Activation)	(None, 38, 38, 32)	0
conv2d_2 (Conv2D)	(None, 36, 36, 32)	9248
batch_normalization_2 (Batch	(None, 36, 36, 32)	128
activation_2 (Activation)	(None, 36, 36, 32)	0
max_pooling2d_1 (MaxPooling2	(None, 18, 18, 32)	0
dropout_1 (Dropout)	(None, 18, 18, 32)	0
conv2d_3 (Conv2D)	(None, 16, 16, 64)	18496
batch_normalization_3 (Batch	(None, 16, 16, 64)	256
activation_3 (Activation)	(None, 16, 16, 64)	0
conv2d_4 (Conv2D)	(None, 14, 14, 64)	36928
batch_normalization_4 (Batch	(None, 14, 14, 64)	256
activation_4 (Activation)	(None, 14, 14, 64)	0
conv2d_5 (Conv2D)	(None, 12, 12, 128)	73856
batch_normalization_5 (Batch	(None, 12, 12, 128)	512
activation_5 (Activation)	(None, 12, 12, 128)	0
max_pooling2d_2 (MaxPooling2	(None, 6, 6, 128)	0
dropout_2 (Dropout)	(None, 6, 6, 128)	0
flatten_1 (Flatten)	(None, 4608)	0
dense_1 (Dense)	(None, 180)	829620

activation_6 (Activation)	(None, 180)	0
batch_normalization_6 (Batch	(None, 180)	720
dropout_3 (Dropout)	(None, 180)	0
dense_2 (Dense)	(None, 90)	16290
activation_7 (Activation)	(None, 90)	0
batch_normalization_7 (Batch	(None, 90)	360
dropout_4 (Dropout)	(None, 90)	0
dense_3 (Dense)	(None, 3)	273
activation_8 (Activation)	(None, 3)	0

===

Appx M
(Refers to para 7.4)

TRAINING METRICS (CURTAILED) : NURSING ACTIVITIES

```
Epoch 226/500
4/4 [==============================] - 7s 2s/step - loss: 0.1518 - acc:
0.9450 - val_loss: 0.4132 - val_acc: 0.8639

Epoch 00226: val_acc did not improve from 0.90476
Epoch 227/500
4/4 [==============================] - 7s 2s/step - loss: 0.1239 - acc:
0.9533 - val_loss: 0.7064 - val_acc: 0.8111

Epoch 00227: val_acc did not improve from 0.90476
Epoch 228/500
4/4 [==============================] - 8s 2s/step - loss: 0.1565 - acc:
0.9483 - val_loss: 0.7216 - val_acc: 0.7733

Epoch 00228: val_acc did not improve from 0.90476
Epoch 229/500
4/4 [==============================] - 8s 2s/step - loss: 0.1085 - acc:
0.9600 - val_loss: 0.8451 - val_acc: 0.7800

Epoch 00229: val_acc did not improve from 0.90476
Epoch 230/500
4/4 [==============================] - 7s 2s/step - loss: 0.1132 - acc:
0.9650 - val_loss: 0.5869 - val_acc: 0.8277

Epoch 00230: val_acc did not improve from 0.90476
Epoch 231/500
4/4 [==============================] - 8s 2s/step - loss: 0.1160 - acc:
0.9524 - val_loss: 0.5350 - val_acc: 0.8333

Epoch 00231: val_acc did not improve from 0.90476
Epoch 232/500
4/4 [==============================] - 8s 2s/step - loss: 0.1106 - acc:
0.9633 - val_loss: 0.9450 - val_acc: 0.7733

Epoch 00232: val_acc did not improve from 0.90476
Epoch 233/500
4/4 [==============================] - 7s 2s/step - loss: 0.1016 - acc:
0.9567 - val_loss: 0.2730 - val_acc: 0.9022

Epoch 00233: val_acc did not improve from 0.90476
Epoch 234/500
4/4 [==============================] - 7s 2s/step - loss: 0.0882 - acc:
0.9650 - val_loss: 0.2962 - val_acc: 0.8980
```

```
Epoch 00234: val_acc did not improve from 0.90476
Epoch 235/500
4/4 [==============================] - 7s 2s/step - loss: 0.0855 - acc:
0.9633 - val_loss: 0.3549 - val_acc: 0.9067

Epoch 00235: val_acc improved from 0.90476 to 0.90667, saving model to
nursing.h5
Epoch 236/500
4/4 [==============================] - 8s 2s/step - loss: 0.1008 - acc:
0.9650 - val_loss: 0.3719 - val_acc: 0.8956

Epoch 00236: val_acc did not improve from 0.90667
Epoch 237/500
4/4 [==============================] - 7s 2s/step - loss: 0.1022 - acc:
0.9667 - val_loss: 0.3422 - val_acc: 0.8733

Epoch 00237: val_acc did not improve from 0.90667
Epoch 238/500
4/4 [==============================] - 8s 2s/step - loss: 0.0958 - acc:
0.9617 - val_loss: 0.3427 - val_acc: 0.8733

Epoch 00238: val_acc did not improve from 0.90667
Epoch 239/500
4/4 [==============================] - 7s 2s/step - loss: 0.0681 - acc:
0.9783 - val_loss: 0.1473 - val_acc: 0.9478

Epoch 00239: val_acc improved from 0.90667 to 0.94785, saving model to
nursing.h5
Epoch 240/500
4/4 [==============================] - 7s 2s/step - loss: 0.0738 - acc:
0.9711 - val_loss: 0.3254 - val_acc: 0.8933

Epoch 00240: val_acc did not improve from 0.94785
```

Appx N
(Refers to para 7.5)

TESTING DETAILS : PATIENT STATE

The result array for 100 Blood pressure images is as under:-

```
[[8.03774297e-01 1.93704456e-01 2.52128392e-03]
 [9.99542594e-01 4.23110032e-04 3.43194188e-05]
 [9.96704638e-01 3.20822047e-03 8.71832672e-05]
 [9.99329686e-01 3.02352448e-04 3.67978326e-04]
 [2.20345631e-01 7.79162049e-01 4.92329767e-04]
 [9.99998689e-01 8.94549942e-07 3.57162833e-07]
 [9.99990940e-01 5.09541906e-06 3.90009654e-06]
 [9.99999881e-01 1.34151108e-07 2.38756637e-09]
 [9.99957681e-01 3.02386507e-05 1.20776458e-05]
 [9.99978065e-01 1.12794878e-05 1.05499075e-05]
 [9.98054147e-01 1.75696879e-03 1.88884718e-04]
 [9.75859582e-01 2.38819774e-02 2.58431683e-04]
 [9.64124799e-01 3.43508497e-02 1.52434269e-03]
 [9.48031664e-01 5.14817610e-02 4.86557517e-04]
 [1.27821313e-02 9.86260116e-01 9.57780750e-04]
 [9.99998569e-01 1.21391520e-06 2.88329545e-07]
 [9.89391088e-01 1.03021963e-02 3.06645350e-04]
 [9.99873161e-01 1.20773104e-04 6.07600714e-06]
 [9.99961376e-01 3.63071485e-05 2.20980064e-06]
 [9.98364151e-01 9.43734602e-04 6.92022266e-04]
 [9.99816000e-01 1.61828808e-04 2.21502069e-05]
 [9.98344898e-01 1.59481203e-03 6.03839399e-05]
 [5.91031432e-01 4.08166319e-01 8.02233757e-04]
 [9.88467991e-01 1.12086637e-02 3.23336484e-04]
 [7.93843746e-01 2.04710603e-01 1.44558377e-03]
 [9.99953151e-01 1.03995662e-05 3.65343476e-05]
 [3.35430354e-01 6.63226306e-01 1.34331698e-03]
 [9.99526501e-01 4.20833181e-04 5.26998265e-05]
 [9.96633112e-01 3.03722057e-03 3.29739210e-04]
 [9.96311247e-01 1.23362371e-03 2.45505059e-03]
 [8.61748517e-01 1.09283544e-01 2.89680008e-02]
 [9.81134057e-01 8.55323765e-03 1.03127575e-02]
 [9.77662027e-01 1.81429889e-02 4.19499818e-03]
 [9.70514357e-01 2.85731386e-02 9.12524061e-04]
 [9.75709498e-01 2.42041908e-02 8.63460809e-05]
 [9.98768747e-01 8.55075778e-04 3.76091833e-04]
 [8.81364882e-01 1.17510885e-01 1.12417631e-03]
 [9.98380184e-01 1.48057682e-03 1.39285039e-04]
 [9.96176839e-01 1.01380039e-03 2.80939834e-03]
 [6.39469326e-01 3.54580283e-01 5.95033448e-03]
 [9.97372985e-01 2.52531050e-03 1.01630445e-04]
 [9.99972582e-01 2.66292991e-05 8.28360498e-07]
 [5.00638008e-01 4.97494876e-01 1.86715776e-03]
```

```
[9.99454796e-01 5.28331497e-04 1.68865117e-05]
[9.99695301e-01 2.91788281e-04 1.30230173e-05]
[9.99963760e-01 3.94281159e-07 3.58732941e-05]
[9.99934912e-01 1.07135884e-05 5.43530150e-05]
[9.99432504e-01 4.23163525e-04 1.44306658e-04]
[9.95174229e-01 4.70341695e-03 1.22452402e-04]
[9.99032736e-01 9.04628425e-04 6.26745095e-05]
[9.99948978e-01 3.85900858e-05 1.24562894e-05]
[9.99958515e-01 1.72820237e-05 2.41573271e-05]
[8.97190571e-01 9.94941741e-02 3.31525807e-03]
[9.99668002e-01 3.00441839e-04 3.16031619e-05]
[9.98693526e-01 1.17674121e-03 1.29823093e-04]
[9.19303954e-01 7.98398405e-02 8.56233994e-04]
[8.48016739e-01 1.48689702e-01 3.29357688e-03]
[9.99487400e-01 4.55747242e-04 5.68462965e-05]
[9.60033298e-01 3.52193192e-02 4.74741077e-03]
[9.93935049e-01 6.00271253e-03 6.22215812e-05]
[1.00000000e+00 1.34188678e-08 8.63360228e-09]
[9.97948229e-01 1.87080575e-03 1.80923700e-04]
[9.99837518e-01 1.54145731e-04 8.33426293e-06]
[8.84725690e-01 2.01859195e-02 9.50883552e-02]
[9.96761918e-01 2.50396342e-03 7.34146801e-04]
[8.94009173e-01 1.03856377e-01 2.13448657e-03]
[1.00000000e+00 6.61588828e-09 1.40452148e-08]
[9.14128006e-01 8.46614391e-02 1.21057010e-03]
[8.33439946e-01 1.66342586e-01 2.17524139e-04]
[9.99980927e-01 1.57097384e-05 3.32851391e-06]
[9.99999404e-01 4.27826734e-07 1.02700348e-07]
[9.99995351e-01 3.47794889e-06 1.21521771e-06]
[9.99947548e-01 4.47068523e-05 7.75257467e-06]
[9.99998689e-01 7.67668553e-07 6.33044294e-07]
[3.00551243e-02 6.37044966e-01 3.32899928e-01]
[9.70926762e-01 5.72556979e-04 2.85006762e-02]
[9.99351799e-01 5.58573927e-04 8.95808771e-05]
[8.94534588e-01 1.04148999e-01 1.31646963e-03]
[7.48619974e-01 2.50373542e-01 1.00649858e-03]
[9.99891639e-01 9.81320773e-05 1.02075719e-05]
[9.99642134e-01 3.24078370e-04 3.37089587e-05]
[9.99976873e-01 1.99334991e-05 3.16190017e-06]
[9.99979854e-01 1.72405962e-05 2.82493465e-06]
[9.99969006e-01 2.44716157e-05 6.50838274e-06]
[9.98936236e-01 1.03984575e-03 2.39856017e-05]
[6.13717735e-01 3.54358584e-01 3.19237038e-02]
[9.99375641e-01 5.18823326e-05 5.72522928e-04]
[9.99896049e-01 8.11918289e-06 9.58090095e-05]
[9.98942196e-01 1.04428024e-03 1.35445562e-05]
[9.99855280e-01 4.64321744e-07 1.44237376e-04]
[3.50808978e-01 6.44935429e-01 4.25557746e-03]
[9.99993324e-01 5.53037398e-06 1.15908892e-06]
[5.91970742e-01 4.07626241e-01 4.03049577e-04]
[9.99950051e-01 4.78845068e-05 1.97524241e-06]
[4.80544046e-02 9.50994909e-01 9.50732327e-04]
[9.96516705e-01 3.37109016e-03 1.12185815e-04]
```

[8.63917947e-01 1.32096559e-01 3.98551673e-03]
[9.99970436e-01 2.18192999e-05 7.77273999e-06]
[9.99999881e-01 2.38373161e-08 9.10397588e-08]
[1.60767958e-01 ***8.33930075e-01*** 5.30192442e-03]]

The result array for 100 “Injection” images is as under:-

[[7.96215050e-03 9.91767883e-01 2.69934651e-04]
[8.71446729e-03 9.89002585e-01 2.28301203e-03]
[3.04213911e-03 9.96366739e-01 5.91160089e-04]
[7.54511654e-02 8.97567749e-01 2.69810185e-02]
[4.12944611e-03 9.92554486e-01 3.31605808e-03]
[2.52729049e-04 9.99554813e-01 1.92378386e-04]
[2.08286215e-02 9.77236509e-01 1.93484058e-03]
[6.36812707e-04 9.99033928e-01 3.29314906e-04]
[1.55079423e-03 9.98268127e-01 1.81060779e-04]
[3.11738476e-02 9.67348337e-01 1.47774664e-03]
[2.09321850e-03 9.61340010e-01 3.65667902e-02]
[3.87025578e-03 9.95881081e-01 2.48726632e-04]
[2.86128759e-01 7.07753956e-01 6.11728337e-03]
[5.98019105e-04 9.99256909e-01 1.45056940e-04]
[1.47173458e-04 9.99807060e-01 4.57666392e-05]
[9.70798374e-06 9.99987125e-01 3.24095572e-06]
[***9.00559008e-01*** 9.24645141e-02 6.97648292e-03]
[***7.93428779e-01*** 2.02907234e-01 3.66402883e-03]
[1.33600067e-02 9.83802080e-01 2.83788471e-03]
[3.08160932e-04 8.00572395e-01 1.99119434e-01]
[2.15867208e-03 9.88833964e-01 9.00731701e-03]
[1.14211731e-03 9.98635590e-01 2.22248535e-04]
[2.47973412e-01 7.48046875e-01 3.97970807e-03]
[4.92980480e-01 4.97909158e-01 9.11031850e-03]
[9.12768446e-05 9.72590089e-01 2.73186937e-02]
[4.42555189e-01 5.14922440e-01 4.25223559e-02]
[1.20472221e-03 9.94799137e-01 3.99608677e-03]
[3.90251516e-03 9.95241046e-01 8.56450817e-04]
[9.98178963e-04 9.98724163e-01 2.77685118e-04]
[4.44131568e-02 9.51044381e-01 4.54238011e-03]
[6.01564034e-06 9.99964714e-01 2.93440316e-05]
[8.75109606e-07 9.99654531e-01 3.44663917e-04]
[2.68827751e-02 9.63872015e-01 9.24520567e-03]
[3.13162833e-04 9.99521732e-01 1.65089616e-04]
[6.92686517e-05 9.99911666e-01 1.91258423e-05]
[3.55595117e-03 9.95693684e-01 7.50449777e-04]
[2.22820272e-05 9.99911189e-01 6.64903200e-05]
[5.29468209e-02 9.34835911e-01 1.22173270e-02]
[2.66117394e-01 7.31246769e-01 2.63576279e-03]
[1.32813022e-01 9.39020291e-02 ***7.73284912e-01***]
[5.77343030e-07 9.99980688e-01 1.87004462e-05]
[1.33974318e-04 9.99785841e-01 8.02688737e-05]
[4.49574691e-05 9.99908090e-01 4.69556508e-05]
[8.71069438e-04 9.99054372e-01 7.45458528e-05]
[5.14172483e-03 9.91166174e-01 3.69217107e-03]
[2.38102674e-02 9.75137413e-01 1.05226086e-03]

[3.28663737e-05 9.99910831e-01 5.62855967e-05]
[2.93566845e-03 9.96725678e-01 3.38662299e-04]
[4.69240302e-04 9.99321938e-01 2.08823898e-04]
[3.62228616e-06 9.99994278e-01 2.17494426e-06]
[8.68369185e-04 9.98268008e-01 8.63661582e-04]
[7.35741248e-03 9.91406322e-01 1.23630080e-03]
[6.14669733e-03 9.91701782e-01 2.15152721e-03]
[7.05101993e-05 9.99903917e-01 2.55667092e-05]
[3.00752989e-04 9.99632120e-01 6.71190282e-05]
[7.49084938e-06 9.99980927e-01 1.15505200e-05]
[1.38715655e-03 9.98384714e-01 2.28179924e-04]
[3.25247273e-03 9.95708585e-01 1.03891443e-03]
[3.89761082e-03 9.64348793e-01 3.17535661e-02]
[1.68702521e-04 9.99773562e-01 5.77473984e-05]
[2.61399616e-02 9.71885920e-01 1.97415380e-03]
[***7.69948184e-01*** 2.26033926e-01 4.01784666e-03]
[6.06476096e-03 9.93675530e-01 2.59678054e-04]
[2.10815319e-03 9.91647959e-01 6.24392321e-03]
[6.53017387e-02 9.06661510e-01 2.80368309e-02]
[5.98755505e-05 9.97851253e-01 2.08887877e-03]
[2.20448142e-04 9.99716222e-01 6.32395531e-05]
[7.75121804e-03 9.85751569e-01 6.49714610e-03]
[6.10284274e-03 9.92950916e-01 9.46185843e-04]
[2.72477075e-04 9.99675989e-01 5.16155887e-05]
[4.55634261e-04 9.98060048e-01 1.48420967e-03]
[3.90018910e-01 5.98967969e-01 1.10131633e-02]
[6.40049693e-04 9.98680055e-01 6.79922057e-04]
[3.97974811e-03 9.95735884e-01 2.84295937e-04]
[1.20001454e-02 9.85997319e-01 2.00258568e-03]
[7.72912463e-04 9.99148250e-01 7.88077523e-05]
[7.68195465e-02 9.21907544e-01 1.27302413e-03]
[1.76679119e-02 9.80675399e-01 1.65670249e-03]
[1.71850785e-03 9.98021007e-01 2.60501431e-04]
[4.54620633e-04 9.99426603e-01 1.18825599e-04]
[2.53581326e-03 9.96782899e-01 6.81211823e-04]
[3.48817892e-02 2.45035648e-01 ***7.20082521e-01***]
[3.83088918e-04 9.99306321e-01 3.10525560e-04]
[3.47690769e-02 9.11978126e-01 5.32528609e-02]
[5.90948574e-03 9.93904173e-01 1.86425445e-04]
[1.46320954e-05 9.99531507e-01 4.53878572e-04]
[5.95408604e-02 9.40287530e-01 1.71662963e-04]
[8.34407751e-03 9.91224945e-01 4.30966116e-04]
[2.01305188e-02 9.60559547e-01 1.93098374e-02]
[4.13595146e-04 9.97649848e-01 1.93653314e-03]
[4.94010805e-04 9.99341190e-01 1.64771031e-04]
[1.11696245e-02 9.87749040e-01 1.08125887e-03]
[6.05310233e-05 9.99026895e-01 9.12636810e-04]
[2.05064751e-03 2.85310209e-01 ***7.12639153e-01***]
[1.08152302e-03 9.98419285e-01 4.99196991e-04]
[8.58440399e-02 9.10613179e-01 3.54276551e-03]
[2.08962150e-03 9.97592211e-01 3.18190549e-04]
[6.11730963e-02 9.37915266e-01 9.11657058e-04]
[4.66874242e-02 8.90297651e-01 6.30148947e-02]

```
[3.71924695e-03 9.56005096e-01 4.02757116e-02]]
```

The result array for 100 “Medicine” images is as under:-

```
[[2.52760074e-12 6.01763604e-12 1.00000000e+00]
[7.74351647e-04 7.44517019e-04 9.98481095e-01]
[7.30846841e-06 1.08532311e-06 9.99991655e-01]
[2.87229381e-15 4.58676405e-14 1.00000000e+00]
[9.51746129e-04 1.87981746e-03 9.97168481e-01]
[1.06984865e-09 1.36054232e-05 9.99986410e-01]
[3.43410429e-05 4.79725248e-04 9.99485850e-01]
[1.41109238e-04 4.71031626e-06 9.99854207e-01]
[4.45451569e-08 7.04649551e-07 9.99999285e-01]
[3.84790794e-04 1.76016672e-03 9.97855008e-01]
[9.83518930e-07 1.22368001e-04 9.99876618e-01]
[5.63869271e-08 7.43852661e-06 9.99992490e-01]
[4.88860046e-08 7.95321000e-08 9.99999881e-01]
[9.55895008e-09 3.63803265e-05 9.99963641e-01]
[3.18105481e-12 1.12173271e-10 1.00000000e+00]
[3.53051582e-05 3.27677008e-05 9.99931931e-01]
[1.06107949e-10 1.84846272e-09 1.00000000e+00]
[2.42742044e-05 1.40864437e-03 9.98567104e-01]
[1.26318824e-07 2.87076055e-05 9.99971151e-01]
[9.78494863e-05 2.26019663e-04 9.99676108e-01]
[7.40587129e-05 1.19827035e-07 9.99925852e-01]
[2.25694887e-02 1.58059727e-02 9.61624563e-01]
[7.19243108e-05 2.95728655e-03 9.96970773e-01]
[2.68005340e-10 2.02050963e-08 1.00000000e+00]
[2.18374898e-05 5.77706331e-03 9.94201124e-01]
[1.06562620e-04 4.27292980e-05 9.99850631e-01]
[4.09725764e-08 2.30086769e-07 9.99999762e-01]
[4.25115942e-08 1.09666553e-06 9.99998808e-01]
[5.11072976e-05 8.51634832e-04 9.99097228e-01]
[2.48242664e-04 1.14714459e-03 9.98604596e-01]
[2.97310709e-08 1.25028441e-06 9.99998689e-01]
[2.85460119e-05 1.06138912e-04 9.99865294e-01]
[2.68453150e-05 1.80628649e-06 9.99971390e-01]
[2.60836387e-05 1.59126020e-03 9.98382688e-01]
[3.39744729e-03 4.29792225e-01 5.66810429e-01]
[9.27924191e-07 6.40585313e-06 9.99992609e-01]
[2.37103067e-12 1.42504161e-10 1.00000000e+00]
[1.03651239e-07 2.33425817e-05 9.99976516e-01]
[1.44918067e-06 3.15966759e-06 9.99995351e-01]
[6.34261710e-08 9.69370194e-06 9.99990225e-01]
[6.80747831e-08 5.03869257e-09 9.99999881e-01]
[4.62857679e-05 9.27264709e-03 9.90681112e-01]
[5.99505313e-07 6.16921852e-06 9.99993205e-01]
[6.64238720e-10 4.26664712e-08 1.00000000e+00]
[1.37581053e-04 7.04105652e-04 9.99158263e-01]
[2.00278863e-10 9.77548993e-08 9.99999881e-01]
[2.58335564e-02 9.40175056e-02 8.80148947e-01]
[1.30356802e-03 4.78184642e-03 9.93914545e-01]
[2.46079708e-05 8.60377477e-05 9.99889374e-01]
```

```
[7.57852513e-06 3.29305563e-04 9.99663115e-01]
[2.61109608e-06 1.72455002e-05 9.99980092e-01]
[1.29632483e-07 2.46248746e-05 9.99975204e-01]
[2.92251752e-06 6.90901788e-06 9.99990225e-01]
[1.14946000e-04 3.57372919e-04 9.99527693e-01]
[1.06554262e-05 1.15627554e-04 9.99873757e-01]
[1.02915642e-07 2.56729049e-06 9.99997377e-01]
[3.27311754e-01 3.04393977e-01 3.68294328e-01]
[2.15345541e-09 1.41598747e-07 9.99999881e-01]
[9.39731766e-03 1.97165385e-02 9.70886171e-01]
[6.55611366e-05 2.13859021e-04 9.99720514e-01]
[2.97631141e-06 1.84169983e-06 9.99995232e-01]
[3.61923526e-06 6.54638352e-05 9.99930859e-01]
[2.99250694e-11 1.89980542e-09 1.00000000e+00]
[4.77490403e-07 3.31109118e-06 9.99996185e-01]
[1.85169881e-06 5.33499042e-06 9.99992847e-01]
[1.66271019e-09 3.74875367e-06 9.99996305e-01]
[1.49055410e-07 1.39446385e-07 9.99999762e-01]
[3.27885719e-10 1.78892208e-08 1.00000000e+00]
[6.46434302e-08 1.61680491e-05 9.99983788e-01]
[2.53193207e-06 9.93669601e-05 9.99898076e-01]
[2.19785136e-07 3.00689135e-06 9.99996781e-01]
[5.65456276e-07 2.59459534e-06 9.99996781e-01]
[4.07330572e-06 1.34320158e-04 9.99861598e-01]
[1.77236155e-01 1.41748682e-01 6.81015193e-01]
[1.00075781e-07 2.28282570e-05 9.99977112e-01]
[3.05967296e-09 2.61815813e-07 9.99999762e-01]
[2.19429385e-05 4.06315638e-04 9.99571741e-01]
[8.12886921e-13 3.08772868e-11 1.00000000e+00]
[9.34697346e-06 4.58084134e-04 9.99532580e-01]
[1.08425729e-05 3.92816510e-05 9.99949932e-01]
[1.39562573e-04 9.83846257e-05 9.99761999e-01]
[9.29953007e-04 2.98398100e-02 9.69230235e-01]
[3.74362941e-08 1.24775042e-05 9.99987483e-01]
[2.53333064e-06 1.26889674e-04 9.99870539e-01]
[1.54290829e-05 2.98698634e-01 7.01285958e-01]
[7.47860351e-04 4.17574821e-03 9.95076358e-01]
[1.14421752e-07 6.50946595e-06 9.99993324e-01]
[4.88924161e-06 4.90987368e-05 9.99945998e-01]
[1.32491350e-01 3.43716070e-02 8.33137035e-01]
[1.15326708e-04 1.21905270e-03 9.98665571e-01]
[2.43126192e-06 1.43478654e-04 9.99854088e-01]
[3.29428405e-01 2.25779876e-01 4.44791764e-01]
[2.11236160e-02 1.57740917e-02 9.63102221e-01]
[7.21532702e-02 2.06572309e-01 7.21274376e-01]
[3.45049083e-01 5.46077907e-01 1.08873002e-01]
[2.97648227e-03 1.57547314e-02 9.81268823e-01]
[6.41919996e-07 7.69956205e-06 9.99991655e-01]
[2.09403807e-14 1.05992085e-13 1.00000000e+00]
[2.36924103e-09 3.20481763e-06 9.99996781e-01]
[4.72682528e-04 5.43374990e-05 9.99473035e-01]]
```

Appx O
(Refers to para 8.3)

<u>MODEL SUMMARY : PATIENT MOOD</u>

Layer (type)	Output Shape	Param #
conv2d_11 (Conv2D)	(None, 26, 26, 32)	896
activation_17 (Activation)	(None, 26, 26, 32)	0
conv2d_12 (Conv2D)	(None, 24, 24, 32)	9248
activation_18 (Activation)	(None, 24, 24, 32)	0
batch_normalization_11 (Batc	(None, 24, 24, 32)	128
max_pooling2d_7 (MaxPooling2	(None, 12, 12, 32)	0
dropout_11 (Dropout)	(None, 12, 12, 32)	0
conv2d_13 (Conv2D)	(None, 10, 10, 64)	18496
activation_19 (Activation)	(None, 10, 10, 64)	0
conv2d_14 (Conv2D)	(None, 8, 8, 64)	36928
activation_20 (Activation)	(None, 8, 8, 64)	0
batch_normalization_12 (Batc	(None, 8, 8, 64)	256
max_pooling2d_8 (MaxPooling2	(None, 4, 4, 64)	0
dropout_12 (Dropout)	(None, 4, 4, 64)	0
conv2d_15 (Conv2D)	(None, 2, 2, 128)	73856
activation_21 (Activation)	(None, 2, 2, 128)	0
batch_normalization_13 (Batc	(None, 2, 2, 128)	512
max_pooling2d_9 (MaxPooling2	(None, 1, 1, 128)	0
dropout_13 (Dropout)	(None, 1, 1, 128)	0
flatten_3 (Flatten)	(None, 128)	0
dense_7 (Dense)	(None, 600)	77400

```
________________________________________________________________
activation_22 (Activation)   (None, 600)               0
________________________________________________________________
batch_normalization_14 (Batc (None, 600)               2400
________________________________________________________________
dropout_14 (Dropout)         (None, 600)               0
________________________________________________________________
dense_8 (Dense)              (None, 300)               180300
________________________________________________________________
activation_23 (Activation)   (None, 300)               0
________________________________________________________________
batch_normalization_15 (Batc (None, 300)               1200
________________________________________________________________
dropout_15 (Dropout)         (None, 300)               0
________________________________________________________________
dense_9 (Dense)              (None, 3)                 903
________________________________________________________________
activation_24 (Activation)   (None, 3)                 0
================================================================
```

Appx P
(Refers to para 8.4)

TRAINING METRICS (CURTAILED) : PATIENT MOOD

```
Epoch 766/1000
4/4 [==============================] - 7s 2s/step - loss: 0.1343 -
sparse_categorical_accuracy: 0.9405 - val_loss: 0.8160 -
val_sparse_categorical_accuracy: 0.7714

Epoch 00766: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 767/1000
4/4 [==============================] - 7s 2s/step - loss: 0.1747 -
sparse_categorical_accuracy: 0.9262 - val_loss: 1.0553 -
val_sparse_categorical_accuracy: 0.7048

Epoch 00767: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 768/1000
4/4 [==============================] - 7s 2s/step - loss: 0.1980 -
sparse_categorical_accuracy: 0.9238 - val_loss: 0.7627 -
val_sparse_categorical_accuracy: 0.7857

Epoch 00768: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 769/1000
4/4 [==============================] - 8s 2s/step - loss: 0.1237 -
sparse_categorical_accuracy: 0.9429 - val_loss: 0.7884 -
val_sparse_categorical_accuracy: 0.7619

Epoch 00769: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 770/1000
4/4 [==============================] - 6s 2s/step - loss: 0.1251 -
sparse_categorical_accuracy: 0.9648 - val_loss: 0.8828 -
val_sparse_categorical_accuracy: 0.7409

Epoch 00770: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 771/1000
4/4 [==============================] - 7s 2s/step - loss: 0.1150 -
sparse_categorical_accuracy: 0.9571 - val_loss: 1.0112 -
val_sparse_categorical_accuracy: 0.7262

Epoch 00771: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 772/1000
4/4 [==============================] - 8s 2s/step - loss: 0.1051 -
sparse_categorical_accuracy: 0.9619 - val_loss: 0.6998 -
val_sparse_categorical_accuracy: 0.7905

Epoch 00772: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 773/1000
```

```
4/4 [==============================] - 7s 2s/step - loss: 0.1258 -
sparse_categorical_accuracy: 0.9548 - val_loss: 0.7664 -
val_sparse_categorical_accuracy: 0.7714

Epoch 00773: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 774/1000
4/4 [==============================] - 6s 1s/step - loss: 0.1628 -
sparse_categorical_accuracy: 0.9381 - val_loss: 0.7301 -
val_sparse_categorical_accuracy: 0.7714

Epoch 00774: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 775/1000
4/4 [==============================] - 7s 2s/step - loss: 0.1485 -
sparse_categorical_accuracy: 0.9476 - val_loss: 0.7821 -
val_sparse_categorical_accuracy: 0.7713

Epoch 00775: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 776/1000
4/4 [==============================] - 8s 2s/step - loss: 0.1155 -
sparse_categorical_accuracy: 0.9524 - val_loss: 0.8211 -
val_sparse_categorical_accuracy: 0.7786

Epoch 00776: val_sparse_categorical_accuracy did not improve from 0.83841
Epoch 777/1000
4/4 [==============================] - 7s 2s/step - loss: 0.1138 -
sparse_categorical_accuracy: 0.9571 - val_loss: 0.5395 -
val_sparse_categorical_accuracy: 0.8405

Epoch 00777: val_sparse_categorical_accuracy improved from 0.83841 to
0.84048, saving model to patient28.h5
Epoch 778/1000
4/4 [==============================] - 6s 2s/step - loss: 0.0821 -
sparse_categorical_accuracy: 0.9690 - val_loss: 0.6850 -
val_sparse_categorical_accuracy: 0.8119

Epoch 00778: val_sparse_categorical_accuracy did not improve from 0.84048
```

Appx Q
(Refers to para 8.5)

TESTING DETAILS : PATIENT MOOD

The result array for 100 “Negative” class images is as under:-

```
[[9.9923480e-01 3.1832719e-04 4.4689904e-04]
 [6.5612507e-01 2.0866489e-04 3.4366629e-01]
 [9.8103184e-01 1.5075251e-02 3.8929486e-03]
 [9.2853242e-01 5.0593102e-03 6.6408269e-02]
 [9.8118562e-01 1.3506557e-04 1.8679274e-02]
 [8.6104131e-01 1.3392425e-01 5.0343643e-03]
 [6.0200792e-02 8.9338166e-01 4.6417542e-02]
 [1.3251624e-01 8.6642116e-01 1.0626466e-03]
 [9.1380006e-01 9.0868752e-03 7.7113062e-02]
 [4.4209650e-01 3.7942415e-01 1.7847931e-01]
 [1.8485542e-02 7.4176671e-04 9.8077273e-01]
 [4.4779361e-05 1.2142767e-05 9.9994302e-01]
 [9.9541509e-01 2.2744851e-03 2.3103063e-03]
 [9.6226823e-01 1.9852223e-03 3.5746615e-02]
 [9.9960738e-01 3.2010442e-04 7.2538307e-05]
 [6.0692781e-01 3.6926681e-01 2.3805380e-02]
 [5.4403150e-01 3.3052796e-03 4.5266327e-01]
 [9.9442202e-01 9.6737704e-06 5.5682999e-03]
 [9.2827463e-01 5.3161435e-02 1.8563870e-02]
 [7.9163593e-01 1.1375028e-03 2.0722651e-01]
 [9.9663478e-01 4.4989029e-05 3.3202551e-03]
 [1.9136512e-03 3.7810539e-03 9.9430531e-01]
 [6.0718268e-01 3.5049411e-04 3.9246681e-01]
 [3.2111499e-03 1.1643675e-03 9.9562448e-01]
 [9.9991572e-01 3.3579585e-05 5.0630650e-05]
 [9.9126899e-01 2.2620065e-04 8.5047688e-03]
 [1.9502122e-02 9.5583347e-04 9.7954202e-01]
 [9.9951255e-01 9.4449082e-05 3.9293262e-04]
 [7.4232143e-01 3.3668559e-03 2.5431165e-01]
 [1.9172680e-01 9.2326006e-04 8.0734992e-01]
 [9.9969244e-01 3.3526016e-05 2.7409405e-04]
 [7.5085503e-01 7.6857889e-03 2.4145924e-01]
 [9.9530560e-01 8.2723935e-05 4.6116700e-03]
 [9.9944633e-01 6.1237726e-05 4.9241475e-04]
 [8.7426019e-01 5.1382031e-02 7.4357785e-02]
 [9.9321610e-01 8.0691534e-04 5.9770257e-03]
 [1.8258497e-01 8.1667507e-01 7.3987170e-04]
 [8.4408176e-01 4.6991897e-03 1.5121904e-01]
 [9.9649364e-01 7.8853825e-04 2.7178030e-03]
 [9.3423724e-01 5.1302597e-04 6.5249600e-02]
 [4.1909196e-04 2.1601169e-04 9.9936491e-01]
 [9.0117401e-01 1.3126454e-02 8.5699499e-02]
 [3.1739697e-01 2.3996817e-04 6.8236303e-01]
```

```
[9.9980336e-01 1.8830401e-04 8.3762088e-06]
[9.1489649e-01 7.5208506e-04 8.4351391e-02]
[3.9166179e-01 3.0201662e-04 6.0803622e-01]
[9.9999797e-01 1.8694556e-06 9.1145573e-08]
[9.9833268e-01 6.0846464e-04 1.0587960e-03]
[9.9999559e-01 1.2792441e-06 3.1152781e-06]
[8.7151045e-01 1.1188362e-01 1.6605893e-02]
[5.2923989e-02 2.9914388e-03 9.4408458e-01]
[3.4109959e-03 8.2196267e-03 9.8836935e-01]
[8.5687745e-01 1.7164134e-03 1.4140619e-01]
[9.8255116e-01 1.8789953e-03 1.5569845e-02]
[9.9954969e-01 5.6422032e-06 4.4470734e-04]
[9.9583340e-01 2.9419740e-05 4.1371891e-03]
[9.6987110e-01 4.0827447e-04 2.9720623e-02]
[9.8725975e-01 1.2665826e-02 7.4437885e-05]
[6.2521213e-01 8.4683845e-05 3.7470320e-01]
[9.8733985e-01 3.0485804e-03 9.6116615e-03]
[6.9054258e-01 8.9566717e-03 3.0050084e-01]
[4.2135379e-04 6.8832940e-04 9.9889034e-01]
[7.8406471e-01 1.6294602e-02 1.9964065e-01]
[9.9982232e-01 1.1107785e-04 6.6607725e-05]
[9.9978703e-01 2.1592934e-05 1.9142938e-04]
[9.9885309e-01 7.9305064e-05 1.0676213e-03]
[9.7734528e-04 8.9889102e-02 9.0913355e-01]
[2.4840317e-04 3.5221219e-05 9.9971634e-01]
[5.9575945e-01 2.4581652e-02 3.7965882e-01]
[9.4423592e-01 8.3117244e-05 5.5681024e-02]
[9.9013978e-01 1.0348287e-03 8.8253887e-03]
[9.9739432e-01 1.6221305e-03 9.8357315e-04]
[9.9310958e-01 1.3353238e-04 6.7568738e-03]
[6.9095290e-01 2.5661987e-01 5.2427296e-02]
[9.9958128e-01 1.2708576e-05 4.0602317e-04]
[9.9792755e-01 9.6962479e-04 1.1027356e-03]
[5.4378128e-03 4.5516548e-01 5.3939676e-01]
[2.8087676e-04 9.9847392e-05 9.9961925e-01]
[9.3906778e-01 1.1409700e-03 5.9791308e-02]
[9.0612369e-03 9.5891571e-01 3.2023046e-02]
[2.1950652e-01 7.6151067e-01 1.8982787e-02]
[2.5343731e-01 1.6199972e-02 7.3036271e-01]
[9.8118562e-01 1.3506557e-04 1.8679274e-02]
[1.0000000e+00 5.5549584e-08 5.1529208e-09]
[9.7709072e-01 1.6986099e-03 2.1210667e-02]
[9.8780340e-01 1.0093963e-02 2.1026372e-03]
[9.3404639e-01 2.6081322e-02 3.9872278e-02]
[9.9492234e-01 2.6048761e-04 4.8171896e-03]
[9.9320048e-01 2.5343182e-03 4.2652292e-03]
[9.9093014e-01 2.1688088e-03 6.9010304e-03]
[2.3084557e-02 1.5750690e-04 9.7675794e-01]
[9.2842329e-01 6.9694892e-02 1.8818706e-03]
[5.8490473e-01 2.6065108e-01 1.5444414e-01]
[9.9288428e-01 3.9526890e-04 6.7204209e-03]
[9.8640788e-01 4.8989266e-05 1.3543087e-02]
[9.3330657e-01 6.9069592e-03 5.9786439e-02]
```

```
[9.9505252e-01 2.1131025e-03 2.8343974e-03]
[9.8150128e-01 3.7280843e-04 1.8125974e-02]
[9.9982184e-01 2.0740824e-06 1.7612972e-04]]
```

The result array for 100 “Neutral” class images is as under:-

```
[[6.09640963e-03 9.92139876e-01 1.76367618e-03]
[5.69683325e-04 9.98850942e-01 5.79390558e-04]
[4.45651449e-03 9.95486796e-01 5.67408133e-05]
[8.96378700e-03 9.87853885e-01 3.18234344e-03]
[4.28669434e-03 8.90422523e-01 1.05290785e-01]
[1.66772131e-03 9.75791693e-01 2.25405265e-02]
[3.25096189e-04 9.93829548e-01 5.84537303e-03]
[1.54151826e-03 9.86201584e-01 1.22568961e-02]
[9.10727176e-05 7.56404623e-02 9.24268484e-01]
[1.92623734e-02 9.69024420e-01 1.17132030e-02]
[4.61832946e-03 3.93265873e-01 6.02115750e-01]
[5.55539317e-03 1.10064290e-01 8.84380281e-01]
[4.09969594e-03 9.66008008e-01 2.98922881e-02]
[3.12107586e-04 1.15351088e-03 9.98534322e-01]
[8.75649273e-01 1.08919576e-01 1.54311564e-02]
[2.52619875e-03 9.93203878e-01 4.26989561e-03]
[5.66789368e-03 5.78510128e-02 9.36481059e-01]
[2.89706513e-04 9.99622941e-01 8.73615281e-05]
[1.91815046e-03 6.69141824e-04 9.97412741e-01]
[3.66152526e-04 9.49212685e-02 9.04712558e-01]
[3.57015728e-04 9.99623895e-01 1.90344654e-05]
[2.72498019e-02 3.34949270e-02 9.39255238e-01]
[6.12782873e-02 9.38187242e-01 5.34491322e-04]
[7.96082197e-04 1.66540340e-01 8.32663536e-01]
[6.65226951e-04 1.49541274e-01 8.49793494e-01]
[6.04806514e-03 9.93554115e-01 3.97799275e-04]
[4.29918407e-04 8.85428786e-01 1.14141285e-01]
[1.39300004e-02 9.33805287e-01 5.22647016e-02]
[7.17749703e-04 9.66467679e-01 3.28145288e-02]
[1.82148186e-04 9.99815166e-01 2.79206120e-06]
[2.85363873e-03 9.94788527e-01 2.35783472e-03]
[6.34861470e-04 9.94698524e-01 4.66662413e-03]
[2.94279128e-01 3.12346313e-02 6.74486279e-01]
[1.54241177e-04 9.92872715e-01 6.97298860e-03]
[3.59724276e-03 8.79684210e-01 1.16718546e-01]
[3.91302630e-03 8.29641223e-01 1.66445717e-01]
[2.59485375e-03 9.97348428e-01 5.67399547e-05]
[3.69908143e-04 9.99187052e-01 4.42985212e-04]
[1.28832646e-02 9.34227705e-01 5.28890528e-02]
[1.59924328e-01 8.40021431e-01 5.41308509e-05]
[2.79424735e-03 9.59726516e-03 9.87608433e-01]
[9.60502401e-03 9.89305615e-01 1.08941202e-03]
[1.56786677e-03 7.45219737e-03 9.90979970e-01]
[3.22473198e-02 8.35052609e-01 1.32700056e-01]
[6.48071989e-04 9.98070776e-01 1.28121511e-03]
[1.35695242e-04 9.97616649e-01 2.24773912e-03]
[6.82912841e-02 9.57823619e-02 8.35926354e-01]
```

[***7.33698666e-01*** 2.59287059e-02 2.40372613e-01]
[2.37326929e-03 9.24230576e-01 7.33961090e-02]
[2.98362792e-01 6.94687784e-01 6.94941496e-03]
[5.55719482e-03 9.84870613e-01 9.57220700e-03]
[8.74905891e-05 9.99674320e-01 2.38194712e-04]
[7.88191042e-04 9.86850262e-01 1.23615470e-02]
[4.53679916e-03 9.07325685e-01 8.81374404e-02]
[2.09192242e-02 9.78144705e-01 9.36130295e-04]
[4.90157008e-02 5.92862725e-01 3.58121574e-01]
[1.93869101e-03 9.94286716e-01 3.77460266e-03]
[9.26165640e-01 6.92639202e-02 4.57045436e-03]
[3.85639374e-03 9.90413845e-01 5.72972000e-03]
[5.37937507e-02 9.22741413e-01 2.34647896e-02]
[1.04569858e-02 9.89514232e-01 2.87714392e-05]
[2.79817893e-03 2.09050059e-01 ***7.88151741e-01***]
[1.54875163e-02 9.34837043e-01 4.96754125e-02]
[1.29992608e-03 9.80468273e-01 1.82317588e-02]
[6.36198511e-03 9.00851548e-01 9.27864537e-02]
[1.14649197e-03 7.77069688e-01 2.21783772e-01]
[9.03716937e-05 9.96984541e-01 2.92507489e-03]
[6.10250165e-04 9.88501668e-01 1.08880969e-02]
[3.90774367e-04 9.99376953e-01 2.32285849e-04]
[2.60595456e-02 7.82556415e-01 1.91384047e-01]
[1.44504313e-03 5.61501801e-01 4.37053144e-01]
[2.72617675e-03 9.94184911e-01 3.08884936e-03]
[2.29828496e-04 7.19158910e-04 ***9.99051034e-01***]
[2.00174283e-03 9.95462239e-01 2.53604352e-03]
[1.03334254e-02 9.89336133e-01 3.30465642e-04]
[2.06393050e-03 9.45896029e-01 5.20400591e-02]
[2.10548788e-02 9.71218765e-01 7.72630936e-03]
[7.17749703e-04 9.66467679e-01 3.28145288e-02]
[1.27878669e-03 2.42172573e-02 9.74503934e-01]
[1.15172064e-03 7.79607654e-01 2.19240606e-01]
[3.34394239e-02 1.75905764e-01 ***7.90654838e-01***]
[1.42324269e-02 9.73821104e-01 1.19463857e-02]
[***8.12869251e-01*** 1.86815649e-01 3.15149315e-04]
[5.44832386e-02 9.40159738e-01 5.35697350e-03]
[3.49898599e-02 9.63494182e-01 1.51605788e-03]
[2.11316487e-03 9.96517777e-01 1.36914337e-03]
[2.99074396e-04 1.87729264e-03 ***9.97823596e-01***]
[1.44366044e-04 9.99855280e-01 3.83125183e-07]
[3.85151543e-02 5.24062157e-01 4.37422723e-01]
[6.52322453e-03 9.85022724e-01 8.45406298e-03]
[1.37676168e-02 9.75802124e-01 1.04302764e-02]
[3.87234963e-04 9.97477591e-01 2.13508797e-03]
[3.03187262e-04 9.90518153e-01 9.17862542e-03]
[2.77844936e-01 5.89065552e-02 6.63248539e-01]
[1.28268534e-02 9.73753631e-01 1.34195304e-02]
[1.15368038e-03 8.76568019e-01 1.22278191e-01]
[5.27631346e-05 9.99804795e-01 1.42392018e-04]
[1.43335601e-02 9.42343950e-01 4.33225669e-02]
[5.38931272e-05 9.99911189e-01 3.48722606e-05]
[2.99377658e-04 9.83884633e-01 1.58160459e-02]]

The result array for 100 “positive” class images is as under:-

```
[[1.74323074e-03 1.67606995e-02 9.81496036e-01]
 [9.54321658e-05 6.52654126e-05 9.99839306e-01]
 [1.99692076e-04 1.00890023e-03 9.98791397e-01]
 [3.31829637e-02 9.73291244e-05 9.66719747e-01]
 [1.05791762e-04 9.20288076e-05 9.99802172e-01]
 [1.33711452e-04 8.24771087e-06 9.99858022e-01]
 [1.14636881e-04 1.12848675e-05 9.99874115e-01]
 [4.79452312e-03 9.88078654e-01 7.12675182e-03]
 [7.57458183e-05 3.81518839e-05 9.99886036e-01]
 [1.40045704e-05 1.90407751e-04 9.99795616e-01]
 [4.30737418e-04 1.10585766e-03 9.98463392e-01]
 [1.25348493e-01 1.04344282e-02 8.64217103e-01]
 [3.95110389e-03 3.33741482e-04 9.95715082e-01]
 [1.94535509e-03 9.41661537e-01 5.63931428e-02]
 [2.08774691e-06 8.67449944e-06 9.99989271e-01]
 [2.42326278e-04 3.86639964e-04 9.99371111e-01]
 [2.07971025e-05 5.92660581e-05 9.99919891e-01]
 [3.04920902e-03 3.78108351e-03 9.93169665e-01]
 [2.43154481e-01 2.01567277e-01 5.55278242e-01]
 [7.06567476e-03 4.11677599e-01 5.81256747e-01]
 [2.38435646e-03 1.46418251e-02 9.82973814e-01]
 [3.93938652e-04 7.45918427e-04 9.98860121e-01]
 [2.67314375e-04 1.04611705e-03 9.98686612e-01]
 [9.04431818e-06 9.79327160e-05 9.99893069e-01]
 [5.78015018e-03 4.00615332e-04 9.93819296e-01]
 [1.94029836e-03 3.80562805e-03 9.94254053e-01]
 [9.81780469e-01 1.04443170e-02 7.77527411e-03]
 [1.66633356e-04 2.44264054e-04 9.99589145e-01]
 [2.33821645e-02 1.76154282e-02 9.59002435e-01]
 [1.95927365e-04 3.00057745e-03 9.96803522e-01]
 [3.16621899e-03 1.83222219e-04 9.96650517e-01]
 [6.08265772e-03 3.29873338e-03 9.90618646e-01]
 [1.36405796e-01 9.43305960e-04 8.62650871e-01]
 [4.70361760e-04 3.38227954e-04 9.99191463e-01]
 [1.65794190e-04 9.10188246e-04 9.98923957e-01]
 [5.48303463e-02 4.12072539e-02 9.03962374e-01]
 [7.58083304e-03 7.33592606e-04 9.91685629e-01]
 [1.38845548e-01 8.35331619e-01 2.58227717e-02]
 [5.84058216e-05 6.03502813e-05 9.99881268e-01]
 [4.86578420e-03 3.38574545e-03 9.91748452e-01]
 [1.47681290e-04 9.87033243e-04 9.98865366e-01]
 [1.29655022e-02 7.06300855e-01 2.80733645e-01]
 [4.10081644e-04 7.69929611e-04 9.98820007e-01]
 [1.61997974e-02 4.11281735e-01 5.72518468e-01]
 [5.42492839e-04 9.96205032e-01 3.25256027e-03]
 [3.86519678e-05 1.22899219e-04 9.99838471e-01]
 [6.20880892e-05 2.08240544e-05 9.99917030e-01]
 [4.29496431e-04 1.80382014e-03 9.97766733e-01]
 [1.76338456e-03 6.40452206e-01 3.57784361e-01]
 [1.54491849e-02 2.44435761e-03 9.82106447e-01]
 [1.78894392e-04 1.87830392e-05 9.99802291e-01]
```

```
[9.94102629e-06 1.91517993e-05 9.99970913e-01]
[8.90632582e-05 4.71356725e-06 9.99906182e-01]
[3.53160067e-05 8.50779397e-05 9.99879599e-01]
[7.56249651e-02 2.25716876e-03 9.22117889e-01]
[4.38557297e-01 6.63212547e-03 5.54810643e-01]
[9.88238037e-01 1.17312642e-02 3.07380469e-05]
[1.00349270e-01 5.77911967e-03 8.93871605e-01]
[1.59148232e-03 7.40210016e-05 9.98334467e-01]
[1.71834149e-03 1.69780469e-04 9.98111844e-01]
[1.15682806e-05 6.87065153e-07 9.99987721e-01]
[3.60467820e-03 5.99878728e-02 9.36407506e-01]
[9.04720582e-05 1.14012973e-05 9.99898076e-01]
[7.20936456e-04 5.70445597e-01 4.28833425e-01]
[2.85125291e-03 6.60712831e-05 9.97082651e-01]
[4.34638379e-04 1.52207876e-03 9.98043299e-01]
[1.58830990e-05 2.16932633e-04 9.99767244e-01]
[1.10141678e-04 2.92484590e-04 9.99597371e-01]
[1.20027491e-03 1.83795951e-02 9.80420113e-01]
[9.57479569e-05 2.11700288e-04 9.99692559e-01]
[6.95292983e-05 1.93065876e-04 9.99737442e-01]
[1.96280133e-04 1.05160971e-05 9.99793231e-01]
[7.80810937e-02 5.86812501e-04 9.21332121e-01]
[6.65184343e-05 2.01417846e-04 9.99732077e-01]
[9.93244350e-03 4.56619251e-04 9.89610910e-01]
[2.07770900e-05 6.87100794e-07 9.99978542e-01]
[1.79680553e-03 9.97696698e-01 5.06510260e-04]
[1.27356900e-02 3.81268784e-02 9.49137449e-01]
[2.87573406e-04 9.63375205e-05 9.99616027e-01]
[5.61817506e-05 3.15662270e-04 9.99628186e-01]
[4.95447148e-06 1.22778988e-06 9.99993801e-01]
[2.46307179e-02 7.72464206e-04 9.74596798e-01]
[3.75658646e-02 4.54280106e-03 9.57891345e-01]
[1.25006703e-03 1.01474291e-02 9.88602579e-01]
[1.05167776e-01 9.38483421e-03 8.85447383e-01]
[1.22617825e-03 6.63883626e-01 3.34890127e-01]
[4.05908504e-04 3.72313894e-04 9.99221802e-01]
[3.31263145e-05 6.11132127e-05 9.99905705e-01]
[5.54792117e-03 3.00970040e-02 9.64354992e-01]
[6.14137165e-02 1.87793994e-04 9.38398540e-01]
[2.58749455e-01 1.56599954e-02 7.25590587e-01]
[1.04351260e-04 7.33091729e-05 9.99822319e-01]
[8.36910156e-04 4.66903439e-03 9.94494021e-01]
[1.55328031e-04 7.20661410e-05 9.99772608e-01]
[5.10976752e-05 3.34740840e-02 9.66474831e-01]
[1.76150340e-03 3.01888864e-03 9.95219648e-01]
[8.16579337e-09 4.82870810e-08 1.00000000e+00]
[5.56376217e-05 2.47791877e-06 9.99941826e-01]
[5.90785094e-05 3.10680916e-05 9.99909878e-01]
[3.27804238e-02 1.08275833e-02 9.56391990e-01]]
```

Appx R
(Refers to para 9.2)

SUB MODEL SUMMARY : CDM

Layer (type)	Output Shape	Param #
conv2d_15 (Conv2D)	(None, 90, 90, 32)	896
activation_21 (Activation)	(None, 90, 90, 32)	0
conv2d_16 (Conv2D)	(None, 90, 90, 32)	9248
activation_22 (Activation)	(None, 90, 90, 32)	0
batch_normalization_11 (Batc	(None, 90, 90, 32)	128
max_pooling2d_7 (MaxPooling2	(None, 45, 45, 32)	0
dropout_11 (Dropout)	(None, 45, 45, 32)	0
conv2d_17 (Conv2D)	(None, 45, 45, 64)	18496
activation_23 (Activation)	(None, 45, 45, 64)	0
conv2d_18 (Conv2D)	(None, 45, 45, 64)	36928
activation_24 (Activation)	(None, 45, 45, 64)	0
batch_normalization_12 (Batc	(None, 45, 45, 64)	256
max_pooling2d_8 (MaxPooling2	(None, 22, 22, 64)	0
dropout_12 (Dropout)	(None, 22, 22, 64)	0
conv2d_19 (Conv2D)	(None, 22, 22, 128)	73856
activation_25 (Activation)	(None, 22, 22, 128)	0
conv2d_20 (Conv2D)	(None, 22, 22, 128)	147584
activation_26 (Activation)	(None, 22, 22, 128)	0
conv2d_21 (Conv2D)	(None, 22, 22, 128)	147584
activation_27 (Activation)	(None, 22, 22, 128)	0

```
batch_normalization_13 (Batc (None, 22, 22, 128)       512       
_________________________________________________________________
max_pooling2d_9 (MaxPooling2 (None, 11, 11, 128)       0         
_________________________________________________________________
dropout_13 (Dropout)         (None, 11, 11, 128)       0         
_________________________________________________________________
flatten_3 (Flatten)          (None, 15488)             0         
_________________________________________________________________
dense_7 (Dense)              (None, 140)               2168460   
_________________________________________________________________
activation_28 (Activation)   (None, 140)               0         
_________________________________________________________________
batch_normalization_14 (Batc (None, 140)               560       
_________________________________________________________________
dropout_14 (Dropout)         (None, 140)               0         
_________________________________________________________________
dense_8 (Dense)              (None, 70)                9870      
_________________________________________________________________
activation_29 (Activation)   (None, 70)                0         
_________________________________________________________________
batch_normalization_15 (Batc (None, 70)                280       
_________________________________________________________________
dropout_15 (Dropout)         (None, 70)                0         
_________________________________________________________________
dense_9 (Dense)              (None, 37)                2627      
_________________________________________________________________
activation_30 (Activation)   (None, 37)                0         
=================================================================
```

Appx S
(Refers to para 9.4)

EXPERIMENT NUMBER 1 CDM

```
Same image, Set No :   1   result is :  1.0
Same image, Set No :   2   result is :  1.0
Same image, Set No :   3   result is :  1.0
Same image, Set No :   4   result is :  1.0
Same image, Set No :   5   result is :  1.0
Same image, Set No :   6   result is :  1.0
Same image, Set No :   7   result is :  1.0
Same image, Set No :   8   result is :  1.0
Same image, Set No :   9   result is :  1.0
Same image, Set No :  10   result is :  1.0
Same image, Set No :  11   result is :  1.0
Same image, Set No :  12   result is :  1.0
Same image, Set No :  13   result is :  1.0
Same image, Set No :  14   result is :  1.0
Same image, Set No :  15   result is :  1.0
Same image, Set No :  16   result is :  1.0
Same image, Set No :  17   result is :  1.0
Same image, Set No :  18   result is :  1.0
Same image, Set No :  19   result is :  1.0
Same image, Set No :  20   result is :  1.0
Same image, Set No :  21   result is :  1.0
Same image, Set No :  22   result is :  1.0
Same image, Set No :  23   result is :  1.0
Same image, Set No :  24   result is :  1.0
Same image, Set No :  25   result is :  1.0
Same image, Set No :  26   result is :  1.0
Same image, Set No :  27   result is :  1.0
Same image, Set No :  28   result is :  1.0
Same image, Set No :  29   result is :  1.0
Same image, Set No :  30   result is :  1.0
Same image, Set No :  31   result is :  1.0
Same image, Set No :  32   result is :  1.0
Same image, Set No :  33   result is :  1.0
Same image, Set No :  34   result is :  1.0
Same image, Set No :  35   result is :  1.0
Same image, Set No :  36   result is :  1.0
Same image, Set No :  37   result is :  1.0
Same image, Set No :  38   result is :  1.0
Same image, Set No :  39   result is :  1.0
Same image, Set No :  40   result is :  1.0
Same image, Set No :  41   result is :  1.0
Same image, Set No :  42   result is :  1.0
Same image, Set No :  43   result is :  1.0
Same image, Set No :  44   result is :  1.0
```

```
Same image, Set No :  45   result is :  1.0
Same image, Set No :  46   result is :  1.0
Same image, Set No :  47   result is :  1.0
Same image, Set No :  48   result is :  1.0
Same image, Set No :  49   result is :  1.0
Same image, Set No :  50   result is :  1.0


The mean of all 50 predictions is :  1.0
```

Appx T
(Refers to para 9.4)

EXPERIMENT NUMBER 2 CDM

```
Same image, different lighting, Set No :   1   result is :  0.2
Same image, different lighting, Set No :   2   result is :  0.17
Same image, different lighting, Set No :   3   result is :  0.24
Same image, different lighting, Set No :   4   result is :  0.17
Same image, different lighting, Set No :   5   result is :  0.28
Same image, different lighting, Set No :   6   result is :  0.21
Same image, different lighting, Set No :   7   result is :  0.27
Same image, different lighting, Set No :   8   result is :  0.42
Same image, different lighting, Set No :   9   result is :  0.3
Same image, different lighting, Set No :  10   result is :  0.04
Same image, different lighting, Set No :  11   result is :  0.38
Same image, different lighting, Set No :  12   result is :  0.23
Same image, different lighting, Set No :  13   result is :  0.08
Same image, different lighting, Set No :  14   result is :  0.14
Same image, different lighting, Set No :  15   result is :  0.23
Same image, different lighting, Set No :  16   result is :  0.16
Same image, different lighting, Set No :  17   result is :  0.19
Same image, different lighting, Set No :  18   result is :  0.18
Same image, different lighting, Set No :  19   result is :  0.06
Same image, different lighting, Set No :  20   result is :  0.15
Same image, different lighting, Set No :  21   result is :  0.37
Same image, different lighting, Set No :  22   result is :  0.24
Same image, different lighting, Set No :  23   result is :  0.19
Same image, different lighting, Set No :  24   result is :  0.11
Same image, different lighting, Set No :  25   result is :  0.3
Same image, different lighting, Set No :  26   result is :  0.2
Same image, different lighting, Set No :  27   result is :  0.16
Same image, different lighting, Set No :  28   result is :  0.36
Same image, different lighting, Set No :  29   result is :  0.24
Same image, different lighting, Set No :  30   result is :  0.07
Same image, different lighting, Set No :  31   result is :  0.19
Same image, different lighting, Set No :  32   result is :  0.36
Same image, different lighting, Set No :  33   result is :  0.25
Same image, different lighting, Set No :  34   result is :  0.25
Same image, different lighting, Set No :  35   result is :  0.24
Same image, different lighting, Set No :  36   result is :  0.07
Same image, different lighting, Set No :  37   result is :  0.09
Same image, different lighting, Set No :  38   result is :  0.24
Same image, different lighting, Set No :  39   result is :  0.18
Same image, different lighting, Set No :  40   result is :  0.21
Same image, different lighting, Set No :  41   result is :  0.11
Same image, different lighting, Set No :  42   result is :  0.24
Same image, different lighting, Set No :  43   result is :  0.3
Same image, different lighting, Set No :  44   result is :  0.19
```

```
Same image, different lighting, Set No :  45   result is :  0.15
Same image, different lighting, Set No :  46   result is :  0.28
Same image, different lighting, Set No :  47   result is :  0.26
Same image, different lighting, Set No :  48   result is :  0.17
Same image, different lighting, Set No :  49   result is :  0.28
Same image, different lighting, Set No :  50   result is :  0.36

Max result is (depicts min difference) : 0.42
Min result is (depicts max difference) : 0.04
The mean of all 50 predictions is      : 0.21
```

Appx U
(Refers to para 9.4)

EXPERIMENT NUMBER 3 CDM

```
Slight patient movement only, Set No :   1   result is :  0.86
Slight patient movement only, Set No :   2   result is :  0.8
Slight patient movement only, Set No :   3   result is :  0.78
Slight patient movement only, Set No :   4   result is :  0.72
Slight patient movement only, Set No :   5   result is :  0.84
Slight patient movement only, Set No :   6   result is :  0.77
Slight patient movement only, Set No :   7   result is :  0.74
Slight patient movement only, Set No :   8   result is :  0.71
Slight patient movement only, Set No :   9   result is :  0.8
Slight patient movement only, Set No :  10   result is :  0.88
Slight patient movement only, Set No :  11   result is :  0.68
Slight patient movement only, Set No :  12   result is :  0.87
Slight patient movement only, Set No :  13   result is :  0.86
Slight patient movement only, Set No :  14   result is :  0.85
Slight patient movement only, Set No :  15   result is :  0.78
Slight patient movement only, Set No :  16   result is :  0.8
Slight patient movement only, Set No :  17   result is :  0.15
Slight patient movement only, Set No :  18   result is :  0.21
Slight patient movement only, Set No :  19   result is :  0.69
Slight patient movement only, Set No :  20   result is :  0.29
Slight patient movement only, Set No :  21   result is :  0.44
Slight patient movement only, Set No :  22   result is :  0.24
Slight patient movement only, Set No :  23   result is :  0.28
Slight patient movement only, Set No :  24   result is :  0.48
Slight patient movement only, Set No :  25   result is :  0.25
Slight patient movement only, Set No :  26   result is :  0.17
Slight patient movement only, Set No :  27   result is :  0.18
Slight patient movement only, Set No :  28   result is :  0.46
Slight patient movement only, Set No :  29   result is :  0.35
Slight patient movement only, Set No :  30   result is :  0.91
Slight patient movement only, Set No :  31   result is :  0.24
Slight patient movement only, Set No :  32   result is :  0.16
Slight patient movement only, Set No :  33   result is :  0.66
Slight patient movement only, Set No :  34   result is :  0.14
Slight patient movement only, Set No :  35   result is :  0.35
Slight patient movement only, Set No :  36   result is :  0.22
Slight patient movement only, Set No :  37   result is :  0.15
Slight patient movement only, Set No :  38   result is :  0.29
Slight patient movement only, Set No :  39   result is :  0.4
Slight patient movement only, Set No :  40   result is :  0.23
Slight patient movement only, Set No :  41   result is :  0.31
Slight patient movement only, Set No :  42   result is :  0.27
Slight patient movement only, Set No :  43   result is :  0.34
Slight patient movement only, Set No :  44   result is :  0.36
Slight patient movement only, Set No :  45   result is :  0.36
```

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Slight patient movement only, Set No :  46   result is :  0.17
Slight patient movement only, Set No :  47   result is :  0.39
Slight patient movement only, Set No :  48   result is :  0.64
Slight patient movement only, Set No :  49   result is :  0.97
Slight patient movement only, Set No :  50   result is :  0.97


Max result is (depicts min difference) : 0.97
Min result is (depicts max difference) : 0.14
The mean of all 50 predictions is      : 0.51
```