

## Riconoscimento della patologia con reti di classificazione utilizzando feature

```
clc;
clear all;

%creiamo un database
imagespathCovid = dir('C:\Users\Virginia\Desktop\Ingegneria Biomedica\SEGNALI\PROGETTO MERONE\');
imagespathNormal = dir('C:\Users\Virginia\Desktop\Ingegneria Biomedica\SEGNALI\PROGETTO MERONE\');
imagespathViralPneumonia = dir('C:\Users\Virginia\Desktop\Ingegneria Biomedica\SEGNALI\PROGETTO MERONE\');
```

### PATH DELLE IMMAGINI

```
%COVID
ImagesPathCovid = imagespathCovid(4:end,:);
imagesCovid = struct; %faccio la struct
for i = 1:size(ImagesPathCovid,1)
    imagesCovid(i).images = imread([ImagesPathCovid(i).folder, '/', ImagesPathCovid(i).name]);
end

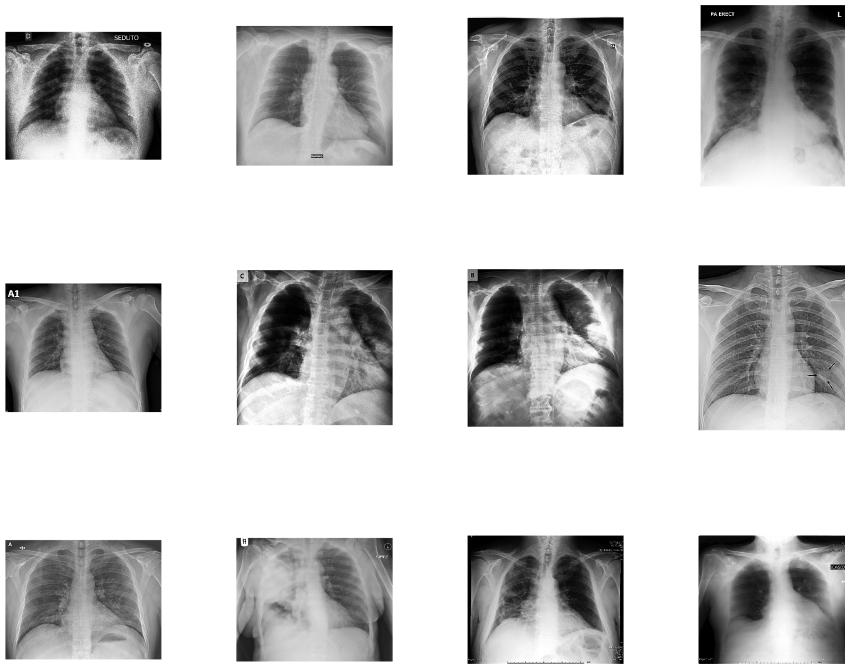
%NORMAL
ImagesPathNormal = imagespathNormal(3:end,:);
imagesNormal = struct;
for i = 1:size(ImagesPathNormal,1)
    imagesNormal(i).images = imread([ImagesPathNormal(i).folder, '/', ImagesPathNormal(i).name]);
end

%VIRAL PNEUMONIA
ImagesPathViralPneumonia = imagespathViralPneumonia(3:end,:);
imagesViralPneumonia = struct;
for i = 1:size(ImagesPathViralPneumonia,1)
    imagesViralPneumonia(i).images = imread([ImagesPathViralPneumonia(i).folder, '/', ImagesPathViralPneumonia(i).name]);
end
```

### FEATURE

```
images = [imagesCovid imagesViralPneumonia imagesNormal]; %structure con tutte le immagini
dimCovid = size(ImagesPathCovid,1);
dimNormal = size(ImagesPathNormal,1);
dimViral = size(ImagesPathViralPneumonia,1);

%mostro 12 immagini randomiche
figure
numImages = dimCovid+dimNormal+dimViral; %sommo tutte le immagini
rand = randperm(numImages,12);
for i=1:12
    I = images(i).images;
    Igray = im2gray(I);
    b = imsharpen(Igray, 'Amount', 2); %aumento il contrasto ai bordi e indico amount che è un p
    subplot(3,4,i);
    imshow(b);
    drawnow;
end
```



```

Feature = [];
for i = 1:size(images,2)
    I = images(i).images;
    Igray = im2gray(I);
    b = imsharpen(Igray,'Amount',2);
    points2 = detectSURFFeatures(b); %rileva zone rilevanti per il cambio di colorazione, tono
    corners = detectHarrisFeatures(b); %rileva la presenza di angoli cercando zone di continue
    FeaturesS = extractFeatures(b,points2); %estraggo SURF
    FeaturesH = extractFeatures(b,corners); %estraggo HARRIS
    FeaturesLBP = extractLBPFeatures(b);
    Feature(i,:) = [FeaturesLBP, mean(FeaturesH.Features),mean(FeaturesS,1)]; %di Harris e Surf
end

```

## ETICHETTE

```

%COVID
etichettaCovid = zeros (size(imagesCovid,2),1); %genero un vettore colonna di soli zeri e con 2
for i = 1:size(imagesCovid ,2)
    etichettaCovid(i)=0;
end

%VIRAL PNEUMANIA
etichettaViralPneumonia = zeros(size(imagesViralPneumonia,2),1);
for i = 1:size(imagesViralPneumonia,2)
    etichettaViralPneumonia(i) = 1;
end

```

```

%NORMAL
etichettaNormal = zeros(size(imagesNormal,2),1);
for i = 1:size(imagesNormal,2)
    etichettaNormal(i) = 2;
end

etichetta = [etichettaCovid; etichettaViralPneumonia; etichettaNormal];
DB = [Feature, etichetta];

```

## ADDESTRAMENTO RETE

```

accuracy = [];
Accuracy = [];
Precision = [];
Recall = [];

%3foldcrossvalidation - interazioni - 3 cartelle
for i = 1:3
    numImages = size(DB,1);
    Random = DB(randperm(numImages,:),:); %immagini randomiche
    Training = Random(1:250, :); %80%
    Validation = Random(251:282,:); %10%
    Test = Random(283:311,:); %10%
    numInput = size(Random,2); %input da inserire
    for j = 60:20:200 %Mi trovo la migliore Epoca
        layers = [ %strati
            featureInputLayer(numInput-1,'Name','input') %stiamo dando feature
            reluLayer('Name','rel1')
            fullyConnectedLayer(3, 'Name','fc1')
            softmaxLayer('Name','sm1')
            classificationLayer('Name','output')];

        lgraph = layerGraph;
        lgraph = addLayers(lgraph,layers);
        figure
        plot(lgraph) %grafichiamo ciò che stiamo costruendo

        options = trainingOptions('adam','MaxEpochs',j,'Verbose',true); %do le opzione di training
        net = trainNetwork(Training(:,1:end-1),categorical(Training(:,end)),lgraph,options); %addestriamo
        YPred = classify(net, Validation(:,1:end-1)); %Classificare i campioni di validation - vettore
        C = confusionmat(categorical(Validation(:, end)), YPred);
        accuracy(j)=(sum(diag(C))/30)*100;
    end

    [M I]= max (accuracy) %M accuratezza e I indice a cui corrisponde accuratezza maggiore
    layers = [
        featureInputLayer(numInput-1)
        reluLayer
        fullyConnectedLayer(3)
        softmaxLayer
        classificationLayer];

    lgraph = layerGraph;

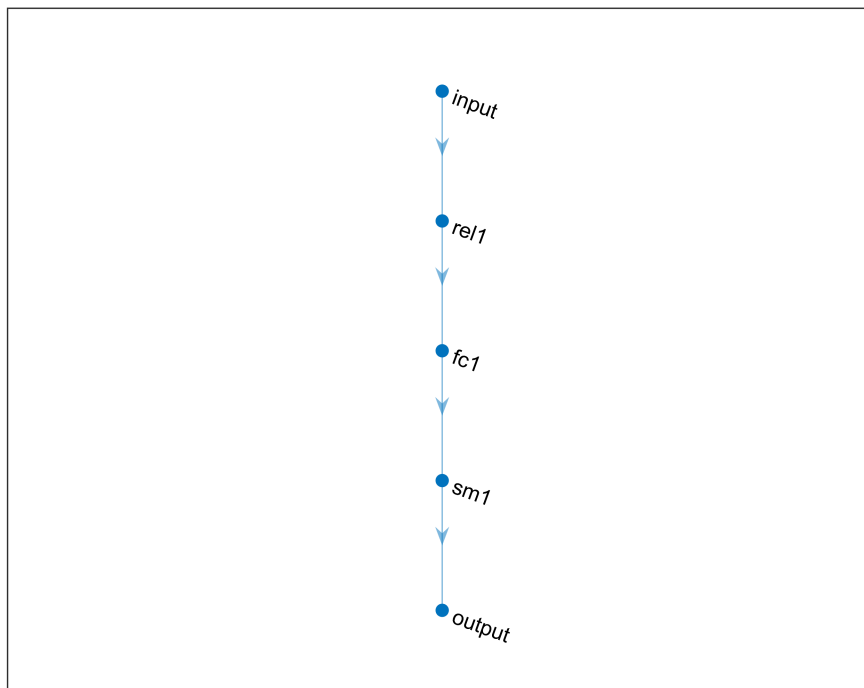
```

```

lgraph = addLayers(lgraph, layers);
figure
plot(lgraph)

options = trainingOptions('adam', 'MaxEpochs', I, 'Verbose', false);
net = trainNetwork(Training(:, 1:end-1), categorical(Training(:, end)), lgraph, options);
YPred = classify(net, Test(:, 1:end-1)); %Test anziché validation
C=confusionmat(categorical(Test(:, end)), YPred) %nuova matrice di confusione sul test
Accuracy(i)=(sum(diag(C))/32)*100
Recall(i, :)= [C(1,1)/sum(C(1,:)) C(2,2)/sum(C(2,:)) C(3,3)/sum(C(3,:))]
Precision(i,:)= [C(1,1)/sum(C(:,1)) C(2,2)/sum(C(:,2)) C(3,3)/sum(C(:,3))]
end

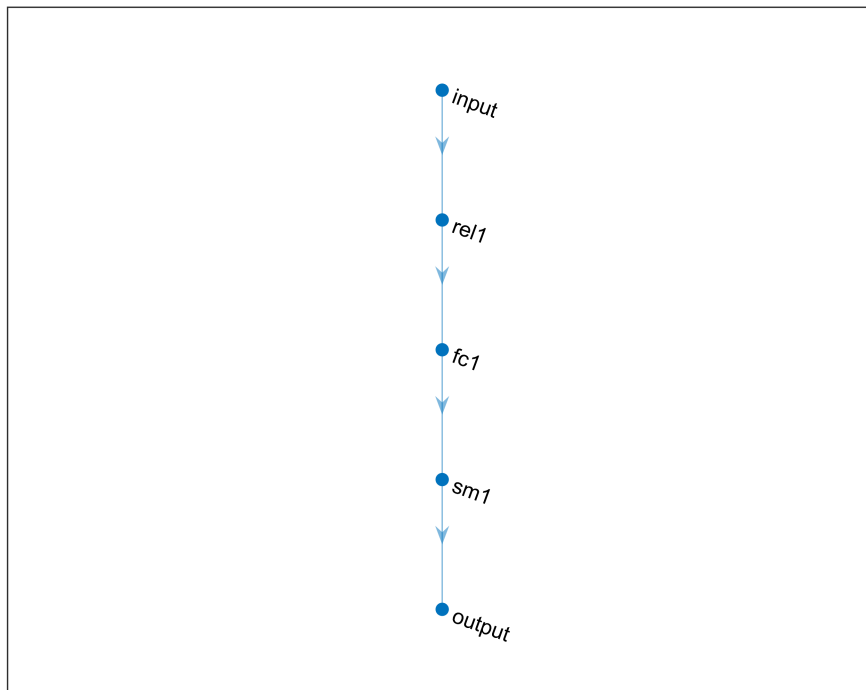
```



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	30.47%	11.0849	0.0010
50	50	00:00:01	41.41%	5.2695	0.0010
60	60	00:00:01	43.75%	4.9832	0.0010

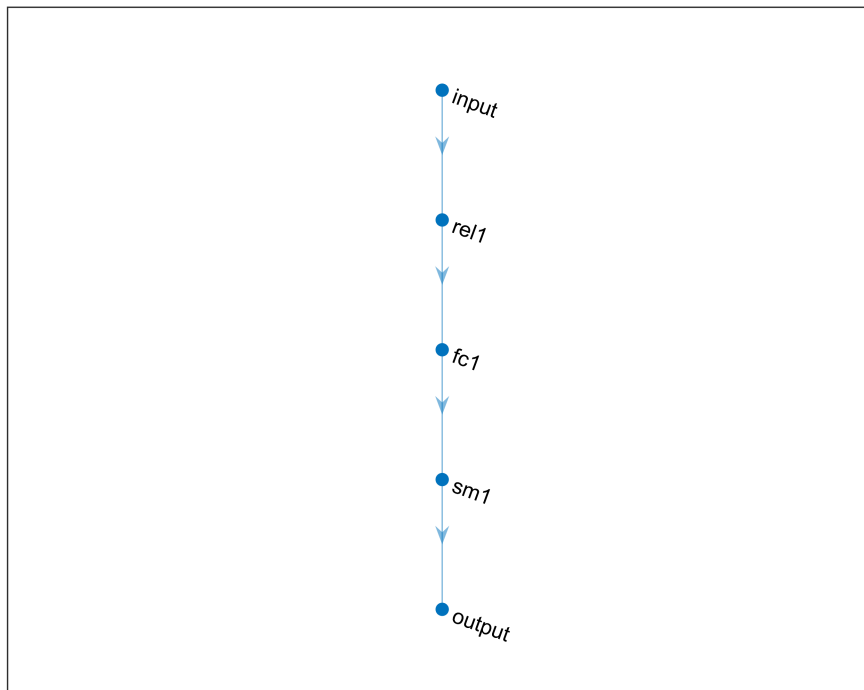
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	33.59%	10.4522	0.0010
50	50	00:00:00	43.75%	5.7611	0.0010
80	80	00:00:00	44.53%	5.3250	0.0010

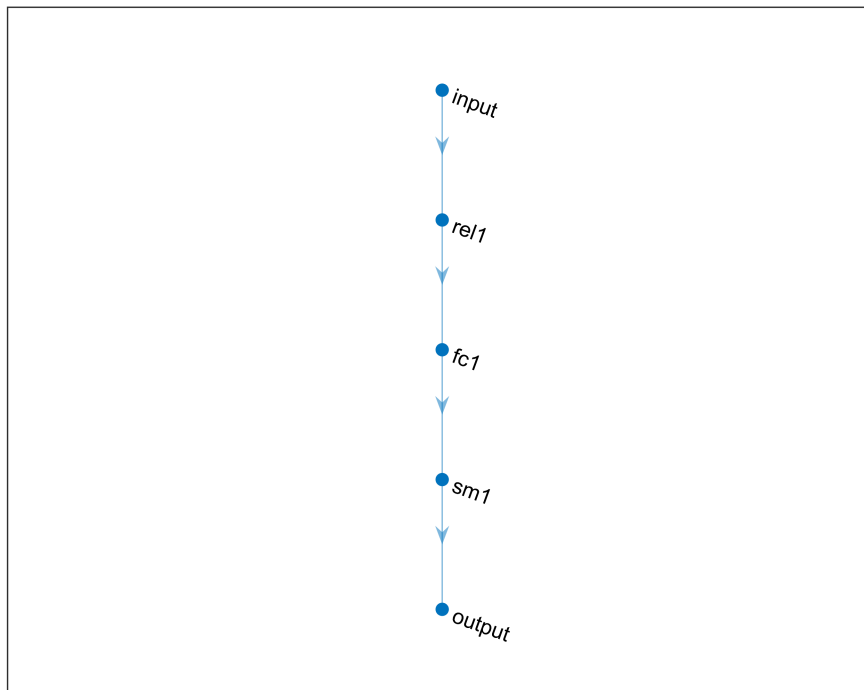
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	34.38%	9.7891	0.0010
50	50	00:00:00	30.47%	6.9087	0.0010
100	100	00:00:00	40.62%	5.0534	0.0010

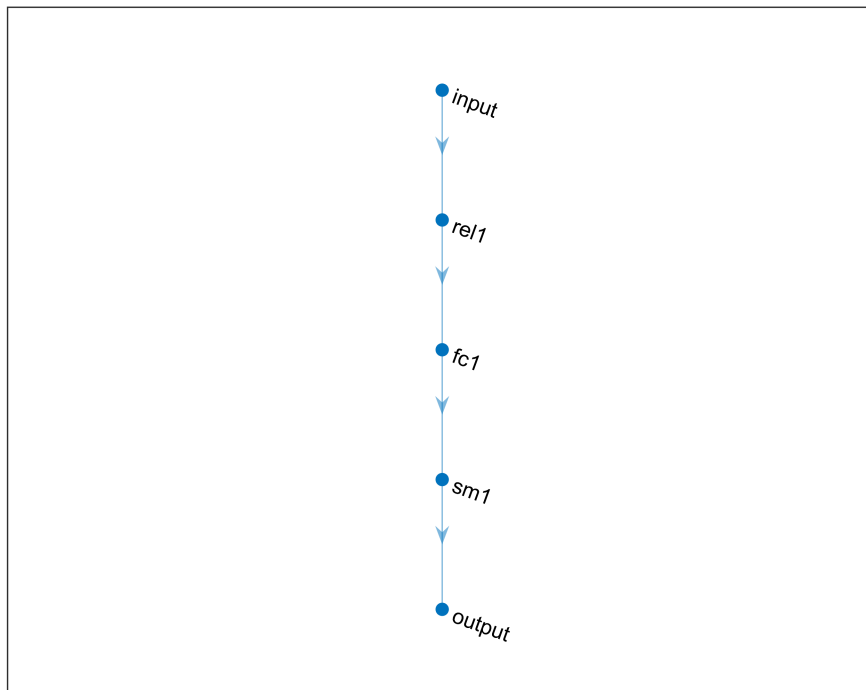
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	30.47%	11.0933	0.0010
50	50	00:00:00	41.41%	6.1099	0.0010
100	100	00:00:00	42.19%	5.4386	0.0010
120	120	00:00:01	42.97%	5.0455	0.0010

Training finished: Max epochs completed.

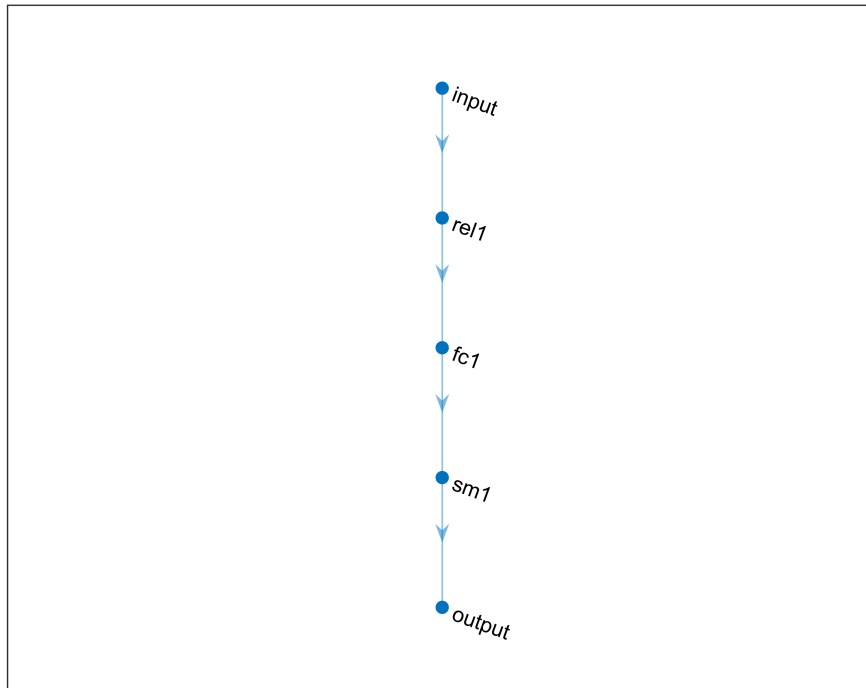


Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	36.72%	9.8570	0.0010
50	50	00:00:00	25.00%	8.0535	0.0010
100	100	00:00:00	32.81%	6.7846	0.0010
140	140	00:00:01	35.94%	5.9740	0.0010

Training finished: Max epochs completed.

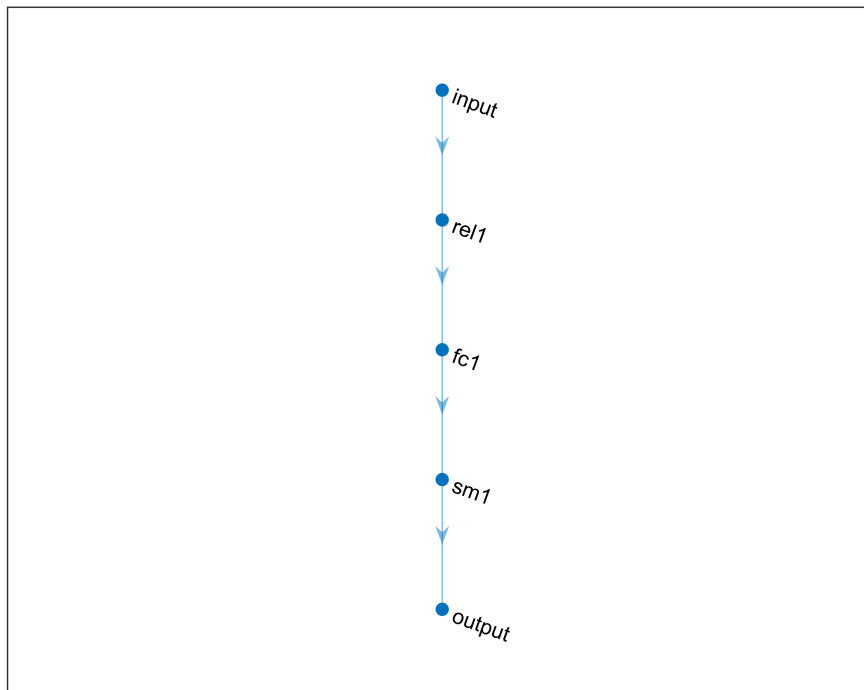




Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	30.47%	10.9694	0.0010
50	50	00:00:00	32.03%	7.9045	0.0010
100	100	00:00:00	40.62%	6.1344	0.0010
150	150	00:00:01	51.56%	4.2951	0.0010
160	160	00:00:01	52.34%	4.0096	0.0010

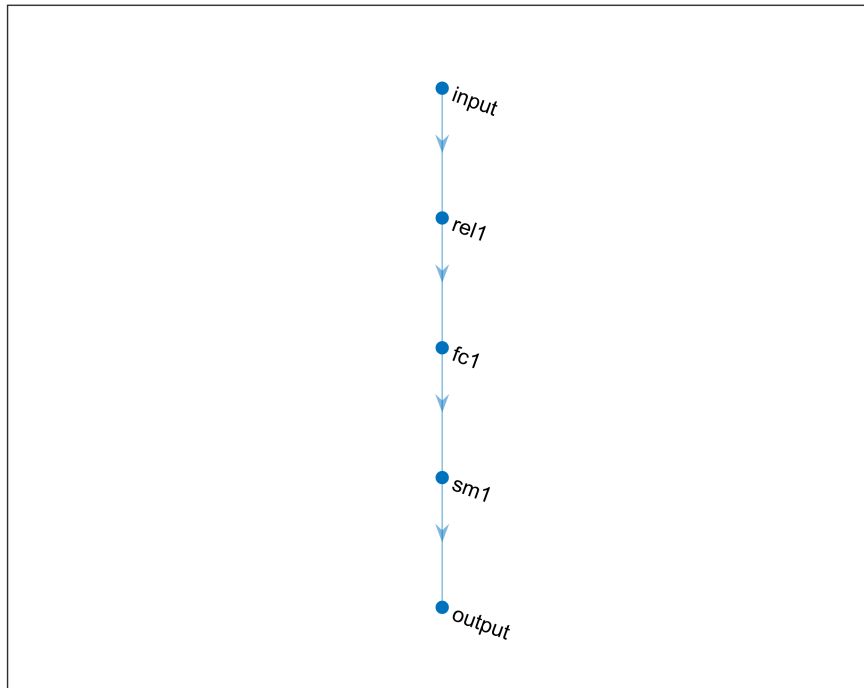
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	29.69%	11.0168	0.0010
50	50	00:00:00	32.81%	7.1162	0.0010
100	100	00:00:00	37.50%	6.1031	0.0010
150	150	00:00:01	40.62%	5.4184	0.0010
180	180	00:00:01	39.84%	5.0399	0.0010

Training finished: Max epochs completed.



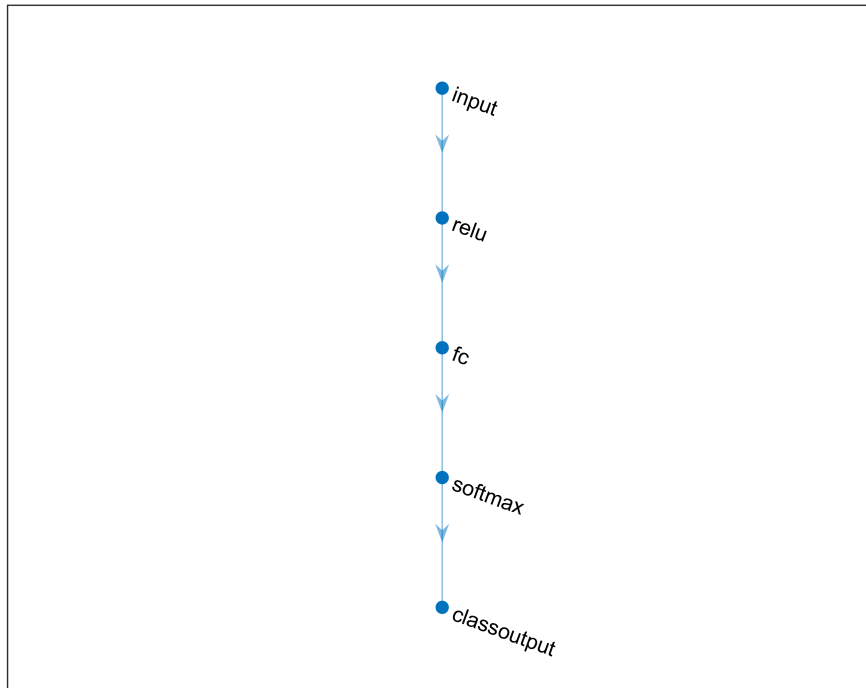
Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	30.47%	10.4709	0.0010
50	50	00:00:00	38.28%	8.0420	0.0010
100	100	00:00:00	49.22%	5.6932	0.0010
150	150	00:00:01	53.91%	4.4502	0.0010
200	200	00:00:01	54.69%	3.7906	0.0010

Training finished: Max epochs completed.

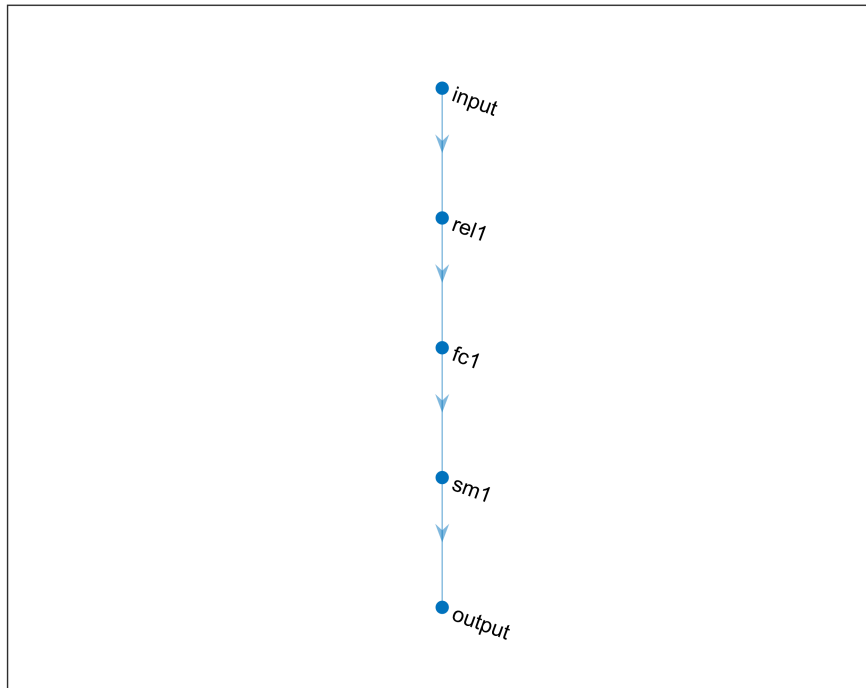
M = 50

I = 80



```

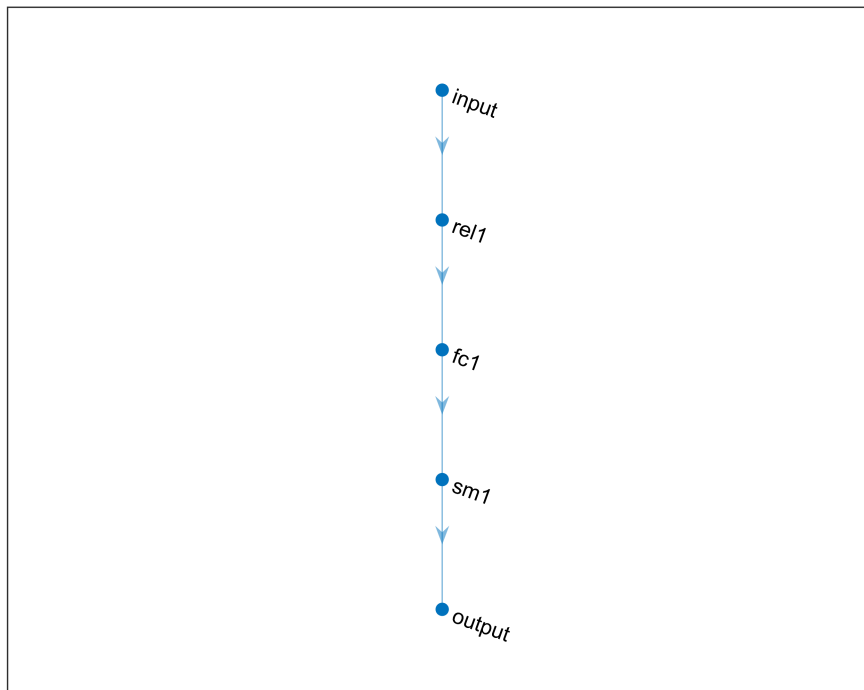
C = 3x3
    8    5    2
    3    2    2
    2    2    3
Accuracy = 40.6250
Recall = 1x3
    0.5333    0.2857    0.4286
Precision = 1x3
    0.6154    0.2222    0.4286
  
```



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	42.19%	9.1003	0.0010
50	50	00:00:00	27.34%	8.4896	0.0010
60	60	00:00:00	22.66%	7.3343	0.0010

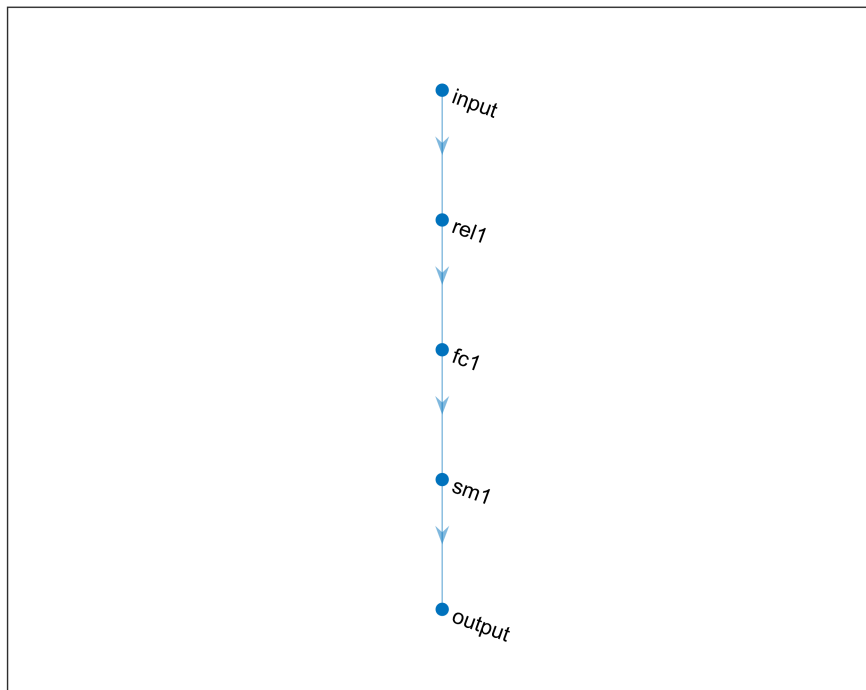
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	23.44%	12.2127	0.0010
50	50	00:00:00	28.12%	8.9613	0.0010
80	80	00:00:00	30.47%	7.8263	0.0010

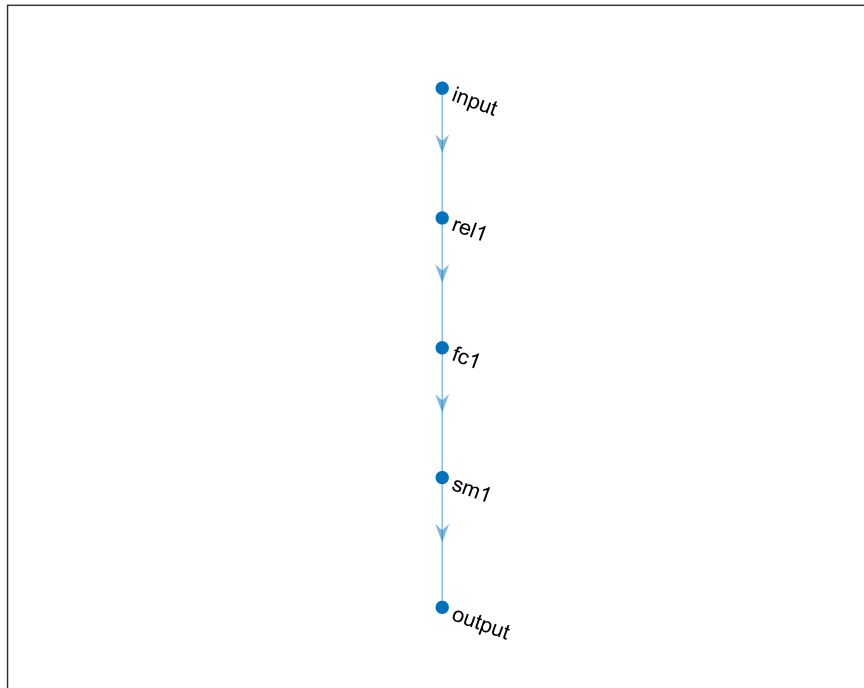
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	25.78%	11.7182	0.0010
50	50	00:00:00	28.91%	6.7497	0.0010
100	100	00:00:00	34.38%	5.2178	0.0010

Training finished: Max epochs completed.

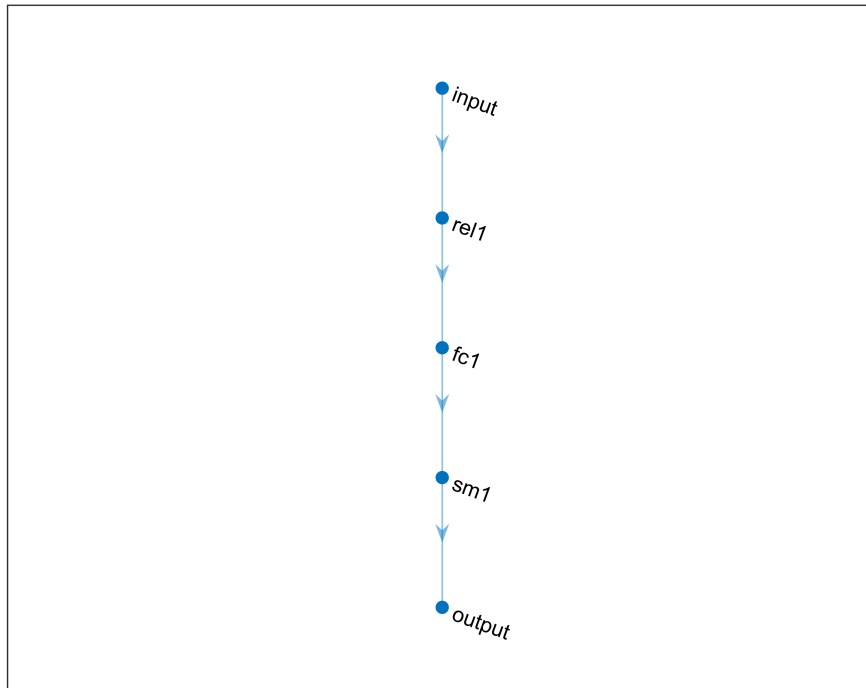


Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	35.16%	9.9925	0.0010
50	50	00:00:00	33.59%	8.6542	0.0010
100	100	00:00:01	35.16%	7.7486	0.0010
120	120	00:00:01	36.72%	7.1996	0.0010

Training finished: Max epochs completed.

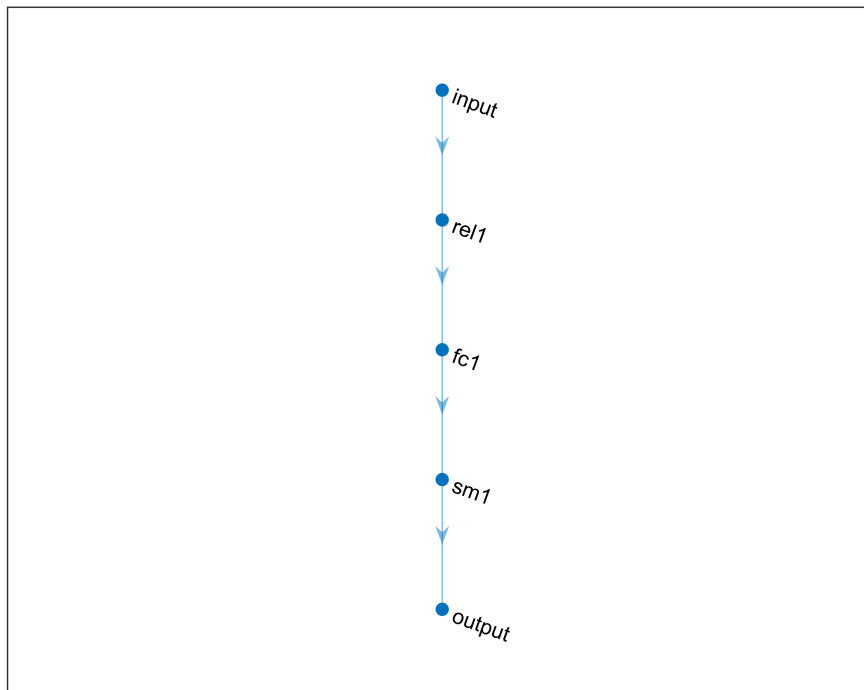




Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	48.44%	6.6610	0.0010
50	50	00:00:00	45.31%	5.6899	0.0010
100	100	00:00:01	48.44%	4.6817	0.0010
140	140	00:00:01	50.78%	3.9648	0.0010

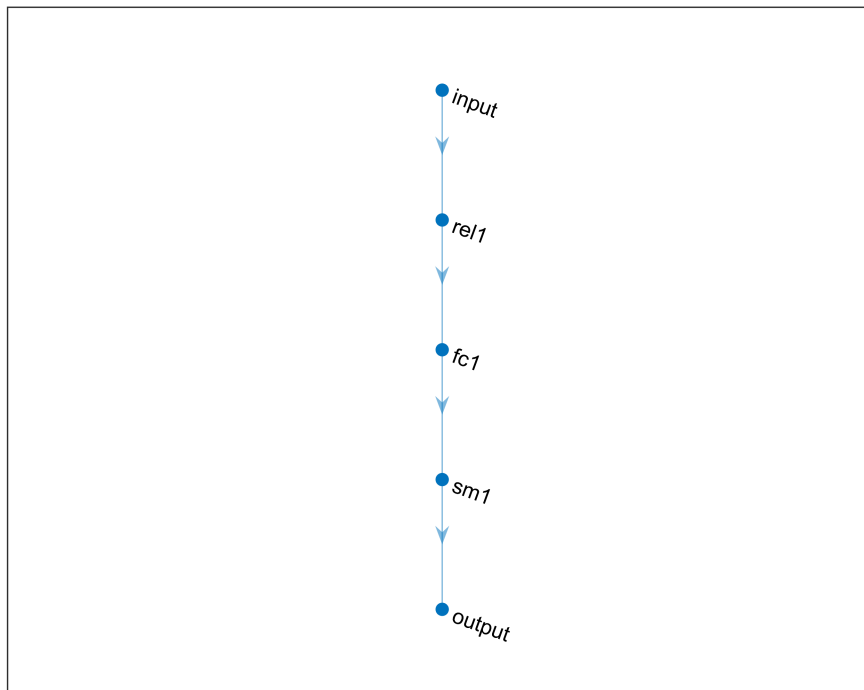
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	23.44%	12.1449	0.0010
50	50	00:00:00	29.69%	7.4088	0.0010
100	100	00:00:00	37.50%	6.1913	0.0010
150	150	00:00:01	42.97%	5.3285	0.0010
160	160	00:00:01	44.53%	5.1729	0.0010

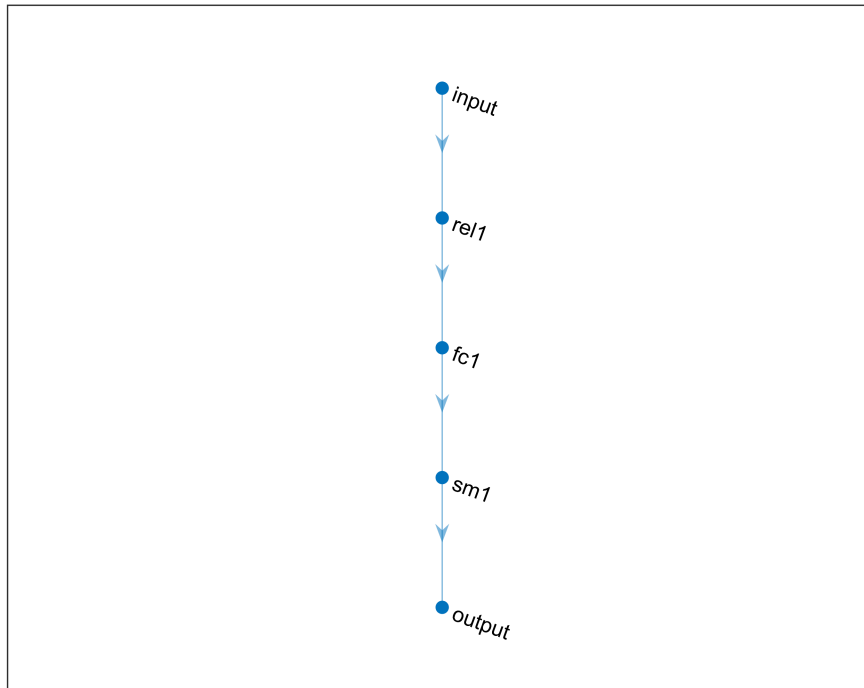
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	28.12%	11.0528	0.0010
50	50	00:00:00	50.00%	4.4984	0.0010
100	100	00:00:00	51.56%	3.9176	0.0010
150	150	00:00:01	51.56%	3.7379	0.0010
180	180	00:00:01	51.56%	3.6286	0.0010

Training finished: Max epochs completed.



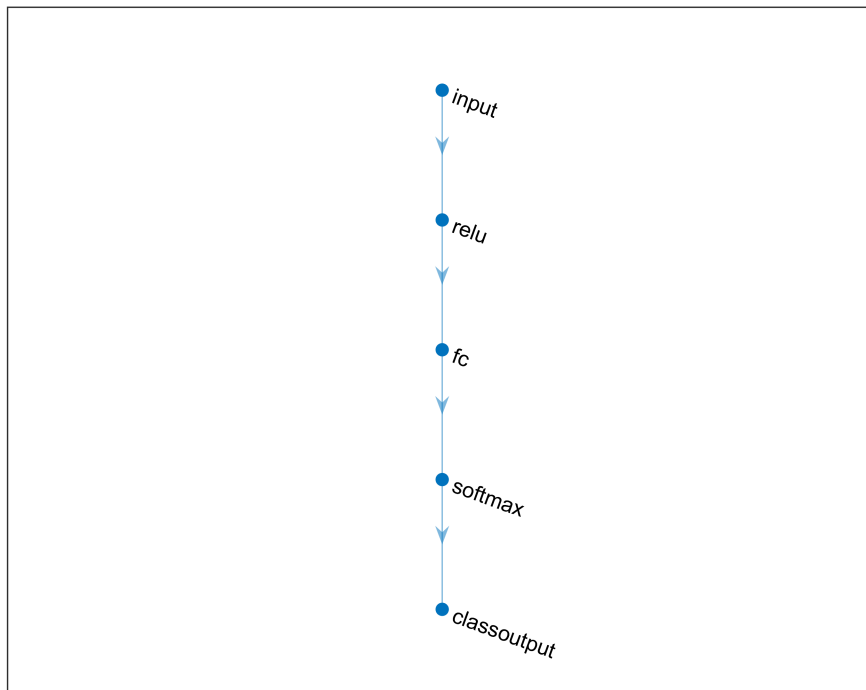
Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	29.69%	10.6729	0.0010
50	50	00:00:00	43.75%	5.3340	0.0010
100	100	00:00:00	50.78%	4.6430	0.0010
150	150	00:00:01	52.34%	4.1972	0.0010
200	200	00:00:01	51.56%	3.7338	0.0010

Training finished: Max epochs completed.

M = 66.6667

I = 200



C = 3×3

6	1	4
6	4	1
1	3	3

Accuracy = 1×2

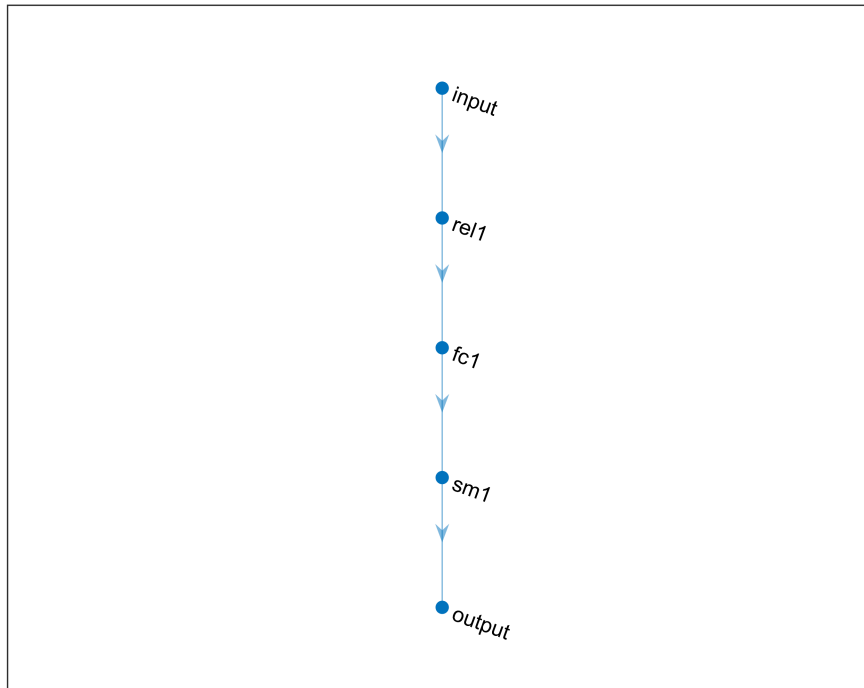
40.6250	40.6250
---------	---------

Recall = 2×3

0.5333	0.2857	0.4286
0.5455	0.3636	0.4286

Precision = 2×3

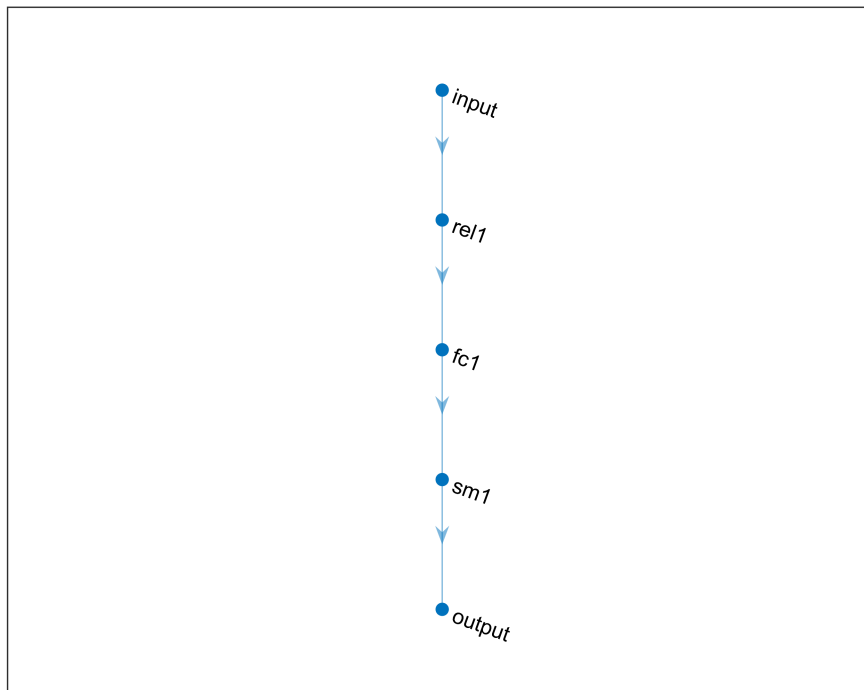
0.6154	0.2222	0.4286
0.4615	0.5000	0.3750



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	22.66%	12.2149	0.0010
50	50	00:00:00	31.25%	6.7295	0.0010
60	60	00:00:00	32.81%	6.6461	0.0010

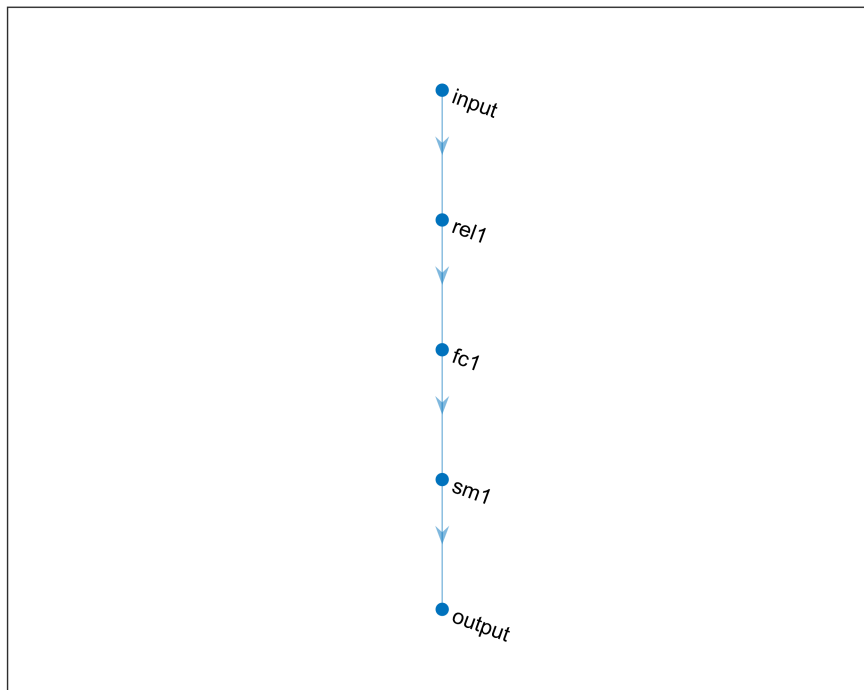
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	30.47%	11.1002	0.0010
50	50	00:00:00	38.28%	7.6881	0.0010
80	80	00:00:00	30.47%	7.4104	0.0010

Training finished: Max epochs completed.

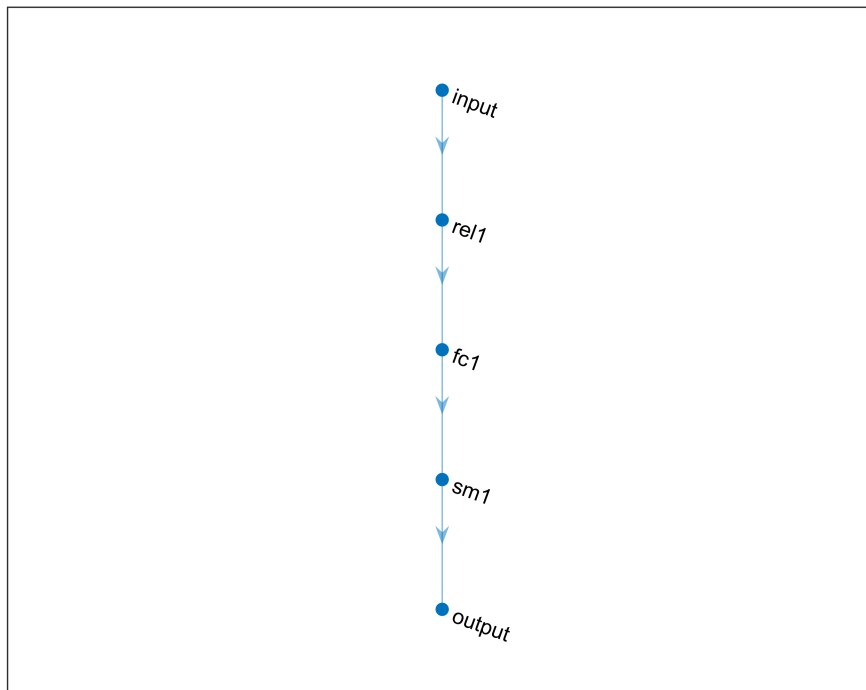


Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	33.59%	10.6073	0.0010
50	50	00:00:00	33.59%	8.1076	0.0010
100	100	00:00:00	34.38%	7.0680	0.0010

Training finished: Max epochs completed.

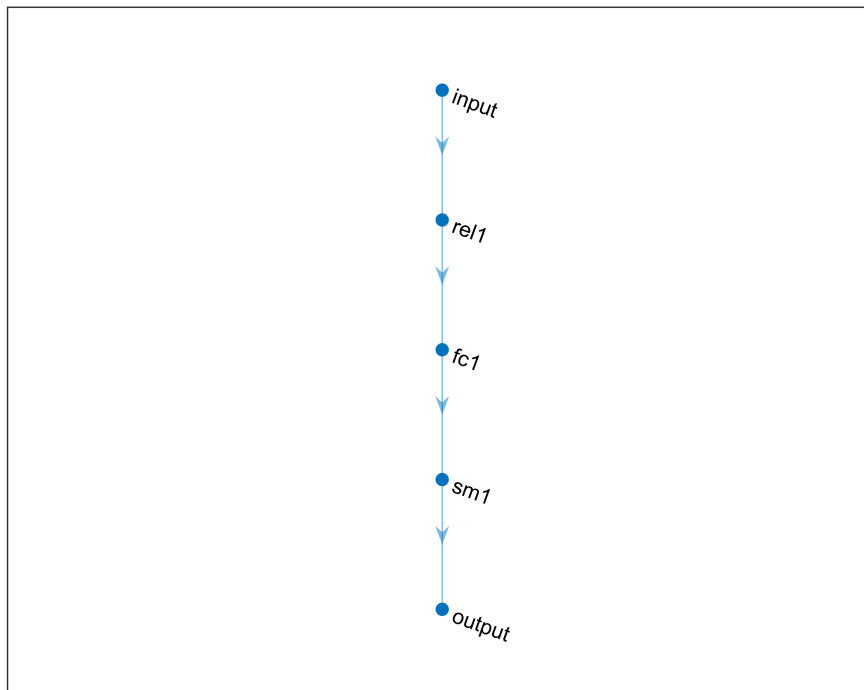




Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	32.03%	10.0016	0.0010
50	50	00:00:00	33.59%	7.8433	0.0010
100	100	00:00:00	40.62%	6.7012	0.0010
120	120	00:00:00	42.19%	6.1862	0.0010

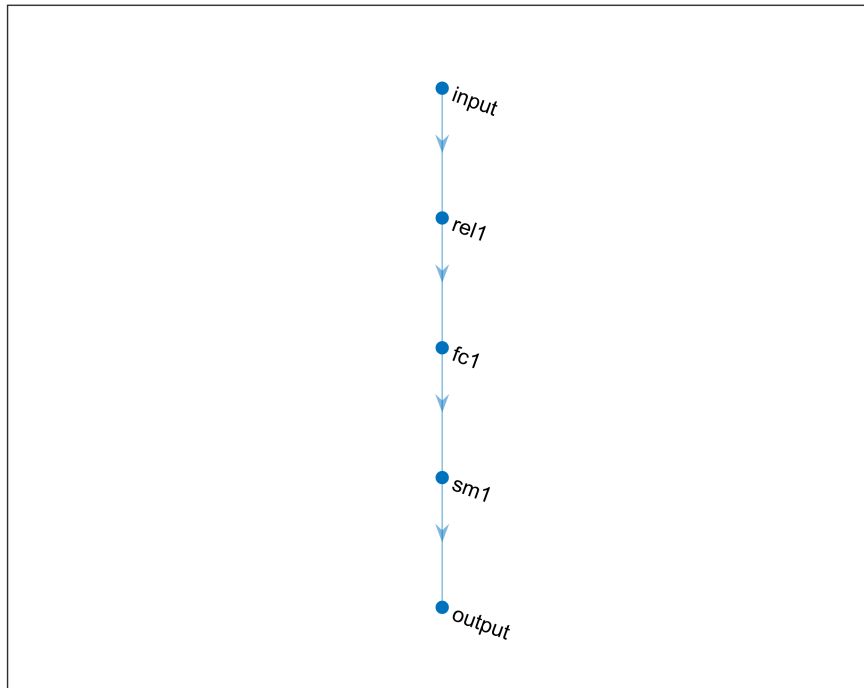
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	43.75%	7.0438	0.0010
50	50	00:00:00	41.41%	6.4966	0.0010
100	100	00:00:00	47.66%	4.3340	0.0010
140	140	00:00:01	56.25%	3.5158	0.0010

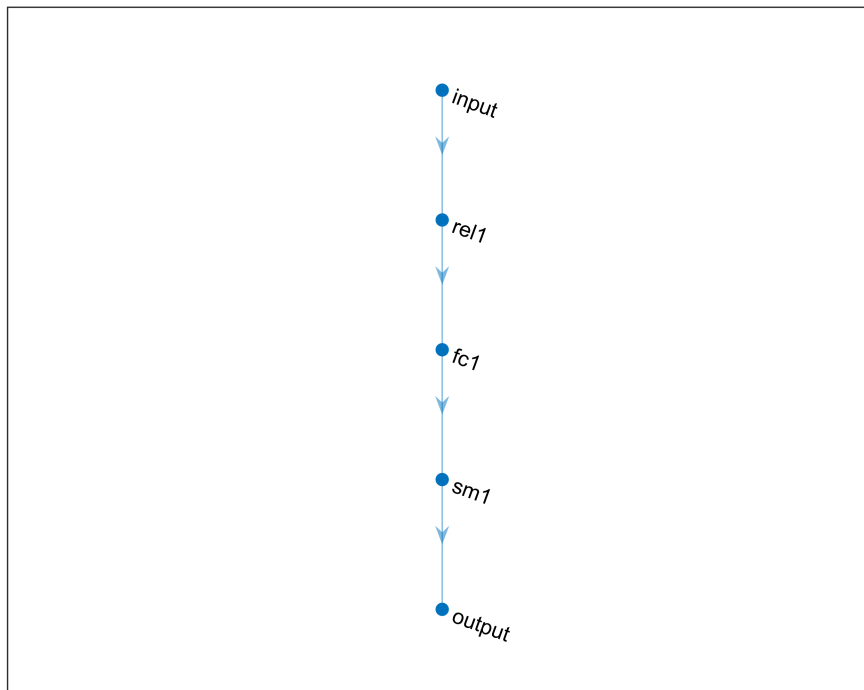
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	28.12%	11.1133	0.0010
50	50	00:00:00	37.50%	7.1710	0.0010
100	100	00:00:00	38.28%	6.6737	0.0010
150	150	00:00:01	42.97%	6.1359	0.0010
160	160	00:00:01	42.19%	6.0115	0.0010

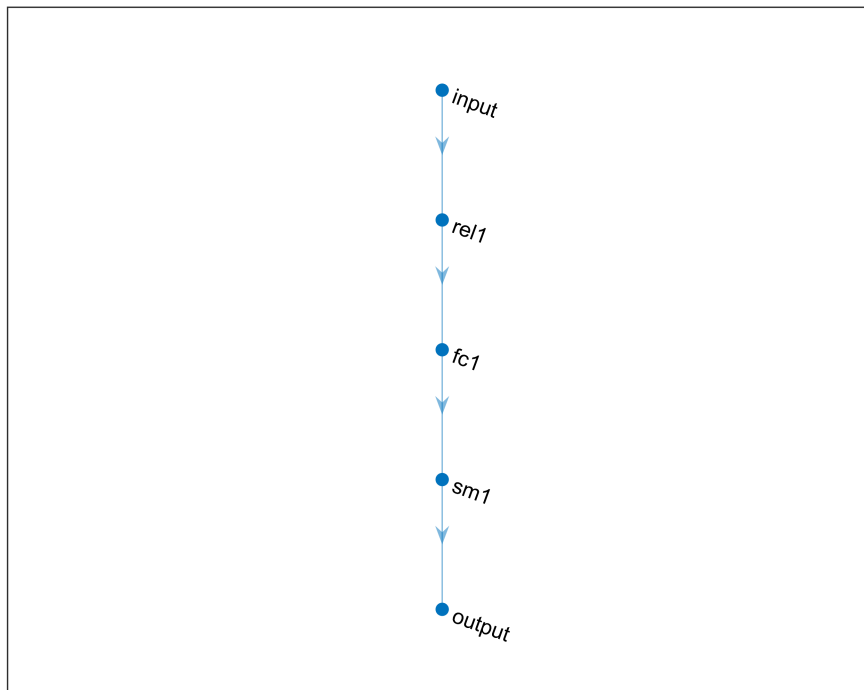
Training finished: Max epochs completed.



Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	41.41%	8.9021	0.0010
50	50	00:00:00	36.72%	7.6259	0.0010
100	100	00:00:00	44.53%	4.7509	0.0010
150	150	00:00:01	50.00%	3.9133	0.0010
180	180	00:00:01	54.69%	3.5868	0.0010

Training finished: Max epochs completed.



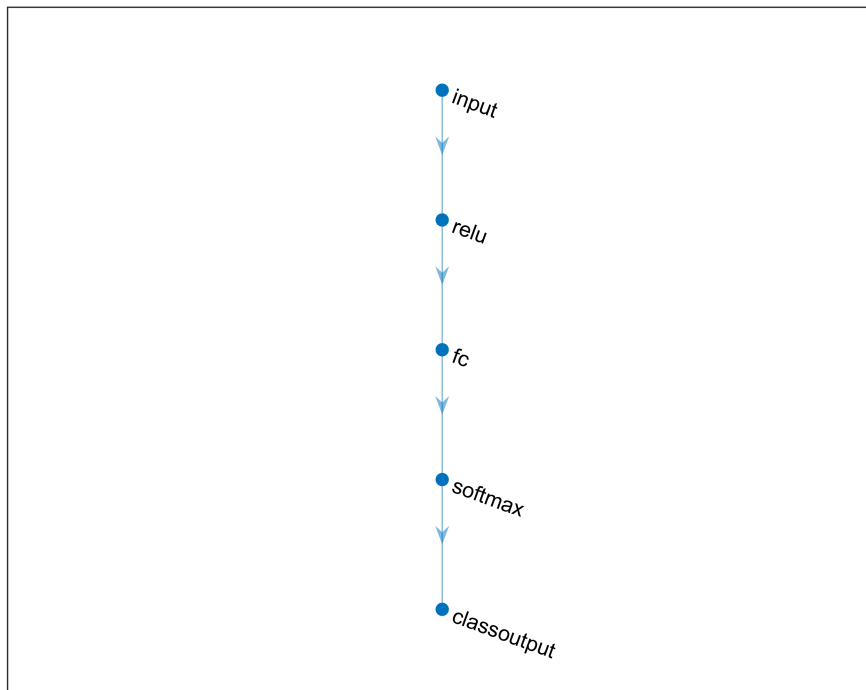
Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Mini-batch Loss	Base Learning Rate
1	1	00:00:00	40.62%	8.6180	0.0010
50	50	00:00:00	32.03%	6.9706	0.0010
100	100	00:00:00	51.56%	4.6184	0.0010
150	150	00:00:01	53.91%	4.0292	0.0010
200	200	00:00:01	58.59%	3.5059	0.0010

Training finished: Max epochs completed.

M = 66.6667

I = 140



```

C = 3x3
  6   2   5
  7   1   0
  2   2   4
Accuracy = 1x3
40.6250  40.6250  34.3750
Recall = 3x3
  0.5333   0.2857   0.4286
  0.5455   0.3636   0.4286
  0.4615   0.1250   0.5000
Precision = 3x3
  0.6154   0.2222   0.4286
  0.4615   0.5000   0.3750
  0.4000   0.2000   0.4444
  
```