Filters

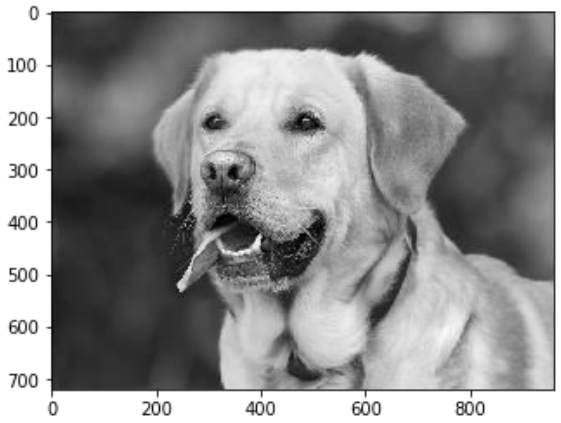
Feature Extraction using Filter

filter

Original Gray Scale Image

Vertical lines detected in Image

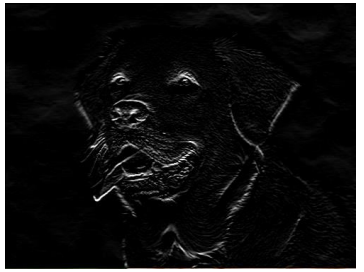
Different kinds of Features Extracted



filters

Blur

Outline



Horizontal lines

Contrast

What are Filters?

Original Image

×

-1	0	1
-1	0	1
-1	0	1

Filter – Right Sobel

=

Extracted Feature – Vertical lines

Some Common Filters

-1	0	1
-1	0	1
-1	0	1

Right Sobel Filter

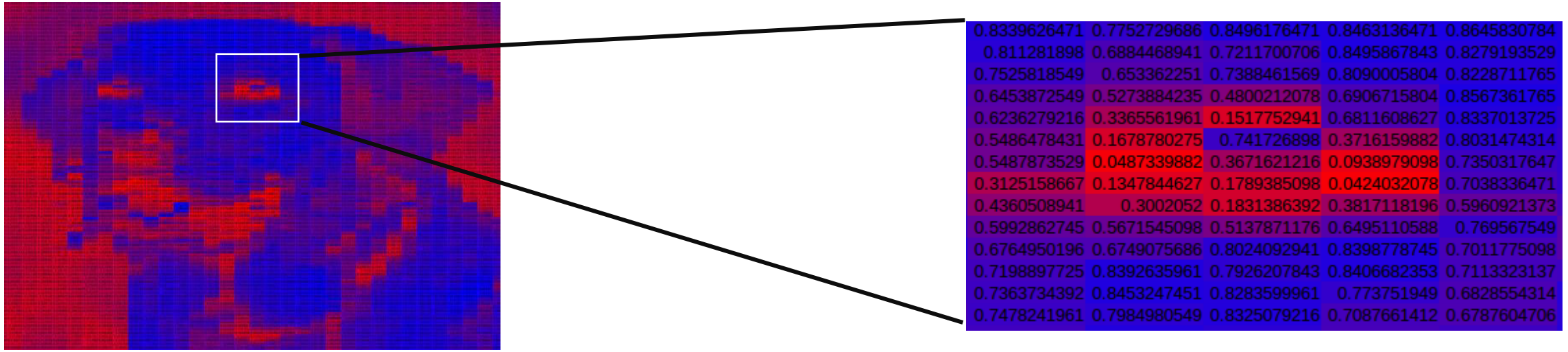
1	1	1
0	0	0
-1	-1	-1

Top Sobel Filter

0.0625	0.125	0.0625
0.125	0.25	0.125
0.0625	0.125	0.0625

Blur Filter

Filter Multiplication - Intuition



= (36 x –1) + (31 x 0) +(28 x 1) + (38 x -1) + (34 x 0)
+ (29 x 1) + (39 x -1) + (35 x 0) + (32 x 1)

-1	0	1
-1	0	1
-1	0	1

Filter

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

Image

-24					

Feature Map

= (31 x –1) + (28 x 0) +(24 x 1) + (34 x -1) + (29 x 0)
+ (26 x 1) + (35 x -1) + (32 x 0) + (28 x 1)

-1	0	1
-1	0	1
-1	0	1

Column Stride = 1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22				

= (28 x –1) + (24 x 0) +(23 x 1) + (29 x -1) + (26 x 0)
+ (25 x 1) + (32 x -1) + (28 x 0) + (27 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15			

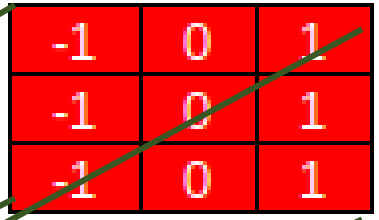
= (24 x –1) + (23 x 0) +(27 x 1) + (26 x -1) + (25 x 0)
+ (30 x 1) + (28 x -1) + (27 x 0) + (33 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12		

= (23 x –1) + (27 x 0) +(33 x 1) + (25 x -1) + (30 x 0)
+ (37 x 1) + (27 x -1) + (33 x 0) + (40 x 1)



36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	

= (27 x –1) + (33 x 0) +(39 x 1) + (30 x -1) + (37 x 0)
+ (41 x 1) + (33 x -1) + (40 x 0) + (43 x 1)

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-1	0	1
-1	0	1
-1	0	1

-24	-22	-15	12	35	33

= (38 x –1) + (34 x 0) +(29 x 1) + (39 x -1) + (35 x 0)
+ (32 x 1) + (42 x -1) + (38 x 0) + (34 x 1)

-1	0	1
-1	0	1
-1	0	1

Row Stride = 1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23					

= (34 x –1) + (29 x 0) +(26 x 1) + (35 x -1) + (32 x 0)
+ (28 x 1) + (36 x -1) + (34 x 0) + (30 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	29	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23				

= (29 x –1) + (26 x 0) +(25 x 1) + (32 x -1) + (28 x 0)
+ (27 x 1) + (34 x -1) + (30 x 0) + (30 x 1)

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-1	0	1
-1	0	1
-1	0	1

-24	-22	-15	12	35	33
-23	-23	-13			

= (26 x –1) + (25 x 0) +(30 x 1) + (28 x -1) + (27 x 0)
+ (33 x 1) + (30 x -1) + (30 x 0) + (36 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23	-13	14		

= (25 x –1) + (30 x 0) +(37 x 1) + (27 x -1) + (33 x 0)
+ (40 x 1) + (30 x -1) + (36 x 0) + (43 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23	-13	14	39	

= (30 x –1) + (37 x 0) +(41 x 1) + (33 x -1) + (40 x 0)
+ (43 x 1) + (56 x -1) + (43 x 0) + (46 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23	-13	14	39	32

= (38 x –1) + (39 x 0) +(37 x 1) + (34 x -1) + (37 x 0)
+ (36 x 1) + (31 x -1) + (35 x 0) + (35 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23	-13	14	39	32
-22	-23	-11	18	41	31
-22	-23	-6	22	41	29
-20	-19	0	25	40	26
-18	-15	4	27	37	23
-15	-10	9	28	36	23
-13	-7	13	29	34	23
-8	-3	18	29	33	25
-2	2	20	28	32	25
5					

= (39 x –1) + (37 x 0) +(40 x 1) + (37 x -1) + (36 x 0)
+ (39 x 1) + (35 x -1) + (35 x 0) + (39 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23	-13	14	39	32
-22	-23	-11	18	41	31
-22	-23	-6	22	41	29
-20	-19	0	25	40	26
-18	-15	4	27	37	23
-15	-10	9	28	36	23
-13	-7	13	29	34	23
-8	-3	18	29	33	25
-2	2	20	28	32	25
5	8				

= (37 x –1) + (40 x 0) +(44 x 1) + (36 x -1) + (39 x 0)
+ (43 x 1) + (35 x -1) + (39 x 0) + (44 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23	-13	14	39	32
-22	-23	-11	18	41	31
-22	-23	-6	22	41	29
-20	-19	0	25	40	26
-18	-15	4	27	37	23
-15	-10	9	28	36	23
-13	-7	13	29	34	23
-8	-3	18	29	33	25
-2	2	20	28	32	25
5	8	23			

= (40 x –1) + (44 x 0) +(49 x 1) + (39 x -1) + (43 x 0)
+ (48 x 1) + (39 x -1) + (44 x 0) + (49 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23	-13	14	39	32
-22	-23	-11	18	41	31
-22	-23	-6	22	41	29
-20	-19	0	25	40	26
-18	-15	4	27	37	23
-15	-10	9	28	36	23
-13	-7	13	29	34	23
-8	-3	18	29	33	25
-2	2	20	28	32	25
5	8	23	28		

= (44 x –1) + (49 x 0) +(55 x 1) + (43 x -1) + (48 x 0)
+ (54 x 1) + (44 x -1) + (49 x 0) + (53 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23	-13	14	39	32
-22	-23	-11	18	41	31
-22	-23	-6	22	41	29
-20	-19	0	25	40	26
-18	-15	4	27	37	23
-15	-10	9	28	36	23
-13	-7	13	29	34	23
-8	-3	18	29	33	25
-2	2	20	28	32	25
5	8	23	28	30	

= (49 x –1) + (55 x 0) +(58 x 1) + (48 x -1) + (54 x 0)
+ (56 x 1) + (49 x -1) + (53 x 0) + (55 x 1)

-1	0	1
-1	0	1
-1	0	1

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

-24	-22	-15	12	35	33
-23	-23	-13	14	39	32
-22	-23	-11	18	41	31
-22	-23	-6	22	41	29
-20	-19	0	25	40	26
-18	-15	4	27	37	23
-15	-10	9	28	36	23
-13	-7	13	29	34	23
-8	-3	18	29	33	25
-2	2	20	28	32	25
5	8	23	28	30	23

Shapes with Single Filter

-1	0	1
-1	0	1
-1	0	1

3 X 3

36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

13 X 8

-24	-22	-15	12	35	33
-23	-23	-13	14	39	32
-22	-23	-11	18	41	31
-22	-23	-6	22	41	29
-20	-19	0	25	40	26
-18	-15	4	27	37	23
-15	-10	9	28	36	23
-13	-7	13	29	34	23
-8	-3	18	29	33	25
-2	2	20	28	32	25
5	8	23	28	30	23

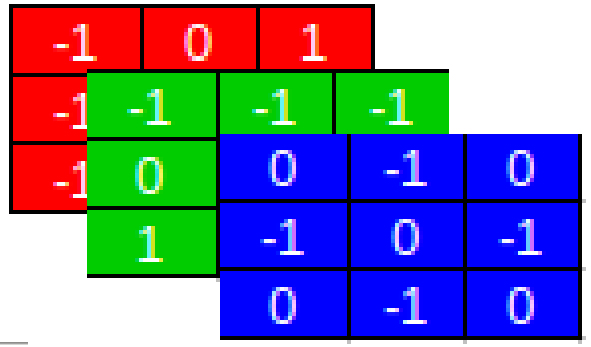
11 X 6

Calculating shape of Output(Feature Map)

$$OutputHeight = \frac{InputHeight - FilterHeight}{RowStride} + 1$$

$$OutputWidth = \frac{InputWidth - FilterWidth}{ColumnStride} + 1$$

Shapes with 3 Filters and 2-D Image



3 X 3 - 3

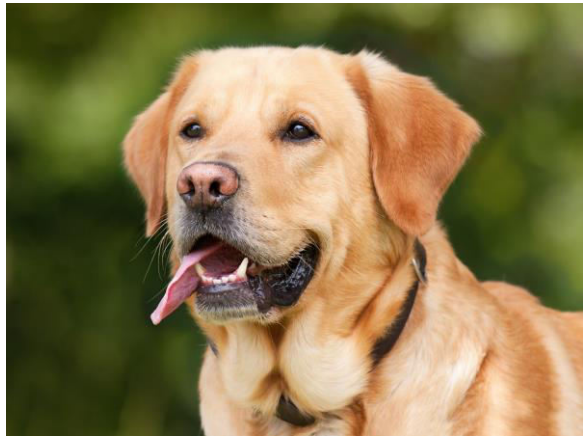
36	31	28	24	23	27	33	39
38	34	29	26	25	30	37	41
39	35	32	28	27	33	40	43
42	38	34	30	30	36	43	46
43	40	36	32	34	40	48	50
44	41	37	35	37	43	51	52
45	42	39	37	41	46	53	54
45	42	40	39	42	48	54	55
43	42	39	40	43	49	55	57
41	41	38	39	44	49	55	58
38	39	37	40	44	49	55	58
34	37	36	39	43	48	54	56
31	35	35	39	44	49	53	55

13 X 8

-24	-22	-15	12	35	33		
-23	11	12	12	14	17	17	
-22	13	-134	-119	-106	-105	-121	-144
-22	14	-142	-127	-114	-116	-132	-156
-20	9	-151	-136	-124	-126	-146	-170
-18	6	-159	-144	-134	-139	-161	-183
-15	4	-164	-151	-144	-153	-174	-196
-13	-2	-168	-156	-153	-163	-186	-205
-8	-7	-168	-159	-159	-171	-192	-211
-2	-10	-165	-159	-160	-175	-196	-215
5	-13	-159	-156	-161	-176	-197	-217
	-13	-152	-153	-160	-176	-197	-215
		-144	-148	-158	-176	-194	-212

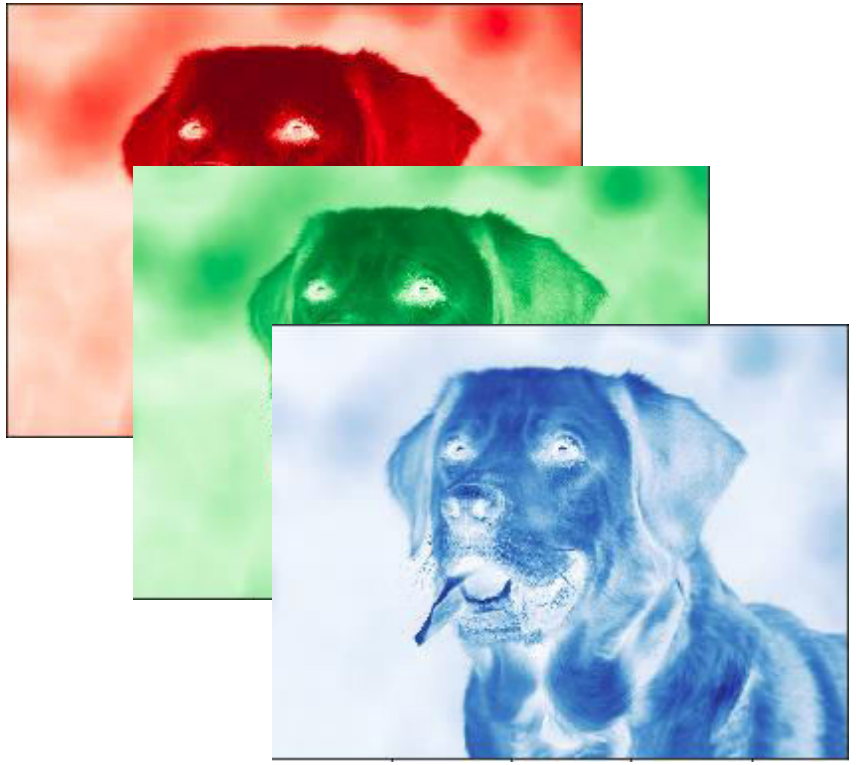
11 X 6 X 3

Shapes with 1 Filter and 3-D Image

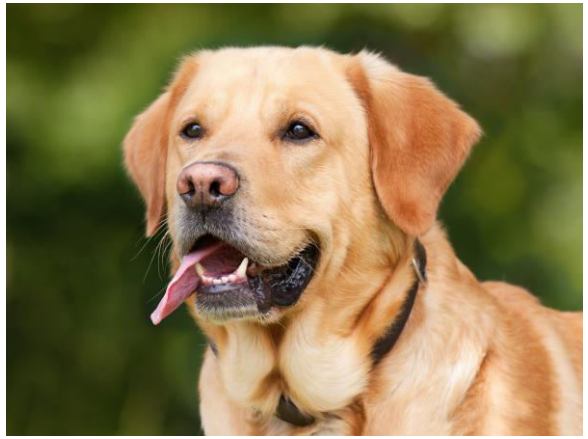


720 X 960 X 3

R G B



Shapes with 1 Filter and 3-D Image



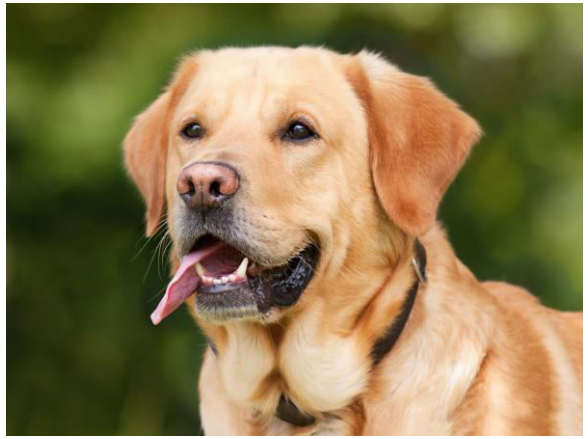
-1	0	1
-1	0	1
-1	0	1

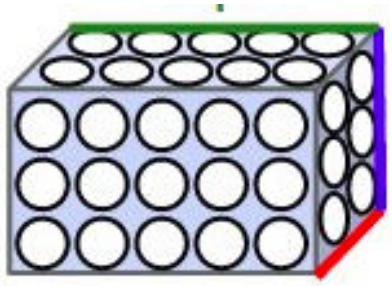
720 X 960 X 3

R G B

3 X 3

Shapes with 1 Filter and 3-D Image



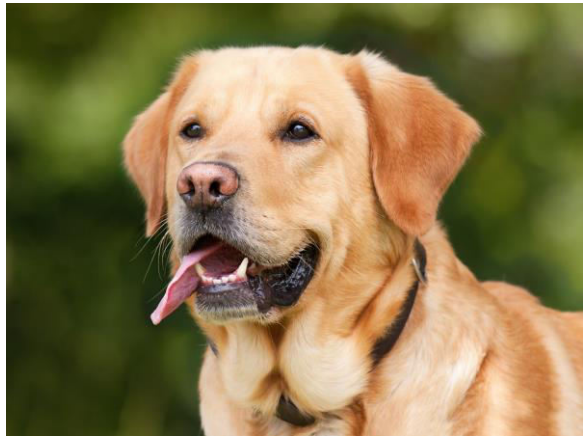


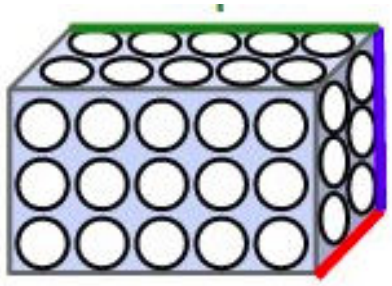
720 X 960 X 3

3 X 3 X 3

Same

Shapes with 1 Filter and 3-D Image



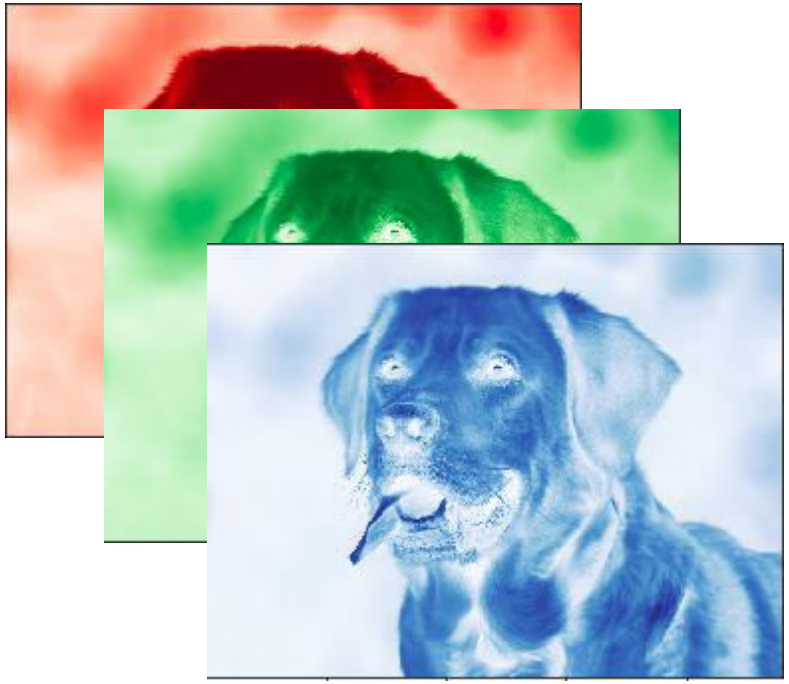


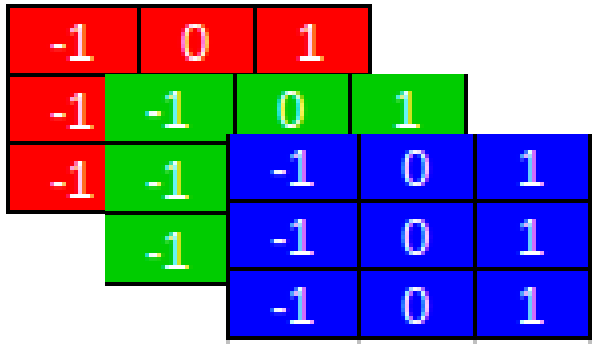
720 X 960 X 5

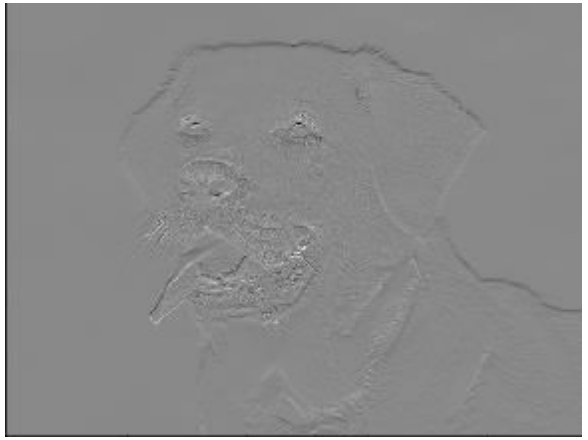
3 X 3 X 5

Same

Shapes with 1 Filter and 3-D Image







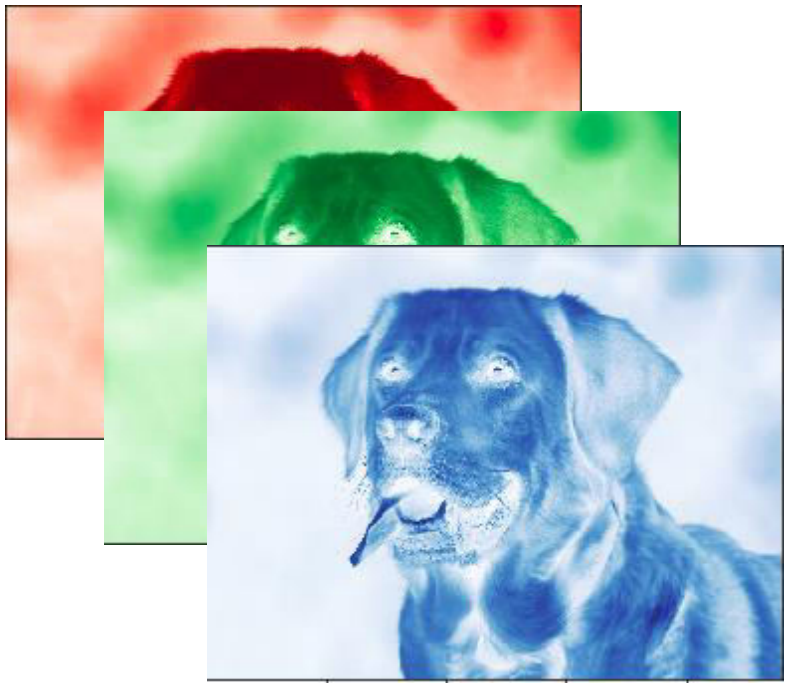
720 X 960 X 3

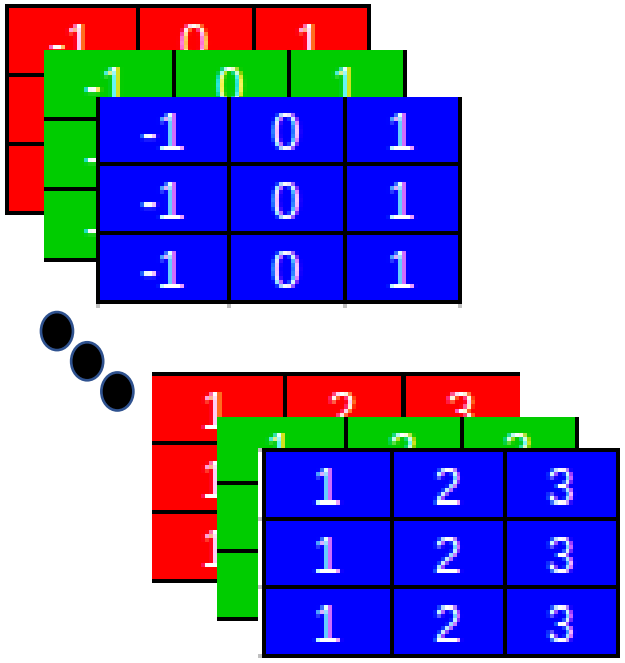
3 X 3 X 3

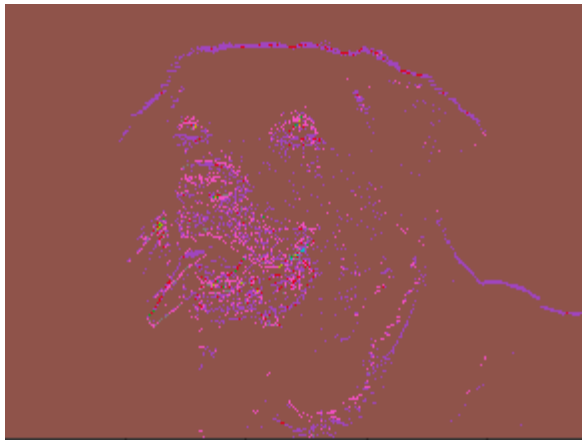
718 X 958

Same

Shapes with N Filters and 3-D Image







720 X 960 X 3

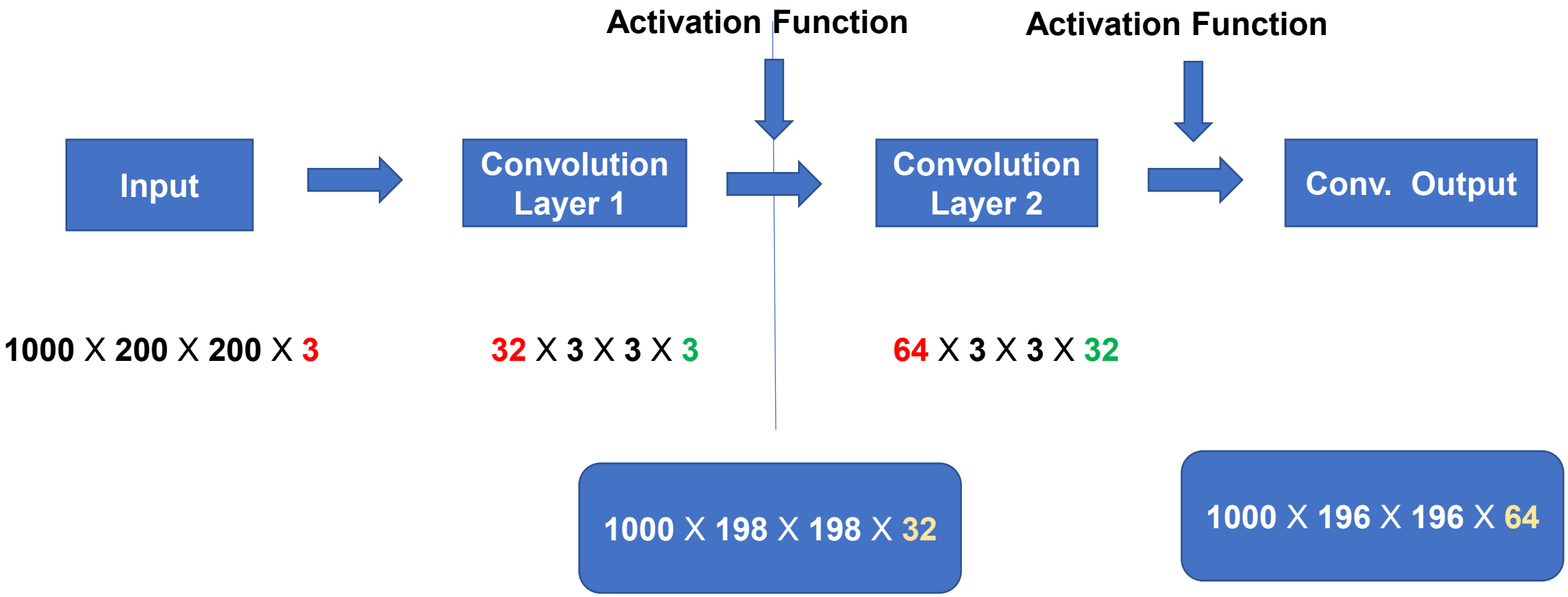
N

3 X 3 X 3

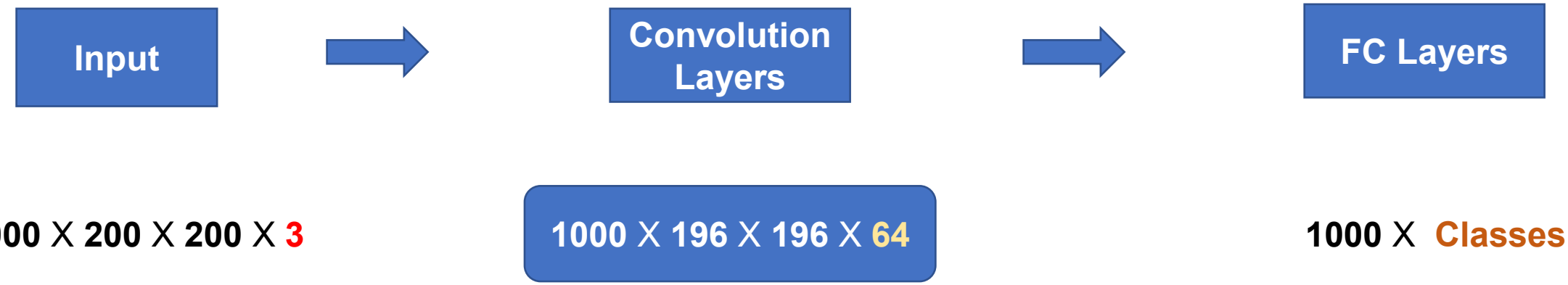
718 X 958 X N

Same

Output of Successive Convolutions



Forward Propagation with Convoluted layers



Forward Propagation with Convoluted layers

Input to FC can only be 2-Dimensional

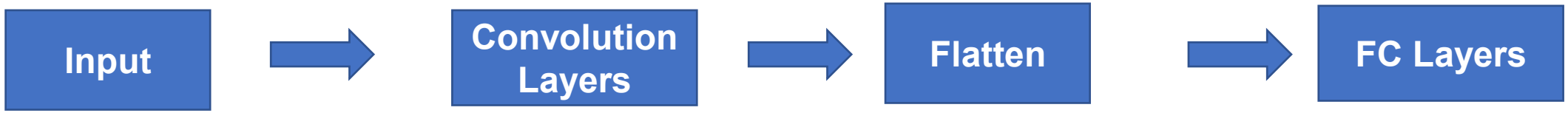
1000 X 200 X 200 X 3

1000 X 196 X 196 X 64

1000 X Classes

4-Dimension

Forward Propagation with Convolution layers



1000 X **200** X **200** X **3**

1000 X **196** X **196** X **64**

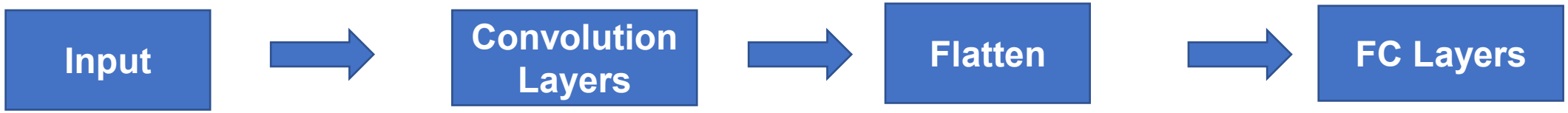
4-Dimension

1000 X (**196** X **196** X **64**)

2-Dimension

1000 X **Classes**

Forward Propagation with Convolution layers



1000 X **200** X **200** X **3**

1000 X **196** X **196** X **64**

4-Dimension

1000 X (**2458624**)

2-Dimension

1000 X **Classes**

Thank You