# Character recognition: neural network application

Machine intelligence class



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#### Outline

- Color and RGB images
- Gray images
- Black and white images
- Number recognition example using ANN

#### Color Images



Images are divided into pixels

The number of pixels depends on the resolution of the image

#### **RGB** Images

- The color of each **pixel** is determined by the combination of the **Red**, Green, and Blue intensities stored in each color plane at the **pixel's** location.
- Graphics file formats store RGB images as 24-bit images, where the red, green, and blue components are 8 bits each (i.e. 256 possible combinations for each color



Pixel of an RGB image are formed from the corresponding pixel of the three component images

#### Gray Scale Images

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155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	84	6	10	83	48	105	159	181
206	169	6	124	191	111	1 20	204	166	15	56	180
194	68	197	251	237	259	239	228	227	87	71	201
172	106	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	160
189	97	165	84	10	168	134	11	31	67	22	148
199	168	191	193	158	227	178	143	182	105	36	190
206	174	155	252	296	231	149	178	228	43	95	234
190	216	116	149	295	187	85	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	163	143	95	50	ż	109	249	215
187	196	235	75	1	81	47	۰	6	217	255	211
189	202	237	145	0	0	12	108	200	135	243	236
195	206	123	207	177	121	123	200	175	13	96	218

157	153	174	168	150	152	129	15
156	182	163	74	75	62	33	1
180	180	50	14	34	6	10	3
206	109	5	124	131	111	120	20
194	68	137	251	237	239	239	22
172	105	207	233	233	214	220	23
188	88	179	209	185	215	211	15
189	97	165	84	10	168	134	1
199	168	191	193	158	227	178	14
206	174	156	252	236	231	149	17
190	216	116	149	236	187	86	15
190	224	147	108	227	210	127	10
190	214	173	66	103	143	96	6
187	196	235	75	1	81	47	
183	202	237	145	0	0	12	10
196	206	123	207	177	121	123	20

Gray Scale images uses one 8-bit component

#### Numbers in Black and White



Each number is decoded into black/white 5x5 pixel image Each pixel is either '0' or '1'



### Numbers in Black and White



Create a 5x5 matrix with '0' or '1'

1	0	0	0	1
0	1	1	1	0
0	1	1	1	0
0	1	1	1	0
1	0	0	0	1

**Restructure the 5x5 matrix into 25x1 vector** 

This vector will be the input to the network

Flattening



#### Handwritten Numbers

n	2	2	4	5	6	7	8	9
v	a	1		)	U	1	0	

- 0 1 2 3 4 5 6 7 8 9
- 0123456789
- 0123456789
- 0123456789
- 0 1 2 3 4 5 6 7 8 9
- 0123456789

Suppose we want to use a neural network to recognize the handwritten numbers shown

If each number is 5x5 pixel → 25 inputs

How many outputs?

How many patterns?

#### Input-Output Data

IN	OUTPUT											
Χ	d9	d8	d7	d6	d5	d4	d3	d2	<b>d1</b>	d0		
<b>'0'</b>	0	0	0	0	0	0	0	0	0	1		
<b>'1'</b>	0	0	0	0	0	0	0	0	1	0		
<b>'2'</b>	0	0	0	0	0	0	0	1	0	0		
<b>'</b> 3'	0	0	0	0	0	0	1	0	0	0		
<b>'4'</b>	0	0	0	0	0	1	0	0	0	0		
<b>'5'</b>	0	0	0	0	1	0	0	0	0	0		
<b>'6'</b>	0	0	0	1	0	0	0	0	0	0		
<b>'7'</b>	0	0	1	0	0	0	0	0	0	0		
<b>'8'</b>	0	1	0	0	0	0	0	0	0	0		
<b>'9'</b>	1	0	0	0	0	0	0	0	0	0		

#### Neural NetworkArchitecture

#### **25 Inputs**



Use Backpropagation and update the weights to minimize the error

## Input-Output Data using simplecoding

IN	OUTPUT										
Χ	d3	d2	d1	d0							
<b>'0'</b>	0	0	0	0							
<b>'1'</b>	0	0	0	1							
<b>'2</b> '	0	0	1	0							
<b>'</b> 3'	0	0	1	1							
<b>'4'</b>	0	1	0	0							
<b>'5'</b>	0	1	0	1							
<b>'6'</b>	0	1	1	0							
<b>'7'</b>	0	1	1	1							
<b>'8'</b>	1	0	0	0							
<b>'9'</b>	1	0	0	1							

Reduce the output neurons from 10 to only 4

#### Images of Alphabet: A, B, and C

#### 28 x 28 black/white images



# Using a Neural Network for recognition How many inputs? How many outputs? How many patterns?

#### Image Recognition



#### Conclusion

- Images are divided into pixels
- Color images use RGB code
- Images are processed using filters
- Neural networks can be used to recognize images