MACHINE LEARNING

A TEASER

COMPUTER SCIENCE IS…

SOLVING PROBLEMS THROUGH ALGORITHMS, ENCODED AS PROGRAMS

- Problem analysis
- Mathematical modeling
- Thinking an algorithm
- Implementing it in a programming language
- Verifying correcteness and efficiency of the program

THINKING AN ALGORITHM

A SEQUENCE OF SIMPLE STEPS WHICH SOLVE THE PROBLEM IN GENERAL

How many ‘i’ occur in this text?

When Mr. Bilbo Baggins of Bag End announced that he would shortly be celebrating his eleventy-first birthday with a party of special magnificence, there was much talk and excitement in Hobbiton. Bilbo was very rich and very peculiar, and had been the wonder of the Shire for sixty years, ever since his remarkable disappearance and unexpected return. The riches he had brought back from his travels had now become a local legend, and it was popularly believed, whatever the old folk might say, that the Hill at Bag End was full of tunnels stuffed with treasure. And if that was not enough for fame, there was also his prolonged vigour to marvel at. Time wore on, but it seemed to have little effect on Mr. Baggins. At ninety he was much the same as at fifty. At ninety-nine they began to call him _well_-preserved, but _unchanged_ would have been nearer the mark. There were some that shook their heads and thought this was too much of a good thing; it seemed unfair that anyone should possess (apparently) perpetual youth as well as (reputedly) inexhaustible wealth. 'It will have to be paid for,' they said. 'It isn't natural, and trouble will come of it!' But so far trouble had not come; and as Mr. Baggins was generous with his money, most people were willing to forgive him his oddities and his good fortune. He remained on visiting terms with his relatives (except, of course, the Sackville-Bagginses), and he had many devoted admirers among the hobbits of poor and unimportant families. But he had no close friends, until some of his younger cousins began to grow up. The eldest of these, and Bilbo's favourite, was young Frodo Baggins. When Bilbo was ninety-nine, he adopted Frodo as his heir, and brought him to live at Bag End; and the hopes of the Sackville-Bagginses were finally dashed. Bilbo and Frodo happened to have the same birthday, September 22nd. 'You had better come and live here, Frodo my lad,' said Bilbo one day; 'and then we can celebrate our birthday-parties comfortably together.' At that time Frodo was still in his _tweens,_ as the hobbits called the irresponsible twenties between childhood and coming of age at thirty-three.

A DEFINITION OF "I"

- We need a definition of character "i" that allows people to recognize it
- It shows up in a single way: as *i*
- This holds, at least, if text is given as sequence of alphabetic characters

A DIFFERENT DEFINITION OF "I"

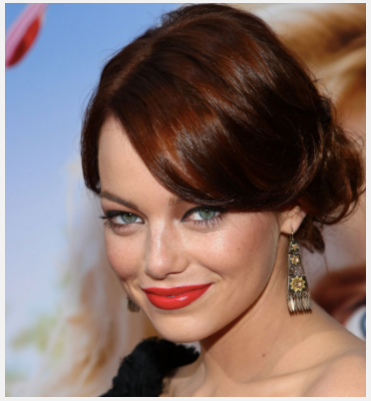
- If text is stored in/for a computer it is encoded as a sequence of bits (0 or 1)
- According to the ASCII encoding scheme, each character is encoded by the 7 bits and "i" corresponds to the sequence 1101001
- The text in ASCII

100111011001011101100110110010010111110111111100101100001100000110010011010011000001110101110
110100000111010011100101100001110110111011111110111011101001101111100000111000011100101101001
110110111000011110110110010111100101101001110110011001011000001101001110111011100111101111111
011001101001111010011000011101101110010111011101110100110010110000011000111100001110110011001
100110111111000001100001111000011100001100001111001011101101100101111001011011111000001110000
111001011001011110011111001111011111000001100111111011001101001100000111001111101001100001110
011111011101101001100000100000...

SOMETIMES IT'S NOT SO EASY…

How many times does Emma Stone appear below?










JUST IN CASE YOU DON'T KNOW HER…

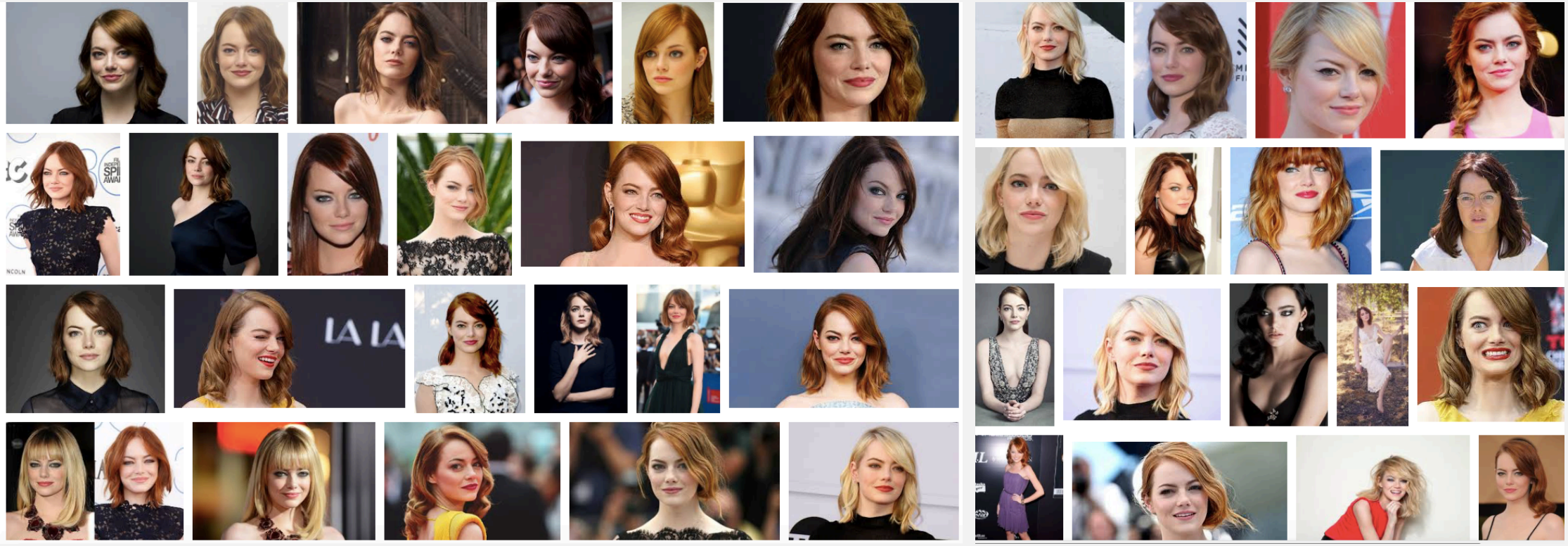
EMMA STONE

BUT HOW CAN WE "DEFINE" EMMA STONE?

- Blonde?
- Green eyes?
- Freckles?

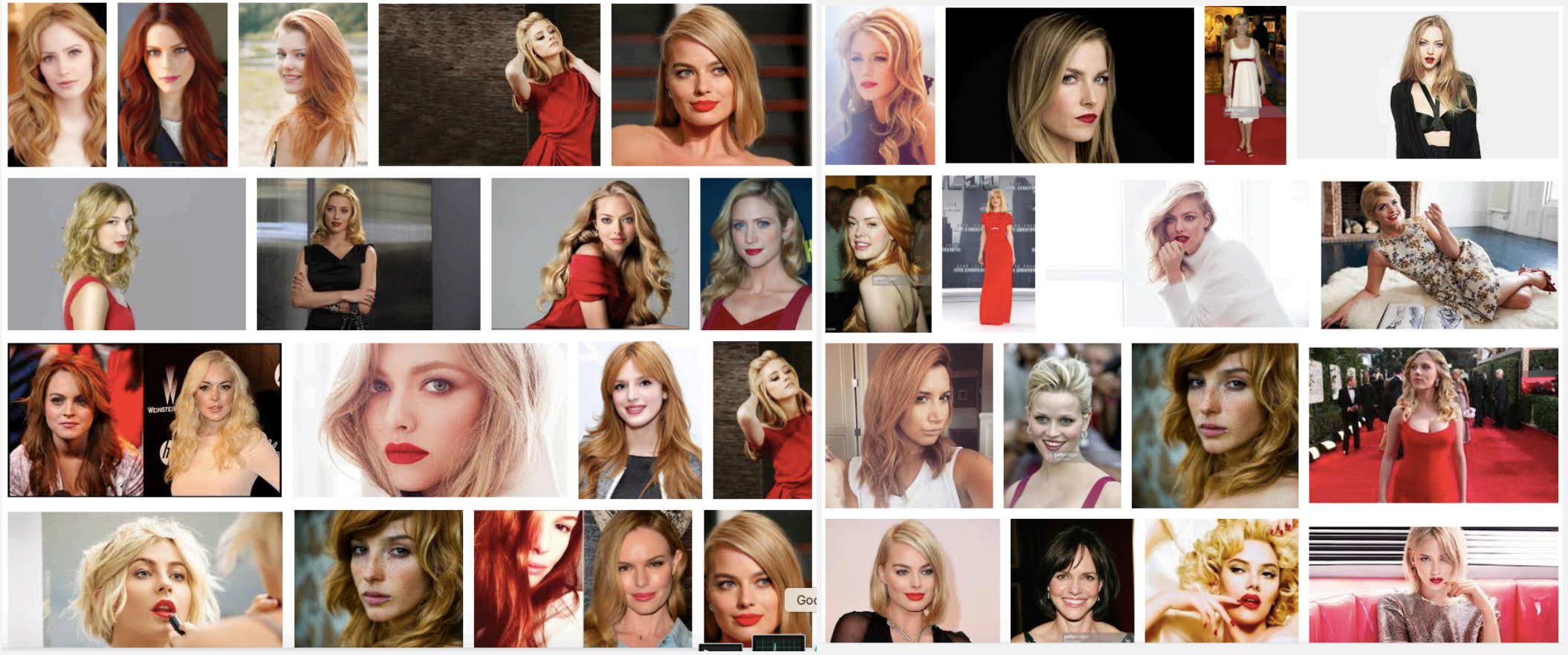
BUT, HOW CAN WE "DEFINE" EMMA STONE?

By examples



BUT, HOW CAN WE "DEFINE" EMMA STONE?

By negative examples



INDUCTION

- We are not able to "explain" how to recognize Emma Stone, and to code it in an algorithm
- We can only show (many) examples of Emma Stone (and of "not Emma Stone")
- We need an algorithm that, from such examples, "learns" how to recognize Emma Stone, in such a way that…

Emma Stone?

YES

Emma Stone?

NO

RECOGNIZING DIGITS

RECOGNIZING DIGITS

HOW TO DEAL WITH THE PROBLEM?

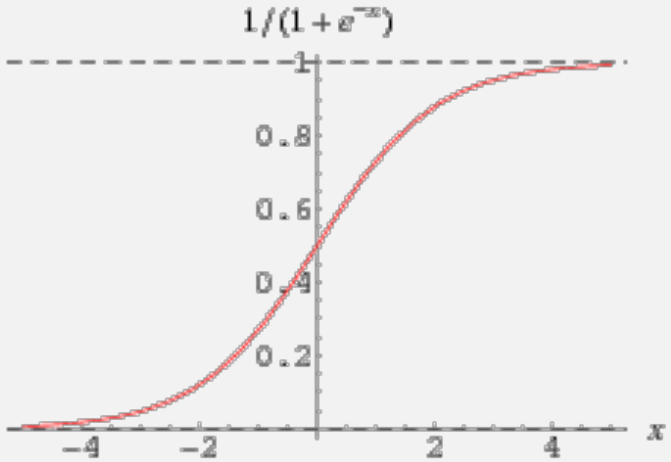
- Build a "model" of 0, of 1, of 2, …, of 9 from their images
- An image: 28x28 dots (pixel): each an integer value ranging from 0 (white) to 255 (black)
- an image: sequence of 28x28=784 values $x_1, x_2, x_3, \ldots, x_{784}$ each in $\{0,1,\ldots,255\}$
- What do we want? A function from $\{0,1,\ldots,255\}^{784}$ to $\{0,1,2,3,4,5,6,7,8,9\}$ making as few mistakes as possible

HOW TO DEAL WITH THE PROBLEM?

- How to do? For example We want to get 10 functions $f_0, f_1, \ldots, f_9$ from $\{0,1,\ldots,255\}^{784}$ to $[0,1]$ with the additional property that, for any image, the sum of their values is 1. then, we can see them as probabilities
- For any image x=[0,3,78,167,…,35,2] (784 values) we see $f_0(x)$ as the probability that it is the image of a 0, $f_1(x)$ as the probability that it is the image of a 1, and so on
- We choose the interpretation corresponding to the function providing the highest value

NOT ALL POSSIBLE FUNCTIONS…

- We do not search among all possible functions; only among the ones with some predefined "structure". for example:
  - all 784 values are combined by summing them (each multiplied with a suitable "weight") → result = a single numeric value
  - The resulting value is transformed to a value in [0,1]



THE BEST POSSIBLE FUNCTION…

- Each of the functions to consider is characterized by the values of the 784 "weights"
- The method, applied to examples, results in a certain number of errors, when applied to available images
- We look for functions with a minimum number of errors → we look for the weight values which result in a function with the minimum number of errors