Artificial Intelligence

Chapter 1

Outline

- ♢ What is AI?
- ♢ A brief history
- ♢ The state of the art

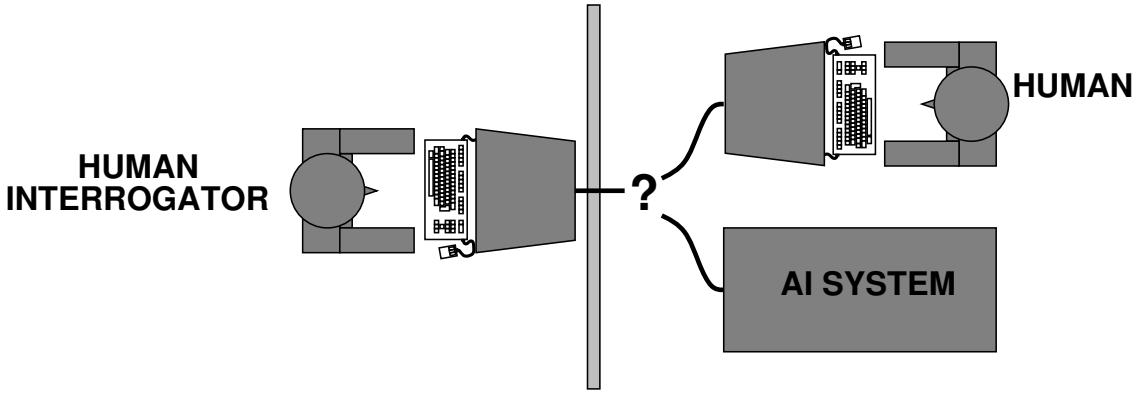
What is AI?

Systems that think like humans	**Systems that think rationally**
Systems that act like humans	**Systems that act rationally**

Acting humanly: The Turing test

Turing (1950) "Computing machinery and intelligence":

- "Can machines think?" $\longrightarrow$ "Can machines behave intelligently?"
- Operational test for intelligent behavior: the Imitation Game



- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
- Anticipated all major arguments against AI in following 50 years
- Suggested major components of AI: knowledge, reasoning, language understanding, learning

Problem: Turing test is not **reproducible**, **constructive**, or amenable to **mathematical analysis**

Thinking humanly: Cognitive Science

1960s "cognitive revolution": information-processing psychology replaced prevailing orthodoxy of behaviorism

Requires scientific theories of internal activities of the brain

– What level of abstraction? "Knowledge" or "circuits"?

– How to validate? Requires

1) Predicting and testing behavior of human subjects (top-down)

or 2) Direct identification from neurological data (bottom-up)

Both approaches (roughly, Cognitive Science and Cognitive Neuroscience) are now distinct from AI

Both share with AI the following characteristic:

the available theories do not explain (or engender) anything resembling human-level general intelligence

Hence, all three fields share one principal direction!

Thinking rationally: Laws of Thought

Normative (or prescriptive) rather than descriptive

Aristotle: what are correct arguments/thought processes?

Several Greek schools developed various forms of logic:
notation and **rules of derivation** for thoughts;
may or may not have proceeded to the idea of mechanization

Direct line through mathematics and philosophy to modern AI

Problems:
1) Not all intelligent behavior is mediated by logical deliberation
2) What is the purpose of thinking? What thoughts **should** I have out of all the thoughts (logical or otherwise) that I **could** have?

Acting rationally

Rational behavior: doing the right thing

The right thing: that which is expected to maximize goal achievement, given the available information

Doesn't necessarily involve thinking—e.g., blinking reflex—but thinking should be in the service of rational action

Aristotle (Nicomachean Ethics):

> **Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good**

Rational agents

An agent is an entity that perceives and acts

This course is about designing rational agents

Abstractly, an agent is a function from percept histories to actions:

$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

Caveat: **computational limitations make perfect rationality unachievable**

$\rightarrow$ design best program for given machine resources

AI prehistory

Philosophy	logic, methods of reasoning
	mind as physical system
	foundations of learning, language, rationality
Mathematics	formal representation and proof
	algorithms, computation, (un)decidability, (in)tractability
	probability
Psychology	adaptation
	phenomena of perception and motor control
	experimental techniques (psychophysics, etc.)
Economics	formal theory of rational decisions
Linguistics	knowledge representation
	grammar
Neuroscience	plastic physical substrate for mental activity
Control theory	homeostatic systems, stability
	simple optimal agent designs

Potted history of AI

1943	McCulloch & Pitts: Boolean circuit model of brain
1950	Turing's "Computing Machinery and Intelligence"
1952–69	Look, Ma, no hands!
1950s	Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
1956	Dartmouth meeting: "Artificial Intelligence" adopted
1965	Robinson's complete algorithm for logical reasoning
1966–74	AI discovers computational complexity Neural network research almost disappears
1969–79	Early development of knowledge-based systems
1980–88	Expert systems industry booms
1988–93	Expert systems industry busts: "AI Winter"
1985–95	Neural networks return to popularity
1988–	Resurgence of probability; general increase in technical depth "Nouvelle AI": ALife, GAs, soft computing
1995–	Agents, agents, everywhere . . .
2003–	Human-level AI back on the agenda

State of the art

Which of the following can be done at present?

♢ Play a decent game of table tennis

State of the art

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- ♢ Play a decent game of table tennis
- ♢ Drive safely along a curving mountain road

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- ♢ Play a decent game of bridge

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- ♢ Discover and prove a new mathematical theorem

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- ♢ Write an intentionally funny story

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- ♢ Give competent legal advice in a specialized area of law

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- ♢ Translate spoken English into spoken Swedish in real time

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- ♢ Unload any dishwasher and put everything away

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Unintentionally funny stories

One day Joe Bear was hungry. He asked his friend Irving Bird where some honey was. Irving told him there was a beehive in the oak tree. Joe threatened to hit Irving if he didn't tell him where some honey was. The End.

Henry Squirrel was thirsty. He walked over to the river bank where his good friend Bill Bird was sitting. Henry slipped and fell in the river. Gravity drowned. The End.

Once upon a time there was a dishonest fox and a vain crow. One day the crow was sitting in his tree, holding a piece of cheese in his mouth. He noticed that he was holding the piece of cheese. He became hungry, and swallowed the cheese. The fox walked over to the crow. The End.

Unintentionally funny stories

Joe Bear was hungry. He asked Irving Bird where some honey was. Irving refused to tell him, so Joe offered to bring him a worm if he'd tell him where some honey was. Irving agreed. But Joe didn't know where any worms were, so he asked Irving, who refused to say. So Joe offered to bring him a worm if he'd tell him where a worm was. Irving agreed. But Joe didn't know where any worms were, so he asked Irving, who refused to say. So Joe offered to bring him a worm if he'd tell him where a worm was . . .

Examples of Current AI

Deep Blue - the massively parallel search computer

1996 became world champion

Why did it worked?

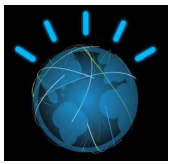
Examples of Current AI

Deep Blue - the massively parallel search computer

1996 became world champion

Why did it worked? - The game is a collection of challenging problems for minds and machines, but has simple rules, and so is perfect for such computer approach.

Examples of Current AI

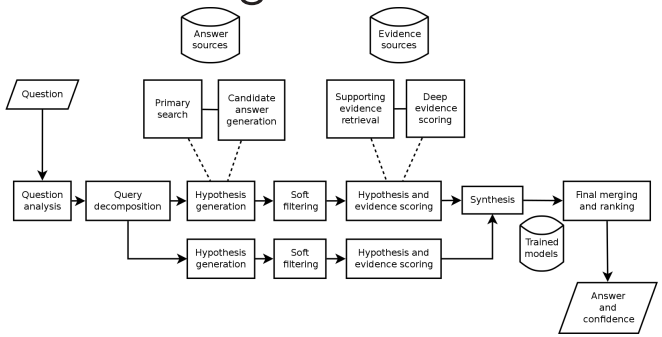


IBM - Watson (2011) Jeopardy

Question Answering Machine in Natural Language

Access to 200 million of pages of structured content (4TB of data)

In 2013 Wtason is used in cancer diagnostics



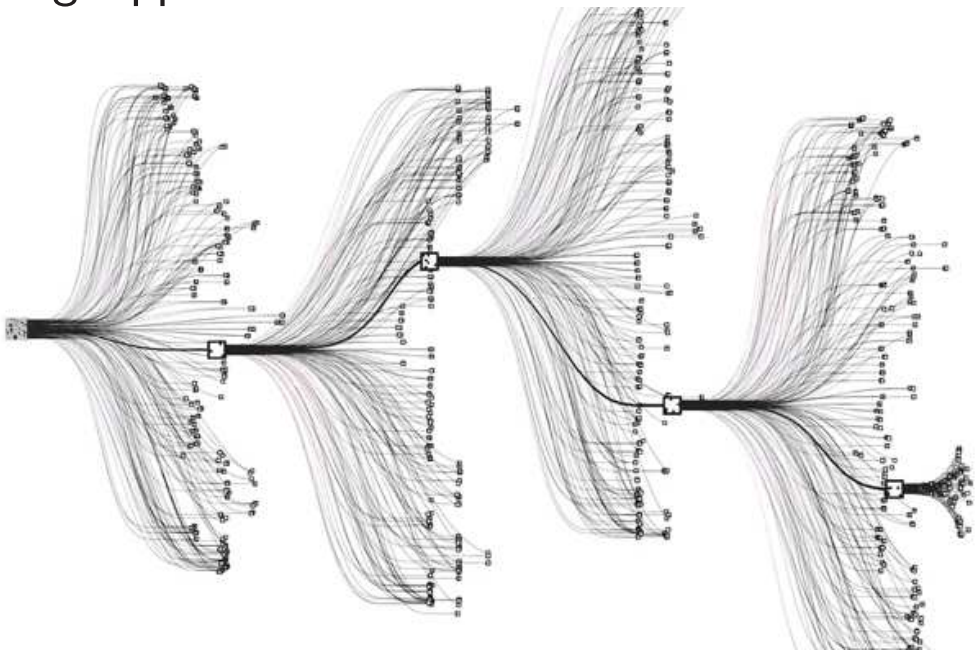
Examples of Current AI

Deep Mind - AlphaGo (2016)

Why would not the Deep Blue approach have worked here?

Examples of Current AI

Machine Learning Approach:



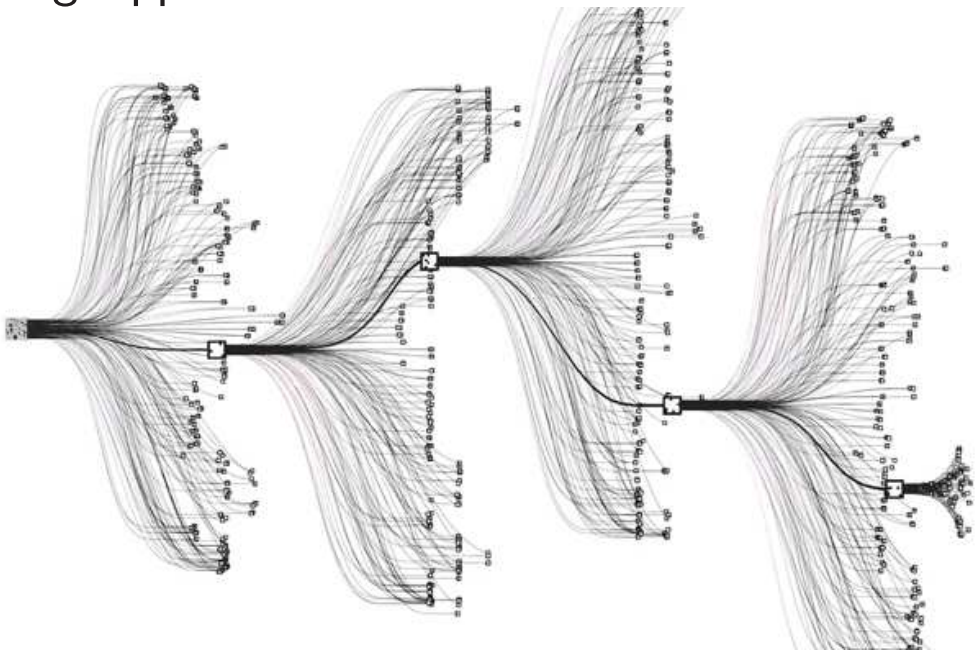
Why would not the Deep Blue approach have worked here? - Go is considered to be the pinnacle of game AI research. Its been the grand challenge, or holy grail if you like, of AI since Deep Blue beat Kasparov at chess. Go is a very beautiful game with extremely simple rules that lead to profound complexity. In fact, Go is probably the most complex game ever devised by humans.

(Demis Hassabis of Google DeepMind)

Go is a vastly more complex game than chess, which may have on average 35 possible moves from each turn; in comparison, Go has 250, and by exponential extension, the number of possible moves by some estimates are greater than the number of atoms in the universe.

Examples of Current AI

Machine Learning Approach:



One network: policy network - estimates moves allowing fastest win

Second network: value network - searches ahead and evaluates each winner position but only small number of selected states (noot like Deep Mind)

Examples of Current AI

Intelligent Cars - Autonomous transportations

What are the main problems and why only now?

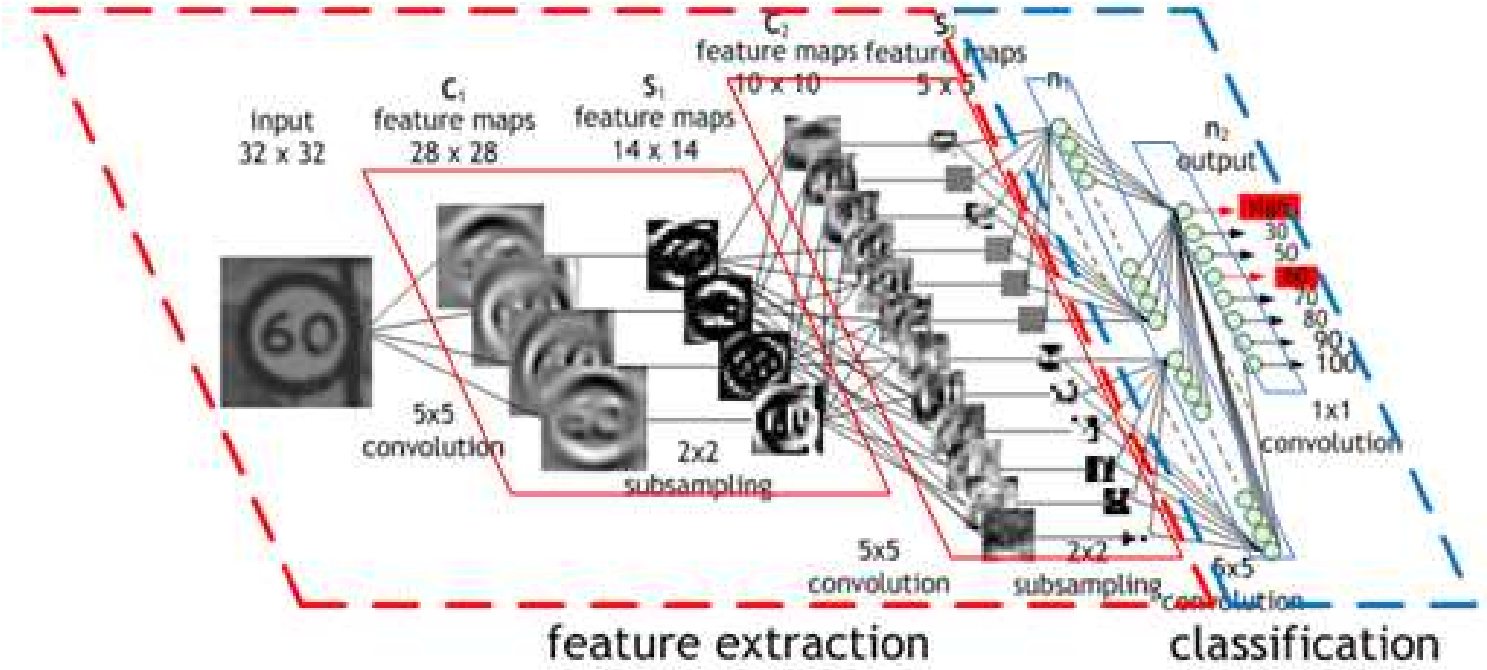
Examples of Current AI

Intelligent Cars - Autonomous transportations

What are the main problems and why only now? Real time recoginition, localization and decision making. But not only that - recent accident shows that DRIVERS must be trained as well. !!!!!!

Examples of Current AI

Deep Learning - ANN approach to data processing



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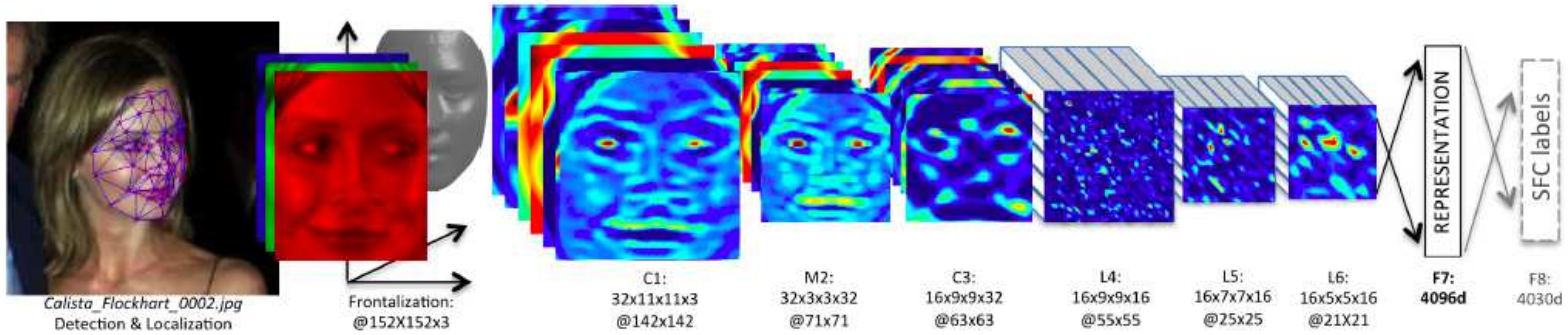

Figure 2. **Outline of the *DeepFace* architecture**. A front-end of a single convolution-pooling-convolution filtering on the rectified input, followed by three locally-connected layers and two fully-connected layers. Colors illustrate outputs for each layer. The net includes more than 120 million parameters, where more than 95% come from the local and fully connected layers.

Examples of Current AI

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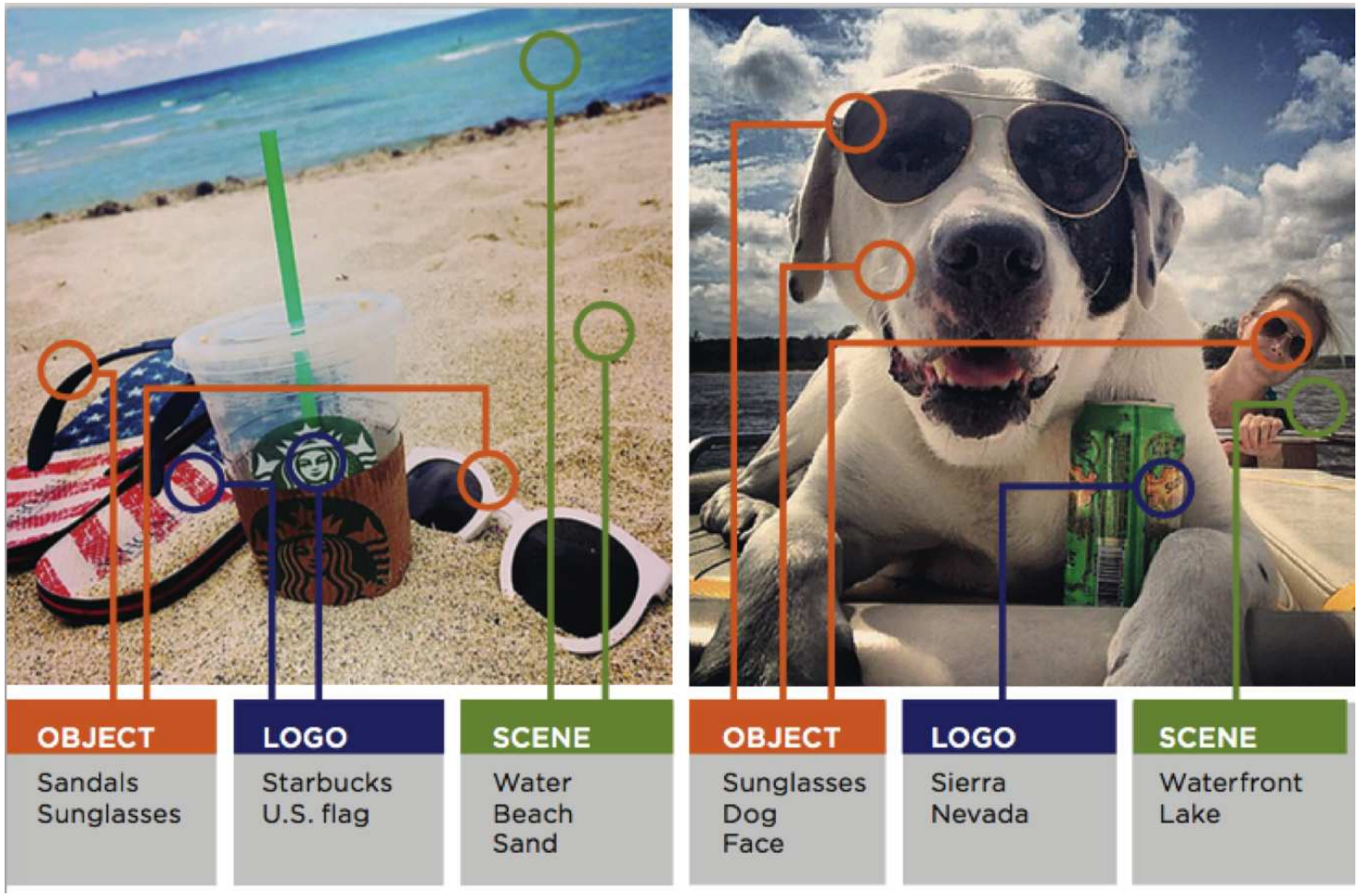
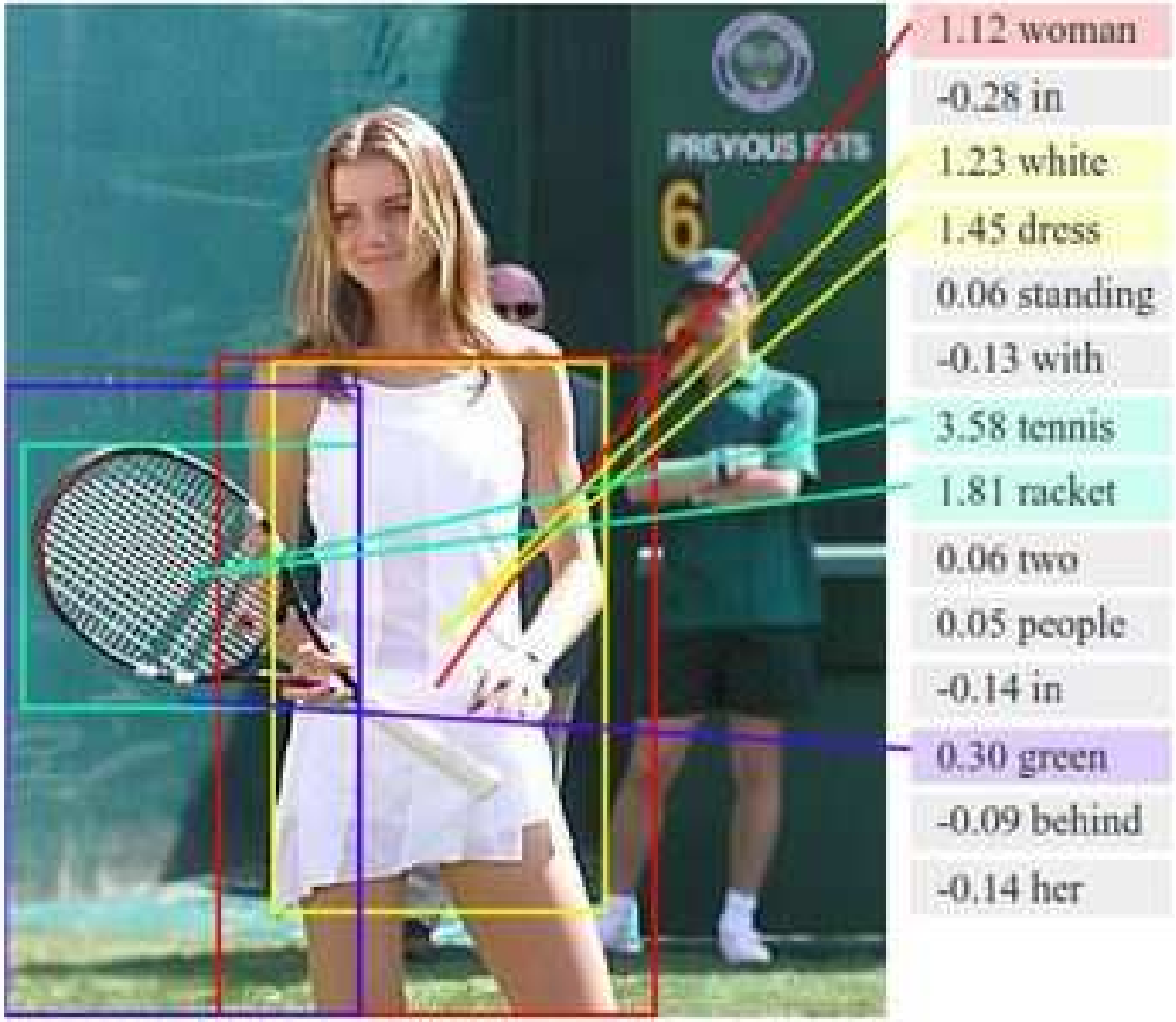



lens cap
reflex camera
Polaroid camera
pencil sharpener
switch
combination lock
abacus
abacus
typewriter keyboard
space bar
computer keyboard
accordion
slug
slug
zucchini
ground beetle
common newt
water snake
hen
hen
cock
cocker spaniel
partridge
English setter
tiger
tiger
tiger cat
tabby
boxer
Saint Bernard
chambered nautilus
lampshade
throne
goblet
table lamp
hamper
tape player
cellular telephone
slot
reflex camera
dial telephone
iPod
planetarium
planetarium
dome
mosque
radio telescope
steel arch bridge


1.12 woman
-0.28 in
1.23 white
1.45 dress
0.06 standing
-0.13 with
3.58 tennis
1.81 racket
0.06 two
0.05 people
-0.14 in
0.30 green
-0.09 behind
-0.14 her